

Notebook No. 223 - Leverett



COUNTY

Baraga: 4, 11, 12-13, 56-62

Dickinson: 6-7, 43-51, 52

Houghton: 62

Iron: 31-35, 37-43

Keweenaw Peninsula: 3-5

Marquette: 2-3, 4, 7-11, 13-31, 45, 51-56

Ontonagon: 1-2

OTHER STATES

Illinois: 1

Wisconsin: 5, 6, 33, 35-37

Other States: 1

I N D E X   T O  
N O T E B O O K   N O .   2 2 8

(June 16 to July 24, 1909)

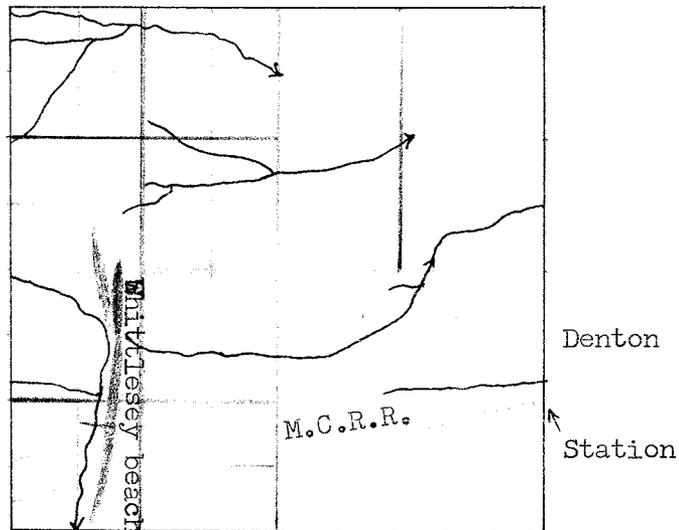
- June 16. Measurements of erosion in Kansan and Illinoian drift.
- June 17 Lane on Porcupine Mountains.  
to 27. Abstract of C. A. Davis paper in 9th Report, Michigan Academy of Science.  
Abstract of F. B. Taylor's paper on high shore lines of Lake Superior  
(American Geologist, June 1894).
- June 28. Trip, Chicago, Illinois to Champion, Michigan. Notes from Wausaukee,  
Wisconsin.
- June 29. Features around Champion.
- June 30. Champion to Michigamme and south of Michigamme.
- July 1. Michigamme to Nestoria and Summit and return to Champion.
- July 2. Champion to Republic and return, via Humboldt.
- July 3. Trip up Peshekee River to Huron Club Landing and return.
- July 4. With Dr. Lane around and west of Ishpeming.
- July 5. Champion to Clowry and return. Dr. Lane and Prof. Wood southwest of  
Champion.
- July 6. Republic to Lake Michigamme and Champion. Rail to Ishpeming.
- July 7. Negaunee to Palmer and Princeton.
- July 8. Princeton, Little Lake, Negaunee and Cascade Junction by train. Cascade,  
Palmer, Ishpeming on foot. Bus, Ishpeming to Marquette.
- July 9. Marquette up Carp River to Eagle Mills and on to Ishpeming. Outwash  
features northeast of Ishpeming and around Negaunee.
- July 10. Striated boss in Ishpeming. Train to Champion and Channing. On foot,  
Channing to Crystal Falls.
- July 11. Train, Crystal Falls to Iron River.
- July 12. Iron River to Lake Chicagon and Pentoga. Train to Florence, Wisconsin.
- July 13. Florence, Wisconsin to Crystal Falls and Fortune Lakes.
- July 14. Crystal Falls to Amasa and return.
- July 15. Crystal Falls to Armenia, Mansfield, Sagola, and Channing. Mr. Wood went  
Crystal Falls to Balsam and Kelso and Channing.
- July 16. Channing to Northland along railway track.

Index (cont.)

- July 17. Northland - Alfred - Foster City and Felch or Metropolitan.  
July 18. Metropolitan to Randville.  
July 19. Randville - Sagola - Channing - Floodwood and northeast to camp.  
July 20. Camp 10 to Kates and Camp 12 of Stevenson Lumber Company.  
July 21. Camp 12 to Camp "A" and Republic past Helen Lake.  
July 22. Champion to L'Anse by train.  
July 23. L'Anse to Taylor Mine switch and Herman and back.  
July 24. L'Anse - Baraga - Pelkie - Limestone Mountain and back.

Back of Notebook: Map of district southwest from Alfred to Foster City, in  
Dickinson County.

## Whittlesey beach west of Denton



June 16, 1909.

Mr. R. A. Smith, a student in glacial geology in the University of Michigan, cut out the eroded part of the Tallula Illinois quadrangle and weighed it to determine percentage of surface eroded and obtained 42.7 per cent.

By measurement he made it only 39.1 per cent (this is Illinoian drift). He measured the Springfield quadrangle and made its eroded part 44 per cent. (This is Illinoian drift).

He measured the Atlanta, Missouri quadrangle, which is Kansan drift, and found the eroded part 71 per cent.

Dr. A. C. Lane gives following data on glacial features near the Porcupine Mountains. "Found the reentrant which starts in at Little Carp Lake (at about 1,770 feet A.T. for water level) draining from the ice, and then afterward a succession of moraines wrapping around the Porcupine Mountains which stood out like nunataks and drained out to the south finally to the headwaters of the Presque Isle.

At a later state there was a well worked spillway from an elevation of 1,319 feet at a large lake in the Ontonagon valley to 1,163 feet for Lake Duluth. Then there were one or two waterlaid moraines besides. The drainage must have been off toward the Driftless Area. In order to do the work at all satisfactorily, I think the reentrant should be followed up from that direction."

--A. C. Lane in letter October 20, 1908.

C. A. Davis on Glacial Phenomena in Marquette Region (Michigan Academy of Science Ninth Report, 1907, pp. 132-136).

1. Light glaciation and especially light erosion on highlands in north half of Marquette County at altitudes above 1,800 feet.
2. Near Marquette glacial scoring imposed on pre or inter glacial weathered surfaces.
3. On highlands north of Lake Michigamme, recently uncovered rock surfaces show no glacial smoothing.
4. Moraines and morainal terraces or outwash plains are banked against north face of Huron Mountains. The terraces rise level with top of moraines, filling space between them and the rock highlands--series of 3 or 4 present.
5. At higher altitude than these moraines and terraces on old pine plain, till deposits are all in valley moraines or are wanting. Bare rock hills and slopes. Valleys have, in places, uneroded talus from the cliffs as well as deposits of gravel.
6. Thin deposits of till banked against south side of the Archean highland west from Ishpeming and north of D.S.S. & A. Railroad and the till in places covers talus.
7. Low moraines branch off from this highland always southeastward. They are too weak to trace easily and are, in places, closely related to lines of rock hills. As one proceeds westward a series of moraines with east-west trend set in south of and parallel with the border of the highland. These are stronger than the ones farther east.
8. The highland ends on the west at Sturgeon River. Farther west is a heavy moraine with terraces on north side which apparently is continuous with the moraines lying against the Copper Range. The till in this deposit is red and clayey with many sandstone fragments, while that south of it is gray and sandy with slates and some granite. The deposits north of the Huron Mountains are red also.
9. Glacial drainage. When the highland of north Marquette County became bare the main lines were southward through rock bound valleys in which the Peshekee River and tributaries now head, then east along the south edge of the highland and

9. (cont.)

then southeast into the Escanaba drainage. West Branch of Escanaba follows the best defined channel. But at earlier stages the water seems to have been forced against the bluffs farther east and may have flowed even as far as Negaunee before finding an outlet to the south. Drainage, probably a little later, was in a valley now occupied by headwaters of Sturgeon River near Nestoria. The stream followed the edge of the highland eastward and formed the sand plain at Three Lakes and then probably at one time entered the Michigamme basin and later flowed to the southwest of it. Extensive gravel plain along the Peshekee with large pebbles at north. No divide between streams that flow south into Lake Michigamme and the head of the Escanaba River. A rise of 4 feet in Peshekee would divert water to the Escanaba through small channels.

10. Slopes. Strong southward slope in the region west and southwest of Ishpeming despite the southeast course of present drainage which is almost wholly in sand valleys.

11. Northward transportation of boulders was noted in places southwest of Ishpeming. Knob and train from west-southwest - east-northeast at a rock hill near Clarksburg which is bare on west side. The till ridge on east side extends out several hundred feet. See if this is pre crag

12. Ice seems to have laid on south border of the extensive sand plain on Escanaba River 15 miles southwest of Ishpeming, there being a descent from the plain to a boulder strewn tract. Look to see if this is not a mere local stagnant ice persistence

13. Around Ishpeming and Negaunee rock erosion is light and there are some characteristics of an interlobate area.

It is suggested that the ice came from the northeast only to the Marquette highland and the Copper Range and that the region to the south was invaded by ice from the northwest.

Red till limits the extent of movement of ice from the northeast, and gray that from the northwest. Moraines south of the highland having border drainage lines on their north side indicate that the axis of movement lay to the south.

Had the movement in the upper Escanaba basin been westward toward the higher land the moraines would seem likely to have northeast-southwest trend and not the west-northwest - east-southeast trend on the north side of the ice lobe.

Had the ice pushed in from Keweenaw Bay and spread to the southeast the main movement would have been southward and that would be likely to give a northeast-southwest trend to moraines on the limits toward the east. There has been found no evidence that the ice pushed in from the northeast over the Laurentian highland,

and much against it. The morainal bank at the foot of the bounding cliff, and the marginal drainage, which evidently was on the present land surface and not on the ice is against such a northeast-southwest incursion.

The ice appears to have lain banked around the borders of the Laurentian highland in a nearly stagnant condition so that the country about 1,800 feet A.T. is practically driftless. This stagnation seems to have prevailed as far west as the axis of Keweenaw Point so that the ice was prevented from pushing inland from the head of Keweenaw Bay. A strong ice stream pushing in from the northwest on the west side of the Keweenaw Peninsula seems to have stopped southward movement from Keweenaw Bay.

-- Presented at Ann Arbor, March, 1907.

From F. B. Taylor's paper in American Geologist, June 1894: Highest beach in west part of south shore 535-590 feet above Lake Superior. Nipissing is less than 50 feet above lake on this shore and at Marquette only about 25 feet. Chocolay River is diverted westward by this beach 4 miles in lower course by westward shore drift. At Au Train the Nipissing has been built across an old bay, converting it into Au Train Lake. Beaches spread out over  $1\frac{1}{2}$  miles at north side Au Train Lake. At L'Anse it is about 20 feet or less above Lake Superior. It can be seen from train nearly all the way from L'Anse to Houghton where it is about 25 feet. It is this shore that filled Portage Canal and joined Keweenaw Point to the mainland. At northeast end of Keweenaw Point it is 40 feet.

Beach 7 miles south of L'Anse at the switch to Taylor mine at about 590 feet in heavy broken ridges of shingle facing northwest. Real altitude here is 1,215 feet (see Notebook 264, pp. 94). Terraces below this beach stand at their front edges 425, 345, 320, and 240 feet above Lake Superior. More clay at lower levels.

On hill back of Houghton on higher ground back of Huron mine a beach at 410 feet, and prospector's holes 20-30 feet higher show beach material but not a shore form. This is the Algonquin beach at about 1,040 feet (see Notebook 229, p. 19).

Striae near Huron Mine N75°-80°W (Magnetic). Nodules have "ice shadows" showing the eastward movement. Beach 2 miles southwest of Houghton on the Ontonagon road at about 410 feet. Large gravel ridge forming a blunt spit projecting southwest and enclosing a small basin. This seems to be the Algonquin beach at about 1,040 feet. Back of Hancock a good beach at 230 feet and a washed appearance on the slope up to 490 feet. Terraces back of Hancock at 100, 150 and 200 feet (exposure to wave action from the northeast). At Calumet a gravel ridge remnant in the railroad yard at 600 feet above lake may be a beach. Terraces near Allouez at about 400 feet. At Lac la Belle on Keweenaw Point a beach above the Nipissing at 75 feet (faint), also narrow terraces at 95, 110, and 120 feet. Back of Eagle Harbor fine shingle ridge 170 feet. Terraces or old deltas at 200 and 220 feet. About a mile west of Delaware Mine and near the mine, faint terracing at 580 feet and gravel deposits looking a little like a beach.

In Northern Wisconsin:

Much red clay up to about 450 feet, or 1,050 feet A.T., where sand sets in. Maple Ridge,  $1\frac{1}{2}$  miles east of station a beach at 535 feet above Lake Superior--yes. The railroad crosses it there and runs back of it for a mile or two, then crosses it west of Blueberry Station. Iron River, Wisconsin, about 1 mile north of town is a good gravel beach at 510 feet. South of town, in front of a sand hill, a faint terrace at 555 feet. Highest beach 2 miles west of Kimball on railroad at about 570 feet (not so, F.L.), also lower beaches.

June 28-29, 1909

Ann Arbor to Champion via Chicago. Left Ann Arbor at 2:33 p.m. with R. C. Allen, A. Ruthven, Mr. Willoughby, and three other men of the Zoological Survey and was joined at Kalamazoo by L. H. Wood who is to accompany me in the Northern Peninsula studies. Allen and Willoughby are to work around Iron River on the iron ore deposits, while Ruthven and party study in Dickinson County between Metropolitan and Norway. Mr. Wood and I are to cover the west part of Northern Peninsula and adjacent part of Wisconsin from near meridian of Ishpeming westward.

My first observations in new territory were at 5:45 a.m. June 29 at Wausaukee, Wisconsin. This village is on a sandy plain but there are ridges and knolls 25-75 feet  $\pm$  in height in groups scattered over the nearly plane country. I notice a few outcrops of granite in them but many of the knolls are rounded out by drift deposits. Cuts across them may be entirely in a sandy drift while bosses of granite show nearby.

At ~~Ain~~berg the stream is on the granite. The drift is a pinkish color and very sandy. Masses of granite are deposited in the sand. The granite bosses have roche moutonnee surface and there are many of them both north and south of ~~Ain~~berg. Glaciation looks to be of about the same vigor here as at Marquette, so far as rounding off and polishing of granite surface goes. A short distance north of Amberg the surface is largely plane and jack pine timber sets in. There is a slight undulation 10-20 feet but slopes, as a rule, are very gradual. Cuts 8-10 feet deep are, in part, colored sand.

Gravel at Pembine <sup>at</sup> crossing of Minneapolis and Sault Ste. Marie road in gravel plain. Granite bosses 50 feet or less in height just north of Pembine heavily glaciated. Sand plain south of Iron Mountain at 1,100 feet to 1,120 feet. Has basins as shown on topographic map. North of Iron Mountain range there is a pitted tract with a few bouldery spots but largely sandy. Cuts in ridge near north edge of Menominee Special map show many boulders in sand and I see no rock in place.

