Notebook No. 229 - Leverett

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NOTEBOOK NO. 229

(July 24 to August 17, 1909)

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NOTEBOOK NO. 229

July 24, 1909.

Near Baraga, Michigan. Mr. Wood and I separated at the range line 3 miles west of Baraga. He went south through a morainic tract between sections 31 and 36, reaching 950 feet on high points. He then went west 1/2 mile and southwest about to line of sections 4 and 5, T 50 N, R 34 W, across moraine, descending to a valley at about 850 feet. Then he went east to head of bay, crossing a moraine $1\frac{1}{2}$ miles wide and then down to Nipissing beach a mile before coming to the shore of the bay. There was rolling sand west of the moraine at about 825 feet. It had scarcely any pebbles or boulders. The moraine was very broken red till ridges with boulders. Sand set in on east slope of the moraine at about 700 feet. This probably marks a weak shore.

I saw a similar shore in Baraga about 30-40 rods west of the school building and about the same distance north of the church in west part of town. It trends parallel with the bay and has low sandy ridges along it that I could see for 1/4 mile or more each side the road I came in on. The altitude, 700 feet $\pm$, makes it correlate with one in Sturgeon valley near Pelkie.

July 25, 1909.

L'Anse, Michigan. Aneroid 29.800 at level of Lake Superior at 8:00 a.m.; 29.775 at railroad crossing on Nipissing beach 2 miles west of L'Anse = 622 feet. The top of bank is 4-5 feet higher.

We follow the beach south 400 paces and then descend to a valley east of it. We then go S30°W through a sandy flat 600 paces that rises gradually. Altitude 654 feet at 1,000 paces from railroad. At 1,100 paces we are 100 feet east of the base of a bluff about 30 feet high. We go south parallel with this bluff and find the bluff increasing in height so that at 1,500 paces it is fully 50 feet

above road or to about 725 feet, the road being 675 feet. The bluff here turns southwest and we continue south across a wet bottom land, crossing a creek at 1,733-1,737 paces, or about 1 mile from railroad. At 2,000 paces the aneroid reads 685. A high bluff 30 rods southeast on east side of valley. At 2,100 paces, 690 feet, there is a steep bank 20 feet high at right (west) side of road which rises a few rods back to 50 feet or more. It is a sandy till of red color.

At 2,200-2,250 is a low bar on west side of road about 710-715 feet that may belong to the 710-foot shore. South of here there is an exposure to 60 rods or more with altitude about 700 feet A.T. that may be delta.

About 1/8 mile southeast from this point is a bold bluff fully 200 feet high or 900 feet A.T. The supposed delta has cobbly gravelly sand a few feet thick that seems to rest on clay or till at about the present stream level, 15 feet ± below surface.

Altitude 715 feet at 2,500 paces. At 2,700 paces the road is 728 feet and there is a cobbly valley filling 30 feet higher that has been trenched by this stream, the road being on the flood plain. At 3,000 paces the valley forks, one branch coming in from the southeast and the other from the southwest. Altitude 735 feet on flood plain here. We take the southwest fork which has a flood plain 1/8 mile wide or more, with bluffs rising abruptly to 900 feet or more, or 175-200 feet above the stream.

At 3,400 paces, 2 miles from the railroad, we are on a terrace 750 feet A.T. 25 feet ± above the stream. Possibly this is a delta in lake. South from here we seem to be ascending the north slope of a moraine. At 3,700 paces the reading is 785 feet and there is a flat area like a delta here. This rises rapidly south, being 795 feet at 4,000 paces. The bluffs each side this valley rise more than 100 feet higher at less than 1/4 mile back. At 4,300, altitude 815 feet on terrace 20-25 feet above creek.

We cross at 4,400 paces to west side of brook by an old camp. Altitude 795

feet at brook. There is a rapid rise to 5,000 paces, altitude 842 feet. Time: 11:00 a.m. It seems probable that the bluff on the east is of rock for the past 1½ miles but on the west it looks to be drift. It is more irregular on the west and morainic in topography. This camp is nearly 3 miles up the valley from the railroad. We ascend a little ravine from the camp, reaching altitude 920 feet at 6,000 paces, with bluffs here 100 feet higher. At 7,000 paces, altitude 1,065 feet at 11:30 a.m. This is fully 4 miles from railroad.

At 7,500 paces the upland is reached. It has very little undulation. Altitude 1,150-1,160 feet. Hardwood and hemlock. At 7,600 another ascent begins to 7,800, altitude 1,205 feet. Stony land, and morainic. This seems to be at border of Lake Duluth. Below 1,165 feet was a sandy gravel and no boulders noted for the last mile or more of ascent along the ravine.

At 8,200 (4½ miles from railroad) altitude 1,215 feet, with points 1,240 feet 1/8 mile west of road. At 9,700 paces, altitude 1,320 feet at end of a long rise through sandy moraine with a few cobbles and rarely a boulder. Knolls 10-25 feet.

At east edge of Cosgrove's old farm in southeast part Section 34, altitude 1,305 feet, 10,100 paces = about 6 miles from railroad. We are told here by a Swedish farmer that along the valley that heads in Section 29, t 50 N, R 34 W and drains through sections 20, 17, 16, 10, 11, 12 and 1 into Keweenaw Bay, there is sandy land all the way and it extends south to the pine plains in Section 5, T 49 N, R 34 W.

There is a new line of the D.S.S. & A. Railroad projected to run through this district and get a better grade than from Nestoria to L'Anse. The tract we came through has some bouldery land but only in narrow strips. There is little or no red clay in the high tracts. We noted it up to the vicinity of the camp at about 800 feet.

We stopped an hour at farm in Section 34 and aneroid changed from 1,305 to 1,320 feet. There is considerable red sandstone in the drift on this farm,

especially surface boulders. Some red clay also occurs in the knolls, more than we saw in three miles north from here.

The northeast part of the pine plains has knolls with sandy flats covering them. There is a fosse in sections 10 and 11 at 12,600 paces, on which aneroid reads 1,250 feet but the knolls are about 1,300 feet in these sections and in sections 2 and 3. On top of bluff-like rise south of the fosse in Section 11 altitude 1,320 feet at 13,000 paces. There is a rapid slope southwest to about 1,300 feet. The material is a fine pebbly sand.

At 14,200 paces we come to southeast edge of this sandy plain at 1,315 feet. There is a narrow, shallow valley leading south from here east of which, as well as west, there is a plain with jack pine. Some knolls occur a little farther north on east side of this depression 10-20 feet high. Probably the ice border was there. At 14,900 paces, altitude 1,305 feet on sand plain. My aneroid read 1,275 feet here. The altitude holds nearly 1,300 feet to edge of the sand plain.

We go into Section 24, SE$\frac{1}{4}$, to see John Schmidt who knows the country well. Section 24 is morainic in southeast part and so are the sections to the north and east. Sturgeon River, he says, has falls about 40 feet near line of sections 19 and 30, T 49 N, R 33 W, and there are rock hills in Section 18. The country west of the pine plains to Sturgeon River is sandy but west of river it is rolling hardwood, probably morainic. Sturgeon River reads 1,250 feet. Some morainic knolls on slope south.

Striae near center Section 2, T 48 N, R 34 W on west side of road bear S30°E magnetic. There is an exposure 30 feet north-south and several feet wide on side of a boss dipping east. A stream just south of this striated boss and 10-15 feet lower reads 1,395 feet. A knoll 40 rods northeast is about 1,450 feet. I do not know whether it has a rock nucleus.

There is a strong clay soil in the district south of the Sturgeon just passed through. Part of it has a slate rock near surface and part of the surface

is plane. The knolls of drift are in isolated clusters in sections 1 and 2, T 48 N, R 34 W, and in sections 35 and 36, T 49 N, R 34 W.

There is another striated boss of quartzite 1½ miles north of Covington with striae S3°E; consecutive gouges are very conspicuous, convex to south and concave north. Some have a span of 2 inches. Altitude 1,675 feet at the striated boss, northwest corner Section 14, T 46 N, R 34 W.

The highest points between here and Covington have rock bosses. The slopes have drift banked against them that is somewhat hummocky. It is mapped by Davis as moraine. The aneroid reads 1,620 feet at Covington, but railway survey gives it 1,588 feet.

July 26, 1909.

Covington, Michigan. Aneroid 28.525 at 5:30 a.m. = 1,588 feet. Just north of this station is a sag about 10 rods wide which is literally paved with boulders and looks like a spillway westward from Worm Lake. It is about 1,550 feet. Worm Lake drains east and north, while the water from this spillway leads west.

There are striated ledges 1/8 mile west of the station in Covington with striae S18°-20°E. A mile east of Covington we go south to a high rock hill, 1,700 feet A.T., that has striae S18°-20°E over its crest but about S12°-15°E on its west slope.

There are swamps from here east to King's Lake with rock knobs and an occasional drift ridge. The drift ridges trend north-northwest - south-southeast about on the line of ice movement. The best defined one is a mile west of Vermilac and looks a little like a drumlin. It is 20-25 feet high and about 1/2 mile long and 1/8 mile wide.

About a mile west of King's Lake we pass striated ledges on north side of track with bearing S30°E. A little farther east a knob on north side of track shows striae S27°E. It is 30 rods ± west of Mile Post 210, altitude 1,618 feet. Looking

south from this knob there is brushy land with knobs for nearly two miles, and south of this, a heavy hardwood forest with rolling surface that Davis has mapped as moraine. About 40 rods east of Mile Post 210, on south side of track, is a striated ledge bearing S30°E.

About a mile east of King's Lake the railway cuts through a till knoll of oval form, long axis, N25°W-S25°E that seems to be a drumlin. The cut is 30 feet deep. The aneroid reads 1,680 feet at top. The knoll is fully 1/4 mile long and 1/8 of a mile wide (where cut near middle). There is a little drumlin at its east side thus  only 15 feet high and 10-12 rods through. The material is very stony gray to blue colored till with a large amount of slaty rock. Many flat stones are horizontally placed but some are on edge. It seems likely to be an accretion rather than a product of sculpturing. These are 1/4-1/3 mile west of Mile Post 208. There is a low ridge of similar trend at this Mile Post, very bouldery and about 10-12 feet high. Around these drumlins and west past King's Lake there are quaking peat bogs. The matrix is not clayey, but rather a gray sandy matrix.

Near line of sections 23 and 24, T 48 N, R 33 W, on a boss on south side of railroad track, striae bear S40°E. The altitude of this rock boss is nearly 1,700 feet A.T. There are occasional knolls of drift in sections 13 and 24, T 48 N, R 33 W, but most of the surface is nearly plane. It seems to be ground moraine instead of terminal moraine.

Much of Section 18, T 48 N, R 32 W is spruce swamp. East of it is hardwood with undulating surface but not strongly morainic. This may become morainic to the south, as the hardwood becomes prominent in that direction. There is considerable swamp in sections 16 and 17, T 48 N, R 32 W--alder and spruce. East of this, in sections 9 and 16, we note the granite boulders become conspicuous both on the surface and in cuts. A group of large ones was passed west of Mile Post 204, 3 miles from Nestoria, near Frank's switch in southeast part Section 9.

From here to Nestoria there is a moraine on south side of railway. Between the railway and the granite area there is a nearly plane, somewhat swampy, tract a mile or more in width in sections 10 and 11, and north part of 14 and 15. This low area and its continuation east of Nestoria on north side of railway may have been occupied by ice while the moraine was forming in the south. It seems probable that the westward movement that extended across Lake Michigamme and the southeastward movement noted by striae, drumlinoidal ridges, etc., on our trip from Covington to Nextoria, had a meeting place not far from the meridian of Nestoria. Unfortunately, the region south of Nestoria in which the features are critical is not traversed by roads, so it will be difficult to determine the relations clearly. From Nestoria to Summit the most conspicuous drift features are the small eskers. These, as noted a few weeks ago, are narrow gravel ridges 10-20 feet high, 6-10 rods wide, strung along the Spruce valley.

