

Open File Report XXVI  
FIELD NOTES OF FRANK LEVERETT

Notebook No. 175 - Leverett

COUNTY

- Antrim
- Benzie
- Charlevoix
- Crawford
- Emmet
- Grand Traverse
- Leelanau
- Mackinac
- Manistee
- Mason
- Oceana
- Otsego
- Roscommon

- July 28. Drive north from Eastport to Norwood, Ellsworth, and back.....13
- July 29. Byers, Central Lake, Bellaire, Mancelona .....15
- July 30. Mancelona – Alba – Bellaire – Central Lake. ....16
- July 31. Trip to Jordan River and East Jordan .....16
- Aug. 1. Central Lake to Charlevoix by rail. Drive southwest from Charlevoix. Rail to Petoskey .....17
- August 2. Petoskey to Boyne City and back.....17
- August 3. Petoskey to Mackinac Island and back. Then by rail to Elmira .....18
- August 4. Elmira to Gaylord and Grayling. ....18
- August 5. Grayling – Frederick – Deward – and back. ....19
- August 6. Drive west from Grayling and back. Drive with Livingston southwest from Grayling .....20
- August 7. Drive southeast from Grayling to Jack Pine and then to Roscommon.....20
- August 8. Roscommon to Grayling.....21
- August 9. Drive northeast from Grayling with Sheriff.....21

July 11, 1902, 9:00 a.m.

Aneroid 29.520 at Manistee River in Manistee = 582 feet, more or less. Aneroid. 29.420 on clay ridge with boulders at 6th and Spruce Streets = 675 feet, more or less. This bears southwest nearly to the shore of Lake Michigan and northeast to Manistee River. There is a river channel south of it standing about 37 feet above Lake Michigan. It is 20 - 30 rods wide and has well defined bluffs. South of it is a pitted gravel plain on which the aneroid reads 29.440 or 70 - 75 feet above the lake, 650 - 655 feet A.T.

After going a mile or more, the angling road that leads through Sections 23 and 27 gets into a valley that runs southwest. It is 25 feet, more or less, below the general level of the gravel plain. There seems to be a finer material in this valley than on the plain, for there the overturned stumps show considerable gravel.

After crossing a creek in Section 34, I find clay near surface and in Sections 4 and 5, there is a hummocky moraine with a crest 90 - 100 feet above the lake. It is 1/2 - 3/4 mile wide and has hardwood timber along it. The definitely ridged part does not extend to the shore of Lake Michigan, but I am told that till extends out to the lake at the mouth of Freesoil Creek in Section 6. There is an unsettled region south of Freesoil Creek west from the wood that runs through Sections 3, 10, 15 and 22, T.20N., R.17W. There seems, from accounts, to be nothing but sand at its surface. Possibly the moraine follows the edge of Lake Michigan southwest from the mouth of Freesoil Creek, but this seems doubtful, for there is said to be no outcrop of till along the lake bluff from the mouth of Freesoil Creek to Ludington. There are some hills south of the creek in Section 5 that may

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- July 11. Trip south from Manistee and back.. ..... 1
- July 12. Trip east from Manistee and back.
- July 14. Trip east from Manistee north of river..... 2
- July 15. Onekama (wells), Arcadia, Frankfort, Benzonia. 2
- July 16. Benzonia – Adams Hill, Joyfield, Bear Lake, Onekama (wells) ..... 3
- July 17. Onekama to Copemish on railroad. Drive west from Copemish, past Humphrey, and Kaleva.. ..... 4
- July 18. Copemish, Thompsonville, Homestead, Honor, Inland, Nessen. Copemish to Traverse City (by rail). Deep wells, Traverse City. .... 5
- July 21. Traverse City to Cedar River and back. Traverse City to Suttons Bay ..... 6
- July 22. Suttons Bay, Provemont, Omena, Northport, Leland..... 8
- July 23. Leland, Duck Lake, Maple City, Judge Williams, Oviatt, Solon, Traverse City. .... 9
- July 24. Traverse City, Lake Ann, Mr. Bates, Inland, Interlochen, Traverse City ..... 10
- July 25. Trip on the Peninsula of Traverse Bay ..... 11
- July 26. Traverse City southeast to Boardman River and north to Williamsburg. By rail Williamsburg to Central Lake. Drive to Eastport. At Byers. .... 12
- July 27. Wells and levels near Eastport ..... 13

belong to the moraine, but I cannot learn whether they are drift knolls or are dunes.

I return to the county line and go east, rising to the moraine at northwest part of Section 3. It covers the southeast part of Section 35 and much of Section 36, T.21N., R.17W. It extends but 1/2 - 3/4 mile south of the county line in Section 3 and covers only the northwest corner of Section 2, T.20N., R.17W. From there it runs northeast to the head of Manistee Lake south of filer in Section 19, T.21N., R.16W. It has nowhere a width of more than a mile and is usually 1/2 - 3/4 mile. The highest points are near corner of Sections 30 and 31, 25 and 36, and reach an altitude fully 150 feet above lake Michigan, or 730 feet A.T. There is sand on the highest points, but till occurs up to a level 125 feet or more above the lake, or over 700 feet A.T.

Southeast of this moraine is a pitted plain with a few lakes and many dry basins for 1-1/2 - 2 miles out from the moraine. A flat swampy plain is then entered which extends to Sable River. I cross it on a road running south through Sections 10, 15 and 22, and also on the range line between T.20N., Ranges 16 and 17 West. There is a strip of sand ridges along the north bluff of Sable River and an occasional low sandy ridge in the swampy plain. This plain has bog iron at slight depth. The poplars are starting up on it since the pine timber was cut off.

South of Sable River, as noted last year, there is a moraine covering the north part of T.19N., R.17W., the southeast part of T.20N., R.17W., the north-west corner of T.19N., R.16W., and southwest part of T.20N., R.16W. I travel it as far as Freesoil Village.

On today's trip, I crossed the Sable River in Section 27 and found a sandy plain there, 60 feet, more or less, above the stream both south and north of the river, but it does not extend far into Section 34, and covers only the northwest part of Section 26, the southeast part being on the moraine. Wells in the southeast part of Section 26, on the moraine, are 30 to 50 feet, and largely through till. Farther east, they are deeper.

#### July 14, 1902

Aneroid 29.300 at Hotel Durham in Manistee, about 610 feet A.T. Aneroid 29.210 on sand plain in Sections 27 and 28, T.22N., R.16W., about 690 feet. Aneroid 29.125 = 750 feet, more or less, at summit on wagon road in east part of Section 22 on moraine. Aneroid 29.100 = 775 feet A.T. on knoll 20 rods west of this road summit. A knoll 1/2 mile northwest is perhaps 50 feet higher. Drift is mixed -- some till and some sandy drift at surface. A few boulders on the surface and in the cuts. Aneroid 29.130 at Mr. Seller's in west part of Section 23. A well here is 105 feet.

Aneroid 29.210 on sand plain on line of Sections 17 and 20, T.21N., R.15W. Aneroid 29.280 on lowest cultivated plain. This is about 40 feet above the river swamp. Aneroid 29.320 in river swamp.

Aneroid 28.960 on crest of moraine near middle of line Sections 11 and 14 T.22N., R.15W. Aneroid 29.030 on sandy plain at Chief. Plain is a mile wide and runs east from Chief Lake. Aneroid 29.020 on plain east of Onekama on line of Sections 29 and 32 = 750 - 760 feet. Aneroid 29.200, 522 feet, at Portage Lake at 4:00 p.m.

Flowing well at Hansen's, in Onekama, is 102 feet. Plowing well at led Bluff, 62 feet. Aneroid 29.090 on hill south of west end of Portage Lake on shore road = 130 feet, more or less, above the lake, or 710 feet.

#### July 15, 1902, 7:20 a.m.

Aneroid 29.290 at E. A. Solomon's well. Depth of well is 157 feet and will rise 20 feet above surface. It was in sand for 130 feet, then a thin bed of clay and sand again near bottom. A boring 1-1/2 miles west, 304 feet deep, was made by W. W. Davis - struck no rock and did not get a flow. Another well, only a few yards away, 25 feet deep, has a good flow. Chas. Canfield has wells about 3/4 mile west of Onekama that are about 162 feet that overflow.

There is a pink till in the low bluff north of Portage Lake and in places on narrow strip of bottom land bordering the lake, 40 - 80 rods.

I take road north when two miles west of Onekama. Aneroid 29.170 on first summit. Drift is sandy here and surface only gently undulating. North of this is a very high range of hills with points over 900 feet A.T. Aneroid 28.930 on hill west of road 30 rods, more or less, = 925 feet A.T. Aneroid 28.930 at summit on wagon road. This is in north part of Section 15. There is a cluster of knobs in Section 10 about as high. They rise 60 - 75 feet -- very abrupt. The high land runs from Section 15 northwest to the shore of Lake Michigan, or Section 9, and is nearly 300 feet high at the lake border.

Pierport is in a recess in the moraine that is only 30 or 40 feet above the lake. There are high morainic hills immediately north, but northeast and east is a sandy plain setting in in the east part of Sections 3 and 34, and extending to Bear Lake. It seems likely to be an outwash from a moraine, trending north-south along the lake.

Aneroid 29.070 on sand plain at corners Sections 2, 3, 34 and 35, one mile east-northeast of Pierport. Aneroid 29.070 at corners of Sections 26, 27, 34 and 35, at edge of sand plain. Much of Section 34 is morainic and the border runs east along line of Sections 26 and 35.

Aneroid 29.090 at corners Sections 25, 26, 35 and 36, on the sandy outwash plain. There are basins 10 - 20 feet deep along the border. Only the northwest corner of Section 25 is on the moraine, the rest being a plain, but Section 26 has only 60 - 80 acres in southeast part on the sand plain. The southeast half of Section 24 is on the sand plain.

I take road northwest Across Section 23 and descend through the moraine to a till plain which sets in in the

southwest part of Section 14. Aneroid 29.320 on till plain where road leads east through center of Section 14. Aneroid 29.330 at railroad in north part of Section 14.

There is till at the cross roads in Section 11 at a level only 20 feet above Lake Michigan. There is a broad flat beach at Arcadia, 15 - 20 feet above Lake Michigan, that may be the Algonquin. It is more than 1/4 mile wide. Aneroid 29.350 on beach at Arcadia = 600 feet A.T.

I drive east into the high moraine through Sections 11 and 12, and stop for dinner at Lafayette Long's in northwest corner Section 7, Pleasanton Township. Aneroid 29.050 at Mr. Long's at 11:30 = about 830 feet A.T. The well at a cemetery 2 miles east of Arcadia is 135 feet and has head about 40 feet above surface. L. L. Frick has one only a mile east of Arcadia 470 feet deep. Aneroid 29.050 at Mr. Long's at 12:30 p.m.

A ridge 1/2 mile north and 3/4 mile east is 75 feet or more higher. I cross it on road east near east end of line of Sections 6 and 7, Pleasanton Township. Aneroid 28.950 = 910 feet. High ridges northeast to Joy's Corners and northwest to the shore of Lake Michigan along south edge of Benzie County. I go north on range line and come to a sandy plain on line of Sections 25 and 30 that may be a line of eastward glacial discharge, though now the drainage is west from a mile or more east of this range line.

Aneroid 29.240 on the sandy plain. Aneroid 29.300 at stream and swamp near corner Sections 20, 21, 28, and 29. This swamp is 1/2 - 3/4 mile wide and has a sandy bottom. Aneroid 29.325 at a lake in Sections 18 and 19, 13 and 24. This is very little above Lake Michigan, for its outlet is through a sandy beach similar to that at Arcadia, 15 - 20 feet, more or less, above L. Michigan.

Aneroid 28.980 on morainic crest on road in south part of Section 2, T.25N., R.16W., or about 870 feet. The highest points near here are 20 - 30 feet higher, or nearly 900 feet. The moraine extends a spur north along the lake shore to South Frankfort that is overridden by dunes.

Betsey River has a terrace with a level 40 feet above Lake Michigan = 620 feet. Aneroid 29.305 on terrace in South Frankfort. Aneroid 29.350 at Betsey Lake in Frankfort, at level of Lake Michigan. Aneroid 29.210, about 700 feet, on first hill, 1-1/2 miles east of Frankfort on Forest Avenue. Aneroid 29.150 on second hill, 3/4 mile farther east, about 750 feet. Aneroid 29.060 1/2 mile farther east. The highest points 1/4 mile north are 75 feet higher, or about 900 feet. Aneroid 29.330 about 600 feet, at Crystal Lake outlet. Gravelly beach material in the swamp 6 - 8 feet above the lake. It is 1/4 mile, more or less, wide. Aneroid 29.210 on first hill east of outlet about 720 feet.

Aneroid 29.110, about 800 feet, at Benzonia Hotel at 6:45 p.m. This is at edge of the prominent moraine. There is said to be a nearly plane table land east and southeast from here.

July 16, 1902, 6:30 a.m.

Aneroid 29.090 at Benzonia Hotel and Post Office. Aneroid 29.280 at Beulah Station = 606 feet. Aneroid 28.860 on hill at Chas. Adams near south edge of Section 13. Benzonia Township, probably the highest point on the range and about 355 feet above Lake Michigan, or 935 feet A.T.

Aneroid 29.240 at Beulah at 9:40 = 606 feet A.T. Aneroid 29.030 at Benzonia Post Office and Hotel at edge of sand plain that lies east of the moraine = 800 feet, more or less. Aneroid 29.235, about 600 feet, at Betsey River south of Benzonia. Aneroid 29\*195 Q& terrace south of river = 635 feet. It has a thin coating of sandy gravel over the till. Aneroid 29.170, 650 feet, on a higher terrace 80 rods south. Aneroid 29.160 at edge of a swamp at corner of Sections 23, 10 and 11, T.25N., R.15W., = 660 feet, more or less.

Aneroid 29.150 at corner of Sections 1, 2, 11 and 12. Gently undulating moraine 650-675 feet, along west bluff of Betsey River in Sections 1, 12, 13 and 24, extends west across Sections 11, 14, 23, 10, 15 and 22. Generally a sandy, loamy soil. Knolls 10 - 30 feet. Altitude 850 feet or less. Aneroid 28.980 at cross roads at line of Sections 15 and 22. Aneroid 28.965 at town hall in Section 22. Aneroid 29.000 at Joyfield at 12:10 p.m. Same at 12:50.

I drive east and enter a basin tract 1/2 mile east. The basins are 20 - 25 feet or more in depth. Some are dry and some hold lakes. Around them is a sandy gravel with hardwood timber. The surface is nearly plane except for basins. It is higher than Joyfield. Aneroid 28.970 on general level of gravelly tract on east part of line of Sections 26 and 35. There is a strong moraine in Section 36, except the northeast part, probably 1/4 of Section, but Section 25 is mainly the basin or pitted plain.

I go south on line of Sections 35 and 36. Aneroid 28.920 near middle of Section line. Aneroid 28.920 at county line at south end of line, Sections 35 and 36. Aneroid 28.950 on terrace west side of Glovers Lake about 30 feet above lake. This lake is at south edge of the prominent moraine. Aneroid 28.900 on nearly plane tract 1/4 mile west on line of Sections 11 and 14. This plain covers all of Section 11 except the north and east borders and all of Section 14; also all of Section 10 except the north border, and the south-east corner of Section 9. There are basins in this corner and the rest of the Section is morainic.

