

Notebook No. 177 - Leverett

COUNTY

Allegheny - copper: 30

Antrim: 20, 23, 24-31

Charlevoix: 3, 4, 14-24

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Emmet: 2-14

Grand Traverse: 31-38

NOTEBOOK NO. 177

Donated by \_\_\_\_\_

September 1 to 15, 1902

Studies in west side of the Southern Peninsula of Michigan, north from Benzie and Grand Traverse Counties.

(Read in October, 1931 and marginal notes made.)

- September 1. Mackinac and Petoskey with Taylor. Drive southeast from Petoskey, short circuit.
- September 2. Drive southeast from Petoskey long circuit, past Littlefield and Epsilon.
- September 3. Drive Petoskey to Alanson with Taylor. Drive northwest - Alanson to Pleasant View and Petoskey.
- September 4. Petoskey to Charlevoix by rail. Drive east from Charlevoix with Lane, Taylor and Parmelee.
- September 5. Map drumlins southeast from Charlevoix.
- September 6. Map drumlins south from Charlevoix.
- September 7. (Sunday) Observations around Charlevoix.
- September 8 and 9. Poor notes; work near Ellsworth. See township maps for data.
- September 10. Drive east from Charlevoix and map drumlins.
- September 11. Drive from Ellsworth to East Jordan and Advance and back.
- September 12. Drive from Bellaire to Alden and along west side of Torch Lake and Byers.
- September 13. Drive Byer's to Central Lake and Bellaire. Drive from Elk Rapids.
- September 14. Traverse City southeast to Kingsley and back.
- September 15. Traverse City to Honor by rail.

September 1, 1902, 7:20 a.m. - Mackinac City, Michigan

Donated by \_\_\_\_\_

Aneroid 29.200 = 590 feet more or less. Aneroid 29.190 at 8:15 a.m. Taylor and I take train on G.R. and I. R. R. to Petoskey. Dry ground, sandy for 2 - 3 miles, then swampy nearly to Carp Lake. The swamp sets in at 675 feet more or less. Aneroid 29.030 at Carp Lake, 740 feet, more or less. Boulderly ridge in swamp a mile south of Carp Lake Station 5 feet more or less high and 3 - 4 rods wide.

Aneroid 29.005 - 29.000 at Algonquin beach. The beach is a well defined ridge. Aneroid 29.035 on Algonquin beach at Petoskey = 693 feet A.T. This is at the United Brethren Church. I return to Mitchell Street and go east, rising to a flat tract at Summit Street standing about 750 feet A.T. that has a coating of sand and firm gravel. There is about 40 acres of this flat lying mainly south of a small stream that comes in from the southeast. Is this a Lake Chicago shore?

I continue east on Mitchell Street and upon crossing this ravine find till thickly set with limestone fragments. Continuing east I find it changeable, with places where there is clay with few pebbles; others that are sandy or gravelly; and others with a stony till.

Aneroid 28.860 = 840 feet at Summit near east edge of city by a large red barn (south of road) in Section 4. There is an extensive flat tract about a mile east-northeast from here that has this altitude. It borders the great depression that leads east from Little Traverse Bay on the south. There is an undulating higher country south of there. I go north into Section 33, coming to brow of bluff 1/4 mile north of town line and find it 750-760 feet. The Algonquin beach is 40 rods farther north. Aneroid 29.040 = 695 feet, more or less. I go east into Section 34 and cross the Algonquin as a gravel and cobble ridge east of a small creek in west part of Section 34.

Aneroid 29.030 = 695 feet, more or less. There are dunes west of this creek

along this beach. The beach runs north along face of a moraine from near the center of Section 34. The moraine in east part of Section 34 is bouldery and has till at surface. There is, as above noted, a nearly plane tract at 830-840 feet in the south part of NE $\frac{1}{4}$  of Section 34, but in the SE $\frac{1}{4}$  of this section there is an undulating tract. I go east on road 80 rods from south side of Sections 34 and 35, reaching a summit at a road that leads north from center of SW $\frac{1}{4}$  of Section 35. Aneroid 28.760 = 940 feet. The altitude is 20 - 30 feet higher 80 - 120 rods southeast from here, near the township line, or about 960 - 970 feet A.T.

There is a hill in west part of Section 36 that reaches 940 feet. I go south to road leading east across center of Section 1, T.33N., R.4W., and take that road up into a high range of hills in the east part of the section that rise a little above 1,000 feet A.T. Aneroid 28.660 at summit on road = 10 - 20 feet A.T. more or less. Points in south part of Section 1 may be 25 feet higher. This is a bouldery tract with large swells rather than hummocks. The largest swells often contain much gravel and sand. At least the slopes are sandy on road. There is a very sharp esker-like gravelly, bouldery ridge north of road in Section 6.

In southeast part of Section 6, I come down to a flat that seems to be below the Algonquin beach and it is fully a mile wide. Aneroid 29.090 on this flat where a road leads south between Sections 7 and 8, T.33N., R.4W. The creek is about 30 feet lower. I go south two miles in this flat and find a rise of only 25 feet. Aneroid 29.060 at intersection with Vanderbilt Station Road at corner of Sections 17, 18, 19 and 20. The valley extends south-southeast beyond the limits of view. There is a high bluff east of it in Sections 9 and 16, 300 - 400 feet. I take the Vanderbilt Station Road northwest across Section 18.

Aneroid 29.030 at west edge of flat at place where a bouldery, gently undulating tract sets in, near center of Section 18. There is a swampy valley heading in Section 2, T.33N., R.5W., and draining southeast across Sections 11, 12 and 13 into the large valley in Section 18. It is 20 - 40 rods wide. It seems to have been below Lake Algonquin. Knolls at the head separate it from a stream draining northwest across Sections 2, 3, 34 and 33 to Little Traverse Bay.

Aneroid 28.715 at Greenwood Church = 930 feet, more or less at corners Sections 10, 11, 19 and 15. Samuel Pletzer in northwest part of Section 14 has well 135 feet. Aneroid 28.715 at well. It has  $2\frac{1}{2}$  feet of water. It was gravel and sand below 80 feet, but the first 80 feet had enough clay to stand without a casing.

A well 80 rods south on Worth farm, east side Section 15, is 133 feet. It had only 25 or 30 feet at top that would not need casing. It was mainly gravel.

The south side of Section 14 is very high, perhaps 200 feet higher. I go north to middle of line of Sections 10 and 11, then west, crossing ridges and sags with rather smooth slopes all the way to Petoskey. There are swampy channels in Section 9 that drain south to Bear Creek. Section 4 also has swampy channels, but they drain north to Little Traverse Bay. Sections 8 and 5 have scarcely any swamp. They are a smooth surfaced, but not level, tract of till. The topography is drumlinoidal in places.

Aneroid 28.940 at cross roads at line of Sections 9 and 10. Aneroid 28.900 in highest part of Petoskey (southeast part of city) = 860 feet, more or less. Aneroid 28.970 at south edge of flat at east end of Grove Street. Aneroid 29.090 at Algonquin Creek, 693 feet. Aneroid 29.110 at Cushman House = 670 feet, more or less.

September 2, 1902, 7:45 a.m.

Aneroid 29.290 at Cushman House = 670 feet A.T., more or less. Aneroid 29.190 at gravel pit at corners of Mitchell and Summit Streets = 760 feet. The cross bedding shows a southward dip. Taylor took a view of this pit. Most of the material is fine sand, but there are thin pebbly beds. The material is coarser below than above. There are boulders at surface.

We go east and cross two ravines and Taylor takes a view of the laminated red clay that appears on west slope of a hill in west part of Section 4. Aneroid 29.130 at top of laminated clay = 810 feet, more or less. The hill at top is 840 feet and sandy. There are boulders on its slope and in the sandy drift in the upper part of the hill.

Aneroid 29.230 in a north-south valley near center of  $NE\frac{1}{2}$  of Section 4 = 710 feet, more or less. This is the valley referred to last night as swampy and nearly connected with one in Section 9 that drains south. Aneroid 29.235 at stream in  $NE\frac{1}{2}$  of Section 3. There are smooth surfaced knolls between these streams in Sections 3 and 4. Aneroid 29.170 at low place in south part of Section 2 -- head of stream that drains northwest. Aneroid 29.130 at cross roads on a knoll in valley. Aneroid 29.200 in swampy valley in Section 11 that drains southeast. There is a branch of same valley in southeast part of Section 2.

Aneroid 28.970 = 935 feet at Greenwood church. Aneroid 28.830 = 1,070 feet at center of Section 14. Aneroid 28.660 = 1,225 feet on highest point on north-south road near north side of Section 23. There is a point slightly higher 100 - 120 rods southeast that seems to be the highest in this range of hills. It does not exceed 1,240 feet. Peaches are grown successfully in Sections 14 and 23 on this high range. The range trends southeast and has a gently undulating crest. Aneroid 28.900 at middle of line of Sections 25 and 36 on crest of ridge overlooking lower land east, west and south, but becoming higher to the northwest.