July 27, 1909.

7:15 a.m. L'Anse, Michigan. We drive northeast along east shore rising through an undulating red till to south part of Section 25, T 51 N, R 33 W, where we come into sandy gravel on a plain at 770 feet. This is probably an old shore.

We go east on road on line sections 19 and 30 and rise to a summit 960 feet, 3 miles east of the lake. On descending to Silver River we find morainic topography down to 780 feet where sand sets in that extends down to the river swamp at 720 feet. The river reads 700 feet above the rapids just south of bridge. There is a fall of about 15 feet in a few rods at the rapids. The rock is a quartzite ledge here and also some slate. Mr. Wood took a picture looking up the rapids where the stream passes under the wagon bridge. Probably a lake extended up this valley to here that corresponds with the one at Pelkie in Sturgeon valley. The river is displaced here against its east bluff. There seems to be a buried channel near west bluff--a flat tract with no rock, altitude 720 feet.

A short distance east of Silver River we rise to a beach or narrow terrace at 740-745 feet that may be a shore. It is sandy. The road soon rises into morainic topography at about 770 feet.

About a mile east of Silver River at altitude 870 feet, just west of an old log stable in the woods, we find a striated ledge on south side of road; bearing of striae S40°W. An exposure 30-40 feet east-west and 5-6 feet wide. About 1/8 mile farther east at altitude 915 feet is a striated ledge on the road S40°W. Another striated ledge about 1/8 mile farther at 940 feet with similar bearing.

A smooth surface rising from 940-980 feet then a steep ascent to 1,015 feet. Here there is a sandy ridge with depression on south side that suggests a shore line. I find, however, a few rods north of the road at same altitude a striated rock surface bearing S40°W so the ridge seems to have a rock nucleus in part, at least. Its width is 10-15 rods and the descent is 5-6 feet on the south side. It trends west-southwest - east-northeast.

About two miles east of Silver River at altitude 1,035 feet, striae bear S32°W, grooves 20 feet or more being cut sharply into the slate. The exposure is 10 rods east-west and from a few feet to 20 feet wide.

At 1,085 feet we are at forks of road; the righthand road to Arvon; the left-hand to Skanee near line sections 19 and 20, T 51 N. R 31 W. We take road toward Arvon and soon descend to a flat tract 1,000-1,010 feet A.T. with small ridges of cobbly material that look to be shore lines. The road follows one for 1/4 mile or more and then crosses a little stream flowing south. Altitude 995 feet at stream. There are occasional boulders on the ridges but most of the stones are small and many of the stones are well-rounded.

Farther east we rise to 1,030 feet on a plain with more boulders than the 1,000-1,010 foot plain. There are a few low swells, 10 feet or less high. A little farther east a bold bluff comes in on the south that looks to be an old lake shore. It has a notch at 1,065 feet. The top is about 1,085 feet. There

is another notch at 1,035 feet and below this is the edge of the flat at 1,000-1,010 feet, somewhat swampy. We soon come into slate benches along edge of bluff which tend to throw a little doubt on the shore interpretation. However, the terracing farther back is in drift.

At Arvon there is a broad flat on which the aneroid read 1,100 before dinner but changed to 1,115 feet 1/2 hour later. Arvon, by railroad survey, is 1,105 feet A.T.

We follow up the old railway grade from Arvon about 2 miles and then take a wagon road across the bend of Slate River. The grade passes up through slate ledges just after turning east and rises to where aneroid reads 1,170 feet. Above this is a flat bottom rising gradually to about 1,200 feet in $1\frac{1}{2}$ miles $\pm$. There is some likelihood that this is related to a lake level--possibly Lake Duluth. There is a low tract north of this west-flowing part of Slate River and a high tract south. Possibly there is a weak moraine north of the stream (see notes June 1911).

When we go south on the wagon road we rise through knolly land to 1,360 feet. There is then a plane-surfaced tract for 3/4 mile or more at south edge of which aneroid read 1,395 feet. Then a steep rise through a bouldery, hummocky moraine for a mile $\pm$ to where aneroid reads 1,525 feet at a camping place on brow of bluff. We descend in about 1/8 mile south from here to the old railroad grade, 1,475 feet at 10-15 feet above Slate River. There is a level tract a mile or more wide between this moraine and the high summit ridge. This summit is 1,867 feet on track and 1,898 feet on rock ridge.

Returning, 1,540 on moraine crest = 1,500 $\pm$
2:10 p.m., 1,405 - 1,360 north edge of moraine.
2:20 p.m., 1,385 - 1,340 $\pm$ at north edge of plain.
2:24 p.m., 1,335 - 1,290 $\pm$ in valley at old railroad grade.
2:30 p.m., 1,215 feet at foot of steep valley grade.
2:42 p.m., 1,260 at first slate outcrops, about 1,200.
2:52 p.m., 1,230 = 1,180 feet corrected.
3:00 p.m., 1,230 at head of slate rapids, = 1,180 feet.
3:07 p.m., 1,105 at flat on north edge of Arvon, corrected 1,115 feet.
3:14 p.m., 1,155 at place where we got dinner = 1,105 feet by railway profile.

We are told that the ridge east of Arvon on north side of the Slate River has gravelly knolls with many boulders. It seems to be morainic. There are said to be steep knolls and sharp, small ridges of drift. There is a flat, swampy tract north and northeast of Arvon in north part of sections 25, 26, and 27, T 51 N, R 31 W and south part of sections 22, 23, and 24 that may have been covered by lake waters. South of it is apparently morainic topography. There seems to be morainic topography just east of junction of the Arvon road and Skanee road to L'Anse in Section 20. Aneroid reads 1,150 feet at summit at junction where it read 1,085 feet at 10:15 a.m. First reading nearly right.

As we descend the slope westward we find features that suggest shore action at about the same altitude as those noted between the forks of road and Arvon. The morainic knolls are washed off and the slope rather smooth from 25 feet below level of the forks down to Silver River, or from 1,060 feet ± to 720 feet. The tract between Silver River and Keweenaw Bay has a flat surface on the summit at about 960 feet A.T. but knolls occur on the east slope.

There is a slough near corner of sections 20, 21, 28 and 29 about 10 feet below border tracts and 30-40 rods wide, trending northeast-southwest, west of which there is a red till with little knolls 5 feet ± high and this sort of topography extends down the slope toward the bay to about 700 feet A.T. from nearly 900 feet. Boulders abound on the little knolls. We cannot see a definite beach on this slope.

We turned north on or near the range line and went down to Indian Mission in southeast part Section 24, T 51 N, R 33 W. There is sandy gravel at about 700 feet and a smoother slope below this level than above but not a clearly defined beach, so far as we can see. There is sand at about 770 feet also but not a clearly defined shore line. It seems remarkable that on this slope facing northwest with deep water offshore there should not be well-defined beaches if there really are lake levels at 700-710 feet and at about 770 feet. We took evening train from L'Anse to Baraga.

July 28, 1909.

7:00 a.m. Baraga, Michigan. We find rock exposed up to 660 feet A.T. on road running north. There are striae S10°W. There is a rapid rise up to 670 feet. At road leading west, 1 mile north of Baraga, a small outcrop in ditch shows striae bearing S15°W. Altitude 720 feet. We are unable to find a definite shore line at 700-710 feet.

The altitude reaches 800 feet about 1½-1-3/4 miles north of Baraga with higher land to the west that is knolly. There is a conglomerate at 775 feet and this furnishes quartz pebbles in large number in the drift. The surface seems to be wave washed at about 790-800 feet. We see scarcely any sign of a shore at 760-770 feet.

As we descend through the Indian village we come to a flat at base of slope at 710 feet. There is a little ridging at about 760 feet but scarcely definite enough to call a beach. North of this village is a spruce and tamarack swamp back of a beach that was built across the outlet at Nipissing stage, that is 25-30 feet above present water level by aneroid. It is a fine, pebbly sand.

Northwest of this valley is a ridge rising to 705 feet where crossed by the railway that has fine laminated clay to within 6 feet of top. There is bouldery till capping this clay. The exposures on the bay bluff east of here show fine sand and laminated clay nearly to top. We cross a deep gulch northwest of this ridge on which rock (red sandstone) is exposed up to about 20-25 feet above lake level. Above this is fine sand and laminated clay nearly to top. There is sharply morainic topography southwest from here up the little gorge crossed by this high railway bridge. The bridge is about 90 feet above the lake.

There is undulating land from the railway west as far north as Keweenaw Bay Station but east there is a rather smooth slope toward the Bay with a steep Nipissing bluff 50 feet ± high. There is rock at slight depth on the high land near Keweenaw Bay Station in places at less than 10 feet. Knolls 10-20 feet high dot the surface. We take train at 10:23 a.m. for Houghton from Keweenaw Bay.

There are no morainic features but the altitude is about 75 feet above lake level for several miles. The soil supports hardwood timber. The hardwood belt follows the shore northward but the railway drops down to a tamarack swamp back of it that extends north along east side of the Sturgeon to Portage Lake. There is a moraine west of the Sturgeon. There is high land east of Portage Lake 150-200 feet above lake level.

We go up to a cemetery back of East Houghton that is on a sand plain 210-215 feet above Lake Superior that Dr. Lane thinks may be an old shore. Over an area 1/4 mile square, there is scarcely 5 feet variation in level. West from here there is a rise over the ledges of the copper range and then we go south to see a beach that stands 440 feet above Lake Superior, a bench mark on it being 440.76 feet. It doubles around a rock point in the southwest part of Section 1 and runs southward on the east of the rock ridge and southwest on the west. It is a well-defined beach with gravel suitable for road ballast and has been used extensively for that purpose. Dr. Lane pointed out the occurrence of a beach of this height on north side of the Portage Channel near center of Section 26. It is plainly visible at that distance ($2\frac{1}{4}$ miles) from where we stand.

We go down to Houghton and over to Hancock to see the great accumulations of gravelly sand preserved on north side of Portage Channel. These deposits are slightly terraced. They rise to perhaps 500 feet above the lake just east of the Quincy Mine.

July 29, 1909.

Hancock, Michigan. We go to end of city line near Park Brewery on electric car. There is a terrace at 740 feet at the brewery 30 rods $\pm$ wide. It is very bouldery. We see a narrow terrace at this level on south side of Portage Lake. From here eastward along north side of Portage Lake the slope is thickly strewn with boulders up to about 980 feet. On the slope above this there is a notch standing 1,025 feet at its back (east) side. The bank east of it is 10-15 feet

and trends northwest-southeast. It is a big bar of gravel and cobble about 25-30 rods wide with a slough east of it separating it from higher land. By accurate levels, 1,042 feet. There is a bouldery strip in the sag back of this bar (This is the one seen yesterday from south side of the Portage).

About 1/8 mile east of the bar is an old hospital building. About 1/8 mile east of the hospital, at about 1,050 feet, is a striated boss with grooves bearing 15° north of west. East from here, near the Quincy Mine shaft, we enter a plain at 1,100 feet ± that has boulders imbedded in sand and gravel--some boulders 3-4 feet in diameter and many 1 foot or more. It may be an outwash formed as ice moved eastward.

