SURFACE GEOLOGY

OF

MICHIGAN

FRANK LEVERETT

MICHIGAN GEOLOGICAL AND BIOLOGICAL SURVEY

Publication 25.
Geological Series 21.

SURFACE GEOLOGY AND AGRICULTURAL CONDITIONS OF MICHIGAN

BY FRANK LEVERETT

WITH A CHAPTER ON CLIMATE
BY C. F. SCHNEIDER

PUBLISHED AS A PART OF THE ANNUAL REPORT OF THE BOARD OF GEOLOGICAL SURVEY FOR 1917.

LANSING, MICHIGAN
WYNKOOP HALLENBECK CRAWFORD CO., STATE PRINTERS
1917

BOARD OF GEOLOGICAL AND BIOLOGICAL SURVEY, 1917.

EX OFFICIO:

THE GOVERNOR OF THE STATE,

HON. ALBERT E. SLEEPER.

THE SUPERINTENDENT OF PUBLIC INSTRUCTION,

HON. FRED L. KEELER.

THE PRESIDENT OF THE STATE BOARD OF EDUCATION,

HON. THOMAS W. NADAL.

DIRECTOR,

R. C. ALLEN.

SCIENTIFIC ADVISORS.

Geologists.—Dr. L. L. Hubbard, Houghton; Prof. W. H. Hobbs, Ann Arbor; Prof. W. H. Sherzer, Ypsilanti; Prof. E. C. Case, Ann Arbor.

Botanists.—Prof. E. A. Bessey, East Lansing; Prof. F. C. Newcomb, Ann Arbor.

Zoologists.—Prof. W. B. Barrows, East Lansing; Prof. J. Reighard, Ann Arbor; Dr. Bryant Walker, Detroit.

LETTER OF TRANSMITTAL.

To the Honorable, the Board of Geological Survey of Michigan:

Gov. Albert E. Sleeper.
Hon. Thomas W. Nadal.
Hon. Fred L. Keeler.

Gentlemen:—The continuous and growing public demand for information concerning particularly the unoccupied lands and agricultural conditions in the northern part of Michigan has exhausted the entire editions of Publication 7 and Publication 9. I am therefore transmitting to you the combined revised manuscript of these two volumes and recommend that it be reprinted and bound as Publication 25, Geological Series 21.

Very respectfully yours,

R. C. ALLEN,
Director.

Lansing, Michigan,
July 14, 1917.

TABLE OF CONTENTS.

CHAPTER V.

PART II. THE SOUTHERN PENINSULA.

CHAPTER I.

CHAPTER II.

CHAPTER III.

CHAPTER IV

LIST OF ILLUSTRATIONS.

PLATES.

FIGURES.

CLIMATIC CONDITIONS OF MICHIGAN

C. F. SCHNEIDER.

Errata. Page 26, Fig. 11. Read temperature curve 5° higher.

CLIMATIC CONDITIONS OF MICHIGAN.

C. F. SCHNEIDER.[1]

MODIFYING EFFECT OF THE GREAT LAKES.

The climate of Michigan is insular to a marked degree on account of the Great Lakes.

The determining factors of climate for any locality are chiefly latitude and the relative distribution of land and water. Other important factors are the topography of the land surface and the situation of the area in question, with relation to the general movement of the cyclones and anti-cyclones.

Large bodies of water tend to equalize the nearby land temperatures. This is especially true of Michigan, where the effect of the great cold waves sweeping from the northwest is modified by the warmer water of the Great Lakes; the movement of these cold waves, or anti-cyclones, is often deflected by the great bodies of water.

The effect of the Great Lakes, particularly that of Lake Michigan, in modifying the temperature effect of cold anti-cyclones and warm cyclonic storms makes for lower Michigan a more equable and less extreme climate than obtains in the states of similar latitude west of Lake Michigan. This influence is very marked in the immediate vicinity of Lake Michigan, although apparent in all parts of the Southern Peninsula; in Wisconsin winter temperatures have frequently continued from ten to twenty degrees lower during periods of extreme cold weather, than in Southern Michigan, owing to the warming influence of the Great Lake which separates the two states. In spring, the influence of Lake Michigan particularly, and of all the Great Lakes in general, is of untold value in modifying the eastward sweep of early hot waves and late cold waves. In summer the refreshing southwest to west winds are making the entire shore bordering Lake Michigan a continuous summer resort.

The effect of this large water area is graphically shown by Figs. 1 and 2, which delineate the location of the mean January and July isotherms. The charts also show the insular character of

[1] With notes on Northern Peninsula by Frank Leverett.

the Southern Peninsula; there is a greater range in mean monthly temperatures in the northern interior counties than in the shore counties; the isotherms are drawn far to the south along the Lake Michigan and also the Lake Huron shore in the summer and correspondingly far to the north in winter.

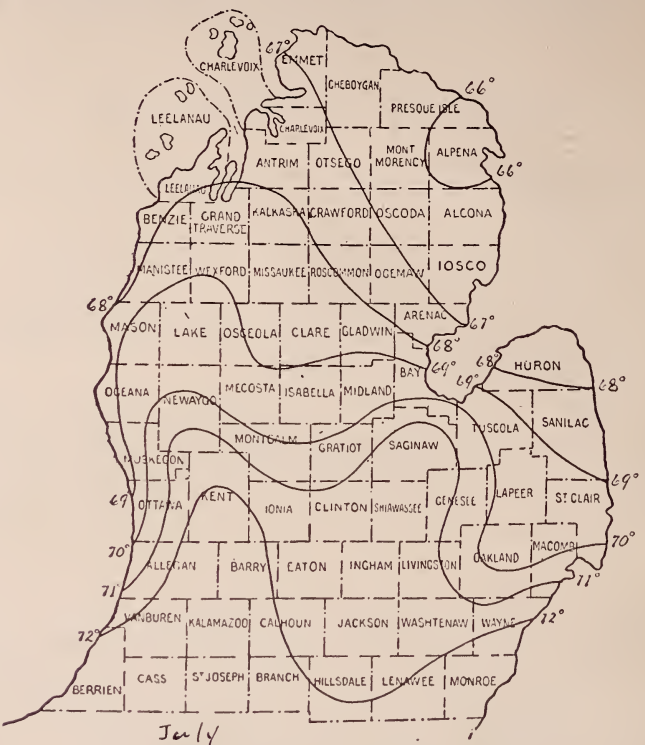


Fig. 1. January mean temperatures, 1886-1911.

SEASONAL AND ANNUAL MEANS.

	Milwaukee.	Grand Haven.	Green Bay.	Ivan.
Winter mean	22	26	18	21
Spring mean	43	43	42	41
Summer mean	68	67	68	66
Fall mean	49	49	47	46
Annual mean	45	46	44	43

The modifying effect of the Great Lakes is quite markedly shown by comparing the seasonal average temperatures of Milwaukee and Grand Haven, whose latitude is almost identical and both of which are situated immediately on the shore of Lake Michigan. It is still further illustrated by comparison of like data of Green Bay, Wisconsin, and Ivan, Michigan, the former being near the shore of Lake Michigan and the latter being far inland in Kalkaska county, Michigan.

The interesting point in a comparison of these figures is that the winter temperature at the two Michigan points is not as severe as at those in Wisconsin and the summer temperatures are not as high.

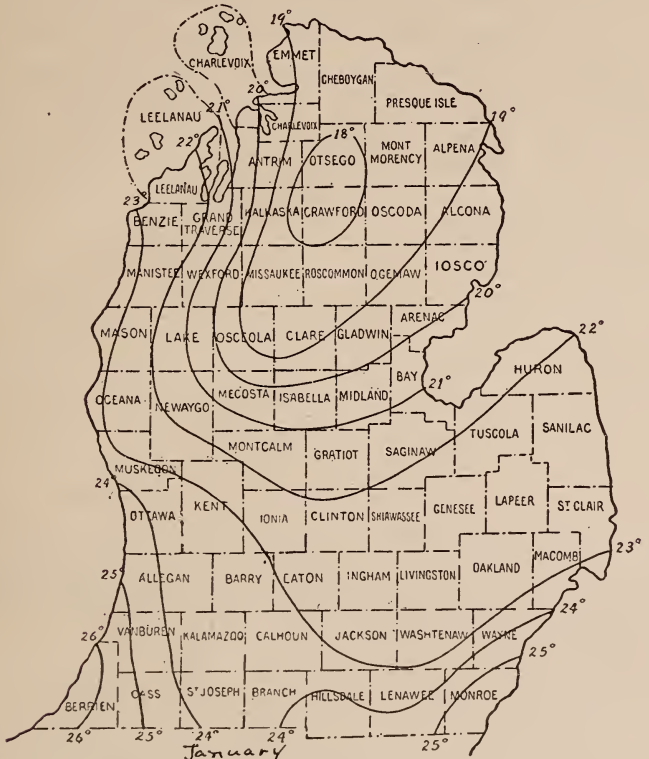


Fig. 2. ~~July~~ January mean temperature, 1886-1911.

A feature of Michigan climate in connection with its soil productivity, is the comparatively long days and short nights due to latitude. In the Northern Peninsula daylight in June extends from 3 a. m. to 9 p. m. In Southern Michigan the longest day of the year at the summer equinox is nearly fifteen and one-half hours whereas at New Orleans the longest day of the year is only a little more than fourteen hours in length. These long days and short nights during the crop season are important climatic factors; the daylight promotes all vegetable growth, and the short nights often prevent late frosts in spring and early frosts in autumn. On the other hand, the frosting of the soil during the late fall and early spring greatly adds to its tilth and fertility.

The topography is not so marked that it exerts a general effect upon climate, but it has some features that exert marked local effects. The high lands of Osceola, Wexford, Missaukee, Kalkaska and Antrim counties are noted for their great snow depth, because the

moisture laden westerly winds from Lake Michigan are deflected upward and the relatively colder temperature of the higher altitude causes the moisture to condense from aqueous vapor; the precipitation formed is deposited as heavy snow from early fall to early spring. Another marked snow belt, due to similar conditions of a less marked altitude, extends from northern Kent county to St. Joseph county. Almost invariably there is more snowfall in these sections than in counties farther east. Also an excessive snowfall is produced immediately along the shores of the Great Lakes by the condensation and precipitation resulting from the adiabatic cooling of the comparatively warm currents of moisture laden air which rise from the surfaces of the lakes.

Another marked feature of Michigan climate is the fact that it is directly in the path of greatest storm frequency. A large majority of the great cyclones and anti-cyclones that cross the United States, move across or near the Lake region. Some of these storms originate in the Canadian Northwest and move eastward across the Lake Superior district to the St. Lawrence Valley. Another class move from the Canadian Northwest to the middle western portion of the United States and then northeastward across the Lake region to the St. Lawrence Valley. A third class either forms over the middle western portion of the United States or moves from the far southwest to that locality and then across the Lake region to the St. Lawrence Valley.

The cyclonic storms, or low pressure areas, vary in size, their average width being about a thousand miles. Their advance is marked by rising temperatures, increasing cloudiness and precipitation. The anti-cyclonic storms, which are areas of high barometric pressure, are characterized in their advance by colder, clearing weather.

The circulation of the wind in a cyclone is spirally inward and in the direction opposite to the movement of the hands of a watch. The circulation of the air in an anti-cyclone, is outward, circulatory and in the same direction as the movement of the hands of a watch. The intensity of these storms is largely dependent on the steepness of barometric gradient, which in turn is modified or increased by the proximity of other cyclones and anti-cyclones.

In this connection, it may be proper to define the difference between the cyclone and the tornado. The tornado differs from the cyclone in being very much smaller in area, more intense in action and of shorter duration. The tornado is really a part of the cyclone, although a large majority of North American cyclones are not accompanied by tornadoes. Cyclones, or large areas of barometric

depression, cross the state on an average of once every three or four days, but the tornado is of rather unusual occurrence. Tornadoes usually occur during the afternoon and are of the most violent of all atmospheric disturbances. They are characterized by a pendant, funnel shaped cloud and their paths are usually not more than two hundred feet wide, never more than one mile, and their tracks rarely exceed ten miles in length; the funnel shaped cloud has a violent rotary motion in the direction opposite to the hands of a watch and the power of demolishing buildings, uprooting trees and otherwise doing great damage.

Michigan is seldom visited by tornadoes. The most destructive storms of this character occurred on May 25, 1896, in Oakland county, and at Omer, Arenac county, May 24, 1897. Owosso was visited by a tornado of exceptional violence on November 11, 1911, at the very unusual hour of about 11 p. m. Two exceptionally destructive tornadoes of recent years occurred June 6, 1917, one in the counties of Calhoun, Jackson and Ingham, the other between Ann Arbor and Dexter, Washtenaw county.

TEMPERATURE.

The mean annual temperature of Southern Michigan as a whole, is about forty-six degrees, ranging from forty-nine degrees in the extreme southwestern part to forty-two degrees in the extreme northeastern portion. The mean temperature of the Northern Peninsula is about forty degrees. The average maximum, or day temperature, ranges from about eighty-two degrees in summer to twenty-eight degrees in winter, and the average minimum, or night temperature is approximately fifty-seven degrees in summer, and twelve degrees in winter. Extreme temperatures of one hundred degrees or more are not of frequent occurrence, although they have been recorded at some places on one or two days, during a majority of the summers in the past twenty-five years. Zero temperatures are an invariable rule during most winter months in the northern half of the peninsula; in the southern half of the peninsula zero temperatures usually occur, although there have been some winters in the extreme southern counties when there has been an entire absence of zero temperature; the lowest known temperatures are shown by Fig. 4, which covers an observation period of twenty-five years.

For the four months, June, July, August and September, the temperature averages through a great part of the Northern Peninsula slightly above 60°, and as this is the main part of the growing

season, the conditions are favorable for the growth and maturing of crops of various kinds. There is considerable variation in the climatic conditions in passing short distances inland from the Lake Superior shore, the effect of the evaporation from the lake being most marked within a limit of 10 miles or less. Where highlands face directly upon the shore of Lake Superior, as in the Copper Range, the Porcupine Mountains, the Huron Mountains and the

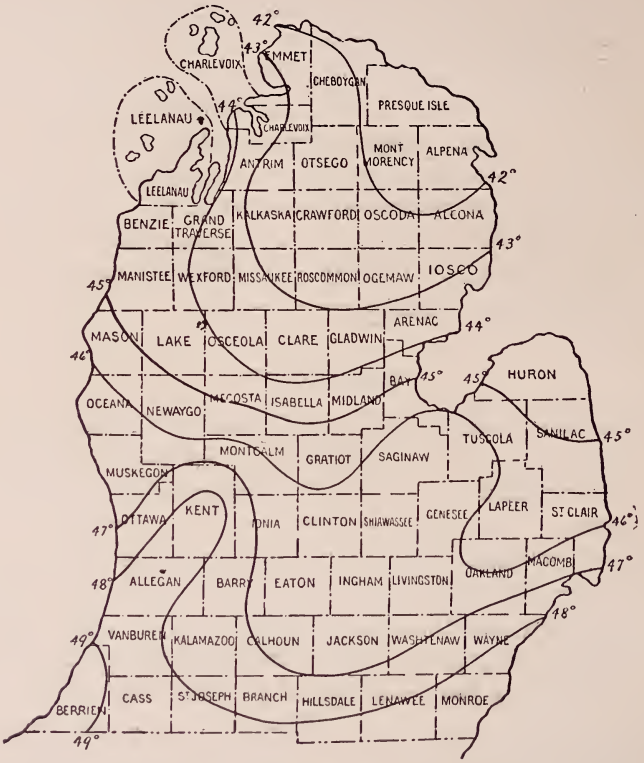


Fig. 3. Annual mean temperature of the Southern Peninsula, 1886-1911.

tableland east from Munising, the conditions are specially favorable for escaping early frosts in the autumn, because of the rise of the air from the lake to these highlands. Very often the highlands on the slope toward the lake escape frosts for nearly a month later than low lying districts in the interior of the Peninsula, or even than the land immediately back of these ranges. The ranges facing upon the lake will therefore be especially favorable places for the cultivation of orchards and raising of fruits of all classes, as well as for the growing of cereals.

Long heated spells in summer or abnormally protracted cold periods in winter are very unusual. Historical periods of abnormal temperatures occurred in the summer of 1911 and the winter of 1899. The continued high temperatures prevailing during the latter part of June and the early half of July in 1911 were phenomenal and had never before been equalled so far as duration is concerned. On the other hand, the phenomenal cold weather which occurred during

Fig. 4. Lowest known temperatures, 1886-1911.

the second and third decades of February, 1899, marked the longest period of low temperatures known. A strong factor in producing the continued cold of February, 1899, was the freezing over, or rather the covering with fields of rubble ice, of Lake Michigan, thus forming a bridge for, instead of a barrier to, the advance of the northwestern cold wave that crossed the northern states that month.

FROSTS.

The Weather Bureau is in possession of a twenty-five-year record from a large number of places in the Southern Peninsula from which it has been able to determine the average date of the last killing frost in spring and the first in autumn and, using these dates as boundaries, we can mark the average beginning and ending of crop

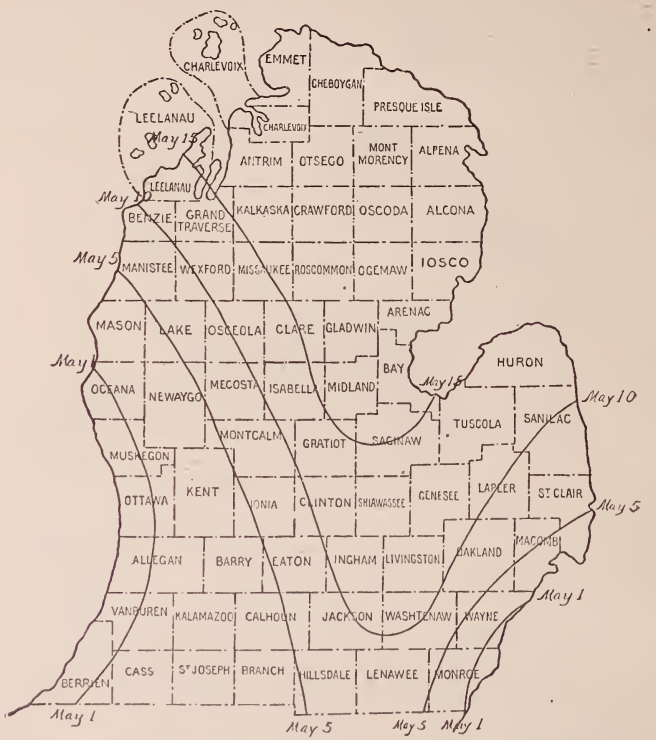


Fig. 5. Average date of last killing frost in spring.

growth and determine the average length of the crop growing season in days for the different counties of the state.

As a rule, destructive frosts do not occur later than May 15th nor earlier than September 30. Over a large part of the Southern Peninsula killing frosts do not occur until October 1st. This gives an average of one hundred and forty-five days or nearly five months when, under normal conditions, there will be no destructive frosts. The shortest crop period obtains over the extreme northeastern portion of the peninsula, where the average length of the season is one hundred and thirty days, while over the extreme southwest

portion the average is one hundred and sixty days. All of this information is graphically shown by Figs. 5, 6, and 7.

The time of the latest frosts in spring and of the earliest in the fall for the five years, 1906 to 1910 inclusive, has been worked out for the Northern Peninsula from the Weather Bureau data and is here presented. It will be noted that the Northern Peninsula stations, located on the shores of the lakes have generally a more

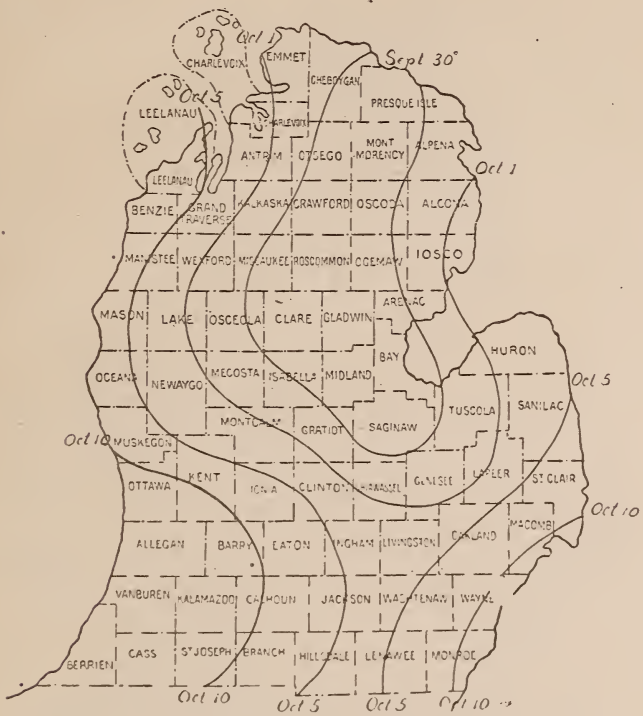


Fig. 6. Average date of first killing frost in autumn.

constant condition of freedom from summer frosts than those in the interior. Indeed, they are free from frosts for nearly as long a period as most of the stations in the Southern Peninsula. But in the interior of the Northern Peninsula there is danger of local frosts any month of the summer. The records do not make clear whether the summer frosts are, in a given case, severe enough to seriously injure crops. In some cases it is known that little or no damage is done by the late spring or early fall frosts. Thus it is stated in the Annual Report for 1906 of the Northern Peninsula Experiment Station at Chatham that no damage could be observed from frosts that

occurred May 28 and 29 and June 12, not even on corn and buckwheat which on June 12 were several inches high. The same was true of frosts on September 1 and 28, the first severe frost being that of October 11. The real season between killing frosts for that station in 1906 extended from May 20 to October 11, or 144 days instead of the 81 days between June 12 and September 1 which the Weather Bureau Records would suggest. In some cases it is known

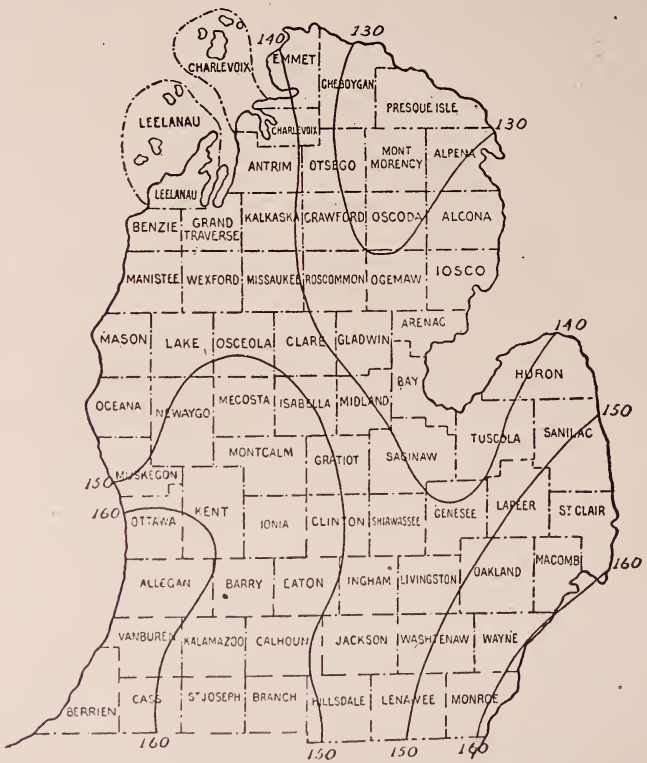


Fig. 7. Average length crop growing season, days.

that these summer frosts are sufficiently severe to injure tender vines such as cucumbers and melons, without affecting the grains and vegetables which form the main crops of the region. *In general it may be stated that there are in the most favorable seasons six months of the growing season throughout the peninsula, from May to October inclusive.* But in some years the growing season is only four months, from June to September.

The tables serve to illustrate the statement made above: that frost is especially liable to occur on the landward side of ranges

that front on Lake Superior at times when the lakeward slope is untouched. It will be noted also that points situated on Lake Superior have an exceptionally long season between spring and fall frosts. This is true even on Isle Royale in latitude 48°.

Reference may be made to the reports of the Weather Bureau for the details of temperature, precipitation, etc., which can not be presented here for lack of space. Reference should also be made

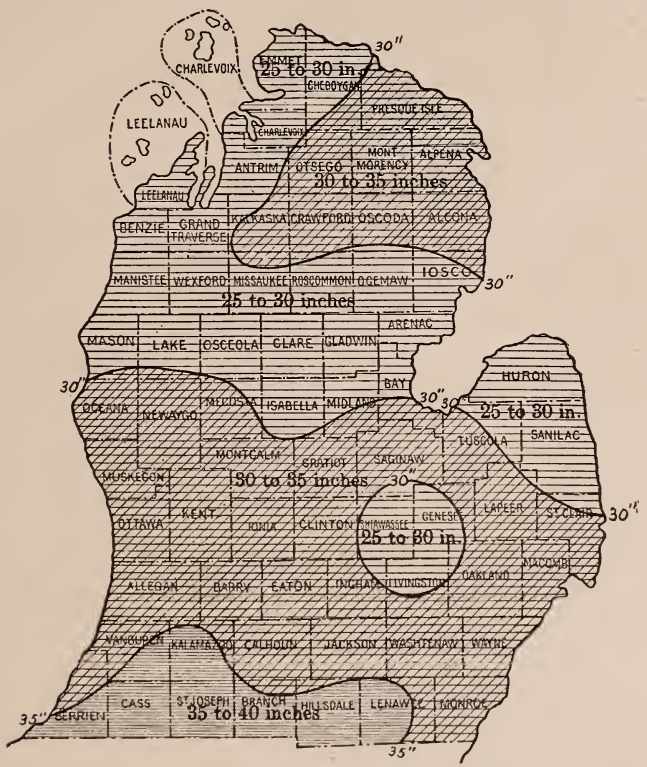


Fig. 8. Average annual precipitation Southern Peninsula of Michigan, 1886-1911.

to the annual reports of the Northern Peninsula substation at Chatham for results of experiments with a large variety of grains, vegetables, forage plants, and orchard and small fruits. These reports present a careful digest of the effect of climatic conditions on the crops.

PERIOD BETWEEN SPRING AND FALL FROSTS AT NORTHERN PENINSULA STATIONS.

Station.	Alt. Ft.AT.	1906.	1907.	1908.	1909.	1910.	Average summer.	Latitude.
Baraga	623	———Sept. 29	119d., M. 29 to S. 25	———Sept. 14	98 d., M. 26 to Sept. 1	106 d., M. 29 to S. 12	108 d. (3 yr.)	46°47′
Bergland	1300				——— Sept. 1	111 d., Jn. 10 to S. 29	111 d. (1 yr.)	46°35′
Blaney		110 d., Jn. 12 to S. 30	112 d., Jn. 2 to S. 22	106 d., Jn. 14 to S. 28		——— Aug. 31	109 d. (3 yr.)	46°11′
Calumet	1246	136 d., M. 26 to O. 9	123 d., M. 27 to S. 27	141 d., M. 12 to S. 30	155 d., M. 10 to O. 12	136 d., M. 30 to O. 12	138 d.	47°15′
Chatham	875	81 d., Jn. 12 to S. 1	116 d., M. 31 to S. 24	80 d., Jn. 15 to S. 3	73 d., Jn. 18 to A. 30	97 d., Jn. 8 to S. 13	89 d.	46°22′
Deer Park	610	153 d., M. 10 to O. 10	140 d., M. 27 to O. 14	———M. 8 to———	156 d., M. 11 to O. 14	141 d., M. 25 to O. 13	147 (4 yr.)	46°47′
Detour	600	135 d., M. 28 to O. 10	121 d., M. 28 to S. 26	162 d., M. 3 to O. 12	161 d., M. 4 to O. 12	146 d., M. 17 to O. 10	145 d.	46°00′
Eagle Harbor	622	154 d., M. 7 to O. 8	122 d., M. 28 to S. 27	149 d., M. 6 to O. 2	147 d., M. 20 to O. 14	140 d., Jn. 3 to O. 21	142 d.	47°27′
Escanaba	612	140 d., M. 20 to O. 7	111 d., Jn. 7 to S. 26	151 d., M. 1 to S. 29	140 d., M. 10 to S. 27	162 d., M. 14 to O. 23	141 d.	45°45′
Ewen	1147		111 d., Jn. 7 to S. 26	110 d., Jn. 11 to S. 29	85 d., Jn. 8 to S. 1	45 d., Jl. 18 to S. 1	88 d. (4 yr.)	46°33′
Grand Marais	610	135 d., M. 28 to O. 10	138 d., M. 28 to O. 13	157 d., M. 8 to O. 12	161 d., M. 5 to O. 13	142 d., Jn. 1 to O. 21	146 d.	46°41′
Houghton	668	153 d., M. 9 to O. 9	133 d., M. 21 to O. 1	150 d., M. 5 to O. 2	163 d., M. 10 to O. 20	166 d., M. 14 to O. 27	153 d.	47°07′
Humboldt	1536	103 d., M. 20 to A. 31	109 d., Jn. 8 to S. 25	96 d., J. 15 to S. 19	——— A. 21	——— A. 19	103 d. (3 yr.)	46°30′
Iron Mountain	1111	152 d., M. 11 to O. 10	104 d., Jn. 10 to S. 22	106 d., J. 15 to S. 29	147 d., M. 4 to S. 26	133 d., M. 27 to O. 7	128 d.	45°48′
Iron River	1504	109 d., Jn. 13 to S. 30	117 d., M. 28 to S. 22	146 d., M. 6 to S. 29	75 d., Jn. 18 to S. 1	49 d., Jl. 23 to S. 10	99 d.	46°06′
Ironwood	1520	122 d., M. 28 to S. 27	———M. 27 to ———	147 d., M. 7 to S. 29	114 d., M. 10 to S. 1	125 d., Jn. 3 to O. 6	127 d. (4 yr.)	46°27′
Ishpeming	1536	70 d., Jn. 12 to A. 21	———M. 29 to ———	106 d., J. 15 to S. 29	91 d., Jn. 18 to S. 17	144 d., M. 31 to O. 23	100 d. (4 yr.)	46°29′
Isle Royale	610	154 d., M. 8 to O. 9	141 d., M. 30 to O. 18	———S. 3	166 d., M. 10 to O. 23	159 d., M. 14 to O. 20	155 d. (4 yr.)	48°
Mackinac Island	600	144 d., M. 24 to O. 11	134 d., M. 27 to O. 8	——— May 8	156 d., M. 11 to O. 16		145 d. (3 yr.)	45°51′
Maple Ridge	957	80 d., Jn. 13 to S. 1	107 d., Jn. 7 to S. 22	112 d., M. 14 to S. 3	110 d., M. 11 to A. 30	106 d., Jn. 8 to S. 22	103 d.	46°04′
Marquette	734	142 d., M. 20 to O. 9	138 d., M. 11 to S. 26	151 d., M. 4 to O. 2	164 d., M. 4 to O. 15	175 d., M. 5 to O. 27	154 d.	46°32′
Menominee	581	153 d., M. 9 to O. 9	126 d., M. 27 to S. 30	149 d., M. 3 to S. 29	140 d., M. 10 to S. 27	177 d., M. 4 to O. 28	149 d.	45°06′
Newberry	773			———M. 3 to ———	138 d., M. 27 to O. 12	92 d., M. 30 to A. 30	115 d. (2 yr.)	46°22′
St. Ignace	593		96 d., M. 28 to S. 1	157 d., M. 5 to O. 9	153 d., M. 11 to O. 11	157 d., M. 5 to O. 9	141 d. (4 yr.)	45°51′
Sault Ste. Marie	614	152 d., M. 10 to O. 9	121 d., M. 28 to S. 26	145 d., M. 10 to O. 2	154 d., M. 11 to O. 12	130 d., M. 14 to S. 22	140 d.	46°30′
Thomaston	1347	125 d., M. 28 to S. 30	107 d., Jn. 7 to S. 22	80 d., Jn. 15 to S. 3	79 d., Jn. 14 to S. 1	——— Jl. 18	98 d. (4 yr.)	46°32′
Victoria Mine	1263				——— O. 2	139 d., Jn. 3 to O. 20	139 d. (1 yr.)	46°41′
Watersmeet	1581				75 d., Jn. 18 to S. 1	68 d., Jn. 12 to A. 19	71 d.	46°16′
Wetmore	878	82 d., Jn. 11 to S. 1	106 d., Jn. 11 to S. 1	91 d., Jl. 30 to S. 29	73 d., Jn. 18 to A. 30	103 d., Jn. 11 to S. 22	91 d.	46°22′
Whitefish Point	610	152 d., M. 11 to O. 10	145 d., M. 28 to O. 20	112 d., M. 13 to S. 3	152 d., M. 14 to O. 13	168 d., M. 13 to O. 28	146 d.	46°48′

PRECIPITATION.

Agriculture, as adapted to most any part of the United States, requires from 20 to 24 inches of annual precipitation properly distributed as a minimum amount to grow successful crops without irrigation. A well distributed annual amount varying from 26 to 30 inches is ample for successful agriculture but greater amounts, if well distributed and not more than 40 inches per year, are not injurious to the class of crops grown in Michigan.

The rainfall in the Northern Peninsula averages about 34 inches, and there are few places in which it falls below 31 inches. A large part of it, 18 to 25 inches, comes in the growing season, so there is little or no deficiency of moisture for watering the crops. The interior of the western portion of the peninsula has an exceedingly high snowfall owing to the fact that the winds rising from Lake Superior laden heavily with moisture become chilled and pecipitate snow, not only throughout the winter months, but often from early in October to the beginning of May, so that the ground is frequently covered almost continuously for half the year. There is, however, a belt along the coast of Lake Superior where precipitation is in the form of rain for a larger portion of the year than on the highlands in the interior. The amount of precipitation decreases perceptibly in passing southeastward from the high tablelands in the western portion of the Peninsula to the border of Green Bay and Lake Michigan, owing to the fact that these districts are in the lee of the higher land and the air becomes warm in descending and is able to hold the moisture.

The following data and maps with reference to temperature and precipitation taken from the Reports of the United States Weather Bureau, will serve to set forth the precise conditions at points widely distributed over the Peninsula. The precipitation maps bring out the variability of rainfall in different years. Portions of the Peninsula which are high in the amount of rainfall one year may be comparatively low another. In some years the western end of the Peninsula has dry conditions because of the extension eastward of these conditions from the Great Plains. In other years the same district is within the sweep of moist winds rising from Lake Superior which give it larger rainfall especially on the elevated portions. There is usually a comparatively high rainfall along the Lake Superior coast near Marquette. This is probably because of the occurrence of winds from the lake which upon rising toward the elevated uplands that there border the lake closely are cooled and made to develop clouds and rain.

The average annual precipitation, which includes melted snow,

hail, sleet and rain, is shown for the Southern Peninsula by Fig. 8, being the greatest in the extreme southern part of the state and least in the northern part. The general average for the entire peninsula is approximately thirty inches. The distribution throughout the year can be better illustrated than described and is shown by Figs. 9, 10 and 11 for each of the three geographical subdivisions

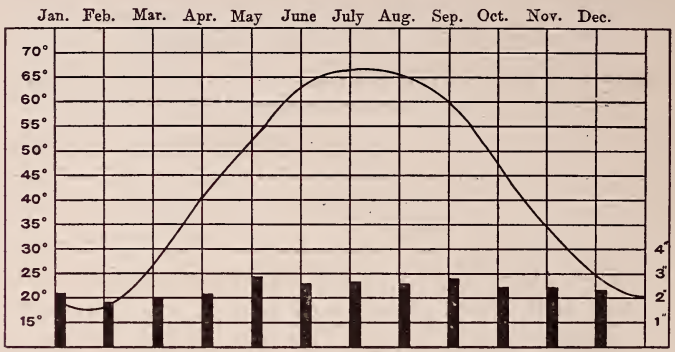


Fig. 9. Monthly mean temperature and precipitation, Northern Section.

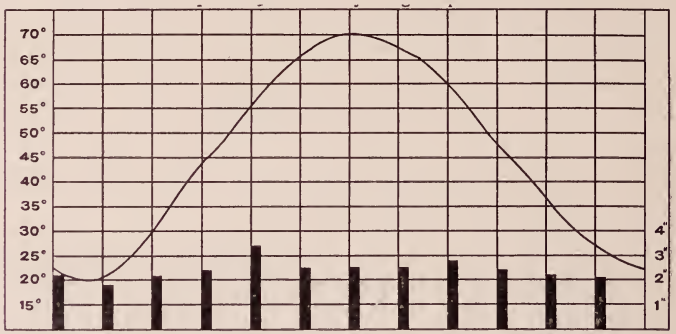


Fig. 10. Monthly mean temperature and precipitation. Central Section.

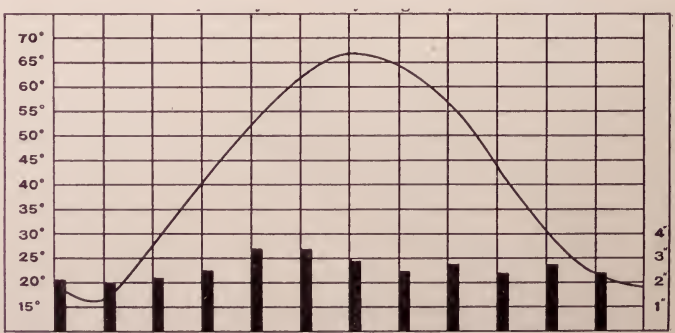


Fig. 11. Monthly mean temperature and precipitation. Southern Section.

of the Southern Peninsula. It is noticeable that the summer precipitation is greater in the southern part of the state during the months of May, June and July, than in the northerly portions.

The average depth of snowfall for each of the three sections can be found in tables on following pages. It will be noted that snow has never been known to occur in July and August, rarely in June and September, but that it usually occurs first during October, increasing in amount to the end of January, after which there is a decrease in amount, which practically ends in April. Light falls are quite usual during May. Nearly sixty inches of snow falls annually in all counties of the Southern Peninsula.

DROUGHT.

Short and irregular periods of drought over limited portions of the state have occurred from time to time, but long periods of deficient precipitation are rare. An exact statement of the conditions which actually constitute a severe drought are hard to make, because much depends not only upon the length of time that there is an absence of rainfall, but upon the condition of the soil when deficient periods of rainfall begin, the time of year when the deficiency actually occurs and, from an agricultural standpoint, the texture of the soil and other physical conditions also have a bearing. Professor Henry in his Climatology of the United States, notes that the greatest drought this country has ever experienced in the last one hundred years, both as to intensity and extent of territory covered, extended over the middle Mississippi and Missouri valleys, the Lake region and Atlantic Coast districts from early summer of 1894 until about the first of August, 1895, the precipitation deficiency being about ten inches. Since then there has been no general serious drought in Michigan.

Previous to 1894 moderately severe droughts had occurred in Michigan in 1881 and 1887.

SUNSHINE.

The sunshine annually will average somewhat over fifty per cent. of the possible amount, the percentage being much higher during the period extending from May to the middle of October, than during the winter months. During December, January and February it sometimes falls as low as twenty per cent. of the possible amount, while during June, July, August and September it exceeds sixty and sometimes seventy per cent. of the possible amount. As a rule, July is the sunniest month and December the cloudiest.

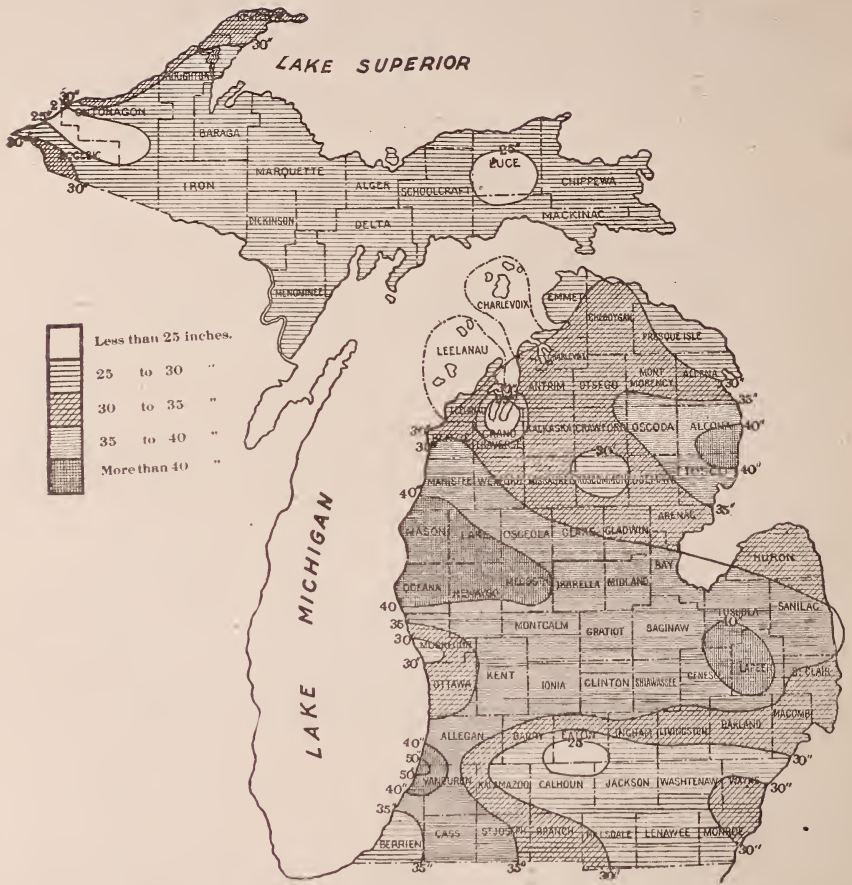


Fig. 12. Annual rainfall map of Michigan for 1912.

Fig. 13. Mean annual isotherms and prevailing winds for 1912.

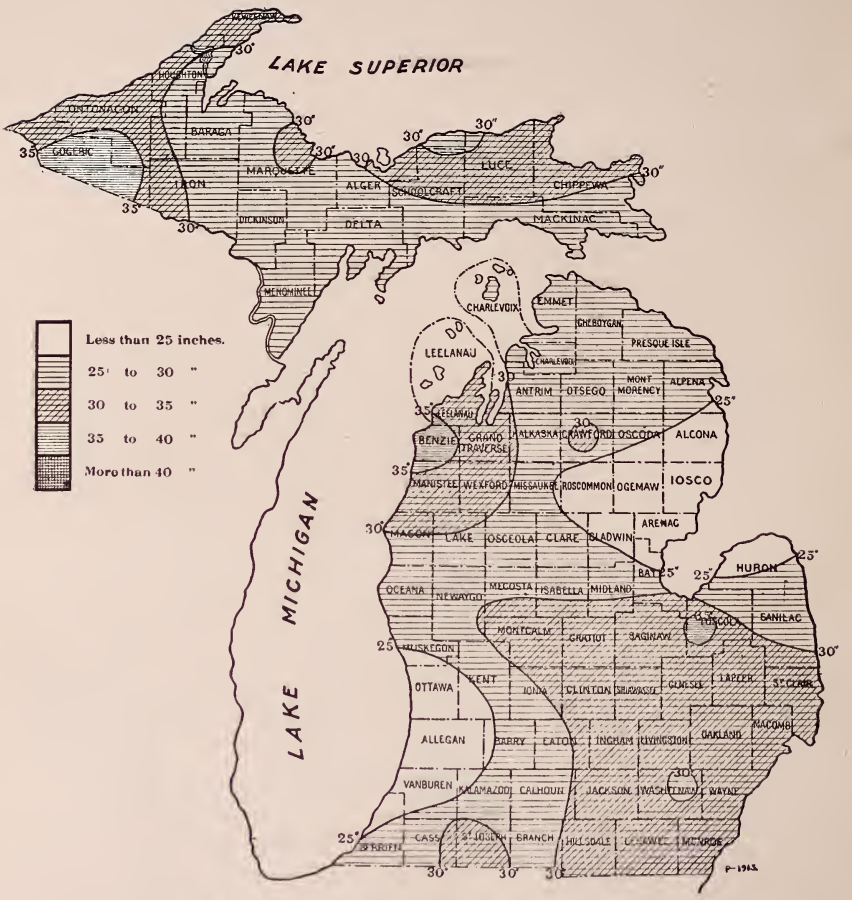


Fig. 14. Annual rainfall map of Michigan for 1913.

Fig. 15. Mean annual isotherms and prevailing winds for 1913.

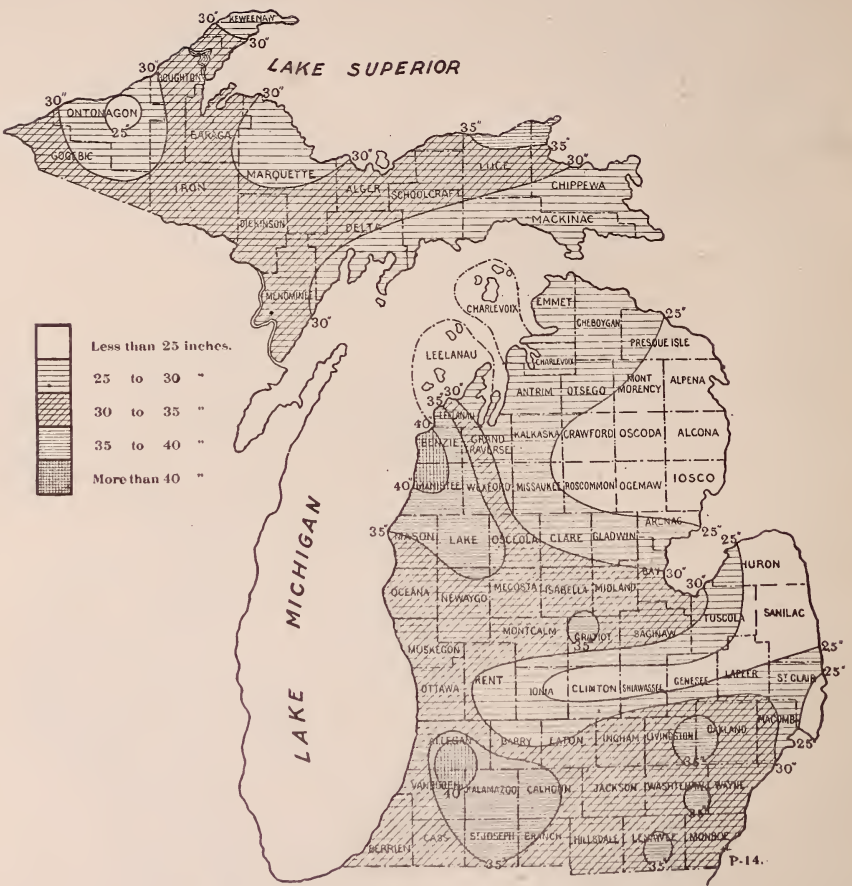


Fig. 16. Annual rainfall map of Michigan for 1914.

Fig. 17. Mean annual isotherms and prevailing winds for 1914.

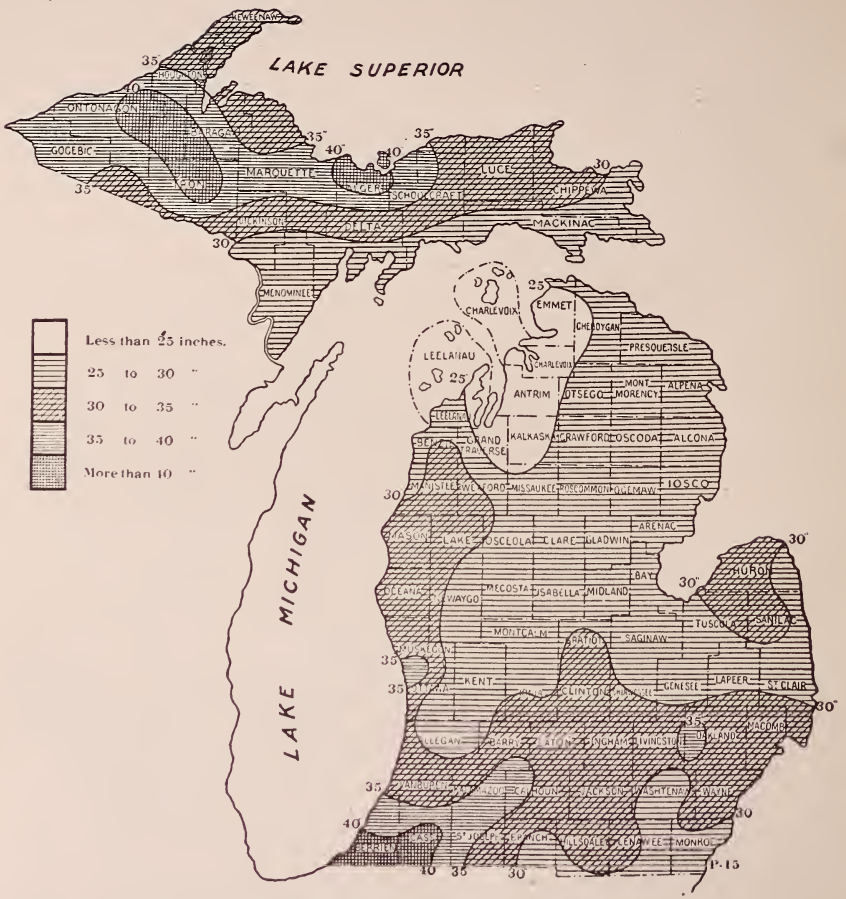


Fig. 18. Annual rainfall map of Michigan for 1915.

Fig. 19. Mean annual isotherms and prevailing winds for 1915.

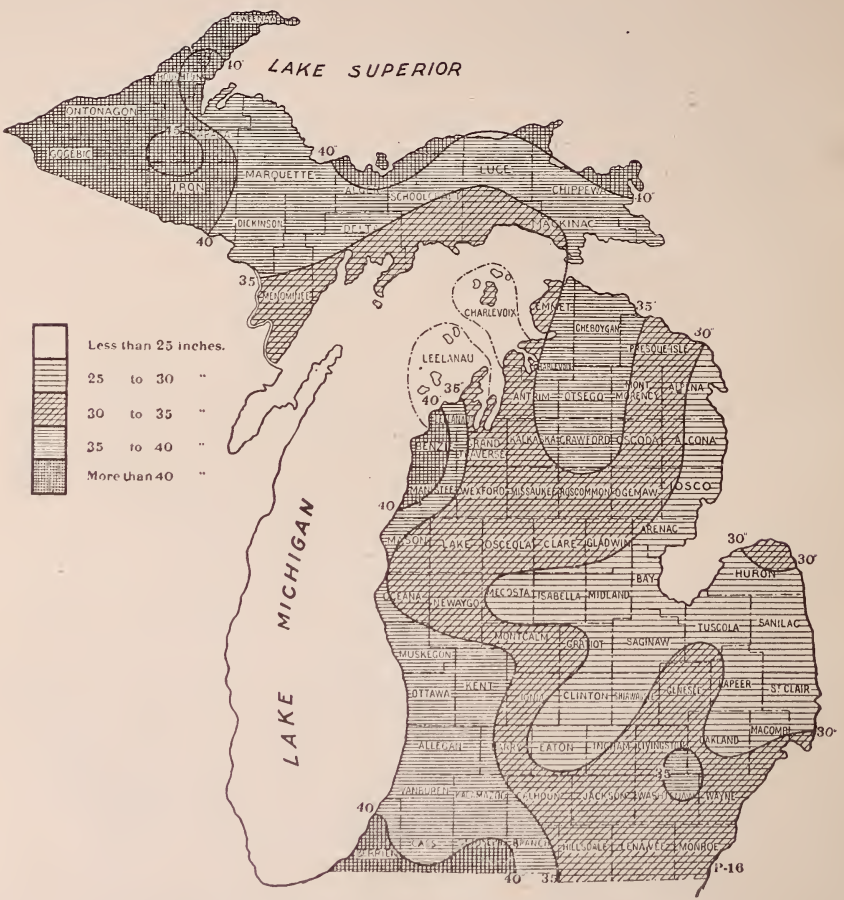


Fig. 20. Annual rainfall map of Michigan for 1916.

Fig. 21. Mean annual isotherms and prevailing winds for 1916.

WINDS.

The prevailing winds for the greater part of the year are from the west and the average hourly velocity ranges from twelve and one-half miles per hour in March and April to a minimum of about nine miles per hour in August and September. The wind is mostly from the west and southwest during the first three months of the year and from June to December; while the prevailing direction is mostly southwesterly during the months of April and May, quite a large period but less than a majority of the time, the surface movement of the air is from the east and northeast.