Aneroid 29.110 at south side of Section 36 = 820 feet, more or less.  
Aneroid 29.110 at township corners on County line. Aneroid 29.200 at Mr. Bright's in north part of Section 6 on edge of swamp from which water drains in opposite directions. This sets in 80 rods from east end of line of Sections 6 and 31 and is fully a mile wide. Aneroid 29.180 at Mr. Bright's, 3/4 hour later. Aneroid 29.190 in swamp in northeast part of Section 32 that drains north. This is scarcely 80 rods wide and is sandy. There is a gradual rise from it to the base of the bluffs east side. A low tract 1/4-1/2 mile wide connects the head of Spring beach with Minnehaha Creek. I go south to county line on east side of Swamp, then go east rising to uplands. Aneroid 28.880 at abandoned house in southeast part of Section 33.

Aneroid 28.800 at sharp summit near corner Sections 33, 34, 3 and 4.  
Aneroid 28.900 on upland west of school house, line of Sections 2 and 35.  
Aneroid 28.950 in basin at school house. Aneroid 28.900 on uplands east.  
Aneroid 28.950 in low tract on line of Sections 35 and 36 near middle. It is morainic on each side. Sections 1 and 2 and south edge of Section 36 and 35 have cobbly drift.

Mr. Alfred Hopper, northeast corner Section 27, Springvale Township, has a well 212 feet deep with only 12 feet of water. It was mainly through sand -- little or no clay. Aneroid 28.860 at the well, 980 feet, more or less. It was dug.

Aneroid 28.880 at Littlefield Post Office. The well at the Post Office (J. E. Hyatt's) struck water at 60 and is 70 feet deep. A. T. Sanborn in Section 22 has a well 230 feet. It is on ground as low as Littlefield. A well across the road from Littlefield Post Office at John Redford's is 130 feet and is only 10 feet higher than at the post office. Dr. Bricker, 2 miles east of Littlefield has a well about 150 feet, and his neighbor, Mr. Colton, on higher

ground, has a good well at about 25 feet. The high tract from Epsilon south to the Charlevoix County line has a hummocky morainic drift with small knolls 10 - 25 feet high on slopes of large ridges and in the broad depressions between the ridges. Aneroid 29.170 in swamp 1 mile east of Epsilon. Aneroid 29.190 at Epsilon in a sandy plain probably at level of Algonquin beach. There is a rise to a moraine immediately south of here. Aneroid 29.220 at sand ridge that runs south across road a few rods east of school house on line of Sections 5 and 8. Aneroid 29.220 at school house. Aneroid 29.255 at Minnehaha Creek.

Aneroid 29.170 at base of bluff a little north of township corners, probably at level of Algonquin beach. (Barometer is changing rapidly.) About 80 rods from east side of Section 36, a gravel ridge 2 - 4 feet high and 40 - 50 feet wide runs north from the bluff about 80 rods and then turns west. North of it is a sandy ridge also running west to the moraine. A few rods south and west of a school house in northeast corner of Section 35 is a cut bank that may represent Lake Chicago. It is 8 - 10 feet high and well defined for 40 - 60 rods. It runs out to the road in a west-northwest course. There is sand in low knolls and ridges west from there at a level 20 feet, more or less lower. The sand sets in at house, barn and outbuildings on the north side of road. The sand continues farther west as a low ridge along the slope of the moraine.

Aneroid 29.090 at base of cut bank and level of top of sand ridge at the dwelling house in southeast part of Section 26. West from here the sand is a little lower down on the slope. The road crosses a low projecting point of the moraine on which the aneroid reads 29.060. Then after passing over a gully it rises to a flat tract where aneroid reads 29.080. This has till in it and is full of limestone fragments. The flat is 20 - 40 rods or more in width. Is it border drainage, or does it represent a lake level? It is at same height

as the cut bank near school house. The moraine rises quite abruptly south of it 30 - 50 feet. Aneroid 29.160, 695 feet, more or less on Algonquin beach near corners Sections 26, 27, 34 and 35 at a ravine that comes in from the southeast. Aneroid 29.185 at Cushman House at 6:30 p.m. = 670 feet A.T.

September 3, 1902, 7:30 a.m.

Aneroid 28.900 at Cushman House. Aneroid 28.880 on Algonquin beach east of Bay View = 695 feet. Aneroid 28.810 on clay terrace near northwest corner Section 35 noted last night. Aneroid 28.795 on summit on line of Sections 26 and 35. Aneroid 28.850 at Algonquin beach, on line of Sections 36 and 25 = 695 - 700 feet. Aneroid 28.885 on till knoll south of west end of Crooked Lake = 720 feet, more or less. Aneroid 28.960 on bank north of till ridge in Section 25. Aneroid 29.025 at Crooked Lake. The till knoll south of west end of Crooked Lake rises abruptly 30 feet, more or less, on its south side and still more on its north side. It is about a mile long and terminates at east in Section 19.

James Hastings in Section 24, south of Crooked Lake and only 15 feet above lake, has well 262 feet. It entered limestone at 13 feet and terminated in it. The head is 9 feet below top. The wells at Conway that overflow (about 12 of them) are 80 to 120 feet. They are through sand nearly to bottom. Then they go through some clay before striking the flow in gravel. Mr. Hastings has a flowing well 25 feet deep in Section 19, Springvale Township, on low ground south of Crooked Lake.

Aneroid 28.870 at base of moraine north of Odin 10 - 15 feet, more or less, above Algonquin beach, or about 710 feet A.T. Aneroid 28.640 = 900 feet, more or less, on summit in northwest part of Section 3 where road heads east.

Aneroid 29.000 at Alanson Station. There are flowing wells along the low ground in Alanson along west side of Crooked River. There are several at about

60 feet. H. C. McPhee has one in south part of Alanson that is about 124 feet. A vein of flowing water is struck at 35 feet. George Rotter has one 66 feet that was clear sand for 63 feet. There is then a hard clayey bed under which water is found. Water rises about to the level of the railway station or 8 - 10 feet above the surface. Those at 35 feet only rise 3 - 4 feet above surface. August Bunce has one in north part of village that is 140 feet. It is at a store. There is one at his house that is shallower. Mr. McCormick has a well near depot in Odin that is 144 feet. At Williams Hotel in Odin it is 106 feet. It was 96 at first, but has been deepened. At Brutus there are several flows. At C. H. Hinckley's mill in north part of village are gravel wells about 45 feet. Mr. Fairborn, hardware merchant, has three wells only 26 feet that overflow. They are near depot in Alanson and 8 - 10 feet lower level. At Pan Che Waing there is a well at Mr. Coppide's cottage 215 feet. Dr. Schwab's, only 50 feet away, is 226 feet. They are both on a rise of ground 15 feet, more or less, above the low flat. On the low flat on Crooked Lake at Pan Che Waing, flows are obtained at about 60 feet.

Aneroid 28.990 at Alanson at 12:10. Aneroid 28.930 on Nipissing beach in west part of village. This is a sandy gravel. Aneroid 28.910 at cemetery in southeast part of Section 4 at level of a plain of sandy gravel. Aneroid 28.915 at Creek on line of Sections 4 and 9. Fully two thirds of Section 4 is morainic, the southeast part only being on the lake plain. There are a few low knolls in northwest part of Section 9. Section 8 is morainic in northwest part -- fully half of section. Section 7 is morainic except on south border. I come to the moraine in the creek valley in southwest part of Section 4. The creek is in a sag between high hills in Section 5 and Section 31. Aneroid 28.880 at upper limits of Lake Algonquin in southeast part of Section 5 in creek valley. Aneroid 28.860 in creek valley at place where road leads west through center of Section 5. I here turn west and rise to a farm on top of the hill. Aneroid 28.630 = 940 feet.

The highest points are about 20 feet higher. This is on William Blunke's farm, northwest corner of Section 5. I go west between sections 6 and 31 and come to a high tract that rises within 1/4-1/2 mile south of the township corners to an altitude of 1,025-1,050 feet and 100 rods west of township corners to 1,010 feet. Aneroid 28.540 at hill west of township corners. Aneroid 28.600 at township corners = 960 feet. The moraine has some clayey till at surface, but is largely a sandy till. Boulders are numerous. The surface is hummocky on slopes of large hills and deep sags. I go north on the township line. I am told that Mr. Williston made a boring about 2 miles southwest of Brutus that cost \$300. and is 200 feet or more deep. It is on high ground.

Aneroid 28.630 at corner Sections 30 and 31, 25 and 36 on general level of high land. There are smoother slopes here than a mile south and drift is more sandy. Aneroid 28.620 at corner Sections 19 and 30, 24 and 25 at store, Ayr Post Office. Hills west are 25 - 30 feet higher. Aneroid 28.640 at creek flowing southeast across middle of line of Sections 19 and 24. Aneroid 28.540 on hill on line of Sections 13 and 18 at Sylvanus Weibers. Aneroid 28.500 near north end of Section line (13 and 18). There is a higher hill near middle of line of Sections 12 and 13, probably 30 - 35 feet above the one I am on or nearly 1,100 feet A.T. Aneroid 28.580 in basin at corner Sections 12 and 13, 7 and 18. Aneroid 28.450 on hill on line of Sections 7 and 12 north of middle. Aneroid 28.420 on hill just south of corner of Sections 1 and 12, 6 and 7. Aneroid 28.380 on hill about 80 - 100 rods west of section corners and 20 rods into Section 1, 1125 - 1150 feet. This seems to be the highest hill in this region. The east half of Section 1 is very high. The drift is a sandy till with numerous boulders. Slopes are not very irregular, though far from smooth. The slope to the west is very sandy till.