We cross the copper range crest past the electric station. It is above 1,200 feet and 20 rods west of this station is a beach line 1,180 feet ± that encircled the high tract near the Quincy Mine. It is well developed on northwest slope but faint on the east side of this high point. Dr. Lane thinks there is an equivalent beach at 1,179 (?) feet at Calumet and a still higher one a little above 1,200 feet. We saw waterworn gravel in a garden on the crest of the ridge at the Quincy Mine above 1,200 feet A.T. that seems to indicate wave action. Most of the crest is a bare rock. There are striae on its north slope east of the electric railroad depot that bear in a general northwest-southeast course. Perhaps further observations will determine whether northwest or southeast.

We took the electric car to Houghton and passed a series of beaches that show well on the northwest slope of the rock ridge. In the afternoon Mr. Wood and I go southeast along south side of the Portage. There is some bouldery material on the low part of the slope and red clay is exposed in places up to about 710-720 feet. We find a beach pretty well defined at about 720 feet in northeast part of Section 6 which lies west of Portage Lake. We trace it across Section 6 southwestward to center of section and then southward into Section 7, to residence of Isaac Oell, probably in northwest corner of NE¼ Section 7. (Fort Brady beach?)

We go west on line of sections 6 and 7 and come to a narrow beach at about

810 feet. Below this there are low glacial knolls. Above it is an outcrop of sandstone. Perhaps this is only a bedrock shelf but it has the general appearance of a shore line and Dr. Lane thinks there is a shore at about this level.

We rise westward over gentle swells to line of sections 12 and 7. We go west along line of sections 1 and 12, rising gradually from 910 feet at the east to fully 1,000 feet at edge of the rocky ridge. It is a plane surfaced tract with boulders, about like that east of the Quincy Mine on north side of the Portage. The rock may be at slight depth for it does not absorb the rain rapidly. We get no exposures in it.

We rise rapidly on a rock ridge 1,060 feet ± in southwest part of Section 1 and pass over a nicely developed beach on its east face at 1,040 feet. We map the course southwestward on west side of ridge to a point opposite Dodgeville in east part of Section 2. It seems to die out here near end of 1,020-foot contour (see Houghton topo map). The island it encircles covers less than 80 acres above its level.

We went southwest to a col between north flowing and south flowing streams in a valley in southwest part of Section 11 and found it a rocky one, standing below 940-foot contour. It seems to have had strong lake currents across it. There is deep red till in Dodgeville (east part Section 11). We return directly to East Houghton, descending the bluff at east edge of the rock outcrops. There is a narrow wave cut beach at top of steep bluff at about 900 feet.

July 30, 1909.

Hancock, Michigan. We go in auto with Mr. C. A. Wright out to Keweenaw Point (or to Mandan). Numerous striated ledges are passed. We pass very little drift in knolls until we approach Calumet. There are low knolls a mile or more south and high ones in and around Calumet and Red Jacket. We go up to a ridge near North Tamarack Mine that catches the 1,260-foot contour. There seem to be lake beaches on its northwest slope but we did not stop to trace them. Later studies showed one

1,303 feet. On the east is a deep swampy depression below 1,200-foot contour. Does it represent a fosse or ice contact with the heavy drift deposit west of the swamp? There are several prominent places around this mining center but the general level is about 1,200 feet and at this level there is apparently a wave washed surface. We went directly to Mandan, reaching there at noon. The trap ridge lies just north of the road much of the way from the crossing of Gratiot River in Section 14, T 57 N, R 32 W northeast to Mandan. The Mandan village is south of it on a tract of thick drift.

Mandan, aneroid 1,060-1,070 at boarding house. Knolls are sandy here with cross-bedding westward dip. West of Mandan some till knolls near Resolute Mine. West from the Resolute is a tract with thin drift, rock bosses, etc., to Old Delaware Mine.

We turn north at Eagle Harbor Gap, 1,180 at forks of road; 1,210 at summit about 1/4 mile north. At 1,160 we pass striated outcrops in west part Section 16, T 58 N, R 30 W. Striae nearly east-west, movement westward. Road is among rock bosses in Section 17 with sandy, gravelly filling between but not much aggregations in drift knolls. 1,125 at sag near line sections 17 and 8; 1,150 at summit in southwest part Section 8 on rock; 920 at foot of steep slope seemingly at a beach; 700 at Lake Superior level. Lane reads 635 feet. Probably the lake breeze makes the wrong reading. There is a low strip 1/2-1 mile wide east from here along the shore that is scarcely 50 feet above the lake. South of this is a very rapid rise to the conglomerate ridge which, in places, is 600-700 feet above the lake. One high place is in Section 4, T 58 N, R 30 W.

So far as I can get a view both east and west from Eagle Harbor there is nothing strongly morainic on the slope between the trap ridge and the lake shore. The depression between the trap and the conglomerate has a lake (Mud Lake) and considerable sandy gravel filling but not aggregated in knolls.

Eagle Harbor is in a sand filled trough back of a low rock ridge that fronts on the lake and stands 25 feet ± above the lake. This low ridge also comes in at

the bog by Grand Marais and Agate Harbor with a sand filled trough back of it. 890 at intersection of roads in Section 7; 1,020 at top of a grade east of Copper Falls Mine. Much disintegrated greenstone. Copper Falls Mine (terrace 1,050 feet) seems to be an old shore. Higher shore 1,125 feet. Rocky knobs and bosses much smoothed by glacial action here. 1,175 at a summit in a clearing that seems to be a shore line at Arnold location. Fine bar ar Humboldt at 1,150 feet, cobble and gravel, 20 rods wide, 1/4 mile long east-west with lower land all around--in Section 21, T 58 N, R 31 W. At Garden City property a good beach 975 feet barometric, north of the Phoenix gap on the trap ridge in Section 20.

710 at Lake Superior by Eagle River village. Nipissing is 35 feet by hand level. Back of it the bluff is 56 feet and there is a faint ridge in the wagon road that comes in from the east at 65-67 feet with a stream valley parallel to it on the south. There is a great pothole in the rock just below the dam back of this beach a few rods southeast of the upper steel bridge on Eagle River. There is a stronger beach at 110 feet ±. Our aneroid reads 810 on it.

There is a flat tract at terminus of the Keweenaw Central southeast of Eagle River at Crestview Station. Aneroid reads 935 feet. It is in Section 19, T 58 N, R 31 W. Correct altitude, 900 feet. The gap in the trap range has about this level. My aneroid reads 955 feet at Phoenix. There is a cut bank at base of the trap range at 975 feet.

The trap range east of the gap reaches 1,255-1,275 feet. Shore line at its west end up to about 1,215 feet (aneroid).

Extensive morainic topography in the depression south of the trap ridge from Phoenix eastward several miles and southward in a belt two miles ±. There are occasional morainic knolls as far southwest as Allouez gap in the low tract south of the trap range. There are also morainic features around Calumet--a rather diffuse or scattered condition, much plane surface, almost swampy, with clusters or ranges of knolls; also some peaty swamps with filling as great as 30 feet.

July 31, 1909.

8:00 a.m. Hancock, Michigan. There is a flat by car barns that may be an old shore. It seems to be 815-820 feet A.T. We go up to the 1,040-1,045 foot beach in northwest part of Section 26 and follow it northward. It has generally a steep rise on west slope of 10-15 feet but stands very little above the ground back of it. It runs northwest about to center of NW¼ Section 26 and then north, curving a little to east near line of sections 23 and 26 and crosses a wagon road about 60 rods into Section 23. There is a boulder strewn, wave washed slope above as well as below it in northwest part Section 26 and in Section 23. The beach contains fine gravel, well rounded, with coarser pebbles mixed in.

In east part of Section 23 it assumes the form of a gravel ridge with a shallow sag back of it occupied by a marsh. This continues to the end of the beach in northwest part of Section 24. The bar or ridge is 15 rods ± wide and 2-4 feet above the swamp back of it.

There is a gap about 1/2 mile across at Swedetown Creek in Section 13 in which water probably extended east or northeast well toward the center of Section 13, but with no beach development because of the protection by the high land west of the creek in Section 14. There is a strong beach west of Swedetown Creek, running along the south edge of this high tract in a course south of west past the center of Section 14, passing a little south of the center of the section. It has a swamp on its back side much of the way. In the west part of Section 14 it curves around the high tract and soon assumes a north-northeast course and leaves Section 14 just east of the quarter post of sections 11 and 14. The high land enclosed by it rises only a few feet above its level, 10-20 feet ±, and is gently undulating till.

In Section 11 the beach bears north-northeast to about the center of the NE¼ and there curves rapidly around and takes a course eastward to the north of center of Section 12 where it dies out at the edge of a swamp that extends southeast and east past Boston Pond into Section 17. Here, as on Swedetown Creek, no beach was developed. But across a small creek that drains this swamp a beach sets in and

runs northward to the central part of Section 1. It has hooks turning eastward that succeed one another from south to north. The land back of these hooks was probably covered with shallow water some distance back, or to the edge of sections 6 and 7 of T 55 N, R 33 W, but not sufficient to form beaches.

Shore features are rather vague from the center of Section 1 northeast about to the southwest corner of Section 31, T 56 N, R 33 W. There, a gravelly beach with a shallow sag east of it sets in which runs northward bearing a few degrees to the east across Section 31. The ridge is 12-20 rods wide and stands 2-6 feet ± above the sag back of it. It is along or near the 1,060-foot contour (see Houghton topographic map).

In Section 30 the trend changes to the northeast so that it strikes the southeast corner of Section 19. It is interrupted by several ravines and is a brushy district across Section 30, hard to work through, but we kept our course along it.

In the southwest part of Section 20 there is a glacial depression back of it with two depression contours, 1080 and 1060. Near the center of the SW¼ Section 20 we find a bench mark, 1,055 feet, on the flat west of the beach and by hand level determine that the beach is about 1,073 feet, that being the level of base of cut bank 15-20 feet high. In Section 20 this shore is a strong cut bank with a sloping plain west of it that drops off in 1/4-1/3 of a mile to a level of only 1,000 feet or 70 feet ± below the beach.

We come upon a higher beach of great strength in Section 20, standing 1,125-1,132 feet ± A.T. It is marked by a cut bank 15-20 feet high and in front of it is a small offshore bar. Its course lies between the 1,120 and 1,140-foot contours across the southeast part of Section 20. Back of it there is a mild morainic topography with knolls and basins and a small lake. The highest points near this beach reach 1,160-foot contour. The altitude is above 1,220 feet about 3/4 mile southeast in Section 29.

I noted a gently undulating drift in the west part of the NW¼ Section 29 and many boulders east of Algonquin (1,073-foot) beach at 1,100 feet to 1,120 feet. I

did not go far enough east there to reach the higher beach. In the south part of Section 17 we go west far enough to find that weak shore lines are developed at about 980 and 1,000 feet, but the shore we have followed from Hancock is almost 1,080 feet, a bench mark on it being 1,079 feet. It rises above the 1,080-foot contour in the northwest part of Section 16. This is probably a storm beach level. The ordinary water level may not have exceeded 1,075 feet. The cut bank is strong across the southeast part of Section 17 and on northeast into Section 16 as far as we travel it. The strong beach above it is also a cut bank in Section 16, in places 25-30 feet high with narrow notches on its face marking probably the storm beach levels.

We found, back of this in the central and south part of Section 16, a still higher tract just below 1,160 feet A.T. that runs north-south. It curves around to the east and fades out east of center of Section 16, but the north-south trending part is a cut bank 10-15 feet high, the top of which is above 1180 feet.