Low rock hills and rather gravelly drift near Randville. Stream just north of Randville flowing east is in a narrow valley 20-30 rods wide and 30 feet deep. Around Sagola are low swells of red till with boulders imbedded as exposed in cuts. Much hardwood timber north from Iron Mountain. Drift is heavy from Channing nearly to Republic. It is very hummocky from Floodwood to within 2 miles of Republic with sharp knolls and winding ridges enclosing basins. Rocky knolls from 2 miles west of Republic most of the way to Champion. Stretches a mile or so wide seem to have drift filling with low swells but the higher points are rock. Champion is 1,586 feet, aneroid 28,700.

Mr. L. H. Wood and I take wagon road north from Champion into Section 29, T 48 N, R 29 W, past east side of Phoenix Mine (see Van Hise map). A short distance southeast of the mine is a glaciated ledge in the road, striae bearing about S35-40°W as determined by trend compared with the road. The compass is of no use here because of deflection by iron in rock formations.

We continue north and find granite rocks setting in as boulders on the surface of the iron bearing rocks in conspicuous numbers. Farther south they are not numerous. The ledges are north of the valley through which the C. & N. W. Railroad runs so the rocks seem to have been carried across the valley southwestward as the striae suggest.

Mr. Wood took a view from north part of Section 29, looking north across the valley to the granite ledges. The ledges are, in places, quite jagged on the south face as if the ice had not pressed against them but had come over them from the north. The valley here is marshy and about 1/4 mile wide. Mr. Wood took another view looking west from west of North Phoenix Mine, showing the valley with its steep granite wall on the north and a more gradual drift covered slope on the south.

We cross the valley and follow the C. & N.W. Railroad west to middle of line of sections 19 and 30 to a divide between tributaries of the Escanaba and the Lake Michigamme basin. It is a gravelly plain which slopes eastward from the west part

of sections 19 and 30. There are bouldery low knolls along the south side of the valley in the northwest part of Section 30. We take an abandoned road southwest across them to the county road in Section 25, T 48 N, R 30 W, and follow it southeast into Champion. There is some drift plastered on the north slope of the ridge in east part of Section 25 but its south slope shows outcropping ledges. The altitude is nearly 1,700 feet where the road crosses. It is about 100 feet higher just south of the North Phoenix Mine north of center of Section 29, T 48 N, R 29 W.

We come down to the east end of Lake Michigamme in southwest part of Section 30. There is some filling with gravelly, cobbly drift to about 20 feet above the lake in north part of Section 31 that is flat surfaced like a terrace. It is north of the swamp that leads east-southeast from Lake Michigamme past Champion. That swamp is about 60-80 rods wide and has a low sandy divide in village of Champion between the Lake Michigamme and the Escanaba drainage. This looks to be a line of glacial drainage eastward and so does the line north of here utilized by the C. & N.W. Railroad. The striae and rock transportation, however, do not harmonize with this, nor the banking of drift against north facing slopes.

On returning to Champion we take the road up to Beacon and the Champion Mine and examine the ledges for striae and rock transportation. The border between the granite and the Huronian is very sharply defined. There is an outcrop of the iron bearing rocks on the south slope of a higher ridge only a few rods from the border line. The granite knobs are so strongly roche moutonnée that steep slopes are polished even with angles of  $45^{\circ}$ . The polishing seems to be most perfect and the rounded form best developed at the northeast end of knobs. At the southwest, some surfaces are rough while others are nearly as smooth as at the northeast end. On the crest of the domes of rock the small irregularities are smoothed and toned down most on the east and northeast and the west facing ones are often quite free from scoring or rounding of angles. The appearance is very

different when one faces westward than eastward. In one case a deep furrow sloping down westward has striae running out away from the groove horizontally like contours and spreading as in lines, as if the ice worked out radially as well as downward along the sloping groove. This all seems consistent with a movement toward the west. Mr. Wood took a view across a striated ledge of granite to show the bluntness on west facing prominences compared with the gentle slope on east facing ones. It was on a ledge 120 rods  $\pm$  nearly due south of the working shaft of the Champion Mine.

We find that many rocks from the iron formation have been carried southwest into the granite area in the district south of the Champion Mine. Many 2-5 feet in diameter are scattered among the granite ones. We go out south into Section 6 as far as the settlement extends,  $1/2$ - $3/4$  mile from the mine, and find Huronian rocks plentiful everywhere on this granite area. It seems very clear that ice movement here was from the Huronian southwestward into the Archean or granite area.

We then made a trip to the knob in west part of Section 36, T 48 N, R 30 W and east part of Section 35. It stands about 250 feet above the lake (Michigamme) and is covered with a thin capping of drift so that rocks are seldom exposed. It is called an eruptive rock. It is a diorite with considerable feldspar. On the east slope we find a large red quartz porphyry. Boulders of diorite are found for  $1/4$  mile or more east of the knob. It does not have a typical crag and tail form with tail on east but simply a broader and gentler slope on the east than on the west. The country east is also higher than the lake on the west, probably 75-100 feet. We may study the knobs of this class of rock north of Lake Michigamme to see what they show as to boulder trains. This one has no chance to exhibit a train on its west if there was a westward movement, as seems probable.

June 30, 1909.

7:45 a.m. Aneroid 28.62 = 1,586 feet at Champion. We examine the ridge in central part of Section 30 and find that its south slope is very hummocky with bouldery knolls 10 feet  $\pm$  high covering only a few rods square. There are an increasing number of granites as we go north toward the granite area on this iron bearing range but most of the boulders are Huronian. Just south of this hummocky morainic-like part of the ridge is the gravel and cobble terrace in the Champion depression (colored brown with crayon—the Van Hise geologic map).

There is a low moraine 30-40 feet above the swamp on Peshekee River running north on east side of the river along and east of the county road in Section 25, T 48 N, R 30 W to the C. & N.W. track. It is very bouldery and has swells 10 feet or less high. The boulders are well exposed in a cut by the C. & N.W. Railroad east of the wagon road. They are largely granite, but quartzite and quartz-porphry are present and Huronian rocks of dark schist. East of this moraine is a terrace of cobble and gravel with a gravel pit in it in northeast part of Section 25. It stands 20 feet  $\pm$  above the swamp. It does not contain boulders or many stones exceeding 6 inches in diameter. Possibly it was built by waters running east, the material being gathered from the moraine and carried a short distance eastward. The same stream continuing through this swamp would cut it down to the level of the swamp. Stagnant ice in Lake Michigamme might force drainage from the receding ice lobe that came across the Huron Mountains to run east through this valley.

In the southwest part of Section 23 in a sag between the granite and the Huronian rocks there are several low knolls of drift 10-15 feet high on which granite boulders are very numerous. They show a south or southwest movement of the ice. They are in a string trending northwest-southeast so the southwest movement seems probable. The southeast end is against the diorite and the northwest end against the granite. The distance across is 1/4 mile  $\pm$ . Mr. Wood took a view of one of them looking northeast toward a prominent granite knob with very steep face on its southwest side. I am standing on the knob. There are small basins

among the knolls and a flat tract also. Mr. Wood took another view looking northwest over some of these knolls by charcoal kilns at base of the main granite area.

Between here and Michigamme there are bouldery, cobbly bars or ridges along south side of the diorite ridges and between them they have considerable granite in them and seem to have been brought in by movement of waters (likely subglacial) in west-southwest course. The striation on quartzite and diorite outcrops a couple of miles east of Michigamme seems to be westward for the ledges are planed down to much greater smoothness on the east slope than on the west. The west has abrupt steps down its slope.

The county road cuts a drift ridge about 1/4 mile northeast of the railroad station in Michigan and 75 feet  $\pm$  above it, exposing oxidized drift 3-4 feet resting in unoxidized drift with much iron ore reduced almost to a state of powder. This ridge has Huronian rocks within 20 feet of top and is just south of the ridge of eruptive rock (diabase or diorite) that runs west across center of Section 19, T 48 N, R 30 W. There are a large number of boulders on the surface in this region in and around Michigamme.

We go west past the mine that obtains a limonite ore by shallow working. It is in northwest part of Section 25, T 48 N, R 31 W. The boulders are almost a pavement in places between this mine and Michigamme. South of the creek that comes into the extreme west end of the lake south of the mine there is thick drift and very strong morainic topography with sharp knobs and deep basins--knobs 30-50 feet above the basins. Boulders are not so numerous as on the tract between the mine and Michigamme. This strong moraine runs southeast to the outlet of Lake Michigamme. We go along the old tote road southeast from Section 35, T 48 N, R 31 W to Section 8, T 47 N, R 30 W and there get a view beyond the head of the outlet and along the whole east shore up to Section 34, T 48 N, R 30 W. The granite knobs in sections 4 and 9, T 47 N, R 30 W which are close to the shore are bare. South of these knobs in southwest part of Section 9 there seems to be considerable drift covering the slopes.

A well in east part of Section 26, T 48 N, R 31 W, was driven 110 feet. It penetrated till and gravel for 26 feet and then 85 feet of fine sand. There was only 10 feet of water. The aneroid here reads 1,670 feet and it reads 1,700-1,710 on the moraine a few rods south. Wells on this moraine are 15-45 feet when dug. The well that is 110 feet is a well on farm of Isaac Pradz. The moraine seems to bear westward along south side of D.S.S. & A. Railroad with a low tract between it and the granite escarpment north of the railroad. We returned to Michigamme for the night.

July 1, 1909

Michigamme, Michigan, 6:50 a.m. We follow the railway track to Nestoria. There is a marshy swampy tract setting in a mile west of Michigamme and extending nearly to Three Lakes. Around Three Lakes is a sandy plain 6-10 feet  $\pm$  above the marshes and lakes. This low marshy tract extends nearly up to Nestoria. There is a strong moraine south of it and this partly blocks this depression north of Nestoria. A sandy gravel plain extends west from west part of Section 2, T 48 N, R 32 W through Section 3 into the westward drainage to Sturgeon River and Lake Superior. It is deeply indented with basins at the east end and is apparently higher than to the west. Its surface is fully 30 feet above the swamps. Bouldery knolls set in north of it at base of the granite knobs in north part of Section 2. There may be a reentrant here between a southwest movement across the massif of granite of the Huron Mountains and the movement south through Keweenaw Bay.

We follow the railway to Summit station. It is close to the stream to the northwest part of Section 21 and then cuts across ridges in Section 17, T 49 N, R 32 W. A large part of Section 21 is spruce swamp. The station marked "Spruce" on Cleveland-Cliffs Company map is now Tama. It is a shipping point for timber, there being no dwellings there. The switch is in west part of Section 21. There is an esker in the southeast part of Section 21 and northwest of Section 27 along east side of stream whose trend is north-northwest - south-southeast. It is continuous for nearly 1/2 mile. There is but little winding. It is 10-20 feet high

and quite steep. It contains cobble as well as gravel. Its southern end is against a granite knob. Farther south near line of sections 27 and 34 are very winding ridges of esker type. Two are 60 rods  $\pm$  each in length and 10-12 feet high.

The variations in width of the valley are very striking. It narrows in places to only a few feet while in others it is  $1/4$  mile or more. In the narrows, striae are found on the wall-like bluffs down to within 10-15 feet of the stream level. They trend with the valley, north-northwest - south-southeast. Mr. Wood took views of two of the narrows. The first was at the south entrance into the granite in northeast corner Section 3, T 48 N, R 32 W. The other is about a mile north. In the granite there are diabase dykes. Mr. Wood counted 18 folds with dykes in the 6 miles from Section 3, T 48 N, R 32 W to Summit. The rock is less resistant where there is no diabase. The Summit switch is 1,750 feet but rock hills near it rise a little above 1,800 feet. We are told that there is a terrace-like flat crossed by the railway 1-2 miles northwest of Summit, probably one of the ice border terraces noted by C. A. Davis on the north and west slopes of this high tract.

We returned by train from Summit to Champion and studied the district just east of Champion. The low tract in which the railway runs eastward is crossed by a moraine near center of Section 32, T 48 N, R 29 W that has some outwash material among its knolls. This is exposed in a cut and shows by the bedding of the stones a westward current of water. There is a swampy depression on its newer border 30 feet  $\pm$  below it that is drained eastward. This is partly filled by drift knolls in the south part of Section 33 in vicinity of the crossing of the C. & N.W. over the D.S.S. & A. Railroad. The morainic knolls and ridges extend across the north part of Section 4, T 47 N, R 29 W into the northwest part of Section 3. We return from Section 3 to Champion, keeping on the south side of the lowland.

We found a striated boss of rock about  $1/4$  mile south of center of Section 32 on brow of bluff with bearing about  $S30-35^{\circ}W$ . Mr. Wood took a view of it with camera, facing in the direction the ice was moving ( $S30^{\circ}W$ ). Just south of this boss is a sharp till knoll opened to get stuff for roads but it seems rather poor

for road ballast. There are a few knolls and terrace-like banks of bouldery drift along the south side of the lowland in Champion at an altitude of about 1,625 feet, or 40 feet above the station. Perhaps they mark an ice border a little earlier than the moraine that crosses the valley just east of Champion from northwest-southeast. Possibly the ice border at one time followed the south edge of this lowland westward from Champion and made the filling with drift that runs westward through center of Section 36 to the diorite knob on line of sections 36 and 35, T 48 N, R 30 W. This drift forms a low ridge that shuts in a swamp south of it in the southwest part of Section 36.

July 2, 1902.

Champion, Michigan. We walk to Republic along the C.M. & St.P. The knolls are partly of drift north and east of Fish Lake in Section 5, T 47 N, R 29 W, but the most prominent have rock clear to the top. The glaciation is very heavy so that the bosses are much rounded. We found distinct striae on ledges on east side of the track near line of sections 8 and 17 bearing about  $S35^{\circ}-40^{\circ}W$ . Another is near line of sections 17 and 20. A third was noted a little northeast of center of Section 20. A striated ledge was passed on west side of the track where it runs southwest in the northeast part of Section 29. This, like the others, bears about  $S35-40^{\circ}W$ . Its surface is very uneven but the north exposure is much more abraded than the south.

The ledges and bosses where hills trend east-west or east-northeast - west-southwest are heavily glaciated on the north face and are more or less jagged on the south and more obscured by brush. The north slopes have much bare rock. The rock hills and bosses are generally 25-40 feet or less in height but a few reach 75-100 feet. Among them are swamps with tamarac and spruce and sphagnum moss. Drift knolls are scattered and low. Nothing that suggested a moraine was seen until in the last mile just north of Republic. There, very bouldery knolls set in and form a strip about 1/2 mile wide that leads eastward or east-southeast from north part of Section 6, T 46 N, R 29 W into Section 5. It is on the divide

between the Peshekee and the west branch of the Escanaba. It is a ridge 50-60 feet in places above the station at Republic, 1,499 or 1,555  $\pm$  feet A.T. The boulders form a literal pavement each side of the wagon road  $1/4-1/2$  mile north-east of Republic. Mr. Wood took views of the boulders. South of this bouldery strip are bare rock bosses and among them flats with cobble and gravel. Also basins that give the appearance of a pitted plain of outwash from the moraine. The boulders are of the type of granite that we saw for 2-3 miles north of Republic. They seem to show southwestward movement. In northwest part of Republic there is a quartzite boss in a north-south street and this has striae bearing only a few degrees south of west, or about in line with the main axis. There are extensive nearly plane tracts among rock hills in the vicinity of Republic and west from there across the Peshekee River.