Aneroid 28.560 at corner Sections 1, 2, 11 and 12. Aneroid 28.800 at intersection with a north-south road near corner Sections 2, 3, 10 and 11 on a

flat at base of moraine. I go west to border of swamp (about 80 rods). Aneroid 28.830. It seems not improbable that this flat surfaced slope is beneath Lake Algonquin level, for the change is very abrupt from morainic topography to this smooth surfaced tract. I go back and take road south along line of Sections 10 and 11 for 1/2 mile, rising to Aneroid 28.760. The road then turns southwest and crosses to a tamarack swamp with marshy grassy places in it.

Aneroid 28.845 at the marsh. It then rises south-southwest to a dwelling at foot of moraine. Aneroid 28.800. This is near south side of Section 10. The slope is very smooth from the swamp up to here, but hummocky above this level. There are sandy ridges in the southwest part of Section 15 that are narrow and sharp and rise 10 - 20 feet above the swamp. The road follows one west for a short distance. Aneroid 28.810 on sand ridge. It seems to terminate near where road turns southwest. There is another south of it that does not run so far west. Aneroid 28.825 on the swepy flat at west end of ridge.

Aneroid 28.820 at Pleasant View Center. There is a sand ridge rising west across the road about 40 rods south of center and curving around to cross the east-west road 50 - 60 rods west of the center. It is 5 - 15 feet high. It seems to rise no further. The swamp extends south past its west end into Section 21. The ranges of hills each side of this swamp seem to have been formed by an ice tongue that pushed south in this swamp, for there is a clayey till along the base of the hills in places. It shows well in Section 15.

Aneroid 28.810 one mile south of Pleasant View Center on flat tract. There are occasional sandy spurs running out into the flat across the line of Sections 21 and 22 from the east bluff. There is a prominent moraine in Section 22. Section 21 is nearly all flat land except its northwest corner.

Aneroid 28.800 on flat tracts near corner of Sections 27, 28, 33 and 34. Sections 28 and 33 are flat except a few ridges along the east edge. There is a rise of over 100 feet along this road near the township line, but the level

is a sand ridge about 650 feet A.T., much of the way from here to Bay Shore. Aneroid 29.180 at Bay Shore, 650 feet, more or less. The sand ridge is 40 - 50 rods north of here and the Algonquin beach about 80 rods south. There is a sag running south from Bay Shore that is little, if any, above Lake Algonquin. It is less than 1/2 mile wide. West of it are hills 50 - 75 feet, more or less, above Algonquin level. This is in view for about 2 miles west from Bay Shore. A flat low tract then extends through to Pine Lake. (See notes taken in connection with Soil Survey of Charlevoix County in 1922.)

Aneroid 29.380 at level of Lake Michigan at 9:20 a.m. There is a strong beach at Charlevoix 47 feet above the lake and 49 feet in Section 24. After crossing the railroad in Section 24, till appears between Pine Lake and Lake Michigan. Some of it was probably originally drumlin, but the waves have cut the drumlins down. The sags at sides are faintly outlined.

Aneroid 29.270 at south end of Susan Lake on Algonquin beach, 19 feet above the lake. Aneroid 29.260 at District No. 6 school house, southeast part of Section 9, Hayes Township on Algonquin beach. There are drumlins for 1-1/2 miles south of here and a combination of drumlins with morainic topography farther south on west, south, and southeast sides of Susan Lake. See township map.

The road in Sections 9, 10, 11 and 12 is near the Algonquin shore till it comes to the railroad pit 1/2 mile west of Bay Shore. The beach there runs southeast across a sag or valley that heads south to Pine Lake. Its height is 690 feet A.T. by hand level from the bay at Bay Shore. Bay Shore Station is 669 or 670 feet. There is a beach north of the Station at Irvington Hotel about 665 feet. One a few rods south of Station is 674 feet. One at an east-west road in Bay Shore is 679 - 680 feet. One south of there, in cornfield, is 685 feet and the highest and best defined shore that leads across the north

looks lower west of here on line of Sections 4 and 33. The hills cover Section 3 except a few acres in the southwest corner, but Section 4 is mostly low. Aneroid 28.800 at corner of Sections 2, 4, 9 and 10 where a poorly travelled road leads west. Aneroid 28.840 at swamp near middle of line of Sections 9 and 10. South of this is a plain of sandy gravel. Aneroid 28.820. This extends west into the southeast part of Section 9. West of it from center of Section 9, south, a little beyond the south line, is a moraine ridge 20 - 50 feet, more or less, above this plain. Aneroid 28.840 at corner of Sections 9, 10, 15 and 16 in a slight depression. The plain west of here is 15 - 20 feet higher.

Aneroid 28.830 1/2 mile farther south, just north of east-west road. Aneroid 28.850 at road at base of steep bank. There is an abrupt drop of 15 feet, more or less, just north of road here so the road is on a terrace that is only 10 - 12 rods wide here. This terrace widens to the east from here. Aneroid 28.850 on this terrace at center of Section 15. The north edge is 50 rods north and the south edge about 50 south of this point. Aneroid 28.880 at base of terrace. Aneroid 28.900 at top of next terrace. Aneroid 28.950 in swamp at level of Nipissing beach = 605 feet, more or less. Aneroid 28.880 at Cushman House = 670 feet, more or less.

September 4, 1902, 7:25 a.m.

Aneroid 29.245 at Pere Marquette Station in Petoskey, 590 feet, more or less. Nipissing beach for about a mile west. The rise is then made past till bluff to a beach at about 630 feet. This, Taylor thinks, may be the same as the Battlefield beach on Mackinac Island at 700 feet, more or less. It is a wide beach.

Aneroid 29.160 at a limestone cut about 3 miles east of Bay Shore. There

side of the sag or valley is 690 feet.

Aneroid 29.320 at Bay Shore, 670 feet at 2:00 p.m. We follow this valley or sag south from Bay Shore to Pine Lake. It is  $1/2-3/4$  mile wide. There is one island in it in Section 13 that stands 20 feet, more or less above Lake Algonquin. (See notes in 1922). The valley is, much of it, far below the level of Lake Algonquin. The road on line of Sections 13 and 24 reaches a level about 70 feet below the Algonquin shore.

I level up to the Algonquin on north side of Pine Lake in Section 2 and find it 102 feet above the lake or 682 feet A.T. The kames back of it reach 175 feet above the lake. Lower beaches are found at 17 feet (gravelly); 29 feet (base of steep bank); 59 - 60 feet, at top of steep bank. There are, above the 60 foot bank, small ridges on the slope between it and the Algonquin beach. The Algonquin here is gravel and cobble. There is considerable gravel in this beach from here to Lake Susan. On the return from Lake Susan we find that there is clay on the ridge at west end of Pine lake at a height of 40 - 50 feet above Lake Michigan. It extends west and south nearly to the outlet. (See later notes on sewer trench.)

A copper nugget weighing 35 pounds was found at South Arm village in an excavation for railroad. (F. A. Kenyon, Register of Deeds.)

September 5, 1902, 7:00 a.m. - Charlevoix, Michigan

Aneroid 29.540 at level of Lake Michigan. Aneroid 29.510 at Belvidere Hotel. Clay in NW $\frac{1}{4}$  of Section 35 at 640 feet, more or less, A.T. Aneroid 29.430 on beach (Algonquin) at John Wakefield's residence in southeast part Section 34, Charlevoix Township. Aneroid 29.370 at William Cooper's northeast part Section 3. Aneroid 29.340 at James Reed's near center of Section 3 on crest of drumlin = 760 feet A.T. Mr. Reed's well is 91 feet deep. There was till 15 feet. The rest is sand. Water does not rise in pipe. Sand sets in

about the level of base of drumlin. There is a ferruginous crest in swamp west of here. Mr. Reed went 18 inches into it in digging post holes. From south side of Section 3 I go east and come to what seems to be the early (pre-Algonquin) lake border near west end of line of Sections 2 and 11. It is a slight wave-cut bank. At the railroad, 80 rods east, there is a ridge that contains some till. It is perhaps the remnant of a small drumlin. The ridge runs south-southeast to center of Section 11 and has a strong beach on its east side. A beach ridge, sandy and gravelly, leads east of north from just east of the north end of this till ridge about to the center of Section 2. It there turns northwest and runs toward Wakefield's where I noted it in Section 3<sup>4</sup>, Charlevoix. Back of it is an extensive swamp which seems to have been covered by Lake Algonquin. On the lakeward side are slightly lower ridges. There is a strong barrier beach (Algonquin) running past the north end of Adams Lake in Section 11, Marion Township. There was a narrow bay back of it extending beyond Adams Lake through east part of Section 1<sup>4</sup> which is now a swamp. The Algonquin shore runs east-northeast past north end of several drumlins through center of Section 12. There was a bay on township line in east part of Section 12 and west part of Section 7 into which the Algonquin beach turns at east side. A swamp occupies the bay. I mapped the shore to Ironton and also some drumlins lying within 1 - 2 miles of the shore in \_\_\_\_\_.