Back of this, in the SE$\frac{1}{4}$ Section 16, is a tract of low gravelly ridged drift of glacial rather than lake features. From there northeastward across the northwest part of Section 15 and south part of Section 10 there is a gravelly, sandy, morainic tract with a few boulders. This rises above 1,240-foot contour. There are basins among low knolls on its southeast edge, west of North Tamarack mine. In east part of Section 15 and west part of Section 14, in the village of Red Jacket, there is a very sandy cluster of knolls with only a few boulders. Northeast of this, in the north part of Section 14, there are clusters of sandy knolls with boulders and also low tabular tracts of sandy gravel, rising 20 feet $\pm$ above the swamps. Beyond these is Centennial Hill that is 120 feet high and touches the 1,300-foot contour. We had not time to visit it tonight. It should be examined for evidence of higher shore action than that found at 1,180 feet west of Calumet in Section 16. (Later study showed a shore there at 1,303 feet).

We take electric car from Calumet to Houghton in the evening. Too dark for

observations. We, however, took some barometer readings from the Quincy mine down to the Portage bridge as follows:

Summit in Quincy	1,175 feet
Beach near electric depot	1,160
Frenchtown stop	1,135
Change to steeper grade at	1,075
Shore we traced today (it should be 1,045 ±)	1,025-30 (1,045 corrected)
At north-south road	950
At carbarn	850
Flat south of carbarn	840
Bank in Hancock	695
Bridge on Portage	630

August 2, 1909.

Houghton, Michigan, at School of Mines. Aneroid 29.480 = 690 feet A.T. at 7:30 a.m. I take car to Hancock. Aneroid 29.550 = 630 feet on bridge over Portage; 29.465 = 710 feet at southeast end of Railroad Avenue in Hancock where road turns northwest to follow up the railroad; 29.415 = 750 feet at terrace by brewery (beach?); 29.350 = 815 feet at cut in bluff by Hancock carbarns, probably a beach; 29.225 = 985 feet at road driving north; 29.100 = 1,045 feet at beach traced July 31; 29.040 = 1,095-1,097 feet at base of cut bank 25 rods west of Frenchtown; 29.025 = 1,110 feet at Frenchtown.

I return west along track to brow of bluff, aneroid 29.060. This is irregular and bouldery and does not seem to be a lake feature but rather a glacial. Aneroid 29.100 = 1,045 feet at bar south of electric car track. I go to bench mark near center of Section 26 that is 440 feet above Lake Superior, or 1,041 feet. The bar is 6 feet higher than this bench, or 446 feet above Lake Superior = 1,047 feet A.T. Top of bluff on electric line = 1,076 feet. In sag on tract east 20 rods ±, 1,074 feet. High water mark on beach east = 1,096.8 feet. The low water mark is about 1,091 feet. To railroad track at 1,102.4 feet. Frenchtown platform is 1,113.8 feet. One sight east, or about 1,120 feet, is base of a bank. Top of bank is 1,126 feet. This is beach like. Top of beach near Limerick Station = 1,159 feet. Points 40 rods northeast may reach 1,160 feet. This is a well defined gravel

bar and runs south to the end of the hill on which Quincy stands. The ledges east of this beach have striae bearing 21° north of west in vacant lots south of the electric. Northeast of Limerick Station 1/8 mile on south side of track are striated ledges with bearing 30° north of west and on north side a few rods west they bear 30° north of west.

There is another beach in the town on south side of track at 1,173 feet. Back of this is the highest part of the hill at 1,178-1,180 feet. Wells up here are about 12 feet deep. There is considerable gravelly material, well-rounded, looking like shore action. Boulders are also present in large number and rock is nearly at surface.

We find the two beaches near Franklin electric station that were crossed near Frenchtown at 1,091-1,096.8 and at 1,113.8-1,120 feet. They circle around the hill on which the Quincy mines stand. I leave Professor Wood to work out the course and return on 11:30 a.m. car to Houghton. They are very well defined on this northwest facing exposure.

Returned afternoon, 1:45 p.m. Aneroid 29.200 at 1,160-foot beach. We stop off at Arcadia Station, 1,137 feet, and take wagon road down the slope northwest to a bench mark 1,100 feet above, 80 rods from the station. We passed a gravel beach at 1,111 feet with gravel pits in it. The ridge is weak. We do not find any well defined beach farther down the slope. The reading at railway, near center of Section 13, is 1,060.6 feet by U.S.G.S. levels.

We continue on this wagon road about to line of sections 12 and 13 and ascend to a ridge in southwest part of Section 12 in south part of $SW\frac{1}{4}$ that has a beach on its crest that is 1,090 feet by aneroid.

We return to Arcadia at 1,137 feet. The road rises northeast from here to 1,148 in 1/8 mile but farther on there is very little ascent for 1/4 mile or more. There is a rock ledge at 1,148 feet. Back on the tract southeast of here is a beach along crest of ridge above 1,160-foot contour.

Striae 1/4 mile northeast of Arcadia between the pike and the electric line bear 30° north of west. The road summit 120 rods north-northeast of Arcadia is 1,157 feet. Surface here is a flat, boulder-strewn area. Southwest of Arcadia 1/8-1/4 mile is a cut at 1,135-1,140 feet in a narrow ridge southeast of which is a low area below 1,140 feet, but above the 1,111-foot beach. This cut at 1,135-1,140 feet seems to be a weak shore line.

A little over 1/2 mile north-northeast of Arcadia the road reaches 1,159 feet. The ridge is flat-topped here. Just north of here gravel is excavated in the slope at 1,150-1,155 feet. There is coarse cobble and rubble in bottom of pit. This runs east 1/4 mile or more at 1,150 feet ± but the road descends the northwest slope of the ridge and is 1,135.4 feet where a road turns east, about 3/4 mile north-northeast of Arcadia.

I go out on this road far enough to look out over a low tract to hills farther east but they are below 1,140 feet. They are in Section 17. About 1/4 mile farther there is a descent in the crest to 1,115 feet and a flat area at that level with gravelly soil. The road opposite here is 1,098.7 feet. Houses and gradens on the 1,115-foot flat show much gravelly, cobbly material around them.

The pike crosses the steam railroad at 1,069. There is a beach on the slope here at 1,072 feet ± at base of bank and 1,077 feet ± at top--not clearly a shore line. We come to a definite shore line in northeast part of Boston that is 1,118-1,120 feet at base of cut bank and 1,130-1,132 feet at top. The top is not coated with gravel. It is bouldery, and looks to be a glacial surface. The lake level was not far from 1,120 feet here. There is a large swamp northwest of the track along and back of this beach. We have not time tonight to trace it but go along electric railroad to a summit near line of sections 8 and 5 where level is 1,166.5 feet. There may be a faint shore on the face of the rise to this summit at about 1,145 feet. The rise, however, is pretty uniform from about 1,130 feet up to the summit at 1,166.5 feet.

1,184 at the pavillion for dancing in south part of Section 33, T 56 N,

R 33 W, on a summit. Large swamp with alder, spruce, black ash, cattail, white birch, poplar east of this pavillion at about 1,180 feet. Hardwood timber from Boston up to this pavillion. 1,203.6 feet at east end of swamp in Section 34. There is ground 1,220-1,230 feet north of here. This is 1/2 mile southwest of place the electrics go over the steam railway.

Much gravelly, sandy land with low hummocks 5-10 feet near Osceola. Altitude 1,183.1 feet at road crossing in Osceola. Morainic topography 1/2-3/4 mile east-northeast from Osceola and high undulating land farther east.

Mr. Wood reports that the beach at 1,135 feet ± and one at 1,110-1,115 feet are traceable in faint form all around the hill on which the Quincy mine stands (see map). He did not find the beach at 1,091-1,095 feet so well developed. It presents some irregularities in strength, probably due to differences in exposure to wave action.

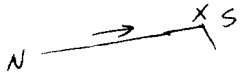
Mr. Walker, topographer of Calumet Special Map, says 2 points about 1 mile southwest of Cliff on the trap range are 1,400 feet. One of them seems to be considerably over 1,400 feet. Just north of Ojibway is a gravelly ridge in north part of Section 14, T 57 N, R 32 W, at 1,080 feet ± that Mr. Walker thinks may be a beach. It is 1,000 feet east of the railway, 2,200 feet northeast of Ojibway depot along a cut out section line.

August 3, 1909.

Calumet, Michigan. Southeast of the ball park between Laurium and Red Jacket are striated bosses with large grooves 15° south of west. Altitude is 1,204 feet at Keweenaw Central Station. Lake south of Centennial Hill is 1,197 feet. South of Centennial Hill on west side of a low ridge of trap there is some resemblance to a shore on a flat tract at 1,240 feet.

We find a strong shore line of Lake Duluth on west and north sides of Centennial Hill at about 1,300 feet with a spit at south end running around to the southeast. The hill rises 10 feet ± above it. A rock ledge at north end of the

hill at about 1,300 feet has striae 8-10° north of west. Another set of striae well down on the north slope has bearing S25°E and the movement, as shown by stoss and lee features was southward. Probably the earlier set was protected by drift at time of the later (westward) movement but was later exposed by lake action. Both sets here have grooves 1/4 inch or more deep and 1½ inches wide.



Sharp angle at "X" shows south movement.

The beach encircles the hill and a bench mark at south side shows 1,303 feet on crest of the bar in cut 2 feet deep. The foot of bank south is 1,294 feet. The lake level was probably about 1,300 feet, for the bar is not likely to exceed 5 feet above ordinary water level. It will now be necessary to look for this high shore on Wheal Kate hill, a few miles southwest of Houghton.

I return to the depot of Keweenaw Central Railroad. Aneroid 28.810 = 1,204 feet at 9:00 a.m., and take the train to Mandan.

The drift ridges and knolls around Centennial Hill are of a toned down aspect. In places there is a suggestion of shore lines as at 1,240 feet as noted above and also at about 1,200 feet, but where there are knolls and basins the waves could not well develop a good shore. One could only expect notching of such knolls as are close to lake level and spits from them.

The drift knolls are conspicuous for a mile or so east along line of Keweenaw Central Railroad but when the railroad turns northeast it runs into rocky knobs with much bare surface.

There are sharp, gravelly knolls and ridges 1/4-1/2 mile west of Copper City at an altitude between 900 and 950 feet. Height of knolls 15-30 feet. Copper City is below 900-foot contour. There are low beach-like ridges here with north-south trend but I doubt if they are shore features. East of Copper City about a mile after crossing a bouldery swamp, a drumlin-like ridge largely till 20-25 feet high and about 30 rods wide is cut through about midway by the railway. It is 1/4 mile ± long. There is considerable bouldery material.

Between here and Mohawk there are many small drift hummocks and an ascent of about 100 feet, the aneroid reading being 1,060 at Mohawk. Some hummocks of only an acre or two are 15-20 feet. They extend but little beyond Mohawk. I then enter a plain with reddish till and maple, birch forest with spruce in the shallow depressions. This extends about to Ojibway. Around Ojibway are sloughs 15-20 feet below the dry land. The dry land is sandy gravel. There is also a stream here flowing northwest. The barometer reads 1,070 feet. It should be 1,050 feet. This is opposite the very steep wall of trap noted July 30 near Cliff and northeast from there nearly to Mandan.

Red laminated clay overlain by bouldery material is cut through about a mile southwest of Cliff Station at barometer altitude 1,025 feet. The reading is 1,000 feet at Cliff (correct). A cluster of drift knolls is passed just northeast of Cliff with knolls 10-30 feet high. There seems to be heavy drift east from here as noted July 30. There are also low places in the trap range northwest from here, filled deeply with drift. In these places, however, the surface is not hummocky. These fillings are conspicuous near Phoenix gap and in the gap.

Barometer reads 930 feet at Phoenix Station; 910 feet at Crestview on the plain noted July 30. This is probably a delta of Eagle River in a lake standing about 900 feet A.T.

