

I N D E X

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Donated by _____

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WELLS

June 21, 1901 - Alma, Michigan:

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Aneroid 29.195 at 6:20 a.m., Altitude 742 feet. Data at 7:00 a.m. Drift at Sanderson well, Alma, 500 feet. Depth of well 2860. (See Volume V, Geology of Michigan). St. Louis well at Harrington House, drift is 350 feet (See Lane's Water Reserves). Ithaca Village well has about 1325 feet (See Lane's Report).

We drive to St. Louis on angling road. It is in river flats much of the way and the soil is a sandy gravel. The moraine only extends 1/2 mile east of St. Louis -- sharp knolls 20 - 25 feet high just north of St. Louis, some of which contain gravel and sand. There is a pit north edge of St. Louis and two small ones on line of Sections 12 and 13, Pine River Township. The northeast part of Section 12 and east half of Section 1 are a till plain. The remainder of these sections and the sections on the west (Sections 2 and 11) have a swell and sag till - moraine swells 10 - 20 feet. Boulders not numerous.

There is a thin coating of sand on the plain on line of Sections 35 and 36, 25 and 26, Coe Township, Isabella County. There is an occasional boulder and a stony till appears in ditches at a depth of a foot or less.

LAKE SAGINAW BEACH

A beach crosses at corners of Sections 23, 24, 25, and 26, Coe Township, in a northwest-southeast course. The altitude seems to be about 730 feet A.T., Aneroid 29.200, 9:00 a.m. Moraine is 3/4 mile to the west. The beach is 10 - 20 rods wide and 3 - 5 feet high above outer plain.

In the mile north from here, aneroid indicates descent of 10 feet. Aneroid 29.210 (more or less), or 720 feet. The beach is 1/3 mile west.

FLOWING WELLS

J. C. Conklin, who lives on beach, has flowing well 167 feet deep in north part Section 23. There are several on the road a mile north, as follows:

Mr. Allen Clay's	one well
Mr. Ed. Rivett	" "
Mr. Henry Gosse	" "
Mr. Mike O'Boyle	" "

One on Midland and Isabella County line 2 miles north of here.

Mr. W. Struble, in southeast part Section 1
Patrick Roberts - plain near by there
Only other - Chas. Hudson in Section 14 -
south side - has one flowing well.

Chas. Clifton, well driller, in Section 3, Coe Township, reports ordinary wells 26 - 72 feet. Flowing wells 40 - 85 feet in Sections 3 and 4, Coe Township and Sections 32 and 33, Chippewa Township. He knows of no others farther north on this side of Chippewa River nor of any towards Mt. Pleasant. There are flows a few miles north of Mt. Pleasant.

LAKE SAGINAW BEACH

The beach has a north by northwest course across the southwest part of Section 14, the northeast part of Section 15, central part of Section 10 and west part of Section 3, Coe Township. It is interrupted at Little Salt River for about 80 rods and there is but little delta material here.

In Section 34, Chippewa, there are sandy ridges east of this beach and the beach or westernmost ridge is not so continuous as farther south. It is, however, well marked most of the way across the section. It crosses at corners of Sections 27, 28, 33 and 34, and heads northward across the east part of Section 28 in a well defined ridge to Alum Creek.

Between Alum and Union Creeks there is a sandy plain and only a fragmentary beach. The greater part of Section 21 is sandy but the beach ridges seem

to be mainly near its middle north-south quarter line. There is a sandy tract east and north from Section 28 as far as I can get a view and a belt of sand extends up the south side of Chippewa River to Mt. Pleasant which has its south border in middle part of Section 18, Chippewa, and Section 13, Union Township. From there the border bears through the south part of Section 14 into the south edge of Mt. Pleasant. The sand is only a few feet in depth wherever ditches cut down. The surface is flat and it seems likely to be a delta of the Chippewa River. The lake probably extended west in Chippewa Valley about to the line of Chippewa and Union Townships, but I saw no sandy ridges west of Sections 8 and 17, Chippewa. There is a well defined one in southwest part of Section 8.

The moraine we have been tracing is well defined as far north as the south part of Sections 20 and 21, Chippewa. There are a few till swells in Section 18 that may constitute its continuation though it seems more probable that the ice margin took a westward turn from the south part of Chippewa Township and formed a low undulating ridge that leads from Section 31, Chippewa, northwestward on the north and east side of the Ann Arbor Railroad to Section 22, Union. The part of the moraine from Sections 32 and 33, Chippewa, northward to Sections 20 and 21 would, in that case, be a spur extending back from the curving part of the ice margin. This moraine or spur is scarcely 1/2 mile wide from Shepherd northward, and stands 15 - 25 feet above border tracts.

The undulating tract along northeast side of Ann Arbor Railroad from Section 31, Chippewa Township northwestward is also narrow, scarcely 1/2 mile wide.

Between these morainic strips in southwestern Chippewa and southeastern Union Townships, is a flat till tract.

There is a channel along the Ann Arbor Railroad from Mt. Pleasant southwestward across Union Township that seems to be a line of glacial drainage, at the time the moraine northeast of the railway was forming. It is, in places, coated with gravel, but is usually sandy and peaty. There is a gravel pit in it just south of the Ann Arbor Railroad on line of Sections 35 and 36, Union Township, in a bar that covers two or three acres. The bar stands 3 - 4 feet above the bordering swamp. The gravel is rather coarse. Perhaps it is due to the cutting down of a gravelly drift knoll rather than entirely a fluvial deposit. There is very little gravel on the moraine that borders the channel.

The channel passes just west of Shepherd. It is there and for two miles north, a shallow sag, 60 - 80 rods in width. In Union Township it is $1/2 - 3/4$ mile wide. There is a moraine on its southwest border in Union Township, and the same moraine seems to have its river border a mile west of Shepherd, but in tracing this channel, we lost track of the moraine for 2 or 3 miles in northwest part of Coe Township and northeast of Lincoln.* We take the road south a mile west of Shepherd through the moraine and come to the outer border of the moraine about a mile south of the county line. A large channel follows its outer border from Little Salt River across Sections 6, 7, 8, and 17 to Henry Creek and thence southward to Pine River. It is about $1/2$ mile in average width, has a sandy bottom where not peaty. The Alma moraine has an outwash apron of sandy gravel in Sections 29 and 32, similar to that noted yesterday on south side of Pine River. There is a drift ridge leading south-southwest from Section 19, Pine River, into Section 36, Seville Township. It is only a half mile wide. There is a flat till plain, $1-1/2 - 2$ miles wide, between it and the Riverdale moraine in Seville Township. We did not attempt to trace it beyond Section 36. Professor Davis will make a detailed study of the county

*See Mt. Pleasant map showing the moraine in Sections 2 and 11, Lincoln.

for the State Geological Survey, so my work in this county is mainly for conference.

I take train from Alma to Mt. Pleasant at 8:50 p.m.

Aneroid 29.070 at Alma, 748 feet
Aneroid 29.045 at Forest Hill
Aneroid 29.050 at Shepherd
Aneroid 29.060 at Mt. Pleasant

June 22, 1901 - 7:15 a.m.

Aneroid 28.920 at Mt. Pleasant at Donovan House about the level of Pere Marquette Station and 15 feet above Ann Arbor Station.

The waterworks wells here are shallow wells in Chippewa River bottom. The water is chalybeate and may contain calcium or magnesium sulphate for it has laxative effect on bowels - some.

I drive south through Section 22 and find that the sag that the Ann Arbor Railroad follows has its beginning near the line of Sections 22 and 27 and widens from there southeastward. It is sandy at this section line but is quite narrow and is not a well defined channel farther north. It is rather obscure here. The till tract is gently undulating westward from here across Section 22 and east half of Section 21 to the bank of Chippewa River.

The ridge south of the Ann Arbor Railroad leads westward to the river across Sections 28 and 29 (see Mt. Pleasant topographic map) and appears on the north side of the river in Section 20. The river valley makes a break in it scarcely 1/2 mile in width. This seems to be the Alma moraine. There is no line of glacial drainage outside of it for several miles southeast from the Chippewa River, there being a till plain with scarcely any sandy coating and no apparent modification by a stream. From Section 9, Lincoln Township southward, there is a flat, nearly swampy tract along Little Salt River that constitutes the head of the channel that we traced yesterday across the divide between Little Salt River and Pine River.

There is a prominent group of hills in Section 17, Lincoln Township, 930 - 990 feet above flat tracts in the south and east - 840 feet A.T. There are also sharp hills in north part of Section 16. These sharp hills are at the east end of a spur in the moraine.

The river border of the moraine leads from there through Sections 8 and 5, Lincoln, and southwest part of 31, Union Township, and Sections 36, 25, 26, and 27, Deerfield Township, from which it passes to the north side of Chippewa River in Sections 21, 22, and 28. From this hilly tract in Section 17, there is only a gently undulating till tract south and southeast in Sections 20, 21, 22, 26, 27, 28, 29, 32, 33, 34, 35, and 36, Lincoln Township, but in Sections 18, 19, 30, and 31, there is a strong moraine with swells 20 - 30 feet (more or less) in height. Sections 24 and 25, Fremont, are gently undulating till, but a range of very bouldery hills leads across Sections 36, 35, and 26, and after a narrow gap in south part of Section 23, continues to Winn (Duskville) through Sections 22, 23, 15, and through Sections 10 and 11, 2 and 3, into Deerfield Township. This very bouldery moraine forms the outer part of the Riverdale moraine. It rises 30 - 75 feet above the swampy channel west of it in Fremont Township drained by Cedar Creek.

The swamp leads across from Chippewa River to the north branch of Pine River and is fully a mile wide. It is a hemlock and cedar swamp. It is planned to ditch it soon and drain it southward from near Winn.

The Mt. Pleasant topographic map makes the swamp at Winn in Section 10, Fremont, just above 850 feet.

The moraine fills the bend of Chippewa River on the north side as far south as the north edge of Section 28. Its main part bears northward from there through Sections 21 and 22, 16 and 15, 8, 5, and 6, Deerfield. The village of Two Rivers being just outside. There is a prominent range near Bogden P. O.

(Deerfield Center), running above 910 feet.

Aneroid 28.740 on hill southwest of Bogden, 910 feet
Aneroid 28.900 at Pere Marquette Station in Mt. Pleasant
Aneroid 28.825-840 at Chippewa River west of Bogden in
line of Sections 17 and 20, Deerfield Township

There is a very bouldery, cobbly terrace along the Chippewa in Sections 6, 7, 8, 17, 18, 19, and 20, Deerfield, about $3/4$ mile in average width and standing 30 feet more or less above the stream. Near the village of Two Rivers it lies on the east side of the river, but in Sections 18 and 19, it is mainly on the west side. This has the appearance, near Two Rivers, of an outwash apron, for it rises eastward into the moraine.

Chippewa Valley is quite broad - $1/2$ to $3/4$ mile more or less, from the bend eastward to the mouth of Willow Creek - called North Branch on Mt. Pleasant map, but from there to Mt. Pleasant, the width is less than $1/2$ mile. Probably the glacial drainage from the mouth of Willow Creek was westward to the channel that leads past Winn to North Pine River, for there seems no obstacle in that direction and there is not a channel along the direct line to the head of Little Salt River where I expected one. Willow Creek does not have much gravelly material along it. The strip is only $1/4$ - $1/2$ mile wide from the Big Rapids road on line of Sections 2 and 11, Deerfield southward to Chippewa and this is a sandy gravel. It stands about 20 feet above the stream.

The Riverdale moraine occupies nearly all the interval between Willow Creek and Chippewa River in Deerfield Township.

The Alma moraine lies east of Willow Creek and is about two miles in width. It runs through to Clare in a course slightly east of north, forming the divide between tributaries of Salt River and Willow Creek. It has a swell and sag surface and is composed largely of till.

The moraine west of Willow Creek (The Riverdale moraine), has a hummocky

topography and contains considerable gravel and sand in some knolls along with the till. It is also much more thickly strewn with boulders than the Alma moraine.

FLOWING WELLS

The district east of the Alma moraine in Isabella, southeastern Vernon, Wise, and Dunn townships has many flowing wells. The depth often exceeds 100 feet.

There is a small district with flowing wells along Willow Creek valley in eastern Nottawa Township. I heard of one flowing well in Chippewa Valley in Section 28, Deerfield, on John Wyke's farm, which is 165' deep and flows a strong stream 15 feet above the surface.

There is some gravel suitable for road ballast in the Chippewa gravel plain west of Mt. Pleasant on road south of Indian School, but it is probably of shallow depth, for till outcrops in the banks of the river in Mt. Pleasant at a depth of 8 - 10 feet.

The wells in the valley that supply waterworks are in a low bottom about 10 feet below the Ann Arbor Railroad Station. There are several, and the deeper ones overflow.

WELL DATA NEAR BIG RAPIDS

Mr. Arthur Hanchett of Big Rapids furnished the following concerning wells near that city:

The "Red Cross Mineral Well", SW $\frac{1}{4}$ Section 23, Big Rapids Township, west side of Section, is 1350 feet in depth. Drift about 450 feet. The head is 30 feet below surface. The well is on high ground, nearly, if not fully 975 feet. Water veins were found at 600, 800, 850, and 1300 feet. It is thought that a bed of gypsum (called marble by the drillers) was passed through and also a

thin bed of coal. There was a very poor record kept, so that no further data of value could be obtained.

The G.R. & I.R.R. made a well in Big Rapids about midway between their two depots, 30 rods east of track at an altitude about 915 - 920 feet A.T.

Sand, dry	20'
Gravelly sand and water	3'
Sandy gravel	4'
Quicksand	12'
Sand becoming hard in lower 12 feet	39'
Compact sharp gravel with bits of coal	11'
Sand and gravel	5'
Sand mixed with clay	28'
Clay, probably till, but no stones noted	12'
Sand with a few pebbles	4'
Clay with some stones	4'
Till with a boulder 4 feet in diameter	15'
Mainly clay with a few boulders	85'
Sandy material	<u>5'</u>
Total	245 feet

WELL DATA AT ALMA

At Alma there are probably 100 flowing wells in the valley of Pine River, ranging in depth from 40 feet or less up to about 100 feet. The water seems to be from thin beds of sand and gravel at different levels in the till. A qualitative analysis of one 48 feet deep at the hospital shows magnesium sulphate in marked amount. It is also chalybeate. There is some lime and some silica. Professor C. A. Davis has gathered many statistics concerning these wells.

