

Open File Report LIV  
FIELD NOTES OF FRANK LEVERETT

Notebook No. 278 - Leverett

COUNTY

- Antrim
- Arenac
- Bay
- Benzie
- Calhoun
- Charlevoix
- Charlevoix Co. – The Beaver Islands
- Emmet
- Gladwin
- Grand Traverse
- Iosco
- Jackson
- Lake
- Manistee
- Midland
- Otsego

Frank Leverett Notebook No. 278

Read in June 1932 and marginal notes made.

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Studies near Rhodes, Michigan.

Aug. 8, 1922, Rhodes, Gladwin County, Michigan. I go north on line of secs. 35 & 36, 25 & 26, T 18, R 2 E to the road that runs west passing through sand all the way from within 40 rods of the line of twps. 17 & 18. The only clay land in T 18, R 2 E so far as I can learn is a strip along Tittabawassee River in secs. 6, 7 & 8 and narrow strips along tributaries of the river and swampy swales here & there in the twp. I went west across the twp. from corner of secs. 23, 24, 25, & 26, passing a farm in ne part of sec. 27 and others in secs. 19 & 20. There are a few clay spots on these farms in secs. 19 & 20 but there is generally a sandy coating as deep as post holes.

I crossed the Tittabawassee River at Highwood. There is a narrow clay strip east of the river. I went west over ground traversed yesterday to corner secs. 27, 28, 33, & 34, T 18, R 1 E. I then went south 3 mi. and find clay subsoil in west part of sec. 34 and heavy clay soil in west part of sec. 3 and east part of sec. 4, Billings Twp. This area and a small area in NE of sec. 10 and another in SW of sec. 10 are all I find in the northern two tiers of secs. and in north part of secs. 14, 15, & 16. There is clay covering sandy ridges in the south part of these secs. There is heavy clay in nearly all of the secs. farther south on west side of the river as noted yesterday. I crossed to east side of Tittabawassee River on line of secs. 14 & 23 passing over some clay strips east of the river. I then went south between secs. 23 & 24 through sandy land. In sec. 25 there are clay spots of a few acres each and considerable land with clay at 2 – 4 ft. There are good farms here though the owner says there is not much first class land here.

Studies near Edenville

In Hope Twp., Midland Co. (T 16 R 1 E) there is sandy land in secs. 1 & 12, and bordering parts of secs. 2 & 11 & 13 with very few clay spots. The Port Huron morainic belt shows a few definite knolls of clayey till, in secs. 2, 3, 10, 11, 14 & 23, Hope Twp. and a gently undulating surface westward to the bluff of Tittabawassee River the whole length of the Twp. N-S. Boulders are not rare on this tract and cobblestones also.

In some cases, where the road had been cut through a clay knoll, it shows the knoll to be partly clay and partly sand. In some cases the clay is standing on edge with sand rounding out the knoll thus:



Diagram to show knoll partly of sand and partly clay in Hope Twp., Midland Co., Mich.

This seems to indicate a disturbance by the moving ice sheet. In some cases a lens of red clay is imbedded in sandy material. Such an exposure is found north of Edenville on west side of Tittabawassee River.

There are places where the red clayey till runs to a higher plain than border tracts. Such a place is found about 2 miles north of Edenville. We drove east into Mills Twp. (T 16 R 2 E) along center line road to corner of secs. 14, 15, 22 & 23 through a district with thin and patchy sand coating over till. There is less sand cover along line of secs. 15 & 22 than farther south.

We went north to corner of secs. 2, 3, 10 & 11, then west on line of secs. 3 & 10. We find clay land with sandy spots in all these sections. In sec. 9 there is very little sand. I am told secs. 4 & 17 are sandy where not swamp and there is swamp in much of secs. 4, 5, 6, 7, 8, west of the angling road in secs. 4, 8, 17. This road is partly through swamp and is not used by autos and difficult for teams to travel. The swamps are thought to have spots of clay, but are mainly with sand on their borders, in these sections.

#### Gravel on Lake Warren Shore

We went north on line secs. 3 & 4, Mills Twp., passing through a strip of sand into a till tract. There is considerable clay land in west half of sec. 34 and in most of sec. 33, T 17, R 2 E. The clay is at surface in places as far west as the east half of sec. 31. This land is in the Kawkawlin drainage, the divide being in west part of sec. 31 and in sec. 30. A considerable part of sec. 29 has clay land (till with scattered boulders) and so has SE part of sec. 20. In sec. 28 there is sandy land in north side but the rest is largely clay land. In sec. 21 there is very little clay land. In secs. 22 and 23 clay spots are numerous and also in sec. 27. I went to the gravel pit in the ridge in SE part of sec. 14. The gravel is very sandy probably less than 40 per cent above 1/8 inch.

There is a gravel ridge in south part of sec. 11 and that had a pit in it but it is not now in use. These are both old shore lines of Lake Warren.

Warren Beach – Notes Aug. 9, 1922. (extra page clipped in)

East of Rhodes on line secs. 1 & 12 sand & clay in strips. Sandy ridge in sec. 6, Mt. Forest Twp., Bay Co., bears ENE across S½ of sec. Moraine west of Bently has till at surface of many knolls. Warren shore east of Bently in west part of sec. 21 and northward into sec. 16, Gibson Twp. and catches 740 contour.

The beach crosses the railway 1¼ miles S. of Bently but map makes it only 720' – probably an error, for it is to be only 710' at line of Gibson & Mt. Forest Twps. The ridge in secs. 6 & 7, Mt. Forest is 735' as highest contour. Beach not as well defined in secs. 4 & 9, Gibson, as in secs. 16 & 21, but seems to be in east part of sec. 4 and runs toward center of sec. 9. The beach runs to SW corner of sec. 21.

Warren shore runs across line of secs. 25 & 26, T 19 R 3 E about 100 rods from south end. Another ridge runs WSW from south bank of a stream in east part of SE¼ sec. 25 across NW part sec. 36 into sec. 35. A gravel pit in it at line of secs. 25 & 36. Warren beach runs into Sterling and is 745 there. Warren beach crosses MCRR 1/2 mile east of the Gladwin-Bay Co. line in sec. 7, Mt. Forest and 60 rods east of where the railroad crosses line of secs. 6 & 7, Mt. Forest, at 725' by Coopers contours. Warren shore – crosses road south of Rhodes near north side of sec. 13 and crosses line of secs. 12 & 13 about 80 rods from east end. It is opened for gravel in SW part of sec. 12 and also NE of Estey in sec. 14. There are till knolls and surface boulders in sec. 10, T 17 R 2 E. Near Sterling the Warren beach passes about 20 rods north of center of sec. 30 and leaves the sec. 30 – 40 rods south of NE corner. It cuts NW corner of Sec. 29 and crosses M.C.R.R. 40 rods SE of depot. Its altitude is 2 – 3' above depot or 745' – 6'. In northern Arenac Co. Warren beach being along a rugged moraine is not a well defined mature shore.

August 9, 1922, Rhodes, Mich.

I go east on line secs. 1 & 12, T 17 R 2 E to county line on a tract with strips of sand alternating with clay land. In sec. 6, Mt. Forest Twp., Bay Co., there is a sandy ridge running ENE across its south half. South of this clay is at or near the surface in SE¼ sec. 6. In sec. 7 there is clay land in NW corner but most of the sec. has sand cover several feet thick. In secs. 5 and NE¼ sec. 8, there is mainly clay land with only narrow strips of deep sand. There is a light coating 1 – 2' thick in much of this area.

Both east and west of Mt. Forest Station in south part of sec. 9 the land is sandy to depth of 3' or more and the north part of sec. 16 is also sandy. We go east on line of secs. 10 & 15, 11 & 14, 12 & 13, Mt. Forest Twp. through clay with very few sandy spots. There is more sand 1/2 mile north of this line in secs. 10 & 11 but the entire secs. have much fair farm land with only spots of sand. A sandy strip runs NE across NW part of sec. 12 and SE of sec. 1 into NW part of sec. 6, Pinconning.

Southeast of it is a strip of clay land fully a mile wide with very little sand. A strip of sand runs from NW part of sec. 18 across SE of sec. 7 and NW of sec. 8 Pinconning, and across south part of secs. 5 & 4. It is only 1/4 – 1/2 mile wide and in places thin. SE of this is a wide clay area extending nearly to Pinconning, an area which Mr. Cooper left uncolored on his Pleistocene map of Bay Co. The SE part of Gibson Twp., Bay Co., T 18,

R 3 E is good farm land with only occasional sandy spots or strips. There are places where the boulders are conspicuous. There are also till ridges. There is a conspicuous one in west part of sec. 32 that cause the NE protrusion of 715' contour. This seems to be continued in fainter form across the north part of sec. 6, Mt. Forest Twp.

#### Studies near Rhodes

There is a faint till ridge running ENE from NE part of sec. 9, Mt. Forest into middle of N. side sec. 10 that causes some protrusion of contours to the NE along south side of a small stream. It is a little higher than till tracts NW of it 5 – 10' and it is this ridge that causes the stream to flow north of east or nearly at a right angle to the general slope of the region.

Gravel in pit sw of Sterling 65% N. side sec. 36.

3' sandy cover – 3' more to water in old lake beach.

There is a prominent morainic belt in the western part of Gibson Twp. (T 18 R 3 E) shown well by contours on Cooper's Bay Co. map. He made the crest of the till catch the 810' contour as far south as the NW part of sec. 30. The moraine has strong expression with knolls 10 – 20' high of till clear to surface. There is only an occasional sandy ridge. There is, however, in sec. 7 a chain of dunes that stand on highest part of the moraine and catch the 820' contour. As this is the correlative of Lake Whittlesey, the Whittlesey beach equivalent (2nd Saginaw) and all earlier beaches, Arkona and First Saginaw, are not to be found inside this morainic belt (The Port Huron). The highest shore line is that of Lake Warren. We find this well developed east of Bentley in west part of sec. 21 and northward through 21 & 16 near west side of each sec. Cooper has it catch 740 contour in sec. 16. It is below that contour but above 735' east of Bentley. His contours seem to be out of harmony with this shore farther south for the beach crosses the railroad 1 1/4 miles south of Bentley below 720 contour and it is about 710' by his contours at the line of Gibson and Mt. Forest Twps. Probably the sandy ridge in sec. 6 & 7 that catches 725 contour is the shore. His contours should be correct where they cross the M.C.R.R. but I fear he used barometric readings instead. The greater part of Gibson Twp. (T 18 R 3 E) is good farm land. Part of secs. 6 & 7 are down on the sandy plain west of the Port Huron moraine and are not cultivated. There is some sandy land in secs. 3, 4, 9, 10 below the Lake Warren level. The shore is not so definite here as in secs. 16 & 21 but seems to be in east part of sec. 4 and to run south near center of sec. 9. There are gravel pits along a small stream on line of secs. 16 & 17 about 1/4 mile from north end. This gravel has about same altitude as the shore line on sec. 16 but is not as well defined a shore feature. Probably Lake Warren formed this gravel deposit and had its shore for a time near line of secs. 16 & 17 until the bar in sec. 16 was built. This bar is only 40 – 60 rods from west side of sec. 16 in the

SW quarter of that sec. and is still nearer the line of secs. 20 & 21. It leaves sec. 21 at the SW corner.

#### Port Huron Moraine in Arenac County

There is a flat tract between Bentley and this shore line that has a thin coating of sandy gravelly loam but there is a clay subsoil. It is about the same altitude as the shore line and may have been covered by Lake Warren, the ridge east being an off shore bar.

I mapped the Port Huron moraine in Arenac Co. to where it crosses the M.C.R.R. NW of Sterling. Its outer border is in secs. 32, 33, 28, 27, 22, 15, 11, 2, T 19 R 3 E. Its inner border is in secs. 34, 27, 26, 25. Much of sec. 13 is a plain but little above the sandy area NW of it and the moraine is low in sec. 14. The prominent ridge runs SW across SE part of sec. 13 and NW of sec. 24. The moraine barely touches the SE corner of sec. 21. There is a line in it east of there extending se into sec. 27 and in this there are sandy ridges. The moraine here is less than a mile wide, the se part of sec. 27 being in the plain, covered by Lake Warren. The south half of sec. 26 is on the plain and south part of the NW¼. The south half of sec. 25 is mainly plain and coated with sandy gravel. There is a shore line running across the road about 100 rods from south end of line of secs. 25 & 26 a gravelly strip or slight ridge. Another low ridge runs WSW from south bank of a stream in east part of SE¼ sec. 25 across south part of that quarter sec. in north part of NW¼ sec. 36 and into NE¼ sec. 35. There are gravel pits in it where it crosses the line of secs. 25 & 36. The upper 3' is sandy but below this is gravel that tests 65% on 1/8 inch mesh sieve. It has been dug into about 3'. This gravel contains clay balls, red till, and is not clean but has a loamy or dirty appearance. This beach nearby connects with the lake limit in SE part of sec. 25 there being only a narrow break where a stream runs east (Pine River). There is moraine on north bluff at the line of secs. 25 & 30. The shore of Lake Warren runs into Sterling, so it may be easy to get its altitude there as compared with the station on M.C.R.R. which is 743' A.T.

#### Lake Warren Shore

It will be easy also to get its altitude near Bentley by comparison with Bentley station. On returning to Rhodes we find that the Lake Warren shore crosses the M.C.R.R. about 1/2 mile east of the line of Gladwin and Bay Cos., where a gravelly beach is formed in east slope of a till knoll. This is about 60 rods east from where the railroad crosses the sec. line of secs. 6 & 7, Mt. Forest Twp. It catches 725 contour on Cooper's map. I find that the shore crosses the road south of Rhodes near north side of sec. 13 and crosses the line of secs. 12 & 13 about 80 rods from east end. From there it runs NE into Bay County. It is this beach that is opened for gravel in SW part of sec. 12 and also this beach that is opened NE of Estey in sec. 14 and probably the same at the gravel pit in sec. 17, Mills Twp., Midland Co. The

knolly till in eastern Hope Twp. may be above Lake Warren level.

I went by train from Rhodes to Smith's siding largely through swampy land, there being only an occasional sandy ridge. The swamps are likely to have clay at slight depth. I walked back by the wagon road that runs south from Smith's crossing a mile, then east a mile, south 1/2 mile, and east a mile across sec. 10 to road leading north from Estey. Much of the land is wet with alder bushes and grass, and there seems to be a clay subsoil. Much of sec. 9 is said to be clay land but it is not cleared. Sec. 10 has cleared land and it is largely clay with till knolls and surface boulders. There is a prominent sand ridge forming the NW border of the cleared and cultivated land in this section.

#### Port Huron Moraine

The land rises rapidly westward across sec. 10 and 2 and this is the inner slope of the Port Huron moraine. The crest is in secs. 3 & 9. At Smith's siding the slope and drainage is westward. There is a farm SW of Smith's siding with a few bars of clay land and clay is near surface along a stream south of the station.

#### Studies near Rhodes

August 10, 1922, Rhodes, Mich. We go east to see the gravel shore in sec. 6, Mt. Forest, then back and south across sec. 12 to the shore that runs near line of secs. 12 & 13. Then east 1/2 mile and south on county line between sec. 13 & 18. There is clay in much of sec. 18 except the SW¼. In sec. 13 there is more clay land than sand but it has sandy strips. In sec. 19 the land is rather sandy except on the east and south sides where a clay is at surface. The greater part of sec. 17 is sandy and north part of sec. 16. So also are much of secs. 7, 8, 9.

There is clay land in north part of sec. 20 and NW part of sec. 21. Also in east part of NE¼ sec. 21. The sand covers much of sec. 21 and SE of sec. 20. In secs. 29 & 30 there is more clay land than sandy. The NW part of sec. 28 is sandy but the rest is clay. There is a sandy land in much of sec. 31 but east side has clay. In sec. 32 are sandy ridges but most of the land is clay. In sec. 33 the SE part is sandy and also south part of sec. 34. In sec. 35 the NW and SE parts are clay but SW part is sandy and part of NE¼. In sec. 36 the clay is mainly in east part, about 3/4 of it being sand. There is a clay plain with scarcely any sand in secs. 13, 14, 15, 22, 23, 24, 25, 26, 27. There is a strip of sandy pebbly land along the line of Mt. Forest and Pinconning Twps. in secs. 13 & 18, 19 & 24, 25 & 30. East of this is a clay plain extending nearly to the M.C.R.R. in Pinconning and northward 3 miles. Cooper's map may show this area correctly or nearly so.