Returning, aneroid is 930 feet at Phoenix and 1,000 feet at the junction between Phoenix and Cliff. This is up on the edge of the moraine. The reading is 1,010 feet at south station in Phoenix (it should be 1,000). A wagon road rises southward from here about 50 feet in 1/8 mile to a glacial ridge. Cuts east of this (Phoenix) station are in bouldery, dark brown, sandy till. The topography is hummocky and there is a rapid rise southward for 1/2 mile ±.

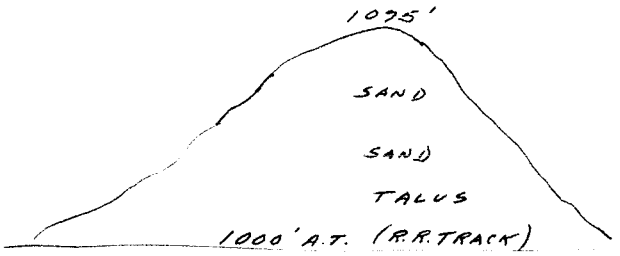
The railway rises eastward in 2 or 3 miles to 1,110-1,120 feet and enters a flat tableland with gravelly, cobbly soil; birch, poplar, spruce, etc., forest--possibly an outwash apron. This is succeeded by a descent to a valley west of Wyoming Station by old mine (Delaware). Around the station are scattered knolls

on a plain at 1,075 feet. Knolls 10-15 feet, partly of till and partly assorted material. Subdued morainic topography east from this mine with knolls 10-15 feet and a few boulders. Considerable nearly plane land with spruce, birch, poplar forest. The altitude between 1,075 and 1,100 feet. There is a spruce swamp for a long distance along south side of the railway, but north of the railway drift is banked against the basalt ridge. In places I get a view across to the high range along south side of the peninsula and there seems to be a flat tract much of the way across.

Reading is 1,075 feet at Delaware mine. It should be 1,085 feet. Good view to south from this mine across a broad spruce swamp to the south trap range. The plain extends nearly to Mandan but there is a rapid eastward slope, the reading being 975 feet at a gravel pit about a mile from Mandan in an esker-like ridge trending north-south that is 60-75 feet high. This is, by profile, 1,000 feet ±. Reading at Mandan Station is 1,025 feet (corrected, 1,050 feet) and at hotel is 1,070 feet where it read 1,060 feet on July 30.

The esker ridge runs north-south from a lake in center of Section 18 along east side of Montreal River to proposed dam site west of center of Section 19. Its south end is 3/4 mile south of railroad. Its north end is at the Resolute mine. Length, 1½ miles. The river west of it, near railway track, is 387.4 feet above Lake Superior. The proposed dam would be 75 feet high.

Miles		Above Lake Superior	
0	Calumet Junction	610	1,212
4.7	M.R. Junction	350	952
5.7	Mohawk	445	1,047
	Crest at 6-3/4 miles	480	1,082
8.1	Ojibway and Gratiot River Branch	450	1,050
	Summit at 9 miles	475	1,075
10.6	Cliff	395-400	997-1,002
12.8	Phoenix (south station)	400	1,002
16.6	Central Mine	520	1,122
17½	Summit at 17½ miles (watershed between Eagle and Montreal Rivers)	555	1,157
21.5	Delaware	485	1,087
22.7	Mendota Junction	440	1,042
25	Low point at 25 miles	370	972
26	Mandan (in Section 17, T58N, R29W)	450	1,052
26.3	Mine	515	1,117



Looking north at esker in Section 18, west of Mandan.

The esker has horizontally bedded sand in its central part with a few feet of cobble and coarser stone up to boulders 2 feet in diameter on its crest and east slope. The west side has coarse rock material with many stones 8-10 inches or more in diameter and an occasional boulder 1½-2 feet. I follow the ridge north to the old Resolute Mine. In places it is 100 feet higher than a lake on its west side. At the north end, near the base of the basalt ridge, it runs out spurs. There is no esker fan. The boulders are present all along the crest.

Mr. A. H. Sawyer took me from Mandan across to Copper Harbor. We go out to the base of the trap ridge and follow it eastward. There is considerable gravel and sand in beds dipping westward.

Lake Medora is 412 feet above Lake Superior, 1,014 feet A.T. This lake is 398 feet above Lake Superior on topographic map of Northern and Northeastern Lakes, 1865. It lies on north side of the trap ridge and discharges southward through a gap in the ridge to Montreal River. On south bluff, just above water's edge, I find glacial grooves bearing east-west. A few rods farther east is an exposure with grooves S70°W. The rock is near the surface and surface is flat for 1½ miles or more east of the lake. Some striae at south side of road about two miles east of the lake at altitude 1,000 feet A.T. bear S68°W.

Flat tract at west end of conglomerate ridge at 700 feet; a more extensive one at 665 feet. The Nipissing, by hand level, is 37 feet above Lake Superior, 639 feet, and so is the flat south of it. There is another beach at 17 feet = 619, and another at 24 feet = 626. The 37-foot is at base of a cut bank in the conglomerate. Near a church a little farther east the gravel ridge is a little below the cut bank or 34-35 feet above Lake Superior or 636-637 feet. There is a striated ledge at

side of road about 1/2 mile from Copper Harbor at altitude 700 feet ± with bearing S80°W. There seems to have been very unfavorable conditions for development of high shores in the district east of Eagle Harbor where the Conglomerate Ridge lies out in front (north) of the trap ridge. The conglomerate itself is nearly bare so has little notching at shore lines.

I return to Mandan with Mr. Sawyer and then go south to Lac La Belle. The aneroid is set at 900 at Montreal River south of Mandan which is its approximate level. There is a rise over drift swells of clayey till to 1,075 feet. Here the surface changes to nearly plane but rising perceptibly southward to base of a steep slope at 1,100 feet ±. This may be a shore. (Algonquin 1,135 feet?). In a few rods I rise to 1,125 feet (20-25 rods). Then a gentle slope for 20 rods to 1,135 feet. Here a cut bank 6 feet ± high and a more rapid rise back of it, with a slight notch at 1,155 feet. This is just north of an old mine 10-15 rods. The road reads 1,160 opposite the shaft of the mine. About 15 rods south is the base of a steep rise at 1,160 feet. It reads 1,220 feet 20 rods farther south. There are bouldery knolls east of here up to about 1,250 feet with pits dug in them to explore for ore. There is a diabase (?) rock in knolls just south of here where descent to south begins at 1,230 feet.

At some cabins (deserted) on west side of Mount Bohemia at 1,025 feet is a flat that may have had wave action from the west or southwest. (Aneroid reads 1,010 feet here the next morning). I leave road and take a path to left and soon descend to what looks to be a shore with aneroid 765 feet. It is by a deserted cabin. There is a gradual slope in front (south) and steep rise back of it. Some rock outcrops along it. The beach south of it is 20-30 rods. I then go down over notches in the bluff whose bases read as follows: (This is where path comes into wagon road).--745 with gravelly ridge on it 720-725 feet (727 feet by hand level). Second notch at 700 feet, very narrow, 704 feet by hand level. Third notch, by an old cabin, 680 feet. Sharp cut (Nipissing) back of dwellings on Lac La Belle, 635. Lac La Belle water level reads 600 feet. It is same as Lake Superior, 601 feet ±.

The base of cut bluff at Nipissing stage is about 34 feet above Lac La Belle, or 635 feet. There is a sandy ridge between the arms of the lake opposite here that is just at the Nipissing level, as shown by hand level. Later I went over and found it 37-38 feet. As far as I can get a view to the southwest from Lac La Belle, there is very low country, much of it below Lake Nipissing level. On the bar between the arms of the lake there is a steep bluff with base 10-15 feet above the lake back of which the ridge rises first to 30 feet then 34 feet, and in highest part, 37-38 feet. These are best shown on south slope.

August 4, 1909.

6:30 a.m. Lac La Belle, Michigan. I level up past Mr. Blozens to beach above the Nipissing. The brow of bluff is 70 feet. A few rods north is a slight notch at 80 feet. At 18 sights is base of a cut bank = 102 or 704. At 22 sights + 1 foot is base of another bank = 125 feet or 727. 28 sights takes to top of bluff = 159-160. There are points on it 165 feet. Soil here is gravelly. It is a broad flat and probably a delta.

Aneroid indicates 790 at higher beach at edge of a rock hill that rises to 815 feet. A swamp back of this is 760 feet. Ascent of Mount Bohemia is then made.

We take the county road toward Mandan and come to a cut bank at 875 feet. We follow up this road to the summit south of a ravine where there two abandoned cabins--aneroid 1,010 feet. It read 1,075 feet here last night. We go east, making rapid ascent to 1,090 feet. There is a good notch at base of a rock cliff at about 1,300 feet, (Beach 1,300 feet?) that runs some distance on north slope of the mountain and, in places, is cut in earth. At 1,375 feet we reach the top of the steep part. Depression at 1,385 feet back of a small bare rock boss on north side of a ledge that rises to 1,400 feet (1,469). This is the summit of Mount Bohemia. A glacial groove here on east slope of the rock boss bears S78°W. It was a westward movement.

At 80 feet below top of hill on the south slope is a gravelly beach 15-20 rods long built across a spur that is notched back of the beach. Barometric height, 1,320 feet; real height about 1,380 feet. At 1,250 feet (corrected 1,317 feet) we come to an east-west gravelly ridge and a parallel one south of it at about same height. There is a slough between them. This seems a pretty definite shore. Probably this is a Lake Duluth shore. In front of this to south is a steep drop to 1,200 feet (1,2,50 ±) with a sag and a low rock boss 6-8 feet high in front of it--not certainly a shore line but possibly so.

We follow out on a rock spur to an old camping place at 1,150 feet. We come to top of an old quarry at 1,100 feet from which I get a view of Mount Houghton. The mountain is notched on south slope at about this level. Mount Houghton is 877 feet above Lake Superior in 1847, or 1,479 feet. Mount Bohemia is 867 feet above Lake Superior or 1,469 feet. On return the aneroid reads 565 feet at lake level so the Mount Bohemia level may be 1,420 feet ±. It is 1,469 feet by U.S.L.S. The lake level is said to be very low now--14 inches lower than last year, or about 601 feet.

There is another bar of Nipissing farther east and in line with that on the point between two arms of Lac La Belle extending to about a mile from the west end of the point. Farther east the Nipissing lake beat against the bluff direct.

I take road toward Delware mine northwest from Lac La Belle, reaching a bluff that looks like an old shore at 945-950 feet at base about a mile out from the lake on north side of an inlet to the lake. Rock bosses at top of this bluff, 980 feet on highest points, 970 feet at level of road. About 1/4 mile farther on I come to the Lac La Belle spur of K.C.R.R. and to base of a low bluff at 990 feet A.T.

After rising this bluff to 1,005 feet I turn west across the railroad. The road soon rises to 1,050 feet and for a mile or more oscillates between 1,050 and 1,070 feet. There is rock at surface in places but some drift knolls 15-20 feet high with gentle slopes are passed.

On terrace of Montreal River by Wyoming, aneroid 1,060 feet at 10:20 a.m. There are a few low knolls in this vicinity with gravel and boulders. They are glacial, not lake, features. I wait here for the 11:00 a.m. train west. The river is about 1,030 feet. The railway track reads 1,060 feet here and 1,085 feet at Delaware. This agrees exactly with railroad profile.