Aneroid 28.425 = 1,499 feet at level of railroad station in Republic at 2:30 p.m.; 28.190 on top of Republic Mountain, 1,710 feet +. On the northeast slope of this mountain granite boulders are very numerous. The mountain crest is a jasper banded rock standing on edge. South of the main ridge just beyond the southern mines on slope above them granite boulders also abound. The mines are the West Republic and Republic mines on Van Hise map. The Huronian at the southeast end of the Republic trough stands above the surrounding granite areas.

Aneroid 28.400 at C.M. & St.P. station at 3:45 p.m. The gravel filling among the rock hills here is 5-10 feet above C.M. & St.P. Station. Bare granite knobs front Peshekee Valley on east side for a couple of miles above Republic and also west of Republic on west side of the river. If there is a moraine up the Peshekee on east side it is likely to be a narrow strip like that just north of Republic.

We take train at 4:00 p.m. from Republic to Humboldt. There is a moraine at bend east of Republic and it extends nearly to the crossing  $1\frac{1}{2}$  miles northeast of Republic. From there northeast there is a sandy drift on the low swells with a little pine and hemlock. The brush on it is largely poplar. The swamps are black spruce and tamarack.

Aneroid 28.475 at Humboldt. There is a great sandy plain north of Humboldt covering much of sections 1 and 2, T 47 N, R 29 W and sections 35 and 36, T 48 N, R 29 W. There are rock ridges in sections 35 and 36 and east part of Section 1 and a little morainic tract in southwest part of Section 2. The slope of a rock ridge in southwest corner of Section 2 and northeast part of Section 10 has drift swells on it. The south part of Section 3 and east part of Section 4 and northwest corner of Section 3 have weak morainic features on a gravelly tract. Swells rise only 5-10 feet above the general level of the gravel. Small boulders occur on the plane part as well as on the swells.

July 3, 1909.

Champion, Michigan, 6:10 a.m. Aneroid 28.600 = 1,586 feet. We go up Peshekee Valley. Aneroid 28.610 on terrace 25-30 feet above the Peshekee at bridge where road turns north on old railway grade in Section 24. There is a little morainic topography in the lower end of this valley in Section 24. About 1/4-1/2 mile up from south edge of the granite, knolls are bouldery. About a mile up the valley we rise onto west bluff, aneroid 28.500. It is very bouldery but drift is thin.

Aneroid 28.650 on hill southeast of Huron Bay Landing where road branches off to Huron Mountain Club House, 12 miles from Champion, at 9:45 a.m. Hills 3/4 mile northeast are about 30 feet higher by hand level. All the knobs in view from here are heavily glaciated with bosses as smooth as those near Marquette. Two miles or more north from here is a timbered range running east-west that is higher than the hills here near the river, but apparently not more than 100 feet above them. Mr. Wood took a view here, facing north. Aneroid 28.500 at bottom lands by the landing.

The valley is rather open here at this junction of drainage lines with flats nearly 1/3 mile wide and no morainic knolls. The drift is very scanty on hills. It seems to be a little thicker on the west bluff than the east so as to have a heavier timber growth. The ice movement was west of south, as indicated by trend of roche moutonnee surfaces. We do not see distinct striae here, however.

We return on foot from the landing, taking a view of a gabbro rock under granite. There is a shelf at top of the gabbro that seems to be glaciated in a course about S20°W but striae are, at best, very indistinct. This is a mile or more south of the landing on the west side of the railroad grade. About 60 rods farther south, Mr. Wood took a view of a greatly veined granite. It is just north of a drift filled pass on west side of the valley. This pass is only 25 feet above the valley bottom. It has many boulders in sandy drift.

About 1/4 mile farther south are beaver dams each side of the railroad grade one being on the grade and the other east of it that are freshly made. Stumps of trees 4-5 inches in diameter are present that were cut by the beavers. Mr. Wood took a view of the one on the east side with a stump and fallen tree in the foreground. There is a swamp running back here 1/4 mile or more west.

Just below here, 1/8 mile or so, is the first narrow place below the landing. It is about 30 rods wide. The general width above here for two miles is 1/4 mile and, in places, nearly 1/2 mile. Just below here it expands to about 1/2 mile for a short distance. The veined granite and gabbro form the bluff at this narrow place. Mr. Wood took a view of the exposure on east side of road at the narrows. The filling at this exposure is coarse gravel and cobble and so is it also in the one above.

In this expanded part of the valley just north of the first bridge, there is a rock island in the midst of the valley about 60 rods long, 20 rods wide, and 60 feet high that is heavily rubbed by ice on its sides and north end, but its south end is rough and jagged in the lower part. The trend is nearly north-south. Mr. Wood took a view of the jagged south end from the railway bridge and of the smoothly glaciated north end from 80 rods north. The location is about 6 miles above the place where the river leaves the granite area. The smooth contours of the sides of this hill lead me to speak of the probable amount of glacial erosion in the valley. There seems to have been a slight removal of the ends of salient points but not enough to efface them and produce a regular line of bluff. There

are recesses between the salients that seem not to have been enlarged by the glacial action. It seems that much of the work is on the projecting points. The valley may have considerable filling but I have no means of knowing how much. No one now lives in it from the edge of the granite area up to its source and it is doubtful if wells were ever made at camps or during the railway's life. Aneroid 28,560 at the bridge by this rock hill 6 miles north of Lake Michigamme at 12:30 p.m.

When at the Huron Club Landing, 3 miles above here, we noted quartz porphyry pebbles; also fossiliferous chert with corals of Ordovician or Silurian age. What is the source? About 2 miles farther down than this rock hill in the valley is a dam at a rock gorge no wider than the stream, 50-60 feet. The rock is about 20 feet up to the first shelf at the dam. The rock is a pink granite. The gorge here is about 1/4 mile long and has precipitous bluffs 20-25 feet high. There is a beaver dam at lower end of the gorge. This seems to be the lower end of a rock basin produced by ice work, the rock being a little more resistant here than above. The valley widens out below the gorge. The rock bluffs are exceptionally high each side the valley by this gorge, and there does not appear to be any other channel past the gorge. The gorge seems to be near the line of Townships 48 and 49 North, R 30 W.

The next basin extends to narrows below the junction of the two forks in southeast of Section 1, T 48 N, R 30 W. There is a double constriction here with a small expanded place between them. The rock walls are about 100 feet apart at narrowest place. There is then a basin extending past an old camp in Section 12. This has a beaver dam at its lower end with water held 4-5 feet above the stream. It has caused the brush to die out.

In north edge of Section 13 is another gorge. There are high hills each side and the space is less than 100 feet between rock on opposite sides of the stream. There is a low tract running around west of the hill on west bluff but where it comes back to the valley on the south there is rock in the low tract with no room for a valley over 30 rods wide. Both above and below this narrows the valley is over 1/4 mile wide. Aneroid 28,625 on terrace at place where the Peshekee River

leaves the granite hills near center of Section 24 where it read 28.610 this morning at 8:00 o'clock. Aneroid 28.655, 1,545-1,550 feet  $\pm$ , at level of Lake Michigamme, 3:30 p.m. Aneroid 28.390 on highest point in Beacon = 1,780 feet  $\pm$ .

July 4, 1909.

9:30 a.m. Aneroid 28.550 = 1,586 feet at Champion. We take train to Ishpeming with Dr. A. C. Lane. The aneroid reads 1,500 feet at station in Ishpeming. We go to east part of Ishpeming and Wood takes views of striae on north side and on south side of a crag just south of the road. The bearing is about  $S65^{\circ}W$  but the striae wrap around the hill on the sides. The sharpest striae are on north side in a chlorite rock in an amphibolite hill. The largest striated exposure is on south slope. The third view is of a crag south of this which shows a steeper stoss end than lee. The hill we use for photographing is about 1,625 feet.

Wood took another view looking north at the south face of a hill that seems to show plucking. It is heavily scored below the supposed plucking and Dr. Lane stands on one of these striated places. Another view was taken looking east past very rugged hills at west edge of Negaunee. They have very sharp north faces in some instances. The road to Negaunee is on the south slope which is rather smooth. Striae in Ishpeming about 3 blocks west of D.S.S. & A. depot bear  $S65^{\circ}W$  Magnetic. They are on quartzite. Sand plain northwest of Ishpeming in Section 4 among knobs stands between 1,400 and 1,450 feet. It is also present in Section 3, T 47 N, R 27 W and seems to extent about to Teal Lake in Section 34, T 48 N, R 27 W. East-west striae 1/2 mile west of Greenwood show westward movement of ice clearly. It is on an amphibolite very smoothly polished.  $S65^{\circ}W$  at Clarksburg at striae.

Dr. Lane, Mr. Wood, and I took road west-southwest from Ishpeming across Section 9, T 47 N, R 27 W, passing a striated quartzite in west part of Ishpeming with a magnetic bearing  $S65^{\circ}W$ . In Section 9 there is a large marshy tract just below 1,400 feet. On its north and east borders is a plain of sandy gravel nearly

up to 1,450 feet that is filled in around rocky knobs in sections 3 and 4. It is probably outwash from a weak ice border near edge of Teal Lake noted in 1905.

In southwest part of Section 9 are oval hills trending east-northeast - west-southwest that look drumlin-like. They rise about to 1,450 feet. The surface is very thickly strewn with boulders. Whether they have a rock nucleus is not clear. One hill extends into the edge of Section 8 and another into northwest corner of Section 16. There is a well defined moraine in Section 8 along south side of Lake Corning that covers the east part of Section 7 and then leads northwest into Section 6. The swells are 10-25 feet high and among them are basins. Boulders are numerous on it. West of this is an outwash apron covering the greater part of Section 7, T 47 N, R 27 W and sections 1 and 12, T 47 N, R 28 W. There are a few low, boulder-strewn swells on it near center of Section 12.

In sections 11 and 14 there are patches of undulating, bouldery drift separated by flat gravelly tracts and by rock hills. One chain of drift ridges passes just east of Greenwood Station. A stronger belt leads across the D.S.S. & A. Railroad track west of the station, passing through the center of Section 15, its west edge being a few rods east of Low Moor. In sections 8, 9, and 16, the greater part of the surface is plane and sandy or peaty. The hills seem to have a rock nucleus and very thin coating of drift.

We passed a striated ledge in the moraine 1/2 mile west of Greenwood that shows clearly a westward movement by the way the ice affected the irregularities of surface. It passed over depressions facing west without striating them but bruised and polished those facing eastward. The bearing is nearly west we could see by the sun.

The low rock hills and sandy, peaty flats extend to the hill north of Clarksburg. This has striation south of west. Dr. Lane makes it range from S60°W to S80°W but from the appearance of the sun, we judge that local deflections of needle by iron in the rock account for part of this difference. The bearing looks to be not far from S60°W.

There are low knolls of drift on east side of the rock hill north of Clarksburg but not closely aggregated and scarcely to be classed as a moraine. West of this hill and northwest into sections 35 and 36, T 48 N, R 29 W, there is much flat, sandy land. We take the train at Humboldt back to Champion.

Dr. Lane agrees with us that there was a westward movement of ice in the region between Ishpeming and Clarksburg and thinks it probably extended to Lake Michigamme.

July 5, 1909.

9:30 a.m. Aneroid 28.550 = 1,586 feet at Champion. Striae on ledges on north edge of Champion where road angles up hill to old furnace, S70°W. Also east of old furnace, S70°W. But on low tract through center Section 29, S30-35°W. Aneroid 28.350 on hill near north Phoenix Mine = 1,750 feet  $\pm$ . This is about as high as any point on the ridge.

The moraine that crosses the valley east of Champion runs northward from center of Section 32 to brow of bluff and there trends westward as a narrow ridge through north edge of NW $\frac{1}{4}$  Section 32 and into the southeast part of Section 30 to where we began tracing it from near the Marine Mine to the mouth of Peshekee River. The ridge is generally 15-20 feet high and 35-40 rods wide--back of it on the north are scattered knolls. Its whole width is not much more than 1/4 mile.

Section 29 is generally thin drift with only low knolls, 10 feet or less, and few of them. On the ridges near Phoenix Mine, rock is usually struck at 5-10 feet. I go down on the C. & N.W. track (aneroid 28.575 = 1,560 feet  $\pm$ ) in Section 29. The swamp is about 1,550 feet. I follow the track to Clowry and find an open valley all the way with gravelly soil. In places the soil is sandy, and in places there is a peaty deposit, but as a rule gravel is present all the way down to Clowry. The gravel plain expands southeastward with the turn of the river southeast from the railway. The plain is present among rock hills at the Bessie Mine. It is timbered with jack pine. From Clowry I return to Champion around south side

of the range of hills that runs past Champion on the north. At its east end as well as on its south slope there are drift knolls. Those on the east have a very much stained gravel, the stain being with iron.

Dr. Lane and Professor Wood made a trip west from Champion while I was on this circuit to Clowry and back, it being their aim to see what the diorite knob on line of sections 35 and 36, T 48 N, R 30 W shows as to boulder trains (or ice movement over it--movement seems to have been southwestward). Also whether Lake Michigamme formerly stood higher than at present. They found a beach at 9 feet and another at 21 feet that seem likely to be old shore features. The one at 9 feet seems likely to correlate with the eastward outlet along the Escanaba utilized by the C. & N.W. above Clowry. The higher one may correlate with a position of the ice that filled the outlet toward Clowry. In that case, the outlet to the south may have been deepened 21 feet. The beach is nicely shown at about 21 feet at the engine house north of Beacon and also around the arm of the lake near there.

Dr. Lane returned to Houghton at 5:00 p.m. Professor Wood and I took train to Republic at 7:30 p.m. to study the valley above that village tomorrow. Aneroid 28.500 at Champion = 1,586 feet. There is a slight rise to Wabik, then a gradual descent southward, 28.625 at Republic.

#### July 6, 1909.

Republic, Michigan. 6:30 a.m. Aneroid 28.615 = 1,500 feet at hotel in Republic; 28.660 at river = 1,465 feet  $\pm$ ; 28.610 at top of rock bluff on west side. Striae here are about S70<sup>o</sup>W. The valley is very uneven above here with knobs of bouldery drift as well as of rock, and among them flat surfaced sandy gravel tracts. Striae on rock knob in southeast part Section 17 between Spruce and Michigamme River S35<sup>o</sup>W. Altitude of knob, 1,580 feet--aneroid 28.570 at 10:10 a.m.