In Section 15 there is a sharp hill, 75 - 100 feet high, that is surrounded by this outwash plain. It lies east of the angling road, trends north-northeast, south-southwest, is 1/2 mile or more long, and runs through the center of the Section.

Aneroid 28.850 at border of moraine on line of Sections 9 and 16. I go south between Sections 16 and 17, and come to the northeast end of a plain that runs southwest across the southeast part of Section 17 and covers

much of Sections 19 and 20. There is a range of morainic hills east of it in west part of Sections 16 and 21. Aneroid 28.930 on the gravel plain at corners of Sections 16, 17, 20 and 21. There is a narrow strip of moraine running to corners of Sections 20, 21, 28 and 29.

Aneroid 28.670 on hill in southwest corner of Section 23, on Hulbert's Hill (1,000 feet, more or less). A hill 120 rods east-northeast and one 80 rods east-southeast, are fully as high. Aneroid 28.840 at cross roads near corners Sections 21, 22, 27 and 28.

Aneroid 28.920 on lower plain at east end of Bear Lake (765 feet, more or less). This is less than 10 feet above the lake and is the outlet for the glacial waters from the sand plain or outwash apron northwest of the lake. Aneroid 28.730 on crest on line of Sections 17 and 18, Bear Lake Township.

Aneroid 28.760 on hill 1-1/2 miles northeast of Onekama, west end of line of Sections 19 and 30. Aneroid 29.010 on clay bluff back of Onekama = 660 feet, more or less. Aneroid 29.100, 580 - 585 feet, at Portage Lake in Onekama at 6:30 p.m. Mr. A. W. Farr of Onekama states that marl is found in southwest part of Section 22, that is 12 - 20 feet. One of Mr. Canfield's flowing wells, 168 feet deep, flows 50 gallons in 19 seconds from 2-inch well, or about 150 gallons per minute.

Mr. Farr's well – 304 feet:

1. Sand .....	10 feet
2. Gray clay .....	12 feet
3. Very fine sand .....	3 feet
4. Streaks of clay with sand .....	10 feet
5. Fine white sand .....	205 feet
6. Clay of blue color .....	4 feet
7. Earthy sand that did not cave ....	60 feet
<b>Total .....</b>	<b>304 feet</b>

Andrew Kulgren has a flowing well 5 miles east-southeast of Bear Lake on east bank of Bear Creek, just south of Hopkins Railroad 138 feet. Head 6-1/2 feet above surface. It is 40 feet or more above Bear Creek. Clay was struck at 38 feet and there was 100 feet. Gravel 27 feet at top, then sand. Canfield's first well was 40 feet, and it was extended to 148 feet and was sand from 40 to 145 feet, then a bed of clay. Well at east end of lake at north side at Hansen's:

Sand .....	8 - 10 feet
Clay - blue - sticky .....	60 feet
Sand .....	10 feet
Clay, blue and hard .....	22 feet
<b>Total .....</b>	<b>102 feet</b>

One at Henry Smith's, in block east, is 129 feet, and was largely a clay with some sand admixture. It was of a reddish tinge.

The level of Portage Lake was about 9-1/2 feet above Lake Michigan prior to 1871, or 590 feet. A ditch was then opened across the dunes direct to the lake, and it fell to the present level. There was an outlet with 9-1/2

feet fall north of the present outlet. There is a strong gravelly beach standing 12 - 13 feet, or 595 by hand level, above the present lake level. The lake washed against it and has made a bank 3 - 4 feet high along its south edge in Onekama. It is well displayed north of the railway station. It stands out a few rods from the clay bluff here, but a short distance east, it is at the base of the bluff. Mr. E. H. Solomon, the hotel keeper at Onekama, says that Bear Lake stands 180 feet, by surveyor's level, above Portage Lake, or 760 feet A.T.

July 17, 1902, 6:30 a.m.

Aneroid 29.090 at Onekama = 585 feet. Aneroid 29.130 at 7:30 a.m. = 585 feet. Aneroid 28.960 at Onekama Junction at 7:40 a.m. A well is being driven here that is down 90 feet. There was 55 feet of dry sand and below this, wet sand.

Aneroid 28.780, or 885 feet A.T., on hill 1/4 mile south of Junction. Another, 1/4 mile farther south, is 60 - 65 feet higher, or about 950 feet A.T. Aneroid 28.715 on highest point south of Onekama Junction 1/2 mile. Aneroid 28.785 on return, where read 28.730. Aneroid 28.980 at Onekama Junction, 755 feet, at 8:30 a.m. Aneroid 29.020 at Goodrich = 733 feet. Aneroid 28.950, 728, on plain at Chief Lake Station.

There is a plain 1/4 - 1/2 mile wide on north side of Chief Lake. Aneroid 29.025 at Bear Creek. Aneroid 28.970 at Kaleva, 747 feet. Flat from Bear Creek to Kaleva. Plain northeast from Kaleva for several miles, an unsettled pine stump region. The aneroid is 28.940 - 28.950 for several miles, or about 800 feet. An occasional low sandy ridge, but nearly all is flat surface. Aneroid 28.940 at Lemon Lake Station, 792 feet. The flat tract runs north from Lemon Lake to Copemish, but there is a moraine in view 1 - 2 miles east.

Aneroid 28.910 at Copemish = 807 feet. Same 1/2 hour later – 10:30 a.m. I drive west from Copemish and descent 25 feet in less than a mile. Aneroid 28.940 at crossing of the Arcadia Railroad, about 1-1/2 miles west of Copemish. Aneroid 28.950 at Pere Marquette Railroad in northeast part of Section 15. Aneroid 28.950, 795, at Henry Station at Pere Marquette and Arcadia Crossing.

Aneroid 28.985 at corner Sections 7, 8, 17 and 18. Aneroid 28.850, about 900 feet, on hill on Mr. Burlingaine's, near center of Section 7. A hill in the northwest part of Section 18 is fully 75 feet above this hill, or nearly 1,000 feet. Aneroid 29.020 at Mr. Burlingaine's residence at foot of hill in Section 7. It read 28.990 here an hour ago. Probably altitude is 740 feet. Boulders are numerous on the low ground along line of Sections 7 and 8 south of Betsey River, and with them are low swells. Till is near the surface here also. The ice margin seems to have passed from a range of hills in Section 18 northeastward to a range in Sections 33 and 34 and 27 in Southern Benzie County. I drive south in Section 18 nearly to the south end of the high range of

hills, the hills being over all but the east edge of Section 18, and covering the north end of Section 19 from this road east.

I go west past Humphrey Post Office. Aneroid 28.940 at the railroad at township line of Pleasanton and Springdale, corner of Sections 18 and 19, 23 and 24. This is in a low channel-like tract leading southeast from Glover's Lake. Aneroid 28.930 on general level of plain in Sections 13, 14, 23, 24, 25, and 26. The east edge of Section 24, and fully half (southeast part) of Section 25, are on the lower plain. I go west across Section 26 and south between Sections 26 and 27, 34 and 35 to Bear Lake outlet. The higher plain extends to the middle of line of Sections 34 and 35. It carries a few low swells and occasional boulders, as north of Bear Lake. The swells are only 10 - 20 feet, and are rare. The drift is a sandy gravel, like the gravel plains that have no knolls. Aneroid 29.020 at Bear Lake outlet, on line of Sections 34 and 35. The swamp, or low plain, here is only a half mile wide. There is a strip of the higher plain 1/2 mile wide south of this outlet. It reaches the middle of the line of Sections 2 and 3. There are low knolls and occasional boulders on it, but the drift is a sandy gravel and there is much plane surface. Aneroid 28.930 on plain at middle of line of Sections 2 and 3. South of this is a prominent moraine. Aneroid 28.750 on crest at corners of Sections 2, 3, 10 and 11, 1,010 feet, more or less. The moraine has a loose, sandy texture, with very little till. In places the sand is pink like the till.

The greater part of Sections 10 and 15 is in a gravelly plain that leads southeast across Section 14 and northeast part of Section 23 to the edge of the swampy plain that Bear Creek runs through. There is a drop of 75 feet or more to this plain. Aneroid 29.030 on the low plain in Section 13 = 755 feet, more or less, A.T. Aneroid 29.050 at corners of Sections 24 and 25, Bear Creek, and Sections 19 and 30, Maple Grove Township. I turn east here. The swampy plain extends about to west end of line of Sections 24 and 25. The greater part of Section 23 and north part of Section 26 are moraine, but the south part of Section 26 is low land -- a part of the tract that leads east from Chief Lake.

Aneroid 29.080 at Bear Creek bridge, 710 feet, more or less, 8 feet above stream on line of Sections 19 and 30, Maple Grove Township. Aneroid 29.050 at crossing of the M. & N. E. Railroad. Aneroid 29.040 at Kaleva = 747 feet.

Aneroid 28.950 at border of moraine on town line Sections 19 and 24. Aneroid 28.970 at a creek in west part of Section 18 that leads northwest from Section 20. There is clay subsoil under parts of Sections 18 and 19, Marilla Township, and Sections 13 and 24, Maple Grove Township, on the plain west of the moraine. The moraine covers the east edge of Section 18 and much of Section 19. I am told by Mr. Gilson, in Section 18, that clay was struck in wells at old lumber camps for 2 - 3 miles west of here at 8 - 10 feet, and is of considerable depth. The west border of the moraine is along the road near line of Sections 17 and 18, 7 and 8, 5 and 6, Marilla

Township. It rises abruptly, in most places 50 - 75 feet or more.

Aneroid 28.950 on the plain at Yates. Aneroid 28.880, 870 feet, more or less, on upland 1/2 mile north. This is flat topped and coated with gravelly sand. There are boulders on the face of the bluff, but few, if any, on top.

The edge of the moraine passes 1/2 mile west of the road in Section 31, Cleon Township, but swings east across the northwest corner of Section 32, and runs past the center of Section 29. It then bears west of north to Copemish, keeping near a diagonal road in Section 20. There are numerous basins on the slope in Section 20.

Aneroid 28.950 at Copemish, 807 feet.

July 18, 1902, 7:00 a.m.

Aneroid 29.100 at Copemish = 807 feet. Aneroid 29.130 at township line 1/2 mile west = 780 feet. Aneroid 29.130 at Thompsonville, 795 feet. Part of the sand plain is 8 or 10 feet higher than the stations. Basins set in north and west of Thompsonville on the sand plain, Betsey River is about 50 feet below the sand plain west of Thompsonville. Aneroid 29.185 at river in Section 35, Weldon Township. Aneroid 29.125 on plain west of river.

Aneroid 29.100 at base of moraine on north-south road, south end of line of Sections 26 and 27. Aneroid 29.070 on remnant of a higher plain on east border of the moraine. This level is not maintained far east, but is supplanted by knolls and swamps. The altitude at the base of the high hills in Sections 13 and 24, Weldon, is about 850 feet, and the hills are 950 - 1,000 feet. Aneroid 28.970 at base of hills at corner Sections 13, 14, 23 and 24. Aneroid 29.125 at Weldon Station = 799 feet. Aneroid 29.175 at creek valley on line of Sections 15 and 16. Aneroid 29.125 on plain north of creek. Aneroid 29.120 at middle of line of Sections 8 and 17. Aneroid 29.120 two miles north, at township line.

Aneroid 29.115 at Homestead Station = 803 feet. There are cobble and coarse gravel in places between this station and the moraine a mile northwest. The material is finer to the south. The moraine here rises abruptly 100 feet or more above the plain, or to fully 900 feet. I go west a mile and turn north between Sections 29 and 30, Homestead Township. The moraine covers only the northeast corner of Section 30, and is full of basins on its slope that extend down to the level of the gravel plain. There are many boulderets on the surface and in the drift here. Aneroid 29.050 on first crest = 860 feet. This commands a view of Crystal Lake between hills 1/2 mile or more west of this road. Aneroid 29.030 on second crest near middle of line of Sections 19 and 20. There are points in the northwest part of Section 20 and southwest of Section 17 that reach 925 feet or more.

Aneroid 29.330 at Honor at noon, 611. There is a prominent moraine south of Platte River here. On the north side the moraine does not extend below Honor, but

is prominent above here. The west border bears west of north from Honor to the shore of Lake Michigan near the county line. Aneroid 29.280 at railroad crossing on south side of Platte River at the state road, 1-1/2 miles above Honor. A stiff clay is exposed up the road to south bluff for 75 feet above railroad. Aneroid 29.200 at top of clay. Above this there is a sandy gravel. Aneroid 29.060 at top of bluff. This is on the edge of the moraine about 40 feet above the gravel plain, or 850 feet A.T.

Aneroid 29.100 on plain in northeast part of Section 28. The moraine extends a short distance into Section 22 on west side. Its border is said to follow up the north side of Platte River into Inland Township.

I go east through Sections 27, 26 and 25, Homestead, and find very little change in altitude. It is a plain of sandy gravel. The wells are 25 to 40 feet and are driven to the water. Aneroid 29.085 at township line east side of Section 25, Homestead. I go south to township corners and am there only 1/4 mile from the west edge of a hilly morainic tract. Much of Section 6 is on the moraine. In Section 7 and east part of Section 8, there is a tract of nearly plane land, aside from basins. Aneroid 29.090 on plain north of Betsey River on line of Sections 8 and 19. The river is only 20 feet below this plain.

Aneroid 29.090 on ridge. South of this ridge is a tributary of Betsey River and south of this tributary is a more fertile tract than north, which may have clay at slight depth, though I see no exposures. It has a gradual rise south to the foot of a prominent moraine at lessen.

Aneroid 29.035 at lessen, 855 feet. Aneroid 28.840 at top of hill south of Hessen 1/2 mile = 1,050 feet, more or less. There are boulders and low knolls 10 - 30 feet, south from here in Sections 3 and 4, Cleon Township, Manistee County. A knoll in the west part of Section 3 is 1,080 feet. Aneroid 28.810. The center east-west road crosses it. Near south end of Section line of 3 and 4, the road crosses a ridge, 1,060 feet. Aneroid 28.830. This prominent moraine has its west edge in the east part of Section 4, and the border bears south of east, passing 1/2 mile east of Pomona. I trace it no farther than the T. & A. A. Railroad in Section 15.

Aneroid 28.990 on plain at corners of Sections 9, 10, 15 and 16. Aneroid 29.000, 1/2 mile west, in midst of a border drainage channel that leads south from here. This has cobble and boulderets in a gravelly drift. West of this, near corners of Sections 8, 9, 16 and 17, is a rise to a gently undulating gravelly tract. Aneroid 28.970 at section corners at about the general level of this tract. There are a few boulderets. There is a basin near middle of line of Sections 9 and 17 in which boulders 2 feet in diameter occur. Aneroid 28.970 on upland 1/2 mile east of Copemish, near corners Sections 7, 8, 17 and 18, Cleon Township. Aneroid 29.075 at Copemish Station at 5:00 p.m., 782 feet. Aneroid 29.070 at 5:30 p.m., 782 feet.