After dinner, I continued mapping of drumlins and shore to the north side of Eveline Township, T.33N., R.7W. The lake shore was definitely mapped as far south as the line of Sections 21 and 28. South from there it lies 1/4-1/2 mile west of South Arm of Pine Lake beyond the township line. I return on a course a little farther west and map drumlins as indicated on the township maps. They have a somewhat uniform north-northwest - south-southeast trend, are composed of a thoroughly commingled stony till and carry only a moderate number of surface boulders. The sags among them are generally nearly plane and in some

cases swampy. The height of drumlins runs from 10 feet or less up to 60 or 75 feet and they stand at various altitudes from just above Lake Algonquin (680 feet, more or less) up to 800 feet or more in Eveline Township. There are but four wells on them for people usually get water on low ground at their sides. In some cases there are narrow swampy tracts trending in the same direction as the drumlins that are bordered by nearly plane till tracts which at the border of the swamp rise as abruptly as the side of a drumlin. There are usually drumlins on these till tracts back some distance from the swamps. It is probable that the swamps are products of ice sculpturing about as the drumlins are. The diagram shows a cross section.



In a few places, small drumlins are perched in all sorts of attitudes on large drumlin-like aggregations. For example in the west part of Section 18 and north edge of Section 19, T.33N., R.7W., is a drumlin-like mass 200 feet above Lake Michigan that is over a mile long and about 1/3 of a mile wide. At its south end is a small drumlin perched on the large one and trending about due southeast while the large one trends north-northwest - south-southeast or even nearer south (See map). To the northeast of this is a fine drumlin on which C. Erick's house stands which is nicely outlined and rises 40' above sags east and west of it. Following it south, the end is readily made out, but continuing south on a gradual descent another smaller drumlin appears which crosses the east-west road in Section 18 at A. Bird's house. It is only 10 - 15 feet high and is 50 feet or more lower than the main drumlin at Erick's. Near the corner of Sections 28, 29, 32 and 33, T.33N., R.7W., the altitude is about 800 feet, but the large drift aggregation there shows only slight drumlin ridges. It rises however on the east border, with the steep slope characteristic of drumlins, about 100 feet above the sag east of it. There are some fine regular bordered steep sided drumlins in Sections 19, 20, 28 and 29. The sides are usually about as steep as eskers.

September 6, 1902

I continue mapping drumlins in a tract west and south of that mapped yesterday. I drive south through Sections 3 and 10 Marion Township, T.33N., R.8W., passing over the southeast end of a regular drumlin near center of Section 10 that is 30 feet high. There is another fine regular drumlin 50 - 75 feet high and about 1/2 mile long. At its southern end at a lower altitude is a sort of appendix of oval drumlin connected by a neck with the main one. There is a closely aggregated group of drumlins making a single elevated mass in the southwest part of Section 14 and southeast of Section 15. The eastern one reaches an altitude of 800 feet A.T. about 80 rods southeast of the town hall. The sags between the middle parts of these drumlins are only 20 - 30 feet or less and are 50 feet or more above low ground at the ends of the drumlin group. The drumlins run down at the south ends nearly to the level of Twin Lakes or about 725 feet A.T. A very large drumlin runs from near center of Section 15 east of south for a mile. Its highest point is about 840 feet. H. Black has a well 94 feet deep near its north end that probably reaches about the level of low ground north of there. There is another elevated drumlin west of West Twin Lake near line of Sections 22 and 23 which stands 820 feet, more or less. It is about 75 feet high. A well is being made on it at Walter Black's which is down 51 feet now and has been in till all the way. There are reported to be three large drumlins between East Twin Lake and Newland Lake as shown on map. They are about 50 feet high and each 3/4 mile, more or less, long and 1/8 mile, more or less, wide. There is said to be another large one 50 feet high and 1/2 mile long in north part of Section 25. Aside from these the drumlins in Sections 25, 35 and 36 and east half of Section 26 are low, seldom exceeding 25 feet high. The Twin Lakes are of especial interest because they drain in different directions and yet are separated by a space of only 15 - 20 rods and a very low ridge 6 - 8 feet above west Twin Lake. West Twin is 4 feet, 9 inches higher than East Twin

as determined by Mr. Cooper of Phelps. It drains southward through Lake 26 and on to Intermediate Lake. East Twin drains east and north through Adams Lake into Pine Lake. There is probably till separating the lakes, though the surface is sandy. The altitude of the lakes is about \_\_\_ feet, as determined by aneroid on train.

South from the south end of the lakes a low drumlin rises gradually along the wagon road in Section 23. It is cut by the Pere Marquette railroad to a depth of 15 - 20 feet.

I take dinner at Phelps Station and receive considerable help in mapping drumlins from Mr. Cooper of the Grand Rapids Bark and Lumber Company. I then drive southeast through Section 36, crossing drumlins at frequent intervals before reaching the road in Section 36 and following them across this section. A well at John R. Walker's in north part of Section 36 on a low drumlin, is 36 feet deep and entirely through till. The drumlins are very narrow (10 - 15 rods) and long and seldom exceed 20 feet high in Section 36. I come to the level of Lake Algonquin near east end of line of Sections 31 and 6, T.33N. and T.32N., R.7W., at a creek valley. From here southeast the low ground around by the lake soon reaches 1/2 mile wide. Its extent is roughly indicated on map of South Arm Township (T.32N., R.7W.)

There are several fine regular drumlins in Sections 4, 5, 6, and north parts of Sections 7, 8, and 9, T.32N., R.7W., as indicated on map. The north-west part of Section 5 has some elevated land with irregular surface. In south-east part of Section 6 is an elevated tract between two drumlins that has a nearly plane surface. It stands 50 - 60 feet, more or less above Lake Algonquin level while the drumlins reach 75 - 80 feet, more or less. Lake Algonquin seems to have covered a swamp in Sections 7, 8, and 18, T.32N., R.7W., and extended a little into Section 6 and Section 17. (See map) The swamp is drained east across Section 9 and the altitude at line of Sections 8 and 9 is scarcely 40

feet above South Arm of Pine Lake or about 620 feet A.T. This swamp, as noted in latter part of July, connects South Arm of Pine Lake with Intermediate Lake. The swamp surrounds several drumlins (See notes, September 11). I return to Phelps and take road north between Sections 26 and 27, 22 and 23, 14 and 15, past some elevated drumlins west and northwest of Twin Lakes. There is a drumlin ridge two miles long and scarcely 1/8 mile wide setting in 1/4 mile northwest of Phelps and running north-northwest nearly to the center of Section 22. It is the longest I have seen in this drumlin area, though one east of Norwood is nearly as long, as noted in July. I go back from Twin Lakes on the same road I came out.

Sunday, September 7, 1902

I spend part of forenoon examining the plain south of outlet of Pine Lake in Charlevoix. There is a sandy material extending west from Pine Lake for 1/2 mile which is capped by a thin coating of clay in the area colored blue on the map (Charlevoix Township). This clay is usually but 2 - 5 feet, is very stiff and sticky, and has few pebbles. Coarse pebbles, cobbles, etcetera, are very rare from Pine Lake east for 1/2 - 3/4 mile on this flat that stands 45 - 50 feet above the lake, but west from there, cobblestones and boulders abound. In places, there are low ridges of cobbly material south of the west part of Charlevoix village, only part of which I mapped. Wells are obtained at about 30 - 35 feet near the east border of the cobbly material. One fourth mile farther east, on same elevation, they go about 50 feet, or to the level of Pine Lake. (See notes of same in back end of notebook.)

In the afternoon, I examine the clay tract north of Pine Lake outlet and find it has the extent shown on township map. The clay is thin and seldom has pebbles. There is a fine exposure in a sewer one block north of bridge on east-west road. It shows clay and clayey quicksand 8 - 10 feet deep, overlying coarse gravel. There are small lentils or masses of boulder clay in its upper part. There are also a few surface boulders here. It seems to be a still water

deposit, except for these masses of boulder clay and boulders that seem glacial. The fine clayey sand is faulted in places, and seems to have been disturbed, possibly by the ice sheet. At the west, coarse gravel and cobbles of lake level come up onto the slope of this clay. There are cobbly ridges south and south-west of Mount McSauba, 5 - 6 feet above the plain. They trend west-northwest - east-southeast. (See map). Their origin is not clear. One of these, near Alexander McSauba's residence, is full of boulders, and his well was in clay 14 feet. This suggests that the cobbly ridge may have been a glacial knoll that has been reduced by lake action.