There is a moraine on west side of Michigamme in NE $\frac{1}{4}$  Section 17. In Section 8 moraine covers all except the southwest corner. We cross on the dam, aneroid 28.610 at level of lake. We see no signs of much cutting here or at the rapids, of which

we passed two--one at the old bridge site and the other about 1/2 mile below. See the Rominger map for location. The sand plain is well developed from Section 17 down the Michigamme to within 2 or 3 miles of Republic. It stands about 40 feet above the river. The basins in it have a silty, reddish loam and this is, in places, present on the plain itself. We could not see the moraine on east side of river. The sand plain extends back into the rock knobs on that side. It seems probable that the ice border passed from the outlet of Lake Michigamme southeastward to Republic, but the moraine may be weak among the granite knobs. It is well defined but narrow at and east of Republic, very bouldery and with small knolls, but less than a mile wide. There is considerable drift along the east side of the south arm of Lake Michigamme between the lake and the granite knobs. The knolls reach 30-40 feet above the lake but their base is usually 15-20 feet. The old railway grade cuts through some of them.

July 7, 1909.

7:00 a.m. Aneroid 28.890 at depot in Ishpeming = 1,403 feet. We take car to Negaunee. Aneroid 28.845 on sand plain in northeast part of Ishpeming. Striated boss in northeast part of city shows the westward movement clearly. The outwash apron starts at south bluff of Teal Lake and is 1,460 feet  $\pm$ . Aneroid 28.945 at C. & N. W. depot in Negaunee = 1,367 feet. Outwash aprons are finely developed in the north and east parts of Negaunee at altitude of 1,400 feet  $\pm$ .

South of Negaunee is a range of hills with hardwood timber, among which are small drift knolls. Possibly this marks the continuation of the moraine eastward from west Ishpeming. The bearing of striae ( $S70^{\circ}W_{\pm}$ ) seems, however, to favor a southward course or south-southeast course for the moraine from west Ishpeming. I think the D.S.S. & A. track crosses it in Section 17, T 47 N, R 27 W, at least we passed through a belt of knolls last night in northeast part of Section 17 and west edge of Section 16.

We take the road south toward Palmer. It commands a view of the Goose Lake

depression from northeast part of Section 17, T 47 N, R 26 W. The water from the outwash aprons in northeast part of Negaunee seems likely to have got through to the great sand plain southeast of Goose Lake through this depression. It is possible, however, that the outflow was southward across a pass in northeast part of Section 19, T 47 N, R 26 W. This, by aneroid, is below 1,400 feet and is a pine plain with nearly level surface. The material is coarse, many cobblestones and small boulders. There is a swamp in west part of Section 17 that, by the map of Van Hise, is below 1,400 feet. This plain is scarcely any above the south end of the swamp and may be a spillway.

In Palmer there is a gravel plain that seems to head in a moraine 1/2 mile east. The water from it found escape southward through the Cascade brook into Escanaba River. We follow down this brook through a narrow valley for 3 miles and there come out into a tract of pine that extends east beyond the granite. There is hardwood timber where the valley is narrow below Palmer. From Section 4, T 46 N, R 26 W the pine runs east (?) as far as I can get a view from the knobs.

Striae 60 rods north of a schoolhouse in south part of Section 4 bear S75°W. They are just back of a dwelling house on west side of road. We find striae bearing south-southwest near the line of sections 10 and 15 where the road ascends the south bluff of East Escanaba valley. Davis put a moraine here but it is nearly plane pine land with but few boulders. I should class it with outwash. The surface of these tracts is not a uniform level, some flats being 40 feet ± above the streams and others 20 feet or less--probably a result of terracing, for this seems to have been a line of drainage as the ice receded east or northeast.

The soil is better in sections 22, 23, 26, and 27, T 46 N, R 26 W than farther north, being loamy. It is, however, nearly plane surfaced drift and the timber is pine and spruce and, in places, tamarack. There are a few boulders. Mr. Wood suggests calling it ground moraine. It is not clayey but seems to be poorly assorted sandy and gravelly material.

Striae on knobs in this region bear about southwest. We passed several exposures with faint or indistinct lines. There is an unusual amount of bare rock along north side of Greens Creek in sections 34 and 35, T 46 N, and Section 2, T 45 N, R 26 W, standing 25-40 feet above the stream. Between Greens Creek and the Escanaba River is a barren, sandy plain standing only a few feet above either stream in sections 33 and 34, T 46 N, and sections 2 and 3, T 45 N, R 26 W. It is timbered with jack pine.

We cross the Escanaba River at the Cascades about 4 miles northwest of Princeton. There is a rock gorge only about 20 feet wide and 10-12 feet deep where the fall begins. It cascades again farther down. Mr. Wood took a view looking down over the succession of falls and another looking up at them. The total fall is probably 50 or 60 feet. Just south of the Cascades the surface is undulating and bouldery and the land has large pine stumps. A short distance southeast, jack pine plains set in.

There are high rock ledges on south side of Escanaba River setting in about  $2\frac{1}{2}$  miles northwest of Princeton in Section 12 and running to the moraine that sets in a mile west of Princeton. This moraine has hardwood timber on much of its surface from Princeton south two miles and then west past Pike and Bass lakes, as noted in 1905 (October 28 and 30). It was formed by ice moving south or southwest.

We noticed red sandstone fragments in the drift on our trip from Palmer to Princeton in several places. They show a southwestward movement of ice. The aneroid read 1,210 at the head of the Cascades and 1,240 at boarding house in Princeton, 29.075. On the high ground near the mine 40 rods southeast of the boarding house the aneroid reads 29.010. The rock is only a few feet from top of the high points. The drift is till in places and sandy drift in others on this high ground. It is probable that rock causes the relief of this hardwood tract except in the narrow strip that runs westward from Section 29, T 45 N, R 25 W to Section 30, T 45 N, R 26 W.

We have not crossed a well defined moraine from Negaunee southward to the Cataract. The drift seems to be either ground moraine or outwash and nearly all is sandy and loose textured.

July 8, 1909.

6:00 a.m. Aneroid 29.010, 1,200 feet  $\pm$  at Princeton Station of Munising Railroad at about the level of top of rock formations. Take train to Little Lake. Aneroid 29.045 at first stop; 29.125 at the Escanaba bridge, 15-20 feet above the stream; 29.125 at Gwinn = 1,100 feet  $\pm$ . There is very little change of level from here to Little Lake. Aneroid 29.125 at Little Lake at 6:30 a.m.; 29.100 at Little Lake at 7:35 a.m. = 1,121 feet.

Pitted plain around Swanzy. The plain in vicinity of Swanzy is 15-20 feet higher than at Little Lake. The plain rises as we go northward. Aneroid 29.050 at Sands; 29.060 in sag by Powell Lake; 29.000 on plain near line of T 46 and 47 N, R 25 W.

Striae S75<sup>o</sup>W in north part of Negaunee south of east end of Teal Lake. Aneroid 28.700 at striated ledges; 28.790 at Negaunee Station of C. & N.W. Railroad at 9:00 a.m. = 1,380 feet  $\pm$ . There are extensive sandy plains in east part of Negaunee at a level but little higher than the depot. In west part of the city is a high outwash along or near the main wagon road to Ishpeming. East from Teal Lake is a low plain 25-30 feet above the lake, bordered on north by bare rock knobs. An exposure south of C. & N.W. track just west of depot in Negaunee shows fine sand interbedded with till and clay. The till at top is 5-6 feet and has a few boulders a foot in diameter. The fine sand is about 6 feet. Below this is 8 feet exposed of clay with no pebbles, so far as I can detect. The till and the clay each have a reddish tinge. The sand is whiter--probably because of washing. Aneroid 28.800 = 1,380 feet at Negaunee at 10:00 a.m.

Aneroid 28.975 at Cascade Junction at 10:15 a.m. = 1,220 feet. There is a sandy pine plain westward across Section 25, T 47 N, R 26 W. The railway is then in swampy land with ash, elm, spruce and tamarack for  $1\frac{1}{2}$  miles. Rock hills are close by on the north but the country is open to the south in Section 26. Drift knolls set in in the northwest part of Section 27 and continue westward for two miles. The summit on the railway, about  $1\frac{1}{2}$  miles east of Palmer, is morainic with some clayey till. West of it, the moraine is sandier. Aneroid 28.850 on the railway summit; 28.880 on outwash

plain east of Palmer. We stop for dinner at Palmer.

West from Palmer there is a little strip of bouldery, gently undulating gravel standing about 20 feet higher than the outwash plain in east part of the village that seems to mark an earlier ice border. A flat tract leads west from it which is utilized by the railroad that runs west to Winthrop. The aneroid read 28.825 on highest part of the weak moraine and ~~28.840~~28.850 on the flat tract a mile west-southwest from Palmer. This flat tract extends west to where the railway turns north with no signs of morainic features along it.

On turning north there is a flat bottomed open valley up to Winthrop in north part of Section 21. There a moraine fills up the valley with little knolls. The knolls are literally paved with boulders. Among them, on the slopes, are glaciated rock knobs, but in the bottom they are entirely drift. The outwash southward is a fine sandy gravel. The moraine seems to find continuation through southwest part of Section 16, T 47 N, R 27 W and northeast part of Section 17, but rock knobs occur too, and so tend to obscure its features and make the course hard to follow.

In Section 16 we find interesting striated ledges. One, of quartzite, north of the northeast road in central part of section has striae running about  $S15^{\circ}W$  on crest, but as far as  $S45-50^{\circ}W$  on the south slope of a small boss. Mr. Wood took a picture showing the variation. The hat is beside striae bearing  $S15^{\circ}W$  but at the near end of the ledge they curve around to  $S45-50^{\circ}W$ . The other exposure is south of the road and is a dark-colored conglomerate. It has the knob and trail from nodules and pebbles with protection on the south side. The bearing is about northeast=southwest. Mr. Wood took a picture of a knob and trail looking southwest. The pencil lies just beyond the place where knob and trail shows. I drew lines each side to show the striation more clearly. The striae curve a little around the projection.

In south part of Ishpeming there are thick deposits of red till on flat areas southwest of Lake Angeline exposed by caving in of mines. The basin of Lake Angeline is considerably lower than the flat tract.

We take a motor auto over to Marquette from Ishpeming at 7:00 p.m., setting aneroid at 1,400 by the D.S.S. & A. Station. The summit between here and Negaunee is 1,500 feet on wagon road. C. & N.W. Station = 1,380 feet. D.S.S. & A. Station = 1,367 feet. The flat tract east of here is 1,380 feet on lower bench. Crag and tail hill near railway in east part of Negaunee with crag at east. The broad plain east of here is 1,390 feet  $\pm$ . There is a descent southeast and east from the east edge of this plain. Bouldery at 1,365 feet. On flat at foot of slope, 1,280 feet. This extends east past Eagle Mills and is traversed by Carp River. The high plain nearly 1,400 feet A.T. is present north of Eagle Mills and has a moraine at its east border, as noted in 1905. There seems need for more study between Negaunee and Eagle Mills north of this road. From Eagle Mills down to Marquette the features are mapped on the Marquette topographic sheet.

July 9, 1909.

6:45 a.m. Marquette, Michigan. We took train to Ishpeming that runs up Carp River to Eagle Mills. The drift is heavy all along the stream and, in places, is in knolls. The amount is greater than my recollection of it. In such a rough country it will be difficult to mark out the course of moraines clearly but with the aid of topographic maps and of barometer it may be feasible.

We go north from Ishpeming to map extent of outwash features. There is a great deal of irregularity with depressions that are bouldery and hummocky bordered by flat outwash standing about 1,430 feet A.T. There are also rocky knobs rising above the outwash plain. The outwash at this high level runs east nearly across Section 2, T 47 N, R 27 W. In places there are little knolls on east and in places an abrupt descent.

We find a gravel pit near middle of north edge of Section 3 at west end of the gravel plain that shows steep westward or southwestward dip of beds toward a basin that covers the northwest part of Section 3. This is just east of a cemetery. Mr. Wood took a picture. There are about 4 feet of very coarse topset beds with horizontal bedding.

We follow the ice contact northward across west part of Section 34, T 48 N, R 27 W to the edge of Deer Lake. It there swings westward across Carp River. We follow it no farther but go southeast across the Siamo Hills area, past Hematite mine. The ice seems to have filled Lake Bacon at this time. From there its border bears northeast to a hill in north part of Section 2. From the east end of this hill it turns south to a diorite knob east of center of Section 2, this knob and one in west part of Section 2 being in the outwash apron. The ice contact crosses to south side of D.S.S. & A. Railroad near line of sections land 2 and follows the L.S. & I. Railroad east 1/4 mile and then passes south across the highway from Ishpeming to Negaunee, forming good morainic knolls in the recesses of the hills in southwest part of Section 1.

The Negaunee gravel plain extends east from center of the city to west part of Section 5, T 47 N and southwest part of Section 32, T 48 N, R 26 W, its north edge being against the quartzite range. It is bouldery at its east edge and on the slope down to the low tract east of it in sections 32 and 5. We follow the border into the southeast part of Section 6 and northwest of Section 8 on north side of a diorite knob flanked with iron-bearing rocks. Here there seems to be a junction with the Ishpeming ice border for morainic country fills the greater part of Section 8 and extends south toward Palmer in the low tract in west part of Section 17 and east part of Section 18, T 47 N, R 26 W. Probably the ice at the Ishpeming stage stood higher on the hills in sections 7 and 18 than at the Negaunee. If there was southward drainage toward Palmer at the Negaunee stage, it probably was along or under the edge of the ice in sections 7 and 18.

We returned along east edge of gravel plain in sections 5 and 32 and crossed over the Makwa range of quartzite etc., and followed the north border eastward. There is a striation on the quartzite at south edge of the range east of center of Section 32, bearing S75°W. On the north side of the range, scarcely 40 rods ~~south~~ northeast from last observation, the striation is southwest. The district between this range and Carp River in northeast part of Section 32 and southwest of Section

29 is nearly plane but slightly bouldery and with a soil suitable for white pine. This pine is starting again and there are large stumps. It looks like a ground moraine topography.

As we go east, more definite knolls set in near middle of line of sections 29 and 32 and the altitude is higher than where we come down in Section 31 from the Makwa Hills. This seems a natural place for the continuation of the Negaunee ice border. It may run up a north tributary of Carp River in sections 29 and 19. The northeast part of Section 30 has flat-surfaced land on north side of Carp River about 60 feet above the stream that we saw from the quartzite hills in Section 31. We follow down Carp River to the Marquette-Negaunee turnpike, past the monument to the first mining operations by the Jackson Mining Company that began in 1847. It is only  $1/8$  mile from where the river cuts through the hills on north face of the hills. Mr. Wood took a picture of it. We walk up to Negaunee and take electric car to Ishpeming.

July 10, 1909.