I take train to Traverse City. Aneroid 29.030 at lessen, 855 feet. The railroad follows the northwest edge or

base of a prominent morainic tract into Grand Traverse County. There is a broad sandy plain northwest of it. Aneroid 29.020 at Karlin. The edge of moraine is 1/2 mile east of here. Aneroid 29.050 at Interlochen = 830 or 846 feet A.T. The moraine bears northeast past the south end of East Betsey Lake into the southwest part of T.26N, R.11W., but there it seems to change to an east or southeast course. The M. & N. E. railroad bears northwest away from this moraine and crosses a pitted gravel plain to a later moraine. I catch glimpses of it about two miles south of Platte River Station on west side of railroad. It is scarcely 1/2 mile away. Aneroid 29.060 at Platte River in a ravine 30 - 40 feet below level of border tracts. There seems to be a plain at that height. Aneroid 29.080 at Lake Ann, 816 feet A.T. The bordering upland or rise of the lake basin is 60 feet, more or less, above the station and about 75 feet above the lake a short distance east of Lake Ann Station. Northeast from Lake Ann the railway seems to be along the river slope of a moraine, so the upland east of the village may be a moraine.

Aneroid 29.140, 756 feet, at Cedar River. This station is 75 - 100 feet below uplands. Till is exposed in cuts northeast of the station. Aneroid 29.290 at Solon, 626 feet. There are hills 200 feet, or more, high to the south of the railroad, but a broad valley-like plain to the north. Aneroid 29.300 at Fouche Station at south end of Carp Lake. Aneroid 29.350 at Traverse City at edge of bay, 7 - 8 feet above lake, or about 605 feet A.T. There are wells at the following places:

Central School building, south of river; 2 on Mr. Hannah's property on 6th Street; one at Lonelier brothers, near Cass between front and State; one at Wilhelm Bartok & Company, near Union, between Front and State; one made by Elijah Hansom (now owned by some one else) between Front and State midway between Franklin and Wellington, near an alley; one in an alley between Washington and Webster (east and west streets) and between Franklin and Railroad Avenue (north and south streets), made by several persons; another near a foundry, east of Union Street. They are about 350 feet. One at the jail barely reaches the surface. The drift is nearly sand, there being only occasional thin beds of clay. The water is from gravel that is coarse enough to screen well.

July 21, 1902, 7:00 a. m.

Aneroid 29.240 at level of Traverse Bay, 580 feet A.T. I go west on Front Street to base of hills in southwest part of Section 4. There are low swells just above the Algonquin beach at 30 - 50 feet above the bay, and back of these are high hills. I take road through south part of Section 5, winding up a ravine. An altitude of 200 feet above the bay is reached at the forks in the south part of Section 5. Aneroid 29.000. I turn west-southwest and make a rapid rise. Aneroid 28.790 at top of steep grade about 60 rods east of corners of Sections 5, 6, 7 and 8. Aneroid 28.770 = 990 feet 10 rods west of these

corners. Points 60 - 80 rods west and southwest reach about 1,025 feet. Aneroid 28.770 at middle of line Sections 5 and 6. Aneroid 28.740 at summit on east-west road near center of Section 6. Aneroid 28.775 on a plane tract in west part of Section 6. This extends south for 80 - 100 rods, but runs north into Leelanau County. There is a range of very high morainic hills west of it in Section 1, standing 1,100 - 1,160 feet A.T. Aneroid 28.585 on high point north of road a short distance west of center of Section = 1,160 feet A.T. Aneroid 28.755 at line of Sections 1 and 2 about 80 rods from south end, = 1,000 feet. The 1,000 foot contour runs northwest across the northeast part of Section 2 and southeast across southwest corner of Section 1. West of here, there is a much lower country.

Aneroid 28.870 = 920 feet at edge of a pitted plain in southeast part of Section 3 near a school house. The school house is in a dry basin 25 - 30 feet deep. All of Section 3 except the northeast edge is on this pitted plain. Aneroid 28.930 at corners of Sections 3, 4, 9 and 10 on a sand plain without deep basins. The plain rises rapidly to the north as well as east from here.

I go north on line of Sections 3 and 4. Aneroid 28,900 on general level of sand plain, at county line. There is a basin about 60 feet deep where this section line strikes the county line. Cobble stones set in just south of the county line, and there is a moraine in the east and north parts of Section 34, T.28N., R.12W. There are boulders along the county line between Sections 4 and 33, and there are low swells south of the center of the section.

Aneroid 28.910 at corners of Sections 4 and 5, 32 and 33 in sand plain. The morainic swells set in less than 1/4 mile north and the edge of the moraine crosses the county line in a course slightly south of west about 100 rods west of this section corner. It has a relief of but 10 or 15 feet and is gently undulating. There are deep basins in north part of Section 5 on the sand plain. I go north 1/4 mile to the crest, aneroid 28.900, and take a road west through south part of Section 32. There is very little undulation. A few surface boulders occur, but the drift is a sandy gravel. In the southwest part of Section 32 are basins like those in the outwash apron, but they have cobble stones and boulders on their borders.

Aneroid 29.120 at Cedar Run Creek at county line. Aneroid 29.080 at Cedar Run Station = 756. I go east, rising through a sandy gravel bluff-like moraine (?) to upland plain. Aneroid 28.960 at top of steep grade. Aneroid 28.950 at a school house at corners Sections 5, 6, 7 and 8. I go south 3/4 mile, then east 1/2 mile, and south 1 mile to some sharp knolls in south part of Section 17, standing 50 - 60 feet above the gravel plain. Aneroid 23.870 on crest on north-south road in south part of Section 17. From here south, as far as I can see, there is a plain, but southwest in Section 19 there are knolls.

Aneroid 28.940 on gravel plain southeast of the knolls on line of Sections 17 and 20. Aneroid 29.000 at Long

Lake. There are boulders on its shore at north end, just west of Neal. Aneroid 28.935 on gravel plain at north end of lake back of Neal. A mile east, boulders and low swells set in.

I take road southeast through Section 14, across a pitted sand plain near corners Sections 13, 14, 27 and 26. I come to till and low swells at a level but little above the sand plain. There are sharp deep basins in it, as on the sand plain.

Aneroid 28.900 at west edge of sharp moraine in east part Section 13. Aneroid 28.830 near middle of line Sections 13 and 18. drift is till. There are hills within 1/2 mile north 60 feet or more higher, or 1,000 feet, more or less, A.T. Aneroid 28.830 at corners Sections 7, 8, 17 and 18 - sharp hills, 75 feet high, in west part of Section 17. Much of Sections 7 and 8 has very sharply morainic knolls 40 - 75 feet high - very bouldery - some till, but largely loose textured.

Aneroid 29.070 at foot of strong moraine at northeast corner of Section 17. There is a plain east of here across a ravine standing about 680 feet A.T. Aneroid 29.220 on low plain in Section 9. Aneroid 29.230 in Section 10 near center. Aneroid 29.250 at Park Place Hotel, 592 feet, at 1:20 p.m.

The sand plain standing 610 - 615 feet may represent Lake Algonquin level. It is a barren sand with Jack pine in Section 10. The terrace south of it, at 680 feet, more or less, A.T., has deep sand where roads ascend to it.

Aneroid 29.250 at Park Place Hotel, 3:00 p.m. I level up to the beach at Norrisville and find a bank is 21 feet. At a northwest turn in road west of Cedar Lake in northwest part of Section 28, T.28N., R.11W., there is a gravelly terrace at about 610 feet A.T., which seems likely to represent the Algonquin shore line, last of Cedar Lake is a narrow clay ridge 50 - 80 feet high.

The old beach shows nicely along the west side of road that angles northwest in north part of Section 20 as a cut bank 5 - 15 feet high, with a cobbly, gravelly platform east of it, 20 - 30 rods wide. The channel leading across from the south end of Carp Lake to Cedar Lake along the M. & N. E. railroad is scarcely 1/2 mile wide in Sections 17, 18 and 20. Aneroid 29.200 at Hatch's Crossing, 601 feet, on M. & N. E. railroad at 4:20 p.m. This is at the level of the channel floor.

Aneroid 29.150 at Mrs. Britton's in central part of Section 6 = 680 feet. A well here, 100 feet deep, has some clay, but is largely through gravel and stops in gravel, (the bottom of well is near the level of Lake Michigan. There is a rather smooth ridge along the east side of the south end of Carp Lake in Sections 1 and 12 that stands 75 to 125 feet above the lake last of it is a shallow sag nearly 1/2 mile wide, and east of this is a prominent morainic ridge with a hummocky surface. I turn east to this high ridge in Section 6. Aneroid 28.950 at line of Sections 5 and 6 - 850. A point 80 rods east is 30 or 40 feet higher, or 880 - 890 feet.

I go north to a summit near north end of Section line. Aneroid 28.930 = 870. I descend to a deep and sharp depression at the Bingham School house near corner Sections 29, 30, 31 and 32, T.29N., E.11W., aneroid 29.110 = 710 feet A.T. There is a very hummocky topography each side of this depression. There is a very high point in southeast part of Section 29, possibly reaching 900 feet A.T. The road on line of Sections 29 and 30 scarcely rises above 800 feet, the drift contours having till and a good supply of boulders of all sizes. I am in a low tract at corners of Sections 19, 20, 29 and 30, aneroid 29.100. The highest points nearby are scarcely 50 feet higher.

I take a road that angles across Sections 20 and 17. It is in a sag with a ridge 50 - 100 feet higher, east of it 1/4 to 1/2 mile. Aneroid 29.070 at corner Sections 3, 9, 16 and 17. The altitude is but little higher to the west between here and Carp Lake. Aneroid 28.970 on hill in north part of Section 16. This range runs north-northeast to Suttons Point.

There is a pitted plain in north part of Section 8 and northwest part of Section 9, aneroid 29.060 on the plain. It has deep basins, 760 feet, A.T. North from here is a swampy low tract into which the road soon descends. Aneroid 29.200 at diverging roads in north part of Sections 4 and 5. The east part of Section 32 and west part of Section 33 are a swamp. Bouldery drift west of swamp, as well as east. Aneroid 29.220 in swamp near north end of line of Sections 4 and 5. There is a gravelly tract like a beach at the diverging roads south of the swamp, which may be the Algonquin Beach.

Aneroid 29.240 at hotel in Suttons Bay, 16 feet above water in bay, = 598 feet, more or less. I level up to the beach in west part of village, and find a bar at blacksmith shop and church is 40 feet above the bay. There is a cut bank west of here 20 rods, on north side of road, where base is 51 feet and a low gravelly ridge running south from it that seems likely to be a beach whose crest is 55 to 56 feet above the bay -- about 637 feet A.T. This level corresponds with the barometric determination of the gravelly tract at head of the swamp two miles south of Suttons Bay village, in north part of Sections 4 and 5, Bingham Township.

July 22, 1902, 6:30 a.m.

Aneroid 29.290 at level of bay at Suttons Bay, Michigan, 581-582 feet at present stage of water. I drive south to line of Sections 29 and 32, and then west and south by turns to township line at corner of Sections 31 and 32, Suttons Bay Township, and Sections 5 and 6, Bingham Township. The road is along the base of the moraine near the beach (Algonquin?) to the center of Section 32. It then rises to the moraine. Aneroid 29.070 at line of Sections 31 and 32, 80 rods north of its south end. There is a very cobbly tract here with nearly plane surface. Section 6 is nearly all plane and so is the south-west part of Section 5. There is a low ridge along the northeast edge of the plain, standing 15 -- 20 feet

above it, and it was on this that the aneroid read 29.070. Aneroid 29.090 on general level of plain on line of Sections 31 and 6. This plain has basins in it in Section 6. West of this, in Section 31 and northwest corner of Section 6, is a sharp morainic strip reaching nearly 250 feet above the lake. Aneroid 29.010 at forks of road on the crest near west end of line. Aneroid 29.270 at foot of moraine, just east of a north-south road in south part of Section 36.

Aneroid 29.300 at fountain well in north part of Section 36, about a mile south of Provemont. This is strongly sulphurous. It is several hundred feet deep, thought to be about 720 feet. It was made by a Frenchman many years ago. It has great force, and spouts up as a fountain 15 feet or more, and spreads out as an umbrella. It is 8 or 10 feet above Carp Lake close to its east bank. It was very largely through drift, but entered rock near the bottom. The Frenchman's name was De Bolois. (For record by A. Winchell, see Proc. A.A.A.S., 1875, p. 31.)

We go north along east side of Carp Lake to Section 14 then up a ravine into Section 11 at school house. Then to the east, to a summit in west part of Section 12. Aneroid 29.000 = 860 feet. This commands a view of Pyramid Point, of both Manitou Islands and South Fox Island. Philip Porter has a well near center of Section 12, 103 feet. It only has 3 feet of water. Aneroid 29.040 = 825. George Steffen, at west side of Section 12, has 180 foot well. Mr. H. Dunkel, in south part of Section 11, has a well 185 feet.

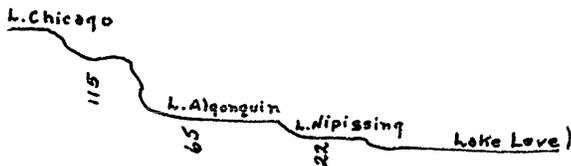
I go north to corners of Sections 1, 12, 6 and 7, then east on line of Sections 6 and 7, crossing a ridge near east end of Section line about 300 feet above the lake. Aneroid 28.980. The ridges here are not hummocky, but have smooth slopes. They are not regular like drumlins. There is a knobby tract east of here thickly strewn with boulders that is evidently morainic. It constitutes the divide between drainage to the bay and drainage to Lake Michigan. The height of the highest points is but little more than that of ridges west of here that are smoother, there being few that exceed 350 feet above Lake Michigan. This sharply morainic tract extends east to the shore of Grand Traverse Bay in northern part of Suttons Bay Township and southern part of Leelanau.

Aneroid 29.280 at Lake Algonquin (?) shore at Peshawbetown, Section 11, Suttons Bay Township = . Aneroid 29.350 at shore of bay. A shore line shows well 1 mile southwest of Omena below the Algonquin. I level up to it and find the base of cut bank is 23 feet and top is 34 feet. The base is very near old water level, for there is a platform extending east 6 - 8 rods on which there is a drop of but 5 feet in that distance. The same east of this takes down to the level of water in bay.

Back of Omena Post Office, I find the lower beach at 23 feet and the flat in front of the upper one, 63 feet, right at brow of bluff Sack of the Post Office building. Back of this, about an eighth mile, is a rise to higher land. Its base is 65 or 66 feet above the bay. Aneroid 29.315 & t

shore of Omena Bay at 1:05 p.m. Aneroid 29.090 on beach at a church where road bears north to Northport. This extends as a bar east to the other bluff with a pond back of it, standing nearly as low as the bay. This bar is about 4 - 6 rods wide at top and is very steep on the back or north side. The front is more gradual. By hand level, the top is 27 feet at the church above Omena Bay.

On New Mission Point, there is a knoll that reaches a height of 125 - 150 feet above the lake. It was completely surrounded both at the Algonquin and Nipissing stage by water. A sandy tract runs across the north end of the channel northeast of the pond referred to above. There seems to be a faint shore line back of the Algonquin a mile north of Omena at a level 50 feet, more or less, above the Algonquin. It shows as a narrow sloping platform at the east edge of the moraine, about 15 rods wide.



Farther north there is a narrow sharp ridge standing 120 feet, more or less, above the bay, (aneroid 29.165 = 170 on crest) that runs out north like a bar, but may be simply a glacial ridge. The ground back of it is lower for 1/2 mile from the north end of the bar-like ridge. Part of it, 30 feet lower, independent of drainage erosion.