June 23, 1901:

I take train from Mt. Pleasant to Farwell on Ann Arbor Railroad, passing through a till plain until I am about two miles north of Rosebush where I enter the Alma moraine and reach its northwest border near Clare. The river border of the moraine is about 1-1/2 miles west of Rosebush. From Clare, the moraine is reported to continue north-northeast across southeastern Grant Township and the western part of Sheridan Township, Clare County. The Tobacco River passes

through it immediately east of Clare. Between Clare and Farwell the railway rises nearly 100 feet, much of it being in the two miles east of Farwell.

MARL NEAR CLARE

I am told by Dr. L. Kelly of Farwell, who is supervisor of Surrey Township, that marl is found in large quantity in Cranberry Lake in T. 17 N., R. 6 W., and around Littlefield Lake in T. 16 N., R. 5 W., and in smaller amounts in many other lakes in this vicinity.

I drive with Dr. Kelly to his ranch in Section 6, T. 17 N., R. 5 W., passing through a nearly plane sandy tract in Sections 25, 22, and 15, that lies on the outer or west border of a moraine that I passed through on the railway between Clare and Farwell. To the west from this sandy tract there is a very prominent moraine which occupies the west part of T. 17 N., R. 5 W., and east and south parts of T. 17 N., R. 6 W. It has a very prominent crest from Section 36, T. 17 N., R. 6 W., northward to Section 6, T. 17 N., R. 5 W., that stands 1100 - 1200 feet A.T., much of it being about 1150 feet. It has a bouldery drift with enough loam to make a fair soil for pasture. It incloses several lakes and has numerous basins and sharp knolls.

From the northwest corner of T. 17 N., R. 5 W., the crest turns eastward and runs near the line of Townships 17 and 18, bearing slightly to the north across Sections 6, 5, and 4, T. 17 N., and Sections 34, 35, and 25, T. 18 N., R. 5 W. There is a plain west of this moraine in T. 17 N., R. 6 W., that has a sandy and gravelly drift and shallow basins. It occupies the divide between Chippewa River and branches of Muskegon River in this township, there being no perceptible ridge on this divide. It extends northward over the greater part of T. 18 N., R. 6 W., and thence up the Muskegon valley.

There is a prominent range of hills setting in in Sections 2 and 11, T. 18 N., R. 6 W., and leading eastward across the south edge of T. 19 N., R. 15 W.,

and north edge of T. 18 N., R. 5 W. It then turns northward and runs along the line of T. 19 N., R. 5 W. and R. 4 W., as outlined by Dr. Kelly. We have it in view for several miles from its western terminus. This ridge has a gravelly apron on its outer or northwest border that covers much of T. 19 N., R. 5 W. The moraine on the south and east borders of the township covers only about 1.3 of its area.

There is a level tract between Dr. Kelly's ranch near Half Moon Lake and Lake George in Sections 17, 18, 19, 20, 29, 30, and 31, T. 18 N., R. 5 W., and the adjoining sections in T. 18 N., R. 6 W. Dr. Kelly says it has some clayey places in it but is largely coated with sand or sandy gravel. It is not so clearly outwash gravel apron as that in T. 19 N., R. 5 W. There seems to be but little clay on the plain west of the eastern range of Sections in T. 18 N., R. 6 W. The greater part of that township is a sandy plain with tamarack and cedar swamps in shallow basins. Dr. Kelly thinks the basins are usually less than 10 feet deep.

The moraine that I am on in the northwest part of T. 17 N., R. 5 W., is quite thickly strewn with boulders as far as I have examined it. On our return, Dr. Kelly drives southward along its west border near the line of Sections 1 and 2, 11 and 12, T. 17 N., R. 6 W. The moraine has greater swells on its west slope and has a relief of but 50-75 feet, with occasional points 100 feet above the plain for the plain is about 1075 feet A.T. Lake Station is 1071 feet and is scarcely up to the level of the plain. The moraine extends to Crooked Lake at Lake Station and passes west on the south side of the lake, covering the southern third of T. 17 N., R. 6 W., as well as much of the township south, T. 16 N., R. 6 W.

There is a sharp spur on the river side of this moraine in Sections 19, 20 and 21, T. 17 N., R. 5 W., that has points near its east end that are 150 feet or more above the bordering level tract along the Pere Marquette Railroad, or 1150 feet A.T., more or less.

There is a swamp south of the Pere Marquette Railroad in Sections 28, 29, 30, 31, 32 and 33, T. 17 N., R. 5 W., which is drained both to Tobacco River and the Willow Creek.

There is a sharp range of hills leading from this swamp southeast past Glass Lake. The highest point, known as "County Line Hill", - rises 185 feet (Barometric) above the Ann Arbor Station, or to about 1115 feet A.T. Its highest point is just south of the county line in Section 2, T. 16 N., R. 5 W. It rises abruptly on its northeast border about 150 feet, but on other sides, is bordered by lower hills.

There is a flat sandy tract about 1/2 mile wide along Tobacco River south of Farwell that follows down the stream past Clare. South of it there is, in Section 36, T. 17 N., R. 6 W., and the neighboring sections 31, 1, 6, and 5, a swell and sag till tract. I presume the sharp range of hills and this swell and sag tract all belong to the Riverdale moraine and the swamp west of Farwell probably marks the border between the Riverdale and earlier moraines. The sandy tract northwest of Farwell probably lies between the Riverdale and earlier moraines.

June 24, 1901 -- Farwell, Michigan:

I drive northeast with Dr. Kelly on the state road through Sections 19, 17, 16, 9 and 10, Grant Township. There is a morainic topography, swell and sag type, in Section 24 and east part of Section 25 and south part of Sections 13 and 14, T. 17 N., R. 5 W., on the west side of the north branch of Tobacco River, that probably belongs to the Riverdale moraine.

There is a narrow strip of gravel plain along the north Tobacco, scarcely a mile wide. East of this is a swell and sag till tract covering the greater part of Grant Township. The swells are more conspicuous on the west border than farther east, the eastern part of the township being nearly plane. This probably all pertains to the Riverdale moraine and its river slope.

There is a very prominent range of hills leading eastward along the line of Grant and Hatton Townships from North Tobacco River in Section 32, Hatton, and Section 5, Grant Township to the corners of Sections 34 and 35, Hatton, and 2 and 3, Grant.

I made the following altitude determinations in going from Farwell to this range of hills.

There are basins in a rather flat tableland in Sections 14, 15, 22 and 23, Hatton Township. It has a sandy and cobbly drift with a moderate number of boulders. It is not so flat as an outwash apron and stands too high to be connected with the range of hills south and southeast from here. Aneroid 28.880 more or less. It also contains some till spots. Beebe Lake on line of Sections 14 and 23 has a large amount of marl. Near corners of Sections 10, 11, 14 and 15, we rise to a higher tract - Aneroid 28.810 on brow of hill. There is cobble and gravel here but within 1/4 mile north we enter till. For a mile or more the aneroid reads 28.800 - 815. There is gently undulating surface with many boulders and some till. Near the line of Hatton and Hayes Townships, we descend into a dry ravine 75 feet, more or less, in depth, 1/4 mile or less wide, and follow it westward to the railway and then north to its head about 2 miles south of Harrison. There is a steep grade in this valley, for its head is higher than the upland is, 1-1/2 miles southeast. The bordering upland has a similar slope.

Aneroid 28.730 1-1/2 miles south of Harrison on a gently undulating moraine.

Aneroid 28.720 at Harrison, 1150 feet at 11:30 a.m.

A strong moraine with very prominent hills was in view on the west in the northwest quarter of Hatton Township and the southwest part of Hayes Township. Its altitude, in places, will reach 1200 feet. It is the continuation of the range that sweeps around the west and north borders of T. 17 N., R. 5 W. From Harrison it bears northeastward through the northeast quarter of Hayes Township, and continues diagonally across Franklin Township. The commissioner of Franklin

Township reports that the entire township has a rolling surface, except about two square miles in the northwest corner that is a gravel plain. The drift in the moraine contains considerable till. It is all a good agricultural region. Hamilton Township (T. 19 N., R. 3 W.) is also largely till. Its eastern half has a heavier clay soil than the western, but all the township is good farming land. The same is true of Arthur Township (T. 18 N., R. 3 W.). That township has its smoothest and heaviest clay land in the south part. The northwest quarter of the township is very broken.

Sheridan Township (T. 17 N., R. 3 W.) has a rather smooth clay tract, except the ridge (Alma moraine) on its west part, and a sandy plain bordering Tobacco River. The sand covers much of Sections 12, 13, 20, 24, 25, 26, 27, 28, 35, and 36, as outlined by the county commissioner from that township.

A boring in northeast part Section 15, Hayes Township is thought to have struck a 22-inch bed of coal at a depth of about 200 feet. (See William Wilson of Harrison for details). The boring was on the "Stewart farm".

There is a prominent hill near the northwest edge of Harrison. Altitude 1250 feet A.T. (Aneroid). From this hill I can see a prominent range along the township line west of here, and have a view over the country. East and north. There is a valley heading in the moraine at Harrison and leading northwest through the range that follows the township line. It is apparently a line of discharge for glacial waters from the Harrison moraine. The width is nearly two miles and it has a flat sandy bottom. It is unfit for agriculture. It leads out to the Muskegon River in central Summerfield Township (T. 20 N., R. 5 W.)

I am told by the commissioner of Summerfield Township that there is a strip of rolling land on the north tier of sections - Sections 2,3,4, and 5. In Sections 12, 13, 24 and parts of 11, 14, and 23, there is a moraine with some till. The remainder of the township is a sandy plain. In Sections 33, 34, 35, the plain is more productive than elsewhere in the township. Much of it is unfit for agriculture.

The eastern half of Winterfield Township (T. 20 N., R. 6 W.) is a barren sandy plain. The commissioner, Mr. Chapin, states that the only good land is in the southwest part in Sections 18, 19, 20, 21, 29, 30, 31 and 32, where there is an undulating till tract.

The northwest part of the township is largely swamp, but has some gravelly tracts interspersed. This may be of some value for agriculture.

Reading Township (T. 19 N., R. 6 W.) has a small tract of undulating clay in Sections 5 and 6. The remainder of the township, except the southeast corner, is a plain. There is a strip about 2 miles wide on each side of Muskegon River in this township that is either swamp or barren sand. The southeast part of the township is not so barren and may be worth cultivating. It embraces Sections 13, 23, 24, 25, 26, 27, 34, 35, and 36. Greenwood Township (T. 19 N., R. 5 W.), has only a little barren sand in northwest part of the township. The south and east parts are morainic and a gravel plain borders the moraine on the northwest which is a fair agricultural tract.

Frost Township (T. 20 N., R. 4 W.) is morainic in its south half, but the north half is largely a plain with sandy drift. It appears probable that the Muskegon River passes through a moraine near the north line of Clare County at the head of a reentrant between the Saginaw and Lake Michigan drift. Further study is, however, necessary to clear up the relations of the two lobes.

On my return from Harrison to Farwell, I drive northwest in the valley above noted and find it a barren tract of Norway timber, with small pines coming up in it. I cross the moraine west of this valley on line of Sections 1 and 12, Greenwood, and find considerable till in it and a good farming community. The moraine here only rises about to the 1200 foot contour but south from here, in Sections 13 and 24, points reach about 1350 feet. Greenwood Hill and two neighboring hills near the corners of Sections 13 and 24, Greenwood, and Sections 18 and 19, Hayes, are the highest in the range.

Aneroid 28.450 on Greenwood Hill at 4:45 p.m.

It read 28.690 at Harrison, 1150 feet, at 2:40 p.m., but there is a slight change to low barometer in progress, so that the Greenwood Hill can scarcely exceed 1350 feet, and may not exceed 1325 feet.

I follow the state road south to Farwell through Townships 19, 18, and 17, one mile from the east side of townships.

The drift is very sandy in the high hills in vicinity of Greenwood Hill, compared with what it is 2 - 3 miles north of there on the moraine, and it is rather sandy all the way south across T. 18 N. I cross a summit near corners of Sections 23, 24, 25, and 26, Greenwood (T. 19 N., R. 5 W.), where aneroid reads 28.500 (1275 more or less A.T.). The range trends west-southwest from here and overlooks a gravel plain on its outer (northwest) border. It is a rather stony and also sandy drift so that it is not very good for agriculture. Possibly it will make good pasture land. White clover and bluegrass have started along the roadside and made a good turf. The roadsides are, however, fertilized and tramped so much by horses that the sandy drift is enriched and packed along there more than at some distance back.

After passing the higher range I am in lower hills to south part of Sections 35 and 36, T. 19 N., R. 5 W. The knolls are sandy but the sags among them have till and boulders. The aneroid read 28.540 on several of the swells crossed in Sections 25, 26, 35, and 36.

I descend to a swamp on line of Sections 1 and 2, T. 18 N., R. 5 W., where aneroid reads 28.650. The altitude is perhaps 1150 feet here. From the swamp south for about 3 miles the road leads through a gently undulating tract of sandy, gravelly and bouldery drift. Aneroid 28.600 - 620. There are few knolls that exceed 20 feet. The sags have not so much till as farther north. It is a rather barren tract and has no settlers, but bluegrass and white clover thrive along the road and it may make fine pasture land.

In the southeast part of T. 18 N., R. 5 W., I go through a sharp range of hills with height of 20 - 75 feet more or less, and make a gradual descent. Aneroid 28.730 at first place where I can look out to the south, probably near the township line.

In Sections 11 and 12, I enter a barren tract (Aneroid 28.800 - 28.820) that is probably the continuation of that crossed this morning in Sections 22, 23, 26 and 27, Hatton Township, T. 18 N., R. 4 W. It extends to a creek crossed near middle of line of Sections 13 and 14. From there south to Farwell, I am in a gently undulating moraine. Aneroid 28.920 at Farwell - 931 feet A.T.

June 25, 1901:

Aneroid 29.030 at Pere Marquette Railroad Station in Farwell. I drive southeast along south side of Tobacco River across Section 36, T. 17 N., R. 5 W., through a gently undulating till tract. This tract occupies Sections 31 and 32, T. 17 N., R. 4 W., south of Tobacco River, and Sections 4, 5, 6 and 8, T. 18 N., R. 4 W. Section 7 has sharp knolls and the knolls are more prominent in Sections 5 and 6 than in sections bordering them on north and east, some being 30 feet or more in height.

There is a very sharply morainic tract from Glass Lake in Sections 12 and 13, T. 16 N., R. 5 W., northwest to the swamp in Section 34, T. 17 N., R. 5 W., with knolls 50 - 100 feet or more in height. But south of this range there is only a gently undulating till moraine that graduates on the east into a smooth till plain.