Maximum velocities of short duration ranging from twenty-five to forty miles per hour, occur during most months of the year and velocities from forty to sixty miles an hour are not uncommon but rather infrequent. Extreme velocities of sixty miles and over are of comparatively rare occurrence; at Grand Rapids the wind velocity has not exceeded sixty miles but twice in the past nine years.

Winds are more variable during the cooler half of the year. At all seasons the southerly winds are usually warm and moist, the northerly winds cold and dry. The easterly winds usually herald unsettled weather, the westerly winds fair and settled conditions.

Owing to the fact that the prevailing summer winds are southwesterly, the shore of Lake Michigan from the southern limits of the state northward is rapidly becoming one continuous summer resort, where much relief can be found during the hot months; the water breezes are refreshing, especially at night, and insure greater comfort than can be obtained at any point inland.

RELATIVE HUMIDITY.

There is both an annual and a diurnal variation in relative humidity, which is the reverse of the temperature. The relative humidity is the greatest in winter and the least in summer; diurnally it is the greatest just before sunrise, and the least at about the time that the maximum temperature occurs in the afternoon.

The average relative humidity for the year, as deduced from observations taken at 7 a. m. and 7 p. m., is approximately seventy-two per cent., the average at 7 a. m. being seventy-eight per cent., and at 7 p. m., sixty-six per cent. Annually the relative humidity is the least during July, sixty-two per cent., and the greatest during January, eighty-eight per cent.

GENERAL CLIMATIC DATA

(1886 to 1911)

NORTHERN SECTION.

Month.	Temperature—Deg. Fahr.									Precipitation in inches.			Number of days.				Prevailing winds.
	Mean.	Mean maximum.	Mean minimum.	Highest.	Year.	Day.	Lowest.	Year.	Day.	Average total.	Greatest in 24 hours.	Total snowfall (unmelted).	With .01, or more of precipitation.	Clear.	Partly cloudy.	Cloudy.	
January	20 0	27.5	12.4	59	1908	2	−39	1899	31	2.27	3.20	17.5	10	6	7	18	SW
February	17.8	26.7	8.8	65	1899	19	−49	1899	11	1.80	3.05	15.1	9	8	8	12	NW
March	27.4	36.9	17.9	83	1910	29	−35	1890	6	1.97	2.50	9.0	8	12	8	11	NW
April	41.1	51.9	30.8	93	1899	29	−11	1911	2	2.13	2.56	3.6	7	12	8	10	NW
May	52.3	63.6	40.8	98	1895	29	10	1900	4	2.96	3.50	0.8	9	11	10	10	NW
June	63.2	75.2	51.2	106	1887	28	21	1891	5	2.63	4.80	T	7	14	9	7	SW
July	67.4	79.4	55.4	103	1901 1910	1 2	25	1898	11	2.71	4.00	0	7	15	10	6	SW
August	65.2	76.8	53.5	103	1891	8	22	1887	25	2.63	5.87	0	7	14	10	7	SW
September	58.8	70.2	47.7	101	1891	20	15	1894	24	2.83	4.60	T	8	12	9	9	SW
October	47.0	56.7	37.4	90	1910	6	4	1887	30	2.66	4.00	1.2	8	10	8	13	NW
November	34.8	42.0	29.6	77	1903 1911	4 12	−6	1895 1904 1897	21 28 24	2.52	2.40	8.3	9	6	7	17	SW
December	24.9	31.6	18.2	66	1891	23	−22	1903 1904	26 13	2.19	3.92	14.3	10	6	7	18	SW
Averages or extremes	43.3	53.2	33.6	106	1887	6–28	−49	1899	2–11	29.30	4.80	69.8	99	126	101	138	SW

GENERAL CLIMATIC DATA

(1886 to 1911)

CENTRAL SECTION.

Month.	Temperature—Deg. Fahr.									Precipitation in inches.			Number of days.				Prevailing winds.
	Mean.	Mean maximum.	Mean minimum.	Highest.	Year.	Day.	Lowest.	Year.	Day.	Average total.	Greatest in 24 hours.	Total snowfall (unmelted).	With .01, or more of precipitation.	Clear.	Partly cloudy.	Cloudy.	
January	22.2	29.9	14.8	62	1907	10	−31	1893	15	2.26	4.90	12.3	8	6	8	17	SW
February	20.5	29.3	11.9	64	1900	8	−36	1899	11	1.89	3.35	24.0	7	7	8	13	SW
March	30.7	40.1	22.0	84	1905	.....	−15	1890	6 7	2.08	2.70	6.6	7	9	10	12	SW
April	43.9	54.6	33.4	90	1899	29 30	−2	1899	1	2.39	3.00	1.8	7	11	9	10	SW
May	55.5	66.7	43.6	96	1911	20	17	1903	1	3.37	4.10	0.2	9	11	11	9	SW
June	65.7	77.6	53.4	101	1888	19	25	1907	4	2.67	4.42	0	7	14	10	6	SW
July	70.0	81.9	57.5	110	1911	2	31	1900	3	2.65	5.13	0	7	16	11	4	SW
August	67.5	79.7	55.4	100	1900	5	30	1894	23	2.57	3.53	0	6	15	11	5	SW
September	61.2	72.9	49.4	98	1898	3	19	1893	29	2.79	5.50	T	7	13	10	7	SW
October	48.8	59.2	38.5	88	1896 1897 1898 1900 1901	27 1 3 5–6 4	10	1887	26	2.64	4.00	0.4	7	11	9	11	SW
November	36.7	44.6	29.0	77	1888 1911	1 11	−6	1905	21	2.37	3.51	4.2	8	7	8	15	SW
December	26.9	33.8	20.1	66	1909	5	−18	1895	13	2.10	3.82	9.2	9	5	8	18	SW
Averages or extremes	45.8	55.8	35.8	110	1911	7–2	−36	1899	2–11	29.78	5.50	58.7	89	125	113	127	SW

GENERAL CLIMATIC DATA

(1886 to 1911)

SOUTHERN SECTION.

Month.	Temperature—Deg. Fahr.									Precipitation in inches.			Number of days.				Prevailing winds.
	Mean.	Mean maximum.	Mean minimum.	Highest.	Year.	Day.	Lowest.	Year.	Day.	Average total.	Greatest in 24 hours.	Total snowfall (unmelted).	With .01, or more of precipitation.	Clear.	Partly cloudy.	Cloudy.	
January	23.7	31.1	16.4	70	1906	21	−26	1892	20	2.14	3.55	10.7	10	6	8	17	SW
February	22.3	30.6	14.2	66	1890	4	−43	1899	12	2.02	2.59	10.7	9	7	8	13	SW
March	33.1	42.1	24.6	89	1910	27	−14	1900	12	2.25	2.75	6.1	9	9	10	12	SW
April	45.6	56.3	35.3	94	1899	21, 28	3	1896	3	2.49	4.36	1.6	9	11	9	10	NW
May	57.3	68.1	45.9	100	1895	31	19	1905	1	3.42	5.09	0.2	10	11	11	9	SW
June	67.1	74.2	55.7	101	1894	15, 23	29	1897	2	3.37	5.89	0	9	13	11	6	SW
July	71.4	82.7	59.5	107	1911	5	32	1898	11	2.96	4.59	0	8	15	11	5	SW
August	69.2	80.7	57.5	104	1890	3	26	1887	24	2.62	4.96	0	7	15	11	5	SW
September	62.5	73.7	51.3	100	1897	8, 9, 13, 14	21	1893, 1899	29, 30	2.85	4.79	T	8	13	9	8	SW
October	49.9	60.0	39.8	94	1897	1	4	1906	11	2.43	5.30	0.3	8	12	9	10	SW
November	37.6	45.4	29.9	78	1895, 1901, 1909	5, 2, 1	−5	1891	30	2.72	2.78	4.1	9	7	9	14	SW
December	27.6	34.5	20.7	66	1895	19	−22	1909	29	2.31	3.66	9.7	10	6	8	17	SW
Averages or extremes	47.3	56.6	37.6	107	1911	7-5	−43	1899	2-12	31.58	5.89	43.4	106	125	114	126	SW

THE SURFACE GEOLOGY OF MICHIGAN.

FRANK LEVERETT.

PART I. THE NORTHERN PENINSULA.

CHAPTER I.

PHYSIOGRAPHY OF THE NORTHERN PENINSULA.

GENERAL GEOGRAPHICAL FEATURES.

The geological formations of the Northern Peninsula fall readily into three classes, viz. (1) The Pre-Cambrian rocks of igneous as well as metamorphosed sedimentary kinds, (2) the sedimentary Paleozoic rocks which are consolidated but not markedly metamorphosed, and (3) the unconsolidated glacial and lake deposits. The glacial drift is deposited irregularly over all the hard rock formations, but considering only the indurated rocks, the Northern Peninsula may be divided into two distinct provinces, an eastern and a western, the boundary being near the meridian passing through Marquette. West of this meridian Pre-Cambrian rocks are only slightly covered by the Paleozoic sandstone, shale, and limestone rocks, while east of it the Paleozoic rocks completely cover the older formations. The rocks of the western province have been folded and partly or wholly recrystallized. They embrace many diverse types such as greenstones, granites, gneisses and schists, and metamorphosed sedimentary rocks, such as quartzite, slate, dolomite, conglomerate, etc. On the other hand, the rocks of the eastern province are relatively unmetamorphosed. They include beds or strata of shale, sandstone and limestone, which lie in an almost undisturbed position, dipping gently southward, so one passes from older to younger formations in going from north to south across the peninsula.

The Pre-Cambrian rocks of the western province differ greatly in hardness, in consequence of which there has been unequal weathering and degradation. Hills, rock knobs, and sharp ridges occur wherever the more resistant formations appear at the surface, while lowlands or troughs mark the position of relatively soft rocks. The glacial drift is sufficiently thick, however, over perhaps three-fourths of the area to completely conceal the irregularities of the rock surface. The principal areas in which the rocks protrude above the drift, and have a rugged outcrop are found in the Huron Moun-

tain region east of Keweenaw Bay, in the Copper Range along the Keweenaw Peninsula, in the Porcupine Mountains on the border of Lake Superior near the western end of the Peninsula, in the Gogebic Range from Ironwood eastward to Lake Gogebic, and in the region of Iron Mountain on the southern edge of the Peninsula. There is also a small area of rugged country leading from Marquette westward past Ishpeming, another in the vicinity of Crystal Falls, and a very small area in the vicinity of Republic.

Like the crystalline rocks, the Paleozoic rocks of the eastern province differ in hardness and have weathered unequally. They form what has been termed a belted lowland. Some formations stand in the form of tablelands, while others occupy the intervening troughs. The Niagara limestone, for example, forms a tableland on the north border of Lake Michigan and Lake Huron, but the shales and softer formations north of it occupy a trough overlooked by the bold outcropping edge of the Niagara formation. Another tableland formed by calciferous Cambrian sandstone, is found in eastern Marquette County and Alger County. It either directly overlooks Lake Superior or a narrow low plain lying between it and the lake shore.

The glacial drift is a confused mass of boulders, gravel, sand, and clay, differing greatly in constitution from place to place. The drift was once included in a sheet of ice or continental glacier such as now covers Greenland. The ice moved from the high lands of Canada to the east, south, and southwest of Hudson Bay, southward across the Great Lakes region into the northeastern part of the United States. The deposit made by the melting of the dirt-laden ice has a very irregular thickness; in places it is several hundred feet thick, in others it is very thin or absent, the hard rocks coming quite to the surface. There is evidence that the drift deposit was not made by a single invasion of ice, but by two or more invasions separated by long intervals in which the country was free from ice as it is today, for old land surfaces are buried in it.

The oldest invasion into the Northern Peninsula appears to have come from the northwest across the Lake Superior basin, the evidence for this being found in the grooves which bear southeastward, made by the ice on the underlying rock, and also in the presence of rock material which could have been derived by the ice only from the rocks on the northwest border of Lake Superior. The material brought in from the northwest is found at the base of the drift and is therefore known to be the oldest part of it.

A later invasion of the ice came into the Northern Peninsula

from the northeast and brought in from that direction material which is found scattered all over the Peninsula forming the upper part of the drift. The striae or grooves made by the ice during this later invasion bear southwestward or westward in such a way as to show that the ice came in from the northeast. On Keweenaw Peninsula at Centennial Hill in the northern part of the city of Calumet, the two sets of grooves made by the ice occur on a single rock ledge, those on the north slope being directed southeastward, but those on the eastern slope and on the upper part of the ledge are directed nearly westward. The earlier set of grooves directed southeastward, are preserved only in the lee of the ledge where the later ice movement could not erode them away.

Certain terms have come into common use among geologists to define the various topographic features presented in the drift. Among the most prominent of these features are *moraines*. These are belts of rolling or hummocky surfaced drift in which basins and lakes are enclosed among sharp knolls. Morainic belts may be traced continuously for long distances across the country. These belts were formed at places where the edge of the ice held for a long period nearly a constant position. Their uneven surfaces are probably due to the difference in the dirtiness of the ice, the dirtiest parts when melting giving rise to hills or knolls of drift, the cleanest parts naturally depositing less material, thus leaving corresponding depressions. The glacial map (Pl. I) represents the principal moraines of the Northern Peninsula, and these will be described more fully further on.

While the ice was occupying a given moraine, the water escaping from it would often spread out broad plains of sand on the southern border of the moraine in the district lying just outside the ice. These plains are known as *outwash aprons*. The outwash aprons are shown by symbol on the glacial map. They are most abundant in the eastern half of the Peninsula but are present also on some of the highest portions of the western half. During rapid recession of the ice border from one moraine to another, there is usually deposited a somewhat clayey and stony drift known as *boulder clay* or till. Because of the relatively smooth surface the term *till plain* is applied to such areas. Extensive areas of this nature are found in Menominee, Delta, southern Marquette and Western Alger Counties, and also in Iron County. In some cases during such a recession where the ice border is poorly drained, a large amount of sandy material is laid down instead of till or clayey drift. This is the

explanation for the occurrence of the sandy plains which occupy broad areas of the Peninsula.

On some of the clayey plains small oval hills are found which present remarkable regularity in their trend, and usually have very smooth slopes. These hills are known as *drumlins* and are found in great numbers on the clay or till plains of Menominee County and of Iron County. Drumlins occur also on Les Cheneaux Islands at the eastern end of the Peninsula. These peculiar hills are supposed to have been formed by one or both of two processes, either a sculpturing by the movement of the ice across a prominent part of the drift beneath it or by more rapid deposition of the drift at these places than on adjacent lower land. On this latter interpretation, the drumlins bear the same relation to the glacial deposits that sandbars bear to river deposits. The former process resembles that of the formation of islands in the cutting down of a river valley. The structure of the hills usually discloses which of these methods of development will apply. If a section through the hills shows the material to be without any bedding concentric with the surface of the hills, but instead a jumble of stones and clay, the drumlin was probably formed by sculpturing a mass of drift that had been deposited at an earlier time. But if the structure is such as to show definite bedding and evidence of slow building up by the plastering on of one layer of material after another, the drumlin is then likely to have been formed by the second process. These drumlins are formed almost exclusively on plains lying between the moraines, and the trend of their longer axes is in the same direction as the grooves formed by the ice on the underlying rock, and therefore in the direction of the ice movement, whereas the moraines have a trend either oblique to or at a right angle to the ice movement, being formed along the ice border. The relation of the drumlins to the moraines in Menominee County may be clearly seen on the glacial map. Those in Iron County are directed toward a moraine which lies in the northern edge of Wisconsin, and those of Les Cheneaux Islands are directed into Lake Huron and the moraine if present is in the bed of the lake.

In the same situation, on plains between the moraines, there are often found sharp gravel ridges which have a trend the same as the drumlins, conformable to the direction of the movement of the ice. They are so sharp as to be locally known as *"hogback ridges,"* and often bear resemblance to railroad embankments. Their length ranges from a fraction of a mile up to several miles, and they constitute features of much curiosity wherever present. It is a

matter of some surprise that a gravel ridge which evidently was formed by water should stand so sharply defined with considerable relief above the border plain. The manner in which such ridges are formed was discovered by Professor Russell during his studies in Alaska. He there found that streams running in or beneath ice through tunnels which ramify through the base of the ice become more or less clogged up with the gravel and sand which they are carrying, so that when the ice melts away and the stream ceases action, these deposits which fill the tunnels are left as ridges of the same dimensions that the tunnels possessed. The material in the tunnels, however, is thickest in the middle portion and thin at the borders and has a level surface while the ice is supporting it, but upon melting of the ice the thin portions along the sides of the tunnel drop down and leave the thicker central portions of the tunnel standing as a ridge. The name *esker* is applied to these sharp gravel ridges, a term which originated in Great Britain where they abound.

ALTITUDES AND RELIEF.

The altitude of the Northern Peninsula ranges from 580 feet, the level of Lakes Huron and Michigan, to 2,023 feet on the highest point in the Porcupine Mountains. The eastern portion of the Peninsula from the meridian of Marquette eastward (see altitude map, Pl. II) is generally less than one thousand feet above the level of the sea and less than 400 feet above the bordering lakes. The general elevation is probably not greater than 250 feet above the lakes. From the meridian of Marquette westward, there is a rapid rise to a tableland standing 1,600 to 1,800 feet above the sea, or 1,000 to 1,200 feet above the Great Lakes. From this tableland, the prominent portions of the crystalline rock formations rise only a few hundred feet at the most and constitute hilly rather than mountainous districts (See Pl. II), although the term "mountain" has been applied to some of these areas, as for example the Huron Mountains and Porcupine Mountains.

The Porcupine Mountains, which stand near the northwest end of the Peninsula, are the most conspicuous features in this entire area, for they rise on their north slope very abruptly from the shore of Lake Superior to a height of 1,400 feet above the lake. But one can pass southward from these mountains with only a moderate descent to the tableland which lies between them and the Gogebic iron range. In the case of the Huron Mountains, there is an abrupt rise from the shore of Lake Superior of

nearly 1,000 feet and a gradual ascent toward the interior to a height of 1,200 or 1,300 feet above the lake. The Huron Mountains have very little relief above the country lying south of them, but differ from that country in being thinly covered with drift. The Copper Range which leads from the Porcupine Mountains east and northeast across the entire length of the Keweenaw Peninsula is also a prominent topographic feature, but its altitude is seldom more than 800 feet above the level of Lake Superior, and only small portions of it are 600 feet. The Gogebic Range rises only 200 to 400 feet above the tableland on its north side, and still less above the tableland on the south, and the variations in its altitude are usually within a range of 100 to 200 feet.

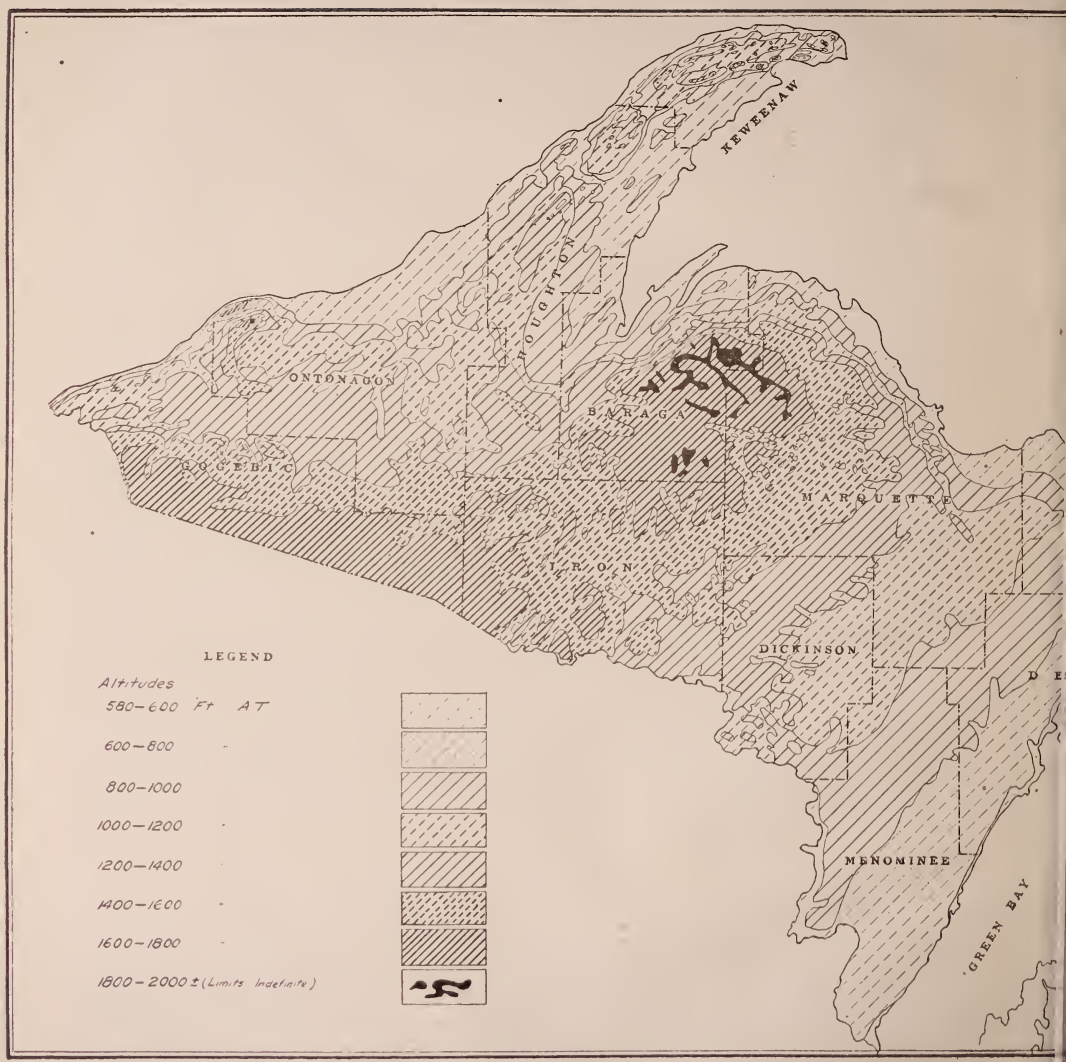
The relief of the limestone tableland which borders the north side of Lake Michigan and Lake Huron is much more abrupt on the north face than on the south, and in places it presents a bluff-like appearance with an altitude of 200 to 300 feet. The usual relief, however, is only about 100 feet above the plain on the north, which has a filling of drift so great as to reduce very materially the original relief which this formation presented. The calciferous Cambrian sandstone rises usually 100 to 200 feet above the plain north of it, but it has scarcely any relief above the district on the south. The drainage, however, starts near the north border of the formation and leads southward to Lake Michigan.

In the large portion of the Peninsula which is thickly covered with drift, the reliefs are very moderate, the hills being seldom more than 100 feet above the basins or depressions among them, although in a few cases sharp hills may reach a height of 200 feet above the surrounding country. On the whole, the Peninsula is easy of access for railway lines or highways, the only exception being in the passage from the Lake Superior shore across the ranges which border it.

THE DRAINAGE SYSTEM.

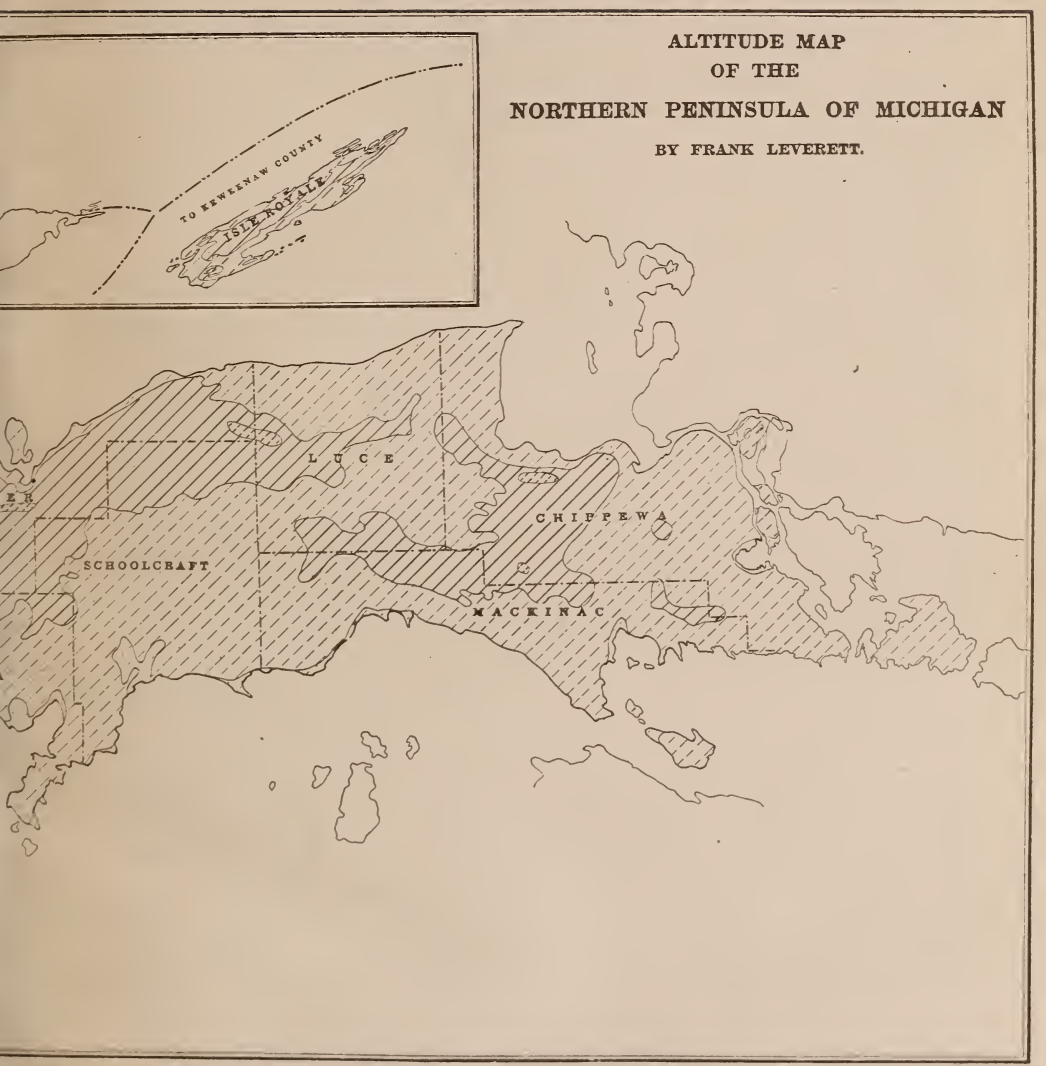
The drainage of the Northern Peninsula discharges to Lake Superior, Lake Michigan and Lake Huron, and a few square miles drain into the Wisconsin River and thence to the Mississippi River and Gulf of Mexico. The greater part of the drainage is into Lake Michigan. This includes the broadly branching system of the Manistique River, which forms the outlet of some of the largest lakes in the Northern Peninsula, and which has a drainage area of 1,400 square miles, principally in Schoolcraft County and parts of neighboring counties; the White Fish River with a drainage area

Michigan Geological and
Biological Survey.



ALTITUDE MAP OF TH

Publication 25, Geological Series 21,
Plate II.



RTHERN PENINSULA.

of 350 square miles leading into the head of Little Bay de Noc; the Escanaba with a drainage area of about 800 square miles; and the Ford River, with a drainage area of 500 square miles, which discharge into the west side of Little Bay de Noc; and the Menominee River, which forms a large part of the boundary between Wisconsin and Michigan and discharges into Green Bay. This river has a drainage area of about 4,100 square miles of which 1,450 are in Wisconsin. Aside from these there are numerous small streams whose drainage area amounts to from 100 to 300 square miles.

Of the streams draining to Lake Superior the most important is the Ontonagon, which with its widely branching system drains 1,250 square miles, and is the outlet for a large elevated basin lying south of the Copper Range. Next in importance is the Tahquamenon, which drains 800 square miles in the eastern part of the Peninsula into White Fish Bay. The third stream in size is the Sturgeon River with a drainage area of 720 square miles, draining the eastern slope of the southern portion of the Keweenaw Peninsula into Portage Lake. Numerous small streams flow directly into Lake Superior from the Copper Range and the Gogebic Range, as well as from the districts to the east of the Keweenaw Peninsula.

In the drainage to Lake Huron the only important streams heading within the Peninsula are Pine River and Carp River, which discharge into St. Martin Bay, and each of which has a drainage area of 150 square miles. The St. Mary's River leads from Lake Superior to Lake Huron along the eastern end of the Peninsula and is commercially the most important of all the streams, both for navigation and water power.

The drainage to the Wisconsin River is in the vicinity of Lac Vieux Desert, Gogebic county.

The extent of the drainage systems is determined to a large extent by geological features, of which the moraines are perhaps the most conspicuous. The rock formations, although more prominent than the moraines, are more likely to be broken by gaps. For this reason, it is not uncommon to find a drainage system gathering its waters in a district with no exceptional prominence, such as that south of the Copper Range in the case of the Ontonagon River, and then leading through a gap in a prominent rock range.

In considering the drainage of this region it should be borne in mind that swamps still occupy a considerable part of the surface, showing that the drainage lines are not sufficiently developed to carry off the surplus water. The extent of many of the swamps may be materially reduced by a well planned system of drainage.

In many of the swamps there are no miry places, so that they may be safely crossed on foot, and the solid bottoms which they present indicate that if drained they may be profitably cultivated. The lakes of the Northern Peninsula are as a rule very shallow. However, an occasional depth of 60 to 75 feet is reported, but more often a depth of scarcely 10 feet.

CHAPTER II.

GLACIAL FEATURES OF THE NORTHERN PENINSULA.

THE MORAINES AND THEIR SIGNIFICANCE.

By reference to the general map (Pl. I) it will be seen that the moraines form long narrow belts which are separated from one another by either sand or clay plains, except where these features are disguised by the bolder rock topography. The morainic belts were formed when the ice border was melting back during the last ice invasion. The drift which was deposited at earlier invasions, and even that deposited during the advancing stage of the last ice invasion has been buried beneath the moraines and their intervening plains.

The ice border shrank back in a general way from south to north and formed a succession of moraines at halting places, or perhaps in some cases at the limits of slight readvances of the ice border. In the district west of Green Bay the ice border receded eastward down the slope toward the bay. But from the Bay itself the recession was northward.

That portion of the Northern Peninsula first uncovered seems to have been in southern Iron County in a district where occasional drumlins appear but where moraines are not well defined. On the north border of this district there is a strong moraine which forms the divide between Paint River and the Ontonagon and Sturgeon drainage, and in fact, the divide between Lake Michigan and Lake Superior as far east as Perch River. This strong moraine may be traced westward through southern Gogebic County into Wisconsin. From Perch River eastward it is somewhat diffuse in the region drained by the Net, Deer, and Fence rivers, but becomes well defined in eastern Iron County in the vicinity of Michigamme River, and there swings southward along the line of Iron and Dickinson Counties into Wisconsin. The course of the moraine is such as to indicate that the southern half of Iron County was in a great recess in the ice border during the formation of this moraine.

After forming this great moraine the ice border shrank back in a northward direction toward the part of the Superior basin west of Keweenaw Peninsula. The moraines of that portion of the peninsula have a general east to west course, though forming slight

loops at some of the valleys or lowlands. The Keweenaw Peninsula being more prominent than the basins on either side, caused a thinning of the ice over its crest and a more rapid recession of the ice border there than occurred in the basin of Keweenaw Bay. As a result the Keweenaw glacial lobe was developed, and the ice, as shown both by the moraines and the glacial striae, moved westward from Keweenaw Bay over the crest of the peninsula. As it shrank toward the bay moraines were formed on the eastern slope which have a nearly north-south trend. To the south of Keweenaw Bay, however, the moraines have a trend from west of south to north of east as far as Huron Mountains.

Eastward from a line running from Crystal Falls past Lake Michigamme to the northernmost point of the Huron Mountains the ice seems to have shrunk in an eastward direction toward the lower tracts on the borders of the Green Bay basin and the low district to the north of the bay. But from Green Bay and the northern part of Lake Michigan the ice border receded in a northward direction across the low district in the eastern half of the peninsula. The distribution and relations of the moraines are such as to indicate that the portion of the Lake Superior basin east of the Huron Mountains remained completely filled by the ice sheet down to a time when the western part of the basin had become nearly free from ice. As a result of this recession a large lake known as Lake Duluth was formed in the western part of the Superior basin outside the edge of the ice while the eastern part was still occupied by the ice sheet. This lake expanded eastward as the ice melted away until eventually it covered the whole area of Lake Superior and some of the bordering country and became merged with Lake Algonquin of the Huron Basin, as is indicated in more detail below.

The kind of material in the moraines throws considerable light upon the direction of ice movement for the moraines vary in their rock constituents to correspond with the changes in the rock formations over which the ice passed. In the district underlain by crystalline rocks to the west of the meridian of Marquette, there is a great preponderance of crystalline material, (See Pl. III B) while in districts underlain by sandstone and limestone to the east of the meridian of Marquette those rocks are the most plentiful constituents of the drift. A very bowldery moraine north of Republic is shown in Pl. III B.

The moraines vary greatly in their topographic expression so that a general description which will adequately set forth their

A. CUT IN MORAINE NEAR CHAMPION, MICHIGAN.

B. BOULDERS ON MORAINE NORTH OF REPUBLIC, MICHIGAN

features can scarcely be given. In some cases they are made up of rather steep sided gravelly knolls among which are basins and small lakes with very little inclosed level land. In other cases they are broken up into small strips or clusters of sharp knolls which are separated by level or even swampy tracts. In such cases it becomes somewhat difficult to map the exact position of the ice border during the development of the moraine because of so many gaps or parts only feebly developed. By reference to the general map one may see how fragmentary and disjointed are some of the morainic belts. In general, however, the morainic tracts are characterized by more numerous and sharper knolls than are found on the intervening districts.

THE OUTWASH APRONS, OR GRAVELLY PLAINS.

The *outwash aprons* as already indicated are plains of sand and gravel which were formed on the district immediately outside the ice border by water escaping from the ice sheet. The term *apron* is applied to them because they often have an apron-like relation to the moraines with which they are correlated. Where best developed one passes from the moraine with its sharp knolls, irregular surface, and commingled drift, in which the material is only partly assorted by water, into a nearly level tract of sandy gravel in which complete assortment has taken place. It is such a change as one would look for in passing from a district which lay under the ice to one which lay outside its border. The presence of well defined moraines and the bordering plains of gravel and sand in sharply outlined belts, indicates that the melting away of the ice was not at all regular. Instead, the border must have held a given position for a long time during the development of a moraine and its outwash apron and then made a rapid recession over the district back of the moraine to the next succeeding moraine and outwash apron.

The principal outwash aprons are so clearly shown on the general map that it seems unnecessary to outline their position and extent. They are especially prominent in the district east of the Whitefish and Au Train valleys in the drainage basins of Sturgeon and Manistique rivers. But they are also well developed in Marquette, Dickinson, Baraga, and Houghton counties. They are less extensive on the high tableland of Iron and Gogebic Counties, though upon passing into the neighboring portion of Wisconsin they are found in extensive areas.

The outwash aprons are often occupied by pine forests while the

moraines are more frequently covered with maple, birch, and other hardwood. Lumbering operations, therefore, which began with the clearing away of pine, early resulted in the changing of the outwash aprons to desolate looking tracts of stump land. The moraines and till plains still carry a beautiful covering of hardwood forest.

FEATURES BETWEEN THE MORAINES.

The outwash aprons and sandy plains stand outside the moraines and occupy partially their outer border. Inside of the moraines and often across the entire space between the moraines there is a diversified drift in which the constitution ranges from loose sand to stiff clay, and from sharp gravel knolls and ridges to a featureless plain. The knolls and ridges are usually *kames, eskers,* or *drumlins,* and the remainder of the districts may be classed as *till plains* ranging from flat to undulating and from stiff clay to sandy constitution.

The till plains are composed of drift that seems to have been deposited as the ice was melting but without much attendant water action. The sandy portions, however, in places had water action, and the material is more or less assorted as in the outwash aprons. It seems rather remarkable that in the course of the recession of the ice across the interval between one moraine and its successor there should not have been more water action than seems called for by the constitution of the drift. This condition, however, does not seem so surprising when we consider that the ice border was in a state of nearly constant recession so that the water escaping from it was making frequent shiftings of its course. *The till plains, as indicated in the discussion of soils, are in general well suited for agriculture because of the loamy texture and gently undulating surface.*

DRUMLINS.

The oval or elliptical drift hills, known as drumlins, are found on the till plains but are restricted in the Northern Peninsula to a few localities. The largest district is in Menominee, western Delta, and southern Marquette counties, there being several townships in which they are present and in which they are so numerous as to be a striking feature of the landscape. Another large district is found in Iron County in the area already referred to as the first to be uncovered by the ice. In this district the drumlins are more scattered than in the Menominee district. A few drumlins occur

immediately west of Chatham in western Alger County. There is also a small drumlin district on Les Cheneaux Islands and neighboring parts of the mainland at the northwest end of Lake Huron.

The drumlins are generally composed of a clayey drift thickly set with small stones. Sand or gravel are rarely found in drumlins. They owe their oval or elliptical form to a shaping by the overriding sheet of ice. The ice was moving in the direction of the longer axes of these hills, as might be inferred from their shape and is shown by the striations on the rock surfaces in the drumlins districts. In the Menominee district there is an interesting shifting of the trend of the drumlins from a nearly due east-west trend in the northern part of the district to a trend about 30° west of south (S. 30° W.) in the southern part of the district, which corresponds to the radiation of the flow of the ice in that region. In the Iron River district the drumlins have a nearly uniform trend about S. 25° W. The drumlins near Chatham trend nearly north-south, those on Les Cheneaux Islands southeastward.

The drumlins range in size from barely detectible ridges 5 to 10 feet high to prominent hills 60 or even 75 feet in height. The larger ones often have a length of nearly a mile and occasionally reach 1½ miles. Their size is somewhat exaggerated on the map (Pl. I) because on the true scale many of them would have to be represented as mere dots. It should be remembered that the number of drumlins is much greater than can be shown on a map of this scale, moreover, the full extent of their occurrence is undetermined.

The districts in which the drumlins occur, and the drumlins themselves, are among the choicest agricultural lands in the peninsula. Their clayey constitution and the well drained slopes render them productive and easily tillable.

ESKERS, OR GRAVEL RIDGES.

The eskers, or gravelly hogback ridges, are easily distinguished from drumlins, though like the drumlins they have a trend in the direction of the flow of the ice. They are composed of gravel and sand with only occasional small deposits of boulder clay. In form they are long narrow ridges but a few feet or yards in width. While their general trend is in the direction of ice movement they have a more or less winding course consistent with their mode of origin, for they appear to have been formed in tunnels in the lower part of the ice sheet. These tunnels would be opened by escape of the water from the under part of the ice along the lines of least resistance which would naturally be more or less devious.

The eskers are of high commercial value as sources of road ballast in places where gravel is otherwise difficult to obtain. But fortunately the Northern Peninsula has an abundance of gravelly road material throughout nearly its entire extent not only in the drift hills and ridges but in the outwash plains and among the rocky knobs.

The eskers are usually so small as to need a large scale map for their proper representation and for that reason very few of them have been represented on the general map. They abound in the Menominee drumlin district, yet they are much less conspicuous than the drumlins for they are usually but 10 to 15 feet high and only a fraction of a mile in length. They are present in many places among the rocky knobs in the region west of Marquette and in the Gogebic Iron range and districts to the south. Indeed these little ridges are apt to occur almost anywhere in the Northern Peninsula except in the outwash aprons and certain plains in which lake clay is of considerable depth.

KAMES, OR GRAVELLY HILLS.

The name *kame* has been applied to sharp gravelly hills which occur either singly or in clusters on till plains and also in the moraines. These hills are thought to have been formed where streams emerging from the edge of the ice dumped their material without spreading it out into a plain. They are often found at the ends of eskers and represent the accumulation of material brought out of the ice during the development of the eskers beneath its margin. Their distribution is general and widespread. They are especially abundant among the rocky knobs of the western half of the peninsula. A kame or a kame cluster usually occupies but a small fraction of a square mile or too small an area to be easily represented on a scale such as that of the general map. (Pl. I). They are also so numerous that no attempt was made to map them in detail. *Like the eskers, kames are of commercial value as road material, wherever there is a demand for it.*

EFFECT OF THE ICE SHEET ON ROCK SURFACES.

In regions which have not been overridden by an ice sheet there is a mantle of soil, rock waste and rotten rock several feet deep over the rock ledges, except where slopes are so steep that it is washed away. This mantle represents a long period of weathering and disintegration of the rock surfaces. In regions that have been

A. STRIATED LEDGE ON HILL, SOUTHWEST PART OF CHAMPION.

B. STRIAE CURVING ROUND A ROCK BOSS NEAR ISHPEMING.

A. GLACIATED ROCK BOSS NEAR CHAMPION.

B. GLACIATED GRANITE KNOBS, FOURTEEN MILES NORTH OF CHAMPION.

A. ROCK SURFACE NEAR ISHPEMING, ILLUSTRATING PROTECTION FROM ICE ABRASION IN THE LEE OF A SMALL OBSTRUCTION.

B. GLACIATED ROCK SURFACE EAST OF ISHPEMING.

glaciated, firm rock surfaces are laid bare by the removal of the mantle of soil and loose rock material. Prominent knobs of rock are sometimes rubbed to almost glassy smoothness, or their surfaces are scored heavily with deep furrows running in the direction of the ice movement. The rock surfaces also often exhibit a multitude of fine lines or striae trending in the same direction. In many parts of the elevated western end of the Northern Peninsula the smooth rock bosses are striking features of the landscape. From commanding points one often obtains a view several square miles in extent in which the bare rock surfaces may be seen glistening among the tree tops or rising above the highest of the forest trees. Such a landscape is shown in Plate V, B which contains a view taken in the Huron Mountain district north of Champion. These rock bosses are often more heavily glaciated on the side against which the ice advanced than on the opposite or lee side (See Pl. V A) so that one can determine by an examination of a rock knob the main direction of ice movement even where the striae have been removed by weathering. Small inequalities of the surface are also useful in the determination of the direction of ice movement. Thus in Plate VI A. the slight prominence near the lead pencil is found to have so protected the rock on the lee side that it stands above the surrounding portion of the rock surface. The ice is found to have been very flexible in its movements around some of the rock bosses, the striae being curved to correspond to the surface of the boss, an illustration of which is found in Plate IV. B. In some cases, however, the striae preserve a remarkably direct course in spite of inequalities of the rock surface. (See Pl. IV. A.)

While the effect of glaciation on the whole has been to render the districts over which the ice passed more productive by commingling all sorts of rock material into a fine earthy deposit the effect on rock bosses has frequently been such as to leave them naked and barren. They, however, constitute but a small part of the surface even in the most rugged portions of the peninsula and elsewhere they are so few as to be negligible in amount.

On the north border of Lake Michigan and Lake Huron there are extensive tracts in which the limestone is covered by a very thin mantle of drift, insufficient to conceal the irregularities of the surface and yet of sufficient depth to support a good forest cover and to give a productive soil for agriculture. These limestone formations present bold bluff-like escarpments on the north over which the ice sheet must have passed without greatly altering the preglacial condition. In places great thicknesses of drift are banked

against the north base of the escarpment, but throughout much of Mackinac County it still stands as a bold bluff, rising often 200 feet or more above the lowland on the north. From this it is inferred that the effect of the ice sheet has been sufficient to remove only the rotten surface and to alter slightly the outline of the firm ledges over which it passed. *There is no evidence to support the idea that the great lake basins, Superior, Huron and Michigan, were ploughed out by the ice.* Instead, Michigan and Huron seem to have been reduced to lowlands in preglacial times by the erosion of soft strata which once underlaid the regions they occupy, while the Superior basin is a structural trough resulting from the folding of the rock formations in and around it. The rock reliefs between the beds of these basins and the uplands which border them were probably as great in preglacial times as at present.

CHAPTER III.

LAKE HISTORY OF THE PENINSULA—ABANDONED SHORE LINES.

EARLIER INVESTIGATIONS AND DISCUSSIONS.

That the Great Lakes have stood much higher than their present level was noted in the Northern Peninsula as well as in other parts of the Great Lakes region many years ago. The shore lines made by the beating of the waves are so distinct as to be unmistakable even where they are covered with heavy forests and are many miles inland from the present shores of the Great Lakes. Among the earliest notices in print of the abandoned shore lines of the Northern Peninsula are references to them in a paper by Dr. John Bigsby, published in the American Journal of Science in 1821. He made mention of the sand belt along the base of precipices and on the sides of heights and "the belt of rolled masses that gird every slope and often marked the recessive retreats of the lakes."

Henry R. Schoolcraft in his "Narrative Journal of Travels in 1820," published in 1821, also noted the wide occurrence of the high shore lines and called attention to those on Mackinac Island, where several very conspicuous old beaches occur on the tableland immediately back of the fort, as well as a very strong beach at the base of the tableland in the village. As a further indication of a former greater extent of the Great Lakes, Schoolcraft also noted the wide occurrence of lake deposits.

During the progress of the United States Land Survey of the Northern Peninsula, the surveyors came upon these shores and mapped portions of them on the survey plats, one of them being represented a few miles back from the present shore of Lake Superior nearly all the way from Munising to the meridian of Newberry.

Among the earlier students of the Lake Superior region, E. Desor presented the clearest and most interesting discussions of the old shore lines and their lake features. His official papers appear in the Foster-Whitney Reports on the Lake Superior Land District, published in 1850 and 1851, the main discussion being in Chapter 8 of Part 1 and Chapters 14 to 16 of Part 2. Desor inclined to the

view that the surface boulders and the surface sand at all altitudes are due to the action of lakes, a view which is now known to be erroneous. It was at first thought that the deposition of the boulders was effected by winter ice rather than by icebergs detached from a glacier, but it now appears that they were deposited by a mass of ice which moved directly over the surface of the land without floating in the water to any marked extent, and are therefore the deposits of glaciers rather than lakes or inland seas.

Louis Agassiz in a paper on "The terraces, ancient river bars, drift boulders and polished surfaces of Lake Superior," published in the American Journal of Science in 1850, and also in his book on Lake Superior of the same date, referred briefly to the old shore lines, whose presence he noted at various altitudes on the Keweenaw Peninsula and elsewhere on the coast of Lake Superior. Agassiz explained the high stages of the lake on the assumption that the region has been affected by uplifts which have caused the shores to be carried above their former elevation. In this respect his explanation is in part correct, although the presence of the ice as a barrier in the line of the present discharge of the lakes is the real cause of the high stage of the water, as will be shown more clearly below.

Mr. F. B. Taylor has given more study than any one else to the shore lines of this region, and has published several brief papers between the years 1892 and 1897 giving the results of investigations made at private expense. It is through his investigations that the succession of lakes and the relation of the lakes to different outlets have been clearly interpreted. These matters will be taken up in connection with the discussion of each of the several lakes. The high shore lines were first referred by Taylor to marine occupancy, but reference to his later papers published in and after 1895 shows that this view was discarded, and the ice sheet was assumed to have held the waters of the earlier lakes at their high altitude.

Very little precise levelling has been done on the shore lines of the Northern Peninsula. Lines of levels have, however, been run to the highest ones on Mackinac Island and to neighboring parts of the mainland by F. B. Taylor and J. W. Goldthwait, and to points in the vicinity of the head of Green Bay by Professor W. H. Hobbs. The results of Professor Hobbs' work are presented in a paper published by the Michigan Geological Survey.[1] A series of levels have also been run by the present writer, assisted by Lloyd A. Hornby, in the Autrain-Whitefish lowland, and in other places. The results

[1]Publication 5. Geological Series 3.

of the leveling by Taylor and Goldthwait and the present writer are published in part, in Monograph LIII, United State Geological Survey.

NATURE OF THE PRESENT INVESTIGATIONS.

Inasmuch as the writer attempted only a reconnoissance of the region and restricted his routes chiefly to the roads and trails, the shore lines have received less attention than is required for a full mapping or complete correlation or connection. An endeavor was made to ascertain the upper limits of lake action, but the highest shore line was not in all cases continuously traced. The study, however, was carried far enough to warrant the representation on the map of the approximate extent of the lakes. The altitudes of the old shore lines have been accurately determined chiefly where they lie near railway stations, or in some cases by hand level from points on the shores of the present lakes. Enough has been determined to show that the shore lines are not in the horizontal position in which they were originally formed, but that through an uplift of the region they have been tilted perceptibly, the altitude of a given shore line becoming progressively higher northward. On this account it is difficult to connect shore lines across wide intervals. It cannot be assumed that a shore line of a given altitude in one district will connect with one of the same altitude in another district, for the reason that the uplift which the region has experienced has made great changes in the original levels.

In the course of the advance of the ice sheet into the region around Lake Superior, the drainage was shifted from one outlet to another along the rim of the basin, the discharge being always through the lowest available point on the rim. It is not unlikely that when the ice came into the northeastern part of the Superior basin the drainage was along or near the present course from the Superior into the Huron basin, but when it covered the eastern end of the Northern Peninsula higher lake levels were produced with discharge southwest and eventually the ice completely occupied and filled the Superior basin. During the progress of the extension of the ice, the lakes which were standing in front of it laid down their sediments and these became covered with glacial material when the ice passed over them. The presence of these sediments in the bluffs of the deeper valleys thus bears witness to the existence of lakes whose shores are no longer traceable because completely effaced by the advancing ice. At the culmination of the last glacial stage or ice advance, the ice border reached beyond the watershed between the

Lake Superior basin and the Mississippi River. At this stage the waters escaping from the ice were drained down the Wisconsin and St. Croix and other streams which lead to the Mississippi. Then the ice border began to recede with the waning of the ice sheet, and shrunk back to the north of the present divide between the Mississippi and the Lake Superior drainage. When this occurred a ponding of the waters in front of the ice again took place. Clear evidence of the ponding of waters is found in the shore lines which stand so high above the present levels of the lakes. These shore lines will now be discussed in order from higher to lower, and the names which are applied by geologists to the different levels of the lakes will be used. A new name is usually given whenever the drainage of the lake shifted from one outlet to another, but it should be remembered that the younger lakes are direct successors of the older with changes in level and shiftings of the lines of discharge.

LAKE ONTONAGON.

The oldest and highest of the large glacial lakes in the Northern Peninsula is one which was held in the basin of the Ontonagon River to the south of the Copper Range. During the existence of this lake, the southern edge of the ice sheet appears to have rested on the Copper Range so that the waves were beating against an ice barrier on the north side of the lake. The shore is more or less distinctly traceable along the south border in southern Houghton, southern Ontonagon and northeastern Gogebic counties, as indicated on the general map of the Peninsula (Plate I). This lake had the surprising altitude of more than 700 feet above Lake Superior, the outlet which led west from Gogebic Lake being about 720 feet above the level of the Lake, or 1,320 feet above sea level. Over the area covered by this Lake there is generally a deposit of fine loamy material; but it is not of sufficient depth to greatly conceal the glacial deposits which underlie it. In the eastern part of the old lake area, from Trout Creek northward to Pori, there are extensive deposits of sand, but as a rule the old lake bed is of a clayey character rather than sandy. Its northeastern limits in southern Houghton County are at a gravel plain which extends from Sidnaw to Frost Junction. During the life of this lake, the ice appears to have been occupying the district immediately northeast of this gravel plain, and the outwash from the ice carried the gravel out into the edge of the lake as far as the currents or streams could roll their load.

There are several small areas within the limits of Lake Ontonagon

which are not covered with the sand or silt which prevails so widely on the old lake bed. It is probable that they were covered by the ice at the beginning of the development of this lake and became uncovered only as the ice melted back near the end of the period when that lake had its existence. The existence of the lake as already noted was determined by the presence of the ice as a barrier on the north, and it continued in existence at this high level only so long as the ice prevented the escape of the water by a line of discharge lower than the one leading west from Gogebic Lake.

The existence of this lake seems to have been rather brief, for the outlet is only a small channel, usually less than one-fourth of a mile in width and 20 to 40 feet deep. Such a channel might have been formed in a few centuries. The lake lasted merely during the melting back of the ice from the high lands on the south edge of the Ontonagon basin to the north slope of the Copper Range. The outlet, which has an altitude of 1,320 feet at its head, falls about 200 feet, or to about 1,120 feet in the short distance between Gogebic Lake and the Michigan-Wisconsin line. Thus it is certain that the outlet stream flowed rapidly and if it had been long continued a better defined channel must certainly have been formed.