The slope to the Algonquin shore is steep and shows sand with cobble stones and boulderets. There is another narrow ridge on east side of this north-south road in Section 10, T.31N., R.11W., that has boulders in it. It stands about 20 feet above the sag west of it through which the road passes and is very sharp in the back as well as front. Aneroid 29.180 in sag. Aneroid 29.160 - 29.165 on crest.

The Algonquin beach back of the Congregational Church in Northport is 69 - 70 feet at highest part above lake level, but part of it is 68 feet and that seems likely to be above the water level. Aneroid 29.220 on the Algonquin beach. I follow the beach only to the angling road in Section 27, T.32N. The road follows it northeast in that section. The shore turns abruptly west in Section 22, and crosses the line of Sections 22 and 21 at the quarter post. There is a bluff 50 feet high here. Aneroid 29.220 at base. Aneroid 29.160 at top. The SW 1/4 of Section 22 has about the level of top of bluff and is nearly plane. Its soil is a sandy loam. The south part of Section 21 is at about the same level, 120 - 130 feet above the lake, and has a sandy loam soil. The extreme southeast corner has a knoll and there are low undulations along the south border. There is a hill near north end of line of Sections 27 and 28, aneroid 29.110 at summit. There is a higher one 1/3 - 1/2 mile west-southwest. The south end of Section 28 and much of Section 33 has a hummocky moraine.

Aneroid 29.200 on Algonquin beach at east side of north end of Carp Lake = 648 feet, more or less. Aneroid 29.260 on low place at head of lake. There is a strip of sand dunes between the road and Lake Michigan here and also northeast for 1-1/2 miles or more from the north end of Carp Lake. Aneroid 29.220 at beach on west side of Carp Lake, 1 mile north of Leland where a low till tract sets in on the east side of the road. Aneroid 29.220 on beach on the Lake Michigan side of the till tract in northeast part of Leland. Aneroid 29.260 on low plain bordering Carp Lake outlet in Leland. Aneroid 29.275 & Lake Michigan. There is a fall of 9 feet at the dune on Carp Lake outlet in Leland and this probably represents nearly all the fall from Carp Lake to Lake Michigan.

Lake bank in north part of Leland is 18 feet. There is a gradual rise to 23 or 24 feet at the place rushed by the Nipissing lake east of the livery barn and north hotel. The brow of steep bank back of this beach is 50 - 56 feet. The platform formed by the Algonquin rises to about 63 feet at the old shore at base, is back 20 rods north of the school house. A narrow clayey ridge terminates 20 rods north of school house at an altitude of 70 - 75 feet, or slightly less at the point, but it rises to over 80 feet a short distance north.

July 23, 1902, 6:45 a.m.

Aneroid 29.310 at hotel in Leland, 600 feet A.T. Leland Station is 656 feet. I drive south and find a strip of dunes south of Carp Lake outlet for a mile. A prominent glacial knob sets in at corners of Sections 8, 9, 16 and 17 and runs south forming the lake bank to the northeast part of Section 20. Its highest part is fully 200 feet above the lake. The glacial knolls along the lake front 1 - 2 miles north of Leland are 100 - 150 feet. The Algonquin beach sets in west of Carp Lake at 648 feet, more or less.

Duck Lake, in Sections 20 and 21, stands 36 feet above Lake Michigan and 28 feet above Carp Lake, as determined by Professor Davis of University of Michigan (37 feet above present stage of Lake Michigan). There is a sandy ridge between Duck Lake and Carp Lake that is 49 feet above Carp Lake, or 52 feet above Lake Michigan. This is at William J. Buckingham's residence.

The Lake Algonquin beach runs south on east side of road into the northwest part of Section 28. It then passes into Section 29 and follows the shore of Lake Michigan more closely along the slope of a high hill in Sections 29 and 32. I go southeast in Section 28, rising to a narrow terrace-like flat of sandy gravel. Aneroid 29.140 = 730 - 740 feet. This is bordering a high range of hills that lies east and south of it. The slope northwest has till much of the way up and so have the hills southeast. Possibly this narrow terrace is a line of border drainage. I reach an altitude of about 250 feet above Lake Michigan in the southeast part of Section 28. Aneroid 29.050. In the northwest part of Section 33, the altitude is more than 300 feet above the lake. Aneroid 29.100 at railroad grade near corners of Sections 27, 28,

32 and 33, where it crosses a north-south road. Aneroid 29.030 at line of Centerville and Leland Townships, corners Sections 3, 4, 33 and 34. There are hills 30 - 40 feet higher a short distance west of these corners and the range runs south through the east edge of Section 4. A hill 1/2 mile west on township line, is about 50 feet above this level. Aneroid 29.040 at crossing of railroad grade, 50 - 60 rods south of township line on line of Sections 3 and 4. The railroad runs south along this line and seems to reach a summit near middle of line. Aneroid 29.030.

There is a very sharp hill in northeast corner of Section 9, about 75 feet, whose slope extends into Section 10. Boulders are quite numerous on this upland tract and parts of it are hummocky. There is enough clay or fine material to give a good soil. The south part of Section 9 and much of Sections 16 and 21 and the west edge of Sections 15 and 22 is a rather smooth, very fertile tract of clay loam. East and south of it is a hummocky range of hills extending to Carp Lake in the east, and the "Bayou" on the south. It stands 250 - 300 feet, more or less, above the lake.

Aneroid 29.160 at railroad. Aneroid 29.150 on hill at corners Sections 16, 17, 20 and 21. Aneroid 29.240 at railroad on line of Sections 17 and 20 in ravine. The bayou swamp comes north to within 40 rods of this section line. Lake Algonquin probably reached to the north end of the swamp, for this ravine at the section line is, by aneroid, only 60 feet above Lake Michigan.

Aneroid 29.170 on sandy plane tract at corners of Sections 17, 18, 19 and 20, Centerville Township. This may be an outwash apron, but it only covers a small tract near the section corners. West of it 80 rods is a rise to a gently undulating bouldery till tract. Aneroid 29.120 on this till tract, 1/2 mile west of the section corners. Aneroid 29.100 on gently undulating till on line of Sections 13 and 24, south of Sugar Loaf hill. This knob is 125 - 150 feet higher. Aneroid 29.300 on stamp bordering Lime Lake. This may be at the level of the Algonquin beach. Aneroid 29.250 at road intersection in north part of Maple City. Aneroid 29.230 at general level of village. There is a high range of hills south and east from here than runs north about to Section 25, T.29N., Range 13 West. There is a high range west of Lime Lake extending from Section 15 south, about to the township line, but it there dies out in an undulating tract. This proves to be very small, or rather is a narrow strip running west which has high morainic hills both north and south of it. Aneroid 29.220 about 1/2 mile west of Maple City on an undulating till tract.

Aneroid 29.260 at line of Sections 4 and 5, T.28N., R.13W. Aneroid 29.000 at top of steep grade, north-south road in Section 9. Aneroid 28.980 about the south line of Section 9, where a by-road comes in from the east. Aneroid 29.000 at Mr. Williams' at northeast corner of Section 20, Kasson Township.

Mrs. Mina Coleman, in southwest part Section 16, has a well 198 feet, that does not strike rock. It struck gas or

air in dry gravelly sand at about 140 and it continued down to the bottom where water was struck.

Aneroid 28.980 at Mr. Williams' at 1:30 p.m. This seems to be a gravel plain though it has low swells 5 - 10 feet. There is a hardpan crust at 1-1/2 to 3 feet in many places, that holds water. Below this is said to be gravel and sand. There are numerous cobblestones but very few larger stones at the surface. I go south between Sections 20 and 21 across a plane tract with few basins, and those shallow saucer-like depressions, but farther south, deep basins set in.

Aneroid 29.070 at Oviatt in a basin 30 - 40 feet below the general level of plain = 865 feet, more or less. Aneroid 29.020 on plain on county line at west side of a high knob that covers the southeast corner of Section 33 and northeast of Section 4 = 910 - 920 feet. Aneroid 28.810 at summit of knoll = 1,100 feet, more or less. Aneroid 28.990 on plain 1 mile southeast of this hill. It is a sandy plain with occasional basins. Aneroid 29.020, 890 feet at corner Sections 22, 23, 26 and 27. Aneroid 29.310 at flat 1-1/2 miles west of Solon = 630. West of this swamp there is a moraine in Section 24 and northeast part of Section 25, T.28N., R.13W., and Sections 19 and 30, T.30N., R.12W. It is of sandy constitution, but has a good supply of small boulders. There is some terrace land just south of Solon, 60 feet, more or less, above the station, but a mile south of the station it is an undulating tract, like that noted July 21 along the south edge of the county. Aneroid 29.300 at Solon = 640 feet.

Aneroid 28.850 at middle of line of Sections 25 and 36 on hill. There is a hill fully 50 feet higher at middle of east line of Section 25, or about 1,100 feet A.T. Aneroid 28.865 at range line at corners Sections 25, 36, 30 and 31 = 1,035 feet. The contour for 1,000 feet will pass north-south about 80 rods east of here. Sections 25 and 36 are nearly all above the 1,000 foot contour and more than half of Section 31 and the southwest corner of Section 30, T.28N., R.11W. Aneroid 28.890 at township corners, Townships 27N and 28N, Ranges 11W and 12W. Aneroid 28.850 on crest of ridge in road, 1/2 mile east on line of Sections 31 and 6. Points close by in fields are 20 feet higher. Aneroid 29.320 at the Algonquin shore line, about 50 rods east of bay on the county line. Aneroid 29.355 at Traverse Bay.

July 24, 1902, 7:30 a.m.

Aneroid 29.400 at Traverse Bay, 580. Aneroid 29.010 = 940 feet on ridge in central part of Section 8, T.27N., R.11W. Aneroid 28.950 in southwest part of Section 8 = 990. A hill about 80 rods east of center of Section 7 rises a little above 1,000 feet. A hill at middle of south end of Section 7 is about 1,000 feet. The road along its base is 970 feet. Aneroid 28.970 on road. There is considerable part of west half of Section 7 above 1,000 feet.

There is a basin tract in south part of Section 12 and in Section 13, T.27N., R.12W., that has a nearly plane surface, but with till as well as gravel, so it is not a pitted outwash apron. Surface boulders are quite abundant. West of a couple of lakes between which the east-west road passes, the sand and gravel seems to be a continuous sheet of considerable depth. It is a pitted plain with basins from 10 to 90 feet deep. Aneroid 29.050 on plain near corner of Sections 11, 12, 13 and 14. Aneroid 29.150 in lake basin near west end of line of Sections 11 and 14. Aneroid 29.070 on nearly plane tract west of this lake. This has swells about 10 feet high and occasional boulders. Aneroid 29.160 at Long Lake at 9:45 a.m. Aneroid 29.100 = 835 feet, more or less, on plain west of lake, on line of Sections 17 and 20 = 890 feet, more or less. Aneroid 29.180 in swamp near center of Section 19 = 820 feet. There is a knoll in the southeast part of the section and knolls extend southeast-east for more than a mile.

Near the county line, I come to the gravel plain, aneroid 29.140, and soon ascend to a higher plain, aneroid 29.100 - 890 feet. This is very sandy. There are low swells on it of sand that may be dunes. I see no boulders or cobble on this plain. The road descends to Lake Ann through a ravine in which a slightly pebbly sand occurs. Aneroid 29.180 at Lake Ann, 816 feet A.T. Aneroid 29.210 at edge of lake = 779 feet (J. J. Hubbell gives level).

I take road west along north side of the lake. Aneroid 29.140 in a pitted plain west of Lake Ann. Aneroid 29.140 on same plain at corners Sections 15, 16, 21 and 22. There are low knolls with boulders in them in the west part of Section 15, standing 15 - 25 feet or more above this plain, but they do not extend south of Section 15. This chain of knolls seems to connect on the north with the high knobs noted yesterday in Sections 3 and 4 and on the county line at north end of Sections 3 and 4.

Aneroid 29.130 at corner of Sections 16, 17, 20 and 21, on gravel plain. There is coarse gravel along much of the line of Sections 16 and 21 and west from there about to the township line. It is a pitted plain with basins 30 - 40 feet deep and lies just outside (southeast) of the moraine. Wells are 60 - 70 feet deep on this plain along the old state road in Sections 16, 17 and 20.

Aneroid 29.130 at Mr. Bates in central part of Section 20 where I stop for dinner at 11:40 a.m. Aneroid 29.300 at Platte River in Section 7, Inland Township. Aneroid 29.180 on plain southeast of river near corners Sections 7, 8, 17 and 18, Inland Township. Aneroid 29.150 on high plain near corners of Sections 8, 9, 16 and 17. Aneroid 29.140 at corners of Sections 9, 10, 15 and 16 on gravel plain. The southeast part of Section 15 and east part of Section 10 are morainic.

Aneroid 29.040 at corners of Sections 10, 11, 14 and 15. The south half of Section 11 and much of Sections 14 and 15 are gravelly and nearly plane, though elevated. The sections north of Section 11 and south of 14 and 15 have much till. Aneroid 29.020 at corners of Sections

11, 12, 13 and 14. About 60 rods east there is a rise of 10 feet, quite abrupt, to a nearly plane gravelly tract like that to the west. Aneroid 29.020 at county line Sections 12 and 13, Inland Township and Sections 7 and 18, Green Lake Township. There are knolls 10 - 15 feet high, 100 - 120 rods north of here each side of county line. Aneroid 29.090 on lower plain east of county line 1/2 mile. Aneroid 29.120 at Betsey Paver on line of Sections 8 and 17, Green Lake Township. This is in a swamp 80 rods, more or less in width.

Aneroid 29.090 at M. & N. E. railroad, 3/4 mile north of Interlochen at general level of sandy plain. There are a good many small pebbles in the sand of this plain. Aneroid 29.100 at crossing of Pere Marquette railroad near corner of Sections 10, 11, 14 and 15. There are a few low sandy knolls 10 feet, more or less, high, west and northwest of Grawn but they may be dunes. Aneroid 29.070 at Grawn at 4:50 p.m., on general level of plain. I go north along west side of Silver Lake. Aneroid 29.070 at lake. Aneroid 29.040 on plain bordering the lake in southwest corner of Garfield Township. There are no decidedly morainic features in the strip between Bass Lake and Silver Lake, simply a plain with a few basins. It is a sandy gravel, with more coarse pebbles than west of Grawn.

East of Silver Lake there is only a weak moraine of low swells in Sections 4 and 5. Blair Township and Sections 32 and 33, Garfield. A strip of nearly plane gravel 1/2 mile wide lies on the east side of the south half of the lake. The north end is bordered closely for a mile by sharply morainic topography. Aneroid 28.970, 980, on crest of moraine just east of where road comes in from south to the northeast road I am on. Aneroid 29.320 at a tamarack swamp crossed by the angling road in Section 9. Aneroid 29.340 at Park Place Hotel, 593 feet, more or less.

July 25, 1902, 7:30 a.m.