There is very little rise along the Montreal swamp for two miles west of Delaware. There is a chain of low swells at the divide between Montreal and Eagle Rivers 10-20 feet high, and a sharp ridge south of track trending north-south that is 25 feet. Knolls continue west to Central Mine but the station is 35 feet below the summit. Within 1/2 mile a sandy flat is entered that probably corresponds to an outwash. It was timbered with hemlock, spruce, etc. This extends $1\frac{1}{2}$ miles $\pm$. Then knolls of variable constitution set in that extend past Phoenix. They mark a moraine, I think. The aneroid registers 1,000 at Phoenix, which is correct. Topography here is decidedly morainic. At Copper City the aneroid reads only 900 feet (corrected 880 feet). It is 20 feet $\pm$ above the stream in the Allouez gap. There are gravelly ridges with basins and sloughs among them here along the stream, but within 1/2 mile southwest one passes up over till swells to rock knobs and bosses.

I go east from Calumet across Section 24. There are striae on an uncovered ledge north of road and east of the railroad about 60 rods northeast of center of Section 24, bearing S82°W--large glacial grooves. Near the east quarter post of Section 24, on south side of road, a striated ledge is uncovered with faint striae east-west. I find rock is near surface in the little knolls and ridges east of Calumet so I doubt if this should be classed as morainic, though the hummocky surface and numerous boulders give a morainic aspect.

I could not find a definite shore at the 1,160-foot contour but there is one near the 1,140-foot that is well defined near the road in Section 19. It is a gravelly ridge with a slough back of it. I followed it southwest into the northwest part of Section 30 and northeast across Section 19. There is a broad flat east of it, nearly swampy in places, between the 1,140 and 1,120-foot contours.

This seems to be a little above 1,140 feet. The wave washed surface is its most conspicuous feature. The district west of it has hummocks and basins, so contrasts strikingly with it.

There is a faint trace of shore action near the 1,100-foot contour along a private road leading northeast from the public road in east part of Section 19. Below this, clear down to the base of the range near quarter post of sections 20 and 29, there is a rough surface with shelves of rock that may mark shore action but not clearly so. The drift is a red till, in places sticky clay, but usually of rather sandy texture. It is only a thin veneer on the rock. Red sandstone occurs from about 850 feet down.

At the base of the bluff, at about 670 feet, there is a wave notch that I was able to trace through to the village of Lake Linden. Old deltas and alluvial cones are adjusted to it. These deltas and cones have been trenched to meet the present lower drainage. Lake Nipissing does not present a beach in this valley or trough north of Lake Linden but there is a delta near a church $2\frac{1}{2}$ miles north in the southeast part of Section 20 and southwest of Section 21 where a stream entered Lake Nipissing. It is just below 640 feet.

I make careful note of notches and traces of shore work along the main highway from Lake Linden to Calumet. After passing the 670-foot shore the first notch in the slope is at 712-715 feet and there is a very smooth wave washed surface east of, or below, it. At about 765 feet is a very faint suggestion of a shore expressed by a change in slope thus ___/. Back of it is a steep rise to the brow of the sandstone escarpment. This has a flat surface rising gently westward from 840 to 855 feet. On the face of the sandstone escarpment there is a thin veneer of red till 10-15 feet $\pm$ thick. There is an abrupt change at 855 feet from a plane surface to an undulating till with swells 10-15 feet high that cover the space between 855 and 915 feet on a rather steep slope. There is a smoother and more gradual slope from 915 to 965 feet and a strong suggestion of a shore at about 965 feet. Back of this is a bluff-like rise from 965 to 990 feet and then a gradual

rise over an undulating slope to 1,040 feet. There is a plane surfaced strip about 1/8 mile wide at 1,040-1,045 feet with sandy, gravelly soil. This may be a wave washed flat or a glacial outwash outside a weak moraine represented by the gently undulating surface at 990-1,040 feet, or it may be a rock shelf. Rock underlies it at very slight depth and outcrops in places. It was timbered with hemlock and there are some very large stumps.

At 1,050-1,055 feet there is a low ridge of bouldery material of glacial, rather than lake, aspect. It has a slough back of it and is as narrow as a beach. I presume it has a rock nucleus. There is a faint indication of shore work at about 1,080 feet and also a delta-like flat. I noted shore action south of the stream on west side of road near line of sections 25 and 36 and southward toward the railroad. There is also a faint beach ridge on east side of road north of the creek. There are scarcely any traces of shore action at 1,130 feet.

At 1,170 feet there is a narrow ridge of bouldery material 6-10 rods wide and 3-6 feet high with a slough back of it that, in form, suggests a shore but in constitution is glacial. It also is, in part, determined by an outcropping hard ledge. I should hesitate to plot a shore line at this level. Possibly a flat at about 1,160 feet, just east of it, is a shore.

I made several observations of striae on this ascent:

1. In east part of Section 36 on east side of road at about road level, bearing N70°W.

2. Near north line of Section 36 on west side of road an exposure shows two sets; one N65°W and another S25°E. This last set is on the <u>south</u> slope and thus rather hard to explain. With it there is a deep grooving that trends about northeast-southwest with an appearance a little like slickensides. The groove is 8-10 inches wide and there are faint lines in it with northeast-southwest trend. It is just south of a higher ledge and I suspect it passes between the ledges, but could not set a clear indication. The striae bearing N65°W are evidently glacial and are on the high part of the rock exposure.

3. South of center of Section 25, on east side of road is a striation S75°W.

4. A few rods north of No. 3 is a striation S20°E that I think is glacial. It is on a north sloping ledge.

5. At a higher altitude on the slope near 1,180-foot contour are heavy grooves east-west and across these a later set touching only prominent parts of the ledge that bear southeast-northwest. There is an exposure in field on west side of road that shows this best but it is also to be seen on the road. I wonder if lake ice can have had power enough to produce this northwest set. Possibly the striae bearing S25°E-N25°W near line of sections 25 and 36 are also lake ice features.

August 5, 1909.

In the open tract between Laurium and Red Jacket a short distance northwest of the Calumet Hotel at 1,240 feet + is a gravelly ridge filling in gaps in a rock ridge that seems likely to be a shore. It swings around eastward and runs through north part of Laurium past the Methodist Church about two blocks. It is there encircled by 1,240-foot contour. Northwest of this at about 1,220 feet or just above is another place that suggests shore action. It has rock in part but the gravel is built in between and there is a drop of several feet from it down to a plain that runs past the ball grounds southwest into Red Jacket.

We go west through Red Jacket to the hill in west part Section 14. It has a cut bank where its east border curves around from southeast to south but from this bank a bar runs out across the recess on its east face and then southeast with the turn of the hill in that direction. There was probably some cutting against the base of the hill here prior to the building of the bar. The 1,220-foot cut shows on south end of this hill a low bank 2-4 feet high back of it. In vacant ground on the southwest part of the hill on the edge of Section 15 we find a forked bar running west at the 1,240-foot level or just below the contour and dying out without tying on to the point of the hill west of there. West of this hill about 80 rods is a small isolated one with a cut bank at about 1,220 feet on its east face. On the large hill we are examining, boulders are numerous above 1,240-foot beach on its southwest part, but not elsewhere. The 1,240-foot cut is strong at the northwest end of this large hill.

We go west to the cemetery along the morainic ridge in north part of Section 15. This ridge has basins and hummocks and numerous boulders. At the cemetery we

find a beach just below 1,220 feet, running across the west part of it and tying the hill at 1,220 feet to one farther north. Its level is about 1,217 feet. It is a gravelly bar, 10-12 rods wide where it ties the two knolls together with a low sag east of it. It was built by waves from the west. The part of the cemetery above 1,220 feet is bouldery and glacial. There is another well defined beach very close to the 1,200-foot contour that runs northward through the western edge of the cemetery, a gravelly bar in north part of cemetery standing 30-35 feet above the ground east of it.

I level from the 1,140-foot beach up to one at 1,168 feet and to one at 1,205 feet. The next is 1,222 feet. The next is 1,245 feet. On top of ridge is a beach at 1,266 feet. The 1,240-1,245-foot beach is exceptionally strong and, in places, makes a cut bank 20 feet high against the north face of the moraine. The 1,260-foot is a bar on the crest at highest part of the ridge and its strength is not easy to determine.

Mr. Wood studied these beaches on Centennial Hill yesterday and says the 1,240-1,245-foot beach is very strong on the northwest face of the hill but he did not find a strong beach between that and the 1,300-foot beach at top of the hill. Mr. Wood traced the 1,080, 1,140, 1,168, and 1,205 shores northward yesterday around the hills north of Calumet to south side of the Allouez gap. There is a fine curved bar of the 1,080-foot beach in northeast part of Section 35, running out to the southeast from north end of a hill. Mr. Wood noted shore lines at about 1,000 feet, 965 feet, 665 feet, and 635 feet on road to the pumping station northwest from Calumet. The last one is the Nipissing. He found two narrow glacial ridges parallel to and east of a rock ridge in east part Section 34, northwest of Section 35 and southwest of Section 26 that, in places, look a little like eskers but they contain till and boulders. They drop down to lower altitude northward. These are north of center of Section 25 at altitude 1,180 feet.

We return to Calumet and go after dinner on road to Lake Linden where Mr. Wood takes photos of the bosses that show southeast-northwest and east-west striae.

In one the roll of maps shows trend of the northwest movement and the heavier grooves show the earlier westward movement. The second view shows the northwest movement more clearly. It has painted surface with "Gordon & McNam, Painters, Laurium" on it.

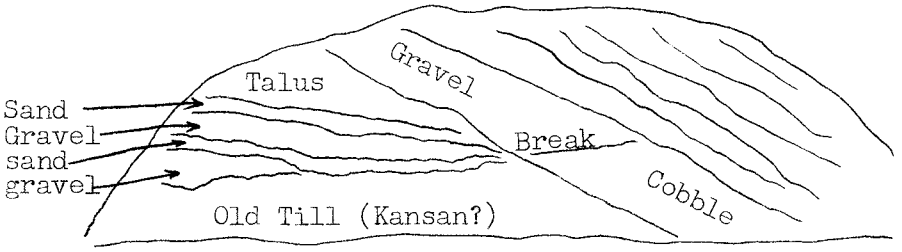
We trace the 1,075 foot ± and 1,125 foot ± shores across Section 1 and then follow the M.R. Railroad to Mills. This station reads 720 feet. Going west on wagon road the first notch in bluff is at 860 feet by my aneroid and Mr. Wood's reads 820 feet. His was set at Nipissing shore 15 minutes ago. There is a sloping plain for 20 rods east of the cut in the face of the bluff. There is a gravelly beach 10 feet higher, 1/2 mile from lake. There is a notch at 960 feet by Wood's and 1,000 feet by my aneroid, with a chain of drift knolls back of it. This is about 3/4 mile from the lake. There is a dwelling north of road here at east side of a morainic knoll.

We rise to 1,000 feet by Mr. Wood's and 1,040 feet by my aneroid to a plain 1/8 mile or more wide west of which is a rise like a shore bluff of 8-10 feet. Generally plane, but with an occasional drift knoll 10-15 feet high west from here and a very gradual rise. There is a slight bank 3/4 mile - 1 mile west where Wood reads 1,048 feet and I read 1,100 feet. This may be the shore that is 1,080 feet near Calumet but it is very ill defined.

About 2 miles from Mills at edge of a clearing is the west edge of this plain. Mr. Wood's barometer reads 1,075 feet and mine 1,140 feet at edge of plain. There is an undulating tract to the west with rapid rise to a rock outcrop at a mine 1/4 mile farther west where my aneroid reads 1,165 feet. Mr. Wood read 1,120 feet here. At top of hill west with altitude 1,190 feet on post Mr. Wood reads 1,160 feet and I read 1,210 feet. Just north of this point is a gravel pit in what proves to be a beach at 1,180 feet that is likely to be the equivalent of the one at about 1,200 feet northwest of Calumet.

August 6, 1909.