#### CHARLEVOIX WELLS

John Beatty - a rock well 32 feet:	Gravelly	2 feet
	Sand	18 feet
	Clay, yellow	10 feet
	Hard sand, rock	2-3 feet
	Water that has no head	

W. J. Stevenson's well:	Clay	5 feet
	Sand, dug	13 feet
	Hard material, driven	14 feet
	Water at 32 feet rises	3-1/2'

Captain Aldrich's well is 56 feet. John Akert's well is 32 feet. R. S. Shopla's well is 51 feet. Ed Preston, 40 rods south, has a well also 51 feet. Alexander McSauba, in northeast part Section 23, has well 14 feet through clay. Many boulders near his house. A well on Moore's land in northeast corner of Section 23 was over 100 feet to rock. Well in southeast part Section 14, on H. W. Kane's land is 22 feet to rock. Well is in gravel 45 - 50 feet above Lake Michigan. Chris Trimble, north part Section 28, T.33N., R.8W., has well 130 feet. There was some sand under the surface till. Water rises 15 - 20 feet. Aneroid 28.700 = 850 feet. Aneroid 28.825 at Phelps.

Closely aggregated drumlin ridges west of railroad near line Sections 2 and 3, 10 and 11. W. A. Boss well, 111 feet. Altitude 770. Well probably in east part Section 10, T.32N., R.8W. Mr. Stephens, 3/4 mile east, has well 190

feet in Section 11, T.32N., R.8W. Drift hummocks in ravine north of Ellsworth. Aneroid 28.920 at Ellsworth. Hill near center of Section 24, 850 feet. Aneroid 28.630. Top of gravel ridge at Ellsworth 650 feet. Base of west bluff at Ellsworth, 660; 860 on ridge east of lakes, Section 8, Bates; 730 at swamp between lakes, Section 8, Bates.

September 9, 1902.

Aneroid 28.880 at level of Lake Michigan. A. Edwards' well, south part Section 13, T.34N., R.8W., is 137 feet. Water is 15 feet below surface. Mr. Hartwell drilled it. Aneroid 28.570 at noon at F. Sneatham's in southeast part Section 27, T.34N., R.7W. His well is 248 feet; altitude = 850 feet. There is only 5 feet of water, but it is a strong well. It penetrated much till. Aneroid 28.515 = 915 feet on highest part northwest of Sneatham's.

September 10, 1902, 7:45 a.m.

Aneroid 29.140 at Pine Lake = 580 feet. Aneroid 29.040 at Algonquin beach in Section 12, Marion Township = 675 - 680 feet. Aneroid 29.050 on Algonquin beach at Ironton. Aneroid 29.160 at South Arm of Pine Lake. Aneroid 29.070 at center of Section 16 in what seems to have been a drumlin, but is now cut down to this level. The swampy sags on its east and west sides are still traceable. (See map for outline of size and shape). It is very thickly strewn with boulders.

There is an abrupt bluff, 60 - 75 feet high in southwest part of Section 15 and southeast corner of Section 16 where Lake Algonquin cut back into a hill. Under this bluff and for 80 rods northwest of it, boulders are very numerous. The trend of bluff is north-northeast - south-southwest. This bluff runs eastward just south of center of Section 15, bearing slightly south of east. It continues with this trend only to south part of Section 14 south of center. A valley there runs south just east of center of Section 23 and across northeast

part of Section 26. It is 80 - 120 rods wide and is below Lake Algonquin level on line of Sections 23 and 26. From center of  $SE\frac{1}{4}$  of Section 23, the east bluff of this valley bears northeast and passes just west and north of the school house about 80 rods west of center of Section 24. It continues northeast past a drumlin to a point 80 rods north-northwest of center of Section 24. It there swings around to the southeast and passes 30 - 40 rods east of center of Section 24 and strikes the line of Sections 24 and 19 about 60 rods from south end. The beach there is gravelly, but generally in Section 24 it is a cut bank. It curves northward around a low hummock in southwest part of Section 19, then runs a little east of south along east side of a prominent drumlin to a point 40 rods southwest of center of Section 30. It then swings east nearly to the shore of Pine Lake and passes around the east side of another drumlin that lies southeast of center of Section 30. Devonian shale with concretions 2 feet in diameter outcrops on south shore of Pine Lake, 1 mile northwest of Advance near center of Section 30. The concretions show a radiated structure, (see specimens). They are at a level 5 - 10 feet above the water. The shale extends up to a height of 30 feet, more or less. 610 feet - 580 feet. Shale concretions on Pine Lake.

Aneroid 29.160 at Pine Lake in Section 30 at 11:00 a.m. Aneroid 28.860 = 845 feet on high drumlin near north end of line of Sections 25 and 30. Aneroid 29.060 = 670 feet at outlet of lake at south side of Section 23. Aneroid 28.870 at George Johnson's farm, northwest part of Section 26 on a drumlin = 835 feet, more or less. The altitude is 15 - 20 feet higher 80 rods west at a drumlin that crosses near corner of Sections 22, 23, 26 and 27.

M. J. Slating's well, in Section 22, is 156 feet. Aneroid 28.830 = 870 ft.

1. Clay	14 feet
2. Sand, coarse	14 feet
3. Blue stony clay	42 feet
4. Sand (fine, silty)	80 feet
5. Water bearing gravel	6 feet

Water rose up 85 feet or to top of sand. Cost \$200. for well.

Aneroid 28.850 at Johnson's at 1:15 p.m., when it read 28.870 1-1/2 hours ago. Aneroid 28.970 in swamp north of center of Section 26. For outline of swamps that intersect this peninsula see township map. Aneroid 28.820 on hill in northwest part of Section 36 at 2:10 p.m. From here I go south 2 miles, then west a mile, and map border of Lake Algonquin back to Ironton.

September 11, 1902, 7:50 a.m.

Aneroid 29.160 at Pine Lake at Charlevoix. I take train to Ellsworth. Aneroid 29.070 on Algonquin beach. Aneroid 29.040 at outlet of East Twin Lake = 700 feet, more or less. Aneroid 29.010 at overhead bridge south part of Section 23 = 725 feet, more or less. Aneroid 29.010 = 725 feet, more or less, at Phelps. Aneroid 29.140 at Ellsworth = 621 feet A.T.

I drive east on north side of beach of Intermediate Lake along base of hills north of me into Section 18, South Arm Township. This section is swamp except in southwest, northeast and southeast corners which have drumlins. I go north between Sections 18 and 17 and find that Sections 18 and 17 have drumlins in the swamp that was covered by Lake Algonquin. These drumlins stood above the lake, for they are 50 - 75 feet, more or less, above the swamp and the swamp is about 35 or 40 feet above Lake Michigan. Sections 16 and 17, 19, 20, 21, 22, 28, 29, 30 and 33 have drumlins, but among the drumlins are knolls and short ridges of gravelly or sandy constitution and the south edge of South Arm has a decidedly morainic upland tract.

East of South Arm Lake in South Arm Township -- there are drumlins in Sections 1, 2, 10, 11 and 14 and a slight ridging in the west part of Sections 12 and 13 on the west edge of an elevated morainic tract that is gravelly and sandy drift. Drumlins run east on south side of Pine Lake about a mile east of Advance and appear in Sections 4, 5 and 6, Wilson Township, T.32N., R.6W. There is a swampy tract about 1/2 mile wide in Sections 5 and 6, 8 and 9, (see map). It trends northwest-southeast. There are elevated morainic hills north

of it, 850 feet, more or less, A.T. in Section 4 and farther east. South of it is still higher tract, a point in southwest part of Section 7, Wilson Township being 1,060 feet, and several on or near line of Sections 7 and 18 are 1,000 feet or more. This is sharply morainic with hills 100 feet higher than sags among them, and is very hummocky. It seems to extend only to southwest part of Section 9 and northwest part of Section 16, and does not cover the east part of Section 17. There is a low tract east of it, a mile or more wide, beyond which I can see elevated land.

All of Section 18, the west half of Section 17, the west side of Section 20, Section 19, part of Sections 30 and 29 are morainic and very rough. See county and township maps. I saw the south edge of this tract in latter part of July, so only drive today into Section 17. I crossed it on line of Sections 8 and 17, 7 and 18, T.32N., R.6W., and Section 13, T.32N., R.7W. Some hills, as shown in the township map, trend northwest-southeast like the drumlins, but they do not have till in such great proportions as the drumlins, but are, instead, very largely sandy and gravelly drift.

On my return I go west from South Arm on line of Sections 22, 27, 21 and 28, 20 and 29, 19 and 30. The highest altitude reached is about 875 feet on drumlins in south side of Section 21. Much of Section 21 is nearly that high. The altitude is nearly as great south from there in Sections 28 and 33, as noted in July.

I take train to Bellaire in the evening.

September 12, 1902, 8:00 a.m.

Aneroid 29.440 at Bellaire, 614 feet. I drive west to Grass Lake along south edge of a prominent range of knobs. The slope is smooth up to about 650 feet on line of Sections 24 and 25, but on line of Sections 22 and 20, the hummocky topography comes down to 630 feet. This altitude probably represents

about the level of Lake Algonquin. There is considerable clay on the slope below this level on the line traversed by the wagon road. Aneroid 29.490 at Grass Lake. This is at base, 590, and perhaps 595 feet.