Aneroid 29.300 at Traverse Bay, 580 feet. I drive to south end of the Peninsula and find the Nipissing beach first as a bar 17 feet above the bay and then as a cut bank. Just east of the forks of road in north part of Section 1, T.27N., R.11W., is the Algonquin beach which, by aneroid, is only 30 feet above the bay, or 611. At the time this beach was formed, there was a connection between the head of West Bay and last Bay in Sections 1 and 6.

There is a prominent hill in Sections 31 and 36, nearly filling the space between the two bays and reaching a height of 220 feet above the bays on its highest point 60 rods north of the south end of line of Sections 30 and 25, Aneroid 29.050. Aneroid 29.170 in sag in southwest part of Section 30. This low tract has gentle swells and is boulder strewn. There is some clayey till, but the surface is largely a sandy loam and gravel.

I come out to the west shore of last Bay in Section 19, and level up to both beaches. The Nipissing cut bank

here is 23 feet at base, and the Algonquin is 41 feet, or 622 feet. I set the Algonquin where a bar extends south from a cut bank so I am quite sure of its representing the lake level. Judging from the appearance of the present shore, the base of the Nipissing cut bank is liable to be 1 - 2 feet, or more, above ordinary water level and reach either the high water stage or a shore beach.

There is a high tract in Sections 3, 4, and 9, T.28N., R.10W., and south part of Section 34 and southeast corner of Section 33, T.29N., R.10W. The summit on road in the southeast part of Section 33 is about 815 feet, Aneroid 29.035. It is a bouldery, hummocky tract, but not so rough as to be difficult to cultivate. It extends to the water's edge in Sections 3 and 9, T.28N., R.10W. Between this high tract and the one 6 miles south-southwest, the altitude seldom exceeds 700 feet A.T., but it is all moraine except the narrow strip covered by the Lake Algonquin.

Near Mapleton Post Office, the ridges are flat topped that reach 700 feet, but below this level, there are sharp knolls both east and west of the dividing ridge. Aneroid 29.170 at Mapleton. The flat topped dividing ridge near here is a clayey till.

In Section 15 there are knobs and deep depressions with scarcely any level land except some low land down next to the last Bay. Much of Section 10 is elevated and so is Section 3, many points being 750 feet and a few may reach 775 feet. From the center of Section 10 north, there are smooth slopes. The swells rise 40 or 50 feet above sags among them, but each swell covers 20 to 40 acres. Aneroid 29.170 near center of Section 34 where northward descent begins. Aneroid 29.250 at line of Sections 27 and 34, T.30N., R.10W.

Aneroid 29.270 on old lake plain 1/4 mile from south line of Section 27. Aneroid 29.070 near center of Section 27. There are low bouldery ridges in the north and northwest parts of Section 27, only 6-10 feet high, that may mark an ice margin. About 80 rods east of the center is a sharp clay hill, aneroid 29.230. East of this is a sag 1/2 - 3/4 mile wide, running north-northwest - south-southeast.

Aneroid 29.180 on low moraine near extremity of Old Mission Point on Section line. Aneroid 29.200 on a shore-like terrace just east of the ridge. Aneroid 29.150 at road leading west to Old Mission on crest of moraine. Aneroid 29.280 on plain at base of ridge on west side. Aneroid 29.310 at level of the bay, 581 feet at 12:20 - p.m.

Aneroid 29.220, 620 feet, more or less, on Algonquin beach near middle of line of Sections 33 and 34. It runs southwest from here to the bay as a bar. Aneroid 29.170 on ridge just west of corners Sections 33, 34, 3 and 4. J. D. Marshall's well here is 116 feet. It was nearly all clay for about 100 feet -- some of it very hard. Joseph Eiman has one 180 feet in northwest part of Section 10, aneroid 29.080. William Ayers has one 197 feet in the extreme northwest corner of Section 10.

These wells are all obtained in gravel. Aneroid 29.080 at Eiman's well.

Aneroid 29.240 at swamp on line of Sections 15 and 16. Aneroid 29.255 at Nipissing beach at Bowers Harbor = 600 feet. Aneroid 29.275 at level of bay, 580 - 581 feet. I level it with hand level and find the beach 19 feet above the bay. Aneroid 29.190 at foot of sand bluff south of Traverse City -- probably the level of Lake Algonquin 29.110 at brow of bluff.

July 26, 1902, 6:30 a.m.

Aneroid 29.255 at Traverse Bay, 581. Aneroid 29.220, 615, more or less, at sandy ridge on Garfield Avenue, 2 miles, more or less, south of head of bay near corner Sections 11, 12, 13 and 14. Aneroid 29.200 at base of low bluff a mile farther south on line of Sections 23 and 24. Aneroid 29.140 on bluff on line of Sections 23 and 24. This is on sandy plain like that south of Traverse City on west side of Boardman River.

Aneroid 29.140 on till plain on line of Sections 25 and 26, near north end. Aneroid 29.080 at middle of line of Sections 25 and 26 at north edge of moraine, by a school house and church. Knoll 3/4 mile west very sharp -- about 50 feet high. It is elongated north-south.

Sections 36 and 35 are strongly morainic and stand about 950 - 975 feet on highest points. Aneroid 28.850 at summit on road in southeast part of Section 36. Aneroid 28.860 at south line of Section 36 at road running east. South from here, in Sections land 6, there is some nearly plane sandy land standing about 950 feet, but the southwest part of Section 1 is strongly morainic.

Aneroid 28.950 in ravine at cross roads in northeast part of Section 7, T.26N., R.10W. Aneroid 28.870 on sand plain near line of Sections 7 and 8. Aneroid 28.980 in east-west valley in southeast part of Section 8. The valley is about 60 rods. It has boulders on its bed and on the slopes up to 30 feet, more or less. This valley leads from Crooked Lake west through south edge of Sections 9, 8, 7 and 12 to the Boardman River, and is bordered on each side by an elevated sand plain. It connects with Boardman at the south in Section 16. Aneroid 28.390 on sand plain south of this valley in Section 16.

I return to line of Sections 15 and 16 and take private road north. There is a terrace at top of a deposit of coarse gravel on the north side of the valley above noted, on which the aneroid reads 28.930. Aneroid 28.900 on plain north of terrace. Aneroid 28.890 two miles north. I here enter the moraine. Its highest knolls are scarcely 25 feet above the plain in this place. The moraine covers Sections 31, 32 and the northwest part of Section 33, T.27N., R.10W. Sections 34, 35, 36, 25 and most of Section 26 are reported to be plains.

I take road north between Sections 32 and 33, 28 and 29, 20 and 21, and come to the river border plain near

middle of line of Sections 20 and 21. Aneroid 29.170. Section 21 is very strongly morainic except on the north part of the west border. A ridge in the NW¼ of the section is 200 - 250 feet above the plain at its west base. Aneroid 29.250 at Traverse Bay. The sharp moraine runs east from the head of East Bay through Sections 10 and 15, 11 and 14, 12 and 13. North of these sections is a till tract with smooth sloped swells. The sharp moraine is very sandy and unfit for farming. The till tract is excellent farm land. It stands only 650 - 700 feet A.T., while the sandy moraine reaches about 800 feet. There is a swampy flat with tamarack and cedar in Sections 36, 25 and 24, T.27N., R.10W., and Sections 1, 2 and 3, T.27N., R.10W. It is about 1/4 mile wide and is drained west in its south part and north from Section 36. A range of smooth sloped large hills runs north along its east edge and curves northeast 1-1/2 miles north of Bates. It is 2-1/2 miles or less in width, and there is a gently undulating till tract east of it except for one large hill 3/4 mile northeast of Bates and a small tract of flat gravel at Bates at a gravel pit. Aneroid 29.100 at Bates.

Aneroid 28.990 on hill 1/4 mile west of Williamsburg. Aneroid 29.060, 732, at Williamsburg Station. There is a strong moraine south and east from Williamsburg. There is also a range of hills east of the Elk Rapids branch of Pere Marquette railroad, running north as far as I can get a view, 3 or 4 miles. Aneroid 29.060, 732, at Williamsburg, at 2:00 p.m. Aneroid 29.120 at Barker Creek. Swamp from here to Round Lake, but hills immediately back of the station and within a mile or so east of railroad from here to Rapid City. Aneroid 29.170 at Rapid City - 629. Aneroid 29.190 at Alden, 603 feet, more or less. This is on a beach -- probably the Nipissing. There is another beach about 20 feet higher a few rods east of the station. High ridge follows the west side of Torch Lake whose surface undulates perceptibly. Some hills are fully 200 feet. There is a low place on it directly west from where the Pere Marquette railroad turns from north to east course that is only 50 - 75 feet. It is 1/2 mile, more or less, wide. North of it is as prominent a ridge as south. There is a very prominent range of hills between Grass Lake and Clam Lake on east side of Torch Lake.

Aneroid 29.180 at Bellaire = 614 feet. Very prominent moraine west of Bellaire = 250 feet, more or less. Low for a mile east. Aneroid 29.160 at Central Lake - 631 feet. This is 24 feet above Intermediate Lake, so that is 607 feet. Aneroid 29.145 at Central Lake at 4:00 p.m. Aneroid 29.110 at base of bluff = 660 feet.

Shale outcrops along a ravine on line of Sections 15 and 22 up to a height of about 150 feet above Lake Michigan, or 730 feet A.T. The drift is sandy. Aneroid 28.990 at corner of Sections 15, 16, 21 and 22 in a valley = 780 feet, more or less. Aneroid 28.840 in central part of Section 16 at top of ridge = 900 feet. The highest points in this vicinity may reach 925 feet. Aneroid 29.040 at M. E. Byers in southwest part of Section 5 = 750 feet, more or less, A.T.

July 27, 1902.

Aneroid 29.080 at M. E. Byers. Aneroid 29.185 at Creek 1/3 mile west on line of Sections 6 and 7, Central Lake Township - 650 feet. I level up from Torch Lake and find the altitude 23 feet to first steep bank -- at base of bank, and 29 feet to top, 621 feet. Thirty-three feet to a second bank at base Nipissing 625 feet. The top of bank is 39 to 40 feet, 631 to 632 feet. There is a gradual ascent from here to base of steep bank at 68 feet, 660 feet. This is level of Lake Algonquin, 660 feet. Top of steep bank is 90 to 91 feet, = 682 feet. There is then a gradual ascent to another bank that looks like a weak shore line at 102 feet, 694 feet. Is this Lake Chicago beach? This bank sets in north of the road between Sections 6 and 7, and is best defined 80 to 160 rods north of the road, and shows on the points between ravines farther north. From the south end of this bank, a gravelly bar runs south to the section line road. Where the road cuts its south end. there is about 3 feet of gravel and cobble capping the till.

William G. Mudge, near center of Section 9, has tubular well, 150 feet, that did not strike water. The altitude is perhaps 150 feet above Lake Michigan. J. E. Boice has a dug well in southwest part of Section 9, 65 feet, that is entirely through clay, so it does not need curbing. A. E. Sage, in east part of Section 8, not more than 40 rods from Boice's, has a driven well, 125 feet, that is largely sand. W. E. Wilkinson, southeast part of Section 5, has a driven well about 135 feet.

There is shale 5 to 12 feet high along the shore of Grand Traverse Bay, west of Eastport. It also outcrops a mile farther south at a brickyard, the brick being made from the shale. It there only rises 5 to 6 feet above the surface of the bay.

July 28, 1902, 7:00 a.m.

Aneroid 29.130 at N. E. Byers in southwest corner Section 5, of Central Lake Township, = 750 feet. Aneroid 29.180 at point, on line of Sections 6 and 7 where a faint shore shows at 102 feet above Torch Lake (see yesterday's notes) = 694 feet. The Nipissing beach runs east to west through Eastport, and is 17 feet by hand level above Torch Lake, or 609 feet. It stands 3 to 4 feet above land back of it (north).

Between Eastport and Traverse Bay there is a belt of dunes, and the old lake levels are not clearly shown. I found places yesterday where the shore of the bay has gravel up to 15 - 20 feet above the bay. Aneroid 29.300, or 592 feet at Torch Lake at 7:20. I am told by Daniel Blakelee that Torch Lake was levelled to by Mr. F. L. Church about 10 years ago (formerly county surveyor) and he found it to be 12-1/2 feet above Traverse Bay, or about 592 or 593 feet A.T. The dam at Elk Rapids is 5 feet, so there is 4-1/2 feet fall aside from the dam between Torch Lake and the bay, level being 593 feet, Alden Station makes Torch Lake 593 feet. At 8:00 a.m., the aneroid reads 29.310 at Torch Lake, 593 feet A.T. I

go north on the range line to the township line, aneroid 29.265. The Algonquin beach crosses the range line about 40 rods north of the township line. Aneroid 29.240 at beach = 65 feet above Torch Lake, or 658 feet A.T. Aneroid 29.130 on hill at school house at corner of Sections 30 and 31, 25 and 36 = 750 feet. Mr. Byers states that in Banks and Central Lake Townships, the best land is on the uplands and contains considerable till. The valleys are usually sandy on the slope as well as bottom. The slopes facing east, he says, usually are more clayey than those facing west. Aneroid 29.100 at corner of Sections 19 and 30, 24 and 25, in a small valley 775 feet. Bordering hills are 50 to 75 feet higher, or 825 feet to 850 feet A.T. Aneroid 28.990 on hill in east part of Section 24 near middle = 870 feet. A smooth-crested ridge in Section 19 is fully as high. It is over 1/2 mile long, north-south. North from here, the altitude is somewhat lower. Aneroid 29.035 at corner of Sections 18, 19, 13 and 24 = 830 feet. Aneroid 29.050 at Atwood Post Office, 815 feet. Aneroid 29.020 on crest of ridge 1/4 mile northwest of Post Office, 840 feet. Boulders are very numerous in Section 12.

Aneroid 29.150 on bluff overlooking bay in southeast part of Section 11. This is at a level of a low cut bank that sets in north of the road 40 rods, more or less, and runs north 1/4 mile or more. Aneroid 29.230, 670 feet, at base of steep bluff. Aneroid 29.250 at north-south road in Section 11, 650 feet. Aneroid 29.330 at Traverse Bay = 581 feet. Base of first steep bluff is 16 feet, = 597 feet. Top of first steep bluff is 58 feet, 639. Intersection with north-south road is 70 - 71 feet. The base of the steep bluff east of here is very nearly 90 feet, but I am not sure of Lake Algonquin being more than 76 feet, for there is a rather rapid slope from 76 up to 90 feet above the lake, 657 feet A.T. About 1/2 mile north, I come to a beach on the road where the aneroid reads 29.240, or 80 - 81 feet above the bay, 661 - 662. This is but 10 - 20 rods from the foot of the bluff. By hand level, the base of the steep bluff is 6 feet above the top of this gravelly beach. The lake stood between 80 and 86 feet above the bay, or 661, and 667 feet A.T.