Ishpeming, Michigan. We go to a boss of striated rock on north side of east New York Street in Ishpeming that shows two sets of striae--a heavy one,  $15^{\circ}$  south of west and a lighter, later set, about  $15^{\circ}$  north of west. Mr. Wood took a view of the two sets. My notebook is lying the long way in the direction of the latest and lighter groups. This boss rises a little above the sand plain 5-10 feet. There is a prominent hill east of it  $1/8$ - $1/4$  mile. Probably the striae  $15^{\circ}$  north of west were formed by movement of ice west on south side of the large hill. The rock on the striated boss is a much contorted greenstone schist. The boss also shows stoss and lee sides and Mr. Wood takes a picture of this looking north from out in street over a high picket fence. This boss is on the property of a Mr. Burke.

Aneroid 28.525 = 1,903 feet at D.S.S. & A. Station, 8:00 a.m. We take train to Champion. The swamp west of Ishpeming is about 1,395 feet. The sand plain bordering it is 1,433 feet at Mile Post 172 and west from there to Stoneville.

There seems to be low land at about this level to the south in Section 16 so the discharge could be in that direction for the glacial waters from the Ishpeming sand plain. The next sand plain, at Greenwood, is 1,510 feet. The plain west of the Greenwood moraine is about 1,527 feet. This plain extends to Humboldt and has a good free passage southward by the Escanaba. The plain at Champion is 1,586-1,590 feet at its head.

At 10:00 a.m. we left Champion for Channing. The notes taken on former trips are pretty full to Republic. From Republic to within 2 or 3 miles of Channing there is hardwood timber and morainic topography. The surface is flatter near Channing but has hardwood timber. The soil is rather sandy. In the moraine there is a sandy till with many cuts that show few stones imbedded. This seems to be ground moraine.

We go west along the railway and cross a sharply morainic tract in sections 2 and 3, 16 and 11, T 43 N, R 31 W, with knolls 15-30 feet or more and basins among them. They are thickly strewn with boulders--granite, diorite, etc. We see scarcely any sandstones of Cambrian age. This moraine runs northward on east side of Lake Ellen to the Michigamme River and probably continues northward on west side of the river.

West of this moraine is a flat tract with occasional rock knobs on it extending to the Michigamme River at Kelso Junction. We went into the one on the township line between T 43 and 44 N, R 31 W, sections 4 and 33. It rises above 1,580 feet, or about 200 feet above the surrounding plain which is just below 1,400 feet. The knob has a basic ferruginous schist in highest part but its south flank seems to be a syenitic rock. We found striae on north side of crest bearing  $10^{\circ}$  north of west and on crest about due west by compass. The movement was plainly a westward one for the battered (?) side of depressions is facing east. On another knob in south part of Section 5, just west of a small brook and north of the C.M. & St.P. track, there are striae about  $10^{\circ}$  north of west on the crest. The plane tracts among the knobs are generally gravelly except where so low as to

be peaty. The timber is partly hardwood on the gravelly land, but it seems to be, in part, on outwash plain from the moraine east of it.

Just east of Michigamme River opposite Kelso Junction are a few till knolls rising 40 feet  $\pm$  above the stream. The flat land is about 20 feet above the stream --the till has a pink tinge. From Kelso south for  $1\frac{1}{2}$  miles the railway is among rock knobs that rise 20 to 80 feet  $\pm$  above the surrounding flat tracts. We found no striae on these along side of the track but they are all glaciated bosses with stoss side at east. Near the Hollister Mine a large tamarack swamp is entered east of which are the rock hills on which Hollister Mine and Armenia are located. The small amount of drift among the rock hills standing above the swamp is sandy and slightly undulating. Cuts a mile or less south of Kelso Junction showed sand 5-6 feet capping stony, cobbly drift. There is scarcely a pebble in the sand. Boulders are very scarce on the drift surface but there are some on the rock knobs. There is a bouldery sand on the knob two miles northeast of Crystal Falls at the Hilltop Mine. All around this hill there is a pine plain that runs south as far as I can get a view. East of this strip there is hardwood on the hills.

July 11, 1909.

Crystal Falls. 9:00 a.m. Sunday. Aneroid 28.625 at C. & N.W. Station = 1,344 feet. A copper mass weighing 196 pounds was found near this station in digging a sewer. It is on display in front window of a saloon on Main Street.

We take train to Iron River. The railway enters a broad outwash plain about a mile south of Crystal Falls; The hills immediately south of the city on west side of the river being in hardwood forest and bouldery drift. The sandy plain does not extend more than  $3/4$  mile west of the railroad and, in places, just to the railroad track, the range of hills on the west being in hardwood forest. Hills east of the railroad, northeast of Mastodon Station, are bouldery but were largely timbered with pine. The hardwood forested hills lie just west of the track clear to Stager. To the east there are hills with mixed timber.

Aneroid 28.600 at Stager at 9:45 a.m. = 1,301 feet. Looking southward from here there is a low tract, nearly plane, largely timbered with pine extending into the edge of Wisconsin. The scattered hills east of Stager may be rock hills. There is a prominent range  $1\frac{1}{2}$ -2 miles east-southeast, 200 feet  $\pm$  high. The railroad is on a sand plain west from Stager that extends about  $1/2$  mile north of the track all the way to Armstrong. There is only a narrow sand plain above Armstrong, and up Iron River. It is about 40 feet above stream at Iron River and of rather coarse gravel.

July 12, 1909.

7:00 a.m. Aneroid 28.060 at Iron Inn, Iron River = 1,525 feet  $\pm$ . John E. Nelson at Bates in east part Section 27 has well 160 feet deep that was through till over 100 feet and then 40-50 feet of sandy gravel. The water rises 9 feet in it. Altitude about 1,700 feet. The till was reddish color. It is on east slope of a large drumlin. The highest part of the drumlin is 1,780 feet  $\pm$ .

The drift on east slope of the drumlin east from Bates is exceptionally red, almost like brick, at depth of 5-6 feet, and is very hard. We have seen fully as red a drift from Iron River to Bates as in the districts farther east, yet Russell and Davis map this as gray till. Drumlins are finely developed from Iron River eastward nearly to Chicagon Lake, as indicated on the topographic map.

The country is deeply sculptured north-northeast - south-southwest and slopes all rubbed smooth by glacial action. No hummocks nor basins. The swamps are not nearly so extensive as the topographic sheet indicates but when cleared will make a fine farm land with clay loam soil.

We took the south road from Iron River past Stambaugh to Bates and this led across a number of fine drumlins. Boulders are very numerous on the drumlins and in the sags between them, and are of various kinds and sizes up to several feet in diameter. On the whole they seem more rounded than those we have seen northeast from Crystal Falls. Only a small percentage show glaciated faces.

At the outlet of Chicagon Lake we enter sharply morainic topography and a more sandy and gravelly drift. It runs north along east side of Trout Lake. The timber is mixed hardwood, hemlock and spruce, and there are small basins with spruce among the knobs.

Just after passing the line of T 43 N, R 33 W, we rise to a nearly plane upland with maple forest in Section 30, the north half being chiefly maple forest. We then descend into a sandy, gravelly tract with a prominent esker in its midst that runs from the bend of the road in south part of Section 20 in a course west of south to southwest part of Section 29. It has a plexus at north end in the bend of the road with basins locked in among the ridges. The main esker is 40-50 feet high where sharpest. It has a few boulders on its slopes. The material in it seems to be a gravelly and cobbly sand. The land each side for nearly 1/4 mile from the esker is indented with basins but otherwise is nearly plane. One basin takes 2 depression contours and only occupies a few acres.

There is a high tract of maple forest east of this esker and esker trough on which the soil is not so strong a clay loam as in the district west of Chicagon and Trout Lakes. We go south through the high tract of maple forest east of the esker trough to a road that leads southwest to Chicagon Lake. This high tract has a loamy soil and few boulders and a nearly plane surface, yet it is 1,620 feet or more.

We go toward Chicagon Lake and descend to the esker trough which, in Section 32, is about 1,480 feet. There is a short link of the chain of esker ridges south of this road 20 feet  $\pm$  high and very steep-sided. We follow it 20 rods or more south and it there has a slight break but continues a little farther on. To the south from here in sections 5 and 6 is a tract of sandy, gravelly knolls and ridges enclosing deep depressions. It seems to mark the lower end of the esker and be a sort of irregular-surfaced delta or fan. There is said to be rough land clear through to the west end of Fortune Lakes in sections 6 and 5, T 42 N, R 33 W and to the depression that connects Fortune Lake with the west branch of Armstrong Creek in Section 9.

We find a very sharply hummocky tract along the east bank of Chicagon Lake down to where it comes close to Indian Lake in Section 12, T 42 N, R 34 W. Basins are enclosed among the hummocks. It is a loamy, gravelly till. A short distance east is a strip of nearly level clay that runs south on east side of Indian Lake. It covers much of sections 7, 18, 19 and 30 and west part of sections 8, 17 and 20, T 42 N, R 33 W. There are a few drumlinoidal hills on it as shown by the topographic map. Between Chicagon and Indian Lakes there is very flat-topped clay land 20-25 feet above lake level with few boulders. Its bank next to each lake is steep.

We went east to the town line east of Indian Lake and then south of Pentago, through a tract of hardwood with clay loam soil and a moderate number of boulders. We crossed one drumlinoid ridge two miles north of Pentago with a north-northeast - south-southwest trend. The map shows three others within a mile or so northeast of it.

The bluff at Pentago is very steep to 60 feet and rises back from brow to over 120 feet above the station. The station is about 25 feet above the river. There is a low bottom about 1/4 mile wide on flood plain. The 25-foot terrace is fully 1/2 mile wide here. It is coated in places with a fine sand and, in places, is cobbly. We go east to the Maggie Lakes in Section 29, T 42 N, R 33 W. Their surface is about as low as the low bottom on Brule River. The surrounding land is a pitted plain 20-30 feet above the lakes. It is gravelly and cobbly and the cobbly character extends out to Brule River. The abrupt bluff runs north on west side of this low pitted plain to the southwest end of Fortune Lakes with a general height of about 80 feet. It looks like a river bluff here at west side of Maggie Lakes but farther north the map shows it to be very irregular. There seems to be no rock in it here but we are told by an old resident that a dark-colored rock outcrops about three miles north of the Brule valley on west side of a small lake in Section 16. There is a low tract opposite Pentago extending south-southwest into Wisconsin but above here high hardwood tracts occur on both sides the valley. There was hardwood in the valley at Pentago.

We take train at 6:30 p.m. from Pentago to Florence, Wisconsin. There seems to be an extensive low plain on south side of Brule River opposite the mouth of Armstrong Creek. Rock knobs are cut through on north side of Brule River a mile northwest of Stager. Aneroid 28,500 at Brule River southeast of Stager, or about 180 feet lower than Pentago. Gravel plain with rock knobs between Stager and Brule River. South of river the railway is in sight of rolling hardwood land to the southwest for 2 miles  $\pm$  and then turns into the upland. Drift seems to be very sandy clear to Florence.

Aneroid 28,500 at Florence Station at 7:20 p.m. = 1,290 feet. I get a county map here of register of deeds and put on it data as to pine and hardwood land and general topographic features. Florence itself is at west side of a moraine that runs northward to the Brule River above mouth of Paint River. There is an outwash apron on its west side between the moraine and a range of hills with iron-bearing rocks. The discharge was southwest from Florence through a narrow channel.

July 13, 1909.

7:00 a.m. Florence, Wisconsin. We examine the hill northwest of the village for striae but find it everywhere rotten rock. The rock is close to the surface. The hill rises about 110 feet above the station or to about 1,400 feet. North of Florence, near center of  $NW\frac{1}{4}$  Section 16, we find striae on a rock boss--three places show bearing  $S20^{\circ}W\pm$ . One of them has an earlier set,  $S45^{\circ}W$  preserved in a depression. The stoss and lee side phenomena are clear and show movement to have been southwestward.

We traced the border of moraine and outwash from Florence northward to Brule River in detail. There is a recess in the south part of Florence where the outwash extends back eastward into the moraine  $1/2$  mile or more. The moraine is present in the north part but has only low swells 10 feet or less, and is very sandy and gravelly. Boulders are plentiful. About  $1/2$  mile east the knolls become more conspicuous. From north edge of Florence near center of Section 21, T 40 N,

R 18 E, the border bears northeast to the southeast corner of Section 16 and then north along east side of a little lake, then northwest to the corner of sections 8, 9, 16 and 17 and north through east part of Section 8 to Brule River. Rock bosses are present near it in northwest part of Section 16 but boulders and a heavier soil than the outwash plain show the change to the moraine and knolls also of drift. The moraine is mainly covered with hardwood but some pine occurs near its west edge in and around Florence where it is most gravelly. The Brule River makes a break of only  $1/4$ - $1/3$  mile in the moraine and is very rapid in its descent from the outer to the inner (or eastern) border. North of the river, the moraine is finely developed west of Paint River. It has sharp gravelly knolls up to a height of 150 feet above the stream from a level only 30 feet above it. The stream is bordered by a terrace about 30 feet high.

From a prominent knoll  $1/2$  mile north of the river bridge we could look east to what seems to be a morainic strip between the Paint and Michigamme rivers with a flat tract, probably outwash, on this side extending to Paint River. We could also see a more distant range east of Michigamme River. Looking west we had in view the outwash of the moraine we are on, extending out to Stager, and beyond this a great tract of rolling land with hardwood forest. The outwash tract is indented with basins 30 feet or more in depth between the railway bridge on Brule River and Stager which we saw from the train last night.

We go northward for nearly 3 miles on the moraine and find it generally strewn thickly with boulders and having a good soil. Not far from the line of T 41 and 42 North, we descent to a creek just above where it enters Paint River from the west, north of which, after passing rocky knobs, we enter a high sand plain timbered with pine in Section 35, T 42 N, R 32 W. On one of the knobs we found glacial grooves much weathered but still discernible, bearing  $S70^{\circ}W$ . The rock bosses show clearly a westward movement of the ice.

Near the corner of sections 22, 23, 26 and 27, there are low swells of morainic aspect and boulder-strewn, rising 20 feet or so above the plain. The soil is a little better than on the plain, so some hardwood (maple, etc.) occurs on them. But all around there is a pine plain, largely jack pine, but some Norway. This plain extends northward along the west side of Paint River to within  $1\frac{1}{2}$  miles of Crystal Falls to the borders of Railroad Lake. Its general elevation is about 80 feet above Paint River. There is a lower sandy tract around Railroad Lake and north of it, only 30-40 feet above the river. This is in the recesses east of the high tracts with hardwood forest that lie west of the C. & N.W. Railroad south from Crystal Falls. These high hills have rock near surface. There are also rock hills on the pine plains in sections 16, 17, 20, 21, and 28, T 42 N, R 32 W, that were timbered with larger pine than the plains. Some of these hills are flat-topped as if coated with outwash and are sandy.

There are low swells, perhaps of drift, in the pine plain northwest of Clara Lake in Section 15 and north from there in Section 10, T 42 N, R 32 W. These may belong with the westward movement and be continuations of the Florence moraine that we traced into this plain from the south. There is a hardwood tract north of Paint River east of Crystal Falls and east of the pine plains that may also be a part of the same moraine. This extensive pine plain south of Crystal Falls seems to be in the reentrant between the westward and the south-southwest ice movement. The south-southwest movement was found later to antedate the westward one.