We made some examination of the northern third of Garfield Twp., T 16, R 3 E, and find the sand in ridges or narrow strips with broad flat areas of clay traversed by these sandy strips – Cooper's contour map shows some

of the largest ridges of windblown sand in secs. 4, 5, 6, 7, 8, 9, 10.

#### Beach at Bentley

In NW Fraser Twp., T 16 R 4 E there is sand running ENE from Garfield Store across secs. 6 & 5 to NE corner of sec. 5. Both south and north of it there is clay land, its width is 1/4 – 1/2 mile.

There are slight sandy ridges in sec. 7 as shown in Cooper's map but sec. 8 and sec. 4 are said to be mainly clay land.

I returned to Rhodes and went to Bentley. The beach that runs east of this village is by hand level about 5' higher than the railroad station. There is sandy land just west of the station 3' higher than the station. It has a few pebbles and may be a lake feature formed before the strong bar was built east of the village.

I drive back and forth over the NE part of Gibson Twp. enough to see the land on nearly every sec. 9 and south part of sec. 11 and north part of sec. 14. The NW part of sec. 10 has a ridge of dune sand but clay land north and south of it.

#### At Sterling Lake Warren Shore

There is some pebbly sand over till in secs. 1 & 2 and only part of these secs. is under cultivation. This pebbly sand covers much of sec. 36 and becomes a deep deposit eastward in sec. 31, Deep River Twp. (T 19 R 4 E). This sandy land runs east on south side of Pine River nearly to Standish. There is moraine north of Pine River as noted yesterday in secs. 25 & 26 that runs NE to Sterling covering the NW part of sec. 30 and all of secs. 18 & 19 and west part of secs. 17 & 20, Deep River Twp.

The shore of Lake Warren runs across sec. 30 passing about 20 rods No. of center and leaving it 30 – 40 rods south of the NE corner. It cuts the NW corner of sec. 29 and runs into the SE part of Sterling crossing the M.C.R.R. about 40 rods SE of the depot. Its crest is about 2 – 3' higher than the depot or 745 – 746'. There is sandy gravel back of the beach ridge in the business part of Sterling at same level which is probably the product of Lake Warren before the strong bar was formed east of it. From Sterling SE to Pine River there is some loose textured bouldery drift with more or less sandy material in it. The soil is not first-class but is better than south of the stream. It is inferior to the till in the moraine west from Sterling.

I followed the gravel road from sec. 28 to Standish running east on line of secs. 27 & 34, 26 & 35, and then south through secs. 35 and 2. There is some till along this course but sand covers part of it.

## Algonquin at Pt. Lookout

I am told by Mr. Hayes, an attorney at Standish, that the bluff at Point Lookout is 25 – 30' high and a sandy gravel. Probably it has the Algonquin beach. There is deep sand west of it for 2 miles. The shore is sandy north as far as sec. 13, T.20,R.7 E. or 7 miles from Point Lookout, (also called Gravelly Point), and also Sandy Pt. The AuGres River is draining imperfectly a very low plain much of the borderland being now covered with several inches of water. Where in some seasons it is under cultivation. There is a black soil and he thinks the subsoil is generally clay.

He has noted clay also in low areas west of Duck Lake in T 19 R 6 E and much of the AuGres lowland may have a clay rather than quicksand subsoil. There is considerable variety in the soils of the eastern end of the county. He thinks Gregory's map of extent of sandy areas and of moraines is far from correct. So I will spend a day with auto looking into the matter.

## Extent of Nipissing Waters

August 11, 1922, Standish, Michigan. I take the gravel road leading to Omer and Twining. There is sandy land in NW part of Standish but the most of the village is on clay. The sand is in the part north of a creek and in the SE corner of the village. There is clay land in NW part of sec. 1 on both sides of the creek. The NW half of sec. 31. Arenac, is clay land and east part of sec. 36, Deep River Twp., south of Pine River.

There is a clay strip about 1 1/2 miles wide running eastward from the moraine SW of Sterling across Deep River Twp. to central Arenac Twp., near Omer. It lies north of Pine River in Deep River Twp. except as above noted in sec. 36, and lies south of a stream running through secs. 21, 22, 23 & 24, Deep River Twp. In Arenac Twp it covers NW of sec. 31 and most of secs. 28 & 29, south part of 17 and SW of 16. North of this is what are called "The Plains" in which there is a heavy sand cover ranging from 5' up to 40'. It extends to Rifle River valley in Deep River Twp. and is on both sides of that river in Arenac Twp. Big Creek is near the north border of this sandy in Mason Twp., secs. 29, 28, 34 & 35. But there is a limestone area with clay land south of Big Creek in sec. 36 and in sec. 1, Arenac, and west edge of sec. 6, AuGres. There is a narrow strip of clay land along Rifle River in Omer and it may extend down the valley. The waters of Lake Nipissing seem to have extended about to Omer and to have covered nearly all of Au Gres Twp. and as far north as secs. 31, 32, & 33, Turner and perhaps the east half of Turner Twp. there being a mucky ill drained area from secs. 10, 16, 21, and 28 eastward to AuGres River. Between the two branches of AuGres River there is sandy land as far south as secs. 13 & 18, T 20, Rs 6 & 7 E but clay farther south and this may have been covered by Nipissing waters.

## Studies in NE in Arenac County, Michigan

There is a strip of higher land bordering Saginaw Bay which was probably a peninsula or string of islands in Nipissing time, clear down to Point Lookout. I went as far east on road east of Turner as the east branch of AuGres River, there is a clay ridge on west side of this stream in east part of secs. 8 & 17 standing 8 – 10' above the river. Most of the land in this region is less than 5' above the streams and in places the road east of Turner is only 1 – 2' above streams in ditches along it. This wet season it is largely too wet to be cultivated east from the center N - S line of Turner Twp. The west half is high enough to drain rapidly and is producing good crops. It has rock at slight depth, usually 5 – 20' and the drift is a reddish clayey till with pebbles about as in land that stood above lake level, the clay with but few pebbles seems to be in strips rather than a general deposit - the extent of these strips I have not determined. I noticed pebbly till boulders in the clay strips on west side of the west branch north of Santiago in secs. 14 & 23, T 20 R 6 E and west of the east branch in secs. 8 & 17, T 20 R 7 E.

The sandy plain through which Rifle River flows in Deep River Twp. slopes rapidly eastward. It is about 100' above the stream NE of Sterling and only 20 - 25' near Omer. It may have been formed as an outwash when the ice border was receding, or it may be delta material of Rifle River that was extended eastward as this lake level lowered and the stream lengthened. It is a slightly pebbly sand. It is not likely to be of much value for farming yet Polish farmers are trying to cultivate part of it.

There is a sandy strip 1 - 2 miles wide running from Omer southwest that is at about the height of Nipissing waters 15'± above present lake level. It parallels the present shore clear to Bay City and is followed by the old "State Road". The contours on the Bay Co. map show its crest to be usually below 600' contour. It is pebbly only about 595' where higher it is wind drifted dune sand. Between this sandy strip and the bay there is heavy clay land with scarcely any sand on it in southern Arenac Co., but in Pinconning Twp., Bay Co., there is a light coating usually less than 4', and in places clay is at the surface. There are also places in the sandy strip in the swales where clay is at surface. The highest shore line (Warren) in northern Arenac Co. is on a moraine that is so rugged that the shore line is not a mature one but shows in favorable places for beach formation. I find two or three levels at which terraces and bars were formed on the slope of the moraine. There is one running ENE past center of sec. 11, Mason Twp., (T 20 R 5 E). There is a flat terrace 40 rods± wide below a definite bar or beach ridge. There is a less definite beach crossing the quarter line road in north part of sec. 10. This seems to find continuation south of Cedar Creek in a beach that runs south through west part of SE¼, sec. 9 and then SW into NW¼, sec. 16 across NW corner of NE¼ sec.16, Mason Twp. There is an even crest on a morainic ridge in east part of sec. 17 that may be made

even by later action west of this ridge in NW part of sec. 17 and SW of sec. 8 there is an outwash plain outside this moraine at slightly lower level.

I found a definite shore line west of this outwash plain along the east slope of this morainic ridge on which Maple Ridge stands, a mile east of Maple Ridge. It runs SW across sec. 18, Mason Twp., and along west side of sec. 19 and crosses the SE corner of sec. 24, Clayton Twp. (T 20 R 4 E). It runs WSW into sec. 25 and then curves around to the WNW and passes near the corner of secs. 23, 24, 25 & 26. It dips into the NE¼ sec. 26 and then comes back into SW¼ sec. 23. From there it runs SSW across NW¼ sec. 26 and SE¼ sec. 27 into sec. 34. It then doubles back on east side of a valley into SW part of sec. 27 and runs WSW across south part of SE¼ sec. 28 and north part of NW¼ sec. 33 to center of sec. 32 then westward to Rifle River in sec. 31.

South of Rifle River I found it near corner of secs. 5, 6, 7, 8, Deep River Twp. It runs SSE across west part of sec. 8 and near center of sec. 17, then south through west part of SE¼ sec. 17 and NE¼ sec. 20 and turns SW in the southeast part of the Village of Sterling. From opposite Maple Ridge and Sterling it is formed on the inner slope of the Port Huron morainic belt and there are morainic features of subdued type below it from sec. 25, Clayton Twp. westward to Rifle River for 1/2 mile or so, or down to where Rifle River Terraces set in. This Warren shore is a very definite feature all the way from sec. 18, Mason Twp. to Rifle River and also from Rifle River to Pine River in its course through Deep River Twp. past Sterling. It is less well defined across SE in Adams Twp. (T 19 R 3 E) but becomes definite in Gibson Twp., Bay Co., in vicinity of Bentley and for 2 miles north. My notes made about 1901 may record its course in Iosco Co. for I recall tracing a shore line there near Whittemore and northward to the AuSable sand plains.

My notes in 1921 show extent of farm land in vicinity of Alger and those in 1901 for the north part of county east of Rifle River.

#### Studies near Pinconning

August 12, 1922, Pinconning, Mich. I drove north to White Feather and found the extent of sand correctly shown on Cooper's map. I then went west and found till knolls on the first mile in the area marked sandy by Cooper. There is very little sandy land in this township above the level of Algonquin shore 605'±. It is in narrow strips or in patches difficult to map without detailed study.

I went south into T 16 R 4 E past the east end of a sandy strip that runs 2 miles ENE from Garfield store across secs. 6 & 5. I see no indications of a moraine south from this store along the range line of T 16 Es 3 & 4 E. where it is shown on my map of the surface geology of Southern Peninsula nor did I see anything further north to suggest a moraine. There is a sandy strip on line of Twp. 17 Rs 3 & 4 E. for 3 or 4 miles that I think has

about the level of the Elkton beach 635'± A.T. I do not think a moraine runs through Standish as this map indicates. There is need for considerable revision of the Bay City moraine and some shifting of the Port Huron from the course shown on this map.

I went west into Garfield Twp. on line of secs. 12 & 13, 11 & 14, then south to Crump. Much of this township has a clayey till near the surface and only an occasional sandy ridge. It is fair farm land. I went west 3 miles from Crump to Kawkowlin River, then south a mile to town line of Garfield & Beaver, then east to Linwood. There is a little sandy line along Kawkowlin River but much of this way on this township line, I was passing through good farming country and Beaver Twp. is said to be nearly all good farm land.

I took M.C. train from Linwood to Bay City and P.M. from Bay City to Plymouth and then by electric to Wayne and Ann Arbor.

August 18 I went to Lansing for conference then to Grand Rapids and north at night to Boyne Falls.

August 19, Boyne Falls, Mich. I find exposures of pebbleless clay with calcareous nodules under the till in east part of Boyne Falls up to a level more than 50' above the depot. It shows well half way up a steep hill running east on the quarter line of sec. 15. There is cobbly material in this clay and above this is clayey till. The clay is also exposed at base of the bluff like border of the plain on which Boyne Falls stands at east side of the village. There is till above it. This exposure is 40' or so lower than that in the quarter line road. This does not look like weathered shale and I see no outcrops of unweathered shale here. I went up to the top of a prominent hill about 3/4 mile SW of Boyne Falls in north part of NW¼ sec. 21 south of an angling road. This hill is composed of sandy material with only a few pebbles in it. It rises fully 300' above the valley at Boyne Falls. There are hills fully as high about 1 1/2 miles east in west part of sec. 23 and east part of sec. 22, Boyne Falls Twp. They are more than 1000' A.T. From this hill in sec. 21 I have a wide view to the north and northeast in eastern Melrose and in Chandler Twps. and NE in Boyne Falls Twp. Also a view to the SE and south into northern Warren Twp., Antrim Co., over the lowland in the southern part of Boyne Falls Twp.

#### Local Ponding

This is now partly under cultivation where there was a swamp when I mapped the region about 1901. The hills are still largely in brushy condition. The limits of Lake Algonquin are difficult to determine in some of the lowland areas of eastern Charlevoix Co. because there was a local ponded condition in each of the lowlands as the ice was melting back to the west or northwest from each lowland. Thus at Boyne Falls the lowland plain is considerably higher than the highest level of Lake Algonquin. The plain in which the highway runs drops from more than 700' at Boyne Falls to almost 650' in SE part of Boyne City. The base of moraine hills in south

part of Boyne City in secs. 1, 2, 3, Wilson Twp. is only 650 – 660' or 20' lower than the highest Algonquin level. North of Boyne City there is a higher wavewashed plain so the base of moraine hills is about 680' there.

The Nipissing plain in Boyne City seems to be about 23 – 25' above Pine Lake or 605'± A.T. (Goldthwaite made Nipissing 30' above lake at Charlevoix.

I went with Mr. Hageman, Co. Farm Agt., along north side of Pine Lake to line of secs. 5 & 8, T 33 R 6 W, and was below Nipissing shore about to corner of secs. 21, 22, 27 & 27, and between Nipissing and Algonquin from there NW. There is considerable bouldery drift along the base of the morainic area cut into by Lake Algonquin – but boulders are not conspicuous much below the Algonquin shore.

#### Drumlin Plastered Deposits

There was a bay in the lake covering NE part of sec. 8 and SE of sec. 5 about to east end of the sec. line or to a mile from the shore of Pine Lake. Between there and Boyne City the shore of Lake Algonquin is but 1/4 mile from the later.

We went north on line of secs. 4 & 5 to a prominent drumlin that crosses the NE corner of sec. 5 into sec. 4. This has laminated till exposed on its SE slope where road cuts into it and the limestone blocks in the till are striated on the upper surface, so I infer this was built by plastering on of material under the ice. This drumlin stands high above the country east and south of it. Its trend is NW – SE and the length about 3 times its width – width 40 rods, length 120 rods (not including lower part of slopes). The clayey till in this drumlin is coated with 2 – 5' of loose textured cobbly and sandy material. There is not a decidedly morainic topography bordering it as I had represented in my map. I could now class this as a ground moraine in NW half of sec. 4.

#### Hills of Sandy Gravel

There is a loose textured drift in the south and east parts of this sec. and in the district to the SE past Boyne City. In sec. 9 the prominent hills that I had marked as drumlins in moraine, are sandy gravel and more like huge eskers. The trend is NW – SE but they are somewhat sinuous and narrower than drumlins but not so narrow as the ordinary esker. The surface is bouldery. The character of material is more strikingly different from the clayey till of the drumlins than is the difference in topography. There are rather smooth surfaces in the low areas between these prominent ones so the surface is not of the ordinary terminal moraine type but between it and ground moraine.