Shale outcrops for 1/2 mile or more along the shore of the bay in Section 3, T.32N., R.9W., up to a level 15 feet, more or less, above the bay. Aneroid 29.180 on highest point of road in Section 2. Possibly this was covered by the Lake Chicago waters, or the lake of brief duration that preceded Lake Algonquin. Aneroid 29.240 on Algonquin beach at Norwood (by Goldthwaite's levels, 658 feet). There is a narrow, island-like strip east of it, 15 to 20 feet higher, with a sag back of it (east) that was barely covered by Lake Algonquin. The sag is 1/4 mile, more or less, wide. Aneroid 29.330, 581 feet, at Traverse Bay at Norwood. There is a till bank here, 12 - 15 feet high. Seventeen feet at top of bank at bay, 69S feet; 24 feet at base of steep bank, Ho rods east of shore of bay, = 605 feet; 58 feet at top of bluff at a store and blacksmith shop, = 639 feet; 81 feet at Norwood District #1 school house on the Algonquin beach, = 662 feet. The island-like strip east of this is 90 - 100 feet above the bay. Aneroid 29.260 at Mr. Spaulding's in

Norwood at 11:30, = 640 feet. Aneroid 29.250 at 12:30 at Mr. Spaulding's. Wells near Mr. Spaulding's are about 60 feet deep, or nearly down to lake level.

I go east across Sections 35 and 36, reaching a ridge in west part of Section 36 where aneroid reads 29.080, = 790 feet. Aneroid 29.160 in a sag east of center of Section 36. The sags and ridges have a decided north-south trend. Some of the ridges have slopes nearly as smooth as drumlins. Aneroid 29.080 on ridge near east side of Section 36, = 790 feet. Aneroid 29.070 at intersection with north-south road in Section 31 on a ridge (800 feet). Howard Lake is in a sag east of here, and drains north. There is a till ridge as narrow and sharp as an esker running nearly across Section 6, passing just west of the center. It trends about 10° east of south -- height 20 - 25 feet; width 8-10 rods; length 3/4 mile. Another drumlin lies on the west side of Lime Lake at west side of Section 5. It is 30 - 40 feet high, and very abrupt on the west side. Aneroid 29.170, or 710 feet, at outlet of Lime Lake. Aneroid 29.020, 845 feet more or less, at crest of ridge east of outlet at G. E. Bentley's in Section 3, T.32N., R.8W. His well is only 50 feet deep.

Aneroid 29.080 at Skinner Lake outlet in Section 9, = 790 feet. Aneroid 29.200 at creek in Section 11, = 680 feet. There is drumlinoid hill in Section 10, but the greater part of the surface is wavy and not so markedly ridged and channeled in north-south direction as the sections to the west. There are prominent hills inside the loop of Intermediate Lake, 200 feet or more above the lake. They are less prominent north of the loop, while east of the loop, there is a low tract 1/2 mile to a mile wide, running to the south arm of Pine Lake. The divide in it is said to be almost midway between Intermediate Lake and South Arm Lake. Lake Algonquin probably extended through from South Arm to Intermediate Lake along this low tract.\*

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\*(Studies in 1922 indicate that it did not, because altitude is too high in Sections 6, 8, 17.)

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Aneroid 29.280 at Intermediate Lake at Oxbow Bend = 607 - 609 feet. Aneroid 29.225 at Algonquin shore = 657. Aneroid 29.270 at Ellsworth Station = 623 feet. This is 14 feet by hand level above Intermediate Lake, = 609 feet. Aneroid 29.150 on a terrace south of the Ellsworth school house that may represent an old lake level, = 730 feet, more or less. Aneroid 29.100 at summit on east-west road at house covered with sheet iron.

Aneroid 29.020 on drumlin just east of corner of Sections 14, 15, 22 and 23. This is 20 feet high and 120 rods, more or less, long. There is another west of the section corners, of same height. Aneroid 29.100 in valley on line of Sections 15 and 22, just south of a small lake. Aneroid 29.060 on a till plain west of valley in Sections 15 and 22. The southwest part of Section 22 has high hills, but the rest is plane or gently undulating. Aneroid 29.160 at Essex near corners of Sections 21, 22, 27, 28, T.32N., R.8W., in a valley 60 feet, more or less, in depth. Aneroid 29.080 just south of Mr. Churches residence in

northwest part of Section 34. Aneroid 29.170 at Mitchell Post Office, = 700 feet, more or less, in south part of Section 34. There seems to be an outcrop of greenish shale about 40 rods northeast of here on the east side of a mill pond, 10 - 20 feet above the pond, or about the level of the Post Office. Aneroid 29.115 on first hill west in southeast part of Section 33. Aneroid 29.170 on ravine just west.

Aneroid 29.060 near middle of line, Sections 4 and 33, on a hill. Aneroid 29.000 on a very prominent ridge at corners of Sections 32, 33, 4 and 5. It commands a view of the bay. Its north end is just north of these corners, and it extends south as a ridge only a short distance, but much of the east half of Section 5, and west half of Section 4 are high land. Aneroid 29.040, 830 feet, at road on line of Sections 5 and 8, south of school house, on a drumlin. The ground is 10 - 12 feet higher 20 rods north. Aneroid 29.130 at M. E. Byers, 750 feet, more or less A.T.

July 29, 1902, 7:00 a.m.

Aneroid 29.160 at N. E. Byers, = 750 feet. Aneroid 29.080 at school house drumlin, middle of line of sections 5 and 8. There is a prominent drumlin in northwest part of Section 9, 40 feet high, and several others in Sections 17 and 16, 20 and 21. Aneroid 29.010 at summit east of center of Section 16. Aneroid 29.200 at outcrop of shale on line of Sections 15 and 22. Aneroid 29.250 at Algonquin beach. Aneroid 29.300 at Central Lake, 633 feet, at 8:00 a.m.

I take road west from village, rising near corners of Sections 21, 22, 27 and 28 to a high point, aneroid 29.040. Just north of road, the hill is 30 to 40 feet higher than where the road crosses, or 900 feet A.T. It seems to be a drumlin-shaped hill, but is timbered. I turn south in Section 28 and rise to a drumlin near center where aneroid reads 28.960, or 930 feet. The highest part is about 10 feet higher, or 940 feet, (it was made 975 feet on earlier trip.) There are other lenticular hills both east and west, but the slopes are not so smooth and regular here as 2 miles north. Aneroid 29.280 on Algonquin beach = 655 feet, more or less, near corner Sections 28, 29, 32 and 33. I go south along east side of Torch Lake to road running east between Sections 4 and 9. T.30N., R.8W. These sections rise but little above 700 feet on the highest points, and the low points are 650 - 660 feet. Aneroid 29.250 at school house and saw mill, in a valley, Section 10, that leads south-southeast to Grass Lake. Aneroid 29.270 at swamp near line of Sections 10 and 15, 655 feet, more or less. Probably Lake Algonquin reached to here from the Grass Lake basin.

Aneroid 29.150 on ridge near corner Sections 10, 11, 14 and 15. Aneroid 28.970, 925 feet, on hill in north part of Section 14. There are several southeast of here about as high. There is not a drumlinoid or lenticular shape here, but the topography is of the ordinary hummocky morainic type. Aneroid 29.315, or 616 feet, at Bellaire at 11:40. Aneroid 29.300 at 1:00 p.m. = 616 feet.

I go south 3-1/2 miles along west edge of hills, then turn east in Section 8, T.29N., R.7W., rising to a nearly plane sandy upland, aneroid 29.070 = 790 feet A.T., near middle of Section 8. This plain covers much of Section 9 and west part of Section 10; also north part of Section 16 and all of Section 17 except the southeast corner. I go south between Sections 16 and 17, past the east side of Lake of the Woods. Aneroid 29.150 at lake, said to "be 668 feet by survey. Aneroid 29.070 in uplands southeast of lake near south end of line of Sections 16 and 17 - 750 feet, more or less. This is full of basins and has boulders and cobblestones at surface. The soil is a sandy loam. Aneroid 29.100 at corners Sections 16, 17, 20 and 21, about 20 feet below upland in a basin. Aneroid 29.075 about 40 rods south of Section corners where an ascent begins to higher land. The north edge of Section 20 is very level at this elevation. There is nothing higher in sight west from here for 3 miles.

Aneroid 29.050, 810 feet, at terrace a short distance from the last reading. This terrace extends to the Section corners 20, 21, 28 and 29. Aneroid 29.050 = 810 feet. East from here 1/2 mile, on line of Sections 21 and 28, there is a strong moraine. There is an undulating tract south, rising along the line of Sections 28 and 29 into Sections 32 and 33. I go west on line of Sections 20 and 29, and make but little change in level for this mile. There is then an abrupt descent of 40 feet (aneroid 29.100) just east of the section corners, Sections 19, 20, 29 and 30. Just before making the descent, I pass a house in Section 21 where well was dug 92 feet and only has 1-1/2 feet of water.

The tract of sandy table land extends but little into Helena Township, there being till and surface boulders in sections 24 and 25 that reach an altitude of over 800 feet A.T. I take a road that angles east of south through west part of Section 30, rising from a ravine in the northwest part to a table land in the south part. Aneroid 29.080, 780 feet. The southwest corner of Section 30 is on a high hill, 125 feet or more above this flat, or about 900 feet. The flat is only 100 rods wide at line of Sections 30 and 31. It continues south across Section 31 to the head waters of Spencer Creek. I go west and rise to Aneroid 28.980 at corners of Sections 29, 30, 31 and 32, on a knoll. Aneroid 28.900 (1,025 in notes of 1923) on sandy hill on line of Sections 28 and 32 just west of place where road swings around a hill into Section 28. West from here there has been till and gravel, with very little sand. Much of it is cultivated land. The very sandy drift is only in patches, much of the moraine being good land. It has few very sharp knolls, but is billowy with a few basins.

Aneroid 28.900, 970 feet, where road runs south between Sections 33 and 34, just west of the second northward detour of the east-west road I am on. This is in a basin 50 - 60 feet lower than a hill 40 rods south. Aneroid 28.160 (1,110 feet in notes in 1923) on high hill about 2/3 mile farther east (east of middle of section line of 27 and 34). This is at west edge of a pitted plain of

sandy gravel, and at about the same level as the plain. The pits, in some cases, are 75 to 100 feet.

Mr. Charles Leonard, in northeast part of Section 34, has well 150 feet, has 30 feet of water. It was all gravel.

This plain extends east a mile beyond the G. R. & I. R. R. to a high range of hills (aneroid 28.770 at G. R. & I. R. R.) at line of Sections 30 and 31 = 1,100 feet A.T., more or less. There is a terrace east of the railroad 25 feet, more or less, higher. Aneroid 28.750 on general level of plain 60 rods west of range line, on line of Sections 24 and 25, T.29N., R.7W. I can see low swells in east part of Section 23, rising 20 feet, more or less, above this plain, that mark the beginning of the moraine. I am told that the high altitude is maintained across Section 23 to the west. Aneroid 28.740 at Mancelona, = 1,117 feet. I am told that about 6 miles east of Mancelona, an extensive pine forest sets in on a plain. There is a strip of hardwood this side of it.

The waterworks wells are east of the village in a basin 65 - 70 feet deep, and the wells are 30 - 35 feet through gravel. There are 10 6-inch wells.

July 30, 1902, 7:30 a.m.

Aneroid 28.755 at Mancelona, 1,112 feet. Aneroid 28.630 on hill in Section 18, north part, = 1,240 feet A.T. I look at the hills east through level, and they rise to about 1,300 feet on highest points. This hill is a gravelly, cobbly material with boulders on its surface and slopes. It is nearly a mile from the moraine north and 1-1/2 from that west, but there are a few low swells northwest of it, 10 to 20 feet high, nearly connecting it with the moraine. Section 13, and the southeast part of Section 12 are nearly all on the gravel plain. The rest of Section 12, and north part of Section 7 are morainic. Sections 8 and 9 & re on the plain, and nearly all of Section 4. This plain is productive for agriculture. It has a gravel with a moderate admixture of sand.

Aneroid 28.750 at Wetzel at 9:30 a.m. = 1,128 feet. The northwest edge of the gravel plain is about a mile to the northwest, and the southeast edge is about a mile southeast from this station. From Wetzel to Alba the northwest border of this gravel plain is only 1/4 to 1/2 mile west of the G. R. & I. R. R. The moraine west of it rises 10 - 30 feet above the plain. Alba station is at the border. Aneroid 28.695 = 1,175 feet at 10:15 a.m. Aneroid 28.680 at overhead bridge on crest of moraine 1/4 mile west of railroad crossing.

Aneroid 28.760, 1,115 - 1,120 feet, at foot of steep slope on a narrow gravel plain. Aneroid 28.800, 1,075 feet, on a lower terrace near school house where road leads north across Section 22, = 1,020 feet. West of this I rise 60 feet, but descent down a gradual slope to the next forks in southwest part of Section 22, aneroid 28.860. Aneroid 29.040, 850 feet, at north flowing stream, Green River, on line of Sections 21 and 28. There is a plain here, but it is an unbroken forest, so I cannot see its extent. Aneroid 29.035 at railroad near corner Sections

20, 21, 28 and 29. Aneroid 29.010 in southeast part of Section 20 at noon. There is higher land to the west in south part of Section 20.

I am told that there are no sharp hills between Green River and Jordan River, in Sections 8, 9, 10, 11, 14, 15, 16, 17, 20, 21, 22, 23, 27 and 28, T.30N., R.6W. It is a terraced, rather sandy drift, like that through which I have come from Alba to here. Green River and Cedar River each drain a swampy divide in Sections 28 and 33, which seems likely to have been a line of glacial drainage southwestward, and, in all probability, the line of glacial drainage continued past the lake of the Woods through the gravel plain mapped yesterday.

Aneroid 28.970 at 1:15 where it read aneroid 28,035 at noon. I drive southward in northeast part of Section 29 across the southeast end of a range of hills 100 feet high that terminates near middle of east side SE 1/4 of Section 29. The border drainage sweeps around the south end of this range and I find Cedar River is in a swamp. Aneroid 29.085, 831 feet, at Cedar River in Section 2, Custer Township (T.29N., R.7W.). This level is from survey by C. O. Wisler. There is a swamp here 1/3 mile or so in width. Below here, in Sections 35 and 34, there is but a narrow tract of lowland. Aneroid 29.040 1/2 mile south, at base of a bluff. The channel of border drainage seems to be within this 1/2 mile here. There is a moraine south of this channel in south part of Section 2, that has sharp hummocks. South of this, in Section 11, there is a rapid rise through a moraine to the gravel plain noted this morning. I return to Cedar River and follow it down to Bellaire. There is fully 50 feet descent in the first mile northwest of the old border drainage channel, and still more in the next mile. The level of the Algonquin beach is reached about 2-1/2 miles from the mouth. The valley is very narrow for the 2-1/2 miles down there to the old border drainage channel.

Aneroid 29.290 at Intermediate Lake, at Central Lake = 607 - 609 feet. Aneroid 29,265 at Central Lake Station, 633 feet.

July 31, 1902, 7:30 a.m.

Aneroid 29.340 at Central Lake Station = 631 feet A.T. I cross Intermediate Lake and go east through Section 25. There is a low range of hills next to the valley, standing 700 - 725 feet. In the east part of Section 25, I rise to a high range. Aneroid 29.130 at first summit in a cut 20 feet deep, = 810 feet. East of this is a valley 1/2 mile wide running north-south in which the aneroid reads 29.200, = 750 feet. It only extends to the north end of Section 30. Aneroid 29.080 on hill at east line of Section 30 = 860 feet. There is a sharp knobby surfaced drift from here east to the creek that leads into the head of Intermediate Lake. Boulders are numerous. The soil is a sandy loam, and much of the land is cultivated and yields profitable returns. Aneroid 29.050 at summit on road at the bend in Section 28 = 950 feet.