We drove west from Crystal Falls on road toward Iron River as far as Fortune Lakes and back. The high tract in Crystal Falls shows numerous exposures of striae about north-northeast - south-southwest and so does the high tract  $1-2\frac{1}{2}$  miles west. The range as given by Russell is from  $16-20^{\circ}$  for this set and about southwest for an earlier set. We did not see any exposure of an earlier set, and would put the range as from  $S15^{\circ}W$  to  $25^{\circ}W$ . We passed probably a dozen or more exposures in the road in the 3 miles.

The hillside slopes on this road are remarkably smooth nearly to Fortune Lake but in south edge of Crystal Falls and from there to Railroad Lake we passed drift

hummocks. On the border of Fortune Lakes there are a few sharp knolls of sandy drift but much of the border is a low plain of sand. This sandy land has pine and spruce and but little hardwood, but within 1/2 mile back from the lake on either side is an elevated tract of hardwood. There seems to be thick drift each side of the lake on the uplands. The surface of the uplands is not hummocky but has a few swells of till with gradual slopes and rather smooth surface. Boulders abound on the upland everywhere from Crystal Falls to Fortune Lakes. We found a private road leading south in Section 26, T 43 N, R 33 W, very rough because of the boulders and only traversed it 1/4 mile.

We drive southwest toward the Dunn Mine in Section 30, T 43 N, R 32 W, through a tract of thin drift. There are hummocks in west part of Section 31 that look to be of drift, but they may have a rock core. They are 20-30 feet high and are on a slope to the west. The high tract southeast of Shaeffer Mine is all cleared land and has an undulating surface as if covered to some depth with drift. Farther south the uplands are reported by surveyors here at Crystal Falls (Mr. Wheelwright and Mr. Ascham of University of Wisconsin) to be very thinly coated with drift so that test pits for ore reach rock at 5-10 feet or less.

July 14, 1909.

7:00 a.m. Crystal Falls. We drove to Amasa and back, making detours to the west. The first detour was westward along north side of Brier Creek from Section 19, T 43 N, R 32 W to west part of Section 23, T 43 N, R 33 W, through a plain of sandy gravel about a mile wide. This plain extends southwest to the northeast part of Fortune Lake. It also extends north from the northeast part of Section 23 into Section 14. At its north end there is a fosse like descent and from there to Paint River a hummocky, bouldery moraine. This fosse seems to mark the ice border.

East of this, in sections 12 and 13, and east part of 11 and 14 is a higher hardwood tract with more gentle slopes. The same is true of the high tract of hardwood on the west in sections 14 and 15. Some of the most prominent hills

there are drumlinoidal with north-northeast - south-southwest trend. On the south part of one of these in southeast corner of Section 15, at an altitude of 1,500 feet, a well was dug 133 feet and did not reach rock. Its dump shows some till, but there is a good deal of gravelly material. The well has caved in and is no longer used.

We returned to the Amasa Road and went north along it through the sand plain past some low knobs of rock to Paint River in southeast part of Section 7, T 43 N, R 32 W, and then up the south side of the valley a mile, coming into bouldery land just before we descend to the bridge in northwest part of Section 7. This seems to be an ice border correlative with that noted in Section 14 at the head of an arm of the same gravel plain. There is a moraine on north side of the river west of this bridge with deep basins and a bouldery surface.

East of the bridge, on north side of the river, is a range of high rock hills. Mr. Wood found striae on a knob just east of the road, bearing about S20°W in northwest corner Section 7. Mr. Wood saw some novaculite in this hill.

There is a laminated clay exposed along the road about 1/2 mile north of the bridge where the road descends from the basin moraine just noted into a swamp in the southwest part of Section 6, T 43 N, R 32 W, but there is sandy, bouldery material above it. There seems to have been a sort of ponded condition at the ice border, notwithstanding the outwash plain that we have just mapped between Paint River and Brier Hill Creek.

There is a tract of undulating elevated hardwood country from Paint River in Section 11, T 43 N, R 33 W, northward about to Balsam through which the road to Amasa runs. It is bouldery and the lower parts of slopes are hummocky but the high tracts are nearly plane. There is a large basin in it occupied by Swan Lake, the lake being surrounded by high land except where its narrow outlet leads south. The borders are timbered with hardwood forest. The hardwood forest and bouldery land extends northwest on this road to Amasa just beyond where the road to Balsam branches off.

There is a pitted gravel plain from Section 22, T 44 N, R 33 W northwestward for two miles or about 1/2-3/4 mile past the crossing of the C.M. & St.P. Railroad. This also extends west around Lost Lake and a long lake east of Lost Lake (see topographic map). The surface is about 40 feet above these lakes and there are numerous little basins in the plain. The soil is rich enough, in places, to have a hardwood forest and the pine and hemlock had a rank growth. Cobblestones abound and the gravel seems to have considerable depth. This may extend to Balsam but there is hardwood forest in that direction.

The ridge that lies southeast of Amasa with a north-south trend seems to have considerable drift. It is bouldery and has good soil. The large hill in northeast part of Amasa has a large amount of drift at its southwest end. A cave in by the mine exposes 30 feet or more without reaching rock.. The northeast part of the hill is bare rock and shows striation S28°W. There are drift knolls in Amasa and north and northwest of the village in the low tract between Hemlock and Little Hemlock Rivers. The drift in these knolls is coarse, bouldery and cobbly material. There is gravel in a knoll standing in the bend of Hemlock River 1/4 mile southwest of Amasa that reaches 1,500 feet contour. There are extensive tracts to the southwest from Amasa about 1,500 feet A.T. that may be gravelly but they had considerable hardwood. A rain has prevented our getting around much near Amasa.

We drove directly back to Crystal Falls. I went to the falls and looked at the gorge below. It is about 1/2 mile long and its top is at the 1,340-foot contour. The rock is a slate that breaks up easily. The gorge where deepest is about 60 feet. The water excavated the rock very irregularly so there are winding channels among low rocky knobs rising 15-20 feet above the channels. The present falls are about 30 feet in a series of cascades over hard iron-bearing rocks. A dam holds the water up to the level of the highest part of the ledge over which there was a fall. The stream is a little below 1,340 feet above the falls, or a little lower than the top of the rock gorge 1/4 mile below the falls. It seems probable that at that time the water surface was higher and the falls about 60 feet.

Below the rock gorge there is a boulder-strewn terrace probably due to cutting down of the valley and concentration of the coarse stuff in the drift. There was till west of the river and sandy material east.

July 15, 1909.

7:00 a.m. Crystal Falls. I go east across Paint River to some rock knobs about 1/4 mile from the stream and find one is glaciated with striae S12°W. It stands on the sand plain. I continue east to an elevated hardwood tract about two miles east-southeast of Crystal Falls in sections 27 and 34, T 43 N, R 32 W. It has iron-bearing rock near surface and I find striae near its east side on a ridge that extends northeast in southwest part of Section 26 that bear S12°W. The ridges east from here have bare rock ledges exposed.

I follow an old railway grade across Section 26 northeast to Armenia through a swamp or peat bog. Armenia is on a rock hill but its east slope has considerable till so that railway cuts 10 feet deep do not reach rock. It is a very bouldery till. About 1/3 mile east of Armenia is a rocky knob about 60 feet high not shown on topographic map. It is south of the wagon road and has striae near its base on south side of the road and also about 40 feet higher and they bear S82°W on both levels. It seems that I have got to the edge of the Green Bay westward movement. From here to Mansfield I find numerous exposures of striae bearing from S75°W-S82°W both near base of knobs and high up on them. The knobs also show a shaping by westward moving ice, the lee side being at west end and stoss side at east. There is no moraine in the tract between the westward and south-southwest ice movement near Armenia unless it be the drift on the hill at Armenia.

There is a sandy, gravelly plain from Armenia eastward to the Michigamme River below Mansfield. Hardwood covers the hills northwest of Mansfield and they are all rocky knobs. From the knobs I can see southwest two miles ± across a tract of brushy, stumpy land that seems to be the continuation of the sandy gravel tract I have crossed between Armenia and Mansfield. There are scarcely any

boulders on this tract. The river has been diverted into a new channel by the bridge at Mansfield and exposes a reddish till with gravel interbedded.

I go east on road to Sagola and rise about 140 feet to a rocky country with bosses of rock showing plainly the westward movement and among them till with many boulders. The till is nearly plane-surfaced and is somewhat clayey. In it I notice frequent occurrence of red quartz porphyry. The striation on the knobs is about S72-S75<sup>o</sup>W. The till extends eastward about to the corner of sections 21, 22, 27, and 28 and is rather flat all the way and rock knobs are scarce in sections 21 and 28.

I pass through sandy swamps in Section 27 in which there are rock knobs with striae S70<sup>o</sup>W. There are some sandy plains a few feet above the swamp around the knobs; also bouldery tracts close to the knobs that have some till.

I turn south on line of sections 26 and 27 and after crossing a small creek enter a sand plain. I go east between sections 26 and 35, 25 and 36 and find sandy loam with few pebbles and no boulders until I am within 1/4 mile of the town line. The soil becomes a richer somewhat clayey loam in sections 25 and 36 and I approach a moraine that sets in in the east part of these sections. The moraine is boulder-strewn and has a rich clayey loam soil with till and sandy pockets exposed in cuts. The till is reddish color. The inner border of this moraine is at Sagola, so its width is about 2 miles. There are many small hummocks of an acre or less area 10-15 feet high on its eastern slope 1/2-1 mile west of Sagola. They have many boulders and cobblestones and give it a strongly morainic aspect.

A well in northwest part Section 31 on J. J. Clark farm struck rock at 48 feet and went 26 feet into it to water. Rock is a white limestone. In Sagola at the schoolhouse rock is struck at about 60 feet--kind not certain--either sandstone or limestone.

I take train to Channing at 3:15 p.m. The track is largely through swampy ground moraine with an occasional knoll 20 feet ± high. There are knolls south-

east and southwest of Channing on the borders of Ford River that are steep-sided and 25-30 feet or more high. They are of sandy, gravelly material with a few boulders. The tracts around are nearly plane and have occasional boulders. It seems to be ground moraine with spots of knolly land but not clearly in a definite belt of moraine.

I was told at Sagola that on the road leading southwest to Marys Lake, four miles south of Mansfield, there is a bouldery, rolling hardwood for only 3 miles from Sagola. Beyond there are flat tracts with sandy soil and much of the land is stripped of its timber and now covered with brush and stumps. In places there is pine and some land is so poor as to have jack pine. It seems doubtful if there is a moraine running through the district outside the Sagola moraine.

Mr. Wood walked the railway from Crystal Falls to Balsam and then to Kelso Junction and Channing. He found striae near northwest corner of Section 5, T 43 N, R 32 W, bearing S60°W. There were several exposures. On the sides of bosses they are even more nearly westward. On going farther west into Section 31, T 44 N, R 32 W, he found the bearings south-southwest and noted the striae on several bosses with this south-southwest trend and even nearer south.

There is a large moraine between the railroad and Swan Lake that runs north past Balsam. In the vicinity of Balsam it has many sharp hummocks thickly strewn with boulders. The moraine continues north-northeast from Balsam as far as he could get a view. But to the northwest there are swamps and nearly plane tracts. He considers this moraine the limit of the thick drift of the south-southwest ice movement. From Balsam to Kelso there is thin drift on the hills, rock being at surface. Among the hills there are swamps. At Kelso there is a sharp gravelly drift ridge with a valley west of it through which a creek flows into the Michigamme. He thinks the valley is large enough for the Michigamme.

July 16, 1909.

Channing, Michigan. We go north  $1/2$  mile and take the track east on railroad toward Escanaba. For two miles or more there are frequent knolls 10-20 feet high with variable structure, part being red till and part sand. The sand, in places, is definitely bedded. In the cuts we find the calciferous sandstone and limestone rocks embedded in till.

In the northwest corner of Section 11 at a lumber camp we find sand plain about 5-10 feet above the swamp. This seems to be present as islands in the swamp toward the northeast in sections 1 and 2, T 44 N, R 30 W and sections 35 and 36, T 45 N, R 30 W. Southeast of it in sections 11 and 12, 13 and 14, on each side of Ford River there is morainic topography with good hardwood timber.

We come to a plain of gravelly sand where the railroad strikes the river, about a mile west of a large north tributary in Section 7, T 44 N, R 29 W. It is about 60-70 feet above the river and was timbered with pine. East of this north tributary there is a strong moraine coming in from the north that stands about 100 feet above the river and has sharp hummocks. There are cuts along railway in it that show bouldery till a few feet thick capping a large amount of sand; also cuts with sandy gravel from river up to 75 or 80 feet above the stream.

Turner Station reads 1,075 by my aneroid and 1,130 feet by Mr. Wood's. The granite knobs set in a mile west of Turner in sections 10 and 15, T 43 N, R 29 W. They show a shaping by a westward ice movement but we find no striae. The surface in places is very slick, so but little weathering has occurred. The knobs rise, in some cases, 50-75 feet above Ford River. The river is in a winding valley among them  $1/4$  mile  $\pm$  wide. There has been little or no cutting by the stream since glaciation in the rock and only 20 feet or less in the drift. The moraine just west of the granite area has a height of about 100 feet above the river and is about as hummocky as at its west border. The granite knobs have very little drift on or among them. Just west of the granite area is a slate rock, thin bedded, of blue color. There is considerable calciferous sandstone in the drift west of Turner, but we did not see an outcrop.

East from Turner there is a sandy plain with a few granite bosses rising a few feet above it that covers the southeast part of Section 11 and nearly all of Section 12 and north parts of sections 13 and 14, T 43 N, R 29 W. It extends a little into sections 7, 18 and 19, T 43 N, R 28 W, covering much of Section 19. East of this is a moraine in east part of sections 7 and 18 and much of sections 8, 17 and 20. It is bouldery and hummocky. In sections 21 and 22 there is a large tamarack and spruce swamp along the river but north and south of it there is a strong moraine.

There seems to be rather low land south of the river in Section 28 but in sections 27 and 29 the moraine rises 60-75 feet  $\pm$  above the river. At Rolph, in the southeast part of Section 22, the tamarack swamp ends and morainic knolls occur east side the river, close to it, so the low bottom is scarcely 1/4 mile wide. The one on the east side south of Rolph is shaped like a drumlin and has an east-west trend. It lies along or near the line of sections 23 and 26, T 43 N, R 28 W.

South from here there is a large sandy swampy area around the west and south edge of which the river flows. It covers much of sections 26, 35 and 36. An area of swamp runs southwest from it to the head of Sturgeon. This may be a line of discharge for glacial waters from a moraine east of here.