I went from Boyne City to the camp of the Soil & Economic Survey in sec. 21, Wilson Twp., by the way of the gravel road that runs through secs. 1, 12, 13 & 24, 26 & 27, Wilson Twp. to SE corner of sec. 21 where the camp is located. On the ascent in sec. 1 some cuts in clayey till are made 20' deep. The road runs through a

swale that is considerably lower than land east and west of it and flat bottomed like a drainage course. It also has a gravelly coating. It is much higher than Lake Algonquin. I came down into a passage covered by ponded water in south part of sec. 12. There is a low strip from here west to Porter Creek in south part of secs. 11 & 10 and north part of sec. 9. There is also a low passage southward past Deer Lake to Deer Creek valley and down it to East Jordan. The passage to the west has a swamp only a few feet higher than Deer Lake and perhaps 30' lower than the highest ponded water level. The limits of ponded water are very clear each side of Deer Lake and Deer Creek at about 40' above Deer Lake. The altitude of the ponding at the camp in SE corner sec. 21 has been determined by Mr. Wisler to be 150' above Lake Michigan or 131'. The swamp south of here on border of Deer Creek at line of secs. 27 & 28 is 115' above Lake Michigan, or 696' A.T. Deer Lake is, therefore, over 100' A.T. and the swampy tract west from its north end in secs. 11 & 12 is above Lake Algonquin level. It was probably covered by ponded water in Pre-Algonquin time.

#### Nipissing and Algonquin Beaches

August 20, 1922 – In camp, sec. 21, Wilson Twp., Charlevoix Co. Prof. C. O. Sauer and I go down Deer Creek valley and find a definite ice border of morainic knolls and boulders crossing it from SW corner of sec. 21 to west part of sec. 28 where the N – S road rises to the moraine. Below here there is not so high a wavewashed slope on the valley borders as above. So the ponding above seems to correlate with this ice border.

Lake Algonquin probably came only about to the line of secs. 29 & 30 in the mouth of Deer Creek valley where it opens into the broader one in which South Arm of Pine Lake lies. The altitude of the creek at line of secs. 29 & 30 as determined by Prof. Wisler is 640' A.T. The pond below in sec. 30 is 614' at high stage. The stream below dam is 586' A.T.

In the afternoon I went with Mr. Leighly to the valley of Boyne River to determine how far Lake Algonquin extended up the valley. I got from Prof. Wisler the altitude of the railway at line of secs. 5 & 6, Boyne Falls Twp. – 671'. We find the shore passes just south of this crossing in an E – W course. The land south of the sandy ridge that marks the shore is 676' and seems not to have been covered by Lake Algonquin. The sandy ridge may have been given part of its relief by wind action – it is about 677 – 78' where highest. It is likely the ordinary stage of Algonquin was not over 675'. The beach crosses to the north side of the railway near where it crosses from sec. 5 into sec. 8, Boyne Falls Twp. A low sandy beach runs out to the river bluff near middle of south side of sec. 5 that indicates how far up the valley the later extended.

We went down to the river on the line of secs. 5 & 6 and find that in west part of sec. 5 there are sandy bars

running out into the valley that seem to be Nipissing features. They are just below where a dam has been built. Mr. Wisler gave the following data on the river here and at other points between Boyne Falls and Boyne City.

### Altitudes Near Boyne Falls

River at Boyne Falls above dam - 697'  
" " " " below " - 687'  
The plain opposite here on west side of the stream on the highway is 706' and descends to 699' at the railway crossing on line of secs. 9 & 16, Boyne Falls Twp.  
Stream on line of secs. 5 & 6, Boyne Falls is 604'.  
The bridge is 608'.  
Water above dam in sec. 5 is 32' above water below, and is ~~638~~ 637' and top of masonry 635.5. There is an 18 inch flush board in this making 637'.  
This backs water about 3/4 mile or to near line of secs. 5 & 8. There is 50' fall from below dam at Boyne Falls to head of this pool from 687' to 637' in a little over 2 miles by direct line.  
The low gradient below the dam in sec. 5 is due to the filling of the lower end of the valley in Nipissing time and only partial re-excavation since.

### Lake Algonquin

The Algonquin waters encroached on a plain that sloped to a lower level at head of Pine Lake in Boyne City but the effect of aggradation there seems not to have been marked enough to be easily detected. There is only a strip of very sandy ridges marking the limits at the SE end of the Algonquin Lake.

There is a small area of clay just north of the sandy Algonquin ridges in the west part of sec. 6 on each side of the highway. It is a brown clay at surface and nearly if not quite pebbleless.

Some very gravelly hills border the valley at the line of Boyne Falls and Wilson Twps. in secs. 6 & 1 that Mr. Lehighly thinks may be valuable for highway use.

### Altitudes

Round Top hill in NE $\frac{1}{4}$  sec. 1, he finds has a slope of 60° on its NE face next to the valley as if cut into either by wave action or border drainage. No other hills along the border are as steep.

Deer Creek at bridge in sec. 28, Wilson Twp. is 671'.  
" " " " at line secs. 29 & 30 is 640'.  
" " " line secs. 27 & 28 is 681'.  
Town Hall entrance 716'.  
Highest level of ponded water near school house in SE part sec. 21 - 731'.  
At line of secs. 26 & 27, Deer Creek, is 691'.  
" " " 25 & 26 " " " 701'.

### Studies in Wilson Twp.

August 21, 1922 - In camp in sec. 21, Wilson Twp.

I went west on East Jordan road to edge of the moraine 1/4 mile west of the line of Wilson and South Arm Twps. The moraine covers all of NE $\frac{1}{4}$  sec. 24 a little east of edge of NW $\frac{1}{4}$ , and the NE half of SE $\frac{1}{4}$  of sec. 24. In sec. 30, Wilson Twp., it barely touches the west line near the quarter post and lies within 40 rods of it north from there. It follows north side of Deer Creek closely across sec. 30. I level from the creek at line of secs. 29 & 30 and the shore of Lake Algonquin and find it only 23'

above the creek or 663' A.T. A ridge of dune sand in NE part of sec. 31 has points 35' above the creek or 675' A.T. but parts of it are 8 - 10' lower.

There is ground moraine in this part of sec. 31. Terminal moraine topography is mainly in the SE $\frac{1}{4}$  of sec. 31 and not much into NE $\frac{1}{4}$  or farther west on south side of Deer Creek.

### Drumlins

The drift is shaped somewhat into drumlin form in west part of sec. 31, Wilson Twp. and east part of sec. 36, So. Arm Twp. The NW end of the northernmost one at line of secs. 31 & 36 has a sandy gravel except a veneer of bouldery loose textured drift about 5' thick. There may be till in the middle and SE parts but I see no exposures to test its depth. There are 3 drumlin shaped ridges with NW - SE trend crossing this sec. line. All are low 5 - 15' above the swales between them. There is a more prominent one about in line with this northernmost one. It lies SW of the center of sec. 31. A deep ravine cuts across its SE end and opens into a lowland in S part SW $\frac{1}{4}$ , sec. 31. This lowland probably was covered by Lake Algonquin. The lake covered a terrace in central part of sec. 36 that stands about 20' above the low wide plain in west part of this sec. This is gravelly but the lower plain has clay soil in SW part of Sec. 36. The plain in north part of sec. 37 is coated with sand and there is sandy land from there to East Jordan.

There are drumlin-like ridges in west part of sec. 6, T 31 R 6 W in Antrim Co. like those in secs. 31 & 36, low and slender. They are on a till tract standing 50 - 75' or more above Lake Algonquin. This till extends slightly into the east part of NE $\frac{1}{4}$  sec. 1, T 31 R 7 W. Around its west edge along the east side of the gravel road in NE $\frac{1}{4}$  sec. 1, there is a strip of gravel. It seems in places to be above Lake Algonquin level and to form the substratum of the till area. But it is also along the Algonquin shore and furnishes material for a strong beach in the east part of the sec. There is a gravel pit in it close to the range line near quarter post that is opened 10 - 12' below the base of the beach without reaching the bottom of the gravel.

### Clay under Till

A short distance SE from here there is clay land in the lake bed, likewise to the north in the plain west of the gravel. This clay is pebbleless and is perhaps what the State Geologist, R. A. Smith, regards as weathered shale. I see no shale fragments in it. This clay is found under till where the N - S road in sec. 6 descends to the gravel road in SW part of the sec. The clay is exposed up to 30' or more above the plain that was covered by Lake Algonquin. There is about 20' or ordinary clayey till overlying it at this road exposure.

## Levels in East Jordan

At East Jordan I leveled up from Sc. Arm to the High School with following results:

Railroad – 587'.

Foot of first bank – 592'.

Top of bank at N – S road – 606'.

Foot of next bank – 610'.

Top of bank on plain – 644'. This extends past school site at about same level.

The plain rises to about 660' at corner of secs. 13, 14, 23 & 24, as I determined by sighting back on the school building. The full level of Lake Algonquin is scarcely 5' higher. An isolated knoll in NW corner of sec. 24 is about 665' at base and a plain back of it along a stream coming in from the NE is 665'.

The west half of sec. 24 as well as south part of SE quarter is on the plain. The entire hilly part of sec. 13 is moraine and sandy drift except a drumlin that crosses into it from sec. 14 near quarter post. In sec. 14 the highest land is given a drumlinoid shaping but there is knolly loose textured drift at lower levels in the part above Lake Algonquin. The SW half is below Lake Algonquin. There is a drumlinoid hill west of the N – S quarter line road. In sec. 11 there are drumlins of nearly type form and there is one in the east part of sec. 10. Lake Algonquin washed its west slope and built a bar out eastward from its north end a little beyond the line of secs. 10 & 11 or about 120 rods. I leveled from So. Arm to the highest Algonquin in sec. 10 and made it 666'. There is a terrace next to the lake 592' at back side. The bank is about 8' higher or 600'. Then another terrace rising to 610' at back side. The steep bluff back of it is 627' at brow. There is then a gradual rise to a rather weak shore at a dwelling 650'. The highest shore at base of a cut in north end of drumlin is 666' and the bar that runs eastward has this altitude nearly to its end.

There is a cut on line of secs. 11 & 14 about 60 rods from west end of line that exposes 2 – 3' of lake clay under till and below this is sand of medium coarseness. The clay is pebbleless and gummy-like that so often noted in this region. This clay is at a level a few feet higher than the highest Algonquin beach and it has 15' of till over it of the ordinary kind found in drumlins, clayey with numerous pebbles thoroughly kneaded into it.

The Algonquin shore runs through the west part of sec. 2, So. Arm Twp. within 1/4 mile of west side. There is a low strip in west part of sec. 11 that stood in peat below highest Algonquin level. Perhaps a narrow strip of water laid in it east of the drumlin that is in east part of sec. 10. There is a small till swell at corner of secs. 10, 11, 14 & 15, not more than 5' above highest Algonquin beach. It is tied to the higher land north of it by a bar in SE part of sec. 10. I studied no farther north than line of secs. 2 and 11 today.

## Features Bordering Boyne River

August 22, 1922 – In camp sec. 21, Wilson Twp. I find the hill valley south of the highway in sec. 27 has a little bouldery material capping a sandy gravel. I see no signs of shale or rock nucleus. Its highest point is about 750' or 20' above the ponded water level. It is elongated in WNW – ESE direction and smooth like a drumlin. Its south slope is very steep down to 700'±. I went with Prof. Young to Boyne City and examined the borders of the inner valley of Boyne River from the line of Melrose Twp. westward. There are recesses in the bluffs that Mr. Leighly interpreted to be due to river meanders. In some places there is a sapping by springs and starting of ravines that seem to be the main cause of the recesses. There are small island-like areas cut off by narrow channels from the main bluff. These are shallow opposite middle of island but are deeper toward the ends because of erosion by recent drainage. There are springs in the lower ends of these channels. The sandy deposits are very thick near line of Melrose and Evangeline in the bluffs, but to the west near east limits of Boyne City there is a gummy red clay to within 10' of top. It is well exposed near MP 1 on Boyne City RR where it starts the descent into the valley. This is in west part of sec. 36. The clay extends up to a similar height on north bluff near line of secs. 35 & 36.

I went by auto from Boyne City to Walloon Lake at resort at the SE end. The slope north of the lake outlet seems to be smoothed by wave action up to about 20' above the lake and the moraine hummocks are not conspicuous below 50' above lake level in east part of the resort. In the west part a ridge comes out to the lake at 20' above it.

## Features near Walloon Lake

The lake is held up 3 – 4' above natural level by a dam at the outlet. I find wave notching very definite at south end of the bay in sec. 17 at 20' above present lake level. The lake cuts into a high tract for 1/4 mile south of the outlet. There is then a strip of low sandy land about 40 rods wide bordering the lake around the end of this bay. The highland south of east end of Walloon Lake is rather smooth in NW part of sec. 16 and also around corner of secs. 17, 18, 19, 20, Melrose Twp. The land in secs. 20 & 21 and SE part of 16 is more hilly and of looser drift. The smooth areas have some loose textured drift but there is also clayey till. The highland extends west only to middle of line of secs. 18 & 19 and but a little south of the quarter post of secs. 19 & 20, perhaps 30 rods. There is swamp setting in about 100 rods from south end of this sec. line. This road is at the divide in the swamp between drainage eastward to Bear Creek and drainage northward to Walloon Lake. The new highway now under construction runs through this swamp in sec. 19 and it is reported that the bog is 48' deep at one place. Spikes are being driven to support the roadbed, I am told. This swamp seems likely to be above the level of Lake Algonquin. Perhaps Lake Algonquin occupied Walloon Lake basin to a height of 20' above present

level. Data are needed to show the altitude A.T. I crossed over the range of hills that lies N of Boyne River in sec. 30, Melrose. I then mapped the shore of Lake Algonquin from sec. 31, Melrose westward across secs. 36 & 26 to NW corner of sec. 26. The shore is less than 1/4 mile south of the line of secs. 25 & 36. There is a gravelly bar lead from the point of hills in NW part of sec. 36 in a course south of east across the highway to the line of Evangeline and Melrose Twps. about 100 rods from north end of line of secs. 31 & 36. It is 3 – 5' above land north of it.

The shore passes 30 – 40 rods north of corner of secs. 25, 26, 35 & 36, and circles around through center of sec. 26 to the NW corner and thence west along or near line of secs. 22 & 27.

#### Studies near Boyne City

There is a thin coating of sandy gravel on the Algonquin bed. But on the Nipissing the clay is at surface in places. The Nipissing is about 25' above Pine Lake. There is a lower beach about 9 – 10' formed as the Nipissing Great Lakes were being changed to the modern Great Lakes but perhaps held by a barrier in the outlet through Charlevoix at about 10' above present level. It is reported that the lake was nearly 4' above Lake Michigan until an artificial channel let it down to Lake Michigan level. This was cut about 12' below Lake Michigan level. From Boyne City I went south on line of secs. 2 & 3, Wilson Twp. and came to the shore about 40 rods north from where the road turns southeast. The shore runs west from here to near center of sec. 3 and then begins to bear NW. This is its southernmost point in Wilson Twp.

I cross a range of hills of loose texture in secs. 2 & 11 and come into a swampy valley about where roads lead east and west from this one. The one leading east follows the north side of this valley to the gravel road in sec. 12. This road crosses the swamp near the divide. The valley is scarcely 1/2 mile wide east from here but is wider to the west. The uplands between this valley and Deer Creek have loose textured drift at surface but in a few places the road in sec. 22 cuts into a clay that looks like the lake clay so widely present in this region. It is at an altitude of 300' above Lake Michigan.

#### Features near Advance

August 23, 1922 – In camp sec. 21, Wilson Twp. I go west to road leading north across secs. 20, 17, 8 & 5, Wilson Twp. to Advance in sec. 29, Eveline Twp. There are ridges shaped in drumlin form as far SE as the central part of sec. 21. They are of loose textured drift with very little clay. The highest land is rubbed smoother than lower land, as in the district NE of East Jordan in secs. 1, 12, 13 & 14, So. Arm Twp.