Aneroid 29.350 at inlet of Intermediate Lake in Section 27 - 630 feet, more or less. There is a swamp from here southeast to the Jordan River, covering much of Sections 34 and 35, and south part of Section 36, T.31N., R.7W., Section 1, and much of Sections 2 and 12, T.30N., R.7W., and much of Sections 6 and 7, T.30N., R.6W. Lake Algonquin probably extended up this swamp about to the line of Townships 30N and 31N, where the forks of this inlet come together.

Aneroid 29.220, 760 feet, at Finkton Post Office.

Aneroid 29.280, 710 feet, at outcrop of shale on west bluff of Jordan River on road near center of Section 30, T.31N., R.6W. Aneroid 29.360 at Chestonia Station.

Aneroid 29.360, 636 (Wisler), at Jordan River Station in Ward railroad. Aneroid 29.375, 621 feet (Wisler), at stream on line of Sections 20 and 29. Aneroid 28.920 on hill at line of Chestonia and Jordan Townships.

Aneroid 29.000 at Howard Perry's, in Section 34, east side. Aneroid 28.815 on hill on line of Sections 26 and 27, Jordan Township, = 1,085 feet. Aneroid 28.770 on hill west of center of Section 11, T.31N., R.6W., = 1,130 feet. There is a hill about the same height on line of Sections 11 and 12. Aneroid 29.020 in a valley in south part of Section 4. Aneroid 29.180 at shale outcrop in Section 32, T.32N., R.6W. Aneroid 29.290, 640 feet (Wisler), at flat in Deer Creek, on line of Sections 30 and 31, near east end. This probably near east end of a Lake Algonquin bay. Aneroid 29.350 at railroad 1-1/2 miles south of East Jordan, = 597 feet. Aneroid 29.360 on bridge of Jordan River, 6 feet above stream. Stream here is 581.5 (Wisler). This is only 1-1/4 miles from where the stream enters South Arm Bay, which is 580 - 581 feet.

Aneroid 29.080 on hill at corners of Sections 27, 28, 33 and 34, T.32N., R.7W. There is a drumlin, 20 to 25 feet higher, on line of Sections 28 and 33, 1/4 mile west of corner, and two rudely-shaped ones in the northeast part of Section 28. There are few, if any, south of here on this high ridge. Aneroid 29.050 at county line, corner of Sections 32, 33, 34, 35, on ridge. There are points in Section 33 that rise 50 feet higher.

Aneroid 29.335 at head of Intermediate Lake. Aneroid 29.240 at top of shale outcrop in Section 18, T.31N., R.7W. Aneroid 29.050 on crest of ridge in west part of Section 18. It is perhaps 25 feet higher 1/4 mile north and Northwest. It is a hummocky moraine without drumlinoid forms. Aneroid 29.020 on crest in Section 13. Aneroid 29.355 at Intermediate Lake and Central Lake, = 607 feet A.T., or 609 feet. (The level 607 was obtained on assumption that Central Lake depot is 631 feet by hand levelling, but Gannett's last edition makes it 633 feet).

Flowing wells:

There are three flowing wells along west side of this lake on Central Lake that are shallow. One at Mr. Hastings is only 25 feet.

August 1, 1902, 9:00 a.m.

Aneroid 29.360 at Central Lake = 631 feet. I take train to Charlevoix. Aneroid 29.370 at Ellsworth = 623 feet. The railway here leaves Intermediate Lake and runs up a narrow valley with rapid ascent for 1-1/2 to 2 miles to an altitude about 700 feet. There is but little accent from here to Phelps. The railway is in a sag with drumlin ridges on each side at frequent intervals. Aneroid 29.275 at Phelps. Aneroid 29.320 at a flat that is back of Algonquin beach. The beach is 20 feet, more or less, high. Aneroid 29.415 at level of Lake Michigan. Mr. H. P. Parmelee states that the stage today is 10 inches above the low water average.

The Algonquin beach comes into the south part of Section 33, about 2 miles southwest of Charlevoix. It there curves to the southwest and runs somewhat directly to Norwood, being much of the way about 1-1/2 miles from the shore of Lake Michigan. I trace it to the corner of Section 13, or to within h miles of Norwood. I then go east to Barnard (Inwood Post Office), crossing drumlins that trend slightly east of south. The drumlin proper is usually a small ridge 20 feet, more or less in height, plastered onto the crest of a larger ridge. The valleys, in some cases, are 100 feet below the highest points in the drumlins. The highest drumlins are about 800 - 825 feet. Hilton Hill, a drumlin in west part of Section 18, is 800 feet A.T. Mrs. Hilton's well is only 45 feet. The low ground east of the well 40 rods is 50 feet lower. There are perhaps 3 or 4 drumlins per square mile in the township south of Charlevoix. I do not get them all mapped, but return to Charlevoix on a road west of the Pere Marquette railroad.

There is a remarkably narrow channel where the outlet of Pine Lake enters Lake Michigan in the village of Charlevoix, bordered each side by a gravelly bank 30 feet high that was probably formed as a beach of Lake Nipissing. Mr. Parmelee thinks it was still narrower when white men first settled here, and he suspects that the old outlet was to the north from the west end of Pine Lake through a dune tract. He will investigate the matter and report it to me. Much of Charlevoix is on the Nipissing Lake bottom at 30 - 35 feet, more or less, above Lake Michigan, but the south edge of the town is on the Lake Algonquin bottom, and about 75 - 80 feet above the lake. The Algonquin beach is about 90 feet here.

Rock outcrops 1 mile southwest of Charlevoix at about 75 feet above the lake in several places. It is a limestone, some of which is oolitic. I take train to Petoskey in the evening. (see notes written in 1899)

August 2, 1902 - Petoskey, Michigan

Altitude 656 feet. I drive west past north end of Bear or Walloon Lake, and find that a ridge 40 feet, more or less, higher than the Algonquin beach runs past the north end of the lake. The ridge has a thin capping of sand, but is mainly till. Bear Lake is only about 90 feet, by aneroid,

above Little Traverse Bay, = 671 feet, or 60 feet lower than this ridge, 731 feet. An arm of Lake Algonquin probably extended into it from Bear Creek valley, for the Algonquin beach at Petoskey is 112 feet above Little Traverse Bay, or 693 feet, I leveled up to it at the fuller Street United Brethren Church in Petoskey.

There is a bar at the mouth of Bear Creek with a gap less than 100 feet wide where this Algonquin beach crosses the valley. South of the bar is a flat bottom, about 20 feet lower than the beach. It is only 1/4 mile wide for a couple of miles up Bear Creek, but there it expands to a mile or more, and continues wide past the Bear Creek outlet. From the north end of Bear Lake, I drive south to Pine Lake at Horton's Bay. There are no clearly outlined drumlins here on the high land, but a billowy morainic topography. The highest points rise a little above 900 feet A.T. There is considerable till, and much of the land is under cultivation. I follow up Pine Lake to Boyne City, which stands at the head of the lake. There are high uplands each side of Pine Lake within 1/2 to 3/4 mile back. The upland between Pine Lake and South Arm is smoother than that which I crossed north of Pine Lake.

At Boyne City, flowing wells are obtained at 65 feet or less. There is a flat tract about 1-1/2 miles wide, extending up Boyne Creek from Boyne City, which was covered by Lake Algonquin nearly up to Boyne falls. I take road east two miles up this flat, and then go north over a ridge that reaches 850 feet into a swampy tract 1/2 to 3/4 mile wide that heads east-southeast across Sections 19, 20, and 29, T.33N., R.5W. There is a group of knolls north of it at southeast border of east end of Bear Lake. Bear Lake outlet is in a swamp nearly a mile wide, and this connects with a still wider swamp south of Clarion. The swamp is nearly 2 miles wide east of Clarion. I follow down Bear Creek from Clarion to Petoskey and find the swamp about 1 mile wide from a mile north of Clarion to within 3 miles of Petoskey. The valley is cultivated from there to Petoskey, and has a flat only about 1/4 mile wide. Rock (limestone) outcrops in the south part of Petoskey on east side of Bear Creek, up to a level 125 feet above Little Traverse Bay, or 12 - 13 feet above the Algonquin beach. The Algonquin bar across mouth of Bear Creek was noted above.

#### August 3, 1902 - Petoskey, Michigan

I take train to Mackinac City. This is below Lake Algonquin except for 3 to 4 miles in vicinity of Levering. The uplands are nearby on the west, except at the old strait that led from Pellston to Cross Tillage. There is a group of hills between Douglas and Burt Lakes, 2 miles or so east of the railroad.

Carp Lake Station is, by aneroid, 150 feet above Lake Michigan, and yet seems to be below Lake Algonquin level. The aneroid indicates that the uppers-most of the Lake Algonquin beachlets is 800 feet on Mackinac Island at the cemeteries. The highest point on the island is, by aneroid, very nearly 900 feet.

I come back to Petoskey in the evening and continue on the G. R. & I. R. R. to Elmira. The aneroid shows no higher elevation between Clarion and Boyne falls than at Boyne falls, which is 711 feet A.T. There is a rise of 522 feet from Boyne falls to Elmira, through a morainic tract. Aneroid 28.680 at Elmira = 1,233 feet.

#### August 4, 1902 - Elmira, Michigan

Aneroid 28.600 at 6:00 a.m., 1,233 feet. Wells in this vicinity are 75 to 150 feet deep through gravel and sand, and have very little head. Aneroid 28.630 at 7:30 a.m., at Elmira Station. I follow the G. R. & I. R. R. northeast 1-1/2 miles through a gravel plain. There is a bluffs-like rise just east of the village, and the railroad 75 to 100 feet, and a gently undulating tract. The gravel plain seems to terminate at the bend of the railroad, 1-1/2 miles north-northeast of Elmira, for there is a lower tract to the west that carries boulders.

I go up a ravine in a northeast course to middle of line of Sections 8 and 17, then east to corner of Sections 8, 9, 16 and 17. Aneroid 28.530, 1,325 feet, more or less, at corners. A well here, at Mr. J. Brooks' residence, is 154 feet, and has 18 to 20 feet of water. Mr. Brooks states that wells are often obtained at 125 feet in this high tract. I go north between Sections 8 and 9, 4 and 5, keeping on the high tract about 1-1/2 miles. I then begin a descent, and am down to the level of Elmira near the north line of the township. There is a loamy soil here instead of the sandy gravel of the Elmira plain. There are occasional small boulders, like those on the higher tract.

Aneroid 28.710 where road turns east into Section 33, T.31N., R.4W. Aneroid 28.740 at small lake in northeast part of Section 33. Aneroid 28.760 at Hoffman Lake in Section 34. It has considerable marl, 10 feet or more in depth. There is a rapid rise south from this lake for 1-1/2 miles, to the high table land that I left along line of Sections 4 and 5. The north edge, of this tract bears eastward along the south side of the road that runs between Sections 26 and 35, 25 and 36. I come to spring on the hill side on line of Sections 25 and 36, and there are a lot of shale fragments here that suggest an outcrop. Aneroid 28.750 at spring, or 1,125 feet, more or less, A.T.

I take road that angles southeast across Section 31, T.32N., R.3W., winding up a ravine and reaching an altitude of fully 1,350 feet at top of the table land near where the road turns south. Aneroid 28.500 at 10:25 a.m. at this high place. I go south on road, in 1/2 mile rise 15 - 20 feet more, Aneroid 28.480. A point in a cleared field 40 rods east is 10 - 15 feet higher. One half mile south, at end of north-south road, I go east, rising in 1/4 mile to a summit. Aneroid 28.455 = 1,400 feet, more or less, at Samuel Pike's in southeast corner of Section 6, T.31N., R.3W. There are no sharp knobs right here -- low hummocks and small basins. The soil is loamy. I go south between Sections 7 and 8, and find a more sandy soil, but no marked change in topography. Aneroid

28.500 at cross roads at a school house, corner Sections 17, 18, 19 and 20. The drainage to Sturgeon River is through, deep valleys.

Henry Widger, in Section 19, west side, has well 128 feet. It has very little head, about 13 feet of water. Aneroid 28.510 at well. Drift largely sand. There is a well 250 feet deep about 4 miles south of Elmira, at Mr. Turner's, on the high table land. Altitude 1,375 feet.

There is a morainic border passing about a mile north and a little more than a mile east of Gaylord, in a northwest-southeast course. South of it is a gravelly plain at the elevation of Gaylord, about 1,350 feet. (The station is 1,343 feet). The highest points on the moraine may rise 60 feet above Gaylord, or to about 1,400 - 1,410 feet A.T. Aneroid 28.520 at Gaylord at noon, 1,343 feet. Aneroid 28.500, 12:45 p.m., = 1,343 feet. The sand plain a mile west of Gaylord is nearly 20 feet lower than the station, or about 1,325 feet A.T. Two miles west of Gaylord, on the township line, there is a slight rise visible from the west part of Gaylord, and at this rise, hardwood timber sets in. The sand plain southwest of Gaylord is timbered with jack pine and has a light soil compared to that on which the hardwood timber occurs. All of the northwest township of Otsego County is good farming land. Aneroid 22.590 at Gaylord at 1:30 p.m., 1,343 feet.

I take train to Grayling. Otsego Lake is in a shallow basin about 15 feet below the M. C. railroad track, or 1,265 feet, the two stations being 1,279 and 1,280 on east bank of lake. West of south half of the lake there is a range of hills rising 75 - 100 feet above it. This range bears away from the lake toward the northwest or west of north. This same range appears also on the east side of the south end of the lake. The valley occupied by the lake is nearly a mile wide, and may be the line of discharge for waters from the sand plain that comes to the north end of the lake. The valley continues on from the south end of the lake in a course east of south. It has basins with ponds. Aneroid 29.570 on this plain at Waters Station. The hills are 1/2 mile west and 1/2 - 3/4 mile east of this station.

The valley continues along the railroad past Frederic. Aneroid 28.640 at Frederic = 1,221 feet. The general width of the valley is about 1 mile to 1-1/4 mile. The hills on the west disappear for a couple of miles, 2 - 4 miles south of Frederic, and those on the east die away about 4 miles north of Grayling, so the valley phase is well developed only 2 miles south of Frederic. Aneroid 28.700 at Grayling at 2:15 p.m. = 1,134 feet A.T.

August 5, 1902, 7:15 a.m.

Aneroid 28.440 at Grayling, 1,134 feet. I go northeast to edge of town and take road north between Sections 6 and 5, 31 and 32, 30 and 29, across a low sand plain with but little rise from Grayling. It has a few pebbles in the sand, and, being much of it within 10 feet of the level of the streams, it is not very dry. Aneroid 28.440 at

place where I begin ascent near north end of line of Sections 30 and 29, T.27N., R.3W. Aneroid 28.350 at top of first hill = 1,225 feet. This is near middle of line of Sections 19 and 20. It is nearly flat on top and has cobble and a few boulders.

Aneroid 28.390 at a railroad crossing in valley opening southeast near south end of line of Sections 17 and 18. This is a barren sandy tract. The stumps seldom exceed 15 inches in diameter. Aneroid 28.320 on hill at corners of Sections 7, 8, 17 and 18. This is flat topped much of the surrounding land is lower. There is burnt timber here, but about 1/2 mile north, I enter a green forest that has been culled. It is mixed timber -- maple, hemlock, cherry, birch, etcetera. I soon come to a fine grove of hemlock on east side of road. Aneroid 28.300, 1,260 feet, at south end of grove. From this grove north in north half of Sections 7 and 8, and in south half of Sections 5 and 6, there is a sandy loam soil. Occasional boulders 2 feet in diameter occur.