I go to a sag north of Stevensons Lake that leads across from a south tributary of Tobacco River to Stevensons Lake (which discharges south to Willow Creek). The sag is 1/2 mile wide and has low banks 10 - 15 feet high. It is not boggy and seems to have a clay subsoil where the road crosses it. I think, however, that it was a line of glacial drainage which was cut in the till.

I go west past Gilmore P.O., across a gently undulating swell and sag till moraine, and come to a gravel plain on west part of line of Sections 22 and 27, T. 16 N., R. 5 W. This plain has a few knols in it in Sections 20, 21 and 29, with swamps among them, but the north half of Sections 20 and 21 and much of Sections 15, 16 and 17 are flat. The flat sandy tract follows down Coldwater River from Littlefield Lake.

There is a strong moraine west of it and a weak one east of it. That on the west covers nearly all of Coldwater Township (T. 16 N., R. 6 W.) and extends southward as a great belt through the western edge of Isabella and eastern edge of Mecosta County. The one on the east runs south into the bend of Chippewa River, partly occupying the tract between Coldwater River and Willow Creek. There is a till plain on its east slope and a narrow strip of gravel plain west of it on east side of Coldwater River. (This moraine proves later to be the combined Riverdale and Vestaburg moraine from the bend of Chippewa River northward. See notes July 6.)

I go around the west and north sides of Littlefield Lake over a strong moraine that rises nearly 100 feet above the lake. It commands a view of much of Coldwater Township. That township has a productive soil -- a stony clay not too hilly to be easily farmed. The knolls are usually 20 - 40 feet high. Boulders are said to abound all over the moraine in that township.

North of Littlefield Lake, there is a rather sandy drift and less fertile soil. It is very hilly also and is known as "Jerusalem". It is scarcely fit for anything but pasture. East of Littlefield Lake is a gravel plain and this runs up north to the swamp in Sections 9 and 10, T. 16 N., R. 5 W. This swamp, as previously noted, covers several sections in the southwest part of T. 17 N., R. 5 W., and is drained both by Tobacco River and the north branch of Willow Creek. It is scarcely a mile wide where the state road crosses 4 miles southwest of Farwell.

From Farwell I take train on Pere Marquette Railroad to Hersey and there interview county commissioners (see notes in back part of notebook for this interview and also for a trip from Hersey to Cadillac and from Cadillac to Ann Arbor, made June 26.)

June 27 to July 3 were spent at Ann Arbor correcting the illustrations for my second monograph. I take train July 3 from Ann Arbor to Alma, and on morning of July 4, go from Alma to Edmore where I resume field work.

July 4 - Edmore, Michigan:

This village is near the divide between Flat River and Pine River. There is a moraine on the slope toward Pine River with swells 10 - 40 feet high, but westward from here, on the slope toward Flat River, there is considerable nearly plane land underlaid usually by till, but having some sand and gravel. It seems probable that the divide is along an ice margin in this township (T. 12 N., R. 6 W.) and the north part of the township south (T. 11 N., R. 6 W.). This view is supported not only by the difference in topography just noted, but also by the presence of gravel plains at intervals and of marshy channels that extend west from near the divide. Just north of Edmore, several channels lead westward from the moraine. There is a swampy channel leading northwest from near McBride to Flat River, but this carries an esker and is likely to be of subglacial origin.

An outwash gravel apron appears southwest of McBride in Section 19 and north part of Section 30, Day Township, T. 11 N., R. 6 W., and leads westward along a tributary of Flat River. There is a fine gravel or sandy gravel in it. Another small outwash apron appears south of Stanton in Sections 7 and 18, Evergreen Township (T. 10 N., R. 6 W.) that was formed by a sheet or stream that led southwestward to Dickerson Creek across Sections 24, 25, and 26, Sidney Township (T. 10 N., R. 7 W.). The moraine has a nearly south course across Montcalm County though it trends a little west of south.

I examined, July 4, into the separation between this moraine and the Vestaburg moraine as far south as a point 6 miles east of Stanton. There is, as already noted, a gravel outwash apron west of Vestaburg and a swamp at Cedar Lake on the west border of the gravel apron. This swamp extends southeast across Sections 30 and 32, T. 12 N., R. 5 W., and Sections 5 and 4, T. 11 N., R. 5 W., past the head of a south tributary of Pine River. It then runs west across the divide between Pine River and Fish Creek in Section 8 and follows down Fish Creek. There is no outwash apron east of it in Sections 8, 17 and 20, there being a strong moraine east as well as west of the swampy channel. The channel is $1/4 - 1/2$ mile wide.

In the southwest part of Section 19, T. 11 N., R. 5 W., a gravel apron appears on the east border of the channel and extends back into a recess in the moraine in Section 30 $1/2$ mile or more. From Section 19 southward, the creek has cultivable land along it to its junction with the west fork in Section 23, Evergreen Township (T. 10 N., R. 6 W.) and has a valley about $1/2$ mile wide. The moraine rises 30 - 50 feet above the stream and the gravel tract about 20 feet. The moraine surrounds Loon and Crystal Lakes. It continues south past Vickeryville along east side of Prairie Creek. The channel continues from the junction of the two forks of Fish Creek in Section 23 southward to Prairie Creek and thence down to Grand River. It is 1 - $1-1/2$ miles wide from where Fish Creek leaves it southward into Ionia County, and is rather swampy along the creek.

The moraine west of this channel is strong as far south as Fish Creek in central Evergreen Township (T. 10 N., R. 6 W.) with swells 20 - 40 feet or more in height, and a good many boulders. It is rather subdued south from West Fish Creek in southwest part of T. 10 N., R. 6 W., and west part of T. 9 N., R. 6 W. There are more basins and sags than knolls, there being a general level except for the depressions. Boulders are not so numerous on this subdued morainic tract as they are on the sharply morainic tracts to the north. There is, however, a

bouldery strip in Fairplain Township in Sections 23, 24 and 25, east of Dickerson Creek and to an undetermined distance west of the creek. Where these boulders occur, the surface is sharply undulating with knolls 10 - 20 feet more or less in height. This may be the moraine proper, while the tract to the east in Bushnell Township is simply a till plain with an unusual number of sags and basins.

GENERAL DISCUSSION OF TERRITORY COVERED JULY 4 - 13

(1) Routes traversed:

July 4: From Edmore east $3/4$ mile; then south 2 miles to town here; then east 2 miles; then south 2 miles; then east 2 miles to corners Sections 7, 8, 17 and 18, Ferris, where I found a swamp leading across from the Pine River to Fish Creek drainage; then south to corners Sections 19, 20, 29 and 30; then west to town line and south on town line to township corners; then west to Stanton. North through Sections 31 and 30, Day Township, and between Sections 19 and 20, 17 and 18, and 7 and 8 to road leading east into McBride, then north from McBride to Edmore.

July 5: From Edmore west 2 miles to town line; then south 3 miles to esker in a swamp; then west and south across Section 12, Douglass Township into Section 13; then north $2-1/2$ miles to center Section 35, Belvidere Township; then west $1/2$ mile and north $1-1/2$ miles to corners Sections 22, 23, 26 and 27; west 2 miles; north 1 mile; then west on center east-west road of Belvidere and Cato Townships to state road 1 mile southeast of Lakeview and in to Lakeview for dinner. West from Lakeview past esker to quarter post of Sections 7 and 18, Cato; then north to county line; then into Section 31 and Section 32, Hinton, on by-roads; then east from corners Sections 28, 29, 32 and 33, Hinton, 5 miles to corners Sections 29, 30, 31 and 32, Millbrook; then south to county line and east 1 mile; south $1/2$ mile; east 1 mile, and south to Six Lakes Station; east through Sections 15, 14 and 13, Belvidere; south $1/2$ mile; east 2 miles, and south 1 mile to Edmore.

July 6: North from Edmore 6-1/2 miles, then west and north by short turns to Blanchard. North on town line to state road 1 mile northeast of Millbrook, then along state road north-northeast 8 miles to Chippewa River in Section 27, Sherman. Then east two miles across Sections 27 and 26, and south eleven miles on road one mile west of east side of Sherman, Broomfield and Rolland Townships. Then west one mile across Pine River and south 6 miles and west 2 miles into Edmore. Then take train to Stanton and go up on hill 1-1/2 miles northwest of Stanton and find it about 190 feet above Stanton Station, or 1082 feet A.T.

July 7: From Stanton south 3 miles, then east to Mud Lake in Section 24 (a marl lake), then south between Sections 25 and 26, 35 and 36, then west 2-1/4 miles. Then south 1-1/2 miles and east 3/4 mile, then south through Sections 15, 22, 27 and 34, Bushnell, and east and south 1 mile into Palo for dinner. Then west 2-1/2 miles, north to county line, west 1-1/2 miles and north through Section 31, Bushnell Township. Then west 1-1/2 miles to line of Sections 25 and 26, Fairplain and north 2-1/2 miles, then east to state road at point 2 miles south of Sheridan, and north through Sheridan to Stanton.

July 8: From Stanton I go west 1-1/2 miles, then south across Sidney Township about two miles from its east line. Enter Fairplain in Section 3 and go south along and near north-south center line and enter Ionia County near Long Lake. Then go east to Shiloh and south along state road to Woods Corners. Then westward to Belding; east to Kiddville Junction and north across Section 36 and north to line of Sections 13 and 14, and west into Greenville.

July 9: From Greenville north 4 miles and west 2 miles, then north to Gowen and through Sections 18, 7 and 6, Montcalm Township. Then west 1 mile; north one mile; and west to Trufant. Then north 2 miles and east 1-1/2 miles on center line of Maple Valley Township. Then north 4 miles along range line to corners Sections

25 and 36, Winfield, and Sections 30 and 31, Cato Township, T. 11 N., Ranges 9 and 8 W. Then east 3 miles; then south 2 miles, and southeast across Section 10, Pine Township. Then east 1 mile, south two miles to corners Sections 23, 24, 25, and 26; then east 3-1/2 miles; south 2 miles, and east 3-1/2 miles to Stanton. Took train from Stanton to Mecosta.

July 10: From Mecosta I go east 10 miles to state road at line of Sections 4 and 9, then north across Chippewa River and northwest along east side of River to Sherman City. North through Sections 31 and 30, Coldwater Township, and west 1 mile between Sections 24 and 25, Fork; then north a mile; west a mile; south a mile on border of Section 23; then west a mile and south into Barryton. West and south across Section 33, Fork Township, then south on center road of Sheridan Township 4-1/2 miles; west 1-1/2 miles; south 1/2 mile, and west to line of Martiny Township. Then south on town line to road west into Mecosta. Take train from Mecosta to Big Rapids in evening.

July 11: From Big Rapids to Morley on train. Then east 1-1/2 miles and south across Section 32, Deerfield Township and Sections 5 and 8, Winfield Township. West in Section 8; south 1 mile and west 3/4 mile to Amble (well records). South 1-1/2 miles to south side Tamarack Creek, then east to town line. High point 1025 feet in Section 24, Winfield. North along line of Winfield and Cato 3 miles, then west 1-1/4 and north 1 mile to county line. North through Sections 35 and 26, Deerfield to bluff south of Little Muskegon, then east 3/4 mile and north across the valley on line Sections 23, 24, 13 and 14. West and north across Section 11, then west 2 miles and south past Higbee and across Little Muskegon. Then west to Morley and back to Big Rapids on train.

July 12: Big Rapids to White Cloud on train across elevated moraine. I drive south a mile, then go east to corners Sections 1, 2, 11 and 12, Everett and

southeast across Section 12 into Big Prairie Township. Then east into Section 9 and south to Muskegon River in northwest corner Section 22, Big Prairie Township. Around Section 21 and west across Sections 20 and 19 into Everett Township. South to corners of Sections 26, 25, 35 and 36, then west to Twin Lakes and north to White Cloud. Take train from White Cloud to Fremont. Drive east from Fremont on town line 5 miles, then north two miles, then west and north across Section 22, Sherman Township and west around north end of Crystal Lake through Worcester; then north between Sections 16 and 17, 8 and 9; then west four miles to corners Sections 2, 3, 10 and 11, Dayton, then south across the township to Fremont.

July 13: Drive west on town line three miles, then north and west across Sections 32, 29 and 20, Dayton. North and west on border of Section 18, then south along county line 6 miles to County Line Station, then back 1/2 mile and east through Sections 7, 8 and 9, Sheridan, then north past west side of Fremont Lake to town line and east to Fremont. Take train from Fremont to Muskegon.

(2) Results (given by topics)

(a) Vestaburg moraine:

This leads west of south across central and southwestern part of T. 11 N., R. 5 W., then south along line of T. 10 N., Ranges 5 and 6 W., and T. 9 N., Ranges 5 and 6 W., and through west part of T. 8 N., R. 5 W. It is 2 miles more or less in width; has considerable till so that it is called a clay tract from Vestaburg southward. It has a swell and sag topography and carries a moderate number of boulders.

North from Vestaburg, it lies between the two forks of Pine River as far as the head of the east fork northwest of Winn. It seems to become merged with the Riverdale moraine upon crossing Chippewa River in the southwest part of Deerfield Township (T. 14 N., R. 5 W.) in Isabella County.

(b) Drainage outside the Vestaburg moraine:

There is a gravel plain with sandy intermixture extending from near Littlefield Lake down Coldwater River to Chippewa River. It varies in width from about two miles up to five or six in passing from Littlefield Lake to Chippewa River. It extends nearly to Chippewa Valley in Sections 16 and 22, T. 15 N., R. 6 W. (Sherman Township), but there is a narrow strip of moraine along the east bluff that prevents the river from running east across the plain through this township.

From the bend of Chippewa River in south part of T. 14 N., R. 5 W., a sandy plain leads southwest to Pine River across Sections 30 and 31, T. 14 N., R. 5 W., and Sections 25 and 36, T. 14 N., R. 6 W., into the northeast part of T. 13 N., R. 6 W., where it has a width of over 2 miles. Farther south, it narrows to about a mile and holds that width to the junction with the south branch in Section 17, T. 12 N., R. 5 W. A swampy tract leads southward past Rock and Bass Lakes and thence through Section 32, T. 12 N., R. 5 W., and Sections 5 and 8, T. 11 N., R. 5 W. It is variable in width, ranging from 1/4 mile up to a mile or more. It crosses the divide between Pine River and Fish Creek in Section 8, Ferris Township (T. 11 N., R. 5 W.) and follows down North Fish Creek to its junction with South Fish Creek in Section 23, T. 10 N., R. 6 W., maintaining a width of about 1/2 mile. It then crosses by a swampy channel to the head of Prairie Creek in Sections 23, 26, 27 and 34, T. 10 N., R. 6 W. There is a sag swamp in its lowest part and a sandy plain on its borders that is 1 - 1-1/2 miles wide from the head of Prairie Creek southward past Palo. It is reported to continue down Prairie Creek to Grand River with a good sized channel. Taylor has examined its southern end east of Ionia. It seems to have very little coarse or gravelly material along it as far as I examined it (to Palo). There are places on its east border where terraces of sandy gravel rise 30 feet more or less above the channel and

appear to be parts of an outwash apron from the moraine. The channel, as noted in trip from Mt. Pleasant in June, is very bouldery and cobbly from the mouth of Coldwater River southward to Sections 17 and 18, Deerfield Township and possibly farther.