The drift becomes more clayey north of Porter's Creek in sec. 5 and the drumlin shape is more like type than to the SE with less irregularity of shape. This sort of land extends into NW part of sec. 4 but most of the sec. is

very elevated strong moraine and this runs SE beyond Boyne City. There is a swamp which starts near line of secs. 14 & 23, Eveline Twp. which is drained by the west branch of Porter's Creek. A lake in SE part of sec. 23 is in it. It runs across NE corner of sec. 26 and winds across sec. 25 past center and SE corner and runs across north part of sec. 31. There is an Algonquin shore on north side of the swamp in SE part of sec. 14. It ties onto a drumlin at west end in SW part of SE 1/4 of sec. 23. The swamp lies east of this drumlin. There is drier land west of it that is below Lake Algonquin level. This lowland extends SE to the lake in sec. 23. Its west border runs north across east part of SW 1/4 sec. 14 and turns west near the quarter line and crosses into sec. 15 about 50 rods south of the E – W highway. The SW corner of sec. 23 is very highland about 250' above the lake or 150' above Lake Algonquin.

#### Extent of Algonquin Waters

I went south along the line of secs. 14, 15, 22, 23, 26, 27, 34 & 35, Eveline Twp. through a drumlin area. The swamp in sec. 26 & 27 and 34 is wide near the lake but narrow in sec. 27. It seems to run east to connect with the swamp noted above that runs from sec. 23 and to Advance and is drained by West Branch of Porter's Creek. The connection is in east part of sec. 27 or SW of sec. 26. I did not trace this today but find it shown on my old field maps. Probably Algonquin waters extended through this swampy strip – as well as that along west branch of Porter Creek. There is gravelly drift south of this swamp near the line of secs. 34 & 35 with a pit opened near Schoolhouse in NE part of sec. 34. This is above the Lake Algonquin shore which cuts into its base.

There is also gravelly drift along borders of a small stream in west part of sec. 2 from which road material is now being obtained. It is a very sandy gravel and so is that in sec. 34. A screen is used at the pit in sec. 34 to get rid of sand. The prominent hills in this drumlin area are generally of ordinary clayey till but one in west part of sec. 26 is sandy and irregular though elongated NW – SE. One in west side of sec. 2 has a crest just up to Algonquin level. It is drumlin shaped so deeper water passed around it on the east in Algonquin time. East of this is a high drumlin that runs to NW corner of sec. 2. It is 30 – 40' above Algonquin in highest part. I now think it doubtful if there was a passage for Lake Algonquin waters through west part of sec. 11. The lake extended only into NW part about 120 rods. It extended about 40 rods into SW part of this sec. In East Jordan the Algonquin beach lies west of the N – S highway a little south of center of sec. 14, the cemetery being below it.

#### Drumlins West of South Arm of Pine Lake

August 24. From the camp in sec. 21, Wilson Twp., I went through East Jordan to west side of So. Arm of Pine Lake then north along west shore to quarter line of sec. 4, So. Arm Twp., keeping below the Algonquin shore all the way. The shore is within 1/4 mile of the present shore except in a narrow passage that runs

westward from mouth of Monroe Creek to Intermediate Lake through secs. 9, 8, 7 & 18, So. Arm Twp. as determined in my earlier studies about 1901. There are drumlins in this swampy tract that stood above Lake Algonquin but the swamp was below that lake.

I went west a mile across sec. 4 over drumlins with NNW – SSE trend. I then went north about 1 1/2 mile through drumlin tract and west a mile between secs. 29 & 32, then north to a middle of line secs. 17 & 18, keeping above Lake Algonquin all the way. I went west to center of sec. 13, Marion Twp., then south to the camp of the Soil Survey on west bank of Nowland Lake in sec. 24. I then went with the mail carrier to Charlevoix running back north a mile, west to line of secs. 13 & 14 where I overlook a swamp south of Adams Lake that was covered by Lake Algonquin. There is a notch in the till west of north end of Adams Lake made by Lake Algonquin at a level 25'± above the lake and marsh.

A strong Algonquin bar was built across the lowland north of Adams Lake that has been cut through by the lake outlet. I worked out an intricate set of bars and shore features in this part of the Algonquin shore when here about 1901.

#### Nipissing Shore

The Nipissing shore borders the outlet of Pine Lake on each side leaving a space in Charlevoix less than 1/2 mile wide between bluffs. There was a bar from the south bluff running along the shore of Lake Michigan that turns east on south side of the outlet. It is about as high as the Nipissing beach and is of sand with few if any pebbles. The Nipissing is a cut bank and the material is gravelly above the cut and to some extent under the bed of the passage through which Pine Lake opened into Lake Michigan in Charlevoix. I went south to end of Bridge St. in Charlevoix across a plain about 650' that has a thin coating of sand over clay to end of Bridge St. but farther south in sec. 35 and NE part of sec. 34, Charlevoix Twp., there is clay at surface.

#### Features near Charlevoix

I took the angling road across secs. 2 & 1, Marion Twp. which is below the Nipissing beach and has a lower shore line on its NE side. I then went south in sec. 12 and came to Algonquin shore at center of sec. where the gravel road turns east. There is a cut bluff in till here 40 – 50' high. I went south from here over a large drumlinoid which occupies much of SE 1/4 sec. 12 and NE 1/4 of sec. 13, trending NNW – SSE. The next drumlin south extends to north end of Nowland's Lake and the next one to the camp in sec. 24 at west side of the lake. It has two short ones built against its west slope with no deep depression between. West from line in sec. 24 are two other drumlins. I was taken to East Jordan from this camp in the evening.

#### SE of Boyne Falls

August 25, East Jordan. I went with Schoeneman and Sauer to see features southeast from Boyne Falls. We first stopped at Boyne Falls to examine the pebbleless clay that outcrops under till in east part of the village and which I think is lake clay and not a weathered shale. We then drive to Elmira and noted shoreline features in the lowland between moraines as far up as sec. 2, Warner Twp., and to about 900'. The altitude at which change to moraine occurs near line of GR & IRR in northern part of sec. 35, Boyne Falls, is 850' by aneroid.

#### Studies Between Boyne Falls and Elmira

There are gravelly bars with E – W trend just south of the county line in sec. 2, Warner Twp., that look to be beaches at head of a bay. They are only about 6 – 8 rods wide and they form a series of steps up the slope from north to south with slight vertical intervals of 10'±. At lower levels there is not so good a development of gravelly bars. There is generally a clear contrast between the wavewashed plain and the bordering hummocky moraine. There may have been an ice border across the lowland in sec. 28 & 33, Boyne Falls Twp. on the divide between Boyne River and Deer Creek drainage. There is a prominent knoll in the midst of the lowland in central part of sec. 28 that is visible from the N – S road in sec. 35. It stands more than 50' above the bordering swamp and covers 50 – 60 acres as determined by the Soil Survey men. The bed of the lowland in secs. 26 & 35, Boyne Valley and sec. 2, Warner Twp. has a gravelly sandy loam soil. The ground water is very near the surface so crops do not suffer in the driest times. There has been some diverting of the streams so they separate and then unite farther down and run like irrigation courses. There are cobblestones and small boulders also in the plain pools of these secs. In sec. 11, Warner Twp., a short distance south of the BC & GRR there is a pit in the side of a knoll in which a pebbleless clay with sandy pockets and sandy partings is exposed to depth of 10'. It is at an altitude about 450' above Lake Michigan or 1030' A.T. It probably represents local ponding and may be about the same age as the overlying stony drift. This is the highest exposure of pebbleless clay that I have noted.

#### Features near Elmira

At Elmira, 1226', the bluff is at east edge of village. There is outwash for 1 3/4 miles west. The road that runs north from 1 mile west is an outwash to where it turns NW in sec. 14, Warner Twp. There is a narrow strip of low hummocks 5 – 15' high here that are bouldery. So the SW there are higher points 50'± above the plain just outside. The plain at NW edge read 35' higher than Elmira Station or about 1260'.

There is an abrupt rise of 60 – 70' or to nearly 1300' from the place on which Elmira stands to a higher outwash plain in east part of sec. 19, Elmira Twp., Otsego County. We ran east on this plain to corner of

secs. 16, 17, 20 & 21 and it extends about 1/2 mile further to base of another abrupt rise.

We went north on this plain. It is over a mile wide, its east border being in secs. 4, 9, & 16, and west border in secs. 5, 8, & 17. We came to the west edge about 1/4 mile south of the county line near north end of line of secs. 4 & 5, Elmira. The aneroid there made 1315'. The lower plain – a continuation of that on which Elmira stands, read 1250' near middle of line of secs. 5, Elmira and sec. 32, Hudson Twp. (T 32 R 4 W) in Charlevoix County. This plain runs NE to sec. 10, Hudson Twp., the west border being in secs. 10, 15, 16, 21, 29, 32 & 31. From sec. 29 northward it is in the Lake Huron drainage through Sturgeon River and perhaps as far south as the edge of Otsego County. The moraine west of drains to Boyne River as far north as sec. 9, Hudson Twp.

There was considerable ponding in the headwaters of Sturgeon River in secs. 23, 24, 25, 26, 33, 34 & 35. This ponded water covered the NW slope of a moraine south of the river in secs. 33, 34 & 35. The knolls are small where submergence occurred but are boulder strewn so I class this area clear to south edge of Branch Lake as moraine. The part that was not submerged in secs. 35 & 36, is very rugged and stood over 1300' but with some points about 1400' A.T.

#### Features near Thumb Lake

There is moraine from Branch Lake NNE part, Clear Lake in east part of sec. 27, NW of sec. 26, and the west and north parts of sec. 23. It is not so prominent as that in secs. 11, 12, 13 & 14, Hudson Twp., but is hummocky and boulder strewn. There is a gravelly outwash plain SE of it extending to the lowland that was ponded in the Sturgeon River drainage area. It is about 1250' bar near the moraine and drops down to the SE slightly. There is wave notching on the south side of the area that was ponded, well shown on a hill back of a schoolhouse near corner of secs. 25, 26, 35 & 36, and to the east and west from this hill. It is at about 1250' (barometric)

There is a cobbly pitted plain in NE part of sec. 22 and NW of 23 that seems to be 50' higher or about 1300'. A lower plain runs south on its west side from sec. 15 across sec. 22 to Branch Lake. West of this is a plain about as high as this high one, that fits onto the moraine in secs. 15, 21, 28 & 29. The barometer gave Branch Lake an altitude of only 1100' but I suspect it is 25 to 50' higher.

The drainage from the highest outwash in Hudson Twp. seems to have been southwestward past Elmira though much of it is now tributary to Sturgeon River of Lake Huron drainage. The ponded area was probably held up to this high water stage by ice in the part of Sturgeon River east from here. We went to Thumb Lake and noted a plain on its south side that is about 75 – 80' above the lake in highest part of 1140' by aneroid. This seems to have been formed when there was a passage open eastward.

In secs. 8, 9 & 17 there is a nearby plane tract on borders of a tributary of Boyne River at about 900'. West of it near corners of secs. 7, 8, 17 & 18, morainic features nearly close this valley, so this seems to have been the position of the ice border when the area east of it was ponded. There is a heavier soil, some of it clayey till on south side of this tributary of Boyne River from sec. 18 west to Boyne Falls extending back to south edge of secs. 13, 14, 15, Boyne Falls Twp.

#### Shale Outcrops

August 26, 1922, East Jordan. I mapped the west border of Lake Algonquin in the South Arm basin as far south as the county line and the east border of Intermediate Lake at Algonquin stage from the county line north as far as sec. 7, So. Arm. Twp. There is a shale outcrop in road near middle of line of sec. 26 & 27 at city limits of East Jordan at 660'. I also found shale east of Intermediate Lake on line of secs. 29 & 32 at about 675'.

There are several outcrops of shale and drumlin with shaping of shale in SW part of sec. 17 and SE of sec. 18, So. Arm Twp. Another shale outcrop was passed in sec. 9 on the E – W quarter line road. There does not seem to have been any passage across from So. Arm to Intermediate Lake in Algonquin time unless it is a very narrow one near line of secs. 8 & 17, So. Arm Twp.

Algonquin waters extended up Monroe Creek valley into the central part of sec. 5 and up a branch to near middle of line of secs. 8 & 17. Water in Intermediate Lake basin extended into west edge of sec. 17.

There is a sandy soil east of Intermediate Lake from near corner of secs. 19, 20, 29, 30, southward into Antrim Co. but north from this there is a washed till or a shale. In Monroe Creek valley there is considerable sandy land in secs. 5, 8, 9. I got around to the camp near mouth of Monroe Creek for dinner and went north to Pine Lake and into Charlevoix after dinner. I walked about 20 miles, 12 in forenoon and 8 in afternoon and road 8 miles by autos.

#### Land with Limestone Under It

August 27, 1922 – Charlevoix, Mich. I find the beach is gravelly for about 3/4 mile in sec. 27 and east part of sec. 28. It is more sandy from about 80 rods west of line of secs. 27 & 28 NW about to the point that projects north in secs. 28 & 29. There are a few boulders on the sandy beach. They are very numerous on the gravelly beach and cut into the lake 20 rods or more – on limestone that is exposed near lake level. The limestone rises to 85' above the lake in NE part of sec. 28. It is also present up to nearly this height for a mile west into SE part of sec. 29 and NE of sec. 32.

The land with limestone near surface is too stony for easy cultivation so most of it is covered with brush or in pasture. It will all be good pasture land if the brush is

cleared off. It is all easily drained and the alder swamps on it are now dry land – without artificial ditching.

I went west on line of secs. 27 & 34, 28 & 33, 29 & 32, to the shore and found this stony land with limestone near surface all the way. There is limestone at and below low water level exposed along the shore in north part of sec. 32 and in sec. 29. The strip of dunes bordering the shore in secs. 29, 32 & 31 is hardly 1/4 mile in average width. The altitude is 50 – 60' above the lake – or about 20' above the edge of the stony land east of the dunes strip. This dune strip is along and slightly outside the Nipissing shore. That shore is 25 – 30' above the lake. There are places in the midst of the dune strip where the pebbly Nipissing beach material is at the surface at 605 – 610' A.T.

#### Algonquin Shore Lines

There are gravelly bars in the SW part of Charlevoix in sec. 27 that are above the Nipissing shore. One is 635', another 645-50'. They may be Fort Brady and Battlefield beaches. There is pebbly material and some shaping into beach form on the limestone area in NE part of sec. 33 at about 660' or 20' below the highest Algonquin shore in this sec. I went up to the set of gravelly Algonquin bars in SE part of sec. 33. The ridge that runs across the SE quarter of sec. 33 from NE – SW ties into two till knolls that are along its line in the NE¼ of SE¼ sec. 33. This beach is 680' and one about 40 – 60 rods north of it is 5' lower. There is also one 675 that passes the turn of road in east part of sec. 33 and keeps close to its west side from there SW into Norwood Twp. It is paralleled on the west and north by the one noted above that stands at 675' by aneroid. The middle range is banked against the higher one in SW¼ sec. 31 but the one north of it remains a distinct ridge and stands 30 – 80 rods from it.

South of this set of shore lines there is a strip of somewhat swampy land in the SE part of sec. 33 and SW of sec. 34.

South of this is a shore line wrapping around the base of a till ridge or drumlin in extreme SE part of sec. 33. There is a similar prominence of till in SE part of sec. 34 which is wrapped around by the Algonquin shore in this sec. and in the adjoining part of sec. 3, Marion Twp.

August 28, 1922 – Charlevoix, Michigan. I went SW to center of sec. 4, Marion Twp. crossing the highest beach in SE corner of sec. 33, Charlevoix. It runs near this road within 30 – 60 rods NW of it across NW¼, sec. 4.

I turned west on quarterline road and came to edge of Algonquin near line of secs. 4 & 5 and it follows the highway that runs SW from near center of sec. 5 and center of sec. 7, Norwood Twp.

There is a recess at a stream in SW¼, sec. 7, so only a little land in east and south sides of this quarter sec. stands above Lake Algonquin. The highway leaves the Algonquin shore at corner of secs. 7 & 18, 12 & 13, so I trace the highest shore through fields in secs. 13, 24, 23

& 26, to center of sec. 26 where the highway comes back to it and runs along it past Norwood. There are recesses in the shore between drumlins and protrusions around north end of drumlins so the border is exceptionally irregular. There are bars built across the recesses to some extent, a conspicuous one being in south part of sec. 13. There are only a few acres of sec. 23 outside Lake Algonquin on the slope of a drumlin in SE part of the sec.