There is an upland with rather smooth slopes west of Grass Lake except a group of knobs in Sections 1, 2, 11 and 12. The smooth upland part has ridges with a trend northwest-southeast that approach the drumlin in form, though not quite so regular. The altitude in Sections 34 and 35 is about 700 - 725, and this is about the general altitude northwest from there between Torch and Grass Lakes. It is much lower than this strong moraine north of Grass Lake which reaches 850 - 875 feet or more. The group of hills in Sections 1, 2, 11 and 12, T.29N., R.8W., probably reach 800 feet A.T. Small boulders are numerous on the smooth slopes and there are occasional very large granites. The boulder tract bordering Clam Lake is very narrow. A rise of 100 feet or more is made within 2/2 mile north or south. The uplands south of this lake have about as smooth slopes as those north, at least in Sections 9, 10, 14 and 15, and they stand 700 - 750 feet A.T.

North of Clam Lake outlet there is a gravel tract formed by Torch Lake at a level about 12 feet above present level. There is another beach or cut bank about 30 feet higher. South of mouth of Clam Lake there is beach between Thayer Lake and Torch Lake at about 630 feet A.T. It is a gravelly and cobbly ridge. The moraine or upland sets in immediately east of Thayer Lake. There is a gap 1/4 - 1/2 mile wide south of this upland through which the Pere Marquette Railroad passes.

Aneroid 29.470 at Alden Station, 12 feet above Torch Lake at 1:20 p.m. This is at level of base of a cut bank east of the station. Back of this, 20 - 30 rods, is the Algonquin beach which stands 28 feet above the station at 631 feet A.T. It is gravelly to within 1-1/2 feet of top, but the top is sandy. It is a well define beach ridge with a depression several feet deep back of it. About

1/2 mile south of Alden Station the Algonquin beach crosses the mouth of a ravine and has a depression 3 - 10 feet lower back of it. High hills set in 1-1½ miles east of southeast of Alden, but for that distance back, the altitude scarcely exceeds 700 feet A.T. North of Alden for 2 miles I found a hummocky border of upland that is very gravelly and sandy. This only rises 75 - 100 feet above the Algonquin beach, or to 700 - 725 feet A.T.

Aneroid 29.485 at south end of Torch Lake at 11:30 a.m. = 591 feet. The Algonquin beach is a ridge of coarse gravel where the east-west road crosses in southwest part of Section 6. Aneroid 29.300 = 750 feet, more or less, on upland near corners Sections 1, 2, 3, 5 and 36 at Loring Hoopfirs. The well is 100 feet deep here. This is northeast of Section 2. P. Haller in northwest corner Section 1 has well 105 feet. At school house in Section 36 (northwest part), a well is only 61 feet, and at Mr. R. Fox's, a short distance north, a well is 65 feet. There is considerable hard stony clay called hardpan. Aneroid 29.320 at Mr. Fox's. Aneroid 29.300 at corners Sections 25, 26, 31 and 36 on a swell. Aneroid 29.340 at Frank Hisby's in southeast part Section 26, at 12:25 p.m. The well here is 70 feet. It only has 4 feet of water.

There are smooth slopes on the ridge between Torch and Elk Lakes from its south end in Section 12, T.28N., R.-W northward. The highest parts of this ridge show a slight minor ridging in northwest-southeast direction that suggests the drumlin in form. The ridges are 20 feet, more or less, high, 1/3 mile or less wide, and 1/4 - 1/2 mile long. The drift here is not so clayey as in the drumlin region, but has so much sand in the till that the roads are sandy. Boulders are not so numerous as in the district traversed this morning from Bellaire to Alden.

Aneroid 29.345 at Mr. Hisby's at 1:15 p.m. There are knolls of sandy drift in north part of Section 26 bordering Elk Lake. The road is on the Algonquin beach much of the way in Sections 24 and 13. It is back about 1/4 mile from the

lake. In Sections 13 and 12 there is a low tract back of the gravel ridge for 1/4 to 1/2 mile in places that was probably covered to a shallow depth by the lake. The upland back of it is low, only 30 - 50 feet above Lake Algonquin level, or 660 - 680 feet A.T. There is an extensive tract of gravel of Algonquin level at north end of Elk Lake east of Birch Lake -- a square mile or more. The road leading northeast is fully a mile on this gravel. I rise to the upland in northeast part of Section 2. The slopes are smooth, and there is a slight tendency to ridging in north-northwest - south-southeast course. I reach the crest of one of these slight ridges at Mr. Hollenbeck's in southwest part of Section 36, T.30N.

Aneroid 29.240 = 800 feet, more or less. On the slopes of a ravine crossing north part of line of Sections 35 and 36, there is a clay without pebbles -- bluish and greenish in places, but generally yellow. This is capped by a few feet of bouldery drift. I noticed several cuts in roads along east side of Elk Lake in which a fine sand, nearly free from pebbles and with bedding contorted and disturbed, underlies a few feet of bouldery surface drift. Lake Algonquin extended up the ravine in northeast part of Section 35 to within 100 - 120 rods of east line of Section, but north and south from the ravine it is 1/2 mile or more west of Section line. The east half of Section 24 and northeast part of Section 25 have high land, 250 feet, more or less, above Lake Michigan. The surface, as viewed from the road, on line of Sections 25 and 20, seems more uneven and slopes less smooth than the tract I am on. However, it is not sharply morainic like the tract northwest of Bellaire.

Aneroid 29.300 at school house on general level of upland in northwest part of Section 25. There is a lake east of here 40 - 50 feet lower. Aneroid 29.360 at lake outlet. The outlet is bordered closely by drift knolls that stand above level of Lake Algonquin. The Lake Algonquin border sets in 1/2-3/4 mile west of this small lake, and there is said to be a considerable amount

of sand and gravel between there and the lake, but it is not much duned up yet.

Aneroid 29.300 on upland at corner Sections 13, 14, 23 and 24. It is more undulating east than west of this road as far north as corner of Sections 11, 12, 13 and 14, but for a mile north from this corner, the road is on the crest. Aneroid 29.270 at corner Sections 11, 12, 13 and 14. The surface here is very slightly wavy -- swells 10 feet or less. The soil is a little more sandy than in flatter tracts to the south.

Aneroid 29.290 at hill on line of Sections 1 and 2. Aneroid 29.350 at lowland tract north of hill. This opens out to the northwest into the Lake Algonquin plain with a gently undulating slope. There is a ridge of the heavier drumlin type in east part of Section 2, trending about 5° east of south. This seems sandy at surface, but may have a till nucleus. In west part of Section 31, T.31N., R.8W., there is a typical clay drumlin of linear type, lying just east of the road. It is 15 - 20 feet high and 30 - 40 rods wide and nearly 1/2 mile long. East of it 80 - 100 rods, is a less regular ridge running entirely across Section 31. It is 20 - 30 feet high in north half of Section where it is most regular. This ridge contains some sand and gravel and clayey sand. There is a small drumlin running south about 80 rods from the north line of Section 36, T.31N., R.9W., about 40 rods west of township line. It is 15 - 20 feet high and about 20 rods wide. The south end of line of Sections 25 and 30 is on a similar drumlin for about 80 rods. There is one east of the road in Section 30, and two west in Section 25. The latter are oval or but slightly elliptical. These drumlins contain much more sand than those east of Torch Lake.

Aneroid 29.370 at level of Lake Algonquin about 100 rods from south end of line of Sections 25 and 30. The lake cut the end of a drumlin east of this road and there is a very bouldery tract for about 40 rods north into the lake



plain. There is a descent of 25 feet within 1/2 mile north to where a narrow gravel tract sets in that the road follows northward, winding a little to a belt of dunes that set in a mile south of Torch Lake. There is a couldery, cobbly low ridge, running nearly into Torch Lake Village from the south.

Aneroid 29.415 at Torch Lake Post Office, about 25 feet above Torch Lake. There is a nearly continuous strip of dunes from here to Eastport. It is on the crest of the narrow strip that separates Torch Lake from Grand Traverse Bay. This is gravelly and cobbly, with some boulders. Its height seems to be 20 - 25 feet above Torch Lake. The dunes rise 10 - 20 feet and occasionally, 30 or 40 feet above this level.

Aneroid 29.420 on gravelly beach at north end of Torch Lake at Eastport = 605 feet, more or less. Aneroid 29.335 at possible shore of Lake Chicago, (687 feet) 106 feet above Torch Lake. See notes late in July. Aneroid 29.270, 750 feet at M. E. Byer's house in southwest part Section 5.

September 13, 1902, 5:40 a.m.

Aneroid 29.230 at M. E. Byer's. Same at 6:40 a.m. = 750 feet (Barometer). Aneroid 29.130 at school house on drumlin in south part of Section 5 east (west?) of middle. I go south on line of Sections 8 and 9, 16 and 17, between drumlin ridges that trend a little east of south. There are sharp esker-like ridges with hummocky crests in Sections 17 and 20 on east side of Torch Lake and at a level 100 feet, more or less, above the lake.