(3) The Edmore (?) moraine and its border drainage:

West of the channel and sandy plain just outlined, there is a strong moraine in northern Montcalm County east of the divide between Flat River and Pine River and Fish Creek drainage. There are swampy channels and small outwash aprons leading toward Flat River from the west side of the moraine. The west border of the moraine is not far from the railway from Wyman southward across Home and Day Townships (Townships 12 and 11 N., R. 6 W.) but in the tract to the west, there is, as noted below, considerable morainic topography so the border is not easy to fix upon. The swampy channels and the outwash aprons are aids of some value. These are found at the heads of nearly all the eastern tributaries of Flat River in Home and Day Townships. In Evergreen Township, (T. 10 N., R. 6 W.) there is a small gravel plain or sandy plain in Sections 7 and 18 that seems to have had glacial drainage to Dickerson Creek, though it is now drained by Fish Creek. There is a channel leading across the divide in Sections 25 and 26, Sidney Township (T. 10 N., R. 7 W.) 60 - 80 rods wide, which was probably the line of discharge. Its banks are but 15 or 20 feet high, so it is inconspicuous.

There is a sharp range of hills in Section 19 and east part of Section 24, T. 10 N., Ranges 6 and 7 West, that rises 75 feet more or less above the sandy plain just noted. Another conspicuous hill appears in Section 15, T. 10 N., R. 6 W., 60 feet more or less high, and one about 50 feet high appears 2 miles south-southeast of Edmore. Aside from these, I saw none that would exceed 30 or 40 feet. The drift is largely till and has a moderate number of boulders. The sharpest knolls contain some sand and gravel.

From Sheridan southward into Ionia County there is considerable nearly plane till and boulders are not conspicuous. There are bouldery, hummocky tracts east of Dickerson Creek in Sections 23, 24, 25 and 36, T. 9 N., R. 7 W., and Sections 30 and 31, T. 9 N., R. 6 W., which seem to be at the west border of the moraine, though it is possible that tracts west of Dickerson Creek are but little alike. The hummocks are only 10 - 25 feet high, but are quite thickly grouped or distributed. The interpretation of this strip as an ice margin is supported by the presence of a sand plain apparently an outwash apron that covers much of Sections 26, 34 and 35, T. 9 N., R. 7 W., and Sections 1, 2, 3, 4, 10, 11, 12, 13 and 14, T. 8 N., R. 7 W.

(d) McBride Esker:

An esker sets in just west of the divide and leads northwest down a swampy channel toward Flat River from Section 17 Day Township, across Section 7 into Section 1, Douglass Township. It is a sharp ridge, 10 - 20 feet high, with the usual contour of an esker. There are several gaps in it in the three miles that it covers. The swampy channel is obscure at the southeast end, but becomes conspicuous in Section 7 and from there down to Flat River is $1/2 - 3/4$ mile wide. Possibly it is all in line of subglacial drainage. It suggests the possibility that other swampy eastern tributaries were subglacial rather than extra-glacial lines of discharge.

(e) "Mt. Dodge" and associated hills:

About $1-1/2$ miles northwest of Stanton in Section 25, is one of the most prominent hills in Southern Michigan, known as Mt. Dodge. It rises about 175 feet abruptly above the bordering tracts and about 190 feet above the level of Stanton Railroad Station. Several sharp knolls are closely connected with it on the southwest and west and there are several hills forming a range that leads northward to Westville. The surface of "Mt. Dodge" is gravelly and it probably is composed largely of gravel or sand. The other knolls, so far as examined,

have a gravelly surface. They are, in some cases, but 75 feet, and quite often 50 feet high. This set of knolls does not connect closely with any moraine of similar strength. There is a choppy surface to the south in the east half of Sidney Township which may, together with these sharp knolls, constitute a morainic belt outside of the Edmore. I am not certain, however, that the knolls form a moraine. At least the outwash and glacial drainage seems not to be present to make a clear case.

(f) Moraine of Pine and adjacent townships in Montcalm County:

This is a very strong knob and basin tract with some knobs 100 feet high. It covers a large part of Pine Township and extends north into Cato a mile in great strength. Its knobs extend east into Section 17, Douglass Township. They also extend a little into the northeast corner of Kent County. This may be the continuation of the moraine that I traced north past Greenville last year. It is not well developed in Cato Township, Montcalm County. The west half of that township is largely a till plain and the east half has chiefly gently swells but is traversed by swampy tracts that are much below the general level (30 - 50 feet, more or less). There are also a few large drift knolls in the northeast part of Cato and northwest part of Belvidere Township. Some are 50 - 75 feet high. These carry it into connection with a strong moraine in Millbrook Township, Mecosta County that lies east of the Mecosta gravel plain noted in June. Between the moraine just outlined and the Edmore moraine, there is, in Montcalm County, a tract several miles wide that is, in places, too undulating to be like the usual till plain, yet that is probably where it should be classed. It occupies much of Belvidere and Douglass and the west part of Home and Day Townships, though Mt. Dodge and associated large knolls fall within this area. Much of Montcalm and the west part of Sidney, much of Fairplain, and the part of Eureka Township east of Flat River, falls within this gently undulating till tract. In these townships,

basins are conspicuous and the townships south in Ionia County (Otisco and Orleans) have many basins in a nearly plane till tract. There is a morainic topography in the west part of Otisco, as noted last year, and the belt leads north past Greenville.

This gently undulating tract seems to be a continuation of the basin till tract noted last year south of Saranac, and the moraine west of it seems to be the same that I traced across Grand River just east of Lowell last year. In northern Montcalm County, the gently undulating tract terminates and the moraine west of it becomes coalesced with the Edmore moraine.

(g) The Saginaw moraine of Eastern Mecosta and Western Isabella Counties:

This covers nearly all of Millbrook Township, Wheatland Township and Sheridan Township, Mecosta County, and the southeast part of Fork Township. In Isabella County, it covers nearly all of Coldwater, the western half of Sherman, all of Broomfield except the east and southeast parts, and all but the eastern third of Rolland Township. It is very sharply morainic throughout its course in these counties. The most prominent range leads from central Sheridan Township, Mecosta County, southeast to Section 8, Broomfield Township, Isabella County. It reaches 1150 - 1200 feet, and is 150 - 200 feet above the low tract on its northeast border along the Chippewa Valley. The knobs in Section 8 are nearly 200 feet high. Its width is 1-1/2 to 2 miles.

Throughout the moraine in these counties, knolls 40 or 50 feet high are quite common. Boulders are exceedingly numerous in Coldwater and northwestern Sherman townships, Isabella County, and are plentiful elsewhere.

(h) Gravel Hills Southeast of Amble:

There are gravel ridges and hills in the southeast part of Winfield Township, Montcalm County that, in places, take on an esker type, and an esker leads up to them from Section 31, Cato Township. The highest point is in Section 24,

Winfield and by aneroid is 1025 feet. It rises about 125 feet above the till plain east of it. These ridges seem to be part of a moraine that leads northward from Trufant through eastern part of Maple Valley Township, as noted last year. Gravel plains head in this moraine and lead westward along tributaries of Little Muskegon River through a till tract to the great gravel plain at Howard City. They are rather weak lines of glacial drainage, the width being usually 1/2 mile or less. This belt of hills and the moraine in which it falls are somewhat distinct from a moraine that I traced from Coral northward to Morley. From Amble northward to Little Muskegon River, a till plain 1 - 2 miles wide separates the two moraines. The western one fronts on the great gravel plain from Howard City northward to Morley, and thence northwest to the Big Muskegon, as noted in earlier studies, and seems to be a Saginaw moraine.

(i) Little Muskegon Valley east of Morley:

There is a large valley 1-1/2 miles, more or less, in width and 50 - 75 feet in depth, leading from the gravel plain near Altona through a higher tract, largely morainic, to the gravel plain southwest of Morley. It is evidently a line of vigorous glacial discharge. The Lake Michigan glacier must have lain entirely north of the Little Muskegon valley at this time. The valley above Morley is channelled in drift of variable structure, but assorted material exceeds the till in the bluffs.

An outwash apron was noted on the outer border of the moraine three miles east of Morley on south side of the valley in Section 28 that is 75 feet above the river or about 965 feet A.T. It covers only a part of one square mile. There are deep basins in it. Probably the plain, with its basins, was formed where the valley now is and cut away by the later glacial drainage.

(j) The question of an overriding of the Saginaw drift by Lake Michigan Lobe in central Mecosta County:

The present opinion is the same as that reached on my former trip (in June) that the Lake Michigan Lobe may have crossed the Big Muskegon about 10 miles below Big Rapids and overrode the Saginaw drift in northern Austin Township and had an outwash west of Mecosta.

NOTES ON TRIP FROM HARRISON AND RETURN TO FARWELL

June 24, 6:15 a.m.:

Aneroid 28.920 at Ann Arbor Station in Farwell, 931 feet A.T. Aneroid 28.750 on "Town Line Hill" south of Farwell = 1115 feet A.T., at 7:20 a.m. Hills very prominent from here southeast to Glass Lake.

There is a very prominent range from Lake Station to Section 12, Coldwater Township in view from here. Between the two ranges is a low tract with much level land. A low tract of sand extends north across Sections 22, 27, 14 and 15, T.17N., R.5W., as well as west up the Pere Marquette Railroad to Rennick (?). Aneroid 28.945 at Ann Arbor Station at 8:00 a.m. On ridge on township line northeast, 960. Tobacco River in Section 19 = 900. Gravel plain 940. Ridge east, 970 - 985; 28.950 at base of hill, north part of line of Sections 2 and 3, Grant Township; 28.825 at top of hill just north of township line in southeast corner of Section 34 = about 1075 feet A.T. Aneroid 28.800 on summit on road about 80 rods north of township line on line of Sections 34 and 35, Hatton Township. This is the highest point on this range. Aneroid 28.980 at east flowing stream on line of Sections 26 and 27 near north end of line.

Beebe Lake, on line of Sections 14 and 23, has a large amount of marl. Basins and considerable flat tableland in Sections 14, 15, 22 and 23. Aneroid 28.885 on tableland on line of Sections 14 and 15. Some till spots here, but largely sandy gravel. Near corners of Sections 10, 11, 14 and 15, I rise to a higher tract in which there is gravel and cobble on the borders, but till and boulders within 1/4 mile back. Aneroid 28.810 where gravel and cobble occurs near section corners. It is 1/4 mile north of an old railroad grade. For a mile or more north, the aneroid reads 28.800 - 815. It is gently undulating and has considerable till and many boulders.

We follow up a ravine for 9-1/2 miles that is dry and has bluffs 75 feet, more or less, in height. Width 1/4 mile. Aneroid 28.730 on gently undulating

moraine 1-1/2 miles south of Harrison. Aneroid 28.720 at Harrison at 1130 - 1150 feet A.T. Aneroid 28.705 at main part of town. A boring for coal in northeast corner Section 15, Hayes Township, Clare County, on land that belonged to Mr. Stewart, struck a 22-inch bed of coal at a depth of over 200 feet. W. A. McWatty of Harrison gives information. See William Wilson of Harrison. There is a flowing well in Section 8, Greenwood Township, on Chas. Sargent's land, about 25 feet deep. Hill just northwest of Harrison is 1245 feet. Apple trees on state road in Section 36, T.19N., R.5W. Marsh is in Sections 1 and 2, Surrey Township. Crook in road comes into Section 11. Aneroid 28.690 at Harrison at 2:40 p.m., 1150 feet A.T. W. W. Harper, County Surveyor, of Harrison, Michigan, goes with me northwest of Harrison.

Greenwood Hill, 1365, aneroid 28.450 at 4:45 p.m. Low tract near corners Sections 13, 14, 23 and 24, Greenwood Township, 1200; 28.500 on hill near corners of Sections 23 and 24, 25 and 26; 28.550 at old railroad grade about 60 rods south of hill; 28.540 at crossroads south of railroad grade a few rods. From here to south part of line of Sections 35 and 36, there is sandy drift on low hills and till in sags. Some boulders with the sand. Aneroid 28.540 on several of the swells or low sandy hills between Sections 24 and 36.

Aneroid 28.650 at swamp on line of Sections 1 and 2, T.18N., R.5W., 6:00 p.m. For about 3 miles south from here, I am on a gently undulating tract - aneroid 28.600 - 620 - with a sandy, gravelly, bouldery drift - a good many cobblestones with it. Bluegrass and white clover seem to thrive here. It is an unsettled region and would probably be good only for pasture. I then go through a range of sharp ridges and hills for two miles or more, gradually descending. Aneroid 28.730 where road comes out from hills so as to afford a view to the south; 28.800 - 820 at a basin tract in Sections 11 and 12, T.17N., R.5W.; 28.920 at Farwell - 8:30 p.m. Till ridge sets in south of creek in Sections 13 and 14, T.17N., R.5W. Flowing well 3 miles northeast of Ewart on north side Muskegon River. Frank H. Sebring, Sears, Michigan.

NOTES AT C. H.

June 25, 1901 - 6:45 a.m.:

Aneroid 29.020 at Ann Arbor Station in Farwell, 931 feet. Aneroid 29.030 at Pere Marquette Station. Aneroid 29.130 in channel from Tobacco to Chippewa River, north of Stevensons Lake, line of Sections 17 and 20, Vernon Township. Channel is 1/2 mile, more or less, in width. Till plain, west, has bank 8 - 10 feet. Moraine 1/2 mile east of east bank, on line of Sections 16 and 21, has a relief of 30 feet, more or less. Aneroid 29.070 at outlet of Littlefield Lake at 9:45 a.m.; 28.990 on hill on township line west of Littlefield Lake; 29.100 at inlet to Littlefield Lake, 11:00 a.m.