From NE part of sec. 23, Northwood, there is a bouldery surface nearly all the way to Charlevoix extending from the Algonquin beach to the strip of dunes along the shore of Lake Michigan. The dune strip is seldom more than 1/4 mile wide. There is a lower bar of Lake Algonquin running WSW from a creek in sec. 7 across south part of sec. 12 a little beyond the south quarter post. It only runs a little into north edge of sec. 13. There is swampy land in south half of sec. 23 and I am told the lake bed has but few boulders south from there as compared with their number to the north.

#### Features near Bay Shore

I went no further than center of sec. 26, Norwood, and returned by auto to Charlevoix for dinner. I then took stage at 1:00 P.M. to Bay Shore, running east on north side across secs. 23, 24 & 19, and turning north in sec. 20 on west side of Susan Lake. There is a chain of drumlins west of the lake with connecting gravel bars of Lake Algonquin. The lake covered only the lower part of the slopes. The drumlins crossed by the road in NW part of sec. 16 are low and flat only 10 – 15' higher than swales between them.

The highway follows the highest shore closely from Burgess northeastward to south edge of sec. 2, Hayes Twp., and ESE across N. part NE¼, sec. 11 into NW¼, sec. 12. The shore there turns south on west side of Horton Creek. A strong gravel bar runs eastward about 100 rods and then turns SE and runs through south part of Bay Shore village. This is what causes Horton Creek to run southward to Pine Lake instead of north into Little Traverse Bay. There was a narrow strip of water from Little Traverse Bay to Pine Lake 1/2 – 3/4 mile or less in width. Its east border is in SE part of sec. 12 and it runs near the range line for 3 miles south, then bears SE across sec. 31 to Horton Bay village in sec. 6, T 33, R 6 W.

Algonquin shore is along south side of the highway nearly all the way from Bay Shore to Petoskey. It crosses a projecting point in sec. 9, T 34, R 6 W. I find that a ridge north of the north end of Walloon Lake standing 38 – 40' above the lake has the appearance of being wawashed and it carries a thin coating of pebbly sand. Its crest is of uniform altitude for about 1/4 mile east from the line of secs. 8 & 9 and has about the width of a shore line. There is a lower place in east part of sec. 8 where one can pass over the divide at only 25 – 26' above Walloon Lake, or about 14' lower than this beach-like ridge. The highest shore of Lake Algonquin

at line of secs. 8 & 9 is 15' higher than Walloon Lake or about 23 – 25' below this beach-like ridge. This one above Lake Algonquin seems to be a local feature and I am not able as yet to interpret it. Walloon Lake has swampy inlets in SE part of sec. 8 and SW of sec. 9 on the borders of which I can detect wave work up to 15'± above the lake or to the height of the highest Lake Algonquin beach. I went into Petoskey and over by auto to Harbor Springs and got lodging at the Schomberg Hotel.

#### Well 515' – Studies North from Harbor Springs

August 29, 1922 – Harbor Springs, Mich.

Aneroid 29.475 at Lake Michigan level = 581' at 6:00 A.M.

Aneroid 29.500 at Lake Michigan level at Cross Village 8:45 A.M.

I made an auto trip to Cross Village on the gravel road that runs through secs. 13, 12, 1 & 36, West Traverse Twp. and secs. 26, 23, 14, 11 & 2, Friendship, and secs. 35, 26-27, 22-27, and on line of 22 & 21, 16 & 15, 10 & 9, Readmond, and secs 3 & 4 to edge of Cross Village. Highest point crossed is 980' in N. part sec. 2, Friendship.

I ran east across sec. 10 to a road summit near line of secs. 10 & 11 standing 930' A.T. (Barometric). This gives a view of hills in sec. 16 that are 25 – 50' higher and of still higher land farther south. The barometric readings are found on the county map. The reading on the highest Algonquin beach is 730' or 150' above Lake Michigan. The Algonquin shore is only a mile from Lake Michigan directly SE of Cross Village in north part of sec. 3, T 37 R 6 W. Strong gravel bars run SW from there across NW¼ sec. 3 and SE¼ sec. 4 and NW¼ sec. 9 and central and SE part of sec. 8. There is a recess SE of these bars in extending past the corner of secs. 3, 4, 9 & 10 which is below the highest Algonquin level but has not a strong shore along its border. The bars appear to have early protected it from wave action. The Algonquin bars run across the NW corner of sec. 17 and pass SE of center of sec. 18 and cross NW part of sec. 19 to enter sec. 24 near the east quarter post. The shore then parallels that of Lake Michigan through secs. 25 & 36 at a distance of about 1/4 mile from the present lake. Goodheart, an Indian Village, is on a low flat below the Nipissing beach.

I went east from Goodheart rising to 1010' at corner of secs. 29, 30, 31 & 32 and to 1100' at Mr. Hollands on S. side SE¼ sec. 29. There are points 20 – 30' higher on and near line of secs. 28 & 29 and on line of secs. 28 & 33. Mr. Holland has a well 515' deep that has very little rise of water in bottom. He pumps water with a gasoline engine. I obtained records of several deep wells in this vicinity about 1904.

South from Goodheart the Algonquin shore is only 1/4 mile from Lake Michigan at the widest places. In secs.

12 & 14, Friendship, it is so close that the Nipissing has cut it away and cut back into the moraine so that in places the top of the Nipissing bluff is 730 to 750'. In the south part of sec. 13 a strip of the bed of Lake Algonquin appears and runs southward through sec. 24 into NW part of sec. 30. It is 40 rods or less most of the way but is wider in S. part sec. 13 as there is a recess in the moraine.

#### Studies North of Harbor Springs

The moraine is close to the Lake Michigan shore in S. part of sec. 30 and in sec. 31 scarcely 40 rods from it in places. It is also very close to the lake in sec. 5 at the bend in the shore. The Nipissing is cut away and only a very narrow strip of Algonquin is preserved. From the line of secs. 4 & 9 West Traverse eastward across secs. 9, 10, 11 & 12, there is a strip of Algonquin lake bed 1/4 mile or more wide mainly in these secs. but extending slightly into secs. 13, 14, 15. The Nipissing bluff is 15'± high in Harbor Springs and Forest beach. The level was about 35' above Lake Michigan. In the trip today I found very sandy drift all the way to Cross Village. There is a stiff red clay in the bluff of Lake Nipissing in the village. A similar clay is found north of Little Traverse Bay in places. The altitudes are high in several areas north of Little Traverse Bay but along the line of the gravel road which I traversed the highest point crossed read 980'. It is in north part of sec.2, Friendship Twp. The range of hills in SW part of Pleasant View Twp. is over 1000'. It occupies parts of secs. 19, 29, 30, 31, 32. There is only a moderate number of boulders in the moraine. The farms seem to be productive as there is loam in the drift. The drainage seems to be largely sub-surface for I saw no streams on the road from Harbor Springs to Cross Village and the low areas do not seem to have a continuous slope to a drainage line. The drift is so porous that water disappears in it soon after a rain.

#### Features in Petoskey

There is a remarkably smooth area north of Wequetonsing above the level of Lake Algonquin that I mapped as till plain when here some years ago. It seems to fill the space between Little Traverse Bay and a swamp that runs north through the central part of Pleasant View Twp. In Petoskey I examined the bar that is cut through by Bear Creek. It is the highest Algonquin and seems to have been a complete barrier which has been cut by Bear Creek. The gap in it is only about 300' wide above the bridge near east end of Porter St. and west end of Bridge St. The trend is westward from G.R. & I.R.R. to the west end of Bridge St. It there turns SW and runs to the till upland on south side of Porter St. There is a limestone quarry above Lake Algonquin level south of Porter St. in sec. 6, Bear Creek Twp. Limestone outcrops farther west near the level of Lake Algonquin and up to about 20' above it in a few places in secs. 1, 2, 10, 11, Resort Twp.

I re-examined the low ridge at north end of Walloon Lake and its height compared with the highest Algonquin

shore. It is about 20' above it and 38 – 40' above Bear Lake. So the beaches I noted near SE end of the lake up to 20' above the lake seem to be Algonquin beaches. The sandy bar that forms the divide or rather the coating of pebbly sand on this divide seems the product of some local pre-Algonquin ponding.

I returned by auto to Charlevoix and took boat Aug. 30 to Beaver Island to determine the height of lake action at Algonquin stage.

Algonquin Beach 735' – Well 105'  
Studies on Beaver Island Algonquin Beach 735'

August 30, 1922 – Beaver Island at St. James. Aneroid 29.475 at lake level 581' at 1:00 P.M., 630 in washed dune clay ridge just north of Twp. line, swampy at twp. line. 640 at cross roads in north part sec. 34. 650 on sandy beach 40 rods south of cross roads. Sandy gravelly loam south of it for 60 – 80 rods and flat surface. Boulderly knoll 20' high east of road 30 – 50 rods opposite center of sec. 34. Very boulderly with till of reddish color near surface in south part sec. 34. Low knolls and ridges with rows of boulders imbedded in sec. 3, altitude 650 – 660'. Till seems to be near surface as far as Egg Lake in NE part sec. 9 and NW of sec. 10. On road west on line of 4 & 9 there is deeper sand 670 at corner secs. 4, 5, 8, 9, also a mile south.

Cobbly beach 675' crossed 100-120 rods south of corner secs. 8, 9, 16, 17, runs NE – SW. Sandy stony loam several feet deep in these four secs. 8, 9, 16, 17, also in secs. 20 & 21. Well in NW part of sec. 16 is 105'. Altitude at well 670' (barometric) 675 at corner secs. 16, 17, 20, 21. 700 at quarter post of secs. 20 & 21. 710 on beach line about 1/4 mile from south end of line of secs. 20 & 21. 700 at line of secs. 21 & 28 where a road starts east. 735 on highest Algonquin beach in NW part sec. 28 and along road SW past west side of Fox Lake and Greene's Lake. Fox Lake is around center of sec. 29 and not in NW part of sec. 28 as given on map of Mich. Highway Dept.

Mr. Hewett and I went down from Greene's Lake to the Lake Michigan shore and ran hand levels to Greene's Lake along a road that runs directly from Lake Michigan to this lake. The distance by direct line is about 0.6 mile – so Greene's Lake is likely to be near center of sec. 31 instead of SE part.

Chain – 66'

Levels from Lake Michigan to Greene's Lake across sec. 36 into sec. 31.

|                         | <u>Distance</u> | <u>Altitude</u> |
|-------------------------|-----------------|-----------------|
| Base of Nipissing bluff | 34 ch.          | 618' Nipissing  |
| Top " " "               | 16 "            | 695'            |
| Weak Algonquin beach    | 24 "            | 702'            |
| Algonquin beach         | 27.77 ch.       | 714'            |
| " " "                   | 30.73 "         | 721'            |
| " " "                   | 39.13 "         | 725'            |
| " " (On RR grade)       | 39.6 "          | 725'            |
| Road (main highway)     | 40.6 "          | 726.5'          |
| Algonquin beach         | 41.7 "          | 730'            |
| Highest Algonquin beach | 45.1 "          | 735' Algonquin  |
| Greene's Lake           | about 48 "      | 725'            |

Moraine above Algonquin Level

There is a bar of the highest Algonquin past west side of Greene's Lake. The land is morainic on north side and west from south side across south part of sec. 31. There is moraine to the NE past south side of Fox Lake and marshy land east of it into sec. 28 nearly to north side of that sec.

A lake survey tower is located on almost the highest point on the moraine in south part of NE 1/4 sec. 32. The moraine extends east from there into sec. 33 and is in plain view from Fox Lake. We continued from Greene's Lake SW and came into the edge of the moraine in SW part of sec. 31 and were in it along or near line of secs. 6 & 1, nearly to Miller's Marsh in SW 1/4 sec. 6. The highest Algonquin beach lies on the west side of this marsh and seems to border it on south also. This seems to be at the SW end of the moraine that stood above the highest Algonquin beach. The beach appears to run north of east from this marsh as the land is lower to the east and south.

The Nipissing bluff borders the shore of Lake Michigan closely on west side of Beaver Island from where we crossed it west of Greene's Lake northward to within 2 miles of north end of the island, the distance from present lake being seldom over 40 rods. To the south from where we crossed it in secs. 1, 12, 13, T 37 R 11 W, it lies back more than 1/4 mile or about 1/4 mile east of the west line of these secs. It turns east in SW part of sec. 13 and runs near corner of secs. 13 & 24, 18 & 19, into T 37 R 10 W, and continues in a course south of east across secs. 19 & 20 into sec. 21. There are prominent dunes in sec. 21 that were conspicuous features as seen from the boat.

There is said to be a gentle rise westward from Geneserath (?)\* Lake but NE of the lake there is an abrupt rise in sec. 10, T 37 R 10 W. There is a strip of hardwood timber for 2 miles NE of this lake in secs. 2, 3, 10, 11, and south part of sec. 35 and westward from there to Fox and Greene's Lakes. NE of this is a jackpine plain covering much of secs. 23, 25, 26, 35, 36, T 38 R 10 W and extending into sec. 27. The settled part of the island is north from this sandy area in north half of T 38 R 10 W and in T 39, R 10 W.

Studies on Beaver Island

August 31, Beaver Island, Michigan – beach at St. James. Aneroid 29.490 at 6:40 A.M. at lake level = 581'. I go south with Mr. Hewett on road called the "King's Highway" through secs. 27 & 34, T 39 R 10 W and secs. 3, 10, 15, 22, T 38 R 10 W. This crosses ridges of till with WNW – ESE trend that are probably washed down drumlins. Their crests are about 650' and catch the Fort Brady wave action so there are reefs of boulders on them that are irregular and disjointed, so do not line up like beaches. They have stony concentrate over till. Near center of sec. 10 there are pretty good beach ridges of gravelly material. Gravel is also found near base of the slopes between the drumlin ridges and the

swamps. The swamps are 625 to 635' while the reefs and lake bars are about 650 – 655' by aneroid. There is a reef in north part of sec. 15 and others near center and one near north side of sec. 22 and one near center. A gravelly terrace lies between it and a small stream south of center of sec. 22. The barometer reads 660 at south end of road at line of secs. 22 & 27.

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[\* Stenog's (?)]

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### Nipissing Beach

We go east 3/4 mile descending to the Nipissing shore at about 615 – 620'. There is sandy land from here to the shore in secs. 23, 26 & 25 and southward in much of sec. 35 and all of 36. Where the Nipissing lake cut into the ends of drumlins in secs. 14 & 23 there is a bouldery flat showing how far the shore has cut back into the ridges. In some cases it is 40 – 50 rods and the cliff is 20 – 25' high. This shore is about 1/4 – 1/3 mile from present lake shore in north part of sec. 23 and in sec. 14. It there continues a little west of north not far from line of secs. 10 & 11 and is about a mile from present shore near corner of secs. 2, 3, 10, 11. Drumlins in south part of sec. 2 cause the Nipissing shore to return abruptly eastward 1/2 mile or more and cross the road that runs north across sec. 2. The Nipissing shore passes around the SE end of this drumlin and then runs northward not far from N – S quarter line of sec. 2 into sec. 35. There is a wave-cut cliff of Ft. Brady age at the road on crest of the drumlin in south part of sec. 2. It is only 5 – 6' high and 10 – 15 rods of wave swept terrace east of it, so it contrasts strikingly with the strong cuts made by the Nipissing lake. The Nipissing bluff in sec. 35 is 20'± high. The Ft. Brady is at the top or near it in sec. 35. It turns west in sec. 34 and runs past the church and Weather Bureau Station in north part of sec.