LAKE DULUTH.

The lake shore next lower in level is that of Lake Duluth, which occupied a large part of the western end of the Superior basin. It is named Lake Duluth because of the prominence of its shore lines in the city of Duluth, Minnesota. This lake began as a small body of water at the extreme western end of the Superior basin with an outlet southward through the Brule River into St. Croix River, a tributary of the Mississippi. As the ice border melted back toward the northeast the lake became greatly expanded until it covered the slope bordering Lake Superior as far east as the Keweenaw Peninsula. It is a matter of interest that the shore of this lake is not found far to the east of the Keweenaw Peninsula for the reason that the ice sheet still remained in that portion of the Lake Superior basin and extended up onto the bordering south shore during the whole of the life of Lake Duluth. The lake waters were drawn to a lower level, by the opening of a lower line of discharge than that through the Brule-St. Croix drainage.

The outlet through the Brule at the beginning of the lake was about 500 feet higher than the present level of Lake Superior, but during the existence of the lake the outlet was cut down fully 50 feet and a channel nearly a mile in width leads across the present

divide between Lake Superior and the Mississippi River drainage. As a consequence of the cutting down of this outlet, the shore of the lake was correspondingly lowered and new shore features established at the lower levels. There is a double, and in places a triple, system of beach ridges along the old shore, separated by intervals of 25 to 50 feet.

The elevation of the shore, which was 500 feet at the head of the outlet at the beginning of the life of the lake, is slightly lower at the extreme southwest end of the Superior basin because the region of the head of the outlet has been elevated a few feet more than the western end of the Superior basin. The lowest point of the highest Duluth shore line in Carleton County, Minnesota, is about 470 feet above Lake Superior. As one follows the shore line eastward or northeastward along either the north or south side of Lake Superior, the upper limit of lake action is found to become higher and higher above Lake Superior. On the Keweenaw Peninsula near Calumet it reaches an altitude of 700 feet above the present lake and is apparently fully as high at points near the Minnesota-Canada line on the north side of Lake Superior. Spirit-leveling under the direction of the present writer near Grand Marais, Minnesota, shows the highest Duluth beach there to be 673 feet above Lake Superior or 1,275 feet above the sea. Professor A. C. Lawson at one time made a series of spirit levelings on the north coast of Lake Superior. They were carried high enough to reach the highest beach only in the vicinity of Duluth, though he at the time supposed he had reached the highest beach at several points on the coast further northeast.

Some of the best developed beaches of Lake Duluth occur in the vicinity of Calumet, where the shore was exposed to waves rolling in from the northwest. A series of a half dozen or more gravelly ridges separated by intervals of twenty feet (more or less) are present on the slope immediately northwest of the Tamarack mine, and on Centennial Hill in the north part of the city, is found the highest beach at an altitude of 1,303 feet above the level of the sea, encircling the hill like an atoll or coral reef in oceanic waters, the ridge itself being slightly higher than the portion of the hill which it encloses.

The beaches are also well displayed in the vicinity of Greenland and Rockland, where they are developed on small islands that stood in the lake as indicated on the map (Plate I).

The railway station at Greenland is very near the highest shore, and that at Rockland is about one-eighth of a mile south of the shore and at a considerably lower level. The northern ridge of

the Porcupine Mountains was encircled by this lake and its shores are especially well developed on the north slope of that ridge in a series of beaches corresponding to the lowering of level caused by the cutting down of the outlet. Lake Duluth extended but little beyond the immediate border of Lake Superior from the Porcupine Mountains westward, but in the Ontonagon drainage basin there were shallow bays extending back southward some distance beyond the Copper Range up several branches of the Ontonagon River.

The bed of this lake is in large part occupied by a red clay deposit full of pebbles, and is consequently a product of the ice rather than of the lake. There seems to have been but a thin coating of lake sediment. This is the natural result of the steepness of the slope, for lake sediments are usually found only in deep and quiet parts of the old lake beds and it is probable that during the lowering of the waters of the lake the wave action would remove the greater part of the sediment which had been laid down during a higher stage. *There are places, however, as for example, along the bluffs of the Ontonagon River between Rockland and the Victoria mine where exposures of nearly pebbleless red clay of great depth are to be seen.* It is probable that this clay is a lake product, and it is likely to have been formed during the advance of the ice in a lake much older than the lake formed on the recession as outlined above.

LAKE ALGONQUIN.

Further study will be necessary to determine the manner in which the lake waters were lowered from the lowest shore of Lake Duluth to the highest level of Lake Algonquin, which occupied the eastern part as well as the western part of the Superior basin and also the Michigan and Huron basins.

Lake Algonquin began in the southern end of the Lake Huron basin and increased in size with the melting back of the ice until eventually it became confluent with a lake in the Michigan basin, known as Lake Chicago, and later with the waters of the Superior basin. Its outlet at first was southward from Port Huron along the St. Clair Valley, the present line of discharge of Lake Huron; but as the ice melted away from the district east of Lake Huron, a lower outlet was opened which led the drainage directly from Georgian Bay through the Trent Valley to the Ontario basin. The lake discharged in this direction until an elevation of the land toward the north raised the Trent outlet to such a height that the lake could no longer discharge through it and a return was made to the St. Clair

outlet. It is probable that at the time when the waters of Lake Algonquin became confluent with those in the superior basin, the Trent outlet was still in operation, for a large part of the elevation which took place in this region seems to have occurred at a late time when the ice had melted back out of the lake basins.

The waters of Lake Algonquin were so extensive as to cover the greater part of the Northern Peninsula from the meridian of Munising eastward. Only a few small islands in this area rose above the level of its waters as indicated on the map. (Plate I.)

In the southern part of the Peninsula near Gladstone and on the Garden Peninsula east of Big Bay de Noc, the altitude of Lake Algonquin was about 120 feet above Lake Superior, but at Marquette it was about 340 feet and just north of Sault Ste. Marie it was fully 400 feet, while at the southern end of Lake Huron at the head of the St. Clair outlet the altitude is only five feet above Lake Superior. The fact that the waters stood so high on the eastern end of the Northern Peninsula of Michigan points to the continuance of the low conditions of the country there at the time of the greatest extent of Lake Algonquin, and by inference the low conditions which continued in the eastern end of the Northern Peninsula continued in the region of the Trent outlet. Under this interpretation the Trent outlet was in operation to the time when the lake was covering the eastern part of the Superior basin and the district between the Superior basin and Lake Michigan.

To restore the altitudes which were then prevalent one must sink the district at the north end of Green Bay about 115 feet and the region near Marquette about 340 feet and that near the Sault about 400 feet below its present elevation and give the lake an altitude of about 605 feet above sea level. The highest shore of Lake Algonquin has an elevation approximately 150 feet below the lowest shore of Lake Duluth. This is therefore about the measure of the lowering of the lake in the course of the change from the Brule-St. Croix outlet to an expanded state of Lake Algonquin. There was not a sudden drop, however, from the lowest beach of Lake Duluth to the highest beach of Lake Algonquin, for in this interval of 150 feet between the two shore lines there are several other shore lines which mark the persistence of the waters at different levels for a time sufficiently long to permit the formation of beaches. The occurrence of features of this sort is thought to be due to opening of successively lower and lower passages around the edge of the ice as it was shrinking into the Superior basin from the high land near Marquette.

While Lake Algonquin was in existence considerable uplift of the land took place. In passing from the southern part of the lake to the northern, the beaches are found to split up into several members; the waters fell away from the beaches at the north while they were still washing southern portions of the shore. There are several places in the Northern Peninsula in which a succession of beaches marking a lowering of the lake level may be seen to good advantage. One of the best known places is on Mackinac Island between the fort and the highest point of the Island, and especially along the line of the Target Range where half a dozen or more beaches with intervals of 15 to 20 feet are plainly developed. (Fig. 22) A similar series may be seen north of Sault Ste. Marie, Ontario,

Fig. 22. View from the observatory looking down across the short target range toward the Fort on Mackinac Island.

near the edge of the Granite Highlands. On Sugar Island east of Sault Ste. Marie there are several beaches, but the highest is not the altitude of the highest level of Lake Algonquin. A fine series may be seen along the range line immediately south of Grand Marais, and several beaches are easily traced through the western part of the city of Marquette. The beaches are best developed where the waves were working upon loose textured material which could easily be thrown up into ridges. They are poorly developed in the clayey districts along the border of Lake Superior from the Kewee-

naw Peninsula westward, not only in the Northern Peninsula of Michigan, but also across Northern Wisconsin into Minnesota. They are also poorly developed where the coast is broken by rock knobs as in the district northwest from Marquette. They may be seen to good advantage all around the Michigan and Huron basins, because there was much less elevation there and the waters were held at definite levels for longer periods than on the borders of Lake Superior where rapid elevation was in progress.

In the eastern part of the Northern Peninsula in Chippewa County and the northern edge of Mackinac County there are very thick deposits of red clay which seem to have been laid down in the waters of Lake Algonquin. In some cases wells have penetrated to a depth of 100 feet or more without striking any pebbly material. As a rule, however, the boulder clay lies within a few feet of the surface and may be seen outcropping on low knolls and ridges at many places within that region.

There are extensive deposits of sand in the eastern part of the Northern Peninsula below the level of the highest beach of Lake Algonquin; but it is thought these were laid down in large part during the melting away of the ice, for they are associated closely with the moraines of the region.

NIPISSING GREAT LAKES.

During the entire existence of Lake Algonquin, the Ottawa valley is thought to have been covered by the ice sheet so that there was no opportunity for an eastward discharge into it from Georgian Bay; but as soon as the valley was vacated by the ice, a low outlet became available for the eastward discharge of the waters of the basins of Superior, Huron and Michigan. The altitude of this region was then sufficiently low to be below the St. Clair outlet from the southern end of Lake Huron, and that outlet did not again come into use until the elevation had proceeded far enough to bring the eastern outlet through the Ottawa up to the same level as the head of St. Clair River. During the discharge of the water eastward from Georgian Bay to the Ottawa River, and also for a considerable period while the water was discharging through both the Ottawa and the St. Clair outlet, there was a body of water in the three lake basins Superior, Michigan, and Huron, known as the Nipissing Great Lakes. The extent of the Nipissing waters was but little greater than that of the modern lakes, for the highest part of the shore, on the northern coast of Lake Superior and at the head of the Ottawa outlet near North Bay, Ontario, is about only 100 feet

above Lake Superior. On the borders of the Northern Peninsula, the altitude is from about 10 feet to 50 or 60 feet above the level of the present lakes, and is usually within a mile or two of the present shores. This may be seen by reference to the general map (Plate I).

It is a matter of some interest to know that the beach known as the Nipissing Beach respresents the work of the Nipissing Great Lakes during a two-outlet stage; for there was a rise of water during the change from the single discharge through the Ottawa outlet to the double discharge through the two outlets which completely submerged the shore lines formed in connection with the single outlet, except perhaps in a small area on the northeast coast of Lake Superior which suffered a little more elevation than the head of the Ottawa outlet. It will be readily understood that regions within the reach of the lake which were uplifted to an altitude less than that of the outlet would become submerged.

At the time of the Nipissing Great Lakes there was a strait from Lake Superior to Lake Huron along the line of the St. Mary's River, for the waters then stood about 50 feet higher at Sault Ste. Marie than at the head of the rapids in St. Mary's River. The old banks of the strait may be readily traced through the city of Sault St. Marie and on the borders of the St. Mary's River. In places there is a bluff thirty to fifty feet in height at the base of which numerous boulders which drifted into the strait on the breaking up of the ice of the Lake Superior basin in the spring months were stranded. They testify to the presence of ice gorges of considerable magnitude which probably blocked up the head of the strait more or less while they were being melted away.

On White Fish Point a large number of ridges of sand and sandy gravel which extended the point several miles beyond its early limits were developed at this time. The area occupied by these sand ridges is indicated on the map (Plate I). At the city of Escanaba the currents of this lake gathered up the sandy material laid down at the mouth of the Escanaba River and deposited it in a long ridge which reaches from the mouth of the river beyond the city and has a width of about a mile and a length of five or six miles. The city thus stands on a bar of Lake Nipissing, and the swamp back of the city represents a bay, the land being then submerged. At Au Train there is a similar accumulation of sandy and gravelly material filling in the space between Au Train Lake and the coast of Lake Superior. There are also very extensive sandy bars along the shore of Lake Michigan immediately west of the

straits of Mackinac filling the space between Brevort Lake and Lake Michigan shore. They cover an area one to two miles in width and eight to ten miles in length. These several places are perhaps the most striking examples of the development of sand ridges in connection with the Nipissing Great Lakes in this Peninsula, but the wave work along the shore is a conspicuous feature throughout almost the entire coast of Lakes Superior, Michigan, and Huron. The land survey plats made by the Government surveyors often indicate the position of this shore as the "former coast line," its features being strikingly similar to that of the present coast and its separation from it is slight both in altitude and distance.

The change from the Nipissing Great Lakes to the modern Great Lakes came about with the abandonment of the eastward outlet through the Ottawa River. This, it is estimated, took place at a comparatively recent date, geologically speaking, and may have been not more than three thousand years ago if we may judge from the amount of work done by the Niagara River at the falls since the entire drainage of the Upper Great Lakes was diverted to the present outlet.

DEPOSITS ON LAKE BEDS.

A large portion of the country covered by these old lakes has glacial deposits within a few inches of the surface and in places the lake beds are entirely free from any lake sediment. There are, however, localities in which the lake sediments have considerable thickness. The sediment range from fine clay to coarse sand or even pebbly material. The sandy and pebbly material is usually found closely connected with deltas of streams that entered the lakes but the finer deposits occur in what were deep parts of the lake beds. In the eastern part of the Peninsula, in Chippewa and northern Mackinac counties, there are extensive areas of lake clay in which wells penetrate in some cases to a depth of 100 feet or more before entering glacial material. In the Ontonagon basin and on the slope of the Copper Range toward Lake Superior there are thin deposits of fine lake sediments usually but 1 to 2 feet in thickness. In the basin southwest from Keweenaw Bay the fine lake sediments in places have considerable depth, but over much of the basin they are thin. The fine lake sediments give good soil for grass and oats and other small grains, and large parts of the districts covered by them are already turned into farm land.

CHAPTER IV.

NOTES ON AGRICULTURAL CONDITIONS.

The quality and composition of the soil of a given region depend quite closely upon the nature of the exposed portion of the underlying geological formation. The subsoil is merely the weathered and partly disintegrated upper part of the subjacent formation. The soil contains similar material with some admixture of organic matter. In a glaciated region such as Michigan the mantle of glacial and lake deposits affords generally a well mixed and rich supply of materials suitable for productive agriculture. This is particularly true of the till, or bowlder clay, in which a considerable part of the material is in a finely divided state, and yet has enough coarse material intermixed to render it loose or open textured. The fine material not only is well adapted to yield plant food, but it tends to prevent the soil from drying out too much when rainfall is deficient. A till or bowlder clay consisting of a heavy loam will stand great variation in rainfall and still be highly productive.

In the tables here given an attempt has been made simply to give dominant characteristics of the land. For instance, if the table classes a certain township as having 12 square miles of swamp, 10 square miles of sandy till, and 14 square miles of limestone till, it should be understood that any one of these may contain small patches of other sorts of soil, such as sand or sandy gravel, and that under sandy till may be included a soil of somewhat varied texture; one acre perhaps being clayey enough to class as clayey till, another so sandy as to fall into that class, when 10 or 20 acres around them are of sandy till, the dominant phase.

The term *clayey till* as used in the tables is not restricted to compact or close-textured deposits but embraces also a loose textured loamy material nearly as pervious as the sandy till but containing a larger amount of fine earthy material. The clayey till is, however, rather compact and close textured in parts of the Ontonagon basin and on the borders of Lake Superior west from the Keweenaw Peninsula. It is especially loose textured in the drumlin areas of Iron County and Menominee County. This difference is noted in the Land Survey Plats, the compact till along the borders of Lake Superior being classed as red clay but the till of the drumlin districts is classed as a loam. The drumlins have usually a liberal

amount of clay as a matrix in which the small stones and coarse sandy particles are imbedded. But among the drumlins there are often found deposits of much looser texture with very little clay in their matrix. Both kinds of clayey till are proving to be excellent farm land and bid fair to be kept up without much fertilizing where intelligently tilled.

In most cases the general map of the surface geology (Pl. I) can be used as a soil map though some distinctions have been made in the table which are not brought out on the map. For instance, the large till plain which extends northward from Menominee County nearly to the border of Lake Superior is made up in part of loose textured clayey till and in part of sandy till. In almost every township there are frequent changes from one to the other which would require a great deal of detailed work to map properly. The proportion of each kind of till was estimated in the field but the boundaries were not worked out. The table, therefore, contains the results of these field estimates but the map does not show the extent of each class of till.

Throughout the Northern Peninsula *the morainic areas have a prevailing loose textured deposit classifiable generally as sandy till rather than clayey till, there being as a rule a smaller amount of fine earthy material in the morainic areas than in the till plains.* In places the moraines are composed of very sandy material but as a rule they have sufficient earthy material to render the soils on them productive. Where the moraines are prominent, rising 50 to 100 feet above the bordering districts they will often escape frost that touches the lowlands. They are especially well adapted to the growth of fruit trees not only because of this topographic feature but also because of their loose and mellow soil. The moraines which front on the Great Lakes have additional protection from frosts as already indicated in the discussion of the climatic conditions.

It will be seen by the table below that about 30% of the Northern Peninsula has a sandy till and 12 per cent a clayey till. These two classes of till make up the greater part of the moraines and till plains, the remaining part being occupied by swamps and lakes and small areas of sand or sandy gravel. These tills and the 2.88 per cent of the peninsula classed as glacial lake clay and the 4.14 per cent classed as limestone till give a total of very nearly one-half the area of the Northern Peninsula all of which promises to be good farm land. Of the remaining part of the peninsula considerable areas can be converted into fair farm land. The

swamps and lakes which cover 4,146 square miles or 25 per cent of the entire peninsula, may, by proper draining, be reduced to perhaps three-fourths their present extent. The reclamation of swamp lands by merely clearing off the timber and removing the obstructions along the drainage lines has already been proved successful in large areas of the Southern Peninsula which in an early day were unhealthy malarial districts. The same methods applied to the Northern Peninsula, it is thought, would reclaim 1,000 to 1,500 square miles of the present swamp areas and turn them into as productive land as the best soils of the peninsula. There are also large areas which though remaining boggy because of the impossibility of draining thoroughly may still be made profitable for the growth of cranberries and other water loving plants. Because of the small scale of the Surface Geology Map only the larger swamp areas can be represented.

There are extensive tracts of *laminated red clay* in the eastern end of the peninsula which are classed as glacial lake clays in the table below. These tracts were originally wet and poorly drained but have now been turned into productive farm land by simply clearing the brush away and opening a few ditches. They are especially well adapted to grass and already have a wide reputation as hay producers. There is a small tract of similar land southwest from the head of Keweenaw Bay which is as yet largely unimproved. Elsewhere the glacial lake clays are generally very thin so that the glacial deposits beneath them come to the surface at many places and the forest trees extend down into them. Such tracts have been classed as till tracts in the table.

By *limestone till* is meant a deposit of reddish clayey material, usually only a few feet thick, which is thickly set with limestone fragments and fine calcareous material produced by the grinding by the ice sheet of the limestone upon which the deposit is laid. In parts of the area the limestone affords a subterranean drainage so that the waters percolate down through the till into it instead of finding escape over the surface. Many of the depressions on the surface included small swamps when in a forested condition but after clearing up they were changed into productive farm land so that the swamps remaining in such areas are now so small that they are scarcely worth considering. *The limestone till is considered one of the best soils of the northern Peninsula and is already extensively farmed.* The main belt lies along the coast of Lake Huron and Lake Michigan with convenient access to lake ports for

shipment of produce, and is also traversed by the Soo Line Railway through a large part of its length.

The calciferous sandstone of Alger County and southeastern Marquette County, where standing above the level of the Glacial Lake Algonquin, is covered by a rich and easily cultivated soil fully as good as that of the limestone till along the southern border of the peninsula. The western portion of this area is a till plain, but the eastern portion, from the vicinity of Au Train River eastward, is morainic. On the till plain the rock is generally within a few feet of the surface but in the morainic part it is usually covered to considerable depth. The morainic belt was largely covered by the waters of Lake Algonquin and the effect of the submergence was to enrich rather than to deplete the soil or surface portion of the deposit. This, however, was not the case in parts of the till plain area of western Alger and eastern Marquette counties. The coating of drift there was so thin that over extensive areas the fine material was largely washed away so that the surface is now thickly strewn with sandstone and the coarse material of the drift, making the cultivation of the land very difficult. There are, however, only a few townships of this district in which the drift was so thin as to be washed away by the action of the lake.

It is a rather surprising fact that scarcely 8 per cent of the peninsula is occupied by rocky knobs and ridges, for the western half is generally considered a mountainous district. The actual area embraced in the knobs is considerably less than indicated in the table for the table simply aims to show where the knobs constitute the dominant phase of the region. Where cities have been built among these knobs, as at Ishpeming and Negaunee, one will find the soil covered tracts among them developed into rich garden plats. For general farming, however, these rocky areas are rather forbidding. The lightest soils of the peninsula are those classed as sandy and sandy gravel, and which cover about 17.5 per cent of its area. These will require intelligent treatment and careful cultivation if they are to be farmed successfully for any period of years. Methods of cultivation are already devised by which the sandy soils are kept in a state of nature without the destruction of the cover of humus which they carry and which when once destroyed can not be replaced in a long period of years. In European countries such tracts are turned into forest preserves and made to yield a rich return for the labor and investments. Those countries, however, have the advantage of a strict surveillance to guard against fire and depredations such as would be difficult to maintain in this

thinly settled region. What shall be done with these tracts of light soil is a problem that will repay intelligent study and experimentation.

To sum up the conditions in the Northern Peninsula it may be stated that 60 to 65 per cent may be turned into productive farm land, thus leaving only 35 to 40 per cent of light soil, rocky areas, and swamps difficult to reclaim.

In the tables that follow the soil classes are given in square miles for each county.

DETAILED DATA BY COUNTIES.

ALGER COUNTY.

Township.	Swamp and lake.	Glacial lake clay.	Rock knobs.	Lime-stone till.*	Clayey till.*	Sandy till.*	Sandy.	Sandy gravel.
	sq. mi.	sq. mi.	sq. mi.	sq. mi.	sq. mi.	sq. mi.	sq. mi.	sq. mi.
T. 44, R. 19 W....	18	.....	.....	.....	.....	18	.....	.....
T. 44, R. 20 W....	20	.....	.....	.....	.....	.....	.....	16
T. 44, R. 21 W....	4	.....	.....	.....	.....	32	.....	.....
T. 44, R. 22 W....	18	.....	.....	.....	.....	18	.....	.....
T. 45, R. 19 W....	5	.....	.....	.....	.....	3	.....	28
T. 45, R. 20 W....	4	.....	.....	.....	.....	16	.....	16
T. 45, R. 21 W....	4	.....	.....	.....	.....	32	.....	.....
T. 45, R. 22 W....	12	.....	.....	.....	.....	24	.....	.....
T. 46, R. 17 W....	18	.....	.....	.....	.....	8	10	.....
T. 46, R. 18 W....	8	.....	.....	.....	.....	18	.....	10
T. 46, R. 19 W....	3	1	.....	.....	.....	22	1	8
T. 46, R. 20 W....	4	.....	.....	.....	.....	30	2	.....
T. 46, R. 21 W....	3	.....	.....	.....	.....	32	.....	.....
T. 46, R. 22 W....	3	.....	.....	.....	.....	33	.....	.....
T. 47, R. 17 W....	9	.....	.....	.....	.....	27	.....	.....
T. 47, R. 18 W....	3	.....	.....	.....	.....	24	.....	.....
T. 47, R. 19 W....	2	.....	1	.....	.....	4	.....	.....
T. 47, R. 20 W....	2	.....	.....	.....	.....	12	2	.....
T. 47, R. 21 W....	.....	.....	.....	.....	.....	17	5	.....
T. 47, R. 22 W....	3	.....	.....	.....	.....	30	2	.....
T. 48, R. 13 W....	4	.....	.....	.....	.....	30	2	.....
T. 48, R. 14 W....	8	.....	.....	.....	.....	28	.....	.....
T. 48, R. 15 W....	4	.....	.....	.....	.....	32	.....	.....
T. 48, R. 16 W....	5	.....	.....	.....	.....	21	8	.....
T. 48, R. 17 W....	1	.....	.....	.....	.....	19	.....	.....
T. 48, R. 18 W....	.....	.....	.....	9	.....	.....	2	.....
Grand Is.....	2	.....	.....	.....	.....	18	.....	.....
T. 48, R. 21 W....	.....	.....	.....	.....	.....	2	.....	.....
T. 48, R. 22 W....	1	.....	.....	.....	.....	4	1	.....
T. 49, R. 13 W....	3	.....	.....	.....	.....	8	4	20
T. 49, R. 14 W....	3	.....	.....	.....	.....	12	15	.....
T. 49, R. 15 W....	5	.....	.....	.....	.....	9	12	.....
T. 50, R. 13 W....	.....	.....	.....	.....	.....	.....	3	.....
Total.....	179	1	1	9	.....	583	69	98

*The term *till* is applied to a glacial deposit of commingled coarse and fine material, slightly if at all assorted by water action.

BARAGA COUNTY.

Township.	Swamp and lake.	Glacial lake clay.	Rock knobs.	Lime-stone till.	Clayey till.	Sandy till.	Sandy.	Sandy gravel.
	sq. mi.	sq. mi.	sq. mi.	sq. mi.	sq. mi.	sq. mi.	sq. mi.	sq, mi.
T. 47, R. 31 W.	14				3	19		
T. 47, R. 32 W.	14		2		5	15	15	
T. 47, R. 33 W.	16				2	18		
T. 47, R. 34 W.	13					17		6
T. 47, R. 35 E. ½	4		.5		1.5	9		3
T. 48, R. 31 W.	5		15			12		4
T. 48, R. 32 W.	7		10			16		3
T. 48, R. 33 W.	6		20			10		
T. 48, R. 34 W.	6		3		5	20		2
T. 48, R. 35 E. ½	3					9		6
T. 49, R. 31	6		30					
T. 49, R. 32	5		20			11		
T. 49, R. 33	4		15			14		3
T. 49, R. 34	3					15		18
T. 49, R. 35 E. ½	3					11		4
T. 50, R. 30	3		25			6		2
T. 50, R. 31	4		17			15		
T. 50, R. 32	7		24			5		
T. 50, R. 33	3		14		2	16		
T. 50, R. 34	5				9	22		
T. 50, R. 35 E. ½	2	11				5		
T. 51, R. 30	6		6			24		
T. 51, R. 31	10		2			23		
T. 51, R. 32	4				12	16		
T. 51, R. 33	4				10	10		
T. 51, R. 34	6				22	5		3
T. 52, R. 30	1				8	14	2	
T. 52, R. 31	4				10	10		
T. 52, R. 32	2				4	2		
T. 52, R. 33	10				6	6		
T. 53, R. 30						3		
T. 53, R. 31						1.5		
Total	180	11	203.5		99.5	379.5	17	54

CHIPPEWA COUNTY.

Township.	Swamp and lake. sq. mi.	Glacial lake clay. sq. mi.	Rock knobs. sq. mi.	Limestone till. sq. mi.	Clayey till. sq. mi.	Sandy till. sq. mi.	Sandy. sq. mi.	Sandy gravel. sq. mi.
Drummond Is. (R)[1]	30	.....	.....	95	.....	.....	.....	.....
Lime Island	.....	.....	.....	1	.....	.....	.....	.....
Neebish Island	2	.....	.....	.....	.....	16	.....	.....
Sugar Island	30	9	.....	.....	.....	11	.....	.....
T. 41, R. 4, E	1	.....	.....	.....	.....	.....	3	.....
T. 41, R. 3 E. (E½)	3	.....	.....	.....	.....	.....	1	.....
T. 42, R. 2 E	8	.....	.....	5	.....	.....	15	8
T. 42, R. 3 E	12	.....	.....	6	.....	.....	.....	13
T. 43, R. 1 E	2	19	.....	10	.....	.....	.....	5
T. 43, R. 2 E	22	2	.....	2	.....	.....	.....	10
T. 43, R. 3 E (R)	4	.....	.....	10	.....	.....	2	.....
T. 44, R. 1 E	5	20	.....	.....	.....	.....	3	4
T. 44, R. 2 E	3	3	.....	.....	.....	.....	2	.....
T. 45, R. 1 E	5	8	.....	.....	.....	.....	3	20
T. 45, R. 2 E	4	.....	.....	2	.....	1	2	.....
T. 46, R. 1 E	3	27	.....	.....	1	3	.....	.....
T. 46, R. 2 E	2	.....	.....	.....	.....	.....	.....	.....
T. 47, R. 1 E	.....	18	.....	.....	.....	.....	.....	5
T. 44, R. 1 W	2	20	.....	.....	.....	12	2	.....
T. 44, R. 2 W	.....	36	.....	.....	.....	.....	.....	.....
T. 44, R. 3 W	.....	36	.....	.....	.....	.....	.....	.....
T. 44, R. 4 W	15	2	.....	4	.....	.....	10	5
T. 44, R. 5 W	21	.....	.....	9	.....	.....	6	.....
T. 44, R. 6 W	12	.....	.....	.....	.....	6	18	.....
T. 45, R. 1 W	12	4	.....	.....	1	12	7	.....
T. 45, R. 2 W	14	10	.....	.....	.....	8	4	.....
T. 45, R. 3 W	10	24	.....	.....	.....	2	.....	.....
T. 45, R. 4 W	20	.....	.....	.....	.....	.....	16	.....
T. 45, R. 5 W	10	.....	.....	.....	.....	6	15	5
T. 45, R. 6 W	18	.....	.....	.....	.....	15	3	.....
T. 45, R. 7 W	26	.....	.....	.....	.....	8	2	.....
T. 46, R. 1 W	.....	33	.....	.....	2	1	.....	.....
T. 46, R. 2 W	6	28	.....	.....	.....	.....	2	.....
T. 46, R. 3 W	6	7	.....	.....	.....	10	.....	13
T. 46, R. 4 W	.....	.....	.....	.....	.....	10	2	24
T. 46, R. 5 W	4	.....	.....	.....	.....	32	.....	.....
T. 46, R. 6 W	21	.....	.....	.....	.....	15	.....	.....
T. 46, R. 7 W	28	.....	.....	.....	.....	8	.....	.....
T. 47, R. 1 W	5	18	.....	.....	.....	1	2	.....
T. 47, R. 2 W	5	.....	.....	.....	.....	.....	3	.....
T. 47, R. 3 W	3	.....	.....	.....	.....	5	15	3
T. 47, R. 4 W	4	.....	.....	.....	1	8	4	.....
T. 47, R. 5 W	5	.....	.....	.....	.....	18	.....	.....
T. 47, R. 6 W	8	.....	.....	.....	.....	24	.....	.....
T. 47, R. 7 W	13	.....	.....	.....	.....	23	.....	.....
T. 48, R. 6 W	10	.....	.....	.....	.....	3	10	.....
T. 48, R. 7 W	3	.....	.....	.....	.....	24	9	.....
T. 49, R. 6 W	10	.....	.....	.....	.....	.....	14	.....
T. 49, R. 7 W	20	.....	.....	.....	.....	.....	16	.....
T. 50, R. 5 W	.....	.....	.....	.....	.....	.....	2	.....
T. 50, R. 6 W	13	.....	.....	.....	.....	.....	17	.....
T. 50, R. 7 W	10	.....	.....	.....	.....	3	21	.....
T. 51, R. 5 W	.....	.....	.....	.....	.....	.....	1	.....
Total	470	324	.....	144	5	285	232	115

(R.) Reported by Russel.

DELTA COUNTY.

Township.	Swamp and lake. sq. mi.	Glacial lake clay. sq. mi.	Rock knobs. sq. mi.	Lime-stone till. sq. mi.	Clayey till. sq. mi.	Sandy till. sq. mi.	Sandy. sq. mi.	Sandy gravel. sq. mi.
T. 37, R. 19 W.	.....	.....	.....	3.5	.....	.....	.....	.....
T. 37, R. 24 W (R).	10	.....	.....	.....	.....	4	8	.....
T. 38, R. 18 W.	.....	.....	.....	2	.....	.....	.....	.....
T. 38, R. 19 W.	3	.....	.....	23	.....	.....	.....	.....
T. 38, R. 20 W.	.....	.....	.....	1	.....	.....	.....	.....
T. 38, R. 21 W.	2	.....	.....	2	.....	.....	2	.....
T. 38, R. 22 W.	.....	.....	.....	2	.....	.....	2	.....
T. 38, R. 23 W.	6	.....	.....	.....	.....	.....	15	.....
T. 38, R. 24 W (R).	21	.....	.....	.....	.....	10	5	.....
T. 39, R. 18 W.	7	.....	.....	19	.....	.....	.....	.....
T. 39, R. 19 W.	.....	.....	.....	9	.....	.....	.....	.....
T. 39, R. 20 W.	2	.....	.....	.....	.....	.....	4	.....
T. 39, R. 21 W.	.....	.....	.....	28	.....	.....	8	.....
T. 39, R. 22 W.	.....	.....	.....	.....	.....	.....	14	.....
T. 39, R. 23 W (R).	18	.....	.....	.....	.....	.....	3	15
T. 39, R. 24 W (R).	12	.....	.....	.....	.....	24	.....	.....
T. 40, R. 18 W.	6	1	.....	5	.....	6	.....	6
T. 40, R. 19 W.	3	.....	.....	5	.....	.....	9	.....
T. 40, R. 20 W.	3	2	.....	1	.....	.....	18	.....
T. 40, R. 21 W.	10	.....	.....	16	.....	.....	10	.....
T. 40, R. 22 W.	4	.....	.....	.....	.....	.....	18	.....
T. 40, R. 23 W (R).	15	.....	.....	.....	.....	7	4	10
T. 40, R. 24 W (R).	14	.....	.....	.....	.....	22	.....	.....
T. 41, R. 18 W.	8	6	.....	4	.....	.....	18	.....
T. 41, R. 19 W.	8	.....	.....	2	.....	6	20	.....
T. 41, R. 20 W.	18	.....	.....	.....	.....	.....	18	.....
T. 41, R. 21 W.	3	.....	.....	15	.....	2	16	.....
T. 41, R. 22 W.	8	.....	.....	18	.....	.....	10	.....
T. 41, R. 23 W.	20	.....	.....	.....	.....	16	.....	.....
T. 41, R. 24 W (R).	10	.....	.....	.....	.....	26	.....	.....
T. 42, R. 18 W.	8	2	.....	.....	.....	.....	3	23
T. 42, R. 19 W.	4	.....	.....	.....	.....	26	.....	6
T. 42, R. 20 W.	6	.....	.....	.....	.....	.....	30	.....
T. 42, R. 21 W.	8	.....	.....	24	.....	.....	4	.....
T. 42, R. 22 W.	10	.....	.....	.....	.....	26	.....	.....
T. 42, R. 23 W.	10	.....	.....	.....	.....	26	.....	.....
T. 43, R. 18 W.	2	.....	.....	.....	.....	16	.....	18
T. 43, R. 19 W.	16	.....	.....	.....	.....	10	.....	10
T. 43, R. 20 W.	16	.....	.....	.....	.....	.....	20	.....
T. 43, R. 21 W.	16	.....	.....	.....	.....	20	.....	.....
T. 43, R. 22 W.	16	.....	.....	.....	.....	20	.....	.....
T. 43, R. 23 W.	16	.....	.....	.....	.....	20	.....	.....
Total.	339	11	.....	179.5	.....	287	259	88

DICKINSON COUNTY.

Township.	Swamp and lake. sq. mi.	Glacial lake clay. sq. mi.	Rock knobs. sq. mi.	Limestone till. sq. mi.	Clayey till. sq. mi.	Sandy till. sq. mi.	Sandy. sq. mi.	Sandy gravel. sq. mi.
T. 39, R. 28 W....	4	.....	2	.....	.....	20	.....	10
T. 39, R. 29 W....	4	.....	6	.....	.....	6	.....	10
T. 39, R. 30 W....	.....	.....	1	.....	.....	2	.....	9
T. 39, R. 31 W....	.....	.....	.....	.....	.....	.....	.....	25
T. 40, R. 28 W....	.....	.....	16	.....	.....	5	.....	15
T. 40, R. 29 W....	2	.....	24	.....	.....	5	.....	5
T. 40, R. 30 W....	5	.....	12	.....	.....	12	.....	7
T. 40, R. 31 W....	1	.....	3	.....	.....	5	.....	12
T. 41, R. 27 W....	3	.....	3	.....	16	10	.....	4
T. 41, R. 28 W....	3	.....	5	.....	.....	8	.....	20
T. 41, R. 29 W....	4	.....	14	.....	.....	6	.....	12
T. 41, R. 30 W....	2	.....	14	.....	.....	5	.....	14
T. 42, R. 27 W....	4	.....	.....	.....	20	12	.....	.....
T. 42, R. 28 W....	9	.....	8	.....	.....	7	.....	12
T. 42, R. 29 W....	6	.....	5	.....	2	14	.....	9
T. 42, R. 30 W....	5	.....	5	.....	.....	12	.....	14
T. 43, R. 27 W....	6	.....	.....	.....	15	15	.....	.....
T. 43, R. 28 W....	10	.....	.....	.....	.....	10	.....	16
T. 43, R. 29 W....	5	.....	5	.....	.....	18	.....	8
T. 43, R. 30 W....	8	.....	.....	.....	23	5	.....	.....
T. 44, R. 27 W....	8	.....	.....	.....	.....	25	3	.....
T. 44, R. 28 W....	10	.....	.....	.....	.....	16	.....	10
T. 44, R. 29 W....	10	.....	2	.....	.....	12	.....	12
T. 44, R. 30 W....	10	.....	.....	.....	.....	16	.....	10
Total.....	119	.....	125	.....	76	246	3	243

GOGEBIC COUNTY.

Township.	Swamp and lake. sq. mi.	Glacial lake clay. sq. mi.	Rock knobs. sq. mi.	Lime-stone till. sq. mi.	Clayey till. sq. mi.	Sandy till. sq. mi.	Sandy. sq. mi.	Sandy gravel. sq. mi.
T. 43, R. 38	1	.....	.....	.....	.....	10	.....	.....
T. 43, R. 39	1.5	.....	.....	.....	.....	.....	.....	1.5
T. 44, R. 38	4	.....	.....	.....	.....	32	.....	.....
T. 44, R. 39	6	.....	.....	.....	.....	20	.....	10
T. 44, R. 40	10	.....	.....	.....	.....	16	.....	2
T. 44, R. 41	6	.....	.....	.....	.....	12	.....	.....
T. 44, R. 42	2	.....	.....	.....	.....	6	.....	.....
T. 45, R. 38	6	.....	.....	.....	.....	20	.....	10
T. 45, R. 39	5	.....	.....	.....	4	18	.....	9
T. 45, R. 40	8	.....	.....	.....	.....	14	.....	14
T. 45, R. 41	5	.....	.....	.....	10	21	.....	.....
T. 45, R. 42	4	.....	.....	.....	10	22	.....	.....
T. 45, R. 43	5.5	.....	.....	.....	15	.....	.....	.....
T. 45, R. 44	6	.....	.....	.....	6	12	.....	.....
T. 45, R. 45	4	.....	2	.....	2	6	.....	.....
T. 45, R. 46	1	.....	2	.....	.....	1.5	.....	.....
T. 46, R. 41	5	.....	1	.....	2	28	.....	.....
T. 46, R. 42	5	.....	2	.....	7	22	.....	.....
T. 46, R. 43	2	.....	6	.....	.....	.....	.....	.....
T. 46, R. 44	6	.....	15	.....	.....	15	.....	.....
T. 46, R. 45	15	.....	5	.....	.....	16	.....	.....
T. 46, R. 46	6	.....	15	.....	.....	15	.....	.....
T. 46, R. 47	1	.....	3	.....	.....	2	.....	.....
T. 47, R. 41	4	.....	.....	.....	21	11	.....	.....
T. 47, R. 42	10	.....	5	.....	18	3	.....	.....
T. 47, R. 43	4	.....	12	.....	10	.....	.....	.....
T. 47, R. 44	6	.....	10	.....	10	10	.....	.....
T. 47, R. 45	5	.....	15	.....	8	8	.....	.....
T. 47, R. 46	6	.....	24	.....	.....	6	.....	.....
T. 47, R. 47	2	.....	10	.....	6	3	.....	.....
T. 48, R. 44	6	.....	6	.....	18	6	.....	.....
T. 48, R. 45	5	.....	.....	.....	16	15	.....	.....
T. 48, R. 46	4	.....	4	.....	18	10	.....	.....
T. 48, R. 47	9	.....	.....	.....	17	10	.....	.....
T. 48, R. 48	3	.....	3	.....	10	12	.....	.....
T. 48, R. 49	1.5	.....	.....	.....	5	2	.....	.....
T. 49, R. 45	5	.....	13	.....	18	.....	.....	.....
T. 49, R. 46	7	.....	6	.....	7	5	.....	.....
T. 49, R. 47	3	.....	3	.....	6	8	.....	.....
T. 49, R. 48	1	.....	.....	.....	4	1	.....	.....
T. 50, R. 45	3	.....	3	.....	12	6	.....	.....
Total	199.5	.....	165	.....	260	424.5	.....	46.5

HOUGHTON COUNTY.

Township.	Swamp and lake. sq. mi.	Glacial lake clay. sq. mi.	Rock knobs. sq. mi.	Limestone till. sq. mi.	Clayey till. sq. mi.	Sandy till. sq. mi.	Sandy. sq. mi.	Sandy gravel. sq. mi.
T. 47, R. 35 W ½	2	.....	.5	.....	1.5	7	.....	7
T. 47, R. 36	1	.....	.....	.....	3	20	.....	12
T. 47, R. 37	4	.....	2	.....	5	16	9	.....
T. 48, R. 35 W ½	2	.....	.....	.....	.....	12	.....	4
T. 48, R. 36	2	.....	.....	.....	3	12	.....	19
T. 48, R. 37	4	.....	.....	.....	2	11	16	3
T. 49, R. 35 W ½	3	6	.....	.....	.....	9	.....	.....
T. 49, R. 36	6	12	.....	.....	.....	14	.....	4
T. 49, R. 37	3	.....	.....	.....	2	16	11	4
T. 50, R. 35 W ½	4	13	.....	.....	.....	1	.....	.....
T. 50, R. 36	8	15	.....	.....	.....	10	.....	3
T. 51, R. 35	6	6	1	.....	.....	23	.....	.....
T. 51, R. 36	6	.....	.....	.....	.....	30	.....	.....
T. 52, R. 34	15	.....	.....	.....	6	15	.....	.....
T. 52, R. 35	10	.....	.....	.....	.....	26	.....	.....
T. 52, R. 36	6	.....	2	.....	.....	24	4	.....
T. 53, R. 32	1	.....	.....	.....	.....	6	.....	.....
T. 53, R. 33	16	.....	.....	.....	9	9	.....	.....
T. 53, R. 34	15	.....	.....	.....	.....	21	.....	.....
T. 53, R. 35	6	.....	.....	.....	.....	30	.....	.....
T. 53, R. 36	5	.....	.....	.....	16	10	.....	5
T. 54, R. 32	8	.....	.....	.....	.....	17	.....	.....
T. 54, R. 33	4	.....	.....	.....	.....	15	.....	.....
T. 54, R. 34	9	.....	3	.....	.....	24	.....	.....
T. 54, R. 35	12	.....	.....	.....	4	20	.....	.....
T. 54, R. 36	7	.....	.....	.....	10	10	.....	.....
T. 55, R. 31	8	.....	.....	.....	.....	.....	6	.....
T. 55, R. 32	8	.....	.....	.....	.....	24	4	.....
T. 55, R. 33	5	.....	10	.....	.....	16	.....	5
T. 55, R. 34	6	.....	3	.....	.....	25	.....	2
T. 55, R. 35	5	.....	.....	.....	.....	20	.....	.....
T. 55, R. 36	.5	.....	.....	.....	1.5	.....	.....	.....
T. 56, R. 32	5	.....	5	.....	.....	20	.....	6
T. 56, R. 33	3	.....	13	.....	.....	12	.....	4
T. 56, R. 34	3	.....	.....	.....	.....	12	.....	.....
Total	208.5	52	39.5	.....	63	537	50	78

IRON COUNTY.

Township.	Swamp and lake.	Glacial lake clay.	Rock knobs.	Limestone till.	Clayey till.	Sandy till.	Sandy.	Sandy gravel.
	sq. mi.	sq. mi.	sq. mi.	sq. mi.	sq. mi.	sq. mi.	sq. mi.	sq. mi.
T. 41, R. 31 W.	.....	.....	.....	.....	.....	7	.....	11
T. 41, R. 32 W.	1	.....	.....	.....	.....	2	.....	7
T. 41, R. 33 W.	.....	.....	.....	.....	.....	.....	.....	1
T. 42, R. 31 W.	6	.....	.....	.....	.....	10	.....	20
T. 42, R. 32 W.	4	.....	4	.....	.....	6	.....	22
T. 42, R. 33 W.	5	.....	4	.....	5	22	.....	.....
T. 42, R. 34 W.	6	.....	.....	.....	9	7	.....	2
T. 42, R. 35 W.	3	.....	3	.....	18	10	.....	2
T. 42, R. 36 W.	4	.....	.....	.....	.....	9	.....	4
T. 42, R. 37 W.	1	.....	.....	.....	2	.....	.....	.....
T. 43, R. 31 W.	5	.....	5	.....	2	10	.....	14
T. 43, R. 32 W.	13	.....	8	.....	3	2	.....	10
T. 43, R. 33 W.	5	.....	1	.....	4	21	.....	5
T. 43, R. 34 W.	7	.....	.....	.....	14	15	.....	.....
T. 43, R. 35 W.	7	.....	1	.....	15	13	.....	.....
T. 43, R. 36 W.	3	.....	.....	.....	20	10	.....	3
T. 43, R. 37 W.	6	.....	.....	.....	.....	28	.....	2
T. 44, R. 31 W.	5	.....	.....	.....	5	16	.....	10
T. 44, R. 32 W.	10	.....	6	.....	5	15	.....	.....
T. 44, R. 33 W.	6	.....	4	.....	6	14	.....	6
T. 44, R. 34 W.	4	.....	.....	.....	16	11	.....	5
T. 44, R. 35 W.	7	.....	1	.....	20	6	.....	2
T. 44, R. 36 W.	5	.....	.....	.....	15	13	.....	3
T. 44, R. 37 W.	3	.....	.....	.....	26	4	.....	3
T. 45, R. 31 W.	6	.....	.....	.....	5	22	.....	3
T. 45, R. 32 W.	10	.....	1	.....	4	15	.....	6
T. 45, R. 33 W.	9	.....	.....	.....	4	20	.....	3
T. 45, R. 34 W.	16	.....	.....	.....	4	16	.....	.....
T. 45, R. 35 W.	7	.....	.....	.....	8	21	.....	.....
T. 45, R. 36 W.	8	.....	1	.....	15	.....	.....	12
T. 45, R. 37 W.	4	.....	.....	.....	6	14	.....	12
T. 46, R. 31 W.	9	.....	.....	.....	14	13	.....	.....
T. 46, R. 32 W.	9	.....	2	.....	8	14	.....	3
T. 46, R. 33 W.	9	.....	.....	.....	3	24	.....	.....
T. 46, R. 34 W.	14	.....	.....	.....	6	16	.....	.....
T. 46, R. 35 W.	15	.....	.....	.....	6	15	.....	.....
T. 46, R. 36 W.	5	.....	1	.....	5	25	.....	.....
T. 46, R. 37 W.	4	.....	1	.....	.....	25	.....	6
Total.	241	.....	43	.....	273	491	.....	177

KEWEENAW COUNTY.

Township.	Swamp and lake.	Glacial lake clay.	Rock knobs.	Lime-stone till.	Clayey till.	Sandy till.	Sandy.	Sandy gravel.
	sq. mi.	sq. mi.	sq. mi.	sq. mi.	sq. mi.	sq. mi.	sq. mi.	sq. mi.
T. 56, R. 30	6	.....	.....	.....	.....	.....	6	.....
T. 56, R. 31	10	.....	.....	.....	.....	4	20	.....
T. 57, R. 29	8	.....	.....	.....	.....	.....	.....	6
T. 57, R. 30	12	.....	4	.....	.....	10	10	.....
T. 57, R. 31	3	.....	12	.....	.....	21	.....	.....
T. 57, R. 32	3	.....	18	.....	.....	5	.....	10
T. 57, R. 33	2	.....	3	.....	.....	2	.....	6
T. 58, R. 27	3	.....	11	.....	.....	.....	.....	.....
T. 58, R. 28	3	.....	25	.....	.....	5	.....	.....
T. 58, R. 29	5	.....	24	.....	.....	5	.....	.....
T. 58, R. 30	5	.....	21	.....	.....	10	.....	.....
T. 58, R. 31	.....	.....	20	.....	.....	8	.....	.....
T. 58, R. 32	2	.....	4	.....	.....	.....	.....	4
T. 59, R. 27	.....	.....	1.5	.....	.....	.....	.....	.....
T. 59, R. 28	1	.....	6	.....	.....	.....	.....	.....
T. 59, R. 29	.....	.....	9	.....	.....	.....	.....	.....
T. 59, R. 30	.....	.....	1.5	.....	.....	.....	.....	2
Manitou Island	.....	.....	2	.....	.....	.....	.....	.....
Total	63	.....	162	.....	.....	70	36	28

LUCE COUNTY.

Township.	Swamp and lake. sq. mi.	Glacial lake clay. sq. mi.	Rock knobs. sq. mi.	Lime-stone till. sq. mi.	Clayey till. sq. mi.	Sandy till. sq. mi.	Sandy. sq. mi.	Sandy gravel. sq. mi.
T. 45, R. 8 W.	24	.....	.....	.....	.....	12	.....	.....
T. 45, R. 9 W.	14	.....	.....	.....	.....	20	2	.....
T. 45, R. 10 W.	8	2	.....	.....	.....	26	.....	.....
T. 45, R. 11 W.	4	.....	.....	.....	3	29	.....	.....
T. 45, R. 12 W.	22	.....	.....	.....	14	.....	.....	.....
T. 46, R. 8 W.	34	.....	.....	.....	.....	2	.....	.....
T. 46, R. 9 W.	27	.....	.....	.....	.....	4	5	.....
T. 46, R. 10 W.	26	.....	.....	.....	.....	10	.....	.....
T. 46, R. 11 W.	25	.....	.....	.....	.....	3	.....	8
T. 46, R. 12 W.	21	.....	.....	.....	.....	4	.....	11
T. 47, R. 8 W.	14	.....	.....	.....	.....	22	.....	.....
T. 47, R. 9 W.	31	.....	.....	.....	.....	5	.....	.....
T. 47, R. 10 W.	23	.....	.....	.....	.....	13	.....	.....
T. 47, R. 11 W.	3	.....	.....	.....	.....	13	.....	20
T. 47, R. 12 W.	.....	.....	.....	.....	.....	23	.....	13
T. 48, R. 8 W.	6	.....	.....	.....	.....	30	.....	.....
T. 48, R. 9 W.	13	.....	.....	.....	.....	23	.....	.....
T. 48, R. 10 W.	24	.....	.....	.....	.....	6	6	.....
T. 48, R. 11 W.	21	.....	.....	.....	.....	1	14	.....
T. 48, R. 12 W.	12	.....	.....	.....	.....	24	.....	.....
T. 49, R. 8 W.	20	.....	.....	.....	.....	12	4	.....
T. 49, R. 9 W.	6	.....	.....	.....	.....	.....	2	28
T. 49, R. 10 W.	3	.....	.....	.....	.....	3	6	24
T. 49, R. 11 W.	6	.....	.....	.....	.....	.....	4	26
T. 49, R. 12 W.	10	.....	.....	.....	.....	8	18	.....
T. 50, R. 8 W.	2	.....	.....	.....	.....	10	12	.....
T. 50, R. 9 W.	.....	.....	.....	.....	.....	.....	8	.....
T. 50, R. 12 W.	.....	.....	.....	.....	.....	.....	2	.....
Total.	399	2	.....	.....	17	303	83	130

MACKINAC COUNTY.