There are some small drumlinoid ridges in southeast part of Section 26 and northwest of Section 36 with east-west trend that are composed of reddish till and have a remarkable number of dolomite boulders and other sedimentary rocks of semi local origin or derivation. The limestone was first noted in large amount in the cut just south of Rolph Station. Probably the rock underlies this region or immediately to the east.

We see no more drumlins after turning east in Section 35. There is a very hummocky tract in Section 25 and north part of Section 36. Some of the knolls are largely of yellow sand; others have bouldery surface or boulders in part of the knoll and sand in part. The moraine has very sharp hummocks in west part of

Section 30 and northwest of Section 31, T 43 N, R 27 W with numerous boulders on surface and in the cuts. These in the cuts are chiefly limestone. Those on the surface are of various kinds of rock.

There is continuous moraine and hardwood timber along north side of Ford River to Northland but a strip of swampy bottom extends nearly a mile north of the river just west of Alfred. South of the river there is a low tract extending southwest from Section 33, T 43 N, into Section 4, T 42 N, R 27 W. East and west of it is prominent hardwood forest. Another gap on the south side occurs at Alfred. It extends southwest across Section 35 and south into Section 2. East of it is a very prominent morainic tract extending down the south side the river opposite Northland. Along north side of the river from Alfred to Northland there are a few small ridges 20 rods or less wide and about 1/4 mile long that trend in various directions, some north-south, others nearly east-west. They are of cobble and gravel with a small amount of till. They look a little like eskers but are not of well assorted material. In northland in east part of the village limestone is at the surface. It occurs at considerable altitude a few miles northeast of Northland as noted in October, 1905.

July 17, 1909.

Northland, Michigan. Aneroid 29.075 = 975 feet  $\pm$  at 6:00 a.m. Limestone is exposed 1/4 mile east of the depot at about 15 feet higher altitude. There are faint striae on it bearing about east-west that seem to be glacial but as there may have been travel across it, I am not certain that the lines are not due to human agencies.

There are several short eskers between Northland and Alfred, 10-15 feet or less high and 1/4 mile  $\pm$  long with steep sides. Cuts in them show cobble and gravel, rather coarse for road ballast and largely local limestone.

At Alfred there are outwash tracts of gravel and cobble 20-25 feet above the river above the dam. The aneroid reads 1,000 feet at dam.

The gravel deltas in outwash run in very limited extent there, being in large basin above Alfred, flooded by the dam. On its south border as we go southwest we pass through a tract of sandy loam with a few boulders and smaller stones and hardwood forest. Its surface is nearly plane for 1/2 mile but then becomes morainic. The knolls form an angle along the river, back 1/2 - 3/4 mile from it on the south side for a couple of miles above Alfred.

We followed up this river road about to middle of north side, Section 3, T 42 N, R 27 W and then to a road southward across strongly morainic land to a swamp that drains westward from southwest part of Section 10 through center of Section 9 and thence north to Ford River across Sections 4 and 33. The swamp extends eastward to a small lake in northeast part of Section 15 that drains northeast along a awampy valley to Ford River at Alfred. The moraine we here crossed is thus completely surrounded by swamp. From Section 10 a swamp heads southwest into the east part of Section 16 and thence east across the west part of Section 15, SE to SE corner of 15, south through east part of Section 22 and southwest across sections 27 and 28 to Sturgeon River. Swamp heads into it from high moraine in the east in a westbound course across south part of Sections 13 and 14 and of 24 and 23. From Section 16, there is also a swamp leading westward across Sections 17 and 18 along a west flowing branch of Sturgeon River into T 42 N, R 28 W as far as Section 16 where it is joined by a broad swampy and sandy plain heading from the branch of Ford River south of Rolph southward into Section 2, T 42 N, R 28 W across the divide between the Ford and Sturgeon drainage and thence southwest across Sections 3 and 10 and south through east part of 9, into Section 10. Then logging roads follow these swampy tracts and near Milligan a cruiser for the Morgan Lumber Co. of Foster City outlined for us the distribution of the swampy tracts as given above.

Aside from the swampy tracts, T 42 N, R 27 W is all in moraine with hardwood forest. The moraine extends west into the east part of T 42 N, R 28 W. Then the ice stood at its west edge there was drainage from Ford River at Rolph southwest



to the Sturgeon along the swamp that leads across Sections 2, 3, 9 and 16, T 42 N, R 28 W. But as the ice shrank eastward the drainage probably led through the network of swamps - T 42 N, R 27 W to Sturgeon River. There are rock outcrops in the north of Sections 5, 6, 7, 8, 9, 10, 11, 14, and 15 and possibly in other sections. We examined ledges in sections 6 and 7 but did not find striae. The drift in these sections and in sections 1 and 12, T 41 N, R 28 W has been shaped a little into drumlinoidal forms with east-west trend. They are nicely shown in the road leading directly north from Foster City. They are about like those near Rolph. In some cases one side of a hill shows perfect smoothing while the opposite is somewhat hummocky. There seems to be only the beginning of drumlin shaping, few if any being typical drumlins.

The Sturgeon valley at Foster City is bordered closely by high moraine on each side and the river turns south through the moraine west of Foster.

Morainic topography extends west across the central part of T 41 N, R 28 W in a belt about 2 - a 1/2 miles wide in the bend of the West branch of Sturgeon River. It has a heavy hardwood forest. There is north of this a large tract in the north part of the township and in southwest part of T 42 N, R 28 W with rock knobs and gravelly sandy drift. There is poplar brush on it now. This seems likely to be a line of outwash westward. There are low tracts both north and south of Felch Mountain through which the water could have passed westward. This tract has considerable granite in low knobs and plains where it rises 75 feet  $\pm$  above the swampy tracts.

Felch is at the south base of Felch Mountain, an iron bearing range that runs east-west for a mile or so in north part of Sections 32 and 33, T 42 N, R. 28 W. We were not able to find striae on this range nor on the knobs east of here - but the knobs have been shaped by a westward movement. Russell indicates striae on the map in the 1906 report of Michigan Survey bearing west-southwest just south of Metropolitan perhaps near the Calumet Mine.

July 18, 1909

Felch Postoffice or Metropolitan, Michigan. Mr. Wood and I went up on Felch Mountain and got a fine view to the northwest and north about to Ford River. There is a tract of brushy and ledge land for several miles north and northwest beyond which is elevated land with hardwood timber and a rolling surface presumably a morainic belt. It seems to be in the central and southwest part of T 43 N, R 29 W and northwest part of T 42 N, R 29 W. Probably it pertains to the morainic belt we crossed on Ford River west of Turner.

There is a tract of sandy land from here west to Randville with rock knobs. It seems to be an outwash open from the moraine east of it.

Mr. Wood found a striated ledge in Section 33, T 42 N, R 29 W, being S80<sup>0</sup>W. We stay overnight at Randville.

July 19, 1909

Randville, Michigan. We take the wagon road north and cross to striated ledges with bearing S74<sup>0</sup>W. Several good exposures in Section 28, T 42 N, R 30 W. There is ground moraine from here to Sagola, with occasional knolls and ridges but with much swampy land. The high tract in Sections 3 and 4, T 42 N, R 30 W has iron bearing rocks in its west part and limestone capping in the east part. East from there ledges are said to be conspicuous. There is a rocky district east from Sagola in vicinity of the corner of T 43 N, R's 29 & 30 and T 42 N, R's 29 and 30 in which considerable pine and hemlock was cut. This strip is said to run east along the borders of T 42 & 43, R 29 W and to have a width of 1 to 2 miles. On the north and south there is hardwood forest. The moraine that we crossed last night east of Randville and the one west of Turner probably connects through these hardwood tracts across this rocky pine strip.

We continue from Sagola to Channing and Floodwood on foot. There are small areas of sharp knolls surrounded by marshy flats and gently undulating land as far north as Sawyer Lake 3 miles north of Channing. There basins set in

and are conspicuous to Floodwood. Very sharp small hummocks occur for two miles southwest of Floodwood. The basins are very numerous here also. Granite rocks abound on the drift around Floodwood and granite probably underlies this region at slight depth.

There is a more prominent tract of moraine on west side of the Michigamme along the line of the C. M. & St. P.R.R. north of Floodwood than to the south or southwest of Floodwood.

We enter a wood northeast from Floodwood into the edge of Marquette County through a fine chopping. The topography is sharply morainic but the drift is of a sandy gravelly constitution. Granite boulders are very numerous, and the ledges are probably at slight depth. This moraine is very prominent along the watershed east of the Michigamme and west of the headwaters of Schwartz Creek - reaching an altitude of over 1,500 feet. There are tracts of outwash plain opening westward from the moraine into the Michigamme. The surface is nearly plane and boulders are scarce.

The headquarters of Schwartz Creek are in a great plain of Jack Pine. The streams are in narrow channels cut into the plain 20-40 feet  $\pm$ . This has few if any surface boulders. We traversed it as far east as the range line between 28 and 29, T 45 N., the road being across sections 27, 26, and 25. There is a moraine east of this plain which we enter in Section 30, T 45 N, R 28 W just east of a small lake. There are numerous shallow basins in the east part of the outwash apron.

The moraine is very choppy with basins 20-30 feet deep surrounded by bouldery knolls. This moraine is cut through by West Branch of Flatrock River in Section 19, on both sides the river in Section 30. The course from here seems to be northwestward toward Republic along the \_\_\_\_\_ east of Michigamme River but we cannot learn much concerning it at Camp 10 of the Isaac Stephenson Company, where we stop for the night in Section 30.

July 20, 1909

We look around in the clearings in Sections 19, 20, 30, and 29, T 45 N, R 28 W and find that the moraine does not extend far east in northeast from corner of these sections. It heads northwest as far as we can get a view into Section 18. It is said to follow down this branch of Flatrock toward its junction with Schwartz Creek.

There is a hardwood tract south of the east flowing part of Schwartz Creek in the Northeast part of T 44 N, R 29 W and eastward into T 44 N, R 28 W, which may be morainic but we saw it last night from a distance of two miles  $\pm$  across the jack pine plain. We are not certain as to correlations toward the south of this moraine at Camp 10. It seems likely, however, that its correlation is from east of Turner rather than west.

At 9:30 A.M. we take a loggingtrain from Camp 10 to Kates. It descends into a tamarack and cedar swamp in Section 29 and is in it for about two miles east

We then pass through a strip of pine plain after which we cross a large moraine that extends to within 3 miles of Kates. This moraine runs southward through the eastern part of Dickinson County, so I am told by Mr. Lambert, an official of the Stephenson Company. There are sharp knobs northwest of Kates in Section 34, T 45 N, R 27 W that I was on four years ago when coming across from Princeton (see notes October 28, 1905). Around these knolls is a level tract of pine that heads up in the central part of T 45 N, R 27 W as noted in 1905. There is a higher plain on its east border that seems to have been formed as an outwash from the moraine that heads eastward to Escanaba River through south part of T 45 N, R 26 W. It is 60 feet  $\pm$  above this lower plain. It runs southeast on the north side of Lake Lambert ( a lake in Section 35 and Section 2, Twps 45 and 44, T 27 W) east of Kates Station.

It now seems that in 1905 I crossed the reentrant spur between a southwest and a westward movement in my trip from Kates to Northland.

About 3 miles West northwest of Kates the drift is thin on a plain east of the moraine and granite is exposed that has a glaciated surface. We find striae bearing  $35-40^{\circ}$  North of west that show the stoss and lee features well.

At the gravel pit about 5 miles from Kates WNW there is a high gravel plain 50-70 feet above the low tracts south and west of it.

There is strong moraine for fully a mile east of it full of boulders. This outwash tract shows across bedded structure with beds dipping to the west very sharply so was formed by a west flowing current probably like a delta at edge of the ice into a lake held in front of it. Mr. Wood took a picture to show this crossbedding. It shows best just above a dislodged stump.

There is high moraine around Camp 12 in Section 12. There are knobs 100 feet  $\pm$  above the basins and in places in Sections 1, 2, 11 and 12. The land is very broken for 5 miles east from Camp 12 and the highest point in this region is in Section 4 and parts of neighboring sections in T 45 N, R 27 W. It is timbered with hardwood and can be seen from Republic and from hills near Palmer.

This seems to be a moraine of several miles breadth all the way from Camp 12 south to Ford River.

George Ferguson of Camp 12 states that rolling stony land runs east across T 45 N, R 27 W., Sections 11 and 14 is very rough and stony. Also Section 18 of T 45 N, R 26 W.

In Section 8, T 45 N, R 27 W there is smooth sandy land, but sections all around are very rough and stony.

The greater part of T 46 N, R 27 and 28 W are pine plains. Possibly there are weak moraines traversing them as in the district between Ishpeming and Champion.

July 21, 1909, 6 A.M.

At Camp 12, I. Stephenson Co., Section 12, T 45 N, R 28 W on Prominent

moraine. We go west to a camp in Section 8 crossing a strong moraine for three miles. It dies out to gentle undulations near the camp. There is a break through it nearly two miles wide running NE-SW across Sections 4 and 5, 8 and 17 and east part of Sections 7 and 18. The northwest part of Section 5 is strongly morainic and much of Section 6, also the sections north of them (Sections 31 and 32, T 46 N, R 28 W). The gap in the moraine is largely filled by a cedar and tamarack swamp.

We are guided across this cedar swamp by Chas. Carr of Wells, Michigan, foreman of Camp A in Section 8, T 45 N, R 28 W., and left by him at an old road in the southwest part of Section 6. We are on the edge of a strongly morainic tract with numerous boulders. Its basins contain small lakes, the largest of which is on the line of Sections 5 and 6, and is resorted to by fisherman from Republic. The drift is of gravelly and cobbly constitution and the region was in pine forest now largely cut off. A few groves of Norway are still standing.

We traverse the moraine in a westward course coming out at the south side of Helen Lake into a plain. The moraine has knolls 20-30 feet high and basins 20 feet  $\pm$  below the general level.

The plain extends south from Helen Lake as far as we can get a view and seems to be as far as we can get a view and seems to be a continuation of that crossed July 19 in the southeast part of this township (Helen Lake is in Sections 3 and 4). The rolling country runs north from Helen Lake but not northwest, there being an extensive plain in that direction with some small pine but largely spruce and tamarack.

To the southwest from Helen Lake is a strong moraine with knob and basin topography, some knobs being 60 feet or more above basins among them. This extends to the Michigamme River, there being only a narrow sandy flat along the river south from the dam in Section 5. Above the dam there is a wide sandy tract with only low swells on east side of the river. The moraine has its north border at a creek in Section 6 on west side of the river. We can get a view to

the northeast from here over the sandy plain north of Helen Lake. It extends back 2 or 3 miles from the river or nearly to the divide between the Michigamme and Escanaba Rivers. This divide as noted by C. A. Davis has a moraine along it leading southeast from Republic. It seems to join the larger moraine in the southeast part of T 46 N, R 29 W and follow it eastward to R 27 W and separate from it in the northeast part of T 45 N, R 27 W to run out to the Escanaba River south of Princeton mines.