### Nipissing Shore

There is a sandy bar of Nipissing across NE part of sec. 34 to a drumlin ridge in south part of sec. 27. This drumlin rises high enough to catch the Fort Brady beach in west part of sec. 27 on NE side of Font Lake. The Nipissing follows the north base of this drumlin and runs to the narrows of Font Lake in sec. 28 and also around north end of the lake. There are prominent dunes west of the north end of Font Lake in secs. 28 & 29 and dunes run along the shore north and east around north end of the island. Most of the land in St. James and eastward is 20' or less above the lake but there is a higher place near center of sec. 23 perhaps 50' above the lake. I took boat back to Charlevoix at 1:30 P.M.

### On Railway Charlevoix to Grand Rapids

September 1, 1922 – Charlevoix to Grand Rapids on P.M.R.R. The Algonquin shore looks to be higher on Pine Lake than the wavewashed border of Intermediate Lake. There may be need to run hand levels from some station such as Central Lake to determine this.

On Grand Traverse Bay and on Torch Lake and Elk Lake there was certainly free access of Algonquin waters. The railway cuts into moraine with boulders as it rises toward Grawn after turning west from Boardman valley but is in outwash plain before reaching Grawn. The moraine on west side of the railway from near Interlochen to Thompsonville seems to be more nearly continuous than my State map indicates.

The village of Wellston about 3 miles from Manistee River has a productive farming area around it. There is a rapid rise south of Peacock to the lake that lies east of the railroad and still more to a moraine crest south of the lake. The descent from this crest to Baldwin does not seem to be very much, but this matter needs verification from the railway profile. Prof. Sauer thinks my mapping of moraines in Lake County was poor but I have not learned where he found the errors.

From Newaygo and Lake County line to Grand Rapids I made some observations two years ago when looking for gravel for the Highway Department that led to revision of my earlier work.

I went by P.M.R.R. to Lansing, then on electric to Jackson, having missed the M.C. train at Grand Rapids.

September 3 I went to John Groves farm 3 miles south of Ypsilanti and find that at the farm the beach of Lake Whittling and a narrow strip of alluvium along Stony Creek there is clay instead of sandy gravel. Along the bottom lands of Stony Creek logs are imbedded to depth of several feet some of which are now exposed in gullies.

September 5 I went by electric cars from Ann Arbor to Grand Rapids via Battle Creek and Gull Lake thus having opportunity to review my mapping made some years ago south of Grand Rapids. I took night train on G.R. & I.R.R. to Boyne Falls.

### Studies near Boyne Falls

September 6, Boyne Falls – I went south into sec. 28 to see whether a moraine crosses the swampy lowland from sec. 20 to sec. 33, Boyne Valley Twp. but find there is only the one prominent hill near the center of sec. 28. It is about 5' above surrounding plain. There is a swamp south of it fully 1/2 mile wide. The land is not wet to the north and the space is narrower between this isolated hill and the high moraine in secs. 20 & 21. It is scarcely 1/2 mile. The hills east and west of the G.R. & I.R.R. are near together just south of Boyne Falls – scarcely 1/2 mile of lowland.

Notes from Profile of B.C.G. & A.R.R

|                                       |                              |
|---------------------------------------|------------------------------|
| Beginning of profile in Royno City    | 586.5'                       |
| Plain just east of MP 1               | 647'                         |
| " at MP 2                             | 670'                         |
| Ridge 4 ch. east of MP 2              | 679' (track 672')            |
| Plain at MP 3                         | 666'                         |
| Plain at MP 4                         | 681'                         |
| Plain at MP 5, by road, (track 690)   | 699' (line of secs. 9 & 16)  |
| MP 6 near Moore 2 ch N. of E - W road | 717' ( " " " 16 & 21)        |
| MP 7 south of Royno River 2 chains    | 740'                         |
| Road crossing (not surface)           | 762' (line of secs. 27 & 28) |
| MP 8 Not surface                      | 775'                         |
| MP 9 " "                              | 822'                         |
| County line Charlevoix & Antrim       | 861' at 9½ miles             |
| MP 10                                 | 919'                         |
| MP 11 at road crossing                | 990'                         |
| MP 12                                 | 1100'                        |
| MP 13 (G.R. & I.R.R 2 ch east)        | 1189'                        |
| MP 14                                 | 1260'                        |
| Overhead highway bridge 38 ch east    | 1298' on track               |
| Mosher Station east of highway        | 1311'                        |
| MP 15                                 | 1324'                        |
| Marion 5 ch west of MP 16             | 1352'                        |
| MP 16 top of cut                      | 1375'                        |
| Halleck 3 ch W of MP 17               | 1310'                        |
| MP 17                                 | 1300'                        |
| MP 18 at east end of cut              | 1374'                        |
| Not surface 6 chains west of MP 18    | 1281'                        |
| 9 ch east of MP 18                    | 1275'                        |
| MP 19                                 | 1265'                        |
| Cameron 19½ miles                     | 1360'                        |
| MP 20                                 | 1340'                        |
| MP 21                                 | 1309'                        |
| MP 22                                 | 1226'                        |
| MP 23 also Gaylord 18 ch east         | 1342'                        |
| MP 24                                 | 1342'                        |
| MP 25                                 | 1308'                        |
| MP 26 not surface                     | 1304'                        |
| MP 27 5 ch east of highway            | 1209'                        |
| MP 28                                 | 1154'                        |
| MP 29 at spar                         | 1118'                        |
| MP 30 at road                         | 1097'                        |
| MP 31                                 | 1060'                        |
| MP 32                                 | 1054'                        |
| MP 33                                 | 1042'                        |
| MP 34 at Marl                         | 1043'                        |
| MP 35                                 | 1021'                        |
| MP 36                                 | 1025'                        |
| MP 37                                 | 1030'                        |
| MP 38                                 | 1033'                        |
| MP 39                                 | 1045'                        |
| MP 39½ summit not surface             | 1063'                        |
| MP 40 at Gibbs                        | 1036'                        |
| MP 41                                 | 1019'                        |
| MP 42 between _____ and Whiting       | 964'                         |
| MP 43                                 | 969'                         |
| Black River 10 ch west of MP 44       | 926'                         |
| MP 44                                 | 926'                         |
| MP 45                                 | 921'                         |
| MP 46                                 | 940.5'                       |
| MP 47                                 | 945'                         |
| Summit near 47½ not surface           | 976'                         |
| MP 48                                 | 929'                         |
| MP 49                                 | 918'                         |
| MP 50                                 | 905'                         |
| MP 51                                 | 894'                         |
| MP 52                                 | 883'                         |
| Atlanta 10 ch W of MP 53              | 886'                         |
| MP 53                                 | 883'                         |
| MP 54                                 | 870'                         |
| MP 55                                 | 878.4'                       |

This is close to Thunder Bay River and the railway follows down this valley for some distance. I took no further notes. I corrected the position of the railroad in secs. 21, 27, 28, 34, Boyne Valley Twp. as it is now in a new course east of the old one shown on the county maps. It has a direct course from Moore Jc. in sec. 21 to base of morainic hills in sec. 34.

Studies North of Pine Lake

In the afternoon I went by auto along north side of Pine Lake to Horton's Bay, then north over the hills along line of secs. 31 & 32, 29 & 30, 19 & 20, 7 & 8, Bay Twp. & Resort Twp. sketching in the main drumlins. There are some sharp knolls in SE part of sec. 31 at lower altitudes than the drumlins north and east from them. There are also similar knolls west of Horton Creek in sec. 36,

Hayes Twp. They have a morainic aspect. I am inclined to view that where such knolls appear in low ones and drumlins are higher places that the ice readvanced over a moraine and shaped the prominent parts into drumlins but did not have much effect on low parts of the moraine.

I went to Bay Shore and then down Horton Creek valley through secs. 13, 24, 25, 36, Hayes Twp. along or near west edge of a passage of Algonquin waters across from Little Traverse Bay to Pine Lake. There is an Algonquin gravel bar or set of bars across the north end of this passage that forms the divide at head of Horton Creek. There are points above Lake Algonquin east of this road in south part of sec. 12 and north part of sec. 13 and also in south part of sec. 13 but in secs. 24 & 25 the west bluff is west of this N - S quarter line road, in some places 40 - 60 rods.

The angling road in sec. 36 runs near the west bluff and that east of Horton's creek in sec. 31, Bay Twp. near the east bluff. This passage is nowhere over a mile wide and in places about 1/2 mile. It is only about 1/4 mile at line of sec. 12 & 13, Hayes Twp. There are sandy flats in it south from sec. 13 but in that sec. the surface is uneven. I followed the highway on north side of Pine Lake from Harbor Creek valley westward to Charlevoix. In places the Algonquin shore is a little south of the highway in secs. 1 & 2 while in places it is 1/4 mile or more north of it, as in NW part of sec. 2 and NE of sec. 3. Susan Lake is shut in at both ends by bars of Lake Algonquin - and is below Algonquin level.

Dune 765'

September 7, 1922 - Charlevoix. I leveled from the lake on top of Mt. McSauba and found it to be 185' above the lake at the east side of the tower. This is about 2' higher than east base of the tower. There is a gravelly beach formed by water on south side passing E - W into the sandy belt south of Mr. McSauba which by hand level is 57' above Lake Michigan or 638' A.T. This may be the Fort Brady beach. There is, however, a gravelly bar on the clay plain south of this 10' lower or 628'. The Nipissing here is about 608 - 610' A.T. or between 25 and 30' above Lake Michigan and there are lower Nipissing ridges down to less than 10' above the lake.

Features near Charlevoix

I made tracings at Court House of the several islands in the Beaver Island group for use in field work on scale of 2 inches per mile. In the afternoon I examined "2 Mile Point" west of Charlevoix. It has considerable rubble and some bouldery material covering the limestone ledges. There is a large amount of angular limestone so the lake action seems to have been remarkably ineffective where such material is at surface. The present beach has scarcely say stones that do not show rounding by wave action. Large boulders are numerous all around this point as well as in the recess between it and Charlevoix.

## On Beaver Island

September 8, 1922. I went to Beaver Island in forenoon by steamer Bruce from Charlevoix. In afternoon I made the circuit of Font Lake. There are pebbles in the sandy ridges at its north and up to about 20' above the lake but they are scarce and heavily cobbles with an occasional small boulder. There are dunes near the lake in NE part of sec. 28 and south edge of sec. 21 that are subject to shifting now. They rise 40' or more above the lake.

## Studies on Beaver Island

Font Lake seems to be 20 – 25' above Lake Michigan. There is a cobbly ridge crossed by the railroad grade in NW part of sec. 28 that runs N – S. Its crest is 27' above Lake Michigan by hand level. There is a wave-cut cliff on its west side 15' at base above Lake Michigan. There are grassy marshes between sandy ridges between this and the lake. The railroad grade passes through a depression between dunes that rise to heights ranging from 20' or less up to more than 100' above the lake. The most prominent are in west part of sec. 28 less than 1/4 mile from the present shore, and there are lower ones close to the shore. There is a pebbly sand along the shore with an occasional boulder. I followed the shore south a mile and took a private road leading across central part of sec. 32, rising step by step over sandy ridges until a height of 90' above the lake. The highest ridge is evidently wind formed. It stands 15 – 20' above a boulder strewn plain east of it. The sandy ridges west of it up to about 70' above lake level are probably shore lines like the present. They are a few rods wide and run in parallel courses each one a few feet above its neighbor to the west (5 – 6'±) and all with crest lines about as regular as in gravel beaches. The dunes are much more irregular.

I found the Fort Brady beach east of the dune strip in east part of sec. 32. It is slightly higher than bouldery plain to the south. There are parallel bars of this pebbly sandy shore running west into sec. 32 (NE¼) from the NW part of sec. 33. The highest ridge does not extend into sec. 32 but curves around to the south on south side of the wagon road in NW¼ sec. 33 and dies out. This is a prominent feature in its entire course across north part of secs. 33 & 34 standing 8 – 10' above the plain on its inner (north) border and 5 – 6' above that in the south or outer border. There are boulders scattered along it and on its inner slope east from the N – S quarter line of sec. 33 but very few west of that line. But the plain to the south is boulder strewn westward into sec. 32.

There is a low boulder strewn till ridge on south side of Font Lake that seems partly in sec. 28 and partly in 33. It is like that on NE side of the lake in sec. 27 in being drumlin shaped but much washed down. Probably Font Lake is within the area covered by the highest stage of the Nipissing Great Lakes. There is wet land on its borders in sec. 28 between it and the dunes that seem likely to have been under the Nipissing waters. The

prominent dunes may also cover an area in which pebbly material is all lower than the Nipissing waters at their highest stage. I am, therefore, inclined to put all of sec. 28 in the Nipissing area and all of sec. 27 except the drumlins just mentioned.

Levels near St. James, Sept. 9. Base of steep cut bluff in S. part of village 10'. The bluff has pebbly sand. N – S highway in front of a house with shingles on sides as well as roof, painted red, 34'. This is height of a plain on which low sandy bars about 2' high run N – S parallel with present beach. The summit on road 35 – 40 rods south is 45'. This is on a sandy ridge and may be 5' above lake. The lake was probably fully 620'. This bar is 625 – 626'. Present lake is 580.6'.

I went south across the Ft. Brady beach in north part of sec. 34. This is on a bouldery ridge – south of it the land is lower past Round Lake in sec. 3, T 38. The full limit of the lake is there marked by a gravelly beach that runs eastward from south side of Round Lake to the "King's Highway" on N – S quarter line of sec. 3 and then ESE in south part of NE¼ sec. 3 into sec. 2 to the N – S road. There a wavecut bank which I noted a few days ago marks its position where it crosses a drumlin.

I went with some of the men in the Survey camp to corner of secs. 8, 9, 16, 17, and then east on line of secs. 9 & 16 to determine the course of the Battlefield beach. There is a stony reef crossing the road near the quarter post that is about the level of this beach. There is lower land to the east. The Battlefield beach is likely to take a southward turn toward center of sec. 16.

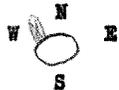
There are stony reefs near corner of secs. 9, 10, 15, 16, that run from there south of east across north part of sec. 15 that stand about 15' lower than the Battlefield beach or 660' by aneroid. There are others near center of sec. 15. I went from center of sec. 15 west across sec. 16 and came to conclusion that the waters at time of Battlefield beach covered much of sec. 16 and formed the cobbly bar that crosses the NW part of the sec. at an especially exposed place for wave work.

I went south to the Algonquin beaches near corner of secs. 20, 21, 28, 29, and out to the camp in sec. 29 for dinner. I then went east on road on line of secs. 21 & 28 and found that the Algonquin beaches are south of this line except one 710' beach that crosses the south part of SW¼ sec. 21 in an ESE direction passing into sec. 28 about 60 – 80 rods from west end of line. There is a lower beach near east end of line of secs. 21 & 23 reading 690' by aneroid that cuts into the SW corner of sec. 22 and turns south into sec. 27 about 50 rods from west end of line of 22 & 27. This is a gravelly beach.

There is a lower beach of altitude corresponding to Battlefield (if aneroid is reliable) that curves around through SW part of sec. 22 and runs into sec. 27 about 80 rods from west end of sec. line. It also is gravelly. I went to the middle of line of secs. 22 & 27 where the King's Highway comes in from the north and got a reading of 660' there, the same as a few days ago. So it seems very likely that the lower of the two gravelly

ridges west of here is Battlefield beach. The one at 690' is below the other Algonquin beaches but may be of that series. If it is developed on line of secs. 20 & 21, it is very faint and ill defined.

There is a beach or bar at 665' running ENE from near center of sec. 34, T 39 N. There is one segment only 30 – 40 rods east of King's Highway. Another sets in about 80 rods east and runs nearly to the sec. line of secs. 34 & 35. This has boulders imbedded in cobble and gravel. It stands 6 – 8' above border land each side that shows wave washing. Perhaps it was shoved up by ice jams and is an ice rampart. Its crest is less regular than the beaches over which waves have rolled. I examined the clay area on east side of Font Lake and find a low clay ridge runs into the recess in sec. 28. It is only 6 – 8' above the Nipissing level. The drumlin south of it is fully 25' above Nipissing at the place where a Ft. Brady beach is formed on it. This is shaped like a staple



There is a slight saucerlike depression on side the ring part – this ring is only 15 – 20 rods across. Font Lake is only a little below the highest Nipissing beach perhaps 5' or not far from 620'.