Township.	Swamp and lake. sq. mi.	Glacial lake clay. sq. mi.	Rock knobs. sq. mi.	Lime-stone till. sq. mi.	Clayey till. sq. mi.	Sandy till. sq. mi.	Sandy. sq. mi.	Sandy gravel. sq. mi.
Les Cheneaux Is. (R)	.....	.....	.....	.....	11	.....	.....	.....
Bois Blanc (R)	10	.....	.....	.....	.....	30	.....	.....
Round Is	1	.....	.....	.....	.....	.....	.....	.....
Mackinac	.....	.....	.....	2.5	.....	.....	.....	0.5
St. Martin's	2	.....	.....	.....	.....	.....	.....	.....
T. 40, R. 3 W	.....	.....	.....	3	.....	.....	.....	.....
T. 40, R. 4 W	5	.....	.....	8	.....	.....	.....	.....
T. 41, R. 3 E (W¾)	2	.....	.....	.....	.....	.....	2	.....
T. 41, R. 2 E (R)	1	.....	.....	.....	.....	.....	2	.....
T. 41, R. 2 W (R)	2	.....	.....	.....	.....	.....	.....	.....
T. 41, R. 3 W	2	.....	.....	1	.....	.....	.....	.....
T. 41, R. 4 W	24	.....	.....	10	.....	.....	.....	.....
T. 41, R. 5 W	4	.....	.....	.....	.....	.....	12	.....
T. 41, R. 11 W	3	.....	.....	1	.....	.....	2	.....
T. 41, R. 12 W	2	.....	.....	.....	.....	.....	3	.....
T. 42, R. 1 E	3	.....	.....	31	.....	.....	.....	.....
T. 42, R. 1 W	6	.....	.....	12	.....	5	7	.....
T. 42, R. 2 W	12	.....	.....	10	.....	.....	2	.....
T. 42, R. 3 W	5	8	.....	2	.....	.....	6	.....
T. 42, R. 4 W	26	.....	.....	10	.....	.....	.....	.....
T. 42, R. 5 W	18	.....	.....	.....	.....	.....	.....	12
T. 42, R. 6 W	2	.....	.....	.....	.....	.....	2	19
T. 42, R. 7 W	3	.....	.....	.....	.....	.....	.....	5
T. 42, R. 8 W	1	.....	.....	.....	.....	.....	.....	.....
T. 42, R. 10 W	2	.....	.....	.....	.....	.....	3	.....
T. 42, R. 11 W	10	.....	.....	21	.....	.....	2	.....
T. 42, R. 12 W	23	.....	.....	11	.....	.....	2	.....
T. 43, R. 1 W	4	15	.....	15	.....	2	.....	.....
T. 43, R. 2 W	5	14	.....	17	.....	.....	.....	.....
T. 43, R. 3 W	2	26	.....	8	.....	.....	.....	.....
T. 43, R. 4 W	12	.....	.....	24	.....	.....	.....	.....
T. 43, R. 5 W	16	.....	.....	18	.....	.....	2	.....
T. 43, R. 6 W	20	.....	.....	.....	.....	16	.....	.....
T. 43, R. 7 W	17	.....	.....	.....	.....	9	.....	10
T. 43, R. 8 W	16	.....	.....	.....	.....	10	6	.....
T. 43, R. 9 W	5	.....	.....	.....	.....	10	12	.....
T. 43, R. 10 W	12	.....	.....	10	.....	.....	10	.....
T. 43, R. 11 W	21	.....	.....	12	.....	.....	.....	3
T. 43, R. 12 W	16	.....	.....	.....	.....	.....	.....	20
T. 44, R. 7 W	22	.....	.....	.....	.....	6	8	.....
T. 44, R. 8 W	10	.....	.....	10	.....	6	10	.....
T. 44, R. 9 W	7	.....	.....	.....	.....	25	4	.....
T. 44, R. 10 W	11	.....	.....	12	.....	3	5	5
T. 44, R. 11 W	20	.....	.....	.....	2	10	.....	4
T. 44, R. 12 W	19	.....	.....	.....	15	2	.....	.....
Total	473.5	63	.....	248.5	28	134	102	78.5

MARQUETTE COUNTY.

Township.	Swamp and lake. sq. mi.	Glacial lake clay. sq. mi.	Rock knobs. sq. mi.	Lime-stone till. sq. mi.	Clayey till. sq. mi.	Sandy till. sq. mi.	Sandy. sq. mi.	Sandy gravel. sq. mi.
T. 42, R. 24	10	.....	.....	.....	.....	26	.....	.....
T. 42, R. 25	12	.....	.....	.....	8	16	.....	.....
T. 42, R. 26	12	.....	.....	.....	.....	24	.....	.....
T. 43, R. 24	24	.....	.....	.....	.....	12	.....	.....
T. 43, R. 25	15	.....	.....	.....	.....	21	.....	.....
T. 43, R. 26	14	.....	.....	.....	.....	22	.....	.....
T. 44, R. 23	21	.....	.....	.....	.....	15	.....	.....
T. 44, R. 24	24	.....	.....	.....	.....	8	.....	4
T. 44, R. 25	17	.....	.....	.....	.....	7	.....	12
T. 44, R. 26	18	.....	.....	.....	.....	11	.....	7
T. 45, R. 23	12	.....	.....	.....	.....	24	.....	.....
T. 45, R. 24	10	.....	.....	.....	.....	14	.....	12
T. 45, R. 25	4	.....	.....	.....	.....	3	.....	29
T. 45, R. 26	5	.....	6	.....	.....	7	.....	18
T. 45, R. 27	5	.....	.....	.....	5	24	.....	4
T. 45, R. 28	10	.....	.....	.....	.....	18	.....	8
T. 45, R. 29	4	.....	.....	.....	.....	17	.....	15
T. 45, R. 30	9	.....	1	.....	.....	25	.....	.....
T. 46, R. 23	8	.....	.....	.....	.....	28	.....	.....
T. 46, R. 24	2	.....	.....	.....	.....	30	4	.....
T. 46, R. 25	2	.....	5	.....	.....	11	.....	18
T. 46, R. 26	4	.....	14	.....	.....	.....	.....	18
T. 46, R. 27	8	.....	3	.....	.....	5	.....	20
T. 46, R. 28	6	.....	4	.....	.....	6	.....	20
T. 46, R. 29	4	.....	4	.....	.....	14	.....	14
T. 46, R. 30	8	.....	4	.....	.....	15	.....	9
T. 47, R. 23 (R)	6	.....	.....	.....	.....	18	6	.....
T. 47, R. 24	4	.....	.....	.....	.....	20	6	.....
T. 47, R. 25	1	.....	8	.....	.....	15	.....	12
T. 47, R. 26	2	.....	28	.....	.....	.....	.....	6
T. 47, R. 27	6	.....	18	.....	.....	5	.....	7
T. 47, R. 28	5	.....	8	.....	.....	8	.....	15
T. 47, R. 29	10	.....	12	.....	.....	10	.....	4
T. 47, R. 30	8	.....	17	.....	.....	5	.....	6
T. 48, R. 25	1	.....	20	.....	.....	3	.....	5
T. 48, R. 26	.....	.....	24	.....	.....	.....	.....	12
T. 48, R. 27	12	.....	14	.....	.....	6	.....	4
T. 48, R. 28	5	.....	20	.....	.....	5	.....	6
T. 48, R. 29	6	.....	18	.....	.....	6	.....	6
T. 48, R. 30	12	.....	17	.....	.....	5	.....	2
T. 49, R. 25	.....	.....	5	.....	.....	.....	1	2
T. 49, R. 26	4	.....	25	.....	.....	.....	.....	5
T. 49, R. 27	4	.....	18	.....	.....	8	.....	6
T. 49, R. 28	4	.....	20	.....	.....	6	.....	6
T. 49, R. 29	6	.....	30	.....	.....	.....	.....	.....
T. 49, R. 30	5	.....	28	.....	.....	.....	.....	3
T. 50, R. 26	4	.....	5	.....	.....	.....	.....	5
T. 50, R. 27	2	.....	18	.....	.....	12	.....	4
T. 50, R. 28	2	.....	6	.....	.....	18	.....	10
T. 50, R. 29	5	.....	16	.....	.....	5	.....	10
T. 51, R. 26	.....	.....	.....	.....	.....	3	.....	.....
T. 51, R. 27	4	.....	10	.....	.....	5	8	.....
T. 51, R. 28	5	.....	12	.....	.....	12	.....	7
T. 51, R. 29	5	.....	16	.....	.....	10	.....	5
T. 52, R. 27	.5	.....	1.5	.....	.....	.....	1	.....
T. 52, R. 28	3	.....	8	.....	.....	2	4	.....
T. 52, R. 29	4	.....	12	.....	.....	6	.....	2
Total	403.5	.....	475.5	.....	13	596	30	358

MENOMINEE COUNTY.

Township.	Swamp and lake. sq. mi.	Glacial lake clay. sq. mi.	Rock knobs. sq. mi.	Limestone till. sq. mi.	Clayey till. sq. mi.	Sandy till. sq. mi.	Sandy. sq. mi.	Sandy gravel. sq. mi.
T. 31, R. 27 W.	.....	.....	.....	.....	.....	.....	2	.....
T. 32, R. 26 W.	1	.....	.....	.....	.....	.....	1	.....
T. 32, R. 27 W.	5	.....	.....	.....	6	12	3	.....
T. 32, R. 28 W.	.....	.....	.....	.....	.....	5	.....	.....
T. 33, R. 26 W.	6	.....	.....	.....	10	4	4	.....
T. 33, R. 27 W.	5	.....	.....	.....	20	8	3	.....
T. 33, R. 28 W.	.....	.....	.....	.....	.....	4.5	.....	.....
T. 34, R. 25 W.	1.5	.....	.....	.....	5	.....	5	.....
T. 34, R. 26 W.	6	.....	.....	.....	18	8	4	.....
T. 34, R. 27 W.	.....	.....	.....	.....	17	8	.....	2
T. 34, R. 28 W.	.....	.....	.....	.....	7	.....	.....	1
T. 34, R. 29 W.	.....	.....	.....	.....	4	.....	.....	11
T. 35, R. 25 W.	4	.....	.....	.....	5	17	5	.....
T. 35, R. 26 W.	10	.....	.....	.....	18	8	.....	.....
T. 35, R. 27 W.	5	.....	.....	.....	27	2.5	.....	1.5
T. 35, R. 28 W.	2	.....	.....	.....	.....	10	22	1
T. 35, R. 29 W.	2	.....	.....	.....	1	6	.....	1
T. 36, R. 24 W (R).	2	.....	.....	.....	.....	.....	11	.....
T. 36, R. 25 W.	3	.....	.....	.....	6	21	6	.....
T. 36, R. 26 W.	4	.....	.....	.....	24	6	.....	2
T. 36, R. 27 W.	4	.....	.....	.....	27	4	.....	1
T. 36, R. 28 W.	.....	.....	.....	.....	2	16	.....	13
T. 37, R. 25 W.	4	.....	.....	.....	16	16	.....	.....
T. 37, R. 26 W.	4	.....	.....	.....	23	6	.....	3
T. 37, R. 27 W.	1.5	.....	.....	.....	32	2.5	.....	.....
T. 37, R. 28 W.	.....	.....	.....	.....	2	23	.....	3
T. 38, R. 25 W.	6	.....	.....	.....	10	20	.....	.....
T. 38, R. 26 W.	4	.....	.....	.....	25	5	.....	2
T. 38, R. 27 W.	4	.....	.....	.....	30	2	.....	.....
T. 38, R. 28 W.	2.5	.....	.....	.....	.....	25	.....	4.5
T. 39, R. 25 W.	6	.....	.....	.....	10	20	.....	.....
T. 39, R. 26 W.	6	.....	.....	.....	20	8	.....	2
T. 39, R. 27 W.	4	.....	.....	.....	20	10	.....	2
T. 40, R. 25 W.	8	.....	.....	.....	12	16	.....	.....
T. 40, R. 26 W.	6	.....	.....	.....	20	6	.....	4
T. 40, R. 27 W.	2	.....	.....	.....	24	10	.....	.....
T. 41, R. 25 W.	12	.....	.....	.....	10	14	.....	.....
T. 41, R. 26 W.	6	.....	.....	.....	18	8	.....	4
Total.....	136.5	.....	.....	.....	469	331.5	66	58

ONTONAGON COUNTY.

Township.	Swamp and lake. sq. mi.	Glacial lake clay. sq. mi.	Rock knobs. sq. mi.	Lime-stone till. sq. mi.	Clayey till. sq. mi.	Sandy till. sq. mi.	Sandy. sq. mi.	Sandy gravel. sq. mi.
T. 46, R. 38	10	.....	1	.....	.....	15	.....	10
T. 46, R. 39	5	.....	1	.....	.....	18	.....	12
T. 46, R. 40	4	.....	.....	.....	4	28	.....	.....
T. 47, R. 38	4.5	.....	1.5	.....	10	20	.....	.....
T. 47, R. 39	2	.....	.....	.....	9	25	.....	.....
T. 47, R. 40	4	.....	.....	.....	28	4	.....	.....
T. 48, R. 38	4	.....	.....	.....	18	14	.....	.....
T. 48, R. 39	2	.....	.....	.....	21	13	.....	.....
T. 48, R. 40	4	.....	.....	.....	17	11	4	.....
T. 48, R. 41	4	.....	.....	.....	32	.....	.....	.....
T. 48, R. 42	9	.....	.....	.....	27	.....	.....	.....
T. 48, R. 43	10	.....	4	.....	15	7	.....	.....
T. 49, R. 38	5	.....	.....	.....	.....	4	27	.....
T. 49, R. 39	2	.....	.....	.....	29	5	.....	.....
T. 49, R. 40	4	.....	1	.....	21	10	.....	.....
T. 49, R. 41	4	.....	4	.....	26	2	.....	.....
T. 49, R. 42	6	.....	7	.....	2	.....	.....	.....
T. 49, R. 43	6	.....	4	.....	12	14	.....	.....
T. 49, R. 44	5	.....	6	.....	11	14	.....	.....
T. 50, R. 37	3	.....	.....	.....	8	25	.....	.....
T. 50, R. 38	4	.....	2	.....	24	6	.....	.....
T. 50, R. 39	4	.....	3	.....	27	2	.....	.....
T. 50, R. 40	2	.....	2	.....	24	6	2	.....
T. 50, R. 41	5	.....	5	.....	24	2	.....	.....
T. 50, R. 42	5	.....	2	.....	27	.....	.....	.....
T. 50, R. 43	6	.....	3	.....	25	2	.....	.....
T. 50, R. 44	4	.....	13	.....	12	7	.....	.....
T. 51, R. 37	5	.....	4	.....	12	12	.....	3
T. 51, R. 38	5	.....	3	.....	24	4	.....	.....
T. 51, R. 39	4	.....	.....	.....	28	.....	4	.....
T. 51, R. 40	4	.....	.....	.....	26	.....	4	.....
T. 51, R. 41	3	.....	.....	.....	25	.....	2	.....
T. 51, R. 42	3	.....	4	.....	16	2	.....	.....
T. 51, R. 43	2	.....	16	.....	6	.....	.....	.....
T. 51, R. 44	1	.....	3	.....	1	.....	.....	.....
T. 52, R. 37	5	.....	.....	.....	12	19	.....	.....
T. 52, R. 38	6	.....	.....	.....	28	.....	2	.....
T. 52, R. 39	4	.....	.....	.....	10	.....	8	.....
T. 53, R. 37	7	.....	.....	.....	20	.....	.....	.....
T. 53, R. 38	5	.....	.....	.....	14	.....	.....	.....
Total	181.5	.....	89.5	.....	675	291	53	25

SCHOOLCRAFT COUNTY.

Township.	Swamp and lake. sq. mi.	Glacial lake clay. sq. mi.	Rock knobs. sq. mi.	Lime-stone till. sq. mi.	Clayey till. sq. mi.	Sandy till. sq. mi.	Sandy. sq. mi.	Sandy gravel. sq. mi.
T. 39, R. 17 W....	2	.....	.....	7	.....	.....	.....	.....
T. 40, R. 16 W....	.....	.....	.....	.....	.....	.....	1	.....
T. 40, R. 17 W....	10	.....	.....	15	.....	.....	.....	9
T. 41, R. 13 W....	3	.....	.....	.....	.....	.....	8	.....
T. 41, R. 14 W....	2	.....	.....	.....	.....	.....	6	.....
T. 41, R. 15 W....	1	.....	.....	1	.....	.....	3	.....
T. 41, R. 16 W....	7	.....	.....	.....	.....	3	10	.....
T. 41, R. 17 W....	1	.....	.....	20	.....	.....	3	12
T. 42, R. 13 W....	24	.....	.....	11	.....	1	.....	.....
T. 42, R. 14 W....	15	.....	.....	21	.....	.....	.....	.....
T. 42, R. 15 W....	18	.....	.....	6	.....	.....	6	6
T. 42, R. 16 W....	17	.....	.....	14	.....	.....	5	.....
T. 42, R. 17 W....	10	.....	.....	10	.....	.....	.....	16
T. 43, R. 13 W....	18	.....	.....	.....	12	.....	.....	6
T. 43, R. 14 W....	24	.....	.....	.....	.....	.....	12	.....
T. 43, R. 15 W....	18	.....	.....	.....	.....	.....	12	6
T. 43, R. 16 W....	18	.....	.....	.....	.....	12	.....	6
T. 43, R. 17 W....	5	.....	.....	.....	.....	5	6	20
T. 44, R. 13 W....	14	.....	.....	.....	18	.....	4	.....
T. 44, R. 14 W....	26	.....	.....	.....	.....	.....	10	.....
T. 44, R. 15 W....	26	.....	.....	.....	.....	.....	10	.....
T. 44, R. 16 W....	26	.....	.....	.....	2	.....	8	.....
T. 44, R. 17 W....	15	.....	.....	.....	.....	6	.....	15
T. 44, R. 18 W....	10	.....	.....	.....	.....	26	.....	.....
T. 45, R. 13 W....	30	.....	.....	.....	.....	6	.....	.....
T. 45, R. 14 W....	28	.....	.....	.....	.....	.....	8	.....
T. 45, R. 15 W....	34	.....	.....	.....	.....	.....	2	.....
T. 45, R. 16 W....	29	.....	.....	.....	.....	.....	7	.....
T. 45, R. 17 W....	23	.....	.....	.....	.....	.....	5	8
T. 45, R. 18 W....	19	.....	.....	.....	.....	5	.....	12
T. 46, R. 13 W....	26	.....	.....	.....	.....	.....	10	.....
T. 46, R. 14 W....	26	.....	.....	.....	.....	5	5	.....
T. 46, R. 15 W....	18	.....	.....	.....	.....	.....	18	.....
T. 46, R. 16 W....	30	.....	.....	.....	.....	.....	6	.....
T. 47, R. 13 W....	.....	.....	.....	.....	.....	.....	36	.....
T. 47, R. 14 W....	3	.....	.....	.....	.....	5	28	.....
T. 47, R. 15 W....	9	.....	.....	.....	.....	8	19	.....
T. 47, R. 16 W....	19	.....	.....	.....	.....	8	9	.....
Total.....	604	.....	.....	105	32	90	257	116

FARM AND CROP DATA FROM THIRTEENTH CENSUS OF THE UNITED STATES.

The data given below concerning the number of farms, percentage of land area in farms (with map, Fig. 24), percentage of improved land, average value of land in each county (with map, Fig 25) and the principal crops in each county, have been obtained from the United States Thirteenth Census Report on Agriculture. It is not possible with the data at hand to indicate the percentage of each class of soil now in farms. However, the clay soils, clayey till, sandy till, and limestone till have a larger percentage of development than the lighter soils, and swamp lands have been reclaimed to only a slight extent.

TABULATED FARM AND CROP DATA FROM THIRTEENTH CENSUS.

	Alger.	Baraga.	Chippewa.	Delta.	Dickinson.	Gogebic.	Houghton.
Land area (square miles)	920	917	1,573	1,153.4	776	1,133	1,020
Number of farms	278	412	1,399	1,128	235	257	1,033
Per cent of land area in farms	5	5.9	17.5	15.1	4.7	1.8	14.4
Per cent of farm land improved	19.1	22.7	45.0	38.1	35.5	36.1	38.3
Average acres per farm	106.3	84.6	126.0	100.0	99.9	51.0	90.9
Average improved acres	20.3	22.7	56.7	38.1	35.5	18.5	34.8
Value of all farm property	$814,237	$1,145,632	$5,030,568	$3,509,854	$941,392	$852,988	$3,863,719
Cereals in 1909	$7,096	$19,015	$249,623	$121,928	$29,195	$2,697	$75,778
Other grains and seeds	$5,362	$1,995	$93,286	$46,143	$1,067	.....	$16,395
Hay and forage	$31,220	$72,890	$353,559	$207,125	$51,682	$61,182	$340,594
Vegetables	$35,350	$46,361	$89,868	$123,960	$35,266	$22,830	$166,175
Fruits and nuts	$3,964	$7,731	$9,374	$19,727	$1,534	$462	$8,786
All other crops	$33,738	$69,543	$70,873	$212,947	$34,817	$45,596	$152,926
Total crop value in 1909	$116,730	$217,535	$866,583	$731,830	$153,561	$132,767	$760,654

	Iron.	Keweenaw.	Luce.	Mackinac.	Marquette.	Menominee.	Ontonagon.	Schoolcraft.
Land area (square miles)	1,200	563	920	1,044	1,870	1,056	1,333	1,207
Number of farms	381	36	195	490	661	1,677	371	441
Per cent of land area in farms	3.8	0.8	3.5	8.7	5.7	24.8	4.5	5.9
Per cent of farm land improved	30.7	45.3	38.2	36.3	34.0	38.6	31.5	33.9
Average acres per farm	77.1	75.9	106.3	118.8	102.6	99.8	102.6	103.1
Average improved acres	23.6	34.3	40.6	43.1	34.9	38.5	32.3	35.0
Value of all farm property	$1,277,764	$95,131	$626,546	$1,345,783	$1,867,952	$5,584,532	$1,334,300	$1,200,507
Cereals in 1909	$15,154	$65	$20,806	$43,236	$30,858	$203,630	$23,711	$25,988
Other grains and seeds	$310	.....	$18,212	$80,505	$3,107	$41,186	$3,658	$47,249
Hay and forage	$89,807	$7,769	$21,120	$62,972	$39,976	$294,667	$93,808	$64,595
Vegetables	$35,821	$5,413	$27,589	$49,092	$102,080	$124,007	$34,648	$49,954
Fruits and nuts	$3,553	$887	$3,856	$7,138	$10,854	$29,051	$14,540	$11,864
All other crops	$43,415	$210	$17,128	$38,245	$126,006	$195,987	$28,252	$48,651
Total crop value in 1909	$188,060	$14,344	$108,711	$281,188	$312,881	$888,528	$198,617	$248,301

CHAPTER V.

WATER SUPPLY—UNDERGROUND WATERS.

In the area of crystalline rocks from the meridian of Marquette westward the glacial deposits alone are drawn upon to any great extent for water, the supplies in the rock formations being as a rule very limited. The glacial deposits are loose textured throughout much of this area and water is found in great abundance wherever the deposits have sufficient depth to collect it.

In the sandstone formations on the borders of Lake Superior in the western as well as in the eastern part of the Peninsula water is found in abundance and in some cases flowing wells have been obtained. Such wells are likely to be struck on the low land bordering Portage Lake and around the head of Keweenaw Bay. Few tests have been made for flowing wells since springs abound and wells can often be obtained without entering the rock.

In the Ontonagon basin south of the Keweenawan range there is a thick deposit of clay which often must be penetrated before wells can be obtained. Flowing wells have been struck in the Ontonagon valley at Ewen at a depth of about 200 feet in sandy beds under the clay. It is probable that such wells can be obtained along other branches of the Ontonagon at levels slightly above the streams. The source of supply for these wells is probably in the district to the south where a loose textured drift is present at the surface, and where the altitude is much higher than in the clay covered part of the Ontonagon basin.

For the district east of the Meridian of Marquette the writer has already published in Water Supply Paper No. 160 of the U. S. Geological Survey a special report on the flowing well districts. A map from that report is here presented showing the extent of flowing well districts and also the areas not yet tested in which there is a probability of obtaining flowing wells. (See Fig. 23)

The flowing wells are in part from glacial and lake deposits and in part from rock formations. In consequence of the dip of the strata water absorbed in the northern and central parts of this eastern end of the peninsula passes toward the basins of Lake Huron, Lake Michigan and Green Bay, and maintains sufficient head to flow at moderate elevations above these water bodies.

Fig. 23. Map of the flowing well districts of the eastern part of the Northern Peninsula of Michigan.

The most important districts with flowing wells from glacial and lake deposits are found around Pickford, and between Rudyard and Fiber. There are also flowing wells in Emerson at the mouth of Tahquamenon River, and at several points in the Tahquamenon swamp above the falls—in the vicinity of Soo Junction, Newberry and Dollarville as well as in recesses in the moraines west and south of the swamp, notably at Strong and Eckerman and south of Dollarville. The special report may be consulted for data as to depth, rate of flow, temperature of water, etc. The water is generally of excellent quality.

The flowing wells from rock are found at numerous points along the north shore of Lake Michigan and the west shore of Green Bay and the borders of Big Bay de Noc and Little Bay de Noc, where altitudes are but a few feet above lake level. The quality of water is not so uniformly good as in the flowing wells from the drift since it sometimes holds in solution minerals which render it salt or bitter or sulphurous. The deep wells are more likely than the shallow ones to have these objectionable properties. Ordinarily wells in rock if 200 feet or less in depth have palatable water suitable for domestic use.

Over the greater part of the eastern half of the peninsula flowing wells can not be obtained, the altitude being too high. But it is not difficult to obtain good supplies of water at moderate depths. The driven wells are seldom more than 150 feet and many are 100 feet or less, while excavated wells are generally 50 feet or less.

The water is distributed so irregularly in the glacial and lake deposits, owing to their complexity and variety in constitution, that neighboring wells often vary greatly in depth and one can seldom forecast the depth necessary to obtain a well.

PUBLIC WATER SUPPLIES.

The following data concerning public water supplies of the Northern Peninsula were collected in 1906 and first published in Water Supply Paper No. 160 of the U. S. Geological Survey. In some cases the data may need revision.

MUNICIPAL AND INSTITUTIONAL WATER SUPPLIES.

Town.	Ownership.	Source.	System.	Remarks.
Atlantic mine	P.	Creek and well		Partial domestic supply from well.
Baraga	P.	Keweenaw Bay		
Bay Mills	P.?	Whitefish Bay	T.	
Beacon	M.?	?		Hydrants for fire.
Bessemer	M.	Springs and impounded water		Springs for domestic use.
Blaney	P.	Creek		Operated by lumber company.
Crystal Falls	M.	Impounded water		
Dollar Bay	P.			Partial distribution for employees of Mining Co.
Escanaba	P.	Little Bay de Noc	D.	
Ewen	M.	Flowing wells		Partial system.
Garden	M.	Rock wells, 104-220 ft.		Partial system.
Gladstone	M.	Little Bay de Noc	D.	
Grand Marais	M.	Lake Superior	D.	
Hancock	M.	Filter gallery	R.	Manual American Waterworks.
Houghton	M.	Springs	R.	Reservoirs, high pressure and low pressure.
Iron Mountain	P.	Infiltration wells	R.	The wells are developed springs.
Iron River	M.	Iron River		
Ironwood	P.	Montreal River	T.	Manual American Waterworks.
Ishpeming	M.	Small lake	G. and D.	Manual American Waterworks.
Lake Linden	M.	Well and creek	D.	Manual American Waterworks.
L'Anse	M.	Spring fed creek	G.	Manual American Waterworks.
Laurium and Red Jacket	P.	Lake Superior	D.	Manual American Waterworks.
Mackinac Island	P.	Lake Huron	R.	
Manistique	M.	Indian Lake	G. and D.	Runs to reservoir in city.
Marquette	M.	Lake Superior	D.	High parts of city have private tanks.
State prison	St.	Small stream		
Menominee	P.	Green Bay	D.	Manual American Waterworks.
Munising	M.	Springs and Lake Superior	T.	Lake Superior for emergency.
Negaunee	M.	Teal Lake	D.	Manual American Waterworks.
Newberry	M.	Tubular wells	D.	
State asylum	St.	Tubular wells	T.	
Norway	M.	Impounded water	R. and D.	Manual American Waterworks.
Ontonagon	M.	Lake Superior	T.	Manual American Waterworks.
Palmer	P.	Springs and wells	Wm.	Partial system.
Quinnesec	M.	Mine water		Chiefly fire protection.
Rapid River and Masonville	M.	Rock wells, 275 feet	D.	Fire hydrants on flowing wells.
Republic	M.	Springs and lake		Installed in 1906.
Rockland	P.	Springs	Wm.	Partial system.
St. Ignace	M.	Lake Huron	T.	
Sault Ste. Marie	M.	Whitefish Bay	T.	Base of tank 114 feet above Lake Superior.
Stambaugh	M.	Iron River	D.	Manual American Waterworks.
Vulcan		Impounded water		Supplied from Norway.
Wakefield	M.	Sandy Lake		Fire protection.

a. Abbreviations under ownership as follows: P.—Private; M.—Municipal; St.—State.
b. Abbreviations under system as follows: T.—Tank or standpipe; R.—Open reservoir; G.—Gravity; D.—Direct pressure; Wm.—Windmill.

PART II. THE SOUTHERN PENINSULA.

CHAPTER I.

PHYSIOGRAPHY OF THE SOUTHERN PENINSULA.

GENERAL GEOLOGICAL FEATURES AND GEOLOGIC TERMS.

In the Southern Peninsula of Michigan the rock formations present less variety of features than in the Northern Peninsula, and are much less open to view, because of the greater thickness of the glacial deposits. None of the rock formations in the Southern Peninsula have been subjected to such upheaval and folding as characterize the formations in the western part of the Northern Peninsula. They all lie in nearly horizontal position with a gentle dip toward the center of the peninsula. The beds of shale, sandstone, and limestone which outcrop in the eastern part of the Northern Peninsula, also dip toward the center of the Southern Peninsula, and pass beneath the beds which form the surface of that peninsula.

The rock formations of the Southern Peninsula range in age from the upper part of the Silurian, through the Devonian, to the lower part of the Carboniferous, and consist of a series of limestone, shale, and sandstone beds with which are associated deposits of coal, gypsum, and salt, each in its own particular horizons. The arrangement of the several formations has been likened to the piling up of plates or saucers in a series of diminishing size, and diminishing amount of dishing, from bottom to top. The uppermost and youngest formation though resting on those which precede it in age does not stand above some of their outlying parts.

The highest bed rock surface in the Southern Peninsula is found in the area of outcrop of the Marshall sandstone of early Carboniferous age in Hillsdale and neighboring parts of Jackson and Calhoun counties,[1] where an altitude of 1,000 to 1,100 feet is reached. The lowest altitude of the rock surface is on the borders of Lake Michigan, in the vicinity of Manistee and Ludington, where it falls below sea level. It is in the area where shales of late Devonian, and of early Carboniferous age, form the uppermost beds of rock. In the midst of Lake Michigan immediately west from there, the rock surface, over an area 30 miles in length

[1] See Plate VI, Annual Report, 1907.

and 2 to 8 miles in width, has an altitude more than 300 feet below sea level. There is thus a range of about 1,400 feet in the altitude of the bed rock of this region.

There are, in the Southern Peninsula, two large areas in which the rock surface has a marked relief above bordering districts. One of these, in the southern part of the state, extends from near Kalamazoo and Coldwater northeastward to the terminus of the "Thumb" of Michigan, which lies between Saginaw Bay and the southern part of Lake Huron. From an altitude of 1,100 feet in northern Hillsdale county it drops off somewhat rapidly to about 900 feet in central Jackson county, and then more gradually to 700 feet or less at the end of the "Thumb." There is also a rapid decrease in altitude southward in Hillsdale county, and adjacent parts of Indiana and Ohio, to an altitude of only 600 feet, and this low altitude of the rock surface is maintained over much of northwestern Ohio and northern Indiana.

The other area with relatively high rock surface is found in the northern part of the peninsula, north of latitude 44°. That region is so heavily covered with drift that few borings have reached the rock. These indicate that the rock surface may not reach an altitude of more than 250 feet above Lakes Michigan and Huron, or but little more than 800 feet above the sea. In southern Cheboygan and southwestern Presque Isle counties the rock is either exposed, or struck in borings, at an altitude about 800 feet above sea level, and no borings in neighboring districts to the south have reached it at a higher altiture. From this relatively high rock area there is but little descent to the northeast and east until one reaches the immediate border of Lake Huron. There is also comparatively little descent in passing westward to Lake Michigan over the district immediately south of Little Traverse Bay. But from the vicinity of Bellaire southward there is a very low rock surface for some distance inland from the Lake Michigan shore, portions of it being about at sea level. The altitude is also very low in a strip running westward through the center of the peninsula from the southern end of Saginaw Bay to Lake Michigan, the general altitude of the rock surface being only 300 to 500 feet. This low area lies about midway between the two relatively high areas just noted, and there is a gradual rise from it toward these areas. In the southwestern and the southeastern parts of the peninsula, there are extensive areas with an altitude about 500 to 600 feet above sea level.

From preceding statements it appears that the relations of the

rock surface to the level of Lakes Huron and Michigan are such that, were the drift removed, and these lakes held at their present level, there would be two large islands within the area of the present peninsula; one 100 to 250 feet above the lake, lying north of latitude 44° and occupying perhaps half the present land surface north of that parallel, the other in the southeastern part, with an altitude 100 to 500 feet above the lake. The latter area would be bordered by broad stretches of very shallow water, interspersed perhaps with low islands in the district adjacent to Lakes Erie and St. Clair, and across the northern part of Indiana and northwestern Ohio and the southwestern part of Michigan. There would be relatively deep water in what is now the central part of the peninsula from Saginaw Bay westward, and exceptionally deep water on the western side of the northern island from the head of Grand Traverse Bay to Ludington.

A series of planimeter measurements made by Mr. W. F. Cooper from a map of bed rock contours prepared by Dr. A. C. Lane[1] show the average elevation of the rock surface to be about 554 feet above the sea. It thus appears that if the drift were removed, and the rock brought to a uniform level, its surface would stand about 25 feet lower than Lakes Huron and Michigan. No doubt the preglacial drainage had developed valleys which greatly dissected the rock surface. Where the drift is thin as in Hillsdale, Jackson and Calhoun counties the courses of some of the valleys are still visible for they were not filled to the level of their rock bluffs. In other places where the rock is concealed by drift, borings have thrown some light on the position of deep valleys. This is especially true of the district west from the head of Saginaw Bay, where borings indicate the presence of a valley in the rock along a line leading from near Bay City to Alma. This drainage line apparently was discharging westward, or in the reverse direction from the present drainage, for the rock bottom at Alma is lower than at any place to the east, being 350 feet below the level of Saginaw Bay, or only 230 feet above the sea. It seems probable that this valley continued westward into Newaygo county, and thence northwestward to the part of the Michigan shore near Ludington in which the rock surface is below sea level. A valley with rock bottom only 400 feet above sea level, was struck in a boring at Saranac, a few miles west of Ionia, which may be a southern tributary of the one leading westward from Alma. There are some indications from borings, that a valley came to the present St. Clair valley from the northwest a few miles

[1]See Plate VI, Annual Report, 1907

south of Port Huron, whose rock bottom at the crossing of the St. Clair River is about 200 feet below the present stream, or less than 400 feet above the sea. But aside from these few instances of deep valleys struck by borings, very little has been obtained to show the distribution of the preglacial valleys and direction of drainage. In fully nine-tenths of the state practically nothing is known concerning the old drainage.

The fact that the rock surface in part of the western side of the peninsula is below sea level is rather surprising, but perhaps no more so than that the neighboring part of the bed of Lake Michigan has a small area that is more than 300 feet below that datum. It is evident that considerable change in level of the rock surface has been effected here, either by ice erosion, or by depression of the earth, since the time when this region had a discharge to the ocean.

The glacial drift, which covers so deeply much of the rock surface of the Southern Peninsula, consists of a more or less commingled mass of boulders and small stones in a sandy or clayey matrix, though it differs greatly in constitution and in texture from place to place. It was brought in largely, if not wholly, by an ice sheet or continental glacier which moved *southwestward* from the highlands of Canada across the several Great Lakes basins, carrying in it the earthy and stony material gathered from the loose surface material of the districts over which it was moving. The Canadian highlands were thus extensively denuded of soil and subsoil, while the district south of the Great Lakes was correspondingly enriched by the glacial action. As indicated below, the average thickness of the drift in the Southern Peninsula is about 300 feet. There are places near the border of Lake Michigan where the drift is known to exceed 600 feet. Places in the high interior of the north part of the peninsula may have over 1,000 feet.

There is evidence that the drift of this peninsula like that of the northern is not the product of a single ice invasion, but instead, of two or more invasions, between which were long periods of warm climate such as prevails today. Between the deposits of glacial material are soils, and peat beds, and other indications of the presence of vegetation such as would thrive under a genial climate.

The moraines or belts of rolling or hummocky surfaced drift form the most conspicuous features of the Southern Peninsula. These belts have been followed in some cases for scores and even hundreds of miles in their broad sweep around the Erie-Huron, Saginaw, and Lake Michigan basins. They were formed at places where the edge of the ice held a nearly constant position for a long period,

and, by a continual advance to this line, brought in the material which furnished the irregular surfaced moraines. The map of the surface formations (Plate VII) represents the moraines of this peninsula and these will be discussed more fully farther on.

While the ice was forming a given moraine, the water escaping from it spread out broad plains of sand and gravel on ground immediately outside over which the water escaped. These plains known as *outwash aprons* are notably prominent features of the Southern Peninsula. There are other sandy plains less definitely related to the ice border, to which a special symbol has been applied in the glacial map. These were probably formed in some cases as an outwash during rapid recession of the ice from one moraine to another. In other cases the sandy deposits may have been made under the margin of the ice. In all cases they indicate the influence of water. It is perhaps more remarkable that in the course of melting, the ice over large areas, failed to make such deposits, than that they should occur to the extent shown on the glacial map.

Over wide areas lying between moraines, there are till plains with boulder clay at the surface, and with scarcely any coating of sandy material such as might be left along the receding ice border. Their extent is set forth on the glacial map. They are exceptionally broad in the district southwest of Saginaw Bay.

On portions of the till plains, in restricted areas, *drumlins*, or small oval to elliptical hills of boulder clay, are found, whose longer axis corresponds in trend to the general direction of ice movement. They are especially numerous in the Grand Traverse region, and show a divergence in trend to conform to the ice movement.

On certain other till plains, and also to some extent among the drumlins, *eskers*, or sharp ridges of gravel and sand, are found. They also have a trend conformable to the direction of the movement of the ice. They are so sharp as to be popularly classed as "hog backs" and are often as steep as the ordinary railroad embankments. They usually stand 20 to 40 feet or more above the bordering plains, and have lengths of several miles, thus constituting striking and puzzling features. The sustaining walls of the ice which confined the gravel deposition to narrow tunnels, as pointed out by the late I. C. Russell, having now disappeared, one must in imagination restore it, to reach a satisfactory understanding of the mode of development of these ridges. As discovered by Russell in his Alaskan studies, streams running in tunnels at or near the base of the ice sheet became in time clogged up with the gravel and sand which they were carrying. Upon the melting of the ice

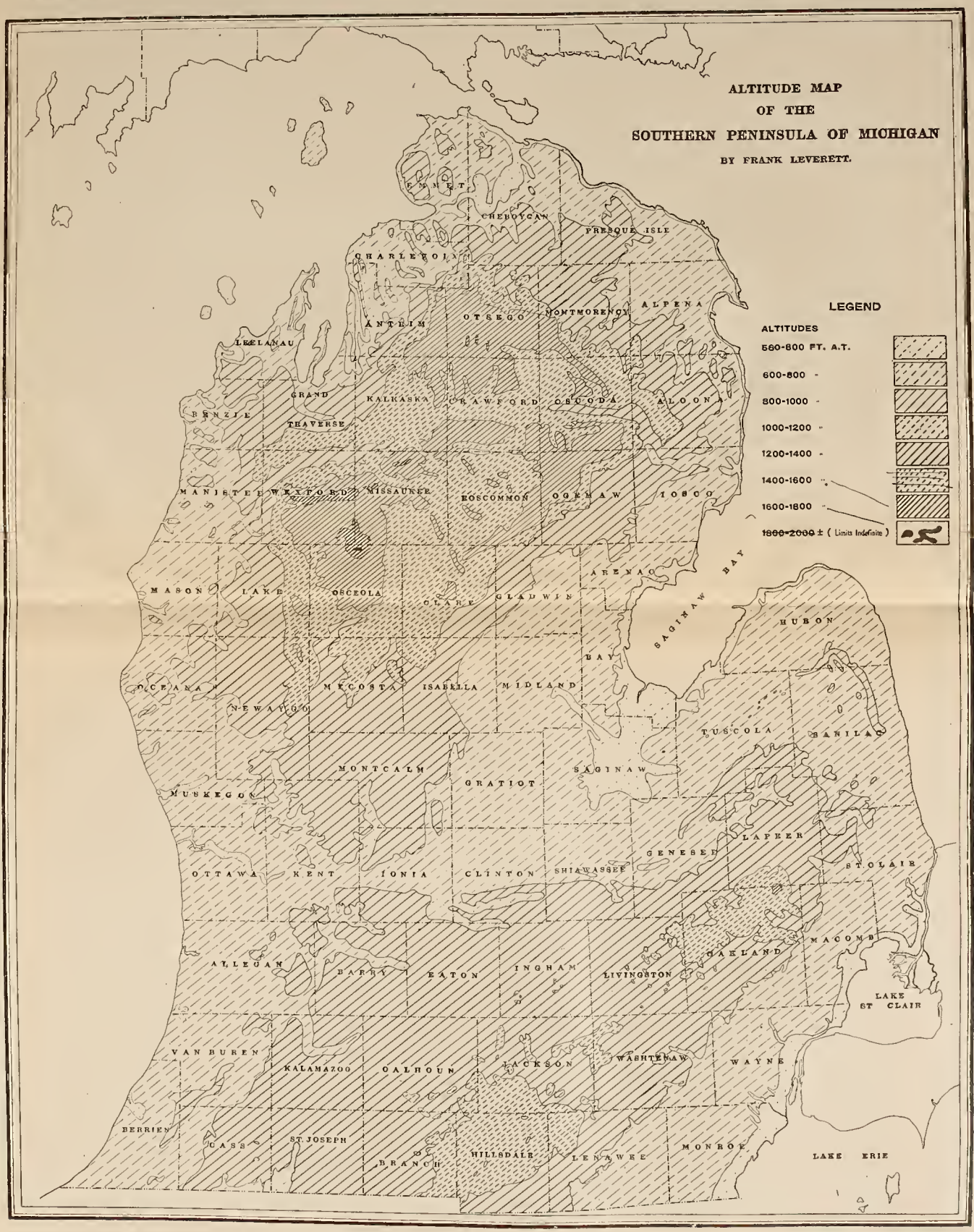
in Michigan the deposits came to be left as ridges of dimensions corresponding to the size of the tunnels. The Mason and Rives eskers south of Lansing, and numerous others in the district south of Saginaw Bay, form the most conspicuous instances in the Southern Peninsula, but they are scattered widely over the state. Sharp gravel hills or *kames* also abound throughout the state. (Plate IX A.) They often appear in groups at the terminus of an esker, as well as in other situations.

ALTITUDE.

The altitude map (Plate VIII) brings out the essential features of altitude and relief of this drift covered region. It is based on a more elaborate map with 100-foot contours published in Water Supply Paper No. 182, U. S. Geological Survey, Plate II.

It appears that the highest part of this peninsula lies a few miles southeast of Cadillac near the corners of Wexford, Massaukee and Osceola counties. There are two hills in the edge of Osceola county, about 1½ miles south of the county corners, that by aneroid measurement rise above 1,700 feet, and an area of perhaps 2 square miles stands above 1,600 feet. An area of only 60 square miles, or about one-seventh of one per cent of the peninsula, stands above 1,400 feet. This is mainly embraced in the three counties just mentioned but includes small areas in Otsego county both north and south of Gaylord. The areas standing above 1,200 feet amount to only about 1,500 square miles or 3.66 per cent of the peninsula, and are found chiefly in the northern half and very largely in five countnes, Osceola, Wexford, Missaukee, Crawford, and Otsego. There are only very small areas, amounting to less than 5 square miles, in the southern part of the peninsula, chiefly in Hillsdale county, and in northern Oakland county. It thus appears that about 96 per cent of the peninsula falls between 1,200 feet and the level of Lakes Michigan and Huron, 580 feet. Of this about one-half falls below 800 feet, and one-third between 800 and 1,000 feet, thus leaving only one-sixth of the area above 1,000 feet, and that is very largely in the northern half of the peninsula. The average altitude of the peninsula is estimated to be about 835 feet.

It is noteworthy that the range in altitude of the present surface and of the bedrock surface, within the limits of this peninsula, are practically the same, being about 1,100 feet. But it should also be noted that the highest bed rock surface does not appear to be responsible for the highest altitude of the present surface. The



ALTITUDE MAP OF THE SOUTHERN PENINSULA.

bed rock in the high area southeast of Cadillac in all probability is 1,000 feet lower than the highest points in that area, or about 700 feet above the sea. In Hillsdale and Jackson counties where the rock surface attains its highest altitude there is in places only a thin veneer of drift, and the rock surface is thus responsible for the high altitude, though on Bunday Hill, the highest point in that region (1,284 feet), there is probably nearly 200 feet of drift. The prominent tract leading from Hillsdale county northeastward to the end of the "Thumb" also owes its prominence to high rock surface. The exceptionally high tract on the line of Lapeer and Oakland county, which in one place rises, by aneroid measurement, above 1,300 feet, does not seem to overlie a correspondingly high rock surface, but instead, if we may judge by a neighboring boring at Orion, the rock surface is nearly 500 feet below this point, or similar to its altitude in neighboring lower districts.

So far as low areas are concerned, there is only a general correspondence between the drift surface and the rock surface. The low tract leading from Saginaw Bay to Grand River, which as shown below was an outlet for glacial lake waters, lies some 20 miles or more south of the axis of the low rock area that extends from Saginaw Bay, westward to Lake Michigan.

DRAINAGE SYSTEMS.

The drainage of the Southern Peninsula is almost equally divided between west-flowing streams that enter Lake Michigan, and east-flowing streams that enter the Huron and Erie basins. The Michigan basin is estimated to receive the drainage of 20,500 square miles, while the basins on the east receive the drainage of 20,952 square miles. The line separating the western from the eastern drainage departs considerably from a median N-S line though running the entire length of the peninsula. Near Big Rapids it is considerably west of the middle longitude, while near Howell it is considerably east of it. The great indentation made in the peninsula by Saginaw Bay would cause the central line of the state to pass considerably west of its middle longitude, and there is no great departure along the drainage divide from this central line. It passes considerably east of the highest land in the peninsula, that being all drained to Lake Michigan.

Of the several river systems only two of importance have any drainage area outside the peninsula, namely the two St. Joseph rivers, tributary, the one to Lake Michigan, and the other to the Maumee and Lake Erie.

The largest river system, that of the Saginaw and its tributaries, embraces an area of about 6,250 square miles, or nearly one-third of the eastern drainage. It is a very widely branching system encircling Saginaw Bay, and is peculiar in having its mouth near its geographic center, because of the great indentation of Saginaw Bay. The Saginaw drainage system combines several rivers, which, during the existence of a higher stage of water in the Saginaw basin (explained below), were independent streams. In their lower courses all these streams traverse the old lake bed and become united just before entering Saginaw Bay.

Grand river is second in size, with a drainage area of about 5,600 square miles, tributary to Lake Michigan, at Grand Haven. Much of the thickly inhabited portion of the western part of the peninsula lies within its area.

The next river system in size, St. Joseph river of the Lake Michigan drainage, embraces the southwestern part of the state. It has only about 2,900 square miles of drainage area in Michigan, there being nearly 1,700 square miles of its watershed in Indiana. The drainage area of Pawpaw river, over 400 square miles, is included in the above estimate, though the stream is really independent, for it joins the St. Joseph at Lake Michigan level and within a mile of its mouth.

Other drainage systems are much smaller. The area of the Muskegon watershed is 2,700 square miles, while the Kalamazoo, Manistee and AuSable have each about 1,000 square miles, the Cheboygan, 1,600; Thunder Bay river, 1,275; Raisin river, 1,125, and Huron river, 1,050 square miles. All other streams have each less than 1,000 square miles of watershed.

The sources of the main streams are in the high interior portions of the state. Several head near together in the elevated tract in the southern part, near the line of Jackson and Hillsdale counties. This embraces the sources of Grand, Kalamazoo, and St. Joseph rivers of the Lake Michigan drainage, and Raisin and St. Joseph rivers of the Lake Erie drainage.

The elevated tract forming the "Thumb" of Michigan, is the source of several of the large eastern tributaries of the Saginaw river drainage, as well as of Grand river. It is also the source of the main streams tributary to the St. Clair and Lake Erie basins, and Detroit river. The northwest portion of the Saginaw drainage system finds sources in the elevated tract of the northern part of the peninsula. In this tract also head important tributaries of lake Huron north of Saginaw Bay, the AuSable, Thunder Bay, and

Cheboygan rivers. Only two large tributaries of Lake Michigan head in the area, the Muskegon and Manistee rivers.

WATER POWER.

The sources of the several streams that head near the line of Hillsdale and Jackson counties (Grand, Kalamazoo, St. Joseph, St. Joseph of the Maumee, and Raisin river) are about 1,100 feet above the sea, or fully 500 feet above Lakes Michigan and Erie. Their courses are very largely over glacial deposits, rock being encountered at but few places. They all descend to the lakes without cascades or falls, though each has rapids that justify some development for water power.

The sources of rivers that flow from the highlands or plateau in the northern part of the peninsula are at altitudes of 1,200 to 1,300 feet, thus giving a descent of 600 to 700 feet to the lakes. Those flowing to Lake Huron and Saginaw Bay, however, descend 300 feet or more, or to about 900 or 1,000 feet, as small streams, intermittent, or with weak flow, before combining to form perennial streams. The real fall available for water power is, therefore, only 300 to 400 feet. Tho two large tributaries of Lake Michigan, Manistee and Muskegon rivers, descend gradually their entire lengths, and have about 600 feet fall. There are occasional rapids along them available for water power.

There is a great difference among the several drainage systems in their possibilities for water power development. Some are so concentrated in their middle and upper courses that they furnish a large flow with heavy fall through the lower course, which in some cases is rendered steady by the presence of numerous lakes at the headwaters. Others remain as independent branches nearly to their mouths and thus have little value as a combined stream. The first class is well illustrated by the Huron river which has its upper course thickly set with lakes and which gathers the major part of its tributary drainage at Dexter some 9 miles above Ann Arbor, and then has a fall of nearly 250 feet to its mouth. The second class is illustrated especially well by Saginaw river, and nearly as well by Thunder Bay river. The junction of the several tributaries of Saginaw river near the city of Saginaw is practically at Lake Huron level. The branches of Thunder Bay river unite above Alpena at sufficient height to give a fall of a few feet which is developed at that city. Drainage systems in which lakes are numerous in the head water portion are the rule rather than the exception in this state as may be seen by reference to the surface geology map

(Plate VII). There are also several large lakes near the mouths of rivers and on intervening lowlands along the north half of the east shore of Lake Michigan and in the Cheboygan drainage. They are so nearly down to the level of Lakes Michigan and Huron that they are of but slight advantage for water power.

CHAPTER II.

GLACIAL FEATURES.

FEATURES DUE TO EARLY STAGES OF GLACIATION.