8:00 a.m., Hancock, Michigan. A pit 30 rods east of bridge shows hard, caky, red till at base up to 40 feet above the river level. It has weathered seams and looks like old till--much like Kansan till. Above it are beds horizontal at west,



Top of hill 700' A.T.

May be 730' at base of bluff.

but dipping in higher part down to the east. There is a break at a line corresponding to top of till with coarser beds below, yet they dip about like those above. In head of a ravine just east of here there is a pit showing 20 feet ± of red laminated clay with gravel and sand above it. The top of the clay is about 700'.

The first well defined terrace in business part of Hancock is 690-700 feet. This one east of the bridge is 730 feet. There is another at 815 feet. Another at 880 feet--very narrow. Another with triangulation station 910 feet. Surface is bouldery. A pit near the bluff in this shows sand with cross-bedding dipping material. It is very fine sand, almost a quicksand in places, and has ferruginous cemented layers. Bouldery material above it is 20-25 feet. The reading is 892 feet at Bench Mark K11 just back of this pit at about level of top.

There is a well defined beach 1,015 feet (this is really about 1,040 feet) that can be seen westward for something over a mile on all the points. At brow of bluff by the railroad the reading is 1,055 feet. There is a notch in slope of the gravel plain here at 1,060 feet at base, 1,065 feet at top (this is really 1,100 ± feet). This runs west to east, keeping just north of the railroad nearly as far west as west shaft of the Quincy Mine. It develops into a good beach ridge just west of an abandoned railroad grade. The third east of shaft of Quincy Mine is N35°W from this old grade at intersection with the beach. The mine is nearly 1/2 mile away and the brow of bluff to south nearly 1/4 mile.

Lake Linden eastward. Nipissing seems to be only 625-627 feet at base of bluff. No good notch at 670 feet here. Bench Mark 728.83 about 1/2 mile east of north-south road is at edge of drift knoll. About 1 mile east, at altitude 740 feet, we turn north 1/4 mile rising to 762.6 feet at place where road turns east. Low knolls 10-15 feet high; only a few boulders; till rather sandy red to brown color.

We go east another mile than back 1/2 mile to the summit at about 800 feet, then north 1/2 mile to reading 815 feet and west again toward the valley at head of Lake Linden. The 800-foot mark here is 1/2 mile west. More sandy here than on the road 1/2 mile south. From foot of hill we follow the road north. The Nipissing is about 633 feet as shown by U.S.G.S. levels. The road runs above it so that it is 647 feet where a road turns west past the church noted as on the Nipissing delta. The wave action is clear for only 1/2 mile north on the road. Farther north the water was too shallow to cut the banks.

There is a bank west of the church, base 634 feet; top about 640 feet. The Nipissing may be 634 feet but I suspect the cut from 640 to 634 feet is post-Nipissing. The stream west of here is 622 feet. We return along west side of the valley to Lake Linden and take electric car to Houghton via Calumet.

August 7, 1909.

9:15 a.m., Houghton, Michigan. We take the boat to Portage Canal. I mapped the extent of low land on each side. In places there is a tract rising about 70 feet above the lake that has a broader extent back of the Nipissing beach than the tract between the beach and the Portage Lake. The Nipissing beach at about 1/8 mile back from the Lake Superior shore at the end of the canal has cobble up to 34 feet by hand level above the water's edge, on each side the canal. There is dune sand above it, rising in places to 40 feet.

There is a bench mark of U.S.G.S. on the Nipissing beach on the wagon road east of the canal at 634.7 feet. In places the beach along the road reaches 636

feet. There is an island-like tract northeast of the end of the canal with a slough back of it that runs to the southwest end of Bear Lake. This slough is 620-625 feet, in vicinity of the canal and seems to have very little fall to Bear Lake. East of the slough is a rather rapid rise to high land but west of it is a plain standing about 635-640 feet at edge of the slough and rising westward for 1/4 mile ± to a gently undulating tract that has points nearly 700 feet A.T. This extends northeast to central part of Section 22. The undulating part is about 1/4 mile wide and 3/4-1 mile long. On its northwest face is a steep Nipissing bluff. From its southwest end a Nipissing bar rises southward. The wagon road follows it for fully 1/2 mile. It is built across the slough that runs to Bear Lake but not at full height, being about 628-630 feet. The plain west of this slough is very bouldery and barely rises above the Nipissing level at its east edge.

We followed the lake shore northeast to the point where it turns east in northwest part of Section 22. At this point sandstone slabs and large boulders occur on the beach but there are no outcrops of sandstone. No boulders occur between this point and the end of the canal. The Nipissing bluff in Section 22 lies back 100-120 rods from the present shore. It is replaced by a beach along north side of Bear Lake as well as at south end of the island-like tract. There is a strip of dunes between the Nipissing bluff and the shore of Lake Superior northeast from the canal, but to the southwest a bluff of red till and perhaps of sandstone, in part, rises abruptly from water's edge to a level above the Nipissing beach.

Mr. Wood made a trip south to the hill in Section 6 about two miles from the Lake Superior shore and 4 miles southwest from north end of Ship Canal. He found some shore action at about 635 feet (Nipissing), 670 feet, and 710 to 750 feet but got nothing definite at higher altitudes. There is thick drift in the district west of the north part of Portage Lake and the canal. The surface is strongly morainic from 750 up to the highest part of the upland in Section 6, fully 400

feet above the lake. It is also morainic down to within 70 feet of Portage Lake level in the district bordering the lake on the west in sections 5, 8, and 17. There is a wide swamp in sections 4, 5, 8, and 9 covered by Lake Nipissing. Mr. Wood thinks the morainic topography runs west to the Lake Superior shore in this region.

August 8, 1909.

I crossed from Houghton to Dollar Bay on a launch and examined the island-like tract of upland lying between there and the outlet of Torch Lake. There are cuts in red till along the railway leading south from Dollar Bay up to a height of 75 feet above lake level, a red till with sandy interbedding. The Nipissing beach is about the level of the Dollar By station on Copper Range Railroad, or 631 feet--in places it may reach 635 feet. It lies just north of the village and fills in the valley for a space 1/4 mile or more across. Swampy land extends northeast from it to Torch Lake. There is a narrow swampy tract and small bay, "Dollar Bay", along the east bluff of the old valley south of the beach.

The uplands are largely about 750 feet in the district east of Dollar Bay but reach 800 feet toward the northeast end of this island-like upland. This high part is bouldery and morainic, but the south part is largely plain and sandy at an altitude between 710 and 750 feet A.T. It has poplar brush now, but was timbered with pine.

August 9, 1909.

Mr. A. M. Walker, U.S.G.S. Topographer, ran levels for us. Casino, near station, 893 feet (corrected 882 feet); Crestview station, 890 feet. About 1/8 mile north of the station is a cut bank 10-15 feet high with a low beach north of it. Altitude 22 feet below Casino, 860 feet. It is a sandy bar standing out a little from base of bluff. About 1/8 mile farther is a cut into a rocky knoll, faint shore compared with the one above it, 837 feet. Another beach at 806 feet.

There is a drop at a place where two gullies have eaten away the divide = 792 feet. The next lower beach is a cut bluff 15-20 feet high. The base is 735 feet. There is a narrow ~~XXXXX~~ gently sloping plain for a few rods, then comes a descent to base of bluff south of Eagle River (east branch) at 714 feet - 26 = 697 feet. It reads 673 feet at a beach that I leveled to July 30. This is 673 feet. The Nipissing is 640 feet. The next higher, 672-673 feet. One in southwest part of Eagle River, west of schoolhouse, is 712 feet.

At north side of cemetery about 1,200 feet south = 734 feet directly opposite a birch tree 15 paces north of cemetery fence. There are small ridges between this and 712 feet. We go southeast along turnpike about 900 feet to a gravel pit in a low bar on west side of road. Altitude 769 feet. We go 170 paces farther and are just below an offshore bar in which there is a gravel pit. The base of bluff back of this is 815 feet. There is a rock boss about 25 feet south. The next beach is at a small clearing by a tumbled down building at 832 feet. There is a broad plain setting in at 854 feet. The plain at the Casino is 882 feet. The platform of the depot is 890 feet.

	Line down		Line up	
Top of plain	898-900			
Beach	860			
Cut bank	837		832	beach
Beach	806		815	Cut bluff
Cut bank	735	Group	(734	Birch by cemetery
Base of bluff	695		(712	Battlefield
Beach	673		673	Fort Brady
Nipissing	640		640	

Mr. Wood spent today in the district northeast of Portage Lake north of Hancock and found beaches at 815 and 850 feet as well as the lower ones at 635, 670, and 710 feet ±, at various places. There is a morainic tract around Lake Annie.

Mr. A. M. Walker, Topographer of Calumet quadrangle, corrected his levels in letter of August 12, making the beaches as follows:

Going down	Going up
864	
837	832
806	815
735	734) series of bars
695-base of bluff	712)
673	673
640	640 Nipissing

Railway station at Crestview, 890 feet; Casino, north step, 882 feet; Mills Station near Torch Lake, 634.09 feet, Nipissing; Dollar Bay Station, 75 yards west of station at northeast corner of T Street, iron post, 634.24 feet (iron post perhaps 1 foot above surface of ground); Mason flag station on Copper Range Railroad, two miles northeast of Dollar Bay, 665 feet.

August 10, 1909.

7:30 a.m., Houghton, Michigan. We set aneroid at 815 on beach south of School of Mines. It reads 855 at next beach? or at a change in angle of slope from gradual to steep about 1/8 mile south of brow of steep bluff and 6 rods north of Bench Mark 8, a boulder. It reads 275 at Bench Mark 8.

We come to section line (east-west) between sections 1 and 36 and Bench Mark 9. Aneroid read 323 feet. We take an old railroad grade southwest from here. There is a sort of ridge looking like a beach about 30-40 rods back of this bench mark at 325 feet. It is 6-8 rods wide where the railroad grade crosses it.

The aneroid reads 1,050 feet on the 440-foot beach so there is a slight correction. The air is very clear this morning so Mr. Wood attempts to get a view of the Huron Mountains from this beach looking across Portage Lake and the land between it and Keweenaw Bay. The water in the bay is barely visible. There proves to be more than one bar or beach on east side of this ridge in southwest part of Section 1. The highest is 5 or 6 feet above the main one and there is a faint one below the main one, perhaps 6 feet lower. Mr. Wood followed the lowest and I the highest of the three and the one I followed cut into the crest ridge of

rock in places and rounded the point about 60 rods north from where the lowest one does. That rounds the south part of the ridge about 40 rods north of the quarter post of sections 11 and 12, east of the saloons in Dodgeville.

We go to the road in Section 11 and follow it southwest across the pass in southwest part of Section 11. This is about 340-345 feet above Lake Superior by hand level to bench mark 66 in southeast part of Section 10, which is 386.99. We come to a beach on True Hill on this road near the line of sections 10 and 15 that is 1,025 feet where first ridge shows, but there is gravelly material shaped more or less into bars up to 1,040 feet. The hill is encircled by this beach in north part Section 15 and south edge of Section 10, in an area of less than 1/4 mile length northeast-southwest and about the same breadth. We then descend in northwest part of Section 15 to a sandy plain at 385 feet above Lake Superior (985 feet ± A.T.) which continues about to the corner of sections 9, 10, 15, and 16.

We then pass through a slightly lower tract, thickly strewn with boulders and somewhat hummocky. The bench mark at a slough in northeast part Section 16 is 350 feet above Lake Superior. We rise rapidly over a tract with rock exposures, in central and southwest part of Section 16, reaching 1,138 feet about 80 rods east of southwest corner of Section 16. There are rocky knolls in the woods north of here, 1,150-1,160 feet, that look to have wave work around the sides.