#### On Garden Island

Sept. 10, 1922 – Trip to Garden Island. Aneroid 29.370 at Lake Michigan level is 581'. The island is so low that it does not reach the highest level of the Nipissing waters. I found nothing above 620' A.T.

I went from the harbor near center of sec. 2, T 39 R 10 W NE past the church and the schoolhouse to Mr. Jensen's on the north shore.—In north part of sec. 36, T 40 R 10 W. There is a gravelly shore line at an Indian's clearing north of the church that is 615'. At the schoolhouse about midway between the harbor and the NE shore there is a sandy shore line 620'. A clearing SE of the schoolhouse of 20 – 30 acres is nearly level sandy and slightly pebbly material about 615'.

North from here there is much balsam and white cedar and wetter land than to the south. This wet land has beaches in it that stand 3 – 5' above swales between them but these as well as the swales have cedar & balsam. The SW border of the island has a "hardwood" forest with considerable maple.

There may be limestone at slight depths on Garden Island for I find angular strips in swales between the beaches that look to be the top of a limestone ridge. The exposures are too slight to make clear whether rock is in [6?]. This matter will be given attention by the Soil Survey party. There are a multitude of Nipissing shores covering nearly all of the island, the beaches being only a few rods apart.

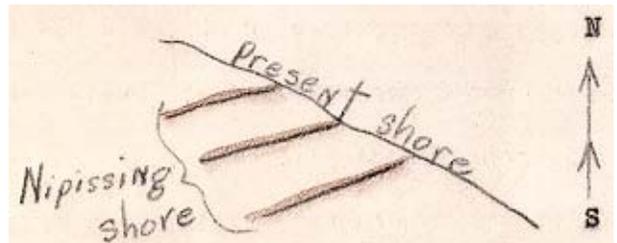
September 11 – St. James.

Low for whole width of sec. 22. But in sec. 21 gravel is 34' above Lake Michigan in the bluff. I go south to N. end of Font Lake and level to the cobbly material there and find it 15' above the lake. The lake is fully 615' so this is a few feet above the ordinary highest Nipissing; - Nipissing shore bearing west in west part sec. 28 at RR grade is 516 paces or about 83 rods from present shore. It is only 480 paces from present storm beach. Dune in sec.28 is 184' by hand level, 175' by aneroid. It is about 1/4 mile from shore and is known as Mt. Pisgah. There are no others in this strip along the west side of Beaver Island so high. And about a mile north has trees on it perhaps 50' high, the tops of which are scarcely up to the height of the dune I am on.

I went around Indian Point at the extreme NW part of Beaver Island. There is a bouldery strip of very shallow water for 20 – 30 rods into the lake for 1/2 – 3/4 mile south from the tip of Indian Point. The shore is also thickly set with limestone fragments so I suspect there may be a ledge here almost at lake level.

East from Indian Point there is a boulding pavement along the shore in places completely covering the soil for a width of 20 – 30' or more. The shore is very low for 1/2 mile both south and east from Indian Point. About 1/2 mile east the Nipissing beaches come to the shore and it gets more and more prominent as one goes east of sec. 20 into sec. 21 to where I leveled this morning and found it 34' above present lake level.

Near the center of sec. 21 the Nipissing shore lines come in from the WSW to the present shore and are cut off one after another.



Relation of present shore to Nipissing shores in sec. 21 near St. James.

#### Studies on Beaver Island

The higher Nipissing beaches do not seem to come into sec. 22 & 23 and NE part of sec. 27 (in village of St. James), there being pebbly material scarcely to 20' above present lake level. But in sec. 21 & 28 and NW part of sec. 27 and pebbly material gets up to 35 – 45' above the lake, the highest altitude noted being at N. end of Font Lake where it seems to reach 630'.

I noted boulders in wet land close to the NW end of Font Lake. They may have been drifted in here by ice on the lake from the edge of the boulding drumlin ridges that border the lake closely on each side near its middle part

and in NE side to the SE end, for I see no evidence of till here.

A change from pine to maple forest sets in opposite the north end of Font Lake. There is mainly maple in west part of sec. 21 and in sec. 20 except near the shore where cedar, balsam, etc., occur. In the hardwood there is sand, some of it the ordinary dune sand, so the soil is no heavier than in the pine forest but it is more moist. Is this because of vapor from Lake Michigan brought in by west winds?

There is considerable red oak with pine in vicinity of St. James. Bluff at west end of road near corner secs. 5, 6, 7, 8, is 84' above the lake or 665'. Barney's Lake is in a depression below Lake Nipissing, its altitude being about 610'. There are dunes at its west end. The Nipissing beach is formed around the east end of the lake as a steep cut bank 15' or more in height south of the depression in which Barney's Lake lies is a boulder stream plain about 665 – 670'.

Sept. 12, 1922. I went out to the camp by Fox Lake and followed the highest shore east along north side of Fox Lake and a muskig east of it past the line of secs. 28 & 29. The beach there swings around to the south at east end of the muskeg into sec. 33. South of Fox Lake is higher land that is shaped into drumlin forms trending WNW – ESE. The lake survey tower is on one of these in SE part of NE¼ sec. 32. It reads by barometer 15' above the altitude of Mt. Pisgah or 780'. It is only 20' above the level strip south of it but is 45 – 50' above the wet land in the NE, this being nearly at level of Lake Algonquin. There is land above the level of Lake Algonquin to the east of the wet strip. From the tower it appears to reach nearly to east side of sec. 33 or about a mile. It has a sandy boulding drift where I went into it NW of center of sec. 33. The drift is sandy at the tower, a loamy sand with a moderate number of boulders. None of the uprooted trees show any clay nor is clay reached at 3' by auger borings.

There is red clay in ridges near Font Lake that have been washed down by lake action. Possibly these ridges near the Tower that stand above the highest Algonquin have a clayey base but I see no evidence of it.

From the tower we went west in sec. 32 to the old railroad grade coming to it about 80 rods west of center of sec. 32. We followed it northward to the wagon road in sec. 29 near SW corner of that sec. Ohio RR grade cuts a sand ridge that seems to be wind-formed in NW part of sec. 32 on all sides of which are glacial ridges of bouldery sandy drift. It is less than 1/4 mile from the Algonquin shore and its base is nearly as low. It is 10 – 12' high and has E – W trend for 40 rods and mainly east of the RR grade.

In the afternoon I tried to trace the Battlefield beach SW across sec. 17 but it dies out before reaching the south side of the sec. and I was not able to find any definite ridge farther SW. I want fully 80 rods beyond the line of secs. 17 & 20 into land that is flat and bouldery.

Sept. 13. I went with Mr. Schoenemann from the camp on north side of Fox Lake in sec. 29 past the U.S. Lake Survey tower in east part of sec. 32, taking a barometric reading there of 780'. We take a road leading SE past south side of the drumlin in which this tower stands and come to the highest Algonquin shore about 100 rods east of the line of secs. 32 & 33. (110 rods by course of the road). The shore runs southward here and curves to the line of secs. 4 & 33 about 80 rods from west end. There is a ravine coming in from WNW near this sec. line. We map the shore southward and find it crosses into sec. 5 about 120 rods from north end of sec. line of secs. 4 & 5, T 37 R 10 W. The shore continues with this trend about to center of SE¼ sec. 5. It then swings around to a westward course across NW part of sec. 8 and runs near line of secs. 6 & 7 past south side of Miller's Marsh. At an old camp near line of secs. 5 & 8 there is a prominent gravelly ridge higher than the level back of it to the NW. It is likely to have the level of the highest Algonquin beach. There is a wet strip of land running about parallel to the highest shore line and 1/4 mile from it on the SE in secs. 4, 5, 8, T 37 R 10 W – (765 where road crosses line secs. 4 & 5. Algonquin shore E is 37 rods. 705 in swamp in NW part sec. 4)

The swamp is about 25 – 30' lower than the highest Algonquin beach. It has spruce or balsam. The beaches are in Maple forest. There are drumlin shaped ridges north of Miller's Marsh in sec. 6 that trend WNW – ESE. The road bears east of north all the way from Miller's Marsh to Green's Lake. It is in the edge of the drumlin area above Lake Algonquin level nearly all the way to Green's Lake but the border of Lake Algonquin is near by, less than 1/4 mile at any point.

There is a drumlinoid hill in NE part of sec. 5 on which the barometer read 780' or the same as at the Lake Survey tower. There seem to be several that are within 10' of the height of the one at the tower in sec. 32 and secs. 5 & 6. Mr. Schoenman thinks Miller's Marsh is mainly in sec. 7. The beach I followed past the camp near line of secs. 5 & 8 runs just east of the quarter post of secs. 5 & 8 and near the quarter post of secs. 7 & 8. It passes westward not far from center of sec. 7 and then it runs NW into SW corner of sec. 6.

There is high land nearly up to the level of the highest Algonquin beach for about 2 miles south of Miller's Marsh. It seems to cover the north part of sec. 18 as well as sec. 7 and into east part of sec. 12 and NE of sec. 13 (T 37 R 11 W). There is an abrupt drop of 40' to the level of the Battlefield beach about a mile from south end of Beaver Island. It is not far from quarter post of secs. 13 & 18. The drop to the Nipissing is just south of corner of secs. 13, 24, 18 & 19, so I was informed by Mr. Topolinski, a land looker, who is stopping at the Hotel Beaver in St. James. The plain below the Nipissing level is scarcely 1/4 mile wide in sec. 19.

Nip. 620 – 25  
A.B. 650 – 655 & 660 – 665  
B 675  
Alg. (702  
      (714  
      (721  
      (728  
      730  
      735

29,445 at Lake Michigan level at south end Beaver Island

Levels to lighthouse

Top of red till 22'

Gravel flat 28'

Light house level of ground floor of dwelling 60'

A well at the lighthouse 133' deep does not reach rock – the water is from gravel at bottom. Its altitude is 60' above Lake Michigan. A well at Fog Signal Station is 82' deep on ground 8' above lake and has head – 6'.

It stopped in fine gravel with pebbles "size of beans".

Data by Dominick Gallagher – Beaver Island Lighthouse.

There is a stony plain just east of the lighthouse 50' above lake level with a few boulders in view. But the road soon descends to a lower plain about 20' above the lake. The highest dune about 40 – 60 rods NW of the lighthouse is 725' by aneroid or 145' above Lake Michigan. It is in sec. 20 and is 40 – 60 rods back from the lake. There are lower dunes nearer the lake. I followed the road on east side of Beaver Island northeastward to line of secs. 23 & 26, T 38 R 10 W – or a distance of 10 miles. There are dunes all along this shore, those in the area marked "Hardwood" near Coles' Mill in sec. 10 & 11 being as conspicuous as the ones between the lighthouse and Lake Geneserath. There is a gravelly plain 30' above the lake close to it in sec. 1 and south part of 36. The T. J. Bonner Lighthouse, Beaver Island.

Sept. 15, 1922. I went from St. James south and leveled to the Ft. Brady beach in north part of sec. 34 on the "King's Highway" – 753'. There is sandy gravel here and for 1/2 mile west on the ridge. But in sec. 33 there is a bouldery, gently undulating surface along the highest part of the ridge and shore features are not clear. The altitude seems to be about 650' on this ridge. There is lower land in south half of sec. 33 and past the center of sec. 4. So the Ft. Brady shore runs SW from Round Lake past south side of Barney's Lake.

The bars of sandy gravel that run west into sec. 32 from NW¼ sec. 33 are about as high as land to the south until one passes Barney's Lake. I find the Nipissing shore south of Font Lake runs south of the line of secs. 28 & 33, 20 – 40 rods in the NE¼ sec. 33 and still farther in the NW¼. It is cut into the slope of a bouldery ridge that lies in north part of NE¼ sec. 33. This ridge does not seem to have clayey till in it like those in NE side of Font Lake but is of cobble and coarse gravel with boulders

scattered over it. There is a gravel pit in it in central part of NE¼ sec. 33 – north of a dwelling about 20 rods.

I went to a dune sand ridge that starts at Font Lake about 60 rods north of line of secs. 28 & 33 and runs WSW toward the NW corner of sec. 33. It is 675 – 680' where it starts next to Font Lake.

Dunstone on Beaver Island – In the P.M. I got pick & shovel & dug into a rock ledge E. of the lighthouse near Mr. Bissell's house about 100 yds. from water's edge. There is an outcrop on the shore SE of Bissell's house of several square yds.

I got a specimen at the pit back from the shore that shows a coral and a mollusk and bits of other fossils that may serve to identify the geological horizon. It is a pure limestone and may be of value to him for lime. I am told Mr. Bissell had to drill his well in rock and that his cellar is in rock. His house is about 200' from where I dug toward the west. I dug in a hole that had apparently been opened by someone else to test for limestone as a lot of angular limestone blocks were lying around it.

Near the lighthouse a well was dug 12' and it was in loose material so it had to be curbed the entire depth. The beach material is much more angular here than it is 60 rods north. There the well rounded pebbles are the dominant material.

There are dunes to within about 40 rods of the south end of the lighthouse point, rising 10 – 20' above the level of the pebbly material or 30 – 40' above the lake.

I am told at the hotel that the Mormons had a limekiln east of where the Catholic church now stands along or near the base of the Nipissing bluff. Perhaps they used the limestone blocks that are scattered over the island many of which are to be seen near this place.

Well 82' Dune 246' above Lake Michigan "Mt. Lookout". Trip to and Studies on High Island.

Sept. 16. We went to High Island in boat Sylvia. The east side has the sandy land as far up as the Nipissing shore about 32 rods east of 1/4 post of secs. 28 & 33. There is bouldery till west from here to the high sand dune "Mt. Lookout" in NE corner of sec. 32. This is 246' above Lake Michigan as determined by the recent Lake Survey. There are bouldery reefs in west part of NW¼ sec. 33 and SW¼ sec. 28 that are 80 – 85' above the lake. The well on ground between these reefs in SW part of sec. 28 is said by the residents to be 84' above the lake and is 82' deep. The water is drawn by a long bucket 6 inches or less in diameter.

Gull Island in view to the west is very low. South Fox Island in view to the SSW has steep cliffs or banks at its NW and probably 150' and this high part is level. The greater part of the island has a serrated appearance as if of dunes. The North Fox is high at east end and is considerably lower than the South Fox. Whiskey and Squaw Islands lie NE of High Island – are both low not up to the full Nipissing level. The "Cat Head" at N. end of Leelanau Peninsula is also in view to the south. The

mainland in Emmet Co. is plainly visible over Beaver Island.

The Northern Peninsula is in view from the Garden Peninsula around to St. Ignace or from N 60° W to N 45° E from my viewpoint in High Island. I followed the Nipissing bluff eastward from where it leaves the dunes in SW part of sec. 29 in a course north of east to central part of sec. 28 where it makes an abrupt turn southward through west part of SW¼ sec. 28. Mr. Walter Nelson of the "House of David" outlined for me its position in these secs. It runs across NW¼ of SE¼ sec. 29 in NE course passing a few rods south of the NE corner. It then crosses from the SE¼ into NE¼ sec. 29 and leaves the sec. a few rods north of the quarter post of secs. 28 & 29. It runs near the E – W 1/4 line of sec. 28 nearly to the center and then swings around a few rods SW of the center and takes a southward course through west part of SE¼ sec. 28 and continues nearly to center of sec. 33 in a course slightly west of south. There is only a slight bank to mark its course in sec. 33 and the bluff is 10' or less in west part of SE¼ sec. 28. There is not a definite bluff in southwest part of sec. 33 but the altitude \_\_\_\_\_ gently to the SE and the land is wet in much of the SW¼ of the sec. Mr. Nelson has noted boulders in this wet land. It is not like the sandy land that occupies the east part of sec. 28 and north part of NE¼ sec. 33. There is a maple ridge with boulders running south through the east range of forties in sec. 5 that has considerable relief above land east and west of it and Mr. Nelson thinks it is at least 50' above Lake Michigan. It has a red clay subsoil. There is swamp land in secs. 4, 8, 9 except a little gravelly beach near the shore. In sec. 5 the lowland west of the maple ridge has a sandy gravel soil and is drier than land south of it.