Aneroid 29.015 on gravel plain west part of Section 9, Gilmore. Hill 120 rods northeast is 75 feet higher. Aneroid 29.060 at Farwell, F. & P.M. Station. I take train on F. & P.M. railroad to Hersey. Swamp for about 5 miles along south side of railway, then the township line range of hills is entered. The sharp hills are in a narrow belt here, a mile, more or less, in width. There are only gentle undulations for 8 1/2 miles southeast of Lake, and somewhat sandy. Aneroid 28.890 at Lake, 1071 feet. The surface of Crooked Lake is 25 feet, more or less, below level of Lake Station. Sandy plain, entered immediately west of Lake, has basins. Some are small, but those holding lakes are quite large. Cranberry Lake is in one two miles long, north-south.

Aneroid 28.905 at south end of Cranberry Lake on ground 15 - 20 feet above water. This sandy plain extends to Chippewa, but at this station, till sets in. It is nearly plane for 1-1/2 miles west, and as far north as I can get a view. There are a moderate number of boulders in it. The railway does not come in sight of any sharp hills on this range east of Sears. Aneroid 28.880 on crest of moraine. There is a swell and sag till topography for 2-1/2 miles east of Sears.

Aneroid 28.920 at Sears. Topography continues the same west of Sears. Moraine on each side of the Muskegon above Evert, with a plain only - - $1\frac{1}{2}$ miles. Evert is on a plain standing 30 feet, more or less, above the river that extends about a mile north of the village. Aneroid 28.960 at Evert. The moraine is prominent south of Evert and sets in near the south bank. Evert Township is nearly all strongly morainic, I am told, from the river south to south line. The moraine north of the Muskegon near Evert seems to be less prominent than that south. That on the south rises 200 - 300 feet within 3 - 5 miles south, and looks very bold.

Aneroid 28.960 at Brazil Station. Hills are quite sharp north of Brazil and 50 - 60 feet in height, and from there west there is a prominent range of moraine on north side of Muskegon River within 1 - $1\frac{1}{2}$ miles back from the stream. There are, in many places, low, gently undulating tracts at the south border of the moraine, but usually the moraine sets in abruptly. It is conspicuous all the way to Hersey and its border is scarcely a mile at any point north of the railway. Near Brazil it extends to the railway and the river bank for a mile or so.

Aneroid 28.920 at Hersey at 3:30 p.m., 991 feet A.T. G. W. Manley of Orient Township (P.O. Sears), outlines extent of various soils in the township: A well at Chippewa, 192 feet, did not obtain a flow - E. B. Atkinson's well. In Section 33, NE $\frac{1}{4}$, William Moyses well, about 100 feet deep - water rises within 20 feet of surface. Mr. James McNeeley in SW $\frac{1}{4}$ of Section 33, has a well 60 feet deep with head 4 feet below surface. They are both on the sandy plain that covers the SE $\frac{1}{4}$ of Orient Township. West half of township has undulating till with only a few sandy tracts. The northeast part is a flat till tract.

William E. Robinson, Supervisor of Sylvan, residence in Section 6, outlines the extent of different classes of soil in Sylvan Township. The south half has considerable till but Sections 25 and 26 are swampy. There is an uninhabited

sandy tract in Sections 1, 12, 13, 14, 23 and 24, and a narrow strip farther west along the Muskegon. Sections 10, 11 and 2 are also sandy and uninhabited. There is some till in Sections 6 and 5 and north edge of Section 7 and northwest corner of Section 3, but with these exceptions, the part of the township north of Muskegon River is gravelly or sandy and much of it is settled and fairly productive.

H. L. Cowley, Section 31, Ewart, Commissioner for the township, states that wells are 70 - 150 feet on the high land. There is a strip of sandy, gravelly knobs 1 - $1\frac{1}{2}$ miles wide, south of the river. The southeast corner is also a hilly, sandy tract (Sections 25, 36), but 35 and 34 are rather good, though very hilly. The rest of the township has a fair soil.

Samuel Mooney of Middle Branch Township states that the portion east of Middle Branch River is all basins except the north half of Sections 1 and 2, which are till and undulating. The west half of the township is rolling, and the rolling land extends east nearly to Middle Branch River. The eastern one-third is nearly all sandy basins. There are some cedar swamps among the hills in the western half of the township.

A well on Albert Miller's land in Section 11, Sherman Township, Osceola County, is 337 feet and water rises scarcely any. It is very elevated land - about 1580 feet A.T. D. R. Marvin has a well in Section 10, 210 feet deep. The water rises 70 feet in well, or to 140 feet below surface. It was nearly all sand, there being thin beds only of clay. J. B. Bend, Section, has a well 198 feet. There are several other wells of similar depth in that neighborhood.

John E. Beech, southeast part of Section 23, Osceola Township, has a well 120 feet that overflows with strong stream. Henry F. Becker has a well in the southwest quarter, Section 23, that overflows. It is of similar depth to Beech's, just noted. There is very strong spring in southeast part of Section 22, Osceola. Irvin Chase, of Ewart, is Supervisor of Osceola Township. There is a little marl in marshes in Sections 34 and 35. There is also a little in southwest part of

Section 23, near Becker's well. "Wright & Grover" Lake in Section 24, Ewart, has marl.

D. E. Moulton, Section 18, Rose Lake, is Supervisor of that township. He outlined the extent of land unfit for agriculture or pasture. Sections 2 and 3 have some till with rolling surface. There is also a loamy soil in Sections 16 and 17, and a till tract in Sections 31 and 32. The rest of the township is a sandy, gravelly drift with spots of clay. There is a very barren strip west of Rose Lake and the southeast quarter of the township is quite barren in Sections 25, 26, 27, 28, 33, 34, 35 and 36, and south half of Sections 21, 22, 23 and 24. Wells are from 40 - 150 feet.

L. Lambert, Supervisor of Hartwick Township, residence in Section 36, says that the southwest part is hilly in Sections 30, 31 and 32. The rest of this township is undulating to plane. The north half is largely good farming land with some till. There are sandy plains in Sections 34, 35 and 36, and south half of Sections 25, 26 and 27. No flowing wells in this township. The deepest wells are 110 - 120 feet. They are in north part, usually, but are scattered over the township.

James K. Brown, Supervisor of Cedar Township, Section 19, says there is a strip of good farming land on west side of township, 1 - 2 miles wide. The rest is rolling pine land, quite sandy and unsettled. Section 27 has some good land. The wells in west part are, in some cases, 150 feet. William Moffitt, Section 30, has one 150 feet deep. It has but little head of water. There are many springs in this township.

John R. Ladd, of Hersey Township, in Section 33, outlines the bluff of Muskegon River in this township. There are some wells over 100 feet deep in the southeast quarter of the township, but a good many are 35 - 50 feet. Mr. E. H. Marvin, County Treasurer, states that there is a flowing well at Reed City

Waterworks. Mr. Marvin outlines bluff of Hersey River in Richmond Township. The valley is quite irregular. Waterworks well at Reed City is 276 feet, on ground 10 - 15 feet below railroad crossing. Flows a strong stream a few feet above surface. Wells at Hersey are 25 - 30 feet deep, reaching about the level of river bed, and are through sand and gravel to the water.

There is strongly morainic topography in the southwest part of the village and south from here in Richmond Township to edge of Mecosta County, as shown on map. The Muskegon Valley averages about 1-1/2 miles in width from the place where it enters the morainic tract in Sylvan Township southwestward across the county.

June 26, 1901:

Aneroid 29.090 at Hersey, 991 feet, at 9:40 a.m. I take train to Reed City on F. & P.M. Railroad. The valley of Hersey River is about 3/4 mile in average width, but ranges from 1/2 mile to a mile. The uplands north, as well as south, are a gently undulating swell and sag till moraine, standing 50 feet, more or less, above the valley. The sandy tract north of Hersey rises 100 feet, more or less, above the valley, or 125 feet, more or less, above the river quite abruptly.

I find that the waterworks well was largely through sand and gravel but there was some clay near the bottom. There is a flowing well at the electric light plant 1/2 mile east of the waterworks in Hersey River valley. It is a little over 200 feet, perhaps 220 feet, in depth. This well and the waterworks well are within 5 feet of river level.

I take train at 10:17 to Cadillac. The altitude seems to be lower west of Reed City than east, and continues so for 2 - 3 miles north from Reed City. It is a gently undulating tract with swells 20 feet, more or less. About 3 miles north of Reed City, higher land appears toward the west. Hills are 75 - 100 feet above

Hersey River. Aneroid 28.980 at Milton Junction. Boulders are conspicuous on moraine both sides of Hersey River near Milton Junction. The valley bottom is $1/2 - 3/4$ mile wide between Reed City and Milton Junction.

Aneroid 28.910 at Ashton. There is a plain to the west as far as I can get a view, $1 - 1\frac{1}{2}$ miles. It seems to be a till plain. North of Ashton, there is much swampy land with low knolls 10 - 20 feet high. They contain a sandy till where cut by the railway. Knolls continue here and are interspersed with swampy tracts to the divide south of Le Roy at head of Hersey River. Aneroid 28.800 on divide. This is a billowy tract with a relief of 30 - 50 feet above the hummocky tract south of it.

Aneroid 28.840 at Le Roy. This is in a sag. There is a ridge 40 - 50 feet higher $1/2$ mile northeast of Le Roy. It is strongly morainic as far west as I can get a view as I go north from Le Roy, with knolls and ridges 20 - 40 feet. The railway runs through a strip of swampy land with low knolls for a mile or more. The drift is rather sandy, but carries boulders. The railroad cuts show sand and till graduating into, or alternating at same level.

Aneroid 28.840 at Tustin. It is strongly morainic as far as I can get a view, with knolls and ridges 20 - 50 feet, more or less. Some swamps north of Tustin cover nearly a quarter section - largely tamarack. Highest hills rise 50 - 60 feet above swamps. There is a large tamarack swamp south of Osceola Junction, about 100 rods north-south and farther east-west. Aneroid 28.830 at Osceola Junction. Much till in cuts north of Osceola Junction.

Aneroid 28.750 at Hobart. Points $1/2$ mile east are 50 feet higher, or about 1350 feet A.T. There is a plain in view to the west from here up to Caddillac. The moraine along the railway and to the east is so bouldery that there are piles in the fields. The good land seems to extend a couple of miles north of Hobart. There is, north of there, much swamp, and the drift is sandy.

Aneroid 28.750 at Cadillac. Hills 1 - 2 miles east are 75 feet higher, and the east part of the city rises fully 50 feet above the level of the railway stations. The Ann Arbor Station is about 3 or 4 feet lower than the G.R. and I. Station. Aneroid 28.715 at Cadillac at 1:15. I take train east on Ann Arbor Railroad. The railway passes into a strong moraine at once. The highest hills are about 1400 feet. It is strongly morainic all the way to Lucas, with knolls 20 - 75 feet high.

Aneroid 28.715 at Lucas. A plain sets in here and extends north as far as I can get a view - 2-3 miles. The border between plain and moraine bears east of south for a mile or more south of Lucas. The plain is sandy with shallow basins. Gently undulating till with sand coating in vicinity of McBain. None of the swells over 25 feet high. Aneroid 28.780 at McBain. Topography continues gently undulating with till in nearly every cut to Park Lake.

Aneroid 28.825 at Park Lake. Topography but little different to Marion, though swells are occasionally more than 25 feet high. Many contain till, but some are gravelly where cut by the railway. There are but a few boulders.

Aneroid 28.910 at Marion. There is swamp for a mile or more southeast from Marion, but it only extends 1/4 mile or so each side of railway. The till tract extends into Section 2, Middle Branch Township, with an altitude about as high as at Marion. It has a relief of 20 - 30 feet above the sand plain that borders it. The sand plain is very flat.

Aneroid 28.950 at Pancocks. There is a fine gravel with the sand here. The Muskegon swamp is about 25 feet below the plain. Aneroid 28.985 in swamp.

Aneroid 28.985 at Temple on east bank of Muskegon River. The sandy plain sets in just east of river at Temple. About 1-1 $\frac{1}{2}$ - 2 miles southeast, a higher tract is entered.

Aneroid 28.920 at Clarence at 2:30 p.m., 1128 feet A.T. The moraine sets in

1/2 mile southeast and there is only a narrow sag across it utilized by the railway. In places, it is but 20 - 30 rods wide.

Lake George has a plain on the west side, nearly to its south end. The moraine is gently undulating on the borders of this lake, and quite sandy, with but few boulders - more prominent at south end than on east side. About a mile east of the lake, hills become prominent.

Aneroid 29.110 at Farwell, 937 feet, at 3:00 p.m.
Aneroid 29.290 at Mt. Pleasant
Aneroid 29.320 at Alma, 748 feet A.T.
Aneroid 29.290 at Ithaca

The moraine extends west for perhaps a mile - I was outside it for a short distance in Section 26. The surface is undulating to the southeast for but a mile. The railway runs east a mile and enters the plain before turning southeast. Aneroid 29.320 where railroad turns southeast.

There may be a beach where railroad crosses a north-south road north of a schoolhouse (near corners Sections 8, 9, 16 and 17). Aneroid 29.330 at suspected beach. Aneroid 29.340 at North Star. The supposed beach seems to be about 3/4 mile west of North Star. There is a slightly wavy till surface setting in southeast of North Star 1/2 mile, with boulders. The boulders are so numerous for 6 miles or more that piles are to be seen in fields, as well as many still scattered over the surface.

The surface declines within 2 or 3 miles southeast of North Star to a level where aneroid reads 29.380. It holds this level about to Ashley. Aneroid 29.390 at Ashley. The railway cuts a low till ridge in going out of Ashley, 5 - 6 feet above general level. Within 1/2 mile southeast of Ashley, it descends to a swampy flat. Aneroid 29.405, or 670 feet, more or less, above sea level. About a mile farther, it enters a marsh with cattail flags. Aneroid 29.410 on grade 5 feet, more or less, above surface of Marsh. This has evidently been filled by peaty growths - Davis reports only 4 - 5 feet, but the swamp or flat tract

bordering it is muck-clay, or hard ground. This brings the surface of the marsh down to about 660 feet above sea level. The marsh is a little nearer Ashley than Bannister and is only $1/4$ - $1/2$ mile wide.

Aneroid 29.400 at Bannister. Boulders and a gently undulating surface set in southeast of Bannister inside the beach. Aneroid 29.370 on beach. It is a very strong ridge - 8-10 feet high and 30 rods, more or less, wide. There is a gravel pit in it. It is about $1\frac{1}{2}$ miles northeast of Elsie. Between this beach and Elsie, there is a feeble moraine crossed by the railroad. It has wells 10 feet or less in height. Elsie seems to be south of the moraine. Aneroid 29.360 at Elsie. The moraine, as mapped by Taylor, is well developed from near Elsie southeastward on north side of this railroad. There is a ridge a mile or more southeast of Elsie with a remarkably even crest line that may be a beach. It has a gravel pit in it. The altitude seems to be about 10 feet above Elsie - possibly it is a glacial ridge.