We wade Michigamme River at the ford below the dam near the line of Section 5 and 8, T 45 N, R 29 W and go north to Republic on road west of the river.

Rock knobs set in in Section 31, T 46 N, R 29 W and we find striae bearing about southwest on one west of the road. The knobs have very few boulders as well as very little drift so this tract seems to fall between moraines.

There are plains of gravelly drift extending back into the recesses of the bluffs along the river much of the way up to Republic. The altitude is 30-40 feet above the river. In some places the pebbles are very much waterworn and very little sand is intermixed. Rock knobs occur at intervals along the east side of the Michigamme from Section 32 northward to the prominent one at Republic. The Republic knob is 200 feet  $\pm$  above the river but other knobs are scarcely 100 feet.

In Republic just west of the C. M. & S. P. R.R. depot north of the track are grooves that look to be glacial which bear almost S80°W. There are large furrows or hollowings in the rock surface that have a general NE-SW trend but in these we did not find striae.

We later train for Humboldt at 4 P.M. The moraine is crossed in the first two miles. From there to Humboldt there are rock knobs with marshes and low accumulations of sandy drift material around them. It is not moraine.

We later take train at 5 P. M. from Humboldt to Champion.

July 22, 1909

Champion to L'Anse. We take morning train to Summit and stop off there for next train to examine ledges  $1/2 - 3/4$  mile NNW of the station. On one we find striae being about  $25^{\circ}$  east of south curving over the east face of a granite boss. A few rods further north is a ledge on east side of tract low down rising only 2-3 feet above track and this is striated, nearly N-S with very strong grooving.

We take train at 10:20 to L'Anse. There are, as noted by Davis, narrow Morainic strips as well as rock ridges alternating with narrow flat sandy tracts all the way to the Taylor Mine switch. In some the till is red and has few pebbles and in other cuts it is filled with stones. There are sandy ridges from vicinity of the Taylor Mine switch down to L'Anse with very few pebbles so far are exposed in the cuts along the railway probably old shore lines. 29.310 at L'Anse station.

July 23, 1909

L'Anse, Michigan. We level from Lake Superior to base of the Nipissing bluff and find it  $18\frac{1}{2}$  feet above the lake. The offshore bar is 18 feet. The leveling was done on west side of the creek that runs into the lake at L'Anse. We continue the leveling along the wagon road toward the depot. Top of bluff back of the Nipissing beach is 32-38 feet. There is a bank on west side of road at 40 foot base with 45 foot top that runs out to brow of the Nipissing bluff. Back of this is a very gradual rise to base of a cut bluff at  $48\frac{1}{2}$  feet. This may mark level of Fort Brady beach. Possibly it was a little higher or at 50 feet  $\pm$ .

There is a very definite cut bluff/<sup>an</sup> eighth of a mile or more east of the road that has a base at 60 feet.

The railway station is 83 feet at top if rail. A boulder strewn irregular ridge north of the station is 95 feet  $\pm$  on crest. Possibly it is glacial. There is red till in south slope by the depot.

East of the depot near the water tank is a glacial ridge at 98-100 feet. It has reddish sandy till with boulders embedded.

The water tank is about 92 feet or 693 feet A.T. The spur that runs down to L'Anse branches off at about 102 feet above the lake.

A beach about 60 feet south of the switch at top of cut is 118-120 feet at base. Dune sand rises 8-10 feet higher - but the lake seems to have been about 120 feet above Lake Superior. This is likely to be the Battlefield beach. The cut extends down into the red till which outcrops 8 feet  $\pm$  above level of switchboard or to 110 feet. About 1/4 mile south of the switchboard is a knoll on west side of track which lies south of a small stream coming in from the east. This knoll has a flat tract north of it which may mark wave wash but it is not clear. The altitude at base of the knoll is 158 feet. The knoll reaches to 170 feet or more.

The creek level is about 130 feet where it passes under the railway. It is a flat sandy tract back (south) of the ridge, that is 60 rods  $\pm$  wide. It slopes north so that the stream is against the bank on the north side. Probably this flat is a border drainage outside a little glacial ridge 155-170 feet  $\pm$  above the lake. East from here 1/4 mile, near a cemeter, it runs to 800 feet.

We stop leveling at the yard limit at 760 feet A.T. or 158 feet above the lake - about 1/4 mile north of M.P. 16.

The aneroid reading at M.P. 16 is 810 feet on track and 825 feet at the post.

There is a steady upgrade over a ground moraine from the yard limit southward 1/2 mile. The cuts show a red till - capping in dark slate. The south end of the steep grade is in a hummocky tract, with altitude by my aneroid 830 feet and by Mr. Wood's of 870 feet. This is at M. P. 1 mile north of Brennan. About 50 rods south of this mile post at Altitude 850-858 there is a ridge with a flatter tract north of it that suggests a front shore line. This is where there

should be a Algonquin beach (if this is parallel to the Nipissing) as shown in Marquette quadrangle. It is not however a clearly defined beach.

A slate quarry on west side of tract 60 rods north of M.P. 15 has striae mainly  $S18^{\circ}W$  but in some cases  $S20^{\circ}W$ . Altitude is 920 feet by aneroid.

The altitude is 940 at south end of steep grade 20 rods north of M.P. 15. This level continuous to Brennan - 940 feet. There is a sandy gravel here that seems to be a delta in Lake Algonquin. The gravel is well mounded as if on a shore.

Three streams are crossed in this flat area but they do not cross the railway at the same altitude, the south one is about 970-975 feet and the northern 940 feet.

The base of a steep bluff south of the creek at the south in  $983 \pm$  and the top by Mile Post 14 is 1012 feet  $\pm$ . Probably highest Algonquin here at 983-985 feet. The track is about 1,002 feet here. This bluff has a plain back of it 40-60 rods wide and the plain is underlain with a cobbly gravelly sand, looking much like outwash - but possibly a delta of a shore of Lake Algonquin at 1012-15 feet  $\pm$ . Red till is banked up against the north base of a rock knob  $1 \frac{1}{4}$  miles north of the Taylor switch and the railroad cuts into it 15-20 feet. The knob or rock boss is smoothed off by glaciation and has distinct striae being very nearly N-S. The knob is about 1,120 feet or 30 feet  $\pm$  above the track.

Less than  $\frac{1}{2}$  mile south is a till ridge about 1,150 feet - red till. It contains boulders. This is at south end of a steep grade, it being south for  $\frac{1}{2}$  mile south. The till ridge just noticed is 20-40 rods north of M. P. 13. There is another low ridge 40-60 rods south that has sandy gravel. The altitude is 1157 at M.P. 13 and 1180-1190 in the ridge 40-60 rods south. This has basins and irregular surface suggesting outwash but possibly it is a shore feature of Lake Duluth. The aneroid reads 1195 at the Section house by Taylor,  $\frac{1}{4}$  mile north of where the switch turns off. A short ridge of sandy gravel east of the section house is 1200-1205 feet. It is isolated and stands 10 feet  $\pm$  above a

plain south of it.

At the switch is a knoll with some till of red color and some sand with rock fragments, slate, etc. scattered through it. The aneroid here reads 1225 feet. This is where Taylor located the beach of Lake Duluth. Notes in October, 1916 put Duluth beach here at 1215. The switch is 1227 feet. The sandy gravelly basin tract 1/4 to 1/2 mile north of the switch is 1175-1200 feet may be a shore feature but it looks more like a glacial outwash.

The aneroid reads 1275 feet, M.P. 12. Railroad gives it 1281. Heavy cuts 20-35 feet deep in ridges of red till for a mile southeast from this milepost or to Mile Post 11. This is in a cut 20 feet deep and the aneroid reads 1425 on the track. Railroad makes it 1426 Feet. There is more constituent here than further back in the series of cuts this side the switch.

Rich cuts below M.P. 11 and 10, Altitude 1565 at M. P. 10 (R.R. is 1570 feet). Granite 1/4 mile west in knob. Further northwest is the Huronian striae 3/4 mile west of Huron S35<sup>0</sup>E on south side of track at about level of the rail same track as ravine. On south side of track at west end of the Herman switch striae bear S28<sup>0</sup>E in a low ledge about level with the track same as ravine.

The aneroid reads 1645 feet by Herman - Railroad is 1648.

M. P. 18 = 675	Case = 654
M. P. 19 = 620	Newlin = 654
M. P. 20 = 613	M. P. 31 = 675
M. P. 21 = 615	M. P. 32 = 643
M. P. 22 or Baraga = 610	M. P. 33 = 624
M. P. 23 & 24 each = 619	Portage = 621
= 610	M. P. 35 = 618
M. P. 25 & Fennville = 619	M. P. 36 = 609
M. P. 26 = 682	M. P. 37 = 608
Iron bridge = 700	M. P. 38 = 605
M. P. 27 = 690	M. P. 39 = 614
Hemlock = 673	Chassel = 610
M. P. 28 = 605	Houghton = 606

July 24, 1909 - L'Anse, Michigan

We drive around head of Keweenaw Bay to Baraga passing a sandstone cliff

just east of bed that shows crossbedding. There is a cedar and tamarack swamp at head of bay extending back some distance. We come to Nipissing shore at M.P. 21. It is cut into till and has a fine beach of shingle in front of it at about 514 feet.

There is a terrace in west part of Baraga at level of schoolhouse and a church (by aneroid 670 feet) which has red till at east edge but becomes slightly sandy at back side at 695. West of this is a morainic topography with till swells 5-15 feet high - red till. We leave the morainic topography  $\frac{3}{4}$  mile west of lake shore at altitude 750 feet and enter a sandy flat. It extends west to the corner Sections 28, 29, 32, and 33 where another moraine is entered at 775 feet. This has longer swells through the one east of it. Some low sandy knolls and ridges occur at about 800 feet that run northwest rising with higher ground - probably subglacial drainage like an esker, but not a well defined esker.

Aneroid 855 feet at middle of line sections 29 and 32 on inner slope of this moraine. We reach top of a steep ascent at about 60 rods from west end of section line at 910 feet. There is higher land  $\frac{1}{4}$  mile north probably 940-950 feet A.T. No good beach features thus far. Aneroid 930 feet at crest of moraine near west end of line of sections 30 and 31.

In Sections 30 and 31, wells are very shallow usually about 12 feet. There is gravelly material in little knolls west of this summit.

West from Baraga to Pelkie. A descent of 60 feet is made to the range line where a road leads south. There is a deep valley leading northeast across the northwest part of Section 30 and southeast of Section 18, northwest of 20, and southeast of 17, northwest of 16 and southeast of Section 9, T 51N, R 33 W that has high morainic country on each side. It is 790 feet at the wagon road  $\frac{1}{8}$  mile WNW of a schoolhouse in Section 25 near center of SW $\frac{1}{4}$ . There are low swells in the sag southwest of this road and water parts here in southwest part of Section 25 at a level about 800 feet A.T. The drainage in Section 35 and 32, T 51 N, R 34 W being into the Sturgeon River and that from Section 25 direct

northwest to Keweenaw Bay. At cross roads, middle of line Sections 25 and 26, altitude is 815 feet. We go south on a new road across a till plain to corner of Sections 25, 26, 35, and 36. We can see high land a mile south but Section 35 is flat clay land and so is 34 with a few pebbles and boulders.

We return across Section 26 to the stage road and continue west across a gently undulating till plain with higher land to the north. The aneroid reads 800 at line of 26 and 27. Altitude 780 at center Section 27 where road levels south across flat rock. The clay is red and few pebbles in Section 27. Near west side of the section, sand is entered at 765 feet. Surface very flat in Section 27. On channeling to Sturgeon valley we come to base of sand at 725. Red clay of till below to edge of the river. The river has a narrow arm 20 feet  $\pm$  above the water level on its east side. The aneroid reads 675 feet at river level.

First terrace on west side is 715 feet narrow. Top of clay (till) in bluff 740 feet. Fine sand above up to the upland plain 765 feet. This is nearly free from pebbles and may be a delta. If not it may be outwash sand. We turn north on road to Pelkie and soon descend from this plain to a clay at 735 feet that seems to be an old lake bed. About a mile north we come to what looks like a beach crossing the road from SE-NW. Its altitude is 710 feet at top and 700 feet at north base. North of this the soil is sandy much of the way to Pelkie.

Altitude 680 feet at Pelkie at 11:30 A.M.

I take train on Mineral Range railroad west to Gittings siding, at 12:20 P.M. There is a range of hills west of Pelkie that has a morainic aspect on its east slope, with knolls 15-20 feet high. The old lake at 710 feet had its edge at the east base of this ridge about 100 rods west of the line of Sections 8 and 9, T 51 N, R 34 W. Otter Lake River comes out of this ridge into this lake plain in northeast part of Section 8.

Features along Mineral Range Railroad west from Pelkie. The train stopped until 1 P.M. in southeast part of Section 17 at altitude 705 feet to

unload ballast. The aneroid is steady all this time. There is a gradual rise to Papin. Altitude 750. Altitude 765 at station 1 mile beyond Papin at east base of limestone bluff where I leave the train.

875 feet at base of the limestone outcrop on east side.

965 feet at high point in the hill at a cleared part reading of its length. The limestone here is at surface. From the south end of the limestone ridge there is a till ridge 820 feet  $\pm$  crossing the track at Egypt Station. 810 feet at Ha el water tank about 1/2 mile west of Egypt.

There is a flat south from here to the Ontonagon road about 800-815 feet. It reads 815 at Ontonagon road at south end of line Sections 34 and 35 T 51 N, R 35 W. There is flat land south from here about to Silver Mountain. I could see Silver Mountain plainly from this limestone bluff and could also see to the edge of the high pine plains in T 49 N, R 34 W. There may be a lake plain north of this pine plain. There is high land west of limestone bluff about two miles, probably is high as the bluff. It looks to be a moraine. 785 feet on plain on north part of Section 4, T 50 N, R 35 W east of creek.

873 feet on crest of ridge near county line of Baraga and Houghton. It seems to get higher 1/4 - 1/2 mile north. 780 feet at east base of ridge 1/2 mile east. 790 feet at west side of sand plain in Section 32, T 51 N, R 34 W. 785 feet at east side where it read 765 feet at 11 A.M. - It is now 3:45 P.M.

The road crosses a low part of the moraine in Section 26, T 51 N, R 34 W and the high part lies in north part of the section. The summit near center of Section 26 reads 855 feet (corrected 835 feet). The altitude is 40-50 feet higher 1/2 mile north of 875  $\pm$ . The sag in Section 25 reads 815 feet.

The high land north of this sag is morainic and is said to extend 3 miles or nearly to the Mineral Range R.R. in Section 12. The moraine on southeast side of the sag is very hummocky in Sections 25 and 36 and Section 30 of T 51 N, R 33 W. The rolling land keeps south from here two miles or more and southeast to head of Keweenaw Bay. In places the rock is struck at slight depth on it 20-30 feet  $\pm$ .