Aneroid 29.030 on crest of a drumlin near west end of line of Sections 16 and 21. There is another drumlin just east of it that is 20 - 30 feet higher than this, about 1/4 mile north of the road between Sections 16 and 21. Aneroid 29.020 on drumlin west of middle of line of Sections 16 and 21. It is 15 - 20 feet higher 40 rods north. This runs 1/2 mile south into Section 21. There seems to be a drumlin in woods in southwest part of Section 15.

Aneroid 29.220 at shale (top) on line of Sections 15 and 22. Aneroid 29.275 at level of Lake Algonquin. There is a gravelly beach where the ravine opens into Intermediate Lake valley near corner Sections 14, 15, 22 and 23. There are hummocks on west side of Intermediate valley from Central Lake south. On east side, there is a slight ridging on uplands 1/2 mile or so back, that approximates the drumlin form. I saw no well-defined drumlins, however, on this high upland farther east in this county, but they set in in south part of South Arm Township, Charlevoix County.

Aneroid 29.355 at Central Lake Station, 631 feet A.T., at 8:15 a.m. Looking up the valley from Central Lake Station, I can see a drumlin in south-east part of Section 15 and another about a mile north at the west bluff of Intermediate valley. I take road to Bellaire west side of Intermediate Valley. For a couple of miles the Algonquin shore is 1/4 mile or more west of this road, but from there to Bellaire, the road is near the shore. For almost a mile, 1 - 2 miles north of Bellaire, the Algonquin shore is marked by a definite sandy beach, standing several feet above a sag back of it, but usually there is simply a smoother surface up to the level at which the lake stood then above that level. There is a hummocky, morainic topography west of Intermediate Valley all the way from Central Lake to Bellaire. (See notes in July for uplands.)

Aneroid 29.400 at Bellaire at 9:45 a.m. Roswell Leavitt, of Bellaire, tells me that a nugget of copper weighing about 75 pounds was found on a farm north of Eastport. Chas. W. Ball of Bellaire now has it. It was found about 15 years ago. There was a copper knife found in Jordan Township in Section 26. It was 9 inches long and an inch or more wide at base. A copper arrow or spear was found on the hill west of cemetery a mile west of Bellaire, in south-east part of Section 23. Stephen Eldridge, of Bellaire, states that a copper nugget was found about 30 years ago in Martin Township, Allegan County, that weighed 120 pounds.

Aneroid 29.410 on summit in Section 9, T.29N., R.8W., about level of

Algonquin beach. Aneroid 29.350 at Williamsburg. Aneroid 29.445 at Alden Station = 603 feet. Aneroid 29.440 at Barker Creek. This is near the level of the Algonquin beach. Aneroid 29.450 at Angell. Swamp on west side of railroad for 2 - 3 miles south of Angel, and a ridge on east. It is very hummocky to within 1-1/2 miles of Angel, but farther north has rather smooth slopes. Aneroid 29.480 at Elk Rapids. Elk River has 9 foot fall over dam at Elk Rapids to level of Lake Michigan. The station is 594 feet, and there is a bank back of it (west) about 5 - 6 feet higher. Aneroid 29.440 630 feet at shore line north of Elk Rapids cemetery. Aneroid 29.420, 648' on sandy ridge at cemetery.

Aneroid 29.395, 670 feet on till ridge in northwest part of Section 27 on L. R. Smith's farm. This is a stiff clay, very smooth surfaced, and trends a little west of south. The well at Smith's is 112 feet deep. It entered blue clay at 12 feet which extended about to water at bottom. Aneroid 29.420 at foot of a till ridge in north part Section 33 probably on lake margin. Aneroid 29.380 on top of ridge. This soon crosses to west side of road and runs south a little beyond county line between wagon road and railroad. The one on which Mr. Smith's house stands runs south on west side of railroad beyond the county line to Tobosco Lake road. Each ridge is 1/4 mile or less in width and very smooth like drumlins. I go west on county line and cross to a sandy ridge just west of the Elk Rapids and Traverse City wagon road. There is a steep bank 25 feet high here on its west side. The ridge stands 8 - 10 feet above a plain back of it. Perhaps it was formed by wind. There are low undulations along this Elk Rapids road northeast from here for about 2 miles, or about to center of Section 28. I follow road towards Traverse City from county line, soon coming to the deepened outlet of Tobosco Lake. It was cut originally through the Algonquin beach and a little blue till to a depth of 17 feet. It has now been cut ar/tificially about 10 feet deeper through blue till.

Aneroid 29.430 on Algonquin beach at outlet of Tobosco Lake. The beach forms the west side of the lake from near north end. There is a sag at the north end as well as at the outlet to Tobosco pond (where cut has been made). West from the Algonquin beach the cut is in sandy gravel. There is an oval hill in west half of Section 7, about 60 - 70 feet high, covering 100 acres or more. It is longest north-south. A ridge in east part of Section 18 trends north-south and is drumlinoidal in form. It is 1/4 mile or more wide and about 3/4 mile long. I come to another large oval hill 1/4 mile southwest of Yuba and there is high land for two miles southwest from there along the border of Traverse Bay. There are smooth slopes and large swells covering 40 acres or more each. that rise 20 feet, more or less, above general level. Aneroid 29.340 on hill in Section 23. Same at line of Sections 26 and 35. There are very smooth slopes and a tendency to ridging north-south, but not definite drumlins. Somewhat oval or slightly elliptical forms occur. Aneroid 29.240 on ridge on line of Sections 30 and 31 near west end. This is high for 1-1/2 miles north of here. Aneroid 29.340 where road bends east in Section 21. Ridge east 60 - 80 rods is 25 feet higher and has drumlin shape. Another west of road in Section 21 is 15 - 20 feet high and drumlin shaped. South from here there is a more hummocky surface than north. The drift is largely till.

Aneroid 29.470 at Angel at 4:30 p.m. This is only a few feet above Tobosco Lake and probably below Lake Algonquin level, though there is not a definite cut back along the face of the high land east of the station. There is a lowland tract about a mile wide running south from Tobosco Lake nearly to the township line. It there changes to gentle undulations near Williamsburg. There is a similar valley from a mile west of Bob's northward to Yuba, fully a mile in width. The drumlin forms seem to be well defined for about 1/2 mile north of Angel northward to Elk Rapids, but south from here they are rather poorly defined and but few places where there is any north-south ridging. What little ridging there is for

two miles south of Angel is north-south. I take train to Williamsburg from Angel at 4:35 p.m. There is a rise of 10 feet or more per mile in this swamp on west side of the railroad. Aneroid 29.340 at Williamsburg at 5:00 p.m.

I take train to Traverse City. (See notes in July.)

September 14, 1902, 9:00 a.m.

Aneroid 29.485 at Park Place Hotel in Traverse City = 593 feet, more or less, A.T. Aneroid 29.445 at base of bluff below sand plain on east side of Boardman River. Aneroid 29.370 at top of sand plain = 690 - 700 feet. This is opposite Mile Post 3 from Traverse City on G. R. and I. R. R. The material exposed on the slope is a slightly pebbly sand. About 1/2 mile farther south, boulders and cobble stones are exposed where road cuts into slope. About opposite Mile Post 4, this plain breaks up into an irregular surface, and within 1/2 mile south, strong morainic features appear on east side of the valley. There is, south from here, only the terrace that the G. R. and I. R. R. runs on and morainic knolls come down to the level of this terrace and there are recesses in the moraine with but little higher altitude than the terrace.

Aneroid 29.420 on the terrace at Mile Post 5. Boulders become very numerous on this river terrace about 5-1/2 miles from Traverse City near middle of Section 34, T.27N., R.11W., and there is a more clayey soil than to the north. There is a rapid rise from here up to Keystone on this terrace.

Aneroid 29.360, 699 feet at Keystone Station. This is on slope 10 - 12 feet above the terrace, but there is, just south of here, a terrace as high as the station, and the terrace across the river at Britner's is fully as high. Aneroid 29.400 at Boardman River, 1/2 mile southwest of Keystone. Aneroid 29.340 on terrace west of river near Britner's. There are boulders on this terrace and a stiff clay outcrops at about 10 feet below the top. The boulders are in a gravelly and sandy material. Aneroid 29.180 at top of till in bluff south of Britner's. Aneroid 29.140 = 890 feet, on general level of sand plain 1/2 mile south of Britner's.

There is a narrow strip of this plain on north side of Boardman River, directly east of Keystone. The outer ridge of the Grand Traverse moraine is entered by Boardman River within 1/2 mile north of Britner's, and there are very sharp knobs for 2 miles north from there. Directly west from Britner's, on upland north of the Pere Marquette Railroad, there are a few low swells on the sand plain about like those noted in July. I go east to Mr. Bonnell's at center of Section 14, across a smooth sand plain.