A swampy channel 40 - 60 rods wide is crossed about midway between Elsie and Carland. Its trend would take it a mile or so north of Carland, for it runs nearly east-west. There seems, however, to be a broad sag just north of Carland. Aneroid 29.325 at Carland.

Aneroid 29.330 in swamp northwest of Owosso 4 - 5 miles, more or less. It lies north of the railroad in plain view for 2 miles. Probably it is on line of glacial drainage. It is nearly a mile wide. A moraine comes into Owosso from the west. The railway cuts into it 15 feet or so in northwest part of the town. Aneroid 29.335 at Owosso Junction at crossing of M.C. Railroad. The south edge of the city has a more prominent ridge apparently 40 feet above the Junction. Aneroid 29.340 at Owosso on low plain on south side Shiawassee River.

Aneroid 29.310 at Vernon in the Imlay outlet about the level of the bed of

outlet. The outlet is under cultivation for about a mile east of Vernon and is not sandy. The soil is a dark earthy material.

Aneroid 29.280 at Durand at 6:15 p.m., and the same at 6:50 p.m. After crossing the moraine southeast of Durand, there is a till plain for $1\frac{1}{2}$ miles, more or less, on north side Shiawassee River. There is a till cut just north of station, but north of there for $1/2$ mile or so, there is a flat sandy tract. Gravel pit southeast of Depot $1/2$ mile in a ridge or gently undulating strip that trends east-west. It is 30 rods, more or less, in width and 15 feet, more or less, higher than the plain.

South of Byron for a mile the altitude is higher west than it is east of the railway. East, it is flat. Undulating land sets in on the east side of the railway 2 - $2\frac{1}{2}$ miles south of Byron. It is rather stony, there being a few boulder piles in fields. Swells are usually but 10 or 15 feet. Cuts show till. This extends to Cohoctah and is very bouldery near this station.

Aneroid 29.180 at Cohoctah. Peaty marshes appear south of Cohoctah. The drift continues undulating. It is more sandy than north of Cohoctah. Some cuts, however, are entirely till. From here south, Taylor and I mapped the drift features last year.

Alma, July 4 - Aneroid 29.000:

Crest of moraine east of Riverdale - Aneroid 28.830
Riverdale - 28.860
Crest of Vestaburg moraine 28.750 1/2 mile east of Vestaburg
Vestaburg 28.765
Cedar Lake 28.775
28.700 at Edmore at 9:15 a.m., 934 feet A.T.
28.800 at Fish Creek, 6 miles east of Stanton
28.700 on crest 3 miles east of Stanton
Aneroid 28.740 at Stanton, 4:30 p.m.
Aneroid 28.660 at Esker west of McBride. Crosby's ranch $1\frac{1}{2}$ miles
south and 1 mile east of McBride has esker.
28.680 at Edmore

July 5:

28.630, 934 feet at Edmore at 7:00 a.m.
28.650 at Flat River west of Edmore
28.650 at swamps in Sections 14 and 23
28.600 on high point 1 mile southeast of Lakeview
28.625 at Lakeview at 11:30 a.m.; 28.595 at 12:45 noon
Aneroid 28.500 on hill south end of line of Sections 5 and 6,
Cato Township, at 1:25 p.m.
28.630 at Six Lakes 5:15 p.m.
28.595 at Edmore 6:30 p.m.

July 6:

Aneroid 28.690 at Edmore, 934 feet, at 7:10 a.m. I drove north from west
part of Edmore. Aneroid 28.625 on hill at line of Sections 8, 9, 17 and 16, Home
Township. Gravel at top and till on slope.

28.690 at Huckleberry Marsh 1/2 mile south of Wyman
28.650 on hill on southwest edge of Wyman
28.665 at Wyman, 948 feet
28.650 at Murphy Hill at 8:15
28.660 at Blanchard, 918 feet, at 9:00 a.m.
28.530 at summit on road near where road leads east from state road
in Section 16 (?), Broomfield Township. Hills 1/2 mile west are
100 feet higher.
28.700 at Chippewa River, 11:30 a.m.
28.700 at 12:00 noon.
28.590 at river, line Sections 35 and 36
28.590 on hill, line Sections 13 and 14
28.720 at Pine River east of Blanchard
28.620 2 miles east of Wyman where well is to be drilled
28.600 2 miles east of Edmore
28.625 at Edmore, 4:20 pm, 934 feet
28.640 at McBride

Esker sets in near the railroad 1/2 mile south of McBride. The land is all moraine east from there. Aneroid 28.630 at Stanton equals 850 feet, 4:45 p.m.; 28.510 at top of hill in southwest quarter, Section 25, T.11N., R.7W., at 7:00 p.m., "Mt. Dodge", equals 1025 feet, more or less; 28.720 at railroad station in Stanton at 7:30 p.m.

July 7, 1901 - 8:15 a.m.:

Aneroid 28.840 at Central Hotel in Stanton, 868 feet, more or less; 28.860 at railroad station, 8:35 a.m., 850 feet; 28.920 on gravel plain 2 - 3 miles south of Stanton equals 820 feet, more or less. Plain has basins 8 - 15 feet, some containing ponds. Range of hills in Sections 19 and 24 are 60 - 75 feet above gravel plain, or nearly 900 feet. They have a sandy drift - were timbered with pine, but are now growing oak. Gravel plain mainly in Sections 18 and 7, Evergreen Township; moraine in Sections 6, 5, 8, 17, 20 and 19. Sharp hill 50 - 60 feet high in southwest quarter Section 15. Aneroid 28.840 at top at 10:00 a.m. equals 900 feet, more or less. Till in this part of moraine, except on sharpest knolls, which are gravelly. Aneroid 29.000 at Fish Creek on line of Sections 14 and 23 equals 775 feet, more or less. Section 14 is nearly all plane - sandy gravel - standing 15-20 feet above Fish Creek. The plain on Fish Creek north from here is scarcely 1 mile wide.

Aneroid 29.040 at Palo at 1:30 p.m. equals 750 feet, more or less. Dr. C. B. Gauss' well is 100 feet, and terminates in gravel. It was largely blue till. Aneroid 29.070 at Palo at 2:45 p.m. equals 750 feet, more or less. Aneroid 29.020 one mile west on general level of till tract equals 800 feet, more or less. Slightly wavy - moderate number of boulders. Sags and basins more conspicuous than swells. Same topography for 3 miles west, then a moraine with swells 10 - 25 feet high, boulders, basins, etc. sets in that extends to Dickerson Creek west of Fenwick but farther south seems to extend only across

Section 36 and east part of 26, Fairplain Township. On its highest points, aneroid reads 29.000. Aneroid 29.030 at Sheridan at Grand Trunk Station. This is perhaps 5 feet above Pere Marquette Station, or 844 feet. Aneroid 29.050 at swamp 1 mile north of Sheridan, or 825 feet, more or less.

Aneroid 28.980 on summit on road, line Sections 24 and 19 equals 900 feet, more or less. A point 40 rods west is 30 or 40 feet higher, or 930 feet, more or less. A point 120 rods northeast is perhaps 50 feet higher - 950 feet, more or less. Till forms a large part of the ridge on southeast slope, but northwest slope is sandy and hill east of road is sandy. Aneroid 29.030 on gravel plain north of ridge on line Sections 18 and 13 equals 820 feet, more or less; 29.005 at railroad station in Stanton; 28.985 at Central Hotel equals 850.

July 3:

Aneroid 29.090 at Central House in Stanton, 20 feet, more or less, above railroad station; 29.070 on hill $1\frac{1}{2}$ miles west; 29.180 in channel in Section 26, Sidney. Channel is 80 - 120 rods wide and 20 feet, more or less, in depth.

Aneroid 29.230 at crest 1 mile east of Miller near railway. The track is less than 10 feet above C.K. - 29.250 at place where I get dinner on south side of Long lake, 15 - 20 feet above crest at 11:45 a.m.; same at 1:00 p.m.

Aneroid 29.225 at Shiloh at 1:30 p.m.; 29.210 at Woods Corners. Moraine east and southeast of here with swells 20 feet, more or less.

Aneroid 29.180 on upland plain, Section 18, Orleans Township; 29.180 in Section 13; 29.260 at railroad station in Belding at 4:00 p.m.; 29.215 on gravel plain in north part of Belding.

Aneroid 29.170 on till plain east of Greenville; 29.180 on gravelly plain east of river; 29.210 at Pere Marquette railroad station in Greenville; 10 feet, more or less, above level of Flat river at 6:00 p.m. Mainly flat till east of Greenville with a few basins containing lakes - similar topography southeast of Belding. Belt of sandy drift below, along Dickerson Creek.

July 9:

Aneroid 29.200 at Central Hotel in Greenville at 6:15 a.m. Aneroid 29.225 at Grand Trunk station 6:30 a.m. Sandy gravel for a mile north of Greenville, then a gently undulating till tract with basins. Knoll 25 feet high in north-east corner Section 4, Eureka Township.

Aneroid 29.160 at summit on road on line of Sections 27 and 28, Montcalm Township; 29.230 at Gowen, 837 feet, at 8:10 a.m., 15 feet above Flat River; 29.175 at Trufant Station, 872 feet, 9:30 a.m.; 29.050 on moraine east part of line of Sections 23 and 14, Maple Valley Township, 990 feet, at., more or less. Aneroid 29.050 at Mr. Smith's, southeast corner Section 36, Winfield Township, at noon. Aneroid 28.960 on line Sections 23 and 24 Pine, overlooking Flat River, 905 feet, more or less, A.T. Hills northeast are about 75 - 100 feet higher; 29.045 at swampy channel in Section 28, Douglass Township; 28.990 on hill 1-1/2 miles west of Stanton. Marl at lake near Trufant - very deep. Marl near Vestaburg. Marl from Stanton down to Mud Lake - in several lakes.

Aneroid 29.000 at Stanton, 892 feet, railroad station, 6:00 p.m.; 28.950 at McBride; 28.945 at Edmore, 6:40 p.m. (934 feet).

July 10, 7:00 a.m.:

Mecosta - aneroid 28.910, 950 feet. Low swells east of Mecosta for 1 - 3 miles, 15 feet, more or less. I then rise to crest of ridge. Aneroid 28.845 on line of Sections 4 and 9, Wheatland Township, 1015 feet, more or less, A.T. Continue with gradual descent for 1-1/2 miles then rise to an elevated tract that occupies Section 12 and much of Sections 1 and 2, Wheatland. Aneroid 28.740 on summit on road near middle of line of Sections 1 and 12 equals 1110 feet A.T.; 28.710 at summit on road on line of Sections 5 and 8, Broomfield Township, Isabella County equals 1140 feet, more or less. Hills are 75 - 100 feet higher

1/2 - 3/4 mile southeast of here on line of Sections 8 and 9, or fully 1200 feet A.T.

Aneroid 28.950 at railroad crossing on line of Sections 4 and 9, Broomfield, at 9:20 a.m. equals 930 feet A.T.; 29.000 at Chippewa River at crossing of state road in Section 27, Sherman Township equals 890 feet A.T.; 28.960 on sand plain in Section 22, Sherman; 28.980 at river near saw mill corner Sections 16, 17, 20 and 21, Sherman; 28.910 at Sherman City at noon; 28.900 at 1:00 p.m.; 28.780 on road (east-west) 2 miles from south side of township line near County line. Hill in Section 19 near center is 75 feet at least above this level, or 1150 feet.

Aneroid 28.780 on hill on line of Sections 23 and 24, Fork Township, Mecosta County - 2:15 p.m. Valley flats cover much of Sections 14 and 11 and probably all of Sections 10 and 15. High moraine west of the valley, 60 - 75 feet above valley; 28.860 at swamp in Chippewa River in Section 15 southeast part at 2:30 p.m.; 28.875 at Chippewa River north of Barryton. This village is on the sandy bottom 10 - 15 feet above the stream. Aneroid 28.860 at Barryton at 3:00 p.m.; 28.650 on highest point on road on line of Sections 21 and 22, Sheridan Township. Points 1.4 mile northwest are 20 - 25 feet higher; 28.880 at Mecosta equals 950 feet, 6:30 a.m. Well at Henry Chamberlin, southeast corner Section 21, Sheridan Township, is 85 feet. It was till 10 - 12 feet below which is sandy clay and at bottom, a sand.

Wells in Sections 1 and 12, Wheatland, reach 100 - 120 feet. In south part Section 2, well is 56 feet. Most wells on rolling land are 60 or 70 feet deep. (Information by R. D. Parks).

I take evening train into Big Rapids. The Pere Marquette Station seems to be about 15 feet lower than G. R. & I. Station, or 890 feet A.T.

July 11, 1901 - 9:25 a.m., Big Rapids:

Aneroid 29.040 at G. R. & I. Station. I take train to Morley. Aneroid

29.060 at Morley 10:10 a.m., 885 feet. Aneroid 28.950 on summit on road west end of line Sections 29 and 32, Deerfield Township; 28.960 1/2 mile south of County line; 29.030 at Amble at 11:45 a.m.

Boring for coal here - 360 feet - terminates in clay. There was one water vein at 25 feet and sand and gravel from there down to 84 feet, then 30 feet, more or less, of hard cemented clay and sand, then bed of water at 118 - 122 ft.

Pink clay at 122-130 feet
Water vein in sand at 130-132 feet
Head 20 - 25 feet below surface
Pink clay 132-138 feet, more or less
Sand and water to about 160 feet
White clay free from grit (10 feet) 160-170 feet
Sand and water at 170-220 feet
Head 14 feet from top
Clay beds with strips of sand and water at 220-265 feet
Pink clay from 265-360 feet, where well terminated.

No coal was struck except floating bits. No black muck was passed through nor peaty beds. C. A. Denton, driller, Amble, Michigan. Other wells by Denton given below - Henry Hinkle, in east part of Section 11, Pierson Township, 3/4 mile southeast of Maple Hill Station, has a boring 320 feet, made 3 years ago. It was largely through clay. There was much water at 45 feet and from there to 95 feet there were several water veins. Head from bottom vein is about 15 feet below surface. Clay was largely blue color. Well was to obtain a flow.

Wells overflow in the valley at head of Rogue River east of Rice Lake - from depth of 50 to 120 feet deep. A well 1/2 mile west of Grove P. O. in Emsley Township, on ground 50 feet lower than Grove, was 260 feet. It was very largely blue clay. Head from a vein at bottom rises within 60 feet of surface. It was on farm of Sam Blows, but he has since sold it.