As already indicated, the glacial deposits furnish evidences of repeated glaciations, between which were long periods in which the glaciated districts were free from ice. Michigan has not so varied lines of evidence as certain states farther south, notably Iowa, Illinois and Indiana, in support of the diversity of the glacial period. There are, however, clear evidences, in this state, such as buried soils and peat beds, between the drift sheets, and weathered and indurated glacial deposits, beneath fresh and unindurated ones. The amount of weathering and cementation, or induration, of the older drift, that occurred before the deposition of the younger, measures the length of time that must have elapsed between the glaciations. It is found to be much greater than the surface weathering and alteration in the uppermost or youngest drift. In districts farther south, where the older drift extends outside the limits of the younger, there is opportunity to study relative amounts of erosion, as well as of weathering, and to see much wider exposures of the older drift than can be found inside the limits of the younger drift. It is there found that erosion is several times as great on the older drift as it is on the younger.

In Michigan the differences in the hardness of the older and younger drift is so great that many well drillers have come to recognize the differences, and to apply the name hardpan to the older and harder deposit. In places the younger drift covers it to a depth of 100 feet, but more frequently it is buried to a depth of less than 50 feet. On the coast of Lake Huron, between Port Huron and the point of the "Thumb," there are places where the older drift forms part of the lake bluff, as shown in Plate X. The induration is so great that some of the small streams cascade over the hard beds of old drift at their mouths. There are other exposures of old drift along streams in the southeastern part of the state.

Near Avoca, St. Clair county, on a tributary of Black river, a

black soil and peaty bed lies between the old drift and the overlying young drift. A similar exposure was found near East Fremont, Sanilac county. (Plate XI B.) A buried soil between two glacial drifts has been occasionally struck in wells in Michigan, but such a soil seems to be less widely preserved than in Indiana and Illinois. An area of several square miles, however, is found in Hillsdale county, a few miles southeast of Hillsdale, in which the deep wells in many cases pass through a buried soil between the drift sheets. Another such area was found in Allegan county, a few miles southeast of Allegan, and a third in Oceana county, in a flowing well district west of Shelby.

The older drift deposits not only form the main filling in the old valleys and lowlands, but they have been in places heaped up into prominent ridges. Some of the large morainic ridges of the southeastern part of the state consist largely of the old drift, over which the younger drift has formed a veneer, ranging from a few feet up to 100 feet or more. The preglacial topography seems to have been such as to produce a lobation in the earlier glaciation, somewhat similar to that known to have occurred in the later. There was apparently a Saginaw lobe and a Huron-Erie lobe, separated by the elevated "Thumb" of Michigan, just as in the later glaciation. The elevated plateau-like accumulation of glacial material in the northern part of the peninsula, in all probability, was largely formed in an early stage of glaciation, as suggested by F. B. Taylor in an unpublished paper presented in 1910 before the Geological Society of America. The ice currents seem to have converged toward this area from the northwest, the northeast, and the southeast in one of the early stages of glaciation, just as they are known to have done in the latest stage, and it would be but natural that a large amount of drift should accumulate there. The presence of such a mass of drift as a buttress in the path of the later glaciation, may account for the manner in which sub lobes and finger-like extensions of ice were developed on the edge of the peninsula, between the lakes and this plateau.

There are found clear evidences of four distinct glaciations, known as the pre-Kansan or Nebraskan, the Kansan, the Illinoian, and the Wisconsin, each named from geographic localities in which it has most characteristic development.

The pre-Kansan and Kansan drifts are well defined and extensive deposits in the region west of the Mississippi river. The fact that copper is present in this peninsula, and southeastward from it in western Ohio, seems best explained as the result of a southward ice

movement from the Lake Superior region. Such a movement is not easily referred either to the Illinoian or the Wisconsin glaciation, for each of these glaciations was by a southwestward ice movement into this region from the highlands east and south of Hudson Bay, by which only the Lake Michigan basin would seem likely to have received ice from the direction of copper bearing formations in the Superior basin. In the two earlier stages, glaciation seems to have been more vigorous in the central part of Canada than in the eastern, and it may have extended southeastward from the Superior basin through the Huron into Ohio, and thus carried the copper and associated rocks into that state. The main body of drift in Michigan seems, however, to have been deposited in the Illinoian and Wisconsin stages of glaciation. The old moraines in the southeastern part of the state, and the old drift exposed in stream bluffs and along the shore of Lake Huron, appear to be of Illinoian age, and to have been brought in from the northeast rather than from the direction of Lake Superior. The great accumulation of drift in the northern part of the peninsula seems also best explained as a result of the converging ice currents from the northeastern field in the Illinoian stage of glaciation.

The rock striations in the southeastern part of the state all seem referable to the movement from the northeast. In the northern part of the peninsula are striae bearing southeastward, but these seem better explained as the result of a local deflection of ice currents in the closing part of the last or Wisconsin glaciation than as the product of a pre-Illinoian glaciation. The case is not similar to that noted at Calumet, and discussed in the Northern Peninsula report. There the southeastward bearing striae are preserved only on the northwest face of a sloping rock surface, where the later movement from the east could not touch them. They seem likely, therefore, to pertain to an early movement, probably Kansan if not pre-Kansan. But the exposures of striated ledges in the north part of the Southern Peninsula are such as to be in the line of attack of ice from the northeast. So their preservation seems best explained as the result of a local deflection of the latest glaciation.

MORAINES AND THEIR OUTWASH.

The moraines as shown by the glacial map are related to several rather distinct ice lobes which varied greatly in outline from time to time. Those on the western side of the peninsula pertain to an ice lobe in the Lake Michigan basin which at certain times in the earlier and later part of the ice invasion had small projections,

or sub-lobes, in Grand Traverse Bay, and in Little Traverse Bay, and the lakes along the northern part of the east coast of Lake Michigan. The moraines on the eastern side are especially well developed on the borders of a lobe that extended southwestward from Saginaw Bay. Moraines farther south on the eastern slope of the "Thumb" pertain to a lobe, known as the Huron-Erie, that covered the southern part of Lake Huron, the basin of Lake Erie, and the intervening Ontario peninsula. Those north of Saginaw Bay in certain early and late stages of the ice invasion had small sub-lobes, like those in the bays and lakes on the east coast of Lake Michigan, that extended southward and southwestward to the elevated plateau lying northwest of Saginaw Bay.

The moraines show several successive positions of the ice border formed at halting places or in some cases at positions of readvance in the final stage of ice melting. When the ice had its greatest extent, and its border was far to the south in Ohio, Indiana, and Illinois, the lobes just noted were all merged together into a single great ice field. The lobes were a conspicuous feature only at particular stages in the oncoming of the ice and in its disappearance. The small sub-lobes of the northern part of the peninsula apparently preceded the large Lake Michigan and Saginaw Bay lobes to the south in being merged into a confluent ice mass, and were not differentiated in the final stage of melting until a somewhat later time than these larger lobes.

On the outer border of many of the moraines are found extensive plains of sand and gravel, formed as an outwash from the ice border during the development of the adjacent moraines. These plains extend out to valleys which offered lines of discharge from the waters of the melting ice sheet through the country from which the ice had disappeared. These outwash plains and lines of glacial drainage form as interesting a field of study as the moraines themselves, for there were remarkable shiftings in the discharge of the waters, due to the opening of outlets which in the earlier part of the ice melting had been covered and blocked by the ice sheet.

Outermost moraines in Michigan. An inspection of the moraines and outwash plains, shown on the glacial map, will make clear the recession of the ice in the last or Wisconsin glacial stage. The earliest part of this peninsula to become free from the Wisconsin ice sheet lies just west of the place where St. Joseph river passes into Indiana. The outermost moraines in this state are those of eastern Cass and southern St. Joseph counties, east of Cassopolis and south of Centerville. They were formed chiefly by ice moving southwest-

ward from the Saginaw basin, but their western ends seem to have been covered by the Lake Michigan ice lobe.

After forming these moraines, the ice border seems to have melted back somewhat rapidly northeastward, to a system of moraines that lies south of Kalamazoo river, in eastern Kalamazoo and southern Calhoun and northeastern Branch counties. This morainic system also was formed chiefly by the Saginaw lobe, but the portion trending southwest in eastern Kalamazoo county seems to have been covered and formed by the Lake Michigan ice lobe, while moraines in southeastern Branch county, which also trend southwest, are referred to the Huron-Erie ice lobe. At the time this system of moraines was forming, the escaping glacial waters were flowing through and forming the long strips of sandy land leading southwestward from southern Calhoun county across Branch and St. Joseph counties into Indiana.

Kalamazoo-Mississinawa Morainic System. The next position of halting of the ice border is marked by one of the strongest morainic systems in the state, known as the Kalamazoo-Mississinawa system. A double moraine leading southwestward from southern Barry county between Kalamazoo and Lawton and passing just west of Cassopolis and Edwardsburg was formed by the Lake Michigan ice lobe and is known as the Kalamazoo morainic system. A continuation of the same morainic system but formed by the Saginaw lobe leads southeastward across southern Barry, northeastern Calhoun and southwestern Jackson county, into connection with a system trending southwestward across Hillsdale county, which was formed by the Huron-Erie ice lobe and is known as the Mississinawa system. From this system of moraines an interesting network of glacial drainage lines leads westward and southwestward from Hillsdale and Jackson counties across Branch and Calhoun into St. Joseph county, and also southward from Barry across Kalamazoo county near the edge of the Lake Michigan lobe.

Valparaiso-Charlotte Morainic System. From the Kalamazoo morainic system the ice border receded slightly westward to the Valparaiso morainic system, which encircles the head of Lake Michigan a short distance outside the present limits of the lake, and which receives its name from Valparaiso, Indiana. It receded slightly northeastward toward the Saginaw basin into northeastern Barry county and the edge of Eaton, Ingham and Livingston counties, and there formed what has been termed the Charlotte morainic system. Its position in the Huron-Erie lobe was shifted but slightly to the southeast in Hillsdale county and neighboring parts of Lenawee, Jackson, and Washtenaw county.

The drainage conditions were, however, materially altered by the slight recession of the ice border. The ice border for a considerable portion of its course in Michigan was now shrinking to lower levels and the escaping waters instead of flowing directly away were held for long distances between the ice border and the outlying Kalamazoo morainic system. The drainage on the edge of the Saginaw lobe was westward at first to Charlotte, and thence down Battle Creek through the Kalamazoo moraine to the Kalamazoo valley. This it then followed westward past Kalamazoo and back to the inner edge of the Kalamazoo morainic system near Plainwell. From this place it followed the edge of the Lake Michigan lobe southwestward past Niles into Indiana, much of its course being a narrow lake called Lake Dowagiac. Somewhat later the drainage on the edge of the Saginaw lobe followed Thornapple valley past Hastings to Middleville, and there turned down Gun river to Plainwell. The drainage from the Huron-Erie lobe seems also to have followed somewhat closely along the edge of the ice southwestward into northeastern Indiana.

The Series of Slender Moraines. Following the development of the Valparaiso-Charlotte morainic system comes a series of slender moraines, formed apparently in close succession, by each of the three great lobes. The Lake Michigan series is known as the Lake Border morainic system, for it lies close to the lake border not only in southwestern Michigan but also in northwestern Indiana, northeastern Illinois and southeastern Wisconsin. The series in the Saginaw basin is exceptionally full, there being no less than ten members of sufficient strength and continuity to be traced for considerable distances. They are distributed over a tract nearly 50 miles wide at the southwest end of the Saginaw lobe, and show with exceptional clearness how that ice lobe shrank toward the limits of Saginaw Bay. The corresponding moraines of the Huron-Erie lobe are irregular and disjointed and in places weak, so that the recession of the ice into the Erie basin is not well shown in southeastern Michigan. It is, however, clearly shown in neighboring parts of Indiana and Ohio near the axis of the lobe. In the course of the development of these moraines the ice vacated a large part of the Southern Peninsula, and exposed the high tableland northwest of Saginaw Bay, as well as low tracts bordering the Bay. On the borders of this tableland, however, this series is massed into a single large moraine.

The glacial drainage in connection with the series of moraines of the Lake Border morainic system and its correlatives is exception-

ally interesting in the amount of shifting shown, and in the adjustment to the ice border and the outlying topographic conditions.

The drainage from the southern end of the Lake Michigan lobe, and eventually from much of that lobe, was through a lake at the head of the present Lake Michigan, known as Lake Chicago, and thence southwestward to the Illinois and Mississippi, through what has been termed the Chicago outlet. Drainage from the Wisconsin side as well as the Michigan side was southward along the edge of the ice lobe. The courses of drainage were, however, shifted two or more times to positions nearer the edge of Lake Michigan to courses along successive moraines.

The same conditions prevailed at the end of the Saginaw lobe, the waters in the later stages being all brought to Grand river from the western and southern edge of the ice lobe in a succession of courses controlled by moraines that follow one another in narrower and narrower circuits in the Saginaw basin. In the earlier stages there was considerable complexity which we will attempt to briefly outline.

Glacial Drainage Between the Saginaw and Michigan Lobes. As the Lake Michigan and Saginaw Bay lobes became separated in the district north of Grand Rapids, a line of glacial drainage was developed between the ice lobes, which at first had its head near the junction of Little Muskegon with the Muskegon river east of Newaygo. The glacial drainage from the Saginaw lobe was then lengthened northward, first along Muskegon river, and later along Little Muskegon river, while that from the Michigan lobe was forming the great outwash plain west of Cadillac and a plexus of gravel plains in Newaygo and Lake counties. Then for some time the Muskegon valley served as a line of discharge for waters that came in from the Saginaw lobe near the sources of the present Muskegon and of the south branch of the AuSable river in Roscommon county. The Manistee valley served as the line of discharge for waters from the Lake Michigan lobe as they entered its headwaters and the headwaters of AuSable river. From the bend of the Manistee river in southeastern Manistee county the waters continued southward through the plexus of gravel plains in Lake, Newaygo, and Oceana counties to enter Lake Chicago in Muskegon county. As the Saginaw lobe shrank away from the great morainic belt of Clare, Roscommon, and Ogemaw counties and formed the slender moraines that lie between it and Saginaw Bay the glacial drainage kept close to the ice border and discharged southward to Grand river in lines that were shifted as the ice shrank

eastward and lower passages were opened. Eventually the ice border shrank to a position so far east that waters accumulated in front of it to form Lake Saginaw whose discharge was westward through the Grand river outlet to Lake Chicago. At the same time the Lake Michigan lobe had receded to the north so that Lake Chicago occupied much of the Lake Michigan basin and received direct drainage from the major part of the border of that lake.

Glacial Drainage, and Lakes in the Huron-Erie Basin. The conditions on the southeast side of the Saginaw basin and in the Huron-Erie basin were somewhat simpler than in the district between the Saginaw and Lake Michigan lobes. There was merely a shifting of drainage to lower and lower courses along the edge of the shrinking ice lobes on each side of the "Thumb." The drainage from the Huron-Erie lobe led southwestward into a glacial lake, known as Lake Maumee, which at first discharged past Fort Wayne, Indiana, to the Wabash river, but later by the opening of a lower passage across the northern part of the "Thumb," through the recession of the ice it discharged westward to Grand river along what is termed the Imlay outlet, from a city of that name in Lapeer county standing at the head of the outlet. Eventually the ice had receded so far that this lake became confluent with Lake Saginaw, noted above. For this stage the names Lake Maumee and Lake Saginaw were dropped and a new name, Lake Arkona substituted.

Port Huron Morainic System and Lake Whittlesey. The next morainic system after the series of slender moraines just described is known as the Port Huron system. This marks the limits of distinct readvance of the ice border as distinguished from a mere halt in the course of the recession of the border. By this it should not be understood that all the moraines previously described mark mere halting places in the recession, for evidences of slight readvance have been found in connection with some of them. The Port Huron morainic system seems, however, to mark a more pronounced readvance than any of the moraines outside it in this peninsula. This readvance appears also to have affected the ice border over a very wide area extending from the Adirondack Mountains westward past all the Great Lakes basins and across Minnesota into Canada.

On the borders of the south part of Lake Huron and in the Saginaw basin the readvance of the ice was across part of the area occupied by Lake Arkona, and was sufficient to dismember the lake and make separate the part in the Saginaw basin from the main body in the Erie basin and contiguous lowlands. The small

lake is called the Later Lake Saginaw, and the main lake is called Lake Whittlesey. This large lake had a different outlet from that of Lake Maumee and stood a few feet lower than the lowest beach of that lake. From near Port Huron its waters flowed northward along the west edge of the ice lobe to Ubly in Huron county, and there turned westward along the edge of the Saginaw lobe into the Later Lake Saginaw.

Turning now to the distribution of the Port Huron morainic system, it is found to follow closely the southern end of Lake Huron, lying south of Saginaw Bay. It also lies but a few miles back from the shore of Saginaw Bay around the entire coast of that body of water. The portion in the Saginaw basin is largely waterlaid and inconspicuous, yet a ridge of sufficient strength was formed to govern the courses of Cass and Tittibawassee rivers and cause them to flow for long distances on its outer border nearly parallel with the shore of Saginaw Bay before breaking through the moraine at the city of Saginaw. The portion of the moraine bordering the south part of Lake Huron is also waterlaid for a few miles in the vicinity of Port Huron, but elsewhere was formed above lake level and is of considerable strength. It is separable in places into two or more moraines in its landlaid portion.

In the northern part of the peninsula the Port Huron morainic system barely reaches to the northern edge of the plateau which overlooks the northern part of Lake Huron and Lake Michigan. It leads from the AuSable river east of Mio in a northwestward course past Gaylord to the corners of Charlevoix, Cheboygan, and Otsego counties as a massive belt 2 to 8 miles in width, from which spurs extend out toward Lake Huron, in some cases to distances of several miles. There are several disjointed or interrupted moraines between this large ridge and the shore of Lake Huron in the district north of Saginaw Bay which should perhaps be included in this Port Huron system.

On passing from the Lake Huron to the Lake Michigan basin this morainic system makes an abrupt turn to the southwest and presents even greater complexity than in the Port Huron basin. There is an outer moraine which follows the border of the plateau through Antrim, Kalkaska, Grand Traverse, and Manistee counties as far as the bend of the Manistee river in southeastern Manistee county, being throughout this distance a ridge about 1 to 2 miles in width with great relief on the inner or western border but very little relief on the outer or eastern border. From southeastern Manistee county southward across Mason county there are only weak dis-

jointed ridges to mark the continuation of this moraine, and its identification is difficult. It may extend only to Pentwater before passing into Lake Michigan. It seems not unlikely, however, that a ridge which is traceable as far south as Muskegon is to be included in the Port Huron morainic system.

A second well defined moraine of the Port Huron system runs parallel to the outer moraine from Charlevoix county southwestward to the head of Grand Traverse Bay, being separated from it only by a narrow outwash plain, traversed in part by the Boardman river. This moraine has spurs on its inner border which extend out several miles toward the Lake Michigan coast, and especially toward Grand Traverse Bay. There seems to have been a sub lobe of the Lake Michigan glacier occupying Grand Traverse Bay which had several projections into lowlands lying between the morainic spurs just mentioned. At the south it divided into two lobes, occupied now by the two arms of Grand Traverse Bay, between which was formed the prominent ridge known locally as "the peninsula." In the district west of Grand Traverse Bay, on the peninsula known as "the Horn," an interlobate moraine was developed between the Grand Traverse sub lobe and the main Lake Michigan glacier. From the part of the Lake Michigan coast west of Grand Traverse Bay, southwestward to Manistee, the Lake Michigan glacier seems to have had slight finger-like protrusions extending a few miles inland from the present shore, between which were developed the prominent headlands which characterize this portion of the coast. After developing these headlands, the glacier, before shrinking within the limits of the lake, formed a weak moraine which wraps around the western end of these headlands and forms slight loops in the lowlands between them, and which is traceable as far south as the line of Manistee and Mason counties. There it passes inside the limits of Lake Michigan. The glacial drainage from this inner part of the Port Huron morainic system is clearly traceable from the reentrant angle between the Lake Michigan and Lake Huron lobes, in Charlevoix county, southwestward to where the waters entered Lake Chicago, a few miles south of Manistee, though in doing so it traverses a district which is now drained to Lake Michigan by several different streams, as may be seen by reference to the glacial map of the surface formations. (Plate VII.)

There are, in the northern part of the peninsula, nearly pebbleless clay deposits under the boulder clay and other glacial material of the Port Huron morainic system, which seem to have been deposited in lake waters that occupied the area prior to the readvance

of the ice. They are exposed chiefly on the slopes of the prominent ridges that lie between the bays and the lowland areas that project inland from the present coast nearly to the second moraine of the Port Huron system, and have been noted in nearly every ridge between Frankfort and Cheboygan. They may be present also in the district southeast of Cheboygan but exposures were not found. These clay deposits are known to have great thickness, exposures of over 100 feet thickness having been seen, while borings are reported to penetrate even greater amounts. The clays reach in places an altitude of 250 to 300 feet above Lake Michigan, or nearly 100 feet higher than that of any beaches formed by lake waters after the final melting away of the ice from that region. The altitude, may, however, be no greater than would have been reached by lake waters at a time prior to the development of the Port Huron morainic system, for a northward differential uplift was in progress in the northern part of the Great Lakes region near the close of the Wisconsin stage of glaciation. The method of deposition of such a thick body of clay is somewhat problematical, but there seems no question that the clay was laid down in lake waters prior to the readvance of ice marked by this morainic system.

Relation of the Port Huron Morainic System to Lake Chicago. The Port Huron morainic system seems to have been developed at a critical time in the history of Lake Chicago, during the lowering of that lake from the highest beach to lower ones. Before the ice border melted away from the small Manistee moraine, that passes inside the limits of Lake Michigan near Manistee, the lake had been lowered to the level of the third or Toleston beach. The first and second beaches of Lake Chicago are traceable northward along the east side of the Michigan basin nearly to the southern end of the Manistee moraine, but they do not occur on that moraine. The lowering of the lake depended, of course, upon the cutting down of the Chicago outlet, and not upon any relation to the ice border. The lowering to the level of the second beach seems likely to have occurred near the middle of the development of this morainic system, for the highest beach is so weak as to be traced with some difficulty on the slopes of the outer ridges of the system from near Muskegon northward. The lowering from the second to the third beach in all probability took place near the end of the development of the Port Huron morainic system. The strength of the second beach is such as to demand a length of time somewhere near as long as that needed for the development of the later ridges of the Port Huron morainic system. This rela-

tion of the beaches of Lake Chicago to ridges of the Port Huron morainic system renders it feasible to make a correlation with the moraines of this system on the Wisconsin side of the lake. The correlative of the Manistee ridge sets in on the west side at Two Rivers, Wisconsin, and runs northward along the west coast into the peninsula between Green Bay and Lake Michigan, as the latest ridge of a definite series on that side of the lake, and it has only the third beach of Lake Chicago on its slopes. There is a ridge outside it that is traceable southward to Port Washington, Wisconsin, that seems likely to correlate with one on the Michigan side which is traceable southward as far as Pentwater, Michigan. A still earlier ridge, apparently of this series, extends south to Milwaukee, and this seems likely to be a correlative of one on the Michigan side that extends to Muskegon. The highest Chicago beach is faintly developed on its slope, just as on the ridge that terminates near Muskegon.

The Cheboygan Moraine. The latest stand of the ice border on the Southern Peninsula of Michigan seems to have been at a small moraine that lies close to the Lake Huron shore from the Straits of Mackinac southeastward to Cheboygan and which is represented for some miles farther east by a bouldery strip without definite morainic ridging. West of Cheboygan it is sufficiently well defined to be easily traced, though it is a very slender ridge, only one-fourth to one-half mile in width and 20 feet or less in average height above the land back of it.

FEATURES BETWEEN THE MORAINES.

Till Plains. Till plains occupy certain wide areas between moraines over which the ice front appears to have made a rapid recession. The drift is somewhat diverse in constitution and texture, being in places sandy and in places clayey, according to the relation to the drainage from the receding ice border. There is usually, however, a thorough commingling of clay, sand, and stones. The surface is flat to gently undulating, but, as a rule, with sufficient slope to permit of easy drainage. These plains are in general well suited for agriculture, though the sandier portions are rather light and need careful management. A special convention has been applied to these sandy areas on the glacial map. The till plains are in places diversified by as sharp ridges and knolls as are found in moraines. These are classed according to form or constitution as eskers, kames, or drumlins, and are taken up separately below.

Eskers and Kames. The gravel ridges termed eskers and "hog

A. COLON HILL. A LARGE KAME OR GRAVEL HILL IN ST. JOSEPH COUNTY.

B. PRE-WISCONSIN TILL OVERLAIN BY WISCONSIN DRIFT IN THE BANK OF BLACK RIVER, SANILAC COUNTY.

A. PRE-WISCONSIN TILL ON SHORE OF LAKE HURON NEAR RICHMONDVILLE, SANILAC COUNTY.

B. CLOSER VIEW OF PRE-WISCONSIN TILL NEAR RICHMONDVILLE.

backs," as already indicated, radiate toward the ice borders and thus have a trend nearly at a right angle to that of the moraines. They are distributed from the southern to the northern end of the peninsula, as may be seen by reference to the glacial map. They are, however, most numerous in the area covered by the Saginaw lobe, and especially in connection with the Charlotte morainic system.

Eskers are ordinarily very narrow, steep sided ridges ranging in height from a few feet up to 75 feet or more. Although composed chiefly of gravel and sand there is in some cases a thin veneer of boulder clay and in others a bouldery surface without a notable boulder clay deposit.

In Sanilac county are ridges of considerable breadth up to nearly one-fourth mile that have a trend toward the ice border, like the eskers, but are far more bulky than the ordinary esker. They are composed largely of sand and gravel, but have a general veneer of boulder clay. It is probable that they were formed under conditions somewhat similar to those for ordinary eskers, so there seems no need to class them separately.

The eskers, though having a soil of rather an inferior quality, and being too steep for easy cultivation, are yet of high commercial value, since they are an important source of road material.

Kames are commonly known as gravel knolls. They range from low swells of gentle slope to very steep hills (Plate IX). They contain gravelly and sandy glacial material in which there is more or less boulder clay interbedded. They are disposed in clusters and isolated hills instead of in the form of a long ridge characteristic of the esker. They abound in many of the moraines, and are scattered widely over the plains between the moraines. No attempt has been made to show their distribution on the glacial map, since they are so widespread and abundant that time was taken to map only a part of them in the course of the field studies. Already much use has been made of them for road material in almost every county of the state, and for that purpose they are in no way inferior to the eskers.

Drumlins. Drumlins are not so widely distributed in this peninsula as eskers and kames, for they are restricted to the northern end of the peninsula and even to the inner border of the Port Huron morainic system. The main area lies between Little Traverse and Grand Traverse Bay, but there are a few drumlinoidal hills on the peninsula between the arms of Grand Traverse Bay, and in the district west of the Bay. There are also a few near Levering in northern Emmet county and north and east of Douglass Lake

in Cheboygan county. There are several small drumlins east of Mullet Lake in Cheboygan county, and also a small drumlin district a few miles west of Alpena. The drumlins near Alpena, in keeping with the striae bear southward or southeastward in a course nearly parallel with neighboring moraines instead of toward them. This trend, as was noted, in discussing the striae, seems due to some local deflection of the ice currents, the cause for which is not yet apparent. The drumlins east of Mullet Lake also trend southeastward, though in a district where the moraines have a nearly parallel course. In the Grand Traverse region the drumlins show an interesting divergence in trend to correspond with the spreading of the ice in the Grand Traverse lobe, and are directed toward the moraines.

The drumlins range in height from 75 feet or more down to 10 or 15 feet, and in length from fully a mile down to one-fourth mile or less. They have slopes sufficiently regular to be easily brought under cultivation, though in some cases they are rather steep. The quality of soil is usually of a high order because of the clayey constitution and the well drained surface. No matter how steep sided, these hills show remarkable resistance to gullying by the storm waters. Whether this resistance is due to constitution or to a peculiarity of the bedding is not determined. The drumlins under discussion seem to have been formed by slow accretion through a plastering process as the ice sheet moved over them with its coating of dirty material. The bedding planes in the upper portion of the drumlins are not horizontal, but are nearly concentric with the curved surface. So far as those of this particular region are concerned there seems little question that they were built up by the ice at the time it was forming the neighboring moraine of the Port Huron system. In certain other localities, as for example the Menominee county district in the Northern Peninsula, there is some question as to whether they were built up at the time of the neighboring moraine toward which their longer axes are directed, or were merely shaped into drumlin form at that time from an earlier deposit over which the ice sheet was spreading.

CHAPTER III.

LAKE FEATURES.

INTRODUCTORY STATEMENT.

It has been known from the earliest days of settlement in Michigan that the Great Lakes have covered wider areas than they now occupy. The beaches are so conspicuous as to be widely recognized and the flat lake beds are in strong contrast to the neighboring glacial features. The expanded lakes are found to have had southwestward discharges into the Mississippi drainage, and that too by different outlets. One outlet, past Fort Wayne, Indiana, was a line of discharge from the Erie basin to the Wabash river, while another, at the south end of the Lake Michigan basin, conveyed water to the Illinois. The Lake Superior basin also had an outlet from its southwestern end to the St. Croix, a tributary of the Mississippi. The fact that these outlets are at widely different altitudes gave the suggestion that the lakes in the Erie, the Michigan and the Superior basins were at one time independent bodies of water, and it was later shown that these lakes were held in on the northeast by the great ice sheet. It was also found that the old shore lines were tilted, and already considerable data are at hand on the extent of areas of uplift, and the amount of earth movement that has occurred since the lakes stood at these high levels.

In a somewhat voluminous report on this region, by Mr. F. B. Taylor and the present writer, Monograph LIII of the United States Geological Survey, the literature of the subject is given due consideration and the lake history is presented in some detail. It seems unnecessary, therefore, in the presnt discussion to do more than give a brief outline.

LAKE CHICAGO.

Outlet and Beaches. Lake Chicago was a body of water held in the southern part of the Lake Michigan basin by the Lake Michigan ice lobe, and its name is taken from the city whose site it once covered. Its area increased as that of the ice lobe diminished and decreased with any advance of the ice lobe which may have occurred.

Lake Chicago had an outlet southwestward through the Des-Plaines valley to the Illinois river and thence to the Mississippi and Gulf of Mexico. The highest or Glenwood beach stands 55 to 60 feet above the present level of Lake Michigan, and about 45 feet above the head of the outlet. There are two lower beaches, the Calumet about 35 to 40 feet, and the Toleston 20 to 25 feet above Lake Michigan, each of which opens into the southwestward outlet. There are still lower beaches that seem to have been formed after this outlet had been abandoned, by the opening of some lower one to the east. The name Lake Chicago is applied to the lake only so long as it held to its southwestward discharge.

The outlet is a broad channel averaging more than a mile in width, cut largely in glacial deposits but with some excavation in rock near its head. It is probable that the dropping from higher to lower levels, shown by the presence of distinct beaches, has been due to giving way of a rock barrier that had been holding the lake to the level of a given beach. Had there been a steady lowering of the head of the outlet the beaches would be likely to occur at less definite and less restricted levels. Prof. T. C. Chamberlin has suggested the removal of the rock barrier by a stoping process. By this process rapids may have worked back headwards to the upper end of the rock barrier which then suddenly gave way and produced a lower lake level.

In the Michigan portion of the beaches of Lake Chicago the highest beach is the one that has suffered least from encroachments by the cutting back of the shore of Lake Michigan, yet there are wide stretches on the coast in which it also has been removed. The second and third beaches are preserved chiefly in recesses at bays or mouths of rivers, for elsewhere the bluffs of Lake Michigan commonly rise 35 feet or more above its water surface.

As noted in the discussion of the Port Huron morainic system the highest beach is only faintly developed from Muskegon northward to the vicinity of Manistee, but because of the persistence of the ice sheet, neither it nor the second beach are found north from Manistee.

The pebbleless clays beneath glacial deposits of the Port Huron readvance, as noted above, may prove to be the deposits of Lake Chicago in a stage of great expansion prior to that readvance.

The third or Toleston beach may have been only partly developed by Lake Chicago. It seems to have been completed by the waters of Lake Algonquin, whose area embraced the Michigan as well as

Huron basins, after a passage was opened between these basins by the melting away of the ice from the Straits of Mackinac.

Lake Bed Deposits. Lake Chicago covered a very narrow strip on the east side of Lake Michigan, usually but one to two miles or less. But from Holland northward across Ottawa and Muskegon counties it extended 10 to 25 miles beyond the limits of Lake Michigan. In this widest expansion its bed is almost entirely of fine sand. There is also more sand than clay in the narrow strips along the shore. The clayey portions have till at only a few inches depth, there being very little lake sediment over it. Should the pebbleless clays beneath the till of the Port Huron morainic system prove to be the product of Lake Chicago, they would form its most conspicuous clay deposits. The east coast of Lake Michigan has suffered greatly from the encroachment of dune sand brought in by wind from the shore of the present lake. In places near the mouths of the principal rivers it has been heaped to a height of 150 to 200 feet above Lake Michigan level. The high dunes, however, are confined to within one to two miles of the shore of Lake Michigan.

Tilting of the Michigan Basin. The beaches of Lake Chicago are practically horizontal from the south end of the lake northward at least to the latitude of Grand Haven, Michigan, and Milwaukee, Wisconsin. A gradual rise in altitude is found in passing farther north, so that the highest beach which is about 645 feet near Grand Haven becomes 670 to 675 feet in the vicinity of Ludington where its northernmost exposures are found. The Algonquin beach is found to continue the northward ascent past the northern end of the basin. It rises from about 605 feet near Ludington to 812 feet on Mackinac Island. The rise of 25 feet in the highest Lake Chicago beach, shown by levels at Ludington, is perhaps to be attributed in part to the gravitative effect of the ice sheet that was persisting in the northern part of the Lake Michigan basin, but certain irregularities in the slope seem to call for earth movement. The Algonquin beach is practically horizontal from the southern end of Lake Michigan to the latitude of Ludington so any tilting or differential earth movement in districts south from this parallel is likely to have ceased by the time the ice had vacated the Straits of Mackinac, and allowed the merging of Huron and Michigan waters which gave rise to Lake Algonquin.

LAKE MAUMEE.

Outlets, Beaches and Delta Deposits. Lake Maumee, named from its great extent in the Maumee basin, of northwestern Ohio and neighboring parts of Indiana, was the first large lake formed as the ice border shrank into the Maumee-Erie basin.

The outlet of the lake past Fort Wayne, Indiana, was across the lowest available place on the border of the basin. Its altitude seems to have been at first about 785 feet, or 212 feet above Lake Erie, but during its activity the outlet was cut down to about 760 feet. The lake at is highest stage seems to have made use of this outlet alone. During the recession of the ice northward past the head of the Imlay outlet on the "Thumb," the Fort Wayne outlet had been cut down sufficiently to cause a lower level of the lake.

The highest beach is only 785 to 790 feet in the vicinity of the Fort Wayne outlet, but is about 800 feet in the southern part of Michigan, and nearly 850 feet in Lapeer county near the head of the Imlay outlet. The present altitude of the head if this outlet is 805 to 810 feet, or about 50 feet above the bed of the Fort Wayne outlet. Of this, several feet increase is due to peaty growth, so the floor as swept by the lake outlet is not far from 800 feet. If 50 feet be deducted to correct the differential uplift, it leaves the altitude at about 750 feet at the close of the discharge through it, or about 10 feet lower than the bed of the Fort Wayne outlet. The Imlay outlet opened into a small lake east and south of Flint, as indicated on the glacial map. This lake extended to Swartz Creek. Thence westward there was a stream of gradual descent across Shiawassee and Clinton counties to the Grand river channel a few miles northwest of St. Johns.

The mapping of the beaches and deltas of Lake Maumee has brought to light interesting differences in their strength at the different lake levels which suggest a rather complicated lake history. The highest beach is very irregular, probably because of the irregularities in the coast, some places being more exposed than others to wave action. The second beach is more regular, and on the whole somewhat stronger than the highest. There is a third beach which is generally weak and in places difficult to trace. Yet it connects with deltas of greater strength than those of the higher levels of the lake. The extent of the deltas is shown on the glacial map. They are notably large where Raisin and Huron rivers entered the lake. It seems not improbable that the third beach was partially effaced by a rise of the lake. Indeed it appears likely that the second beach was largely formed after a rise from the level of the third

A. VIEW SOUTH ACROSS IMLAY OUTLET NEAR DEANVILLE, LAPEER COUNTY

B. PRE-WISCONSIN TILL BELOW WISCONSIN DRIFT, SEPARATED BY OLD SOIL ZONE, IN SANILAC COUNTY

beach. The third beach is 20 feet below it and seems a little too low to open into the Imlay outlet, though almost up to the level of its floor. The outlet at the time the third beach was developed may, therefore, have been across the "Thumb" in a lower passage a few miles farther north, which became filled by a readvance of the ice to a moraine that closely borders the Imlay outlet.

The lake beaches, because of their sandy or gravelly constitution, form better lines for highways than neighboring clayey tracts and have been so utilized from an early day. In recent years, however, the tendency to put roads on north and south and east and west lines has led to the abandonment of parts of the old roads on the beaches. The beaches also, when gravelly, are of much value for road ballast.

The old river deltas are in part of mixed loam, gravel, and sand that give a productive soil of loose texture. They seldom contain much coarse rubble or cobble and have only a small admixture of pebbly material.

The extent of the Michigan portion of the bed of Lake Maumee outside the limits of Lake Whittlesey is very limited and is all that will be considered at this point, though the deposition of Lake silts, in all probability, was going on at this time over the deep lying part of the lake bed as far back as the edge of the ice sheet. The narrow strip outside the beach of Lake Whittlesey is generally underlain by boulder clay at the depth of but a few inches, so the lake deposits, except in the beaches, and river deltas, are of slight amount.

FIRST LAKE SAGINAW.

When the ice sheet had melted back into the Saginaw basin far enough to expose a land surface sloping toward it, conditions became favorable for lake waters to accumulate and form the First Lake Saginaw. The outlet of the lake was through Grand river to Lake Chicago, this being a line already opened by the glacial drainage from the end of the Saginaw lobe. The limits of the lake on the western and southern borders of the basin are marked by a well defined beach that opens into this outlet at an altitude about 730 feet above sea level, but which becomes somewhat higher as one passes north or east from the outlet, because of differential uplift. The bed of the lake is nearly equally divided between a sandy and a clayey soil as shown in Plate VII. The distribution of the sand was probably determined in part by outwash from the receding ice border and in part by lake action. The sand due to

lakewaves and currents is restricted to the border of the lake, while that from glacial outwash may be present where there was a considerable depth of water, since the water escaping from the ice was liable to have had strong hydrostatic pressure.

LAKE ARKONA.

Lake Arkona represents a stage of water in the Erie-Maumee basin that corresponds closely to the level of the First Lake Saginaw, and it is probable that it was for a time merged with that lake. The altitude (where differential uplift has not affected it) is about 700 feet above sea level. It has three beaches separated by intervals of less than 10 feet, one being slightly less than 710 feet, another a little above 700 feet, and a third a little below 700 feet. In the early part of the lake's history there was probably a discharge into Lake Saginaw through a channel across the northern end of the "Thumb." But with the recession of the ice border there came a merging of the two lakes at the level of Lake Saginaw. This seems to more closely correspond to the second of the three beaches than to the first, so there was perhaps a drop to this beach because of the merging with Lake Saginaw. If so the drop to the third beach is likely to be referable to a cutting down at the head of the outlet.

Lake Arkona was later separated from Lake Saginaw by a readvance of the ice to the Port Huron morainic system. This caused a rise of the lake waters in the Huron-Erie to a level about 30 feet above the highest Arkona beach, and as a result of this rise the beaches were nearly obliterated. They are traceable as a rule merely as gravelly or sandy strips with scarcely a perceptible ridging. There are places, however, where the beaches stand close by the outer border of the Port Huron morainic system, in which the original strength is preserved. On the map (Plate VII) such places are represented by continuous lines to distinguish them from the washed down portions (represented by broken lines).

The higher lake level that was produced in the Huron-Erie basin is termed Lake Whittlesey, and the small lake that persisted in the Saginaw basin and whose level was not raised by the ice readvance is termed the Later Lake Saginaw, the name Arkona being dropped.

The most conspicuous parts of the Lake Arkona shore are the large deltas formed where the streams entered the lake. As shown on the glacial map they are conspicuous at the Raisin, Saline,

Huron, West Rouge, and Clinton rivers. These deltas are of fine gravelly sand.

LATER LAKE SAGINAW.

The Later Lake Saginaw extended about to the limits of the First Lake Saginaw on the west and south, for its outlet was through the same channel, along Grand river to Lake Chicago, and at but a few feet lower level. The limits on the northeast or iceward side were at the Port Huron moraine, and are thus more definitely fixed than the limits of the Earlier Lake Saginaw. The lake extended up the Cass river valley about to Cass City and up the Tittibawassee valley at least to northeastern Gladwin and possibly into southeastern Ogemaw county.

LAKE WHITTLESEY.

This large glacial lake of the Huron-Erie basin stood at about 735 to 740 feet in the part of its basin where the beach is horizontal. This embraces what lies southwest of a line running from Ashtabula, Ohio, in a west-northwest course across the basin of Lake Erie, the Ontario Peninsula, and the middle part of Lake St. Clair. From this line there is a rise of fully 60 feet northward in Michigan to the Ubly outlet, the present altitude at the head of the outlet being about 800 feet. It is not unlikely that the gravitative effect of the ice will account for a small part of the rise, but the larger part seems due to differential uplift. Where the Ubly outlet opened into the Later Lake Saginaw at Cass City the present altitude is about 740 feet, making a fall (by including the differential uplift) of 60 feet along the outlet. But at the time the outlet was in operation there was only 40 to 45 feet. This is known from the fact that in portions of Lake Saginaw and Lake Whittlesey, unaffected by uplift, the levels of the two lakes differ only that amount.

The beach of Lake Whittlesey is a remarkably strong feature throughout its extent in Michigan and was the first to be recognized and mapped. Under the first Geological Survey of Michigan in 1838 to 1840 it was traced for over 60 miles by Bela Hubbard in districts back of Detroit where settlements had been started. The beach is a gravel ridge 10 to 15 feet in height and with a breadth of nearly one-eighth mile. It is a valuable resource for road ballast for the clayey districts through which it passes. Lake Whittlesey was maintained at the level of the Ubly outlet only until the ice melted back on the "Thumb" far enough to lower the lake. Ice

recession at the same time in the Ontario basin opened an outlet eastward low enough to draw down the lake level to about 660 feet. This eastward outlet, however, was later closed by a readvance of the ice, and the lake level raised to the Lake Warren beach at 680 feet, and a westward outlet restored.

The strip of lake bottom between the Whittlesey and Warren beaches in southeastern Michigan is largely a clayey plain, the principal exceptions being at deltas of Lake Arkona. The deltas of streams entering Lake Whittlesey are less conspicuous than of the same streams in connection with its predecessor, Lake Arkona. One reason for this is the fact that the rise of water caused estuarine conditions for some distance up the valleys beyond the Whittlesey beach, and it was necessary to fill these estuaries from their heads down-stream past the beach before the lake bed proper would receive a coating of delta material. The duration of the Lake Whittlesey stage may be fully as long as that of the Arkona.

LAKE WAYNE.

The Wayne beach, so-called from its early recognition in Wayne county, and especially near the village of Wayne, was for some time regarded as merely a lower stage of Lake Warren and described as a lower Warren beach. But F. B. Taylor has found evidence that Lake Wayne succeeded Lake Whittlesey and antedated Lake Warren just as Lake Arkona antedated Lake Whittlesey. His studies in the Saginaw Basin have led him also to the opinion that this lake was a few feet too low to find a discharge through the Grand river outlet. It seems, instead, to have discharged eastward along the edge of the ice past Syracuse, New York, into the Mohawk valley. Such a wide shifting of the outlet seemed to him a sufficient reason for applying the new name, Lake Wayne.

The Wayne beach is only 20 feet lower than the Warren and lies but a short distance inside the limits of the Warren beach. At the type locality in Wayne county, Michigan, it is developed on a sandy tract and is consequently a sandy ridge, but on the till tracts farther north, and also in most of Ohio and farther east, it has a gravelly constitution, and like the Arkona beaches it is greatly washed down. In fact along much of its course it can be identified only by painstaking search.

LAKE WARREN.

Lake Warren, like the most expanded stage of Lake Arkona, included the lake in the Saginaw basin as well as the larger body

of water in the Huron-Erie basin, and discharged directly through the Grand river outlet to Lake Chicago. In the part unaffected by uplift its beach stands about 680 feet above sea level and is barely high enough to open into the head of the outlet, whose bed there is about 670 feet. As indicated in the discussion of Lake Wayne, Lake Warren was preceded by a lower stage of water, with an eastward discharge to the Mohawk valley.

The beach when traced northward from the outlet rises at the rate of about 2 feet to the mile and reaches 800 feet near Gladwin, and on the part of the Port Huron moraine directly east, near the corner of Gladwin, Bay and Arenac counties. It is also nearly 800 feet on the point of the "Thumb" in Huron county north of Bad Axe. The beach is practically horizontal from near the vicinity of Lenox, in northern St. Clair county, south and east through southeastern Michigan and northern Ohio about to the Ohio-Pennsylvania line, a distance of nearly 300 miles. Between there and Batavia, New York, a rise of about 200 feet is made in a distance of 150 miles.

The beach is of medium strength and seems to mark a lake level of considerable duration, though probably somewhat shorter than either the Arkona or the Whittlesey. The delta deposits are not so extensive as those of Lake Arkona. Its shore deposits vary in accordance with those of the lake beds on which it was developed. Where there was till or gravelly material at the surface a gravelly beach was formed, but where there were sandy sediments we find merely a sandy ridge. The glacial map sets forth the extent of sand and clay along this shore and on the bed of the lake. It will be observed that the portion in the Saginaw Basin has much more sand west of the bay than east of it. The sand on the east slope of the "Thumb" is largely in Monroe, Wayne, and southeastern Washtenaw counties.

LAKE LUNDY[1] (GRASSMERE AND ELKTON BEACHES).

The names Grassmere and Elkton are beach names applied to two lower levels of the large lake in the Huron-Erie basin which had, like Lake Wayne, a discharge eastward to the Mohawk. Lake Lundy, however, is a direct successor of Lake Warren, and not of Lake Wayne, hence the need for a separate name. The type localities from which the beach names, Grassmere and Elkton are taken are in Huron county, Michigan, near the north end of the "Thumb," and

[1]The name of this lake was changed by F. B. Taylor from Elkton to Lundy. See Monograph LIII, U. S. Geol. Survey, pp. 399–406.

the names were introduced by Dr. A. C. Lane in his Huron county report.[1]

The Grassmere beach, where unaffected by uplift, is about 640 feet, and the Elkton 620 feet above sea level. They have suffered considerable uplift in the eastern end of the Erie basin, but scarcely so much as the Warren shore. The uplift, therefore, began before the Grassmere and Elkton beaches were formed. These beaches are fainter features than those of the higher lake stages already considered, and seem to mark short-lived lake levels. They are marked usually merely as sandy strips with indefinite ridging. The level of the water was controlled by the relation of the ice border to channels near Syracuse, New York.

BEGINNINGS OF LAKE ERIE AND LAKE ST. CLAIR.

Lake Lundy seems to have persisted until the ice had so completely withdrawn from the lowland south of Lake Ontario, and eastward, that the waters were drawn down there to the level of the lowest or Rome outlet to the Mohawk. Niagara Falls then came into operation, and the country bordering Lake Erie was drained down to the level of its outlet at the head of Niagara river, so Lake Erie became a distinct water body. There were two small water bodies between Lake Erie and the lake in the Huron basin. One in the St. Clair basin is known as the Early St. Clair. Another in the basin south of Detroit, through which Rouge river enters Detroit river is called Lake Rouge.

The Early St. Clair stood about 20 feet above the present lake or 595 feet above the sea, and discharged into Lake Rouge across a low ridge on which Detroit and Windsor stand. The level of Lake Rouge was 585 feet above sea level or 13-14 feet above the Detroit river.

The shores of the Early St. Clair and of Lake Rouge are rather faint features, yet sufficiently distinct to be traceable along much of their length in each basin. Lake Rouge had considerable extent on the Canadian side south of Windsor as well as in the lower part of the Rouge and Ecorse river drainage in Michigan.

The early beach of Lake Erie lies inside the limits of the lake. It was so low that Sandusky river flowed through Sandusky Bay at a level fully 25 feet below the present level of the lake and bay, as shown by soundings in the bay made by Mr. E. L. Mosely.

[1]Geological Survey of Michigan, Vol. VII, Part 2.

MACKINAC ISLAND FROM ROUND ISLAND SPIT.

BATTLEFIELD BEACH ON MACKINAC ISLAND BATTLEFIELD, REAR VIEW LOOKING NORTH.

FRONT VIEW OF ALGONQUIN BEACH IN PETOSKEY.

WAVE CUT TERRACE IN BLUFF OF ALGONQUIN SHORE WEST OF BLACK RIVER, ALCONA COUNTY.

LAKE ALGONQUIN.

The name Algonquin is applied to the earliest body of water in the Huron basin, after lowering occurred which made Lake Erie and Lake St. Clair separate water bodies. This early Algonquin lake seems to have begun with a southward discharge through Lakes St. Clair, and Rouge to Lake Erie for it was the successor of Lake Lundy. An outlet from Georgian Bay through the Trent valley to the Ontario basin was, however, soon opened through recession of the ice front in Ontario and being lower than the St. Clair it diverted the drainage eastward. Then as a result of differential uplift in the northeastern part of the lake, including this outlet, the water level was raised in the southern part to a height sufficient to bring back the discharge to the St. Clair valley, and reestablish the roundabout course through Lake Erie and over Niagara Falls to the Ontario basin. Evidence in support of this succession of events is offered by the character of the Niagara gorge above Lewiston. Its lower end was excavated only to a shallow depth because of the small amount of water derived from the St. Clair and Erie basins, which passed over the falls prior to this diversion. But farther up, the gorge becomes abruptly much deeper, and this is thought to be the result of the increase in volume in the falls after this diversion.

The opening of the Straits of Mackinac and bordering low lands, by the melting away of the ice, caused this early Lake Algonquin to become merged with Lake Chicago. If this opening occurred before the uplift of the Trent outlet had raised the water to the level of the Chicago outlet, there would have been a lowering of the water in the Michigan basin as a result of this connection with the Early Lake Algonquin. Evidences of such a lowering have been noted on the borders of the Michigan basin, there being at the mouths of certain valleys an excavation to levels 50 feet or more below Lake Michigan level. An uplift sufficient to bring the water level up to a discharge into the St. Clair valley would also have filled the Michigan basin about to the height of the Toleston or third beach of Lake Chicago, for the altitude of the Algonquin beach, where unaffected by subsequent differential uplift, is found to be about 25 feet above Lake Huron. It is possible, therefore, that the expanded lake had for a time an outlet southwest from the Michigan basin, the same as Lake Chicago, and also south from Lake Huron through the St. Clair. The latter had an advantage over the former, in being over drift deposits that are easily removed, while the Chicago outlet was over a rock floor of considerable resistance. The

St. Clair outlet seems to have been rapidly lowered sufficiently to take all the discharge.

The Algonquin beach becomes split into several members on passing northward into the region of uplift, a feature which shows the uplift to have been in rapid progress in Algonquin time. The highest member on Mackinac Island is 812 feet above sea level, and on the Canadian highlands north of Sault Ste. Marie, Ontario, it is 1,015 feet.

Lake Algonquin covered a considerable area in the northern end of the Southern Peninsula in Alpena, Presque Isle, Cheboygan, Emmet, Charlevoix and Antrim counties, but elsewhere its shore was very close to the present shore of Lake Huron (including Saginaw Bay) and Lake Michigan. Several islands stood in it in Emmet and Cheboygan counties, and there were deep bays in Charlevoix, Antrim, Grand Traverse, and Leelanau counties, as shown on the map (Plate VII). Its beach forms a strong feature on the borders of Saginaw Bay and Lake Huron. There are places in Alpena and Alcona counties, and in northwestern Presque Isle county, where bluffs fully 50 feet high stand back of its shore, so that it compares favorably in strength with the modern shore of Lake Huron. Around Saginaw Bay it has a strong sandy beach lying usually from 1 to 5 miles from the edge of the bay. It, however, covered the Port Huron moraine near Saginaw and a low district south of it in southern Saginaw county.