Aneroid 29.130 = 900 feet at Bonnell's. There is a channel in the sand plain south of here 1/4 mile, about 45 feet deep (Aneroid 29.180) and 40 rods in width. It runs parallel with Boardman River from east-southeast - west-northwest. It opens out to the river valley in southeast part of Section 14 and seems to descend to the west and crosses into Boardman valley at Britner's. I follow the sand plain east to Mayfield Station. This is in valley about 60 - 70 feet below the level of sand plain. Aneroid 29.185 at Mayfield (834 feet?). On this trip east I noted that the plain extends about 1-1/2 miles south, its south border being in Sections 35, 36, 31 and 32.

Aneroid 29.090 on plain south of Mayfield 1/2 - 3/4 mile. The moraine sets in 1/2 mile farther south. Aneroid 28.990 at Kingsley = 994 feet A.T. The moraine east of here is perhaps 50 feet higher. There is a valley nearly a mile wide extending up to Kingsley from the north.

Mr. Arthur Durga, of Neal, made a well for Henry Sichliber near center of Section 6, T.27N., R.11W., 293 feet. Altitude of well about 1,025 feet. It was clay for 4 or 5 feet and the rest was sand. Water rises 12 - 15 feet. R. Wiedoft, on west side of Section 6, has a well about 220 feet. It is perhaps 75 feet lower there than at Sichlibers. L. Ruthardt, in northwest part of Section 5, at an altitude scarcely 900 feet A.T., has a well 230 feet. It penetrated a good deal of blue clay. Water rises only 20 feet in it. A well for Frank Clark, in east part Section 3, T.25N., R.10W., is 160 feet and water rises within 8 feet of top. John Wiley, about 4 miles south of summit, one mile south of Grand Traverse and Wexford

county line, has a well 190 feet that water rises about 100 feet. It has 25 feet of sand at top, then 75 feet of blue clay, then fine sand - 6 feet, then blue clay to near bottom. Water was found in coarse sand.

Aneroid 28.960 at Kingsley at 2:30 p.m., 994 feet A.T. There is a gently undulating high tract 1,050 - 1,075 feet A.T., for 1 - 2 miles southeast of Kingsley. For two miles west of Kingsley, I find a very sandy drift with but few boulders. Till becomes conspicuous and rather clayey after I pass a stream at middle of Sections 1 and 12, but there are few boulders with it. The topography is a strongly morainic knob and basin type, with variations of 100 feet in level in the sandy part. The clayey part has rather sharp knolls, but not basins. Aneroid 28.825 at summit near east end of line of Sections 2 and 11 = 1,100 feet at Mr. B. A. Stines. His well is 65 feet. It is sand 12 - 14 feet then clay 3 - 4 feet, then sand and gravel to water.

At Joseph Miller's, in northeast corner Section 3, there is a well 170 feet. Water rises only 15 feet. Aneroid 28.840 = 1,075 feet. There is a nearly plane tract in Sections 3 and 10 on which there are a few boulders. The soil is a sandy loam. The line of Sections 4 and 9 crosses a swamp just of Hannah Post Office. Aneroid 28.870 at swamp. It runs north-south for 1.2 mile or more into Section 9, and spreads out in Section 4 towards the west side. There is a gently undulating tract west of here, with swells 10 - 20 feet high.

Aneroid 28.840 at corner of Sections 4, 5, 8 and 9. There is as high an altitude for a mile or more south from here. This seems to be a till tract. I go south between Sections 5 and 4, coming to a more sharply ridged tract near the township line, that stands higher than the gently undulating tract south of it. Aneroid 28.800 at summit on road on line of Sections 32 and 33, Blair Township, = 1,000 feet, more or less. There are points 20 feet higher in fields nearby.

Aneroid 29.010 in plain north of moraine, near north end of line of Sections 28 and 29 = 900 feet, more or less. The south half of Sections 28 and 29 is nearly

all on the moraine, but it extends only a little into the northwest quarter of Section 29 and none into the northeast quarter. The south half of Section 27 and southwest part of Section 26 are upon it. Section 30 is morainic, except on the north border. From there, the north edge of the moraine bears southwest and from Section 27 it bears east of south, so Sections 27, 28, 29 and 30 are at the north side of a spur. There is a tamarack swamp north of this moraine in Sections 21, 22, 26, 27, 28 and 29, 1/2 - 3/4 mile wide. It stands at the level of this plain north of it, but probably has clay at less depth. Its wetness may be partly because of receiving the water from the moraine south of it. Aneroid 29.020 in swamp = 890 feet, more or less. Betsey River drains this swamp and has its head in it. This plain is lower two miles north than at the swamp.

Aneroid 29.050. There are, in Sections 8 and 9, a few low swells with channels around them, and in these channels are boulders. Aneroid 29.120 in ravine at Pere Marquette Railroad on line of Sections 8 and 9. There is till on the north side of this moraine up to within 20 - 25 feet of top. Aneroid 29.060 at top of till.

Aneroid 29.035 at top of bluff. There is cobbly drift here and low swells of cobbly material sets in 40 - 80 rods north, and the aneroid reads 29.020 on these just south of corner of Sections 4, 5, 8 and 9, Blair Township. This is the wavy tract west of Britner's, noted this morning from plain southeast of here. There is a richer soil in Sections 4, 5, 8 and 9 than farther south on this plain, there being a sandy soil to the south. There seems to be earthy material with the cobble in soil in the four sections named. In Sections 4 and 5, there are numerous deep basins, 20 - 40 feet or more, but among the basins, the high land is plane and rises to about the strong moraine north of it.

Aneroid 28.990 in pitted plain at township line, corner of Sections 4 and 5, 32 and 33. The moraine crosses to the southwest corner of Section 33 and touches the north edge of Section 4, but Section 5 and southwest part of Section 32 are in

the pitted plain. Only one-quarter of Section 32, in northeast part, is morainic. Mr. Harry Perry's, in southwest part of Section 32, is 180 feet and largely in gravel. Aneroid 28.990 at well = 925 feet, more or less. Till sets in about the middle of line of Sections 32 and 33, and the moraine is strong from here north.

Aneroid 28.940 = 960 feet on highest point on road on line of Sections 28 and 29, Garfield Township, a short distance south of center. From here, there is a rapid descent to a valley in south part of Section 21. Aneroid 29.175. There is till on the slopes here, but it does not extend far east, for on turning east at a school house near center of Section 21, I enter sandy gravel. There is a low ridge of this sandy gravel running north across east part of NE $\frac{1}{4}$  of Section 21. It stands 10 - 15 feet above the high sand plain noted this morning. Aneroid 29.170 on this sand plain at line of Sections 21 and 22, where road turns north = 725 feet, more or less. North from here, about  $\frac{3}{4}$  of a mile (on line of Sections 15 and 16), basins appear on this sand plain and continue north for a mile to the north end of the high plain. There are a few boulders and some cobblestones on these slopes. This seems to be an outwash apron from a terrace of ice that reached only to south side of Traverse City and laid almost within the limits of the lowland bordering the south end of West Arm of Grand Traverse Bay.

Aneroid 29.200 near the north end of the high sand plain = 700 feet, more or less at corner of Sections 9, 10, 15 and 16. The plain extends about  $\frac{1}{4}$  mile into Sections 9 and 10, but the road descends from it to the level plain through a ravine in Section 10. Aneroid 29.290 at south edge of low sand plain in Section 10, = 620 feet. Aneroid 29.805 at south bluff of Boardman River. Aneroid 29.320 at Park Place Hotel, 592 feet A.T., at 6:20 p.m.

September 15, 1902, 9:30 a.m. - Traverse City

Aneroid 29.385 at level of Traverse Bay. Aneroid 29.375 at M. and N. E. Station = 590 feet, more or less. I take train to Honor.

Aneroid 29.320 = 640 feet at Hatch's Crossing. The sag may be a few feet

lower south of this Station, but not less than 630 feet A.T. Aneroid 29.370 at Fouche = 600 feet, more or less.

Aneroid 29.350 = 625 feet, more or less at Sohn. Railroad gives 640 feet. Very little change for a mile southwest, then rise begins up a swampy narrow valley.

Aneroid 29.220 at Cedar Run = 730 feet A.T. (760 Railroad). Till is cut into 1 mile north of Lake Ann under gravel at 8 - 10 feet. The altitude in cut 15 feet deep is about 15 feet above Lake Ann Station. There is gravel 30 - 40 feet higher, east of Lake Ann.

Aneroid 29.150 at Lake Ann. (Around 790 feet.) Railroad 820. Aneroid 29.180 at a lake south of Lake Ann.

Aneroid 29.140 at Platte River Junction at 10:50 a.m. = 800 feet, more or less, A.T. I take train to Honor.

Aneroid 29.230 at Allen Station. There is an upland plain here, 75 feet, more or less, above station. The swamp is 1/4 mile, more or less, wide.

Aneroid 29.270 at John Ward's Camp = 700 feet, more or less, A.T. Aneroid 29.330 at State Road = 650 feet, more or less. This is in Section 15, Homestead Township. Aneroid 29.370 at Honor at 11:45 a.m.