Aneroid 29.040 at Amble at 1:00 p.m. equals 910, more or less; 29.000 ridge on east-west road; 29.040 at place where I cross road; 28.900 on highest point in Section 24 equals 1030 feet, more or less; 29.060 at Little Muskegon River,

line of Sections 23 and 24, Deerfield Township at 4:15 p.m.; 28.970 at corners Sections 2, 3, 10 and 11. Same 1/2 mile northeast of Higbee. Aneroid 29.000 at Higbee at 5:10 p.m.; 28.985 on ridge 1 mile south; 29.090 at Little Muskegon south of Higbee at 5:35 p.m. - 890 feet, more or less; 29.010 on gravel plain south of Little Muskegon in Section 28 equals 965 feet, more or less; 29.110 at river 1 mile east of Morley. Sandy plain near Morley is fully 25 feet above river level above dam, or about 35 feet above stream below dam. Morley Station is 10 - 15 feet below level of sand plain. Aneroid 29.105 at Morley, 885 feet, at 6:20 p.m.; aneroid 29.100 at Big Rapids, 905, G. R. & I. Station.

July 12, 1901:

Big Rapids, Pere Marquette Station. Aneroid 29.210 equals 890 feet A.T., more or less. I take train to White Cloud. Sandy till in cuts in first two miles. Aneroid 29.100 at north-south road 2 miles west of Big Rapids. Gently undulating here with moderate number of boulders. Soon enter a higher billowy tract that rises above 1100 feet. The hills rise 30 - 50 feet above the railway track in Sections 17 and 18. Aneroid 28.980 on cut 20 feet deep in south part Section 7, Big Rapids Township, equals 1100 feet A.T. Points nearby are 30 - 40 feet higher; 28.940 near county line in cut 20 feet deep. Points north 1/4 mile are 40 feet higher, or 1175 feet A.T; 28.940 at lake (north of track); 28.920 1/4 mile west of lake at a summit; 29.100 at Hungerford; 29.050 at Lamberton - 1044 feet. Strongly morainic all the way. Very sandy from Lamberton to Woodville.

Aneroid 29.110 at Woodville, 986 feet. Hills near here are 30 - 50 feet higher. The moraine has oscillations of 30 - 75 feet between hills and sags much of the way from a point 2 1/2 miles west of Big Rapids to Woodville. There is but a sparse settlement and the soil seems rather sandy for agriculture and very

rough to cultivate also.

Within a mile southwest of Woodville, a plain is entered. It has a sandy surface but there are occasional boulders and the sags seem to have clay. The railway skirts along the west edge of the moraine. Aneroid 29.170 at Fields, 951 feet A.T. Moraine lies immediately east, but it is plane for 1-1/2 miles west. There seems to be a range of hills 2 - 3 miles west, on west side of White River. I come to it upon crossing White River 1 mile north of White Cloud. Aneroid 29.245 at White Cloud, 870 feet, at 8:30 a.m.

Drive south one mile, then east to moraine near middle of line of Sections 3 and 10, Everett Township, across a sandy gravelly plain. Reach crest of morainic ridge near west end of line Sections 2 and 11. Aneroid 29.870 = 950 feet, more or less.

Drop to a sandy plain near middle of section line. Aneroid 29.205 = 920 feet; 29.350 at Muskegon River in northwest part Section 22, Big Prairie Township, 11:00 a.m.; 29.220 on high sand plain at schoolhouse, corners of Sections 26, 25, 35 and 36, Everett Township, at 12:30 p.m.; 29.280 at dry creek bed near middle of line of Sections 26 and 35. Is this a fosse? It has a high gravelly sand plain east of it and a moraine west of it. There are boulders in the valley.

There is a lower sand plain in view to the south in Sections 1 and 2, Brooks Township, and beyond to the Muskegon River valley. It is probably a terrace cut in the original sand plain. Aneroid 29.240 on moraine near west end of line of Sections 26 and 35. This is the south end of the moraine that I crossed $1\frac{1}{2}$ - 3 miles east of White Cloud.

Aneroid 29.300 on sand plain east of outlet of Mud Lake. Aneroid 29.320 at Mud Lake outlet near east end of line of Sections 28 and 33; 29.280 on gravel plain northeast of east Twin Lake, northeast part of Section 32, Everett Township; 29.200 on gravel plain northwest of White Cloud; 29.230 at White Cloud,

2:30 p.m.; sandy plain to Crystal Lake. Till with gentle undulations to Fremont. Aneroid 29.320 at Fremont; 29.290 at DeHass hotel in Fremont - 3:25 p.m.; 29.220 at township corners 1 mile east of Fremont. General level about the same for 3 miles east. A till tract with swells 10 - 25 feet. Narrow gravelly plain leads southeast from Long Lake. Aneroid 29.280 at Long Lake outlet; 29.180 on summit near south end of line Sections 26 and 27, Sherman. This is on the highest range of hills. It trends northwest-southeast from Crystal Lake to Pickerel Lake. Most of Sections 25 and 23 are morainic. Crystal Lake is about 850 feet, or 30 feet below Wooster Station. Aneroid 29.220 at Wooster at 5:00 p.m. High sand plain in Sections 6 and 7, aneroid 29.260, stands about 30 feet above broad low bottom on White River.

Gravelly sand coating in Sections 10 and 15 and probably farther west may be an outwash from a ridge that leads southwest from Aetna across Sections 2, 3, and northwest part of Section 10, Dayton Township. Aneroid 29.180 on prominent ridge near corners Sections 26, 27, 34 and 35, Dayton Township.

Aneroid 29.280 = 820 feet, more or less, at DeHass Hotel, Fremont. The County Surveyor, Mr. Anderson, outlined for me the width of White River valley west from White Cloud and of the rolling country north of White River in Lincoln, Denver, southwestern Beaver, southeastern Beaver and southwestern Monroe townships. There is a prominent range of hills containing gravel and till in southwestern Beaver Township in Sections 27, 28, 29, 31, 32, 33 and 34, T.15N., R.14W., and north edge of Sections 5 and 6, T.14N., R.14W. There is a very prominent hill north of Mountain Lake, at corners of Sections 5, 6, 31 and 32.

Another prominent range of hills sets in east of here in Sections 32 and 33, T.15N., R.13W., and Sections 5 and 4, T.15N., R.13W., that extends northeast to Otia. It is quite sandy compared with the hills of southwestern Beaver

Township. Between these hilly tracts is an unsettled swampy sandy plain.

In Lincoln Township there is a prominent hilly belt south and west of Diamond Lake. The highest points are in Sections 16 and 17 and are nearly as high as the high ridge in eastern part of county crossed this morning on Pere Marquette Railroad. The south border of this range is 1 - $1\frac{1}{4}$ miles north of White River from Section 29 eastward to Section 36. Its western end is in Sections 20, 18 and 7. This range has considerable till and is good farming country. There is another group of hills in Denver Township, north of White River in Sections 8, 9, 16, 17, 19, 20 and 21, that have a sandy drift.

Well at Electric Power house is 223 feet and terminates in gravel. This overflows from pipe 20 feet above surface. It is a 2-inch pipe and flows $6\frac{1}{2}$ gallons per minute at level of ground - temperature 51° . At edge of Fremont Lake, James Odell has a well 219 feet that overflows at same rate - temperature 48° . The wells at Electric plant are about 780 feet A.T., or 12 feet below railroad station. There are 32 flows here at depth of 80 - 100 feet. One at tannery west of the Electric plant is 234 feet and it overflows as at Electric plant.

July 13 - 7:00 a.m.

Aneroid 29.360, 792 feet, at Fremont Station. Marl 87% Carb. of Lime in Fremont Lake, about 400 acres, has about 30 feet of marl. Marl lakes northwest of Newaygo have marl 96% CaCO_3 . Seventy acres in Little Marl Lake and 96 acres in Big Marl Lake; 29.360 at Fremont at 10:00 a.m.; 29.370 at Reeman; 29.400 at Brunswick, 744 feet A.T.; 29.400 at Holton - 734 feet. Sand sets in $1/2$ mile east of Holton and is quite deep. The vegetation is not thrifty - trees - scrub oak. Sand is in low ridges 10 - 20 feet more or less, in height. There are basin-like tracts and sags 20 feet, more or less, below the general level. Aneroid 29.460 at Twin Lakes, 689 - 692 feet A.T. Level here. Some land under

cultivation. Land is wet in places west of Twin Lake with poplar and willow brush in it. Probably sand is a thin coating. Altitude for several miles is almost same as at Twin Lake. A descent begins 1 - 1½ miles east of Berry. Aneroid 29.485 at Berry - 646 feet A.T. Rapid descent to Bear Creek, aneroid 29.560. Aneroid 29.560 in marsh at head of Muskegon Lake, 6 - 8 feet on track above Lake Michigan, or about 590 feet A.T.

I made a trip northwest from Fremont to county line of Newaygo and Oceana, 3 miles south of Hesperia, passing through undulating till much of the way and reaching an altitude about 850 feet A.T. on highest points. There are few boulders on this undulating tract, but it is probably a moraine. A morainic tract leads west on south side of White River beyond the county line a couple of miles about as in Doyle Township, Newaygo County, across Sections land 2, 12 and 11, T.13N., R.15W.

Mr. D. G. Anderson, the county surveyor of Newaygo County, determined the magnetic variation here two years ago to be 45 minutes.

C. F. Gamble, City Surveyor of Muskegon, gave Professor C. D. McLouth the following - Muskegon Lake is 8 inches above certain stages of Lake Michigan.

Mouth of Maple River	16.85 feet
Ferry at Section 25, T.11N., R.15W.	18.70 feet
Northeast corner Section 30, T.11N., R.14W. (at upper end of Maple Island)	22.00 feet
1/4 mile above Bridgeton	28.30 feet
Big Rapids below lower dam	292.05 feet

WELL DATA AT MUSKEGON

Thickness of drift in vicinity of Muskegon (C. D. McLouth): Blodgett well in northeast part Section 35, T.10N., R.17W., - 245 feet; Rodgers well in Section 19, T.10N., R.16W., - drift 216 feet; Ryerson's well near mouth of Ryerson Creek, near middle of line Sections 19 and 20 - 208 feet; Coupling well near northwest

corner Section 20 - 204 feet. There are three wells in North Muskegon in Section 18 that have over 200 feet of drift, and one at mouth of Greene's Creek in north part Section 22 has, it is thought, about 250 feet. The wells are all on low ground, less than 10 feet above Lake Michigan. The rock lies deepest at western ones.

DEEP CHANNELS IN MOUTHS OF LAKE MICHIGAN TRIBUTARIES

The extreme depth of Muskegon Lake is 75 feet, as given by a city map issued by the West Michigan Land Company. Lake Michigan coast chart No. 8 gives the depth as 30 - 40 feet, but the soundings show 1 depth of 11 fathoms. The depth of White Lake is given by the chart to be 25 - 60 feet. The deepest sounding is 11 fathoms. Black Lake, south of Muskegon, reaches 7 fathoms.

July 15, 1901 - North Muskegon:

Locke levelled from Lake Muskegon up to Plain on which village stands and find it 45 feet or 625 feet A.T. Seems to be sandy gravel from top to bottom. The plain descends slightly westward so that it is about 38 feet at south part of Section 13 near middle of south side. There is some till in the bluff here, interbedded with gravelly material. A little farther west there is mainly till from lake level up to 23 feet above. The bank there is very nearly 40 feet above the lake, or 620 feet A.T. Thin bed of damp sand at top of till, 10 - 12 inches thick.

In Sections 14 and 15, there is a sandy plain about 35 feet above the lake which has clay (till) at 10 - 15 feet or less. There is till on each side of Bear Lake 6 - 10 feet above Lake for nearly its whole length. There is clay on both sides of Green's Creek in Section 15, quite continuous on east side and in spots on west side.

There are a few low sandy knolls. At line of Sections 10 and 15 I level up from Green's Creek and find till rises 20 feet. There are springs at this height and above the springs about 15 feet of sand with but few pebbles. Aneroid 29.320 = 622 feet. (See Montague map). West of the creek on this road there are sandy ridges extending to the great dunes. We go north to corners of Sections 2, 3, 10, and 11 and find till exposed in a clay pit just west of the corners. The till rises 15 - 20 feet above the creek at this point and has only 5 or 6 feet of sand on it.

We go west between Sections 3 and 10 and find that wells vary in distance to clay, some being in sand 18 feet, while others reach it at 5 or 6 feet and in sags there is a damp soil that suggests clay very near the surface.

We continue west to the lake, crossing several sandy ridges 6 - 15 feet high. The plain comes out to the lake in Section 6 at an altitude 30 feet above present lake level with low sandy bars up to 620 contour.

There are no dunes for 4 - 5 miles from Section 7, Laketon, T.10N., R.17W., northward nearly to Duck Lake. There are places where clay is nearly up to the level of the plain. The plain is about 40 feet above the lake. On the plain is gravel down to the present beach. It contains cobble stones. The lake bed is said by residents to be bouldery opposite here. North of here, near line of Section 6, Laketon and Section 31, Fruitland townships, till sets in and reaches a height of 12 - 15 feet above the lake. The sandy plain reaches 40 - 50 feet. Low dunes occur at a few points between here and Muskrat Lake, but from there north to Duck Lake, dunes rise 75 feet or more above lake level. The sandy plain south of Duck Lake is 34 feet by level above the lake and the dunes rise nearly 50 feet above this level.

I see no till here on the bluff of Duck Lake but there is coarse gravelly material at base. Aneroid 29.270 on bluff of Duck Lake at 2:40 p.m. = 617 feet A.T.

A well at Robert Hines on south bluff of Duck Lake is 62 feet and enters water at 53 feet. The well is about 50 feet above the lake level or 630 feet A.T.

There is a flowing well in southwest corner Section 36, Fruitland, 88 feet deep with head 3 or 4 feet above surface on land 627 feet (C. D. McLouth). There is clay near here in Section 2, Laketon at 2 feet. This clay is a continuation of the till along Green's Creek. To section 22, from the mouth of Duck Lake eastward, sand seems to be very deep but in that section till appears in the ravines that lead into Duck Creek and along Duck Creek. There is a till ridge or weak moraine in east part of Section 23, northeast part Section 26 and central part of Section 25, Fruitland Township. It is $1/4 - 1/3$ mile wide and stands 20 feet \pm above the level tracts on each side. There are some sandy knolls in the till ridge but in places till and boulders come to the surface. We trace it southeast only to the line of Fruitland and Dalton Townships near corners of Sections 25 and 36, Fruitland and Sections 30 and 31, Dalton. If it continues southward, it is not above the sandy plain (see Montague map). The occurrence of till at slight depth beneath this plain in Sections 35 and 36, Fruitland, and thence to Bear Lake and Muskegon Lake, as noted this morning, suggests a continuation in that direction.