In the northern part of the peninsula the bed of Lake Algonquin is in places very bouldery. It is probable that the bouldery strips were laid down at the ice border and represent feeble moraines whose clayey and fine ingredients were carried away by wave action. Boulder laden masses of lake ice may also have made some contribution of stones in places where the ice grounded.

Lake Algonquin was maintained at a level high enough to discharge through the St. Clair, down to the time when the ice sheet was melting from a lowland that connects the Ottawa valley with Georgian Bay. As soon as this lowland became free from ice, the lake began discharging to the Ottawa valley, for at that time this lowland was not so high as the St. Clair outlet. With this change in discharge the name Algonquin is dropped, and the name Nipissing applied.

NIPISSING GREAT LAKES.

The Nipissing Great Lakes occupied the basins of Lakes Huron, Michigan and Superior, but were not precisely coincident in area with the modern lakes, because of a different attitude of the land. The opening of an eastward line of discharge from Georgian Bay to the Ottawa valley drew down the water level to an undetermined amount. But differential uplift was still in progress, and the water level rose in the districts south of the isobase of the outlet until outflow was resumed through the St. Clair valley. This rise of waters submerged the beaches formed at the low water level, except perhaps in a small district at the north edge of Lake Superior which lies north of the outlet isobase. As a consequence the beach known as the Nipissing is one formed after the level of the lake became high enough to open into the St. Clair valley. The beach has considerable strength at a definite upper level around the eastern shore which seems to indicate a stable condition for the time when the change in outlet was being made. Afterward there was a continuation of northward uplift so that the Nipissing shore is now 100 feet higher on the north side of Lake Superior and near the head of the eastern outlet than at the St. Clair outlet, and the beach is split up into several members in this uplifted area.

Lake Nipissing, like Lake Algonquin, has its history reflected in the character of the channel in the Niagara gorge. There is a part of the gorge embracing the whirlpool and a small section above and below it in which the excavation was not so deep as it is on either side, and this shallow excavation is thought to have been made by the weak waterfall when the Erie basin was the main part of the watershed tributary to the falls. Near the suspension bridges a very deeply excavated section begins which extends up to the present cataract. This seems to have been excavated since the flow from Lake Nipissing was turned into the present line of discharge. At the present rate of recession the falls would require somewhere between 2,700 and 3,500 years to excavate the deep part of the gorge above the suspension bridges. In this comparatively short period there seems to have been a rise of 100 feet in the district north of Georgian Bay and the northeast part of Lake Superior, or from 3 to 4 feet per century. There is some question if the uplift is still in progress. Possibly there has been a stable condition for some time past that would make necessary a more rapid rate than that just indicated during the time it was in progress.

From the transfer of the Nipissing waters to the St. Clair outlet

there has been continuous flow in the present direction, and the outlet has suffered a slight deepening which has lowered the lake level about 14 feet. The beach at 596 feet in the southern end of the Huron Basin seems to have been occupied by Lake Nipissing as well as by the late stage of Lake Algonquin, so the lowering of the lake is from that height to the present. The present beach is 582 to 584 feet with a mean stage of water about 580 feet.

CHAPTER IV.

AGRICULTURAL CONDITIONS.

NOTES ON THE AGRICULTURAL CONDITIONS.

Inasmuch as the investigation of the surface formations of the Southern Peninsula of Michigan has been for the purpose of interpreting the glacial and lake history, the observations upon soils came in only incidentally, and this should be borne in mind in consulting the tables below. It seems inadvisable to attempt such a definite classification as that of the Bureau of Soils merely on the basis of incidental notes. Such a classification demands a careful measurement of the constituent grains of each kind of soil, and also tests of the subsoil by means of borings. For example, a complete series of glacial soils under the classification adopted by the U. S. Bureau of Soils embraces the following in order of grade from coarse to fine: (1) Stony loam, (2) gravel, (3) gravelly loam, (4) sand, (5) fine sand, (6) sandy loam, (7) fine sandy loam, (8) loam, (9) silt loam, (10) clay loam. In all these soils there is a loamy constituent, except perhaps in recently formed dunes, which by the way are given a class by themselves outside the regular series. Whether the word loam should be used in a particular soil may only be determined by careful analysis; so also would be the question whether soil should be classed as sand or fine sand, loam, silt loam, or clay loam. In general it may be stated that the sandy till of our glacial deposits embraces the classes denominated stony loam, gravel, gravelly loam, and to some extent the sand, fine sand, and sandy loam. The clayey till in general embraces the loam, silt loam, clay loam, and in some cases the fine sandy loam. The sandy soils of the glacial series are perhaps the easiest to interpret in terms of the classification by the Bureau of Soils, since they are almost wholly confined to sand and fine sand; but as stated above it is found that the Bureau of Soils has in some cases classed the till as sand. Such is notably the case in the Wexford county area where almost the entire county is classed as Miami sand. It is true that three phases of the sand are noted, the pine hills phase, the pine plain phase, and the hardwood land phase. The pine plain phase alone would be ordinarily classed by a

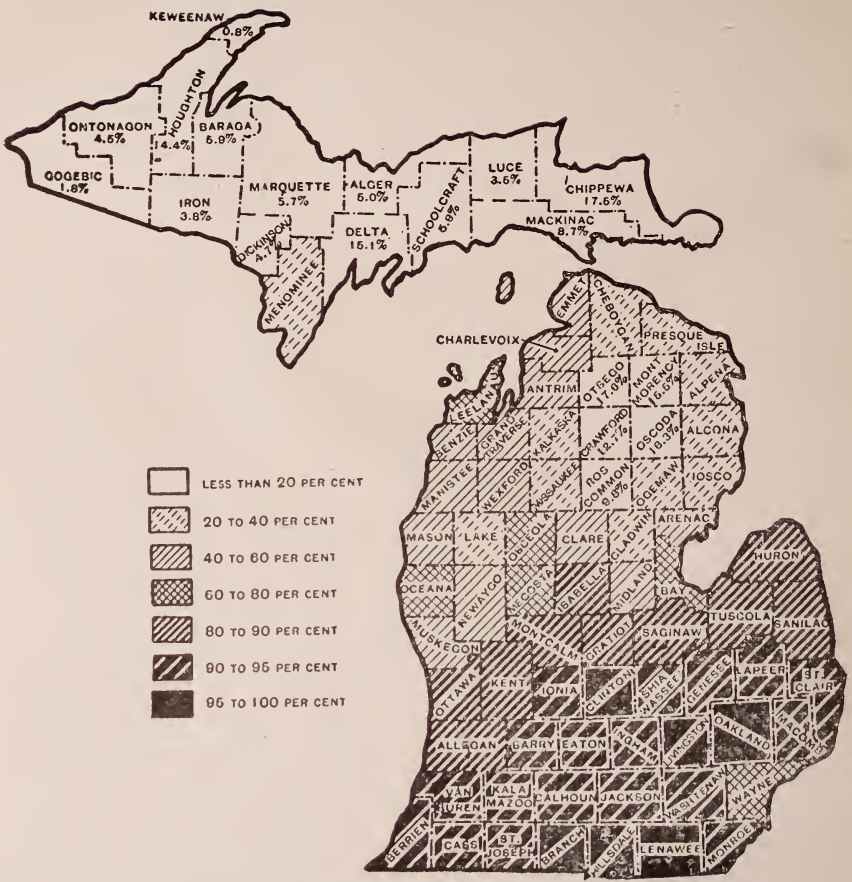


Fig. 24. Percent of land areas in farm in 1910.

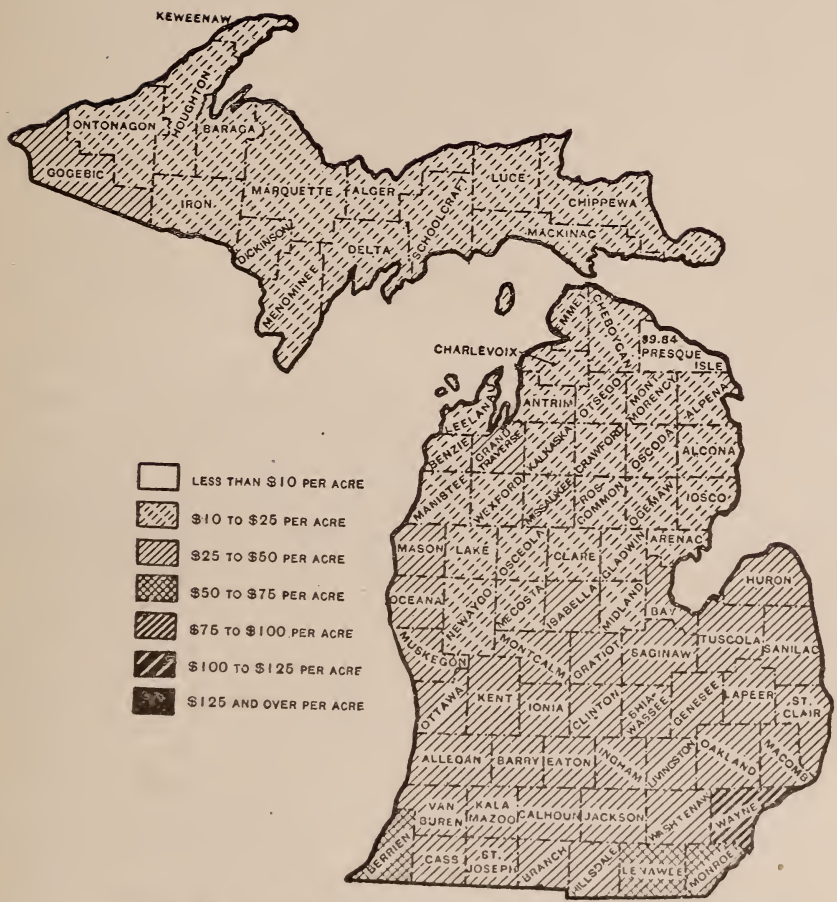


Fig. 25. Average value of farm land per acre in 1910.

farmer or a geologist as sand, the other two phases being a sandy till, of which the pine hills phase contains less fine material than the hardwood land phase.

The classification of soils here presented merely sets forth the general classes of glacial deposits such as are evident to any one not equipped for making a close analysis. The classification is conformable to the mapping of the surface formations given in the general glacial map, and that makes the map an indispensable accompaniment of the table. The map does not, however, set forth the two classes of till nor distinguish the sandy portions of an outwash plain from the gravelly portions for the reason that the work was not sufficiently detailed to fix the precise boundaries. Observations have seemed sufficiently complete, however, to form a basis for the estimates of the relative amounts of sandy and gravelly land given in the tables. Notes given beneath each of the counties will serve to make clear certain points not otherwise shown clearly in the table or map.

As indicated in the description of the soil types the stony loam is found ordinarily in moraines, while the gravelly loam appears in river terraces and has been reworked by streams. The sand is found in both glacial areas and alluvial tracts. The sandy loam is in some cases glacial and in other cases alluvial, but in Michigan it is ordinarily glacial and more or less pebbly. The fine sandy and silty loam is widely represented in the ordinary till plain, the silty phase being classed as clayey till.

The maps of Michigan areas issued by the Bureau of Soils are as follows:

Allegan county, issued in 1901, supply exhausted.

Alma area, in Gratiot county, issued in 1904.

Cass county, issued in 1906.

Oxford area, in Oakland county, issued in 1905.

Owosso area in Shiawassee county, issued in 1904.

Pontiac area in Oakland county, issued in 1903.

Saginaw area, parts of Saginaw, Bay, Tuscola and Huron counties, issued in 1904.

Wexford county, issued in 1908.

Munising area, in Northern Peninsula, issued in 1904, supply exhausted.

The data concerning the number of farms, the percentage of land in farms (with map), the percentage of improved land, the average value of the land in each county (with map), and the principal crops in each county, have been obtained from the 13th Census

Report on Agriculture. It is not possible with the data at hand to indicate the percentage of land now in farms under each class of soil in the accompanying tables, except in a few southern counties where practically all the land is now under cultivation. In those counties the average price of land given in the Census Report represents a combination of all the classes. In the northern part of the state, where a large part of the land has not yet been converted into farms the clayey and sandy till areas are occupied more extensively than the other classes of land. Insofar as these classes have a value above other classes the extra occupancy for farms gives farm prices a higher rate than would be the average for all classes, such as is given in the southern counties. In this connection, however, it should be noted that a class of land which is inferior for general farming may be made highly profitable for certain crops. Thus considerable land of Kalamazoo, Van Buren, and other counties in the southwestern part of the state, which was inferior for general farming has been planted extensively to vineyards, and made to yield even better returns than the better classes of farm land. It should be borne in mind that the price of land here given is exclusive of farm buildings which are separately estimated in the Census Report, and is accordingly a fair representation of relative land values. The land value is 56.5 per cent of the total value of farm property (including buildings, implements, machinery and stock) in Michigan.

The kinds of crops grown in each county are arranged in order of importance as given in the Census Report. Where hay, corn, oats, wheat, barley, rye, beans, and peas are compared the acreage forms the main basis for comparison, though products are reckoned at a general relative value. Thus beans are given four times the value per bushel that is given to corn, while barley, wheat, rye and peas are given twice the value of corn. Potatoes are reckoned by value of crop since the acreage is low, and are given the same value per bushel as corn.

From the statistics given in the Census Report it appears that hay and forage (93.65 per cent being timothy and clover), form the leading crop in 56 of the 68 counties of the Southern Peninsula, distributed over its entire length. Corn leads in 6 counties in the southern part of the state, namely, Berrien, Cass, St. Joseph, Calhoun, Branch and Monroe. Potatoes lead in 6 of the northern counties, Benzie, Leelanau, Manistee, Wexford, Otsego, and Charlevoix. Corn stands second in 18 counties in the central and southern part of the peninsula, while potatoes stand second in 17 of the

northern counties. Oats stand second in 12 of the central and northern countries. Beans stand second in 5 of the central counties, Shiawassee, Genesee, Tuscola, Saginaw, and Isabella. Wheat stands second in Cass county only, and third in but 7 counties, Berrien, St. Joseph, Kalamazoo, Allegan, Barry, Ionia, and Huron counties.

The Census Report furnishes very few data on orchards, small fruits and truck farming, though these are of high importance in the southern and western parts of the peninsula and have great possibilities for further development. The orchards and truck farming are largely developed in the gravelly and sandy areas and areas with a light sandy till, and in many cases yield better returns than could be obtained from general farming. Many of the bogs have proved highly profitable in the growth of onions and celery. The growth of sugar beets is already an important industry in the southern half of the peninsula on land which is sufficiently fertile and which has a loose texture and damp soil.

As a result of the estimates given in the tables it is found that the several classes of land have the following percentages:

	Per cent.
Swamp and lake	11.60
Clayey till	32.65
Sandy till	22.55
Sandy	25.00
Gravelly	8.20

It thus appears that about one-third of the peninsula is embraced in the sand and gravel areas, one-ninth in lakes and swamps, and five-ninths in the sandy and clayey tills.

The moraines are largely of sandy till except in the central and south central parts, southwest of Saginaw Bay, where they have a clayey constitution. The till plains are largely of clayey till, those which are not being designated by a special device on the map. The water-deposited clay in the areas of glacial lakes is a relatively thin deposit, so that the subsoil at a depth of one to five feet from the surface is usually a clayey till.

There is a relatively small part of the Southern Peninsula in which the underlying rock has much influence on the character of the soil. In Alpena, Presque Isle, and on the immediate border of the lake in parts of Cheboygan, Emmet, and Charlevoix counties, limestone is sufficiently near the surface, and is incorporated to such an extent in the till as to make it classifiable as a limestone

till. There are also very limited areas in Wayne and Monroe counties where the limestone is sufficiently near the surface to affect the character of the soil. In parts of Jackson, Calhoun, Branch and Hillsdale counties the Marshall sandstone lies very near the surface and the till owes its sandiness to some extent to the incorporation of this local rock.

The dunes, which form such a conspicuous topographic feature along the east coast of Lake Michigan, and which give such an impression of desolation when viewed from the lake vessels, really occupy but a narrow strip averaging less than a mile in width along this coast. The sandy parts of the glacial lake beds show only a slight amount of drifting into dunes, much of the sand being capped with a loamy soil.

In a large part of the glaciated area of the United States the glacial deposits have been covered to considerable depth by the fine silt known as loess, so that soil and subsoil are entirely in that deposit. But in Michigan the loess deposit is practically wanting. The soil, however, throughout the state carries a small amount of material that has been deposited by the wind, and this has rendered somewhat loamy extensive districts that would otherwise be sandy. This is especially true of the glacial lake sands.

The extensive areas of pine plains of the western and northern parts of the peninsula furnish a problem as to methods of management and development, especially since parts of them have been devastated by fires. It is a question whether forestry may not be more profitable than farming. The outwash plains of the northern part of the state have on the whole a lighter soil than those of the southern part, and have the disadvantage of about three weeks shorter period between spring and autumn frosts.

In the tables which follow the lake clay has been included in the clayey till but with the affix Lc. Where lakes are of considerable extent their area has been given separately from that of swamps and indicated by the affix L, swamps being indicated by the affix S. It will be noted that in the column for area, sections instead of square miles have been designated, for the reason that sections often overrun or fall short of a square mile. Beneath the table for each county an area in square miles is given which has been obtained from Farmer's Handbook of Michigan, and which apparently does not include the areas within the larger lakes.

DETAILED DATA BY COUNTIES—(Alphabetical order).

ALCONA COUNTY.

Township.	Area sections.	Swamp and lake. Secs.	Clayey till. Secs.	Sandy till. Secs.	Sandy. Secs.
T. 28, R. 5 E.	36	7	4	9	16
T. 28, R. 6 E.	36	14	.....	17	5
T. 28, R. 7 E.	36	12L, 5	4	12	3
T. 28, R. 8 E.	36	6	22	8	.....
T. 28, R. 9 E.	29	13	6	8	2
T. 27, R. 5 E.	36	6	10	16	4
T. 27, R. 6 E.	36	6	5	11	14
T. 27, R. 7 E.	36	15	.....	16	5
T. 27, R. 8 E.	36	11	.....	25	.....
T. 27, R. 9 E.	32.5	2.5	21	9	.....
T. 26, R. 5 E.	36	3	.....	21	12
T. 26, R. 6 E.	36	6	.....	20	10
T. 26, R. 7 E.	36	5	14	3	14
T. 26, R. 8 E.	36	5	16	10	5
T. 26, R. 9 E.	30	2	16	9	3
T. 25, R. 5 E.	36	6	4	10	16
T. 25, R. 6 E.	36	4	24	4	4
T. 25, R. 7 E.	36	7	8	.....	24
T. 25, R. 8 E.	36	4	7	21	4
T. 25, R. 9 E.	26	12	5	3	6
Total.	693.5	148.5	166	232	147

Area 680 square miles in 693.5 sections, including lakes
Number of farms, 884.
Average value per acre, $12.76.
Square miles in farms, 163¾.
Per cent of land area in farms, 23.9.
Per cent of farm land improved, 36.3 or 9.67 per cent of county.
Principal crops: Hay, potatoes, oats, peas, rye, wheat, corn.

The area of lake clay was probably occupied by the ice sheet during part of the development of the large Au Sable delta. Its borders are not marked by definite beaches.

ALLEGAN COUNTY.

Township.	Area sections.	Swamp and lake. Secs.	Clayey till. Secs.	Sandy till. Secs.	Sandy. Secs.	Gravelly. Secs.
T. 1 N. R. 11 W.....	36	4	0.5	13	10.5	8
T. 1 N. R. 12 W.....	36	2	8	14	9	3
T. 1 N. R. 13 W.....	36	2	16.5	10	4	3.5
T. 1 N. R. 14 W.....	36	3	10	13.5	9.5	.....
T. 1 N. R. 15 W.....	36	5	.....	5	26	.....
T. 1 N. R. 16 W.....	36	4	4	8.5	19.5	.....
T. 1 N. R. 17 W.....	3	.....	2	1	.....	.....
T. 2 N. R. 11 W.....	36	9	0.5	4.5	2	20
T. 2 N. R. 12 W.....	36	3	12	19.5	1.5	.....
T. 2 N. R. 13 W.....	36	4	15	9.5	3.5	4
T. 2 N. R. 14 W.....	36	4	.....	11	19	2
T. 2 N. R. 15 W.....	36	6	.....	4	25.5	0.5
T. 2 N. R. 16 W.....	33.5	3.5	10	10	10	.....
T. 3 N. R. 11 W.....	36	3	5.5	4	12	11.5
T. 3 N. R. 12 W.....	36	2.5	19	11.5	3	.....
T. 3 N. R. 13 W.....	36	1.5	2.5	18	13	1
T. 3 N. R. 14 W.....	36	4	1.5	3.5	26	1
T. 3 N. R. 15 W.....	36	7	8.5	3	17	0.5
T. 3 N. R. 16 W.....	28	4.5	4.5	3.5	15.5	.....
T. 4 N. R. 11 W.....	36	4	8	10.5	13.5	.....
T. 4 N. R. 12 W.....	36	2	9	10.5	14	0.5
T. 4 N. R. 13 W.....	36	4	0.5	15.5	16	.....
T. 4 N. R. 14 W.....	36	2.5	21	7.5	5	.....
T. 4 N. R. 15 W.....	36	1	23	3.5	8.5	.....
T. 4 N. R. 16 W.....	22	0.5	3	2.5	16	.....
Total.....	842.5	86	184.5	217	299	55.5

Area 828 square miles in 842 sections, including lakes.
Number of farms, 6,217.
Average value per acre, $37.87.
Square miles in farms, 737.
Per cent of land area in farms, 88.7.
Per cent of farm land improved 74.9 or 66.43 per cent of county.
Principal crops: Hay, corn, wheat, potatoes, oats, rye.
The sandy areas of the western part of the county should, perhaps, be classed as outwash, for they contain scarcely any bowlders or glacial material, and no till was observed.

ALPENA COUNTY.

Section.	Area sections.	Swamp and lake. Secs.	Clayey till. Secs.	Sandy till. Secs.	Sandy. Secs.	Gravelly. Secs.
T. 32, R. 5 E.	36	10	26	.....	.....	.....
T. 32, R. 6 E.	36	5	31	.....	.....	.....
T. 32, R. 7 E.	36	10	19	.....	7	.....
T. 32, R. 8 E.	36	5L 3S	16Lc 9	.....	3	.....
T. 32, R. 9 E.	11	2	7Lc	.....	2	.....
T. 31, R. 5 E.	36	22	10	4	.....	.....
T. 31, R. 6 E.	36	4	24	2	5	1
T. 31, R. 7 E.	36	2	7Lc 10	.....	16	1
T. 31, R. 8 E.	29	2	8Lc	.....	19	.....
T. 31, R. 9 E.	17	2	15Lc	.....	.....	.....
T. 30, R. 5 E.	36	16	8	12	.....	.....
T. 30, R. 6 E.	36	3	18	14	.....	1
T. 30, R. 7 E.	36	3	28	.....	5	.....
T. 30, R. 8 E.	20	4	.....	.....	16	.....
T. 29, R. 5 E.	36	10	.....	26	.....	.....
T. 29, R. 6 E.	36	20	.....	16	.....	.....
T. 29, R. 7 E.	36	2	14	20	.....	.....
T. 29, R. 8 E.	33	8	10	3	12	.....
T. 29, R. 9 E.	9	4	.....	.....	5	.....
Total.	587	137	260	97	90	3

Area 579 square miles in 587 sections, including lakes.
Number of farms, 1,326.
Average value of land per acre, $11.43.
Square miles in farms, 231.2.
Per cent of land area in farms 39.6.
Per cent of farm land improved 34.7, or 13.75 per cent of county.
Principal crops: Hay, oats, potatoes, wheat, corn, rye.

Settlements are chiefly on the till plains and the areas in which rock is near the surface. The latter areas in the state of nature include considerable poorly drained land which, however, may be largely reclaimed by clearing and ditching.

ANTRIM COUNTY.

Section.	Area sections.	Swamp and lake. Secs.	Clayey till. Secs.	Sandy till. Secs.	Sandy. Secs.	Gravelly. Secs.
T. 32, R. 8 W.	36	8	23	3	2	.....
T. 32, R. 9 W.	10	1	7	.....	2	.....
T. 31, R. 5 W.	36	5	.....	24	.....	7
T. 31, R. 6 W.	36	8	.....	26	2	.....
T. 31, R. 7 W.	36	8	.....	26	2	.....
T. 31, R. 8 W.	36	8L 2S	24	2	.....	.....
T. 31, R. 9 W.	6	1	3	.....	2	.....
T. 30, R. 5 W.	36	2	.....	5	.....	29
T. 30, R. 6 W.	36	8	.....	25	.....	3
T. 30, R. 7 W.	36	8	.....	22	6	.....
T. 30, R. 8 W.	36	15L 4S	12	5	.....	.....
T. 30, R. 9 W.	14	2	10	2	.....	.....
T. 29, R. 5 W.	36	6	.....	1	.....	29
T. 29, R. 6 W.	36	2	.....	9	.....	25
T. 29, R. 7 W.	36	2	.....	14	3	17
T. 29, R. 8 W.	36	15L 2S	9	10	.....	.....
T. 29, R. 9 W.	24	8L 1S	12	.....	3	.....
T. 28, R. 8 W.	1	.....	1	.....	.....	.....
T. 28, R. 9 W.	3	.....	3	.....	.....	.....
Total.	526	116	104	174	22	110

Area 478 square miles in 526 sections, including about 46 square miles in lakes.
Number of farms, 1,641.
Average value of land per acre, $17.46.
Square miles in farms, 227.2.
Per cent of land area in farms 47.8.
Per cent of farm land improved 54.2, or 25.9 per cent of county.
Principal crops: Hay, potatoes, corn, oats, rye, wheat, beans.
The moraines as well as the drumlin areas of this county have proved very profitable both for orchards and for general farming.

ARENAC COUNTY.

Section.	Area sections.	Swamp and lake. Secs.	Clayey till. Secs.	Sandy till. Secs.	Sandy. Secs.
T. 20, R. 3 E.	36	.....	8	3	25
T. 20, R. 4 E.	36	.....	21	.....	15
T. 20, R. 5 E.	36	.....	15	.....	21
T. 20, R. 6 E.	36	6	22	.....	8
T. 20, R. 7 E.	34	8	8	.....	18
T. 19, R. 7 E.	12	4	6	.....	2
T. 19, R. 6 E.	35	4	27	.....	4
T. 19, R. 5 E.	36	.....	19	.....	17
T. 19, R. 4 E.	36	.....	8	.....	28
T. 19, R. 3 E.	36	.....	22	.....	14
T. 18, R. 4 E.	36	6	20	.....	10
T. 18, R. 5 E.	16	4	8	.....	4
T. 18, R. 6 E.	2	.....	2	.....	.....
Total.	387	32	186	3	166

Area 367 square miles in 387 sections.
Number of farms, 1,440.
Average value per acre, $18.29.
Square miles in farms, 178.4.
Per cent of land area in farms, 47.7.
Per cent of farm land improved 48.7, or 13.23 per cent of county.
Principal crops: Hay, oats, corn, beans, potatoes, rye, peas.
The mapping of sandy and clayey areas in this county is only rudely approximate and represents the main strips of each class. The mapping was chiefly by W. M. Gregory of the Michigan Geological Survey.

BARRY COUNTY.

Section.	Area sections.	Swamp and lake. Secs.	Clayey till. Secs.	Sandy till. Secs.	Sandy. Secs.	Gravelly. Secs.
T. 4 N. R. 7 W.	36	2	27	7	.....	.....
T. 4 N. R. 8 W.	36	3	22	8	3	.....
T. 4 N. R. 9 W.	36	1	17	12	6	.....
T. 4 N. R. 10 W.	36	2	16	3	8	7
T. 3 N. R. 10 W.	36	10	.....	7	16	3
T. 3 N. R. 9 W.	36	2	.....	19	15	.....
T. 3 N. R. 8 W.	36	2	7	21	6	.....
T. 3 N. R. 7 W.	36	2	16	10	8	.....
T. 2 N. R. 7 W.	36	1	29	4	2	.....
T. 2 N. R. 8 W.	36	2	8	26	.....	.....
T. 2 N. R. 9 W.	36	8	.....	25	.....	3
T. 2 N. R. 10 W.	36	4	.....	25	.....	7
T. 1 N. R. 10 W.	36	7	.....	11	.....	18
T. 1 N. R. 9 W.	36	5	.....	13	.....	18
T. 1 N. R. 8 W.	36	5	.....	29	.....	2
T. 1 N. R. 7 W.	36	2	.....	34	.....	.....
Total.	576	58	142	254	64	58

Area 552 square miles in 576 sections, including lakes.
Number of farms, 3,428.
Average value per acre, $29.57.
Square miles in farms, 526.3.
Per cent of land area in farms, 94.7.
Per cent of farm land improved 74.9, or 70.9 per cent of county.
Principal crops: Hay, corn, wheat, oats, potatoes, rye.

BAY COUNTY.

Section.	Area sections.	Swamp and lake. Secs.	Clayey till. Secs.	Sandy till. Secs.	Sandy. Secs.
T. 18, R. 3 E.	36	.....	2 Lc	4	30
T. 17, R. 3 E.	36	3	.....	.....	33
T. 17, R. 4 E.	36	.....	13 Lc	.....	23
T. 17, R. 5 E.	3	.....	.....	.....	3
T. 16, R. 5 E.	2	.....	.....	.....	2
T. 16, R. 4 E.	34.5	.....	12 Lc	.....	22.5
T. 16, R. 3 E.	36	.....	6 Lc	.....	30
T. 15, R. 3 E.	36	1	29 Lc	.....	6
T. 15, R. 4 E.	33.5	6	17 Lc	.....	10.5
T. 15, R. 5 E.	3.5	1	.....	.....	2.5
T. 14, R. 6 E.	23	4	14 Lc	.....	5
T. 14, R. 5 E.	32.5	4	20 Lc	.....	8.5
T. 14, R. 4 E.	36	1.5	30 Lc	.....	4.5
T. 14, R. 3 E.	36	1	30 Lc	.....	5
T. 13, R. 4 E. (N. Half)	18	0.5	15.5Lc	.....	2
T. 13, R. 5 E. (N. Half)	18	5.5	12.5Lc	.....	.....
T. 13, R. 6 E.	36	6	25 Lc	.....	5
Total	456	33.5	226	4	192.5

Area 445 square miles in 456 sections.
Number of farms, 3,233.
Average value per acre, $35.72.
Square miles in farms, 333.
Per cent of land area in farms, 75.2.
Per cent of farm land improved 69.9 or 52.56 per cent of county.
Principal crops: Hay, oats, corn, potatoes, wheat, beans, rye.
The clayey till as well as the lake clay is a compact clay with few pebbles and needs tile draining.
The classification of soils is largely based on map and report by W. F. Cooper (Geol. Survey of Michigan, Annual Report for 1905).
The southern part is based on the map of the Saginaw area by U. S. Bureau of Soils 1904.

BENZIE COUNTY.

Section.	Area sections.	Swamp and lake. Secs.	Sandy till. Secs.	Sandy. Secs.	Gravelly loam. Secs.
T. 27, R. 13 W	36	5	3	14	14
T. 27, R. 14 W	36	2	25	.....	9
T. 27, R. 15 W	19	3L, 2S	1	13	.....
T. 27, R. 16 W	4.5	.....	2.5	2	.....
T. 26, R. 13 W	36	4	9	17	6
T. 26, R. 14 W	36	2	14	8	12
T. 26, R. 15 W	36	8L, 5S, 7L	16	6	1
T. 26, R. 16 W	20	2S	9	2	.....
T. 25, R. 13 W	36	3	5	28	.....
T. 25, R. 14 W	36	3	3	30	.....
T. 25, R. 15 W	36	5	27	4	.....
T. 25, R. 16 W	13	3	8	2	.....
Total	344.5	54	122.5	126	42

Area 319 square miles. 344.5 sections including 18 sections in lakes.
Number of farms, 1,245.
Average value per acre, $20.71.
Square miles in farms, 49.1.
Per cent of farm land improved 49.6 or 24.35 per cent of county.
Principal crops: Potatoes, corn, hay, rye, oats, wheat, buckwheat.
The coating of loam on the gravel plains is very thin so they are but little more productive than the sandy areas. The sandy till forms excellent orchard and fair farm land.

BERRIEN COUNTY.

Section.	Area sections.	Swamp and lake. Secs.	Clayey till. Secs.	Sandy till. Secs.	Sandy. Secs.	Gravelly. Secs.
T. 3 S. R. 17 W.....	36	5	17	11	3	.....
T. 3 S. R. 18 W.....	20	1	7	2	10	.....
T. 3 S. R. 19 W.....	8	1	2.5	.....	4.5	.....
T. 4 S. R. 18 W.....	35.5	2	2.5	14	17	.....
T. 4 S. R. 17 W.....	36	2	4	.....	30	.....
T. 5 S. R. 17 W.....	36	1	20	14	1	.....
T. 5 S. R. 18 W.....	36	2	8	10	16	.....
T. 5. S. R. 19 W.....	26	2	9	.....	15	.....
T. 6 S. R. 20 W.....	4	.....	2	.....	2	.....
T. 6 S. R. 19 W.....	35.5	8	6	3	18.5	.....
T. 6 S. R. 18 W.....	36	3	5	19	9	.....
T. 6 S. R. 17 W.....	36	2	9	10	4	11
T. 7 S. R. 17 W.....	36	1	.....	6	6	23
T. 7 S. R. 18 W.....	36	3	20	6	7	.....
T. 7 S. R. 19 W.....	36	3	20	6	7	.....
T. 7 S. R. 20 W.....	28	1	24	.....	3	.....
T. 7 S. R. 21 W.....	2	.....	.....	.....	2	.....
T. 8 S. R. 22 W.....	0.5	.....	.....	.....	0.5	.....
T. 8 S. R. 21 W.....	16.5	2	10	.....	4.5	.....
T. 8 S. R. 20 W.....	21	1	18	.....	2	.....
T. 8 S. R. 19 W.....	21	2	14	5	.....	.....
T. 8 S. R. 18 W.....	21	1.5	2.5	8	4	5
T. 8 S. R. 17 W.....	21	1	.....	8	5	7
Total.....	584	44.5	200.5	122	171	46

Area 568 square miles in 584 sections including lakes.
Number of farms, 5,252.
Average value per acre, $64.83.
Square miles in farms, 520.8.
Per cent of land area in farms, 91.5.
Per cent of farm land improved 80.7, or 73.8 per cent of county.
Principal crops: Corn, hay, wheat, potatoes, oats.

The gravel plains generally have a loamy capping of considerable fertility. The sandy till areas form excellent orchard and fair farm land. A narrow strip of barren dunes less than a mile in average width borders the lake shore from near Stevensville southwestward into Indiana.

BRANCH COUNTY.

Section.	Area sections.	Swamp and lake. Secs.	Clayey till. Secs.	Sandy till. Secs.	Sandy. Secs.	Gravelly loam. Secs.
T. 5 S. R. 5 W.....	36	8	4	16	8	.....
T. 5 S. R. 6 W.....	36	2	9	6	9	10
T. 5 S. R. 7 W.....	36	1	24	4	7	.....
T. 5 S. R. 8 W.....	36	2	10	.....	24	.....
T. 6 S. R. 8 W.....	36	5	24	.....	7	.....
T. 6 S. R. 7 W.....	36	2	18	.....	6	10
T. 6 S. R. 6 W.....	36	3	14	3	8	8
T. 6 S. R. 5 W.....	36	5	14	4	7	6
T. 7 S. R. 5 W.....	36	4	18	10	4	.....
T. 7 S. R. 6 W.....	36	8	10	2	10	6
T. 7 S. R. 7 W.....	36	3	18	4	3	8
T. 7 S. R. 8 W.....	36	4	12	5	10	5
T. 8 S. R. 8 W.....	21	2	4	6	.....	9
T. 8 S. R. 7 W.....	21	6	7	2	.....	6
T. 8 S. R. 6 W.....	21	4	.....	7	.....	10
T. 8 S. R. 5 W.....	21	1	2	5	.....	13
Total.....	516	60	188	74	103	91

Area 500.7 square miles in 516 sections, including lakes.
Number of farms, 3,378.
Average value of farms, $40.03.
Square miles in farms, 578.9.
Per cent of land area in farms, 96.4.
Per cent of farm land improved 74.5, or 71.8 per cent of county.
Principal crops: Corn, hay, oats, wheat, potatoes.
The areas included in the last column have generally a rich loam above the gravel.

CALHOUN COUNTY.

Section.	Area sections.	Swamp and lake. Secs.	Clayey till. Secs.	Sandy till. Secs.	Sandy. Secs.	Gravelly loam. Secs.
T. 1 S. R. 4 W.	36	6.5	15	14.5	.....	.....
T. 1 S. R. 5 W.	36	12	20	4	.....	.....
T. 1 S. R. 6 W.	36	4	2	28	2	.....
T. 1 S. R. 7 W.	36	1	.....	24	7	4
T. 1 S. R. 8 W.	36	1	.....	5	6	24
T. 2 S. R. 8 W.	36	1	.....	20	3	12
T. 2 S. R. 7 W.	36	2	.....	12	4	18
T. 2 S. R. 6 W.	36	2	.....	7	6	21
T. 2 S. R. 5 W.	36	3	.....	12	6	15
T. 2 S. R. 4 W.	36	5	.....	22	3	6
T. 3 S. R. 4 W.	36	2	.....	28	2	4
T. 3 S. R. 5 W.	36	2	.....	22	.....	12
T. 3 S. R. 6 W.	36	2.5	.....	9	2.5	22
T. 3 S. R. 7 W.	36	2	.....	15	4	15
T. 3 S. R. 8 W.	36	2	13	19	2	.....
T. 4 S. R. 8 W.	36	1	5	3	27	.....
T. 4 S. R. 7 W.	36	2	.....	6	6	22
T. 4 S. R. 6 W.	36	3	.....	18	.....	15
T. 4 S. R. 5 W.	35	4	.....	18	8	6
T. 4 S. R. 4 W.	36	4	2	16	10	4
Total.....	720	62	57	302.5	98.5	200

Area 698.6 square miles in 720 sections, including lakes.
Number of farms, 3,761.
Average value per acre, $35.49.
Square miles in farms, 643.4.
Per cent of land area in farms, 92.8.
Per cent of farm land improved 75.5, or 70 per cent of county.
Principal crops: Corn, hay, wheat, oats, potatoes.
The loam over the gravel in the areas in the last column is rather thin and patchy.

CASS COUNTY.

Section.	Area sections.	Swamp and lake. Secs.	Sandy till. Secs.	Sandy. Secs.	Gravelly loam. Secs.
T. 5 S. R. 13 W.	36	6	10	.....	20
T. 5 S. R. 14 W.	36	3	15	.....	18
T. 5 S. R. 15 W.	36	8	14	12	2
T. 5 S. R. 16 W.	36	7	2	4	23
T. 6 S. R. 16 W.	36	4	4	16	12
T. 6 S. R. 15 W.	36	2	9	19	6
T. 6 S. R. 14 W.	36	5	10	5	16
T. 6 S. R. 13 W.	36	4	27	5	.....
T. 7 S. R. 13 W.	36	3	28	3	2
T. 7 S. R. 14 W.	36	3	17	8	8
T. 7 S. R. 15 W.	36	3	15	.....	18
T. 7 S. R. 16 W.	36	4	16	4	12
T. 8 S. R. 16 W.	21	2	6	5	8
T. 8 S. R. 15 W.	21	2	.....	3	16
T. 8 S. R. 14 W.	21	1	2	5	13
T. 8 S. R. 13 W.	18.5	2	4	1.5	11
Total.	513.5	59	179	90.5	185

Area 488 square miles in 513.5 sections, including lakes.
Number of farms, 2,556.
Average value per acre, $38.28.
Square miles in farms, 461.6.
Per cent of land area in farms, 93.6.
Per cent of farm land improved 75.9, or 71 per cent of county.
Principal crops: Corn, wheat, hay, oats, potatoes, rye.

The extensive gravel plains are generally coated with a rich loam, as indicated by the map of the U. S. Bureau of Soils, Report for 1906. The sandy till ranges from very stony but loamy till to sandy material containing few pebbles. The principal variations appear on the Bureau of Soils map.

CHARLEVOIX COUNTY.

Section.	Area sections.	Swamp and lake. Secs.	Clayey till. Secs.	Sandy till. Secs.	Sandy. Secs.
T. 34, R. 6 W.	12	4	7	1	.....
T. 34, R. 7 W.	26	5	18	.....	3
T. 34, R. 8 W.	8	1	2	.....	5
T. 33, R. 4 W.	36	3	.....	27	6
T. 33, R. 5 W.	36	3L 3S	5	20	5
T. 33, R. 6 W.	21	2	.....	16	2
T. 33, R. 7 W.	25	2	19	2	3
T. 33, R. 8 W.	35	4	29	.....	2
T. 33, R. 9 W.	9	1	5	.....	3
T. 32, R. 4 W.	36	4	.....	27	5
T. 32, R. 5 W.	36	10	.....	20	6
T. 32, R. 6 W.	36	8	.....	23	5
T. 32, R. 7 W.	33	6	20	5	2
Beaver Island group	65	4	25	24	12
Total	414	60	130	165	59

Area 414.4 square miles in 414 sections, not including Pine Lake.
Number of farms, 1,460.
Average value of land per acre, $15.33.
Square miles in farms, 200.
Per cent of land area in farms, 48.5.
Per cent of farm land improved 48.3 or 23.4 per cent of county.
Principal crops: Potatoes, hay, corn, oats, rye.
A considerable part of the clayey till is in drumlins.

CHEBOYGAN COUNTY.

Section.	Area sections.	Swamp and lake. Secs.	Clayey till. Secs.	Sandy till. Secs.	Sandy. Secs.
T. 39, R. 3 W.	11	2	6Lc 1	.....	2
T. 38, R. 3 W.	36	16	5Lc 1	3	11
T. 38, R. 2 W.	23	2	14Lc 2	.....	5
T. 38, R. 1 W.	9	1	4Lc	.....	4
T. 38, R. 1 E.	11	1	6Lc	.....	4
T. 38, R. 2 E.	1	.....	.....	.....	1
T. 37, R. 1 E.	36	8	13	.....	15
T. 37, R. 1 W.	36	3L 6S	6Lc 2	.....	19
T. 37, R. 2 W.	36	3L 5S	8Lc	10	10
T. 37, R. 3 W.	36	7L 6S	2Lc	12	9
T. 36, R. 3 W.	36	16L 2S	5Lc	2	11
T. 36, R. 2 W.	36	18L 3S	5Lc	.....	10
T. 36, R. 1 W.	36	4L 10S	14Lc	2	6
T. 36, R. 1 E.	36	9L 7S	4Lc 3	2	11
T. 35, R. 1 E.	36	4L 7S	14	.....	11
T. 35, R. 1 W.	36	5	13	14	4
T. 35, R. 2 W.	36	2L 2S	2Lc 2	3	25
T. 35, R. 3 W.	36	11L 3S	3Lc 1	6	12
T. 34, R. 3 W.	36	1	1	25	9
T. 34, R. 2 W.	36	2	11	8	15
T. 34, R. 1 W.	36	4	10	15	7
T. 34, R. 1 E.	36	7	16	6	7
T. 33, R. 1 E.	36	7	10	13	6
T. 33, R. 1 W.	36	3	25	2	6
T. 33, R. 2 W.	36	3	20	6	7
T. 33, R. 3 W.	36	4	15	10	7
Total.	811	194	244	139	234

Area 724 square miles in 811 sections, including about 80 square miles of lakes.
Number of farms, 1,449.
Average value per acre, $13.85.
Square miles in farms, 188.15.
Per cent of land area in farms, 26.
Per cent of farm land improved 42.3, or 11 per cent of county.
Principal crops: Hay, potatoes, oats, corn, peas, rye.
The lake clay is a very thin and patchy deposit usually over a clayey till. There are a few drumlins of clayey till.

CLARE COUNTY.

Section.	Area sections.	Swamp and lake. Secs.	Clayey till. Secs.	Sandy till. Secs.	Sandy. Secs.	Gravelly loam. Secs.
T. 20, R. 3 W.....	36	4	16	13	3	.....
T. 20, R. 4 W.....	36	2	.....	14	4	16
T. 20, R. 5 W.....	36	2	.....	2	32	.....
T. 20, R. 6 W.....	36	8	8	3	17	.....
T. 19, R. 3 W.....	36	2	16	18	.....	.....
T. 19, R. 4 W.....	36	2	.....	24	.....	10
T. 19, R. 5 W.....	36	2	9	20	5	.....
T. 19, R. 6 W.....	36	8	10	1	17	.....
T. 18, R. 3 W.....	36	5	15	12	4	.....
T. 18, R. 4 W.....	36	2	2	20	5	7
T. 18, R. 5 W.....	36	4	.....	20	4	8
T. 18, R. 6 W.....	36	4	2	2	20	8
T. 17, R. 3 W.....	36	3	20	6	7	.....
T. 17, R. 4 W.....	36	4	21	2	9	.....
T. 17, R. 5 W.....	36	6	2	28	.....	.....
T. 17, R. 6 W.....	36	5	2	11	18	.....
Total.....	576	63	123	196	145	49

Area 569 square miles in 576 sections, including lakes.
Number of farms, 1,302.
Average value per acre, $13.42.
Square miles in farms, 257.7.
Per cent of land area in farms, 44.3.
Per cent of farm land improved 32.7, or 14.48 per cent of county.
Principal crops: Hay, corn, oats, rye, beans, wheat, potatoes, peas.

The gravelly outwash areas included in the last column have a very slight loam capping, and are but little better than the sandy areas. Farming has been developed chiefly on the clayey and sandy till.

CLINTON COUNTY.

Section.	Area sections.	Swamp and lake. Secs.	Clayey till. Secs.	Sandy till. Secs.	Sandy. Secs.	Gravelly loam. Secs.
T. 8 N. R. 1 W.....	36	1	31	.....	2	2
T. 8 N. R. 2 W.....	36	8	27	.....	.....	1
T. 8 N. R. 3 W.....	36	1	23	.....	10	2
T. 8 N. R. 4 W.....	36	1	28	.....	4	3
T. 7 N. R. 1 W.....	36	2	28	.....	6	.....
T. 7 N. R. 2 W.....	36	2	32	.....	2	.....
T. 7 N. R. 3 W.....	36	.....	30	.....	6	.....
T. 7 N. R. 4 W.....	36	.....	32	.....	4	.....
T. 6 N. R. 1 W.....	36	.....	30	.....	6	.....
T. 6 N. R. 2 W.....	36	.....	34	.....	2	.....
T. 6 N. R. 3 W.....	36	.....	36	.....	.....	.....
T. 6 N. R. 4 W.....	36	.....	36	.....	.....	.....
T. 5 N. R. 1 W.....	36	2.5	31	2.5	.....	.....
T. 5 N. R. 2 W.....	36	1	32	.....	3	.....
T. 5 N. R. 3 W.....	36	.....	32	.....	4	.....
T. 5 N. R. 4 W.....	36	.....	31	.....	5	.....
Total.....	576	18.5	493	2.5	54	8

Area 570 square miles in 576 sections.
Number of farms, 3,497.
Average value per acre, $42.30.
Square miles in farms, 549.4.
Per cent of land area in farms, 96.2.
Per cent of farm land improved 80.3, or 77.25 per cent of county.
Principal crops: Hay, oats, corn, wheat, beans, rye.
The moraines as well as till plains are of rich clayey till. The other classes of land are chiefly along the lines of glacial drainage.

CRAWFORD COUNTY.

Section.	Area sections.	Swamp and lake. Secs.	Clayey till. Secs.	Sandy till. Secs.	Sandy. Secs.	Gravelly loam. Secs.
T. 28, R. 1 W.....	36	12	.....	1	23	.....
T. 28, R. 2 W.....	36	6	.....	24	6	.....
T. 28, R. 3 W.....	36	4	18	12	2	.....
T. 28, R. 4 W.....	36	8	12	10	6	.....
T. 27, R. 1 W.....	36	10	.....	5	21	.....
T. 27, R. 2 W.....	36	4	.....	19	13	.....
T. 27, R. 3 W.....	36	8	4	10	14	.....
T. 27, R. 4 W.....	36	10	2	11	13	.....
T. 26, R. 1 W.....	36	8	.....	15	13	.....
T. 26, R. 2 W.....	36	4	.....	7	15	10
T. 26, R. 3 W.....	36	6	.....	8	18	4
T. 26, R. 4 W.....	36	10	.....	4	20	2
T. 25, R. 1 W.....	36	7	.....	10	9	10
T. 25, R. 2 W.....	36	5	1	9	15	6
T. 25, R. 3 W.....	36	4	.....	6	16	10
T. 25, R. 4 W.....	36	1	4	4	7	20
Total.....	576	107	41	155	211	62

Area 561.66 square miles in 576 sections.
Number of farms, 248.
Average value per acre, $10.52.
Square miles in farms, 728.
Per cent of land area in farms, 12.7.
Per cent of farm land improved 23, or 2.92 per cent of county.
Principal crops: Hay, potatoes, oats, corn, buckwheat, rye, wheat.

The gravelly outwash plains like the sandy plains have a very thin and patchy capping of loam. Under careful farming some sandy plains land has yielded fair returns. The slight development of farms has been about equally divided between the sandy till of the moraines and the sandy and gravelly land of the plains.

EATON COUNTY.

Section.	Area sections.	Swamp and lake. Secs.	Clayey till. Secs.	Sandy till. Secs.	Sandy. Secs.	Gravelly. Secs.
T. 4 N. R. 3 W.....	36	6	30	.....	.....	.....
T. 4 N. R. 4 W.....	36	4	32	.....	.....	.....
T. 4 N. R. 5 W.....	36	3	33	.....	.....	.....
T. 4 N. R. 6 W.....	36	4	32	.....	.....	.....
T. 3 N. R. 6 W.....	36	4	22	4	6	.....
T. 3 N. R. 5 W.....	36	3	26	.....	7	.....
T. 3 N. R. 4 W.....	36	6	28	.....	2	.....
T. 3 N. R. 3 W.....	36	7	26	3	.....	.....
T. 2 N. R. 3 W.....	36	9	16	6	5	.....
T. 2 N. R. 4 W.....	36	6	22	5	.....	3
T. 2 N. R. 5 W.....	36	3	29	.....	4	.....
T. 2 N. R. 6 W.....	36	1	32	.....	3	.....
T. 1 N. R. 6 W.....	36	2	18	9	7	.....
T. 1 N. R. 5 W.....	36	3	25	6	.....	2
T. 1 N. R. 4 W.....	36	5	31	.....	.....	.....
T. 1 N. R. 3 W.....	36	2	25	2	7	.....
Total.....	576	68	427	35	41	5

Area 572.6 square miles in 576 sections, including lakes.
Number of farms, 3,902.
Average value per acre, $36.16.
Square miles in farms, 540.4.
Per cent of land area in farms, 94.6.
Per cent of farm land improved 77.7 or 73.5 per cent of the county.
Principal crops: Hay, corn, oats, beans, wheat, potatoes, rye.
The moraines as well as till plains are chiefly clayey till.
The gravel in T. 2 N. R. 4 W. is in the Charlotte esker and esker delta.

EMMET COUNTY.

Section.	Area sections.	Swamp and lake. Secs.	Clayey till. Secs.	Sandy till. Secs.	Sandy. Secs.
T. 39, R. 4 W.	16.5	3	.....	.....	13.5
T. 39, R. 5 W.	10.5	4	.....	.....	6.5
T. 38, R. 4 W.	36	16	2	5	13
T. 38, R. 5 W.	33	13	.....	14	6
T. 38, R. 6 W.	5.5	1	.....	.....	4.5
T. 37, R. 4 W.	36	11	.....	9	16
T. 37, R. 5 W.	36	12	.....	20	4
T. 37, R. 6 W.	33	1.5	.....	30.5	1
T. 37, R. 7 W.	2.5	.....	.....	2.5	.....
T. 36, R. 4 W.	36	7	.....	16	13
T. 36, R. 5 W.	36	11	.....	24	1
T. 36, R. 6 W.	35	1	.....	33	1
T. 36, R. 7 W.	2.5	.....	.....	2.5	.....
T. 35, R. 4 W.	36	10	.....	8	18
T. 35, R. 5 W.	26	4	1	9	12
T. 35, R. 6 W.	9	1	.....	6	2
T. 34, R. 4 W.	36	4	.....	23	9
T. 34, R. 5 W.	34.5	7	12	13.5	2
T. 34, R. 6 W.	19	2.5	11	3.5	2
T. 33, R. 6 W.	1.5	.....	.....	1.5	.....
Total.	480.5	109	26	221	124.5

Area 467.5 square miles in 480.5 sections, including lakes.
Number of farms, 1,457.
Average value per acre, $17.12⅔.
Square miles in farms, 195.3.
Per cent of land area in farms, 41.6.
Per cent of farm land improved 43.4, or 17.5 per cent of county.
Principal crops: Hay, potatoes, oats, corn, rye, peas, wheat.
There is a narrow strip of dunes on the coast of Lake Michigan in north end of county. The settlement is mainly on the sandy till.