The strip of dunes terminates in north part of SE¼ of NE¼ sec. 5. The NE¼ of NE¼ sec. 5 is occupied by them and they cover sec. 32 except a narrow strip on the east side 10 – 40 rods wide that is good farm land, and stands 70 – 80' ± above the lake. There is also a narrow strip of good farm land north of the dunes in north part of NE¼ sec. 32. The dunes turn north in sec. 29 and have the east border just west of the N – S quarter line and project into the area north of the wavecut cliff of the Nipissing Great Lakes about to center of sec. 29 with considerable prominence. Mr. Schoeneman was in sec. 33 today and found a wavecut cliff in S. part and in sec. 4 that indicates that a small area in NW part of sec. 4 is above Lake Nipissing.

Flowing well in St. James 285'. On High Island.

This island does not have drumlins nor morainic ridges. The bouldery part has a very gently undulating surface. I am told by Walter Nelson that there are no outcrops of rock ledges on the island but blocks of limestone are common. In St. James there is a flooding well at the base of a steep bluff in S. part of the village at an altitude of about 5' above the present lake level. It is owned by Miss Grassilli of Cleveland, Ohio. It is 285' deep. It is Lot 2, sec. 27, T 39 R 10 W.; V. McDonough in sec. 23,

T 38 R 10 W, well 178' and it flows. It is on low ground near the lake. Whether it was in rock was not ascertained. Mr. Leighly collected fossils from the limestone outcrop east of the lighthouse in N. part of Beaver Island among them a small trilobite. They are Devonian. It is probably Grabau made a study of this exposure when here with F. B. Taylor some years ago.

On Railway to Ann Arbor.

I returned by boat to Charlevoix Sept. 18 and took evening train to Traverse City. The following day I went on P.M. RR to Thompsonville and from there on the Ann Arbor RR to Ann Arbor. This gave opportunity to revise mapping I did in Manistee and Wexford Cos. some years ago. I found no glaring errors in the map. The hills SW of Boose are fully 100' above the station or 1470' or more, brow being 1371'.

The altitudes on Ann Arbor RR given in Gannetts Dict. may need revision to check with the recent survey by Mr. Allen. I notice that the Ann Arbor depot is about 4' lower than the G.R. & I. at Cadillac but by Gannetts Dict. it is 4' higher or an error of 8' on the bases of the G.R. & I. being correct.

With Dr. Hinsdale and Mr. Brigham near Battle Creek

Oct. 2, 1922 – I went to Battle Creek with Dr. W. B. Hinsdale and from there we went with Mr. E. M. Brigham of the Battle Creek schools to a place in SW¼ sec. 23, Emmet Twp. where boulders show a curious altitude, many of them being an edge or standing with points down and usually the small end down several inches into the ground. There is so large a percentage of stones of small size 18 inches or less with this altitude that I am inclined to favor the view held by Mr. Brigham that they have been set up on edge by human agency. They are in a forest that had large white oak trees but now has a "second growth" of white and red oak, etc., with a few maples interspersed. The place is on a sandstone terrace the rock being close to the surface. There is an old quarry along the bluff opposite where these stones occur. The terrace or plain is between 880 and 900'. The top of the rock is about 880'. There are peculiar irregularities of the surface in an open field between this wooded tract and the south line of the sec. which may be due to Indian work but we are not able to make out any definite figure or design. Mr. Brigham plans to do more work here in the near future. We then drove up the Kalamazoo valley past Cerisco and Marshall on north side of the stream and noted boulders along the way. There is sandstone in the railway cuts west of Cerisco in SW¼ sec. 24 up to an altitude a little over 900'. There is a filling of gravel in the SE part of sec. 24 east of Pigeon Creek.

The sandstone seems to be at slight depth from Cerisco to Marshall up to where the 920 contour runs. The part above this contour is coated with gravel and cobble but it is thin and set with boulders below this contour.

With Dr. Hinsdale & Mr. Brigham near Marshall

Above Marshall there is bouldery land along the river opposite the place where a gravel plain is present in secs. 26, 27, 28, Marengo, as well as south of the morainic areas in secs. 29 & 30. The road that runs up the north side of the river does not get to the full height of the gravel plain. But on crossing the river it rises near corner of secs. 25, 26, 35, 36, to the level of the gravel plain at the 960' contour. But in the SW part of sec. 25 it is only the part above 950' contour that is clear gravel and cobble. On the slope toward the river rock with many boulders over it is near the surface. A thick bedded sandstone has been quarried a little SW of the center of sec. 25 at about 940'. There are immense blocks of this sandstone lying in the forest here. One of them has a pothole about 2' deep and 20 inches± in diameter which has been called an "Indian Mill". It has been rimmed out by swirling waters loaded with stones so its wells have spiral furrows and ribs. Mr. Brigham took a photograph of this stone. It is nearly 20' long and 8 – 10' wide and about 3' high in highest part. It seems to have been pushed into its present place by the ice. I doubt if Indiana ever modified the pothole but they may have made use of it for grinding corn.

There is a morainic ridge in the SE part of sec. 25 that runs SE to the limits of the Marshall quadrangle near corner of secs. 31 & 32, Sheridan, and secs. 5 & 6 of the twp. south. There are other morainic strips below here on south side of Kalamazoo River in secs. 33, 34, 35, 36, Marengo Twp. running into the twp. south beyond the limits of the quadrangle.

#### Studies in the Marshall Quadrangle

We returned to Marshall for dinner and there disbanded. In the afternoon I mapped a strip of bouldery land partly morainic knolls and partly nearly plain in the north part of the city of Marshall and northwestward to corner of secs. 15, 16, 21, 22, Marshall Twp.

There is a wide strip of muck land bordering Bear Creek in south half of sec. 15 and in sec. 22. Along its east side is a strip of low sandy land in SE part of sec. 15 and NE of sec. 22 between the 910 and 920' contours. East of this is a narrow bouldery strip that reaches 950' near its east border about 60 rods east of corner of sec. 14, 15, 22, 23. From there east to the "Lansing" gravel road there is a plain of sandy gravel. This kind of land occupies the SE part of sec. 14 and adjacent parts of secs. 13, 23, 24. But a bouldery knoll in NE¼ sec. 23 on west side of the Lansing road marks the beginning of bouldery land that extends south a little beyond the corner of secs. 23, 24, 25, 26. It is knolly around these sec. corners. There are other knolls in the NE part of the city on one of which the standpipe is located. It is just west of the quarter post of secs. 24 & 25 and catches 960 contour.

A very stony ridged belt is found in north part of the city and just outside the city limits in west part of sec. 24 and east part of sec. 23. It reaches the 970' contour. A

group of stony knolls in NE corner of the city in east part of sec. 24 reaches 980'. In the central part of the sec. 24 there is nearly a plane strip running NE – SW that has a few boulders and seems to be of ground moraine rather than outwash material. I crossed the eastern end of a very stony morainic strip west of Bear Creek that runs across the NW part of sec. 22 and through the central part of sec. 21, Marshall Twp. The highest knolls catch the 940 contour. Boulders are very numerous on west side of Bear Creek in SW part of sec. 15 on ground that is nearly plane and about 940'. The marsh or tamarack swamp east of it is about 910'. This bouldery plain is perhaps to be classed as ground moraine. The boulders are said to be found only a short distance north of the morainic strip in sec. 21.

#### In Marshall Quadrangle

October 3, 1922. Marshall, Mich. I go up Rice Creek valley on north side to line of secs. 16 & 17, Marengo Twp., and note a bouldery moraine at the border of the creek flat setting in at about 930 contour. It has enough fine material to make a fair soil. The stones are in piles in fields in nearly every 40 acre lot in the moraine. There is a gravel plain at 930 contour around the cross roads near line of secs. 16 & 17. The plain south of the creek in secs. 20 & 21 is up to the 940 contour. I go north through a rather sandy moraine on line of secs. 16 & 17, 8 & 9, to the quarter post and there turn west into a plain that has good soil with an occasional boulder nearly to the west side of sec. 8. There a lighter more sandy soil sets in which forms the high plain in sec. 7 and west part of sec. 18 as well as west part of sec. 8. Boulders and cobblestones are scarce in this sandy tract. This seems to be the outwash from an ice border that passed across the north part of sec. 7 and turned southward through west part of SW¼ sec. 7. Boulders are piled in the fields along this ice border.

#### Studies in the Marshall Quadrangle

This ice border runs into the moraine that lies outside of it in the SE part of sec. 13, Marshall Twp. There is but a little ridging along this later border in the NW part of sec. 18 and SW of sec. 7, it is lower than the outwash plain east of it. The flat land in NE part of sec. 13 has boulders scattered over it. So was probably under the ice at the time the sandier land to the east was forming as an outwash.

A farm well west of center of sec. 18 at altitude about 960' is 125'. The farmer thinks the rock is limestone but this seems doubtful. In the afternoon I went on electric car 2 miles west and then examined secs. 20 & 21, 17 & 18, Marshall Twp., as to the probability of an ice border along the slope north of the gravel plain in secs. 19, 20, 28. The moraine I noted yesterday extends west only a little beyond the center of sec. 21 but a bouldery strip runs west across the south part of NW¼ sec. 21 and the north half of sec. 20. There are scattered boulders in the south half of sec. 21 and in the wet land as well as the dry. So it is probable that this was covered by the ice at

the time the plain south of it that stands above the 920' contour was formed as an outwash. There is a rather abrupt rise to this plain of 20 – 25' in sec. 20 and NW part of sec. 28.

The drift is bouldery along line of secs. 17 & 18 as far north as the quarter post. The ice probably extended to the SE border of the swamps in sec. 18 at the time the gravel plain SW of the swamp was built up. The chain of swamps in secs. 7 & 6, Marshall, and east part of sec. 1 and NE of sec. 12, Emmet Twp., are likely also to have been formed at this time while the plain to the west was being graded up. There is an outwash gravel plain outside the main Kalamazoo moraine in secs. 8, 9, 16, 17, and north part of sec. 21, Marshall Twp. There is very coarse outwash with small well rounded boulders a foot or less in diameter in north part of sec. 8 and SW part of sec. 5, Marshall Twp. Most of the north half of sec. 9 has such boulding outwash. This may be included in the moraine as it is not so clearly graded up as the north part of sec. 8. Nearly all of sec. 10 is morainic and bouldery and so is the north half of sec. 15. Both secs. have much wet land bordering Bear Creek.

There is a bouldery moraine south of this creek in sec. 11 and bordering parts of secs. 12, 13, 14. But in the NW part of sec. 14 and in sec. 15, there is sandy drift with only a few boulders while the SE part is an outwash plain and so is the adjoining parts of secs. 13, 23, 24. A considerable part of sec. 13 and south part of sec. 12 is plain or gently undulating with bouldery strips and a sprinkling of boulders on plane tracts. The NW corner of sec. 13 and NE of sec. 14 has a prominent moraine that rises above 1000' – the highest land in Marshall Twp.

A gravel plain heads at this prominent moraine in SW<sup>1</sup>/<sub>4</sub>/NW<sup>1</sup>/<sub>4</sub>, sec. 13. There is a lower tract of bouldery till east of this plain occupying the area with depression contours around the corners of secs. 13, 14, 23, 24.

#### Studies in Marshall Quadrangles

October 6. I went to Albion and spent the day in study of the southern two rows of secs. along and south of Kalamazoo River, across the width of the Marshall quadrangle. There is only a narrow and interrupted gravel plain south of the river in secs. 32, 33, Sheridan, and the secs. south of them. There are small gravel pits in the NW part of sec. 3 inside the Albion City limits but the land is boulder strewn in the city SW of the junction of the two branches of Kalamazoo River. The gravel is not in a well graded flat-topped plain but there is a slight waviness. This is true of strips between morainic ridges in secs. 32, 31, Sheridan, and sec. 36, Marengo Twp. There are three of these narrow morainic strips with narrow \_\_\_\_\_ plain gravelly strips between them in secs. 35, 36, 31, 32. As noted Oct. 2, there is a gravel plain around corner of secs. 25, 26, 35 & 36. The two join or the moraine is lost south of center of sec. 35. A stronger moraine curves into the south edge of the quadrangle in secs. 33 & 34, Marengo Twp. and extends to Kalamazoo River. West of it is a gravel plain extending west to west

part of sec. 31, Marengo. It is cobbly with boulderets and with slight modulation.

In the west part of sec. 31 and in much of sec. 36 (Marshall Twp.) there is bouldery land greatly undulating like ground moraine. But it may be a weak terminal moraine for there is a gravel plain on its SW border in SW part of sec. 36 and SE of sec. 35. It stands about 930' A.T. The moraine? rises in places to 950 – 960'. The cemetery in south part of Marshall is on the north slope of this bouldery area. There is a terrace in north part of sec. 35. That is boulder strewn and may be where glacial drainage has cut away the moraine.

The south part of sec. 35 and the part of sec. 34 south of the river and much of secs. 2 & 3 south of them, is gravel plain graded up to a more uniform height than some farther east on this side of the river. In the east part of Marshall from the Fairgrounds eastward across the twp. line into sec. 30, Marengo, there is a nearly plane bouldery strip standing above the 950 contour. It is not quite so high as the sharply moraine tract to the east which is 950 to 980'.

This moraine is separated from a group of morainic hills in secs. 29 & 32 only by a narrow swamp which does not seem to be a glacial drainage line but instead was occupied by ice while the moraine each side was forming. At the south end of the swamp is a rim of bouldery drift that looks like a feature marginal to the ice. In much of sec. 29 and the west part of sec. 28 there is a gravelly area with very few boulders. The strips which catch the 950' contour in SW part of sec. 28 are of this sort as well as the plain that stands below 940'.

In the east half of sec. 28 this higher tract 950 – 70' has a moderate number of large boulders and many boulderets a foot or less in diameter. This extends slightly into south part of sec. 21. East of it in sec. 27 and the edge of sec. 22 & 26 there is a high outwash plain 970' or more. It seems to correlate with a gently undulating somewhat bouldery but cobbly and gravelly drift in SE part sec. 27 or 22 (can't make it out – stenog.), SW of sec. 23 and a narrow strip running south to center of sec. 26 that has points 990'. There is a high gravel plain east of this strip directly NW of Marengo standing above 970'. There is that much complication between Marshall & Marengo – as well as along south side of the river from Albion west across the quadrangle.

I made a circuit north and west from Albion to map the south edge of the Kalamazoo moraine in south part of secs. 26, 27, 28, Sheridan Twp. There is a very bouldery edge with relief of only 8 – 15' above the plain outside. This outwash reaches 1000' at corner of secs. 26, 27, 34, 35, Sheridan Twp. There are numerous small stones in it 6 – 8 inches in diameter for 40 – 60 rods ± outside the slightly ridged margin with large boulders. These smaller stones are somewhat water-worn and are a part of the outwash.

There is a high place in Albion about 1/4 inch north of the MC depot that catches the 990 contour which seems to be of outwash material. I see no boulders in it. It is a

few feet higher than surrounding parts of the outwash. There is another high point above 990' in west part of sec. 34 which stands like a knoll in the outwash. The gravelly area 950 – 960' A.T. around the corners of secs. 28, 29, 32, 33, has a few boulders of good size but is more like outwash than ground moraine.

Oct. 7, Albion and Jackson. Very cobbly gravel in low island-like tracts in swamps about to county line. Bouldery moraine south of track for about a mile to Bath Mills. Knolls in view SE of bath Mills on east side of N – S road but for only a short distance. Plain further east 20 – 35' above swamp along railways. Similar plain north. Swamp becomes bouldery about 2 miles east of Bath Mills and there is a moraine entered here with knolls in view both north and south of the swamp. This is entered a mile west of No. Concord Sta. This is probably at line of secs. 2 & 3 \_\_\_\_\_ (i.a. N. Concord).