There are several sand ridges in Section 22 and west part of Section 23 on the borders of Duck Creek and its tributaries rising 10 - 20 feet above the plain. But south from these sections, on the swampy tract between Duck Creek and head of Green's Creek, there are few ridges. There is one in $SE\frac{1}{4}$ of Section 36 that is 10 - 12 feet high, but no others so prominent were observed. These may be near the level of the upper beach, as they are about 650 feet A.T.

July 16:

Aneroid 29.225 at Muskegon Marsh; 29.180 at Dalton = 662 feet \pm ; 29.165 at north line Section 30 - 666 feet; 29.180 at Duck Creek - 650; 29.170-75 = 674 on

sandy plain east of moraine on east side Sections 13 and 24, Fruitland. Moraine is 15-20 feet; 29.150 on crest on line Sections 13 and 24 = 700, more or less. Moraine is 1/3 mile wide and runs north-northeast across central part Section 13. It turns west across NW $\frac{1}{4}$ Section 24 and NE $\frac{1}{4}$ Section 23 along north side of Duck Creek. It then takes a southeast course as ascertained yesterday. West of the moraine, in south half of Section 14, there are low sandy ridges but the north half is largely a flat swampy tract - below 640 feet. Section 15 is characterized by sandy ridges throughout and they extend into Section 16. They are on a tract that appears to slope westward. Those near the moraine are about 70-75 feet above Lake Michigan, while those near line of Sections 15 and 16 seem to be only 50-60 feet.

Aneroid 29.110 at crest of moraine near west end of line of Sections 1 and 12, Fruitland Township, = 700 feet or more. It reaches 720 feet in east part of Section 2 and in Section 34; 29.120 at belt of dunes on eastern slope of till ridge - a possible shore line - 6-8 feet above base of this sandy ridge; 29.140 at railway track on line Sections 1 and 12, Fruitland Township = 681, 1/2 mile north of Sweet Station. A well in northeast corner Section 11, near crest of moraine is 106 feet; 29.140 at east edge of dunes 80 rods west of township line on line of Sections 1 and 12; 29.135 at Sweets - 677. The east edge of moraine is 100 rods west of this Station.

We go east between Sections 7 and 18, 8 and 17, Dalton Township. There is a plain with occasional low sandy ridges in Sections 7 and 18, and a vegetation that is characteristic of wet land. But in Sections 8 and 17, we enter a series of sandy ridges inclosing basins that have the vegetation of a semi-arid region. The basins here are dry, but to the north and east they contain lakes. Upon turning south between Sections 16 and 17, we find that the south half of these Sections has a flat surface and a swamp vegetation and this flat surface extends

south to the Muskegon River. The border between the flat sand and the sand ridges runs eastward from the middle of line of Sections 16 and 17 toward Twin Lake. It seems to be an important line. Possibly it marks the extent of Lake Chicago. The aneroid indicates that the plain near its north border in Sections 16 and 17 starts about 20 feet above Berry Station or 665 to 670 feet (see Twin Lakes Topographic map).

We find a few low sandy ridges near line of Sections 20 and 29 from the cross road west and south into Section 29 past the center of the Section. They seem to belong to the system of low ridges noted near Dalton this morning. The highest are 10 feet, more or less, but some of them are only 5 feet. They are composed of sand without pebbles. The wells in this part of Dalton Township are said to be entirely through sand to a depth of 10 - 14 feet, more or less.

The surface sand becomes dry upon passing south from Sections 20 and 21, perhaps because drainage lines have been developed. There are no natural drainage lines in Sections 20 and 21 and before the country was brought under cultivation, it was inundated in wet seasons. From near Berry we return by the route we came out.

July 17, 1901:

Aneroid 29.240 at Muskegon Lake, 581 feet, at 8:00 a.m. We go northeast on the road north of river into Dublin Township through a tract of sandy basins with plane surface.

I then go west across Bear Creek into a dune belt and then north between Sections 26 and 27, 22 and 23, 14 and 15. There are low sandy ridges between this road and Bear Creek and occasional ridges west of the road. They are dunes and vary greatly in trend. They are 5-20 feet high. The tract on which they occur has a sandy soil but fallen trees turn up pebbles.

July 19, 1901:

Aneroid 29.435 at White River in Whitehall at 7:10 a.m. Flowing wells in Flower Creek valley in southern Claybanks Township:

Albert Pfund has one about 102 feet in Section 26. Julius Holbrook (Section 26) has one about 80 feet. There are others in same section. Aneroid 29.200 on top of Clay Banks at bluff of lake in Section 21; 29.285 at bottom of sand and gravel. Beds of sand clay - few pebbles; 29.360 at base. Stiff till of pinkish color down to lake level, 29.450; 29.345 at place where I get dinner. Lime has been ground from boulders in Sections 9 and 16, Clay Banks Township, but no wells strike rock. The depths of deeper ones is about 70 feet. Mr. Post's well in Section 9, is 58 feet. Has head 43 feet below surface. Aneroid 29.320 at 12:45 where it read 29.345 an hour ago; 29.340 at Josephson's flowing well in Section 36, Benona Township, 80 feet = 660 feet. George Nelson's in northeast corner Section 36 (Altitude 670, more or less) is 215 feet. Head 16 feet above surface. Clay 156 feet; gravel at 33-44; black mud 15 feet. Andrew Anderson, southwest corner Section 30, Shelby, well 180 feet. M. E. Spekonek, in Section 36 northeast part, 190 feet. John Arnesen, in southeast part Section 25 (Altitude 675 feet, more or less) has one about 175 feet that struck black muck at water horizon near bottom. In Mr. Nelson's well there was probably an old soil at 190-205 feet, more or less. It is called a black mucky soil by well owner. Sand and water under the black muck. Gabriel Anderson, in Section 31, Shelby (Altitude 685 feet), well 180 feet - head 15 feet. No muck noted. Mr. Roberts, in south part Section 30, has flow about 150 feet. Hans Jensen, in south part Section 30, another flow at about 150 feet.

Aneroid 29.110 at top of ridge on line of Sections 29 and 30, Shelby Township; 28.890 on hill in southwest corner Section 22, Shelby Township. On higher ones in view, 1030 feet; 29.120 on flat tableland in southwest part Section 27,

835, more or less; 29.120 at crossroads corners of Sections 27, 28, 34 and 35 on gravel plain, 835, more or less; 29.210 at New Era, 755 feet. The moraine rises abruptly 150 feet just west of here.

There seems to have been a line of glacial discharge southwest from Section 28 across the 835 foot gravel plain. This plain is trenched by what appears to be a glacial channel that New Era stands on and that opens out into a low sand plain 1 mile north of Rothbury Station at about 700 feet A.T. The plain near Rothbury is similar to that on the Muskegon from Twin Lake south. It is wet sand in the headwater parts of the small north tributaries of White River and a dry barren sand farther south. I entered the barren sand 1 mile south of Rothbury. There are a few low sandy ridges seldom 10 feet high, more or less, on this sand plain. It slopes towards White River, just as the Muskegon plain does from Twin Lake towards Muskegon River.

July 20, 1901:

I drive from Whitehall northeast to county line at Carlton Creek. Marl is found in a basin-like expansion of the valley in Section 36. It covers perhaps 100 acres and Mr. Carlton has probed it 20 feet without reaching bottom.

There is also marl in a terrace 15-20 feet above creek, just north of the county line road. It is 20 feet or so below the general level of the bordering plain, or about 615-620 feet, the plain being, by aneroid, 635 feet and the creek 600 feet A.T., at county line.

The road runs north-northeast across Section 31, Otto, and altitude reaches about 635 feet. A rise of 25 feet is made along line of Sections 29 and 30 to the border of a lake. The basin has a rim 25 feet high, so lake is about 635. Low tract leads southwest from this lake. The lake basin only covers about 10 acres. About 1/4 mile north of the lake, a rise is made to 690 feet A.T., in a flat sandy tract. This extends north to the north part of

Sections 17 and 18. Here, a rise of 50-75 feet is made into a tract that is mainly sandy with low knolls and deep basins. I find a nearly pebbleless clay in some of the knolls on line of Sections 8 and 9, Otto, at an altitude about 750-770 feet. The greater part of Section 9 has this undulating topography and it extends slightly into north part of Section 16. Sections 4 and 5 are also undulatory with broad, marshy tracts dotted with knolls that rise 20-30 feet above them. The marshes are about as low as the sand plain to the southeast, or about 700 feet A.T.

There are a few remnants of what seems to be an outwash apron in Sections 8 and 9 and 4, that stand 750 feet A.T. The one in Section 4 is just south of the town line near a schoolhouse. The knolls that are below this level, as well as the channels, may be products of erosion. The pebbleless clay in hills suggests a lacustrine deposit. These hills rise a little above the flat topped tracts that I think may be remnants of an outwash apron.

The undulatory land lies west of north fork of White River as far north as Ferry (or Reed). I cross the north fork of White River on town line of Ferry and Otto Townships. It seems to be 650-660 feet A.T., and the plain east of it 700 feet. A higher plain of sand and gravel or sandy material occurs in Section 36, Ferry Township. Its south end is in north part of Section 1, Otto Township. It extends only a little into Sections 26 and 36. This is 735 feet, more or less, and is probably an outwash apron from the moraine to the west. That moraine occupies the west and north parts of Ferry Township, and is said to be very prominent like it is in Shelby Township, and northern Grant.

I drop down near corners of Ferry, Newfield, Otto and Greenwood Townships to the 700 foot plain. It seems to cover Sections 31 and 32, Newfield, and possibly the sections to the north, and extends southeast to White River. It has only a few low sandy ridges.

Aneroid 29.220 at 11:45 where I stop for dinner at Mr. Van Vleet's, southeast corner Section 6, Greenwood Township. This seems to be 715 feet. Aneroid 29.210 at 1:00 p.m.; 29.185 at north bluff of White River at corners of Sections 3, 4, 9 and 10, Greenwood Township, 730, more or less. Cobbly material in middle part and fine gravel above on bluff. Till at base, 15 feet more or less. Aneroid 29.265 at White River on line of Sections 9 and 10, Greenwood = 660 feet, more or less. Width of bottom land 80-100 rods. There is a narrow beach on north bluff, about 15 feet below top.

Cobble and boulderets in south bluff. At top of bluff, aneroid 29.195. Low swells with boulders in Section 10. Highest in view 10-15 feet, in Sections 1 and 2, 11 and 12. Aneroid 29.180 about 1 mile south of White River at summit in road. Scattered boulderets here, but the surface is sandy and gravelly.

Aneroid 29.235 at Bakers Creek; 29.185 on plain south of creek in Section 21, Greenwood; 29.210 at basin in the plain in southwest part of Section 21. It covers 30-40 acres and is 20 feet deep. Has marsh grass and huckleberry bushes.

A morainic belt with sandy coating extends west along the county line to Skeels Creek. Aneroid 29.140 on crest in south part of Section 33, Greenwood Township. There are a few boulders in the fields where soil is quite sandy.

Aneroid 29.225 at Skeels Creek on county line; 29.170 at border of sand plain one mile west of Skeels Creek on county line at 3:20 p.m. This reading is maintained for several miles southwest through Section 6, Holton Township, and Sections 1, 12, 11, 13, 14, 23, 26 and 27, Blue Lake. Basins are 20-25 feet below this level and in Sections 24, 25 and east part of Sections 23, 26, knolls rise 10-15 feet above it.

Slightly wavy in west part of Blue Lake. Swells 5-10 feet are clear sand and probably wind agency. Aneroid 29.170 to northeast bluff of Silver Creek in

Section 19; 29.185 on southwest bluff; 29.150 on crest of moraine east of Whitehall; 29.245 at Whitehall Station, 7:10 p.m., about 10 feet above Lake Michigan, or 590 feet A.T.; 29.175 at Dalton = 660-665 feet; 29.195 at Berry (Big Rapids Junction) 645 feet A.T.

Proof of Monograph XLI having come, I go to Denmark, Iowa to read it, stopping at Chicago to see Professor Chamberlin on the way.

ANEROID READINGS

Aneroid 29.070 at Alma, 8:40 p.m. = 748 feet; 29.045 at Forest Hill; 29.050 at Shepherd; 29.060 at Mt. Pleasant; 28.800 at swamp in B----- at 10:50 a.m.; 28.700 on high points in Sections 35 and 36; 28.835 at Donovan House, Mt. Pleasant, 1:00 p.m.; 28.875 at Donovan House, Mt. Pleasant, 2:30 p.m.; 28.740 on hill 20 rods southwest of Bogden P.O., 20 feet above Post Office; 28.820 at Chippewa River west of Bogden.

John Wykes has flowing well 165 feet, near center Section 28, Deerfield. Runs on 2-inch pipe full 15 feet above ground. Aneroid 28.900 on edge of sandy bluff at Longwood; 28.925 in valley at Longwood; 28.900 at Donovan House, Mt. Pleasant, 7:00 p.m.; 29.020 at Mt. Pleasant, 6:40 a.m., T. and Ann Arbor Railroad.

Moraine in view $1\frac{1}{2}$ = 2 miles west of Rosebush, aneroid 28.985. A mile north, the railway enters the swells on river slope. Aneroid 28.950 on crest 2 miles south of Clare. On cut 20 feet deep - Aneroid 28.925 at Clare, 834 feet A.T., 7:20 a.m.; 28.930 at Clare at 7:30 a.m.

Gravel plain, rather fine material, at Clare. Moraine $1\frac{1}{2}$ miles west of Clare - just west of where stream is crossed. Aneroid 28.840 at Farwell at 8:00 a.m., 931 feet; 28.830 at Farwell at 9:45 a.m., 931 feet; 28.590 on high point in Section 5, T.17N., R5W.

Aneroid 28.695 at Half Moon Lake, 1/4 mile northwest of hill, = 1040 feet, more or less, A.T. Clear Lake lies south of the hill in Section 5. Bear lake lies in southeast part of Section 6 and extends into Sections 7 and 5.

Aneroid 28.645 at residence (in Section 6) on Dr. Kelly's farm; 28.590 on hill in west part Section 6; 28.590 on hill in Sections 28 and 18; 28.890 at Farwell at 8:00 p.m., 821 feet.