GENESEE COUNTY.

Section.	Area sections.	Swamp and lake. Secs.	Clayey till. Secs.	Sandy till. Secs.	Sandy. Secs.	Gravelly loam. Secs.
T. 9 N. R. 5 E.	36	.....	17	.....	19	.....
T. 9 N. R. 6 E.	36	.....	12	6	18	.....
T. 9 N. R. 7 E.	36	1	22	12	.....	1
T. 9 N. R. 8 E.	36	2	16	14	4	.....
T. 8 N. R. 5 E.	36	.....	12 13Lc	.....	5	6
T. 8 N. R. 6 E.	36	.....	34	.....	2	.....
T. 8 N. R. 7 E.	36	.....	12 12Lc	4	8	.....
T. 8 N. R. 8 E.	36	.....	17	8	11	.....
T. 7 N. R. 5 E.	36	1	34	.....	1	.....
T. 7 N. R. 6 E.	36	1	15 12Lc	2	6	.....
T. 7 N. R. 7 E.	36	1	5 26Lc	.....	3	1
T. 7 N. R. 8 E.	36	1	32	.....	3	.....
T. 6 N. R. 5 E.	36	6	28	.....	2	.....
T. 6 N. R. 6 E.	36	.....	36	.....	.....	.....
T. 6 N. R. 7 E.	36	1	30	5	.....	.....
T. 6 N. R. 8 E.	36	1	34	.....	1	.....
T. 5 N. R. 5 E.	36	5	18	5	8	.....
T. 5 N. R. 6 E.	36	4	24	5	3	.....
Total.	648	24	461	61	94	8

Area 642.2 square miles in 648 sections.
Number of farms, 3,896.
Average value per acre, $35.18.
Square miles in farms, 607.
Per cent of land area in farms, 92.7.
Per cent of farm land improved 80.6, 74.7 per cent of county.
Principal crops: Hay, beans, oats, corn, potatoes, wheat, rye.
The gravelly land is chiefly in beaches, deltas and eskers. The lake clay is a thin deposit over clayey till. Moraines as well as till plains are largely clayey till.

GLADWIN COUNTY.

Section.	Area sections.	Swamp and lake. Secs.	Clayey till. Secs.	Sandy till. Secs.	Sandy. Secs.
T. 20, R. 2 W.	36	1	9	20	6
T. 20, R. 1 W.	36	2	7	7	20
T. 20, R. 1 E.	24	12	2Lc	.....	10
T. 20, R. 2 E.	36	5	12Lc	.....	19
T. 19, R. 2 E.	36	5	3Lc	.....	28
T. 19, R. 1 E.	24	5	5Lc	.....	14
T. 19, R. 1 W.	36	5	13	2	16
T. 19, R. 2 W.	36	4	23	4	5
T. 18, R. 2 W.	36	3	15	8	10
T. 18, R. 1 W.	36	6	6	.....	24
T. 18, R. 1 E.	24	6	6	.....	12
T. 18, R. 2 E.	36	4	.....	.....	32
T. 17, R. 2 E.	36	.....	.....	.....	36
T. 17, R. 1 E.	24	6	.....	.....	18
T. 17, R. 1 W.	36	15	.....	.....	21
T. 17, R. 2 W.	36	5	3	.....	28
Total.	528	84	104	41	299

Area 516 square miles in 528 sections, including lakes.
Number of farms, 1,395.
Average value per acre, $18.52.
Square miles in farms, 201.
Per cent of land area in farms, 38.7.
Per cent of farm land improved 42.1, or 16.3 per cent of county.
Principal crops: Hay, oats, corn, rye, potatoes, wheat.

GRAND TRAVERSE COUNTY.

Section.	Area sections.	Swamp and lake. Secs.	Clayey till. Secs.	Sandy till. Secs.	Sandy. Secs.	Gravelly loam. Secs.
T. 30, R. 10 W.	4.5	.....	2.5	.....	2	.....
T. 29, R. 10 W.	12	1	8	.....	3	.....
T. 28, R. 9 W.	26	3	21	2	.....	.....
T. 28, R. 10 W.	13	.....	10	2	1	.....
T. 28, R. 11 W.	1	.....	.....	1	.....	.....
T. 27, R. 9 W.	36	3	.....	12	.....	21
T. 27, R. 10 W.	29.5	4.5	4	16	.....	5
T. 27, R. 11 W.	34	5	3	23	.....	3
T. 27, R. 12 W.	36	5L 3S	2	4	.....	22
T. 26, R. 9 W.	36	3	.....	4	24	5
T. 26, R. 10 W.	36	4	2	3	15	12
T. 26, R. 11 W.	36	5	.....	8	11	12
T. 26, R. 12 W.	36	6L 3S	.....	2	15	10
T. 25, R. 9 W.	36	4	4	11	.....	17
T. 25, R. 10 W.	36	3	.....	27	5	1
T. 25, R. 11 W.	36	5	.....	5	.....	26
T. 25, R. 12 W.	36	4	.....	9	9	14
Total.....	480	61.5	55.5	129	85	148

Area 458 square miles in 480 sections (including 11 sections in lakes, but not including Elk Lake).
Number of farms, 2,031.
Average value per acre, $27.26.
Square miles in farms, 276.
Per cent of land area in farms, 59.1.
Per cent of farm land improved 61.9 or 36.58 per cent of county.
Principal crops: Hay, potatoes, corn, oats, rye, wheat.
The gravelly and sandy outwash plains have generally a light soil and are largely uninhabited. The clayey and sandy tills are productive both for farms and orchards.

GRATIOT COUNTY.

Section.	Area sections.	Swamp and lake. Secs.	Clayey till. Secs.	Sandy. Secs.
T. 12, R. 1 W.	36	1	18.5Lc	16.5
T. 12, R. 2 W.	36	1	5 20 Lc	10
T. 12, R. 3 W.	36	3	25	8
T. 12, R. 4 W.	36	8	15	13
T. 11, R. 4 W.	36	8	12.5	14.5
T. 11, R. 3 W.	36	5.5	17.5	13
T. 11, R. 2 W.	36	1.5	8 25 Lc	1.5
T. 11, R. 1 W.	36	1	31.5Lc	3.5
T. 10, R. 1 W.	36	2	16 Lc	18
T. 10, R. 2 W.	36	.....	5 30	1
T. 10, R. 3 W.	36	.....	33	3
T. 10, R. 4 W.	36	.....	28	8
T. 9, R. 4 W.	36	.....	34 2 Lc	.....
T. 9, R. 3 W.	36	.....	16 20 Lc	.....
T. 9, R. 2 W.	36	.....	36	.....
T. 9, R. 1 W.	36	4	29 Lc	3
Total	576	35	428	113

Area 570 square miles in 576 sections.
Number of farms, 4,205.
Average value per acre, $39.14.
Square miles in farms, 520.5.
Per cent of land area in farms, 89.9.
Per cent of farm land improved 74.7, or 66 per cent of county.
Principal crops: Hay, oats, corn, wheat, potatoes.

The moraines as well as till plains and the lake clay are largely a rich clayey soil. There may be in the aggregate 8 or 10 square miles of stony till scattered over the county, chiefly in kames. The map of the Alma area by U. S. Bureau of Soils, 1904, has been of service in the classification in the northern part of the county.

HILLSDALE COUNTY.

Section.	Area sections.	Swamp and lake. Secs.	Clayey till. Secs.	Sandy till. Secs.	Sandy. Secs.	Gravelly loam. Secs.
T. 5 S. R. 1 W.	36	2.5	11	18	4.5	.....
T. 5 S. R. 2 W.	36	2	4	18	.....	12
T. 5 S. R. 3 W.	36	3	2	27	4	.....
T. 5 S. R. 4 W.	36	2	.....	28	.....	6
T. 6 S. R. 4 W.	36	2	.....	24	4	6
T. 6 S. R. 3 W.	36	4	3	21	.....	8
T. 6 S. R. 2 W.	36	2	19	14	.....	1
T. 6 S. R. 1 W.	36	2	15	19	.....	.....
T. 7 S. R. 1 W.	36	2	25	7	2	.....
T. 7 S. R. 2 W.	36	2	4	20	.....	10
T. 7 S. R. 3 W.	36	3	.....	23	.....	10
T. 7 S. R. 4 W.	36	3	.....	25	3	5
T. 8 S. R. 4 W.	33.5	2	2	22.5	.....	7
T. 8 S. R. 3 W.	36	1	26	8	.....	1
T. 8 S. R. 2 W.	36	1	35	.....	.....	.....
T. 8 S. R. 1 W.	36	2	32	.....	2	.....
T. 9 S. R. 1 W.	8	.....	8	.....	.....	.....
T. 9 S. R. 2 W.	8.5	0.5	8	.....	.....	.....
T. 9 S. R. 3 W.	9	1	8	.....	.....	.....
T. 9 S. R. 4 W.	7.5	.....	1.5	6	.....	.....
Total.	607.5	37	203.5	281.5	19.5	66

Area 601.5 square miles, or 607.5 sections, including lakes.
Number of farms, 4,298.
Average value per acre, $40.98.
Square miles in farms, 582.2.
Per cent of land area in farms, 97.5.
Per cent of farm land improved 78.6 or 76.6 per cent of county.
Principal crops: Hay, corn, oats, wheat, potatoes.
A coating of rich loam generally covers the gravel of the areas in the last column.

HURON COUNTY.

Section.	Area sections.	Swamp and lake. Secs.	Clayey till. Secs.	Sandy till. Secs.	Sandy. Secs.
T. 19, R. 12 E.	2	.....	1Lc	.....	1
T. 19, R. 13 E.	13	.....	12Lc	.....	1
T. 19, R. 14 E.	3	.....	3Lc	.....	.....
T. 18, R. 15 E.	7	.....	7Lc	.....	.....
T. 18, R. 14 E.	34	.....	34Lc	.....	.....
T. 18, R. 13 E.	36	.....	26Lc	.....	.....
T. 18, R. 12 E.	30	.....	24Lc	.....	6
T. 18, R. 11 E.	21	4	11Lc	.....	6
T. 18, R. 10 E.	4.5	.....	2Lc	.....	2.5
T. 17, R. 9 E.	3	.....	.....	.....	3
T. 17, R. 10 E.	28	.....	20Lc	.....	8
T. 17, R. 11 E.	36	.....	36Lc	.....	.....
T. 17, R. 12 E.	36	.....	36Lc	.....	.....
T. 17, R. 13 E.	36	.....	30Lc	.....	6
T. 17, R. 14 E.	36	.....	36Lc	.....	.....
T. 17, R. 15 E.	23	.....	23Lc	.....	.....
T. 16, R. 16 E.	3	.....	3Lc	.....	.....
T. 16, R. 15 E.	35	.....	35Lc	.....	.....
T. 16, R. 14 E.	36	.....	10 22Lc	3	1
T. 16, R. 13 E.	36	.....	3Lc	9	24
T. 16, R. 12 E.	36	.....	20Lc	2	14
T. 16, R. 11 E.	36	.....	35Lc	1	.....
T. 16, R. 10 E.	36	5	30Lc	.....	1
T. 16, R. 9 E.	18	.....	14Lc	.....	4
T. 15, R. 9 E.	33	2.5	28Lc	.....	2.5
T. 15, R. 10 E.	36	5	30Lc	.....	1
T. 15, R. 11 E.	36	2	14Lc	11	9
T. 15, R. 12 E.	36	1	.....	14	21
T. 15, R. 13 E.	36	5	.....	17	14
T. 15, R. 14 E.	36	1	24	8	3
T. 15, R. 15 E.	36	.....	4 32Lc	.....	.....
T. 15, R. 16 E.	8	.....	8Lc	.....	.....
Total.	841.5	25.5	623	65	128

Area 837 square miles in 841.5 sections.
Number of farms, 4,728.
Square miles in farms, 737.5.
Average value per acre, $30.38.
Per cent of land area in farms, 86.4.
Per cent of farm land improved 75.6, or 65.32 per cent of county.
Principal crops: Hay, oats, wheat, beans, corn, potatoes, barley.

The lake clay forms a thin coating over the compact clayey till, and each need considerable tile draining. The classification is largely based on map and report by A. C. Lane (Geol. Survey of Michigan Vol. 7, Part II, 1900). The southwest part is based on map of Saginaw area by U. S. Bureau of Soils 1904.

INGHAM COUNTY.

Section.	Area sections.	Swamp and lake. Secs.	Clayey till. Secs.	Sandy till. Secs.	Sandy. Secs.	Gravelly loam. Secs.
T. 4 N. R. 2 W.....	36	2.5	26	4	3.5	.....
T. 4 N. R. 1 W.....	36	5.5	25	4	1.5	.....
T. 4 N. R. 1 E.....	29.5	4	19.5	4	2	.....
T. 4 N. R. 2 E.....	36	3.5	27.5	2	3	.....
T. 3 N. R. 2 E.....	36	5	28	.....	2	1
T. 3 N. R. 1 E.....	31	4.5	25	.....	.....	1.5
T. 3 N. R. 1 W.....	36	6.5	27.5	2	.....	.....
T. 3 N. R. 2 W.....	36	8	25	2	.....	1
T. 2 N. R. 2 W.....	36	8	16	12	.....	.....
T. 2 N. R. 1 W.....	36	5	22	8	.....	1
T. 2 N. R. 1 E.....	33	6.5	13.5	12	.....	1
T. 2 N. R. 2 E.....	36	8	20.5	7	.....	0.5
T. 1 N. R. 2 E.....	36	6	6	15	9	.....
T. 1 N. R. 1 E.....	33	7	14	7	4	1
T. 1 N. R. 1 W.....	36	4	14	12	6	.....
T. 1 N. R. 2 W.....	36	4	14	12	5	1
Total.....	558.5	88	323.5	103	36	8

Area 553.5 square miles in 558.5 sections, including lakes.
Number of farms, 3,508.
Average value per acre, $36.95.
Square miles in farms, 520.4.
Per cent of land area in farms, 94.1.
Per cent of farm land improved 74.5 or 70.1 per cent of county.
Principal crops: Hay, corn, oats, beans, potatoes, wheat, rye.
The gravel is principally in eskers. The moraines as well as till plains are largely a rich clay soil. Swamp areas are largely estimated from topographic maps of U. S. Geological Survey.

IONIA COUNTY.

Section.	Area sections.	Swamp and lake. Secs.	Clayey till. Secs.	Sandy till. Secs.	Sandy. Secs.
T. 8 N. R. 5 W.	36	1.5	28	.....	6.5
T. 8 N. R. 6 W.	36	1	30	.....	5
T. 8 N. R. 7 W.	36	2	20	.....	14
T. 8 N. R. 8 W.	36	.....	22	.....	14
T. 7 N. R. 8 W.	36	.....	12	20	4
T. 7 N. R. 7 W.	36	.....	28	.....	8
T. 7 N. R. 6 W.	36	.....	26	.....	10
T. 7 N. R. 5 W.	36	.....	24	.....	12
T. 6 N. R. 5 W.	36	.....	28	.....	8
T. 6 N. R. 6 W.	36	3	32	.....	1
T. 6 N. R. 7 W.	36	1	33	.....	2
T. 6 N. R. 8 W.	36	2	15	13	6
T. 5 N. R. 8 W.	36	1	33	2	.....
T. 5 N. R. 7 W.	36	8	26	.....	2
T. 5 N. R. 6 W.	36	5	30	.....	1
T. 5 N. R. 5 W.	36	.....	34	.....	2
Total.	576	24.5	421	35	95.5

Area 573 square miles in 576 sections.
Number of farms, 3,602.
Average value per acre, $36.85.
Square miles in farms, 549.2.
Per cent of land area in farms, 94.9.
Per cent of farm land improved 79.1, or 75.56 per cent of county.
Principal crops: Hay, corn, wheat, oats, beans, potatoes, rye.
The moraines as well as till plains are largely rich clay soil.
The sandy land, chiefly along lines of glacial drainage, has usually a loam admixture or cover

IOSCO COUNTY.

Section.	Area sections.	Swamp and lake. Secs.	Clayey till. Secs.	Sandy till. Secs.	Sandy. Secs.
T. 24, R. 5 E.	36	7	5	3	21
T. 24, R. 6 E.	36	.....	.....	.....	36
T. 24, R. 7 E.	36	.....	.....	.....	36
T. 24, R. 8 E.	36	10	.....	.....	26
T. 24, R. 9 E.	23	3L 1S	.....	.....	19
T. 23, R. 5 E.	36	4	26	4	2
T. 23, R. 6 E.	36	1	5	.....	30
T. 23, R. 7 E.	36	1	2	3	30
T. 23, R. 8 E.	36	8	5	.....	23
T. 23, R. 9 E.	20	3	.....	.....	17
T. 22, R. 5 E.	36	2	30	.....	4
T. 22, R. 6 E.	36	2	16	.....	18
T. 22, R. 7 E.	35.5	1.5	26	.....	8
T. 22, R. 8 E.	25	3L 4S	2	.....	16
T. 22, R. 9 E.	2	.....	.....	.....	2
T. 21, R. 5 E.	36	2	22	.....	12
T. 21, R. 6 E.	36	5	2	.....	29
T. 21, R. 7 E.	26	2	12	.....	12
Total.	563.5	69.5	153	10	341

Area 553 square miles in 563.5 sections, including lakes.
Number of farms, 958.
Average value per acre, $13.03.
Square miles in farms, 176.
Per cent of land area in farms, 30.9.
Per cent of farm land improved 36.1, or 11.15 per cent of county.
Principal crops: Hay, potatoes, oats, corn, peas, rye.

The productive soil is chiefly in the western part, the remainder being largely a light sandy soil. In the ancient delta of the Au Sable there is very little loam.

ISABELLA COUNTY.

Section.	Area sections.	Swamp and lake. Secs.	Clayey till. Secs.	Sandy till. Secs.	Sandy. Secs.	Gravelly loam. Secs.
T. 16, R. 3 W.	36	2	6 25Lc	.....	3	.....
T. 16, R. 4 W.	36	3	12	17	1	3
T. 16, R. 5 W.	36	4	4	18	2	8
T. 16, R. 6 W.	36	.....	.....	33	3	.....
T. 15, R. 6 W.	36	1	3	10	22	.....
T. 15, R. 5 W.	36	1	10	10	5	10
T. 15, R. 4 W.	36	.....	9 13Lc	10	4	.....
T. 15, R. 3 W.	36	.....	21	.....	15	.....
T. 14, R. 3 W.	36	2	8 2Lc	.....	24	.....
T. 14, R. 4 W.	36	1	20	5	10	.....
T. 14, R. 5 W.	36	4	6	13	5	8
T. 14, R. 6 W.	36	2	10	16	8	.....
T. 13, R. 6 W.	36	.....	7	15	14	.....
T. 13, R. 5 W.	36	4	2	22	8	.....
T. 13, R. 4 W.	36	3	16	12	5	.....
T. 13, R. 3 W.	36	2	27	4	3	.....
Total.	576	29	201	185	132	29

Area 576 square miles and 576 sections.
Number of farms, 3,456.
Average value per acre, $29.14.
Square miles in farms, 466.
Per cent of land area in farms, 81.4.
Per cent of farm land improved 64.8, or 52.7 per cent of county.
Principal crops: Hay, beans, corn, oats, wheat, rye, potatoes.
The gravelly land has only a thin and patchy coating of loam.
The lake clay is a thin deposit over clayey till. The undeveloped land is largely in the sandy portion.

JACKSON COUNTY.

Section.	Area sections.	Swamp and lake. Secs.	Clayey till. Secs.	Sandy till. Secs.	Sandy. Secs.	Gravelly loam. Secs.
T. 1 S. R. 2 E.	36	10	5	9	12	.....
T. 1 S. R. 1 E.	36	9	4	20	3	.....
T. 1 S. R. 1 W.	36	3	3	22	8	1
T. 1 S. R. 2 W.	36	1	.....	28	7	.....
T. 1 S. R. 3 W.	36	5	9	19	.....	3
T. 2 S. R. 3 W.	36	2	.....	27	3	4
T. 2 S. R. 2 W.	36	3	5	26	2	.....
T. 2 S. R. 1 W.	36	5	10	15	6	.....
T. 2 S. R. 1 E.	36	8	.....	9	10	9
T. 2 S. R. 2 E.	36	3	.....	8	4	21
T. 3 S. R. 2 E.	36	3	.....	10	2	21
T. 3 S. R. 1 E.	36	4	3	5	7	17
T. 3 S. R. 1 W.	36	4	.....	10	15	7
T. 3 S. R. 2 W.	36	4	.....	20	4	8
T. 3 S. R. 3 W.	36	5	.....	24	7	.....
T. 4 S. R. 3 W.	36	7	.....	27	2	.....
T. 4 S. R. 2 W.	36	6	.....	23	3	4
T. 4 S. R. 1 W.	36	4	.....	24	.....	8
T. 4 S. R. 1 E.	36	4	.....	20	8	.....
T. 4 S. R. 2 E.	36	5	4	3	8	20
Total.	720	94	43	349	111	123

Area 712.3 square miles in 720 sections, including lakes.
Number of farms, 3,736.
Average value per acre, $33.96.
Square miles in farms, 660.
Per cent of land area in farms, 93.4.
Per cent of farm land improved 72, or 67.25 per cent of county.
Principal crops: Hay, corn, oats, wheat, rye, potatoes.

The sandy till though productive is exceptionally stony, wall fences being common in much of the western half of the county. The gravelly outwash plains have a thin cover of rather light sandy loam. Eskers and prominent kames are included in the gravelly land.

KALAMAZOO COUNTY.

Section.	Area sections.	Swamp and lake. Secs.	Clayey till. Secs.	Sandy till. Secs.	Sandy. Secs.	Gravelly loam. Secs.
T. 1 S. R. 9 W.	36	4	.....	6	3	23
T. 1 S. R. 10 W.	36	4	.....	.....	.....	32
T. 1 S. R. 11 W.	36	5	.....	9	7	15
T. 1 S. R. 12 W.	36	6	.....	10	18	2
T. 2 S. R. 12 W.	36	1	.....	19	10	6
T. 2 S. R. 11 W.	36	6	.....	3	8	19
T. 2 S. R. 10 W.	36	2	.....	1	12	21
T. 2 S. R. 9 W.	36	2	.....	17	7	10
T. 3 S. R. 9 W.	36	1	20	1	.....	14
T. 3 S. R. 10 W.	36	3	1	.....	.....	32
T. 3 S. R. 11 W.	36	5	.....	.....	.....	31
T. 3 S. R. 12 W.	36	3	.....	9	.....	24
T. 4 S. R. 12 W.	36	1	.....	3	.....	32
T. 4 S. R. 11 W.	36	3	.....	.....	.....	33
T. 4 S. R. 10 W.	36	1	12	.....	.....	23
T. 4 S. R. 9 W.	36	3	33	.....	.....	.....
Total.	576	50	66	78	65	317

Area 559 square miles in 576 sections, including lakes.
Number of farms, 3,372.
Average value per acre, $41.72.
Square miles in farms, 517.2.
Per cent of land area in farms, 92.
Per cent of farm land improved 80.7, or 71.25 per cent of county.
Principal crops: Hay, corn, wheat, oats, potatoes, rye.
The extensive gravel plains have usually a rich loam at surface. Vineyards are planted extensively on the lightest portions of the sandy till.

KALKASKA COUNTY.

Section.	Area sections.	Swamp and lake. Secs.	Clayey till. Secs.	Sandy till. Secs.	Sandy. Secs.	Gravelly loam. Secs.
T. 28, R. 5 W.....	36	8	.....	15	13	.....
T. 28, R. 6 W.....	36	4	.....	14	.....	18
T. 28, R. 7 W.....	36	2	.....	7	.....	27
T. 28, R. 8 W.....	35	2L 4S	2	21	6	.....
T. 27, R. 5 W.....	36	6	.....	18	.....	12
T. 27, R. 6 W.....	36	11	.....	7	.....	18
T. 27, R. 7 W.....	36	5	.....	8	10	13
T. 27, R. 8 W.....	36	4	.....	6	14	12
T. 26, R. 5 W.....	36	8	.....	8	20	.....
T. 26, R. 6 W.....	36	16	.....	2	18	.....
T. 26, R. 7 W.....	36	6	.....	11	6	13
T. 26, R. 8 W.....	36	3	.....	21	10	2
T. 25, R. 5 W.....	36	2	3	10	18	3
T. 25, R. 6 W.....	36	4	.....	8	24	.....
T. 25, R. 7 W.....	36	3	.....	14	13	6
T. 26, R. 8 W.....	36	6	.....	22	8	.....
Total.....	575	94	5	192	160	124

Area 561 square miles in 575 sections, including lakes.
Number of farms, 842.
Average value per acre, $16.15.
Square miles in farms, 126.
Per cent of land area in farms, 22.
Per cent of farm land improved 52.9, or 11.64 per cent of county.
Principal crops: Hay, potatoes, corn, oats, rye, wheat.

The gravelly plains like the sandy have only a thin patchy cover of loam. Farming is usually profitable along a morainic belt of sandy till southeast of Boardman River.

KENT COUNTY.

Section.	Area sections.	Swamp and lake. Secs.	Clayey till. Secs.	Sandy till. Secs.	Sandy. Secs.	Gravelly loam. Secs.
T. 10 N. R. 9 W.	36	4	13	3	16	.....
T. 10 N. R. 10 W.	36	2	6	10	14	4
T. 10 N. R. 11 W.	36	2	3	17	13	1
T. 10 N. R. 12 W.	36	1	7	10	18	.....
T. 9 N. R. 12 W.	36	1	10	17	8	.....
T. 9 N. R. 11 W.	36	.....	2	14	20	.....
T. 9 N. R. 10 W.	36	2	16	7	11	.....
T. 9 N. R. 9 W.	36	4	12	8	12	.....
T. 8 N. R. 9 W.	36	4	24	8	.....	.....
T. 8 N. R. 10 W.	36	2	2	26	6	.....
T. 8 N. R. 11 W.	36	2	1	15	14	4
T. 8 N. R. 12 W.	36	1	23	11	1	.....
T. 7 N. R. 12 W.	36	.....	8	19	9	.....
T. 7 N. R. 11 W.	36	2	18	9	4	3
T. 7 N. R. 10 W.	36	2	.....	21	11	2
T. 7 N. R. 9 W.	36	1	2	25	8	.....
T. 6 N. R. 9 W.	36	1	11	17	7	.....
T. 6 N. R. 10 W.	36	1	9	18	8	.....
T. 6 N. R. 11 W.	36	.....	23	2	11	.....
T. 6 N. R. 12 W.	36	.....	.....	8	28	.....
T. 5 N. R. 12 W.	36	.....	.....	26	10	.....
T. 5 N. R. 11 W.	36	.....	25	8	3	.....
T. 5 N. R. 10 W.	36	2	17	7	10	.....
T. 5 N. R. 9 W.	36	1	27	8	.....	.....
Total.	864	35	259	314	242	14

Area 852.2 square miles in 864 sections, including lakes.
Number of farms, 6,276.
Average value per acre, $39.00.
Square miles in farms, 759.44.
Per cent of land area in farms, 88.3.
Per cent of farm land improved 75.2, or 66.4 per cent of county.
Principal crops: Hay, potatoes, corn, oats, wheat, rye, beans.
The outwash and glacial drainage is chiefly sandy with a thin or patchy cover of loam.

LAKE COUNTY.

Section.	Area sections.	Swamp and lake. Secs.	Clayey till. Secs.	Sandy till. Secs.	Sandy. Secs.	Gravelly loam. Secs.
T. 20, R. 11 W.	36	2	.....	20	5	9
T. 20, R. 12 W.	36	5	.....	11	20	.....
T. 20, R. 13 W.	36	1	.....	5	30	.....
T. 20, R. 14 W.	36	8	.....	8	17	3
T. 19, R. 11 W.	36	1	.....	28	7	.....
T. 19, R. 12 W.	36	9	.....	15	12	.....
T. 19, R. 13 W.	36	2	2	6	14	12
T. 19, R. 14 W.	36	9	.....	8	14	5
T. 18, R. 11 W.	36	.....	7	29	.....	.....
T. 18, R. 12 W.	36	11	.....	12	8	5
T. 18, R. 13 W.	36	2	.....	5	17	12
T. 18, R. 14 W.	36	5	.....	8	11	12
T. 17, R. 11 W.	36	2	20	12	2	.....
T. 17, R. 12 W.	36	4	.....	8	16	8
T. 17, R. 13 W.	36	.....	.....	1	35	.....
T. 17, R. 14 W.	36	4	3	12	3	14
Total.	576	65	32	188	211	80

Area 571 square miles in 576 sections, including lakes.
Number of farms, 732.
Average value per acre, $14.03.
Square miles in farms, 137.
Per cent of land area in farms, 23.7.
Per cent of farm land improved 38.6, or 8.15 per cent of county.
Principal crops: Hay, potatoes, corn, rye, oats.

The outwash plains are generally sandy and largely uninhabited. Farming has been developed chiefly in the eastern half on sandy and clayey till.

LAPEER COUNTY.

Section.	Area sections.	Swamp and lake. Secs.	Clayey till. Secs.	Sandy till. Secs.	Sandy. Secs.	Gravelly loam. Secs.
T. 10, R. 10 E.	36	1	27	3	5	.....
T. 10, R. 11 E.	36	1	30	2	3	.....
T. 10, R. 12 E. (South Half)	18	1.5	15	1.5	.....	.....
T. 9, R. 9 E.	36	1	21	5	9	.....
T. 9, R. 10 E.	36	1	8	17	10	.....
T. 9, R. 11 E.	36	8	20	6	2	.....
T. 9, R. 12 E.	36	4	28	2	2	.....
T. 8, R. 9 E.	36	4	14	8	10	.....
T. 8, R. 10 E.	36	2	20	12	.....	2
T. 8, R. 11 E.	36	6	16	14	.....	.....
T. 8, R. 12 E.	36	8	18 2Lc	6	2	.....
T. 7, R. 9 E.	36	2	20	.....	4	.....
T. 7, R. 10 E.	36	2	26	6	2	.....
T. 7, R. 11 E.	36	7	4	3	2	.....
T. 7, R. 12 E.	36	9	4 14Lc	3	6	.....
T. 6, R. 9 E.	36	2	17	11	6	.....
T. 6, R. 10 E.	36	5	7	22	2	.....
T. 6, R. 11 E.	36	5	8	21	2	.....
T. 6, R. 12 E.	36	6	6Lc 15	6	3	.....
Total.	666	75.5	370	148.5	70	2

Area 662.5 square miles in 666 sections, including lakes.
Number of farms, 3,808.
Average value per acre, $25.51.
Square miles in farms, 625.7.
Per cent of land area in farms, 93.9.
Per cent of land area improved 74.1, or 68.58 per cent of county.
Principal crops: Hay, oats, potatoes, beans, corn, rye, wheat.
Sandy land chiefly in lines of glacial drainage. The lake clay forms a very thin coating over clayey till.

LEELANAU COUNTY.

Section.	Area sections.	Swamp and lake. Secs.	Clayey till. Secs.	Sandy till. Secs.	Sandy. Secs.	Gravelly loam. Secs.
Fox Islands	7	.....	.....	.....	7	.....
T. 32, R. 10 W	3.5	.....	.....	.....	3.5	.....
T. 32, R. 11 W	11	1	2	3	5	.....
N. Manitou Island	21	2	.....	16	3	.....
S. Manitou Island	7	.....	.....	7	.....	.....
T. 31, R. 11 W	26	2	18	3	3	.....
T. 31, R. 12 W	5.5	1.5	2	.....	2	.....
T. 30, R. 11 W	23	1	12	6	4	.....
T. 30, R. 12 W	24	5L 1S	7	2	9	.....
T. 30, R. 13 W	1.5	.....	.....	1.5	.....	.....
T. 29, R. 11 W	19.5	0.5	3	9	2	5
T. 29, R. 12 W	35.5	4L 3S	10	15.5	3	.....
T. 29, R. 13 W	33.5	3L 3S	12	9	6.5	.....
T. 29, R. 14 W	20	5L 1S	.....	10	4	.....
T. 29, R. 15 W	1	.....	.....	0.5	0.5	.....
T. 28, R. 11 W	14	1	7	2	4	.....
T. 28, R. 12 W	36	3L 7S	3	16	7	.....
T. 28, R. 13 W	36	2	.....	16	.....	18
T. 28, R. 14 W	36	4L 2S	.....	16	.....	14
T. 28, R. 15 W	3.5	0.5	.....	1	2	.....
Total	364.5	52.5	76	133.5	65.5	37

Area 342.6 square miles in 363.5 sections, including 24 sections in lakes.
Number of farms, 1,444.
Average value per acre, $20.52.
Square miles in farms, 249.
Per cent of land area in farms, 73.6.
Per cent of farm land improved 52.6, or 38.7 per cent of county.
Principal crops: Potatoes, hay, corn, oats, rye, wheat.

This county has a good soil and is in an exceptionally favored situation for growing orchards, fruits, and vegetables, being a peninsula between Lake Michigan and Grand Traverse Bay. But in this direction there has been less development than in neighboring counties. The Manitou Islands in Lake Michigan (which belong to this county) are also favorably situated for growing orchards and fruits.

LENAWEE COUNTY.

Section.	Area sections.	Swamp and lake. Secs.	Clayey till. Secs.	Sandy till. Secs.	Sandy. Secs.	Gravelly loam. Secs.
T. 5 S. R. 1 E.	36	3	5	16	3	9
T. 5 S. R. 2 E.	36	4	10	14	.....	8
T. 5 S. R. 3 E.	36	2	21	10	3	.....
T. 5 S. R. 4 E.	36	1	15	10	8	2
T. 4 S. R. 5 E.	36	1	3 24Lc	3	3	2
T. 6 S. R. 5 E.	36	.....	30Lc	.....	5	1
T. 6 S. R. 4 E.	36	1	6 6Lc	5	7	11
T. 6, R. 3 E.	36	1	27	3	2	3
T. 6, R. 2 E.	36	1	30	5	.....	.....
T. 6, R. 1 E.	36	4	12	20	.....	.....
T. 7, R. 1 E.	36	1	32	2	1	.....
T. 7, R. 2 E.	36	1	33	.....	2	.....
T. 7, R. 3 E.	36	1	16	9	10	.....
T. 7, R. 4 E.	36	1	3Lc	5	27	.....
T. 7, R. 5 E.	36	1	11Lc	.....	24	.....
T. 8, R. 5 E.	36	.....	35Lc	.....	1	.....
T. 8, R. 4 E.	36	.....	34Lc	.....	2	.....
T. 8, R. 3 E.	36	.....	30Lc	3	3	.....
T. 8, R. 2 E.	36	.....	5 4Lc	5	22	.....
T. 8 S. R. 1 E.	36	1	31	.....	4	.....
T. 9 S. R. 1 E.	6.5	.....	4.5	.....	2	.....
T. 9 S. R. 2 E.	6.0	.....	2	2	2	.....
T. 9 S. R. 3 E.	5.5	.....	5.5	.....	.....	.....
T. 9 S. R. 4 E.	4.5	.....	4.5	.....	.....	.....
T. 9 S. R. 5 E.	3.5	.....	3.5	.....	.....	.....
Total.	746	24	443	112	131	36

Area 754.4 square miles in 746 sections, including lakes.
Number of farms, 5,334.
Average value per acre, $53.26.
Square miles in farms, 722.
Per cent of land area in farms, 97.2.
Per cent of farm land improved 82.2, or 79.9 per cent of county.
Principal crops: Hay, corn, oats, wheat, potatoes.

Aside from the sandy land, which is confined largely to the old lake beds and deltas, this county has an exceptionally productive soil under a high state of cultivation. The sandy soil has in places a light loam at surface, while in places in the eastern part a clay subsoil at moderate depth keeps the sand moist and productive.

LIVINGSTON COUNTY.

Section.	Area sections.	Swamp and lake. Secs.	Clayey till. Secs.	Sandy till. Secs.	Sandy. Secs.	Gravelly loam. Secs.
T. 4 N. R. 3 E.	36	4	22	5	5	.....
T. 4 N. R. 4 E.	36	4	26	3	2	1
T. 4 N. R. 5 E.	36	4	23	5	4	.....
T. 4 N. R. 6 E.	36	3.5	16.5	10	6	.....
T. 3 N. R. 6 E.	36	5	18	9	4	.....
T. 3 N. R. 5 E.	36	2.5	29	2.5	.....	2
T. 3 N. R. 4 E.	36	3.5	27	3	2	0.5
T. 3 N. R. 3 E.	36	4	25	2	4	1
T. 2 N. R. 3 E.	36	10	22	2	1	1
T. 2 N. R. 4 E.	36	4	23	7	2	.....
T. 2 N. R. 5 E.	36	5	11	16	2	2
T. 2 N. R. 6 E.	36	4.5	5.5	11	.....	15
T. 1 N. R. 6 E.	36	7	6	8	.....	15
T. 1 N. R. 5 E.	36	9	4	13	.....	10
T. 1 N. R. 4 E.	36	5.5	4.5	17	.....	9
T. 1 N. R. 3 E.	36	7	8	18	.....	8
Total.	576	82.5	265.5	131.5	32	64.5

Area 578.4 square miles in 576 sections, including lakes.
Number of farms, 2,775.
Average value per acre, $27.17.
Square miles in farms, 545.4.
Per cent of land area in farms, 96.
Per cent of farm land improved 70.9, or 68 per cent of county.
Principal crops: Hay, corn, oats, beans, rye, wheat, potatoes.
In the gravelly land are included eskers in the central and northwestern parts. The outwash plains have only a thin cover of loam. Swamp areas are largely estimated from topographic maps of the U. S. Geological Survey.

MACOMB COUNTY.

Section.	Area sections.	Swamp and lake. Secs.	Clayey till. Secs.	Sandy till. Secs.	Sandy. Secs.	Gravelly loam. Secs.
T. 5 N. R. 12 E.	36	2	19 7Lc	2	5	1
T. 5 N. R. 13 E.	36	1	30Lc	.....	4	1
T. 5 N. R. 14 E.	36	1	31Lc	.....	3	1
T. 4 N. R. 14 E.	36	.....	27Lc	.....	8	1
T. 4 N. R. 13 E.	36	.....	23	.....	12	1
T. 4 N. R. 12 E.	36	1	9 9Lc	5	6	6
T. 3 N. R. 12 E.	36	0.5	4Lc	1.5	28	2
T. 3 N. R. 13 E.	36	.....	16Lc	.....	9	1
T. 3 N. R. 14 E.	30	1	25Lc	.....	4	.....
T. 2 N. R. 14 E.	15	4	10Lc	.....	1	.....
T. 2 N. R. 13 E.	36	.....	32Lc	.....	4	.....
T. 2 N. R. 12 E.	36	.....	18Lc	.....	18	.....
T. 1 N. R. 12 E.	36	2	12Lc	.....	22	.....
T. 1 N. R. 13 E.	27.5	.....	25.5Lc	.....	2	.....
Total.	468.5	12.5	297.5	8.5	136	14

Area 479.6 square miles in 468.5 sections.
Number of farms, 3,764.
Average value per acre, $44.85.
Square miles in farms, 447.7.
Per cent of land area in farms, 94.8.
Per cent of farm land improved 80.8, or 76.6 per cent of county.
Principal crops: Hay, oats, corn, potatoes, wheat, beans, rye.

The blue clay is a thin deposit generally overlying clayey till. The sandy and gravelly soils of lake bottoms as well as of outwash plains have in places a light sandy loam at surface and are largely under cultivation.

MANISTEE COUNTY.

Section.	Area sections.	Swamp and lake. Secs.	Clayey till. Secs.	Sandy till. Secs.	Sandy. Secs.	Gravelly loam. Secs.
T. 24, R. 13 W.....	36	2	.....	14	8	12
T. 24, R. 14 W.....	36	2	.....	2	32	.....
T. 24, R. 15 W.....	36	2	.....	9	.....	25
T. 24, R. 16 W.....	19	2	2	8	3	4
T. 23, R. 13 W.....	36	2	3	13	3	15
T. 23, R. 14 W.....	36	4	2	4	26	.....
T. 23, R. 15 W.....	36	3	1	17	.....	15
T. 23, R. 16 W.....	22	6L	.....	11	4	1
T. 22, R. 13 W.....	36	3	.....	15	12	6
T. 22, R. 14 W.....	36	3	.....	9	24	.....
T. 22, R. 15 W.....	36	3	.....	15	16	2
T. 22, R. 16 W.....	33.5	6.5	.....	18	9	.....
T. 22, R. 17 W.....	1.5	.....	.....	1	0.5	.....
T. 21, R. 13 W.....	36	.....	.....	.....	36	.....
T. 21, R. 14 W.....	36	2	.....	3	31	.....
T. 21, R. 15 W.....	36	.....	.....	3	33	.....
T. 21, R. 16 W.....	36	7	.....	1	28	.....
T. 21, R. 17 W.....	15	1	.....	2	7	5
Total.....	559	48.5	8	145	272.5	85

Area 540 square miles in 559 sections.
Number of farms, 1,648.
Average value per acre, $22.75.
Square miles in farms, 226.4.
Per cent of land area in farms, 40.3.
Per cent of farm land improved 51.7, or 20.8 per cent of county.
Principal crops: Potatoes, hay, corn, rye, oats.
Much of the gravelly land as well as sandy till has been farmed profitably. The sandy and is largely uncultivated.

MASON COUNTY.

Section.	Area sections.	Swamp and lake. Secs.	Clayey till. Secs.	Sandy till. Secs.	Sandy. Secs.	Gravelly loam. Secs.
T. 20, R. 15 W.....	36	4	.....	1	31	.....
T. 20, R. 16 W.....	36	6	4	4	22	.....
T. 20, R. 17 W.....	36	10	4	2	20	.....
T. 20, R 18 W.....	9	.....	.....	.....	9	.....
T. 19, R. 15 W.....	36	8	10	10	8	.....
T. 19, R. 16 W.....	36	5	14	2	15	.....
T. 19, R. 17 W.....	36	2	5	8	21	.....
T. 19, R. 18 W.....	31	4.5	1.5	1	24	.....
T. 18, R. 15 W.....	36	7	2	2	13	12
T. 18, R. 16 W.....	36	2	18	5	11	.....
T. 18, R. 17 W.....	36	4	5	4	23	.....
T. 18, R. 18 W.....	16	3	2	1	10	.....
T. 17, R. 15 W.....	36	3	3	18	12	.....
T. 17, R. 16 W.....	36	4	4	18	10	.....
T. 17, R. 17 W.....	36	8	20	2	6	.....
T. 17, R. 18 W.....	11	3	6	.....	2	.....
Total.....	499	73.5	98.5	78	237	12

Area 493 square miles in 499 sections, including lakes.
Number of farms, 2,124.
Average value per acre, $30.08.
Square miles in farms, 267.66.
Per cent of land area in farms, 54.2.
Per cent of farm land improved 58.9, or 31.9 per cent of county.
Principal crops: Hay, potatoes, corn, wheat, oats, rye.

There is considerable uninhabited sandy land in the northern part, and a belt of dunes north from Ludington extending in some places some miles inland. The remainder of the county is largely productive improved land.

MECOSTA COUNTY.

Section.	Area sections.	Swamp and lake. Secs.	Clayey till. Secs.	Sandy till. Secs.	Sandy. Secs.	Gravelly loam. Secs.
T. 16, R. 7 W.....	36	6	3	21	6	.....
T. 16, R. 8 W.....	36	4	.....	27	5	.....
T. 16, R. 9 W.....	36	3	.....	23	10	.....
T. 16, R. 10 W.....	36	.....	10	14	12	.....
T. 15, R. 10 W.....	36	2	.....	24	10	.....
T. 15, R. 9 W.....	36	3	.....	28	5	.....
T. 15, R. 8 W.....	36	8	.....	19	.....	9
T. 15, R. 7 W.....	36	5	6	23	2	.....
T. 14, R. 7 W.....	36	2	8	26	.....	.....
T. 14, R. 8 W.....	36	3	.....	6	13	14
T. 14, R. 9 W.....	36	.....	8	27	.....	1
T. 14, R. 10 W.....	36	.....	.....	17	19	.....
T. 13, R. 10 W.....	36	2	6	10	.....	18
T. 13, R. 9 W.....	36	.....	10	14	12	.....
T. 13, R. 8 W.....	36	2	4	7	18	5
T. 13, R. 7 W.....	36	2	13	13	8	.....
Total.....	576	42	68	299	120	47

Area 565.5 square miles in 576 sections, including lakes.
Number of farms, 2,823.
Average value per acre, $16.67.
Square miles in farms, 446.5.
Per cent of land area in farms, 78.2.
Per cent of farm land improved 55.9, or 43.7 per cent of county.
Principal crops: Hay, corn, potatoes, rye, oats, beans, wheat.

There is very little loam on the sand and gravel outwash plains and they are largely uncultivated. About 40 per cent of the sandy till has light soil, the remainder ranges from sandy loam to stony but is productive.

MIDLAND COUNTY.

Section.	Area sections.	Clayey till. Secs.	Sandy. Secs.
T. 16, R. 2 E	36	16	20
T. 16, R. 1 E	24	10	14
T. 16, R. 1 W	36	10	26
T. 16, R. 2 W	36	9	27
T. 15, R. 2 W	36	15	21
T. 15, R. 1 W	36	11	25
T. 15, R. 1 E	24	2	22
T. 15, R. 2 E	36	19	17
T. 14, R. 2 E	36	15	21
T. 14, R. 1 E	24	9	15
T. 14, R. 1 W	36	8	28
T. 14, R. 2 W	36	9	27
T. 13, R. 2 W	36	11	25
T. 13, R. 1 W	36	19	17
T. 13, R. 1 E	24	18	6
T. 13, R. 2 E	36	19	17
Total	528	200	328

Area 525 square miles in 528 sections.
Number of farms, 2,246.
Average value per acre, $24.08.
Square miles in farms, 276.
Per cent of land area in farms, 52.2.
Per cent of farm land improved 53.6, or 27.98 per cent of county.
Principal crops: Hay, oats, corn, beans, wheat.

Data on distribution of clayey and sandy soils were furnished by F. B. Taylor and Charles A. Davis who covered the county in a general reconnaissance but did not attempt deta ed mapping. The clay is in part clayey till and in part lake clay.

MISSAUKEE COUNTY.

Section.	Area sections.	Swamp and lake. Secs.	Clayey till. Secs.	Sandy till. Secs.	Sandy. Secs.	Gravelly loam. Secs.
T. 24, R. 5 W.....	36	18	.....	4	10	4
T. 24, R. 6 W.....	36	10	3	9	8	6
T. 24, R. 7 W.....	36	5	8	19	.....	4
T. 24, R. 8 W.....	36	11	9	.....	6	10
T. 23, R. 5 W.....	36	16	14	3	3	.....
T. 23, R. 6 W.....	36	20	12	.....	.....	4
T. 23, R. 7 W.....	36	10	6	5	12	3
T. 23, R. 8 W.....	36	6	10	10	.....	10
T. 22, R. 5 W.....	36	13	14	2	7	.....
T. 22, R. 6 W.....	36	7	16	8	5	.....
T. 22, R. 7 W.....	36	14	15	.....	7	.....
T. 22, R. 8 W.....	36	5.5L 3.5	8	.....	8	11
T. 21, R. 5 W.....	36	3	12	12	9	.....
T. 21, R. 6 W.....	36	11	10	4	11	.....
T. 21, R. 7 W.....	36	6	22	5	3	.....
T. 21, R. 8 W.....	36	7	2	20	7	.....
Total.....	576	166	161	101	96	52

Area 567 square miles in 576 sections, including lakes.
Number of farms, 1,439.
Average value per acre, $17.37.
Square miles in farms, 230.
Per cent of land area in farms, 39.6.
Per cent of farm land improved 41.3, or 16.35 per cent of county.
Principal crops: Hay, potatoes, oats, corn, rye, wheat, peas.

The sandy and gravelly areas have very little loam at surface and are largely uncultivated. Some of the swamp land has a clay subsoil and may be drained and brought under cultivation at moderate expense.

MONROE COUNTY.

Section.	Area sections.	Swamp and lake. Secs.	Clayey till. Secs.	Sandy. Secs.
T. 5 S. R. 6 E.	36	.....	27 Lc	9
T. 5 S. R. 7 E.	36	.....	4 Lc	32
T. 5 S. R. 8 E.	36	.....	23 Lc	13
T. 5 S. R. 9 E.	36	.....	24 Lc	12
T. 5 S. R. 10 E.	21	1	19 Lc	1
T. 6 S. R. 10 E.	16.5	1	15.5Lc	.....
T. 6 S. R. 9 E.	34	.....	27 Lc	7
T. 6 S. R. 8 E.	36	.....	21 Lc	15
T. 6 S. R. 7 E.	36	.....	22 Lc	14
T. 6 S. R. 6 E.	36	.....	30 Lc	6
T. 7 S. R. 6 E.	36	.....	10 Lc	26
T. 7 S. R. 7 E.	36	.....	17 Lc	19
T. 7 S. R. 8 E.	35.5	.....	25.5Lc	10
T. 7 S. R. 9 E.	17	5	12 Lc	.....
T. 8 S. R. 8 E.	23	.....	18 Lc	5
T. 8 S. R. 7 E.	36	.....	4.5Lc	31.5
T. 8 S. R. 6 E.	36	1	22 Lc	13
T. 9 S. R. 6 E.	3	.....	1.5Lc	1.5
T. 9 S. R. 7 E.	3	.....	1 Lc	2
T. 9 S. R. 8 E.	1	.....	1 Lc	.....
Total	550	8	315	217

Area 554 square miles in 550 sections, including the patented lands whose areas are estimated in square miles.

Number of farms, 4,321.

Average value per acre, $51.57.

Square miles in farms, 519.

Per cent of land areas in farms, 90.6.

Per cent of farm land improved 84.2, or 76.28 per cent of county.

Principal crops: Corn, hay, oats, wheat, potatoes.

The distribution of sandy and clayey soils here given is based upon W. H. Sherzer's map of Surface Geology in the Geological Survey of Michigan, Vol. VII, Part 1. The lake clay is thin and usually rests on clayey till. The sand in places is underlain at depths of 2 to 5 feet by clay that keeps it moist. There are, however, areas of dry sand, drifted in places into low ridges, especially along the valleys and in the west half of the county.

MONTCALM COUNTY.

Section.	Area sections.	Swamp and lake. Secs.	Clayey till. Secs.	Sandy till. Secs.	Sandy. Secs.	Gravelly loam. Secs.
T. 12, R. 5 W.	36	3	3	22	8	.....
T. 12, R. 6 W.	36	3	9	21	3	.....
T. 12, R. 7 W.	36	6	13	17	.....	.....
T. 12, R. 8 W.	36	3	8	21	4	.....
T. 12, R. 9 W.	36	1	8	18	9	.....
T. 12, R. 10 W.	36	.....	1	1	32	2
T. 11, R. 10 W.	36	4	15	7	6	4
T. 11, R. 9 W.	36	.....	12	16	8	.....
T. 11, R. 8 W.	36	.....	4	20	.....	12
T. 11, R. 7 W.	36	2	4	22	.....	8
T. 11, R. 6 W.	36	.....	18	15	3	.....
T. 11, R. 5 W.	36	1	13	18	4	.....
T. 10, R. 5 W.	36	4	12	14	6	.....
T. 10, R. 6 W.	36	2	8	20	6	.....
T. 10, R. 7 W.	36	2	18	14	2	.....
T. 10, R. 8 W.	36	3	3	20	.....	10
T. 9, R. 8 W.	36	2	6	22	6	.....
T. 9, R. 7 W.	36	2	10	20	4	.....
T. 9, R. 6 W.	36	2	24	4	6	.....
T. 9, R. 5 W.	36	2	28	.....	6	.....
Total.	720	42	217	312	113	36

Area 710 square miles in 720 sections, including lakes.
Number of farms, 4,678.
Average value per acre, $26.44.
Square miles in farms, 613.9.
Per cent of land area in farms, 84.8.
Per cent of farm land improved 67.8, or 57.5 per cent of county.
Principal crops: Hay, potatoes, corn, oats, rye, wheat, beans.
The undeveloped land is chiefly in sandy plains, the more productive land being under profitable cultivation.