Aneroid 28.320 at corner of Sections 5, 6, 7 and 8, where a road leads east. In the next mile north, I rise about 70 feet; aneroid 23.240 = 1,320 feet on summit 1/2 mile south of Township line. This is at the north edge of the good land, there being very sandy land in Sections 31 and 32, T.28N., R.3W. in south part, but the north part is good farming land. Many wells in T.28N., R.3W. are 70 - 80 feet, and a few are deeper. Archie House, in northwest part of Section 17, has a well about 150 feet. Mr. Edgar Wilkinson, in Section 16, has one of similar depth. There is little besides sand and gravel in the deep well. The only clay seems to be near the surface.

Aneroid 28.250 on hill on line of Sections 30 and 31, east of middle. Aneroid 28.240 on hill a mile east-northeast of Frederic overlooking the village. A valley 20 - 40 rods wide leads out to Frederic from here. Aneroid 28.345 at Frederic at 10:30 a.m., 1,221 feet. Aneroid 28.370 at Au Sable River at Frederic. The main plain on river is only 10 - 15 feet higher than the stream.

I take road northwest to north part of Section 28, ascending a ravine to the upland. Aneroid 28.200 on upland, = 1,360 feet. Aneroid 28.260 in sag near line of Sections 28 and 29. Aneroid 28.210 on hill at north side of Section 29, west of middle, where road bears directly west. There is hardwood timber on this elevated tract, to within 1/2 mile of the Manistee valley. Pine then sets in, or rather pine stumps, for it has been cleared. The Manistee bottom, 1 to 1-1/2 miles wide, had pine which has been cleared. The west bluff is still largely forest-clad, and mainly hardwood. Aneroid 28.370 at east edge of the Manistee valley, on line of Sections 19 and 30.

I go north to Ward's mill, through the east part of Sections 19, 18 and 7, T.28N., R.4W. The mill is in Section 6. Aneroid 28.400 at mill by the river, at 12:25. The main bottom is 30 - 40 feet higher than the river. The lower bottom is scarcely 1/2 mile wide. Aneroid 28.420 at 1:40 p.m.

I cross Manistee River at the dam just below the mill, and follow a road near the county line south about 10 miles. The bluff west of river lies just west of the county line, except at recesses which, in some cases, are nearly a mile west of the line. The hardwood timber covers uplands west of the river, as far south as Sections 13 and 14, T.27N., R.5W., but south from there, I see only pine stump land.

I return about 5 miles to a road that runs east to Frederic on the line of Townships 27N and 28N, R.4W., and cross the ridge between the Manistee and Au Sable Rivers. Aneroid 29.450 at Manistee River. Aneroid 28.290 at settlement on ridge 2 miles west of Frederic. Aneroid 28.470 at Au Sable River, southwest of Frederic 1/2 mile. The hardwood timber is a narrow strip west of Frederic scarcely a mile wide, and only extends a mile or so south of this road. The ridge between the rivers extends to within a mile of Portage Lake, terminating at a sharp hill 125 feet high on line of Sections 4 and 5, T.26N, R.4W.

Just south of Grayling is a swamp that heads west from the Au Sable past Portage Lake to the Manistee River that averages nearly a mile wide east of the lake, and more than a mile west of it (see county map). This stands about 1,130 feet A.T. Portage Lake is said to be very deep. The county surveyor, Mr. Newman, thinks it is 450 feet, but this hardly seems probable.

#### August 6, 1902

I drive out to the hill that forms the south end of the range between the Manistee and Au Sable Rivers, on line of Sections 4 and 5. There is a sandy ridge 30 - 40 feet higher than Portage Lake, running to the northwest end of the lake from this high range. It is not pebbly at surface, and may be wind-formed. It is 20 - 30 rods wide.

With B. E. Livingston: I return to Grayling to meet Burton E. Livingston of Botanical Department of University of Chicago, who is to study plant communities in Crawford and Roscommon counties.

We go to Portage Lake and take a road south from the east end, rising to a table land 1,300 feet, more or less, A.T. that is pine stump land growing up to oak. In Section 34, there are prominent hills that extend northwest into Section 28. The highest points are about 1,400 feet. There is some hardwood in Sections 2 and 3, T.25N., R.4W., on a gently undulating tract. The south half of T.24N., R.4W., has a plane surface except the narrow ridge noted last year along the south line. This plain is timbered with jack pine and has a sandy soil, but boulders are scattered over it, and are especially numerous in and around shallow basins. We drive west through Sections 3, 4, and 5, then south 2-1/2 miles.

#### August 7, 1902

I went north along the line between T.25N., Ranges 4W and 3W, to Section 19, on line of T.26N., Ranges 4W and 3W. Upon turning north, we cross a range of hills near south end of line of Sections 25 and 30, T.26N., that reach 1,400 feet. This is at the north edge of a nearly plane tract with loamy soil that stands about 60 feet above the plain south of it, or 1,280 feet. There are boulders on the loamy tract. There is more or less, till from here southeast nearly to Roscommon on the south slope of a range of hills. I noted it last year in Sections 16, 17, 21, 22, 26 and 35, T.25N., R.3W. The moraine extends into Sections 13 and 20, T.26N., R.3W., from the south, but the north half of these sections is flat.

Aneroid 28.430 at Grayling, 1,134 feet. We drive east on south side of the Au Sable River through a sand plain that reaches to the center of Sections 15, 14 and 13, T.26N., R.3W., and Section 18, R.2W. Farther east, its border is in Sections 20, 21, 22, 23 and 24. The plain descends eastward, being 40 feet lower 5 miles east of Grayling than in the village, and 100 feet lower at river in Section 12, T.26N., R.2W., than at Grayling. The sand plain there is about 60 feet higher, or 1,090 feet. There is a swamp and a small lake in Section 23, with some hardwood on the borders, but nearly all the plain is jack pine. East of the south Au Sable is a hilly tract extending north into Sections 17, 9, 10 and 11, T.26N., R.1W.

There is said to be a low sandy plain running up a south tributary of Au Sable River in Sections 12, 13 and 24, T.26N., R.1W., and adjoining sections on the east. We cross the south branch of Au Sable in Section 23. The stream here is bordered by prominent hills on each side, 100 feet or more in height. These hills are largely timbered with jack pine, and have a sandy soil. There are very few settlers on them. The wells are 50 to 150 feet deep. Some clay is found in a well on J. H. Hartman's land in Section 34, T.26N., R.1W., at less than 75 feet. George Harkins, in Section 2, T.25N., R.1W., has a well 187 feet deep. His well is on a high hill. A well on the south side of Section 34, T.26N., R.1W., in a basin, is only 50 feet deep.

There are hills in Sections 1, 2, 3, 11 and 12, T.25N., R.1W., that are a continuation of those in T.26N., R.1W. South of this is a sand plain about 3 miles wide that is timbered with jack pine. There are narrow strips of swamp along tributaries of south Au Sable in the northwest part of the township. This plain is 1,200 feet, more or less. The hills northeast of it are 50 - 100 feet higher. There is a narrow range of hills in the south part of T.25N., R.1W., in Sections 31 and 36, and south edge of Sections 25 to 30. This range covers part of Sections 26, 27, 34 and 35 and 36, T.25N., R.2W., south of south Au Sable River, and appearing on the north bank in Section 23, runs westward through Sections 22, 21, 20, 17 and 18, T.25N., R.2W., and covering much of Sections 13 and 24, T.25N., R.3W., east of the M.C. railroad, and Sections 7, 8, 9, 10, 14, 15 and 16 west of the railroad, as noted last year.

We traverse the plain in T.25N., Ranges 1W and 2W on the stage road from Jack Pine to Roscommon, and reach Roscommon at 5:00 p.m. This is on a plain that lies south of the ridge above outlined. Its general elevation is 1,140 feet, more or less, around Roscommon. The station is in a sag, and stands 1,123 feet. The morainic ridge west of Roscommon was traced last year past the north end of Higgins Lake.

August 8, 1902, 7:00 a.m.

Mr. B. E. Livingston and I drive through from Roscommon to Grayling on a line keeping mainly within a mile east of the M. C. railroad. There is some till in Sections 36, 35, 26, 23, 22, T.25N., R.3W., but the higher tracts north of these sections are on a gravelly sand with pine stumps. The railroad is in a sag in Section 14 that carries jack pine. There is an extensive plain of jack pine north and east of Cheney Station, in Sections 1, 2, 3, 10, 11 and 12, T.25N., R.3W., Sections 6 and 7, T.25N., R.2W., and Section 34 and parts of Sections 33 and 35, T.26N., R.3W., and parts of Sections 36, 25 and 26. It stands about 1,200 feet A.T., Cheney Station being 1,198 feet. The hills southwest of here in Sections 10 and 9, 15 and 16, T.25N., R.3W., have an altitude of over 1,300 feet, and some may approach 1,400 feet. There is a prominent isolated hill, 150 feet, more or less, in height, covering much of Section 8, T.25N., R.2W., which stands on the Cheney plain. Probably the plain that lies east of this hill is of the same age as the Cheney plain. It covers much of Sections 9 and 10, 13, 14, 15, 16 and 17, 24 and 25, and 26, T.25N., R.2W., and continues east in a belt 3 miles wide across T.25N., R.1W., as noted yesterday.

There is a sharp ridge, 75 feet, more or less, high, running northwest across Section 35, T.26N., R.2W., and west across south part of Sections 27 and 28, then south through the west part of Section 33 and east part of Section 32 into Section 4 of T.25N., R.2W. There is a narrow plain cutting this off from the high ridge in Sections 30, 31 and 32 noted August 6th, that reaches 1,400 to 1,425 feet, and this plain is utilized by the M. C. railroad. We find a subdued morainic topography north of this ridge to the edge of the Au Sable sand plain. There are basins rather than knolls, (though some 'round hills' occur).

We spend the afternoon on maps at Grayling. I complete one showing my studies in the Grand Traverse region and send it to Professor Chamberlin.

Aneroid 28.540 at Roscommon, 1,123 feet. Aneroid 28.490 at Cheney = 1,198 feet. The summit 1/2 mile southeast is about 1,215 feet, and the bordering hills 1,300 to 1,425 feet.

Mr. Perry Ostrander, south side Section 4, has well 106 feet:

1. Sand .....	4 feet
2. Grayish clay .....	4 feet
3. Sand .....	22 feet
4. White clay .....	2 feet
5. Sand, coarse .....	7 feet
6. Water bearing sand .....	5 feet
7. Blue clay .....	42 feet
8. Coarse sand and water .....	10 feet

Total ..... 106 feet

Water will rise 53 feet in well, altitude 1,200 feet, more or less.

August 9, 1902, 7:00 a.m.

Mr. George Owen, Sheriff of Crawford County, took Mr. Livingston and myself on a drive over the northeast quarter of Crawford County, in which we mapped the south end of the range of hills that lies between the North Branch and so-called last Branch of Au Sable from Section 36, T.27N., R.3W., to Section 16, T.27N., R.1W. It passes through Sections 31, 32, 29, 28, 34, 26, 25, and 24, T.27N., R.2W., and Sections 19, 20 and 17, T.27N., R.1W., to the west edge of Section 16. The tract south of it is a jack pine plain with occasional swamps. It is mainly light, sandy soil, but in Section 33, T.27N., R.2W., and Section 4, T.26N., R.2W., there is clay near the surface. The upland tract north of this plain has a better soil than the plain, though there is but a small amount of clay land. It was largely pine of merchantable size.

Some hardwood occurs in Section 2, T.27N., R.2W., and Sections 27 and 34, T.28N., R.3W., and perhaps other places. It has numerous small boulders in some sections, especially where there is hardwood. This tract has its east border within a mile of the North Branch from Section 16, T.27N., R.1W., north to the county line, and its west border within a mile east of the East Branch from Section 26, T.27N., R.3W., north of the county line. It is said by Mr. Owen to extend but 1 – 2 miles into Otsego County, there being a sand plain in T.29N., R.2W., except on its south edge. There is a line of glacial drainage down the East Branch 1 – 2 miles wide, that separates this upland from one west of East Branch. The upland between East Branch and North Branch has several points that rise above 1,300 feet – one on the line of Sections 29 and 30, another in Section 24, T.27N., R.2W., and several in Sections 27, 28, 29, 33, and 34, T.28N., R.2W. Perhaps the north part of T.28N., R.2W., has points fully as high as these in the south part. There are deep basins in this tract, some of which are occupied by lakes. The basin of K. P. Lake, in Sections 28 and 33, T.28N., R.2W., is over 100 feet deep and has no swampy border. The lake stands about 1,200 feet A.T., and has no outlet. Mr. Owen thinks the greater part of Townships 27N and 28N, R.2W., can be profitable farmed, but as yet, there are only a few settlers.

There is a sand plain covering nearly all of T.28N., R.1W., and all of T.27N., R.1W., except Sections 6, 7, 8, 17, 18, 19 and 20 in the northwest part, and Sections 13, 23, 24, 25, and 26 in the southeast part. There is a large swamp shown in the U. S. Land Survey Plats in Sections 9, 15, 16, 21 and 22, T.28N., R.1W., and another in Sections 1, 2, 11 and 12.

I had a fine view of the sand plain in Townships 27N and 28N, R.1W., from the hill in Section 16, T.27N., R.1W. East of it, I saw a range of hills running south from near Lewiston through the west part of Oscoda County, nearly to the Au Sable, and entering Crawford County in the southeast part of T.27N., R.1W. Mr. Owen says there are extensive sand plains west and north of Lewiston.

Notes from back of Notebook No. 175:

Lake bluff 40 rods, more or less, south of clubhouse on shore in Manistee is 73 feet by hand level, and is till. The till at the clubhouse is 59 or 60 feet; at its northernmost expanse, 53 feet. 37-1/2 ft. old channel lake bluff south of moraine. 73-8/10 feet = the height of sand plain.

July 14 - Aneroid 29.130 on crest northeast of Manistee in Section 29 at east-west road. Aneroid 29.100 at north-south road in Section 29. Aneroid 29.060 at Orchard Beach. Aneroid 29.100 in outwash apron. Aneroid 29.140 in channel of border drainage. Aneroid 29.130 in lowest part of the till tract west of channel. Aneroid 29.155 at Pere Marquette depot, 600 feet, more or less.

Fort Wayne to Adrian, 241: Aneroid 29.470 at Sable River. Aneroid 29.405 on south bluff. Aneroid 29.310 on south bluff on township line. Aneroid 29.430 at Sable River. Aneroid 29.370 on north bluff. Aneroid 29.280 1 mile north of county line. Aneroid 29.360 on plain north of moraine. Aneroid 29.360 at Filer. Aneroid 29.440 at grove in Manistee. George Hayes, a land broker at Manistee. John Hunter, Copemish. T. J. Elton, Assistant Secretary. Edward Buckley, President. Wesley Andrews, boarding house, 723 West Mitchell Street, Petoskey. E. W. Coulter, Charlevoix, (near house). Try John Williams at Elk Rapids for M. E. Byers. Evelyn Hall, Bay View, Michigan.