MONTMORENCY COUNTY.

Section.	Area sections.	Swamp and lake. Secs.	Clayey till. Secs.	Sandy till. Secs.	Sandy. Secs.	Gravelly loam. Secs.
T. 32, R. 1 E.	36	10	.....	10	16	.....
T. 32, R. 2 E.	36	6	3	11	16	.....
T. 32, R. 3 E.	36	13	5	15	3	.....
T. 32, R. 4 E.	36	8	14	12	2	.....
T. 31, R. 1 E.	36	11	5	12	8	.....
T. 31, R. 2 E.	36	9	4	14	9	.....
T. 31, R. 3 E.	36	7	4	7	18	.....
T. 31, R. 4 E.	36	9	5	5	17	.....
T. 30, R. 1 E.	36	3	18	11	.....	4
T. 30, R. 2 E.	36	10	5	15	6	.....
T. 30, R. 3 E.	36	13	3	15	5	.....
T. 30, R. 4 E.	36	17	10	6	3	.....
T. 29, R. 1 E.	36	6	.....	6	.....	24
T. 29, R. 2 E.	36	4	6	22	.....	4
T. 29, R. 3 E.	36	10	4	13	9	.....
T. 29, R. 4 E.	36	11	.....	23	2	.....
Total.	576	147	86	197	114	32

Area 555.5 square miles in 576 sections, including lakes.
Number of farms, 466.
Average value per acre, $12.04.
Square miles in farms, 87.
Per cent of land area in farms, 15.
Per cent of farm land improved 31.4, or 4.7 per cent of county.
Principal crops: Hay, oats, potatoes, wheat, corn, rye.

The outwash gravel of the southwest part has a fairly productive sandy loam capping. The sandy tracts are largely in lowlands between prominent morainic spurs. Much of the county is sparsely settled, the main inhabitation being near Lewiston and near Hillman.

MUSKEGON COUNTY.

Section.	Area sections.	Swamp and lake. Secs.	Clayey till. Secs.	Sandy till. Secs.	Sandy. Secs.
T. 12, R. 15 W.	36	3	5	2	26
T. 12, R. 16 W.	36	3	.....	.....	33
T. 12, R. 17 W.	36	3	9	.....	24
T. 12, R. 18 W.	15	.....	9	.....	6
T. 11, R. 18 W.	4	1	.....	.....	3
T. 11, R. 17 W.	35	3	5	.....	27
T. 11, R. 16 W.	36	2	1	.....	33
T. 11, R. 15 W.	36	1	.....	.....	35
T. 10, R. 13 W.	36	1	21	14	.....
T. 10, R. 14 W.	36	25	5	.....	6
T. 10, R. 15 W.	36	2	1	.....	33
T. 10, R. 16 W.	36	6	.....	.....	30
T. 10, R. 17 W.	26	7	1	.....	18
T. 9, R. 17 W.	9	2	.....	.....	7
T. 9, R. 16 W.	36	6	.....	.....	30
T. 9, R. 15 W.	36	14	.....	.....	22
T. 9, R. 14 W.	36	3	21	.....	12
Total.	521	82	78	16	345

Area 502.3 square miles in 521 sections, including lakes.
Number of farms, 2,373.
Average value per acre, $26.56.
Square miles in farms, 290.
Per cent of land area in farms, 57.4.
Per cent of farm land improved 59.3, or 34 per cent of county.

The sandy areas are largely uncultivated because of the lightness of the soil. A narrow strip of prominent dunes borders the shore of Lake Michigan, and in places low dunes occur some miles inland. The till areas are highly productive. Considerable areas in the southern part of the county have a compact clay subsoil which tends to keep the overlying sand moist and productive.

NEWAYGO COUNTY.

Section.	Area sections.	Swamp and lake. Secs.	Clayey till. Secs.	Sandy till. Secs.	Sandy. Secs.	Gravelly loam. Secs.
T. 16, R. 11 W.	36	.....	12	24	.....	.....
T. 16, R. 12 W.	36	3	.....	15	18	.....
T. 16, R. 13 W.	36	5	.....	15	6	10
T. 16, R. 14 W.	36	6	.....	3	27	.....
T. 15, R. 14 W.	36	7	.....	11	18	.....
T. 15, R. 13 W.	36	4	.....	18	14	.....
T. 15, R. 12 W.	36	7	.....	5	14	10
T. 15, R. 11 W.	36	1	.....	35	.....	.....
T. 14, R. 11 W.	36	.....	.....	30	.....	6
T. 14, R. 12 W.	36	4	.....	14	10	8
T. 14, R. 13 W.	36	1	.....	22	13	.....
T. 14, R. 14 W.	36	5	.....	15	16	.....
T. 13, R. 14 W.	36	1	6	24	5	.....
T. 13, R. 13 W.	36	4	.....	16	8	8
T. 13, R. 12 W.	36	1	.....	12	18	5
T. 13, R. 11 W.	36	2	.....	15	16	3
T. 12, R. 11 W.	36	2	.....	12	22	.....
T. 12, R. 12 W.	36	4	.....	3	29	.....
T. 12, R. 13 W.	36	2	.....	17	17	.....
T. 12, R. 14 W.	36	5	5	3	23	.....
T. 11, R. 14 W.	36	6	.....	2	28	.....
T. 11, R. 13 W.	36	.....	6	24	6	.....
T. 11, R. 12 W.	36	14	.....	15	7	.....
T. 11, R. 11 W.	36	2	4	24	.....	6
Total.....	864	86	33	374	315	56

Area 847 square miles in 864 sections, including lakes.
Number of farms, 3,130.
Average value per acre, $21.43.
Square miles in farms, 509.
Per cent of land area in farms, 59.8.
Per cent of farm land improved 51, or 30.5 per cent of county.
Principal crops: Hay, corn, potatoes, oats, wheat, rye, beans.
There is very little loam on the sand and gravel outwash plains and they are largely uncultivated. About one-half the sandy till has a light soil, the remainder being fair to good.

OAKLAND COUNTY.

Section.	Area sections.	Swamp and lake. Secs.	Clayey till. Secs.	Sandy till. Secs.	Sandy. Secs.	Gravelly loam. Secs.
T. 5 N. R. 7 E.....	36	4	21	6	5	.....
T. 5 N. R. 8 E.....	36	5	10	18	3	.....
T. 5 N. R. 9 E.....	36	6	3	20	.....	7
T. 5 N. R. 10 E.....	36	5	3	14	.....	14
T. 5 N. R. 11 E.....	36	5	1	24	4	2
T. 4 N. R. 11 E.....	36	3	13	15	3	2
T. 4 N. R. 10 E.....	36	7	3	12	.....	14
T. 4 N. R. 9 E.....	36	4.5	0.5	18	.....	13
T. 4 N. R. 8 E.....	36	6	3	18	.....	9
T. 4 N. R. 7 E.....	36	7	16	12	.....	1
T. 3 N. R. 7 E.....	36	5	3	14	.....	14
T. 3 N. R. 8 E.....	36	7	.....	13	.....	16
T. 3 N. R. 9 E.....	36	7	6	6	.....	17
T. 3 N. R. 10 E.....	36	3	8	18	6	1
T. 3 N. R. 11 E.....	36	1	6 4Lc	11	14	.....
T. 2 N. R. 11 E.....	36	.....	24Lc	.....	6.5	1.5
T. 2 N. R. 10 E.....	36	3	5	20	8	.....
T. 2 N. R. 9 E.....	36	4.5	13	13.5	.....	5
T. 2 N. R. 8 E.....	36	7	1	8	.....	20
T. 2 N. R. 7 E.....	36	5.5	1.5	20	4	5
T. 1 N. R. 7 E.....	36	8	9	7	.....	12
T. 1 N. R. 8 E.....	36	7	16	6	2	5
T. 1 N. R. 9 E.....	36	1	19	12	3	1
T. 1 N. R. 10 E.....	36	1	12	9	13	1
T. 1 N. R. 11 E.....	36	1.5	10	1.5	21	2
Total.....	900	114	215	316	92.5	162.5

Area 899 square miles in 900 sections, including lakes.
Number of farms, 4,993.
Average value per acre, $35.16.
Square miles in farms, 847.2.
Per cent of land area in farms, 95.6.
Per cent of farm land improved 75.2, or 71.9 per cent of county.
Principal crops: Hay, potatoes, corn, oats, wheat, rye.

The outwash plains and glacial drainage strips have generally a light sandy loam cover. The sandy till soil is fair to good, while the clayey till and lake clay are highly productive. The latter is a thin deposit generally overlying a clayey till.

OCEANA COUNTY.

Section.	Area sections.	Swamp and lake. Secs.	Clayey till. Secs.	Sandy till. Secs.	Sandy. Secs.	Gravelly loam. Secs.
T. 16, R. 15 W.....	36	6	1	12	10	7
T. 16, R. 16 W.....	36	2	.....	21	13	.....
T. 16, R. 17 W.....	36	1	1	10	24	.....
T. 16, R. 18 W.....	14	2	.....	.....	12	.....
T. 15, R. 19 W.....	2.5	.....	.....	.....	2.5	.....
T. 15, R. 18 W.....	32.5	2.5	1	12	12	5
T. 15, R. 17 W.....	36	1	3	20	12	.....
T. 15, R. 16 W.....	36	2	2	23	9	.....
T. 15, R. 15 W.....	36	14	4	8	6	4
T. 14, R. 15 W.....	36	5	5	10	10	6
T. 14, R. 16 W.....	36	2	4	20	10	.....
T. 14, R. 17 W.....	36	.....	1	32	3	.....
T. 14, R. 18 W.....	35.5	0.5	2	17	4	12
T. 14, R. 19 W.....	4	.....	.....	3	1	.....
T. 13, R. 18 W.....	25	1	7	13	4	.....
T. 13, R. 17 W.....	36	.....	.....	10	26	.....
T. 13, R. 16 W.....	36	.....	.....	6	30	.....
T. 13, R. 15 W.....	36	1	5	3	27	.....
Total.....	545.5	40	36	220	215.5	34

Area 539 square miles in 545.5 sections, including lakes.
Number of farms, 2,806.
Average value per acre, $27.71.
Square miles in farms, 380.8.
Per cent of land area in farms, 70.1.
Per cent of farm land improved 62.3, or 43.67 per cent of county.
Principal crops: Hay, corn, potatoes, oats, wheat, rye, beans.

The sandy till has proved a highly productive soil for peach and apple orchards as well as for general farming. The sandy soils are largely uncultivated and in the northwest part embrace a belt of dunes. The gravelly soil has in places a light loam at surface.

OGEMAW COUNTY.

Section.	Area sections.	Swamp and lake. Secs.	Clayey till. Secs.	Sandy till. Secs.	Sandy. Secs.	Gravelly loam. Secs.
T. 24, R. 1 E.	36	1	.....	1	.....	34
T. 24, R. 2 E.	36	.....	.....	18	.....	18
T. 24, R. 3 E.	36	2	18	13	3	.....
T. 24, R. 4 E.	36	6	10	16	4	.....
T. 23, R. 1 E.	36	2	.....	10	.....	24
T. 23, R. 2 E.	36	.....	5	19	.....	12
T. 23, R. 3 E.	36	4	10	4	18	.....
T. 23, R. 4 E.	36	5	26	5	.....	.....
T. 22, R. 1 E.	36	2	.....	29	5	.....
T. 22, R. 2 E.	36	2	26	5	3	.....
T. 22, R. 3 E.	36	2	16	.....	18	.....
T. 22, R. 4 E.	36	3	31	2	.....	.....
T. 21, R. 1 E.	36	4	12	13	7	.....
T. 21, R. 2 E.	36	6	5	.....	25	.....
T. 21, R. 3 E.	36	3	4	.....	29	.....
T. 21, R. 4 E.	36	3	30	3	.....	.....
Total.	576	45	193	138	112	88

Area 572 square miles in 576 sections.
Number of farms, 1,283.
Average value per acre, $14.25.
Square miles in farms, 226.
Per cent of land area in farms, 39.
Per cent of farm land improved 38.3, or 14.94 per cent of county.
Principal crops: Hay, oats, potatoes, peas, corn, rye.

The gravel outwash plains have only a thin capping of light sandy loam. These and the sandy areas are largely uncultivated. Considerable rich clayey till in the eastern part of the county is also uncultivated.

OSCEOLA COUNTY.

Section.	Area sections.	Swamp and lake. Secs.	Clayey till. Secs.	Sandy till. Secs.	Sandy. Secs.
T. 20, R. 7 W	36	6	10	20	.....
T. 20, R. 8 W	36	.....	20	16	.....
T. 20, R. 9 W	36	.....	8	28	.....
T. 20, R. 10 W	36	6	.....	22	8
T. 19, R. 7 W	36	2	21	3	10
T. 19, R. 8 W	36	3	16	17	.....
T. 19, R. 9 W	36	4	8	24	.....
T. 19, R. 10 W	36	2	12	22	.....
T. 18, R. 7 W	36	7	7	3	19
T. 18, R. 8 W	36	2	5	21	8
T. 18, R. 9 W	36	1	.....	35	.....
T. 18, R. 10 W	36	2	7	22	5
T. 17, R. 7 W	36	2	10	10	14
T. 17, R. 8 W	36	2	6	24	4
T. 17, R. 9 W	36	.....	.....	21	15
T. 17, R. 10 W	36	2	26	3	5
Total	576	41	156	291	88

Area 574 square miles in 576 sections, including lakes.
Number of farms, 2,574.
Average value per acre, $17.58.
Square miles in farms, 388.2.
Per cent of land area in farms, 67.3.
Per cent of farm land improved 52, or 34.9 per cent of county.
Principal crops: Hay, potatoes, corn, oats, rye, wheat, peas.
A considerable part of the sandy till north of the Muskegon River has a light soil and is sparsely settled.

OSCODA COUNTY.

Section.	Area sections.	Swamp and lake. Secs.	Clayey till. Secs.	Sandy till. Secs.	Sandy. Secs.	Gravelly loam. Secs.
T. 28, R. 1 E.	36	1	3	3	29	.....
T. 28, R. 2 E.	36	2	8	6	.....	20
T. 28, R. 3 E.	36	1	4	16	11	4
T. 28, R. 4 E.	36	3	.....	4	29	.....
T. 27, R. 1 E.	36	1	.....	3	32	.....
T. 27, R. 2 E.	36	1	8	18	.....	9
T. 27, R. 3 E.	36	1	12	9	4	10
T. 27, R. 4 E.	36	1	4	8	23	.....
T. 26, R. 1 E.	36	2	1	10	23	.....
T. 26, R. 2 E.	36	2	12	8	14	.....
T. 26, R. 3 E.	36	1	2	17	16	.....
T. 26, R. 4 E.	36	2	4	10	20	.....
T. 25, R. 1 E.	36	.....	.....	5	19	12
T. 25, R. 2 E.	36	.....	2	8	16	10
T. 25, R. 3 E.	36	1	.....	8	7	20
T. 25, R. 4 E.	36	.....	.....	26	.....	10
Total.	576	19	60	159	243	95

Area 570.5 square miles in 576 sections, including lakes.
Number of farms, 344.
Average value per acre, $12.91.
Square miles in farms, 93.63.
Per cent of land area in farms, 16.3.
Per cent of farm land improved 27.1, or 4.42 per cent of county.
Principal crops: Hay, potatoes, oats, corn, wheat, rye.

The gravelly outwash plains as well as the sandy have at best a light sandy loam cover and are now largely uncultivated, the settlements being chiefly on clayey till.

OTSEGO COUNTY.

Section.	Area sections.	Swamp and lake. Secs.	Clayey till. Secs.	Sandy till. Secs.	Sandy. Secs.	Gravelly loam. Secs.
T. 32, R. 1 W.	36	5	5	15	11	.....
T. 32, R. 2 W.	36	3	.....	15	18	.....
T. 32, R. 3 W.	36	8	.....	13	15	.....
T. 31, R. 1 W.	36	15	2	17	2	.....
T. 31, R. 2 W.	36	4	.....	29	3	.....
T. 31, R. 3 W.	36	5	.....	20	4	7
T. 31, R. 4 W.	36	3	.....	15	2	16
T. 30, R. 1 W.	36	3	27	4	.....	2
T. 30, R. 2 W.	36	4	9	8	.....	15
T. 30, R. 3 W.	36	6	.....	4	.....	26
T. 30, R. 4 W.	36	4	.....	4	.....	28
T. 29, R. 1 W.	36	4	.....	3	.....	29
T. 29, R. 2 W.	36	5	.....	4	.....	27
T. 29, R. 3 W.	36	6	.....	16	6	8
T. 29, R. 4 W.	36	6	.....	22	8	.....
Total.	540	81	43	189	69	158

Area 522 square miles in 540 sections, including lakes.
Number of farms, 551.
Average value per acre, $14.93.
Square miles in farms, 93.
Per cent of land area in farms, 17.6.
Per cent of farm land improved 46.4, or 8.16 per cent of county.
Principal crops: Potatoes, hay, oats, rye, corn, wheat.

The gravelly outwash has a fairly productive soil of sandy and gravelly loam much of which is already farmed. There has been very little development of other classes of land, though profitable returns may be expected from much of the clayey and sandy till.

OTTAWA COUNTY.

Section.	Area sections.	Swamp and lake. Secs.	Clayey till. Secs.	Sandy till. Secs.	Sandy. Secs.	Gravelly loam. Secs.
T. 9 N. R. 13 W.....	36	4	5	22	5	.....
T. 8 N. R. 13 W.....	36	4	14	10	8	.....
T. 8 N. R. 14 W.....	36	4	16	.....	10	6
T. 8 N. R. 15 W.....	36	3	.....	.....	33	.....
T. 8 N. R. 16 W.....	32	8	.....	.....	24	.....
T. 7 N. R. 16 W.....	25	3	.....	.....	22	.....
T. 7 N. R. 15 W.....	36	12	.....	.....	24	.....
T. 7 N. R. 14 W.....	36	2	1	.....	15	18
T. 7 N. R. 13 W.....	36	2	15.5	4	8	6.5
T. 6 N. R. 13 W.....	36	4	13	.....	15	4
T. 6 N. R. 14 W.....	36	8	4	.....	21	3
T. 6 N. R. 15 W.....	36	7	2.5	.....	26.5	.....
T. 6 N. R. 16 W.....	21	1	.....	.....	20	.....
T. 5 N. R. 16 W.....	22	8	.....	.....	14	.....
T. 5 N. R. 15 W.....	36	5	7	.....	22	2
T. 5 N. R. 14 W.....	36	6	16	5	7	2
T. 5 N. R. 13 W.....	36	2	27	4	3	.....
Total.....	568	83	121	45	277.5	41.5

Area 551 square miles in 568 sections, including Black and Spring Lakes.
Number of farms, 4,603.
Average value per acre, $40.76.
Square miles in farms, 506.4.
Per cent of land area in farms, 89.6.
Per cent of farm land improved 76.3, or 68.36 per cent of county.
Principal crops: Hay, corn, oats, wheat, rye.

A narrow strip of dunes borders the Lake Michigan shore. A considerable part of the gravelly land is in the deltas of Lake Chicago, but outwash gravel is present in the northeast part. It has as a rule a fertile loamy capping.

PRESQUE ISLE COUNTY.

Section.	Area sections.	Swamp and lake. Secs.	Clayey till. Secs.	Sandy till. Secs.	Sandy. Secs.	Gravelly loam. Secs.
T. 37, R. 2 E.	27	4	19Lc	.....	4	.....
T. 36, R. 2 E.	36	3L 7S	9Lc	2	15	.....
T. 36, R. 3 E.	19	2	3Lc	.....	14	.....
T. 36, R. 4 E.	14	3	3Lc	.....	8	.....
T. 35, R. 2 E.	36	2L 8S	5Lc 13	.....	8	.....
T. 35, R. 3 E.	36	4	9 14Lc	9	.....	.....
T. 35, R. 4 E.	36	2	5	24	5	.....
T. 35, R. 5 E.	22	1	4Lc 5	2	10	.....
T. 35, R. 6 E.	8	2	.....	.....	6	.....
T. 34, R. 2 E.	36	14	10	12	.....	.....
T. 34, R. 3 E.	36	10	17	6	3	.....
T. 34, R. 4 E.	36	6	2	13	2	3
T. 34, R. 5 E.	36	5	26	5	.....	.....
T. 34, R. 6 E.	36	5	12Lc 8	3	8	.....
T. 34, R. 7 E.	27	3L 3S	15Lc	.....	6	.....
T. 34, R. 8 E.	12	4L 1S	.....	.....	7	.....
T. 33, R. 2 E.	36	9	3	6	18	.....
T. 33, R. 3 E.	36	11	3	4	18	.....
T. 33, R. 4 E.	36	18	.....	10	8	.....
T. 33, R. 5 E.	36	8	25	2	.....	1
T. 33, R. 6 E.	36	5	30	.....	1	.....
T. 33, R. 7 E.	36	2L 5S	11 12	.....	6	.....
T. 33, R. 8 E.	33	8L 4S	13Lc	.....	8	.....
T. 33, R. 9 E.	1	.....	.....	.....	1	.....
Total.	703	169	276	98	156	4

Area 669 square miles in 703 sections, including about 25 sections in lakes.
Number of farms, 1,086.
Average value per acre, $9.84.
Square miles in farms, 205.5.
Per cent of land area in farms, 30.3.
Per cent of farm land improved 30.4, or 9.1 per cent of county.
Principal crops: Hay, potatoes, oats, wheat, peas, rye, corn.
The lake clay is very thin, much of the submerged area having a clayey till at surface. Boulders abound in much of the submerged area as well as on moraines. Limestone is at slight depth in the eastern part and the drift there is to be classed as limestone till.

ROSCOMMON COUNTY.

Section.	Area sections.	Swamp and lake. Secs.	Clayey till. Secs.	Sandy till. Secs.	Sandy. Secs.	Gravelly loam. Secs.
T. 24, R. 1 W.	36	2	18	6	6	4
T. 24, R. 2 W.	36	8	.....	3	22	3
T. 24, R. 3 W.	36	9 L 11 S	.....	8	3	5
T. 24, R. 4 W.	36	6 L 8 S	.....	8	4	10
T. 23, R. 1 W.	36	3.5L 18 S	.....	1.5	3	10
T. 23, R. 2 W.	36	24	.....	6	6	.....
T. 23, R. 3 W.	36	7 L 12 S	8	6	3	.....
T. 23, R. 4 W.	36	11 L 19 S	.....	1	5	.....
T. 22, R. 1 W.	36	8	.....	24	.....	4
T. 22, R. 2 W.	36	18	.....	.....	8	10
T. 22, R. 3 W.	36	9 L 3 S	.....	6	10	8
T. 22, R. 4 W.	36	3.5L 11.5S	7	4	10	.....
T. 21, R. 1 W.	36	6	12	8	10	.....
T. 21, R. 2 W.	36	2	6	20	.....	8
T. 21, R. 3 W.	36	2	.....	7	7	20
T. 21, R. 4 W.	36	4	.....	1	31	.....
Total.	576	205.5	51	109.5	128	82

Area 530 square miles in 576 sections, including lakes.
Number of farms, 249.
Average value per acre, $17.18.
Square miles in farms, 53.
Per cent of land area in farms, 9.8.
Per cent of farm land improved 26.4, or 2.6 per cent of county.
Principal crops: Hay, potatoes, oats, corn, rye.

The outwash plains have only a thin capping of light sandy loam and they are largely uncultivated. The cultivation is chiefly on the clayey till and richer parts of the sandy till. Orchards have been grown successfully on some of the prominent hills and ridges of sandy till. Some of the swamp land has a clay soil and may be drained at moderate expense.

SAGINAW COUNTY.

Section.	Area sections.	Swamp and lake. Secs.	Clayey till and lake clay. Secs.	Sandy. Secs.
T. 13, R. 3 E.	36	3	30.5	2.5
T. 13, R. 4 E.	18	.....	16	2
T. 13, R. 5 E.	18	7	11	.....
T. 12, R. 1 E.	24	.....	13.5	10.5
T. 12, R. 2 E.	36	.....	16	20
T. 12, R. 3 E.	36	3	25	8
T. 12, R. 4 E.	36	3	31	2
T. 12, R. 5 E.	36	2	33.5	0.5
T. 12, R. 6 E.	36	3	33	.....
T. 11, R. 6 E.	36	.....	33.5	2.5
T. 11, R. 5 E.	36	.....	11	25
T. 11, R. 4 E.	36	.....	32	4
T. 11, R. 3 E.	36	1	33	2
T. 11, R. 2 E.	36	.....	20	16
T. 11, R. 1 E.	24	.....	10.5	13.5
T. 10, R. 1 E.	24	.....	1	23
T. 10, R. 2 E.	36	.....	13	23
T. 10, R. 3 E.	36	5	23	8
T. 10, R. 4 E.	36	1	31	4
T. 10, R. 5 E.	36	.....	10	26
T. 10, R. 6 E.	36	.....	6	30
T. 9, R. 4 E.	36	.....	31	5
T. 9, R. 3 E.	36	.....	29	7
T. 9, R. 2 E.	36	.....	30	6
T. 9, R. 1 E.	24	.....	15	9
Total.	816	28	538.5	249.5

Area 812.3 square miles in 816 sections.
Number of farms, 5,370.
Average value per acre, $33.47.
Square miles in farms, 672.
Per cent of land area in farms, 81.2.
Per cent of farm land improved 70.8, or 59.49 per cent of county.
Principal crops: Hay, beans, oats, corn, potatoes, wheat.

The classification is based in part on mapping by A. C. Lane and in part on the map of the Saginaw Area by U. S. Bureau of Soils. The lake clay has considerable thickness in parts of the county. This and the underlying clayey till need tile draining.

ST. CLAIR COUNTY.

Section.	Area sections.	Swamp and lake. Secs.	Clayey till. Secs.	Sandy till. Secs.	Sandy. Secs.
T. 8 N. R. 13 E.	36	17	12	5	2
T. 8 N. R. 14 E.	36	.....	19	10	7
T. 8 N. R. 15 E.	36	.....	16 14 Lc	.....	6
T. 8 N. R. 16 E.	36	.....	14 12 Lc	.....	10
T. 8 N. R. 17 E.	10	.....	7 Lc	.....	3
T. 7 N. R. 13 E.	36	2.5	31.5Lc	2	.....
T. 7 N. R. 14 E.	36	.....	34 Lc	1	1
T. 7 N. R. 15 E.	36	.....	30	.....	6
T. 7 N. R. 16 E.	36	.....	17 7 Lc	.....	12
T. 7 N. R. 17 E.	21	.....	6 Lc	.....	15
T. 6 N. R. 13 E.	36	3	32 Lc	.....	1
T. 6 N. R. 14 E.	36	.....	36 Lc	.....	.....
T. 6 N. R. 15 E.	36	.....	28 Lc	.....	8
T. 6 N. R. 16 E.	36	13	5 Lc	.....	18
T. 6 N. R. 17 E.	18.5	.....	7.5Lc	.....	11
T. 5 N. R. 15 E.	36	3	24 Lc	.....	9
T. 5 N. R. 16 E.	36	6	21 Lc	.....	9
T. 5 N. R. 17 E.	6	1	5 Lc	.....	.....
T. 4 N. R. 15 E.	36	.....	28 Lc	.....	8
T. 4 N. R. 16 E.	36	4	22 Lc	.....	10
T. 4 N. R. 17 E.	4	2	1	.....	1
T. 3 N. R. 15 E.	20	3.5	13	.....	3.5
T. 3 N. R. 16 E.	30	7	10	.....	13
T. 2 N. R. 15 E.	14	.....	.....	.....	14
T. 2 N. R. 16 E.	16	.....	.....	.....	16
Total.	715.5	62	452	18	183.5

Area 666.6 square miles in 715.5 sections, including 23 sections in the delta of St. Clair River by estimate from county map.

Number of farms, 4,527.

Average value per acre, $31.12.

Square miles in farms, 646.5.

Per cent of land area in farms, 91.2.

Per cent of farm land improved 76.6, or 69.86 per cent of county.

Principal crops: Hay, oats, corn, wheat, potatoes.

The lake clay is ordinarily but a few inches in depth and rests upon clayey till. The sandy land is also in places underlain at slight depth by clayey till which keeps it moist and productive.

ST. JOSEPH COUNTY.

Section.	Area sections.	Swamp and lake. Secs.	Clayey till. Secs.	Sandy till. Secs.	Sandy. Secs.	Gravelly loam. Secs.
T. 5 S. R. 9 W.	36	4	5	.....	27	.....
T. 5 S. R. 10 W.	36	4	5	4	23	.....
T. 5 S. R. 11 W.	36	2	.....	.....	34	.....
T. 5 S. R. 12 W.	36	2	.....	12	10	12
T. 6 S. R. 12 W.	36	5	.....	16	7	8
T. 6 S. R. 11 W.	36	2	.....	3	31	.....
T. 6 S. R. 10 W.	36	2	.....	7	27	.....
T. 6 S. R. 9 W.	36	5	.....	5	26	.....
T. 7 S. R. 9 W.	36	4	.....	13	15	4
T. 7 S. R. 10 W.	36	4	.....	27	3	2
T. 7 S. R. 11 W.	36	10	.....	3	18	5
T. 7 S. R. 12 W.	36	2	.....	1	26	7
T. 8 S. R. 13 W.	2.5	.....	.....	.....	2.5	.....
T. 8 S. R. 12 W.	21	1	.....	.....	11	9
T. 8 S. R. 11 W.	21	4	.....	.....	2	15
T. 8 S. R. 10 W.	21	1	.....	1	2	17
T. 8 S. R. 9 W.	21	2	.....	7	3	9
Total.	518.5	54	10	99	267.5	88

Area 502.3 square miles in 518.5 sections, including lakes.
Number of farms, 2,623.
Average value per acre, $40.02.
Square miles in farms, 470.
Per cent of land area in farms, 93.4.
Per cent of farm land improved 81, or 75.65 per cent of county.
Principal crops: Corn, hay, wheat, potatoes, oats.

In the extensive outwash aprons and belts of glacial drainage of this county the areas classed as sandy have less loam at surface than those classed as gravelly loam. Portions of the sandy till have a rich but stony loam at surface.

SANILAC COUNTY.

Section.	Area sections.	Swamp and lake. Secs.	Clayey till. Secs.	Sandy till. Secs.	Sandy. Secs.	Gravelly loam. Secs.
T. 14, R. 12 E.	36	6	12	10	8	.....
T. 14, R. 13 E.	36	11	1	17	7	.....
T. 14, R. 14 E.	36	17	5	12	2	.....
T. 14, R. 15 E.	36	.....	20 13Lc	2	.....	1
T. 14, R. 16 E.	12	.....	12Lc	.....	.....	.....
T. 13, R. 16 E.	15	.....	15Lc	.....	.....	.....
T. 13, R. 15 E.	36	2	28 5Lc	.....	.....	1
T. 13, R. 14 E.	36	24	9	2	1	.....
T. 13, R. 13 E.	36	10	22	4	.....	.....
T. 13, R. 12 E.	36	6	11	13	6	.....
T. 12, R. 12 E.	36	14	19	.....	.....	3
T. 12, R. 13 E.	36	14	19	.....	3	.....
T. 12, R. 14 E.	36	16	6	12	2	.....
T. 12, R. 15 E.	36	6	30	.....	.....	.....
T. 12, R. 16 E.	23.5	1	1.5 20Lc	.....	.....	1
T. 11, R. 16 E.	29	.....	14 14Lc	.....	.....	1
T. 11, R. 15 E.	36	5	25	.....	5	1
T. 11, R. 14 E.	36	13	22	1	.....	.....
T. 11, R. 13 E.	36	16	18	.....	.....	2
T. 11, R. 12 E.	36	5	20	10	.....	1
T. 10, R. 12 E. (North Half).	18	1	4	13	.....	.....
T 10, R. 13 E.	36	13	16	6	.....	1
T. 10, R. 14 E.	36	2.5	29	4	0.5	.....
T. 10, R. 15 E.	36	10	21	4	.....	1
T. 10, R. 16 E.	36	.....	9Lc	19	6	2
T. 10, R. 17 E.	3	.....	3Lc	.....	.....	.....
T. 9, R. 17 E.	5	.....	5Lc	.....	.....	.....
T. 9, R. 16 E.	36	.....	12 16Lc	.....	6	2
T. 9, R. 15 E.	36	.....	3 31Lc	1	1	.....
T. 9, R. 14 E.	36	4	24	8	.....	.....
T. 9, R. 13 E.	36	4	22	10	.....	.....
Total.	969.5	200.5	556.5	148	47.5	17

Area 962.5 square miles in 969.5 sections.
Number of farms, 5,659.
Average value per acre, $27.62.
Square miles in farms, 861.4.
Per cent of land area in farms, 88.3.
Per cent of farm land improved 78.8, or 69.58 per cent of county.
Principal crops: Hay, oats, beans, wheat, corn, barley, potatoes.
The gravelly land is in part in eskers and kames. A considerable part of the swamp land admits of comparatively easy draining.

SHIAWASSEE COUNTY.

Section.	Area sections.	Swamp and lake. Secs.	Clayey till. Secs.	Sandy till. Secs.	Sandy. Secs.
T. 8, R. 1 E.	26	2	18	0.5	5.5
T. 8, R. 2 E.	36	3.5	26	1.5	5
T. 8, R. 3 E.	36	.....	30	.....	6
T. 8, R. 4 E.	36	1	32	.....	3
T. 7, R. 1 E.	26.5	3	15	.....	8.5
T. 7, R. 2 E.	36	5	28	.....	3
T. 7, R. 3 E.	36	1	30.5	.....	4.5
T. 7, R. 4 E.	36	2	32	.....	2
T. 6, R. 1 E.	26.5	1	20	.....	5.5
T. 6, R. 2 E.	36	1	25	.....	10
T. 6, R. 3 E.	36	6	18	.....	12
T. 6, R. 4 E.	36	3	27	.....	6
T. 5, R. 1 E.	27	2	22	.....	3
T. 5, R. 2 E.	36	2	30	4	.....
T. 5, R. 3 E.	36	8	20	5	3
T. 5, R. 4 E.	36	1	25	.....	10
Total.	538	41.5	398.5	11	87

Area 537.5 square miles in 538 sections.
Number of farms, 3,577.
Average value per acre, $35.33.
Square miles in farms, 511.
Per cent of land area in farms, 91.7.
Per cent of farm land improved 81, or 74.28 per cent of county.
Principal crops: Hay, beans, oats, corn, wheat, rye.
The moraines as well as till plains are largely rich clayey till. Portions of the sandy outwash and strips of sandy glacial drainage have a rich loam capping.

TUSCOLA COUNTY.

Township.	Area sections.	Swamp and lake. Secs.	Clayey and loamy. Secs.	Sandy till. Secs.	Sandy. Secs.
T. 15, R. 8 E.	19.5	6	7.5 2.5s. l.	.....	3.5
T. 14, R. 7 E.	20	3	13.5 1.5s. l.	.....	2
T. 14, R. 8 E.	36	3.5	27.5 2s. l.	.....	3
T. 14, R. 9 E.	34	1.5	30	.....	2.5
T. 14, R. 10 E.	36	0.5	20	7	8.5
T. 14, R. 11 E.	36	6	4	15	11
T. 13, R. 7 E.	36	7	24	.....	5
T. 13, R. 8 E.	36	0.5	27	.....	8.5
T. 13, R. 9 E.	36	0.5	20	6.5	9
T. 13, R. 10 E.	36	2	5	5	24
T. 13, R. 11 E.	36	6	10	4	16
T. 12, R. 7 E.	36	.....	32	.....	4
T. 12, R. 8 E.	36	2	10	6	18
T. 12, R. 9 E.	36	1	.5.5	3.5	26
T. 12, R. 10 E.	36	4	.....	9	23
T. 12, R. 11 E.	36	14	6	6	10
T. 11, R. 7 E.	36	2	23	2	9
T. 11, R. 8 E.	36	.....	2	1	33
T. 11, R. 9 E.	36	9	13	3	11
T. 11, R. 10 E.	36	10	12	10	4
T. 11, R. 11 E.	36	12	15	9	.....
T. 10, R. 7 E.	36	.....	25	.....	11
T. 10, R. 8 E.	36	2	24	4	6
T. 10, R. 9 E.	36	4	20	5	7
Total.	829.5	96.5	382	96	255

Area 811 square miles in 829.5 sections.
Number of farms, 5,244.
Average value per acre, $31.45.
Square miles in farms, 703.4.
Per cent of land area in farms, 85.1.
Per cent of farm land improved 73.9, or 62.89 per cent of county.
Principal crops: Hay, beans, oats, corn, wheat, potatoes, rye.

The estimates for the northern part of the county are from the U. S. Bureau of Soils map of the Saginaw area, and the remainder chiefly from C. A. Davis's report on Tuscola County, Geological Survey of Michigan, Annual Report for 1908.

In the column of "clayey and sandy" soil "s. l." stands for sandy loam, as designated by the Bureau of Soils.

VAN BUREN COUNTY.

Section.	Area sections.	Swamp and lake. Secs.	Clayey till. Secs.	Sandy till. Secs.	Sandy. Secs.	Gravelly loam. Secs.
T. 1 S. R. 13 W.....	36	5	2	14	4	11
T. 1 S. R. 14 W.....	36	3	21	10	.....	2
T. 1 S. R. 15 W.....	36	4	2	15	15	.....
T. 1 S. R. 16 W.....	36	2	14	8	12	.....
T. 1 S. R. 17 W.....	21	1	1	6	13	.....
T. 2 S. R. 18 W.....	1.5	.....	.....	.....	1.5	.....
T. 2 S. R. 17 W.....	34	2.5	12.5	6	13	.....
T. 2 S. R. 16 W.....	36	3	21	10	2	.....
T. 2 S. R. 15 W.....	36	4	9	21	2	.....
T. 2 S. R. 14 W.....	36	6	20	6	4	.....
T. 2 S. R. 13 W.....	36	8	.....	5	23	.....
T. 3 S. R. 13 W.....	36	2	.....	9	25	.....
T. 3 S. R. 14 W.....	36	8	.....	8	4	16
T. 3 S. R. 15 W.....	36	2	.....	26	4	4
T. 3 S. R. 16 W.....	36	1	6	23	6	.....
T. 4 S. R. 16 W.....	36	2	.....	18	.....	16
T. 4 S. R. 15 W.....	36	7	.....	6	4	19
T. 4 S. R. 14 W.....	36	12	.....	4	18	2
T. 4 S. R. 13 W.....	36	5	.....	16	3	12
Total.....	632.5	77.5	108.5	211	153.5	82

Area 611.2 square miles in 632.5 sections, including lakes.
Number of farms, 4,952.
Average value per acre, $43.71.
Square miles in farms, 565.
Per cent of land area in farms, 91.6.
Per cent of farm land improved 78, or 71.45 per cent of county.
Principal crops: Hay, corn, potatoes, oats, wheat, rye.
A deposit of rich loam covers much of the gravelly area included in the last column. The sandy areas and sandy till are extensively planted to orchards and vineyards.

WASHTENAW COUNTY.

Township.	Area sections.	Swamp and lake. Secs.	Clayey till. Secs.	Sandy till. Secs.	Sandy. Secs.	Gravelly loam. Secs.
T. 1 S. R. 3 E.....	36	3.5	.....	20	8.5	4
T. 1 S. R. 4 E.....	36	8.5	.....	18	5.5	4
T. 1 S. R. 5 E.....	36	6	4	16	2	8
T. 1 S. R. 6 E.....	36	4.5	16	7	1.5	7
T. 1 S. R. 7 E.....	36	3.5	10	16	.....	6.5
T. 2 S. R. 7 E.....	36	2	19 7Lc	2	.....	6
T. 2 S. R. 6 E.....	36	1.5	25	3	.....	6.5
T. 2 S. R. 5 E.....	36	3	16	7	6	4
T. 2 S. R. 4 E.....	36	7	8.5	18	1.5	1
T. 2 S. R. 3 E.....	36	3	5	26	.....	2
T. 3 S. R. 3 E.....	36	3	3	16	.....	14
T. 3 S. R. 4 E.....	36	4	21	6	.....	5
T. 3 S. R. 5 E.....	36	2.5	22	6	.....	5.5
T. 3 S. R. 6 E.....	36	6	23	2	2	3
T. 3 S. R. 7 E.....	36	4	2 6Lc	2	7	15
T. 4 S. R. 7 E.....	36	1	12	1	19	3
T. 4 S. R. 6 E.....	36	2	3 15Lc	5	6	5
T. 4 S. R. 5 E.....	36	3	18 8Lc	2	2	3
T. 4 S. R. 4 E.....	36	4.5	19.5 2Lc	4	.....	6
T. 4 S. R. 3 E.....	36	2	8	19	.....	7
Total.....	720	74.5	271	196	61	117.5

Area 711 square miles in 720 sections.
Number of farms, 3,837.
Average value per acre, $37.17.
Square miles in farms, 667.2.
Per cent of land area in farms, 94.8.
Per cent of farm land improved 77.7, or 73.66 per cent of county.
Principal crops: Hay, corn, oats, wheat, potatoes, rye.

Gravelly areas in this table include kames, eskers, and ancient river deltas as well as outwash aprons. They have usually sufficient loam in the soil to be productive. The sandy and clayey till are under a high state of cultivation with profitable returns. Orchard and fruit raising are found fully as profitable on the morainic tracts as general farming.

WAYNE COUNTY.

Township.	Area sections.	Clayey till, and lake clay. Secs.	Sandy. Secs.
Northville	18.27	12.27	6
Plymouth	19.14	12.64	6.5
Livonia	35.96	5	30.96
Redford	35.68	7	28.68
Greenfield	34.78	11	23.78
Hamtramck	16.89	10.89	6
Grosse Point	11.31	8.31	3
Detroit	39.38	28.38	11
Gratiot	19.42	17.42	2
Springwells	9.83	8.83	1
Dearborn	34.41	22.41	12
Nankin	35.94	9	26.94
Canton	35.93	17.93	18
Van Buren	36.69	8	28.69
Romulus	35.66	12	23.66
Taylor	23.82	6	17.82
Ecorse	35.41	29.41	6
Monguagon	23.35	22.35	1
Brownstown	40.00	27.00	13
Huron	35.79	5	30.79
Sumpter	37.28	1	36.28
Total	614.94	281.84	333.10

Area 615 square miles by planimeter, 596.2 by Farmers Handbook.
Number of farms, 4,775.
Average value per acre, $82 14.
Square miles in farms, 494.
Per cent of land area in farms, 79.7.
Per cent of farm land improved 82.6, or 65.78 per cent of county.
Principal crops: Hay, corn, oats, potatoes, wheat, rye.

Estimates of area of each class of soil were made by W. H. Sherzer on the basis of the planimeter measurements.

The clay areas have generally a thin deposit of lake clay with clayey till subsoil, but west of Detroit the lake clay is 12 feet or more in depth over a considerable area and is used in brick, tile and roofing slate manufacture. The sandy areas have in places a very light soil drifted into low ridges, but in portions of the sandy areas there is sufficient moisture and a suitable soil for profitable farming.

WEXFORD COUNTY.

Township.	Area sections.	Swamp and lake. Secs.	Clayey till. Secs.	Sandy till. Secs.	Sandy. Secs.	Gravelly loam. Secs.
T. 24, R. 9 W.	36	2	3	6	21	4
T. 24, R. 10 W.	36	2	7	4	17	6
T. 24, R. 11 W.	36	1	1	.....	25	9
T. 24, R. 12 W.	36	.....	.....	5	9	22
T. 23, R. 9 W.	36	1	.....	27	.....	8
T. 23, R. 10 W.	36	1	4	26	.....	5
T. 23, R. 11 W.	36	.....	5	27	4	.....
T. 23, R. 12 W.	36	.....	.....	12	16	8
T. 22, R. 9 W.	36	1	.....	18	8	9
T. 22, R. 10 W.	36	4	.....	9	.....	23
T. 22, R. 11 W.	36	.....	.....	32	.....	4
T. 22, R. 12 W.	36	.....	7	12	17	.....
T. 21, R. 9 W.	36	3	.....	28	5	.....
T. 21, R. 10 W.	36	6	.....	.....	22	8
T. 21, R. 11 W.	36	.....	.....	20	.....	16
T. 21, R. 12 W.	36	.....	3	15	18	.....
Total.	576	21	30	241	162	122

Area 572 square miles in 576 sections, including lakes.
Number of farms, 1,779.
Average value per acre, $18.79.
Square miles in farms, 230.6.
Per cent of land area in farms, 40.
Per cent of farm land improved 53.6, or 21.44 per cent of county.
Principal crops: Hay, potatoes, corn, oats, rye, wheat.

This county was entirely covered by the U. S. Bureau of Soils Survey in 1908. It is nearly; all classed as "Miami sand" of three phases: (1) Pine hills phase of no agricultural value. (2) Pine plains phase of fair agricultural value; and (3) Hardwood land phase of good agricultural value and embracing more than half the county. The classification made by the present writer is on the geological basis to conform to the plan adopted for the entire peninsula. Gravelly land southeast of Boon and that northwest of Manistee River has sufficient capping of loam to be classed as good agricultural land by the Bureau of Soils, so also is nearly all the sandy till.

INDEX.

INDEX.

D

E

F

G

H

I

J

K

L

M

N

O

P

R

S

T

U

V

W

GEOLOGICAL SURVEY OF MICHIGAN
R. C. ALLEN, STATE GEOLOGIST
IN COOPERATION WITH THE UNITED STATES GEOLOGICAL SURVEY
GEORGE OTIS SMITH, DIRECTOR

MAP OF THE SURFACE FORMATIONS OF THE NORTHERN PENINSULA OF MICHIGAN

BY FRANK LEVERETT, UNITED STATES GEOLOGIST

1911

LEGEND

Above lake limits
Lake washed; clayey
Lake washed; sandy
Moraines (rolling to gently undulating glacial deposits). Soil variable within a short space, and ranging from heavy clay to loose gravelly material. Usually fair to very good land. Where moraines are incompletely mapped query marks (?) are inserted.

Sandy to clayey loam
Sandy loam
Plains with a mixed pebbly, and in places sandy clay (bowlder-clay or till). Good clayey loam to sandy loam soil making largely first rate, with some of it inclining to second rate farm land.

Drumlins or oval-shaped bowlder-clay hills trending in the direction of ice movement. Good soil for all kinds of crops.

Gravelly ridges (eskers) trending in the direction of ice movement. Valuable for road ballast but very limited in extent. Small ones occur among the drumlins of Menominee County, and in moraine belts to the western half of the peninsula.

Sand or gravel plains formed by waters escaping from the ice border. This soil will need intelligent cultivation to be highly productive.

Sandy plains not definitely associated with moraines or ice borders, and outside the glacial lakes. Light soil requiring intelligent cultivation.

Sandy plains inside the limits of the glacial lakes. Light soil requiring intelligent cultivation.

Lake clay; thin
Lake clay; thick
Rugged
Nearly level
Lake clay areas. Excellent soil. Some areas need artificial drainage.

Areas with rock formations at surface or very slight depth. The rugged areas are inferior for agricultural land although the soil is often good. Areas not rugged are generally underlain by limestone, sandstone or shale and well adapted to agriculture.

Lake Ontonagon shore. Approximate position.

Lake Duluth shore. Accurate in the main.

Lake Algonquin shore. Approximate position.

Lake Nipissing shore. Accurate in the main.

Glacial striae on rock ledges showing direction of ice movement.

Swamp areas requiring artificial drainage. Large areas may be reclaimed by heavy ditching, and considerable portions by clearing of brush and a moderate amount of ditching.

60′ — 5,000 H. P. Waterfalls with approximate fall in feet or computed horse power (incompletely mapped).

Scale 1:1000000
16 0 0 16 32 48 Miles

Base by United States Geological Survey.
Glacial geology by Frank Leverett, assisted by geologists of the Michigan Geological Survey, members of the United States Department of Agriculture, and others.

NOTE:—A few errors in mapping have been found in the Northern Peninsula map, Plate I, which will be corrected in a future edition, but the present edition had been printed before they were brought to notice. The chief errors are listed below.

Lake Algonquin extended up Firesteel River about to the Copper Range Railroad, and also up into Section 3, T. 50, R. 39 W. along a small tributary of Lake Superior.

Lake Duluth limits were 1-2 miles farther southeast than the map indicates in T. 50, R. 32 W. There was also a very irregular shore in the northwest part of T. 50, R. 31 W. and southeast part of T. 51, R. 31 W.

On the west side of Green Bay there is less sandy land than the map indicates from Cedar River northward to Ford River, the soil being a clayey to sandy loam with till subsoil nearly down to the present shore.

There is till with sandy loam to clay loam soil nearly to the west bluff of Escanaba River in T. 40, R. 24 W.

In eastern Alger County an outwash gravel plain instead of moraine covers all but the north edge of T. 48, R. 14 W. and the southwest part of T. 48, R. 13 W.

There were three islands in Lake Algonquin south of the Soo Line Railroad east of Trout Lake, Chippewa County, at the highest stage of the lake. The shore line that is represented on the map is a lower one; so also is the shore line represented north of Trout Lake.

GEOLOGICAL SURVEY OF MICHIGAN
R. C. ALLEN, STATE GEOLOGIST
IN COOPERATION WITH THE UNITED STATES GEOLOGICAL SURVEY
GEORGE OTIS SMITH, DIRECTOR

MAP OF THE SURFACE FORMATIONS OF THE SOUTHERN PENINSULA OF MICHIGAN

BY FRANK LEVERETT, UNITED STATES GEOLOGIST
IN COOPERATION WITH FRANK B. TAYLOR AND MEMBERS OF THE MICHIGAN GEOLOGICAL SURVEY

1911

Scale 1:1000000
10 0 0 10 Miles

LEGEND

Moraines (a) *Landlaid* (b) *Waterlaid* — Rolling to gently undulating glacial deposits formed at border of ice sheet. Soil variable within a short space, and ranging from very stony material to heavy clay with few stones. Usually fair to very good farm land. The waterlaid moraines are usually low smooth ridges of bowlder clay.

Bowlder clay plains — The bowlder clay or till plains were formed under the ice sheet. The soil ranges from clayey to sandy loam and from first rate to good second rate quality.

Drumlins — Oval shaped to elliptical bowlder clay hills formed under the ice and trending in the direction of ice movement. Found in restricted areas on till plains. Soil usually first rate.

Eskers — Gravel ridges formed under the ice and trending in the direction of ice movement. Usually found on till plains but also in moraines. Valuable road ballast.

Bowlder belts — Strips of exceptionally stony land, but usually with fertile soil.

Outwash plains — Sand or gravel spread out by water escaping from the ice sheet. Soil usually light and requiring intelligent cultivation.

Sandy drift — Sandy deposits not definitely formed as outwash from the ice border, and in part deposited under the ice. Soil variable but usually second rate

Sandy lake beds — The sand of the lake beds is probably partly of glacial deposition. The soil is light and in places is drifted by the wind into low ridges.

Dunes — Sharp ridges of wind-drifted sand chiefly along modern lake shores. Usually unprofitable for agriculture.

River deltas — Pebbly sandy loam formed where streams entered the still water of lakes. Soil ranges from fair to good

Lake clay — Clayey portions of the old lake beds, often with bowldery clay near surface. A soil of high productivity when well drained.

Rock or thin drift (a) (b) — In these areas rock is frequently within reach of tree roots but the soil is well adapted to agriculture. Symbol (a) applies to areas outside the glacial lakes; symbol (b) to areas within lake limits.

Lake shores (incomplete) — The continuous lines (a) represent shores or beaches still intact. Broken lines (b) represent beaches partially destroyed by a rise of the lake water.

Glacial striae — Lines or grooves on the rock surface showing direction of ice movement, and in some cases changes in direction.

Swamps — Areas thus mapped may be greatly reduced by heavy ditching and rendered suitable for agriculture