In South Range there is a rapid westward ascent, our reading at South Range Station being 1,150 feet (it is 1,138 feet), while at west edge of the village the reading is 1,200 feet. There is a beach here. We find another at 1,220-1,225 feet.

As we ascend toward Wheal Kate we pass a rock knob 1,315 feet, and back of this, at 1,325 feet ±, is a narrow plain of sandy gravel, possibly wave worked. From this, there is a rapid rise to the summit at 1,508 feet. Our reading there was 1,495 feet, so the plain may be 1,330-1,335 feet. The top of the hill has a slight bench 8-10 feet below top, on its northeast face, but it does not seem likely to be a beach.

Mr. Wood, in afternoon, made determinations on northwest slope and found there a bench at 1,330 feet with sandy gravel back of it on the slope up to 1,350 feet. There is also a slight notch on northwest slope at 1,400 feet. This is not so definite as the one at 1,330 feet. There is a range of hills north of Wheal Kate that would prevent any shore action much below 1,330 feet between it and Wheal Keat. It has rock knobs and drift knolls.

We took dinner at South Range and then went north to a gravel bar that connects rock knobs in NE$\frac{1}{4}$ Section 17. One rock knob just north of a schoolhouse is fully 1,200 feet. There is a bar at 1,150-1,160 feet connecting it with another 1/4 mile east. The wave action was very strong around the north and east sides of this eastern knob and no bar extends east from it. Large glacial grooves on it bear 35° north of west.

From the west knob a low glacial ridge extends westward fully 1/2 mile that is less than 1/8 mile wide and has a beach on it. The beach material is only 3-5 feet and below this is red till and bouldery stuff. The altitude, by aneroid, is 1,185 feet, but I think it is only 1,150 feet, for it seems to be a continuation of the bar at 1,150-1,160 feet that runs from one rock knob to the other.

Mill Mine Junction is 1,125 feet and this is only about 25 feet higher. West of Mill Mine Junction, on north slope of a morainic ridge, there is a wave worked surface up to about 1,235 feet. There is a wave cut hill 1/2 mile northwest of Mill Mine Junction at about 1,165 feet.

South of Atlantic Station 1/4 mile ± is a beach about 25-30 feet above the station, or about 1,025 feet A.T. North of the Station is one at about 990-1,000 feet. These encircle Naumkeag hill, but we have not time today to work out the course. The beach at 1,025 feet seems likely to be the highest Algonquin.

August 11, 1909.

Houghton, Michigan. We go south from west part of Houghton up a valley. We rise abruptly to 725-730 feet to a boulder strewn flat. The creek here is in a

shallow rock gorge. The rock rises to 775 feet ± a little farther south. Above this level is sandy land which is a sort of bottom land deposit, not clearly a beach. The Naumkeag hill in the west rises abruptly from it.

The reading is 875 feet at place where we turn west onto Naumkeag hill, just north of a small artificial lake. The aneroid reads 1,080 feet at station on Naumkeag Hill. It is above 1,060-foot contour. There is a notch on south side about 30 feet lower and another 50-55 feet lower with beach-like aspect. At 125 paces north from the station is a drop to the 1,050-foot and at 200 paces to 1,025-foot beach. The distance is less on the east and south but on the west it extends farther. The top of hill has a plain of several acres, varying scarcely 10 feet in height.

We go back south to the road at 950 feet and west to a summit at Bench Mark 117 where my aneroid reads 990 feet and Mr. Wood's 975 feet.

About 1/2 mile east of Atlantic we come up to a beach that seems to be nearly 1,040 feet, which follows the road into Atlantic and then runs northeast a short distance along the crest of a drift ridge. There is a slightly lower one farther east that seems to die out or to become merged with this one when traced westward. The roads on my map are so incorrect that I am unable to locate the beach correctly.

There is a small hill less than 1/2 mile southeast from Atlantic that is high enough to catch this beach but we did not go over to it. The hill catches 1,020-foot contour. The beach in Atlantic is about 40 feet above the depot of the Copper Range Railroad. There is a ridge 1/3-1/2 mile north in which much gravel and sand are present but there is also till. It stands about 1,010 feet. Its surface is very smooth as if by wave action across it. This is what we thought to be a beach from the train last night. Looking west from Atlantic station there is low land but just south of the wagon road that runs west across south part of Section 5 there is higher land. The 1,040-foot beach passes about 1/2 mile south-west and south of the station.

Professor Seaman, of the School of Mines, reports a gabbro that seems to be of a type found only in Minnesota and in Wisconsin near Miller that shows a southward or eastward movement. They occur near mouth of Huron Creek in west part of Houghton. Boulders of Peridotite from the region to the east have been found as far west as Silver Mountain, southwest of L'Anse.

August 12, 1909.

Houghton, Michigan. On train, Houghton to South Range. Cuts on east side of track near the smelter 2 miles west of Houghton show a small amount of till of red color interbedded with and giving place horizontally to sand and fine gravel with pockets of coarse gravel and cobble--all of fresh aspect.

We emerge on uplands at altitude 920 feet. It reads 960 feet at Atlantic which is 995 feet. I set aneroid at 1,138 feet at South Range Station. About 1 block northwest of the station is a cut in the slope at 1,160 feet that seems to be a shore and at west edge of the village is a sandy beach reading 1,195 feet. I follow this northwest to where I look across cleared fields to Mill Mine Junction in west part of Section 17. I then follow the road toward north base of Wheal Kate, rising to 1,270 feet at a dwelling north of Wheal Kate. There seems to be no definite beach above 1,195 feet here, though we had a reading 1,225 feet on August 10th. The slope upward to west across the plain on which the beach lies carries it up to 1,210 feet at edge of the steep rise.

I go back to South Range and take wagon road toward Painesdale. The road is in a ravine but the plain at 1,200-1,210 feet borders the ravine for 1/4 mile or more. There is then broken, hummocky topography to the south and west. At road intersection in northeast part of SW$\frac{1}{4}$ Section 20 I emerge onto an undulating tract 1,270-1,300 feet, with low gravelly knolls and ridges 10 feet or less in height. Nothing resembling a shore line was found.

I took the road east down to east line of Section 20 to a bench mark 489.9 above Lake Superior, near the Baltic mine. There is no plain indication of the

shore at 1,200 feet on this road, though the irregularities of surface seem toned down a little. Only northeast storms, or east, could have affected this part of the shore and it is too uneven to be easily worked into a definite shore.

I returned to road intersection near center Section 20 and continued to Painesdale across strongly morainic country with red till. In Trimountain a point near the water tower is about 1,375 feet and much of the village lies above 1,300 feet. The drift is a red till with sandy pockets. I was unable to find any evidence of shore action at 1,330 feet, the level at which narrow benches were noted on Wheal Kate knob. The railroad station in Painesdale is down in a ravine and is 1,202 feet. There is very broken (morainic) topography for 1/2 mile or more east.

I returned by train to South Range. There is a shallow flowing well here just north of depot at about 1,133 feet A.T. The inner pipe is drilled into rock but the outer is short and just reaches rock. The water comes up outside the inner pipe.

The 1,165-1,170-foot beach shows as a cut bank in west part of South Range within a block west of the railway about to northwest edge of the town. It then fades out on the slope.

I go to Mill Mine Junction and study the beaches west of there in Section 7. The highest beach is 1,230-1,235 feet and is built and cut along the north slope of a morainic ridge that runs across the south edge of Section 7. It is built in front (north) of a chain of basins just east of a swamp and pond in SW¼ Section 7. The pond and swamp have a broad exposure of shore material at the northeast end. The west half of SW¼ Section 7 is largely morainic with knolls rising to 1,275 feet ±. I followed the highest beach around the north end of this morainic spur and then southwest along it s west side into Section 12. The lake action was strong here and the surface is very flat though steeply inclined northwestward below the lake level.

I then return to Mill Mine Junction, making notes on beaches at 1,200 and 1,165 feet. The 1,200-foot beach is cut into a knoll in NE¼ Section 7 and on the north slope of the moraine in SE¼ Section 7. It is 60-80 rods north of and nearly parallel with the 1,235-foot beach. The 1,165-foot beach lies west of the Freda Branch of Copper Range Railroad in west part of Section 8 and curves around to the west on the north slope of the knoll in northeast part of Section 7. Mr. Wood made notes on it this morning and thinks it doubles back to the south on the west slope of the knoll and runs nearly to the center of Section 7. A valley there interrupts this and the 1,200-foot beach but they both swing around the point east of the valley near Mill Mine Junction. This series of beaches is not far from the line of the Copper Range Railroad leading to Mass City from Mill Mine Junction.

I went from Mill Mine to Atlantic along the railway track and passed a strong beach at 1,075 feet that comes to the track from the northwest about a mile south of Atlantic. It has interruptions at valleys but shows on points of bluff southwest and south from Atlantic.

There is a bar about 1/2 mile south of Atlantic at about 1,030 feet capping a low drift ridge. The beach or shore action shows well in the beds of the bar. Back of this bar is a slight cut along the bluff at the same level.

From Atlantic Station I went up to the hill in east part of the village and found the position of the 1,035-1,040 foot beach. It is on a rock hill and best developed on the part facing west but runs a bar out to the east for 1/2 mile ± along the crest.

Mr. Wood's trip today extended down to the shore at Redridge. He found a bluff there at edge of the lake 170 feet high, east of where is a moraine that runs northeast toward the Portage Canal.

There is a long stretch of road at about 1,000 feet along the Atlantic and Superior Railroad track about 2-5 miles west of Atlantic. The 1,030 and 1,075-foot beaches are near each other on the bluff in south part of Section 6 that

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runs between this railroad and the Freda Branch of the Copper Range Railroad. They diverge in southwest part of Section 5 at east end of the steep bluff and also in east part of Section 1 at west end of the steep bluff. There is much clay loam, good farmland between Atlantic and Redridge and part of it is now under cultivation.

Lower shore lines than the highest Algonquin at 1,030 feet Mr. Wood found to be inconspicuous but he saw one at about 760 feet near Salmon Trout Station. Another with some sand along it is a little over 800 feet.

August 13, 1909.

Houghton to Gay on Mineral Range Railroad through Calumet and Mohawk. From Mohawk the road runs southward into a morainic tract at head of the valley north of Torch Lake and overlooks Torch Lake. It then turns east and is in moraine to northwest part Section 1 and southwest of Section 36. The altitude is about 800 feet at east edge of moraine. Considerable sand there also in sections 1 and 36. About a mile farther is a sandstone quarry. From here to Gay the surface has been greatly smoothed by wave action. The readings are as follows: M.P. 19 = 815 feet; M.P. 20, 825 feet; M.P. 21, 770 feet; creek 725 feet (flows south); bluffs east rise to about 800 feet; within a half mile; M.P. 22, 730 feet; M.P. 23, 790 feet; Snow Shoe switch, 805 feet; M.P. 24, 760 feet; M.P. 25, 630 feet on sandy plain by a creek--probably covered by Lake Nipissing; Gay = 660 feet on top of a sandstone bluff. This is a flat tract and it extends inland 1-1½ miles from the shore in vicinity of Gay. The Nipissing shore cuts into it south of Gay. I go up on the stamp mill elevator and get a view to the west and north. There is a much higher country 3-4 miles north than in same distance west--probably the Keweenawan range, whereas to the west is sandstone.

I returned to Mohawk on train at 11:00 a.m. and after dinner took electric car to Ahmeek, a new village in the Allouez Gap, just east of the line of the trap range. I go down the valley toward Lake Superior across a pitted gravel plain

that extends to within a mile of Lake Superior at altitude above 800 feet. It has some deep basins and also has isolated mesa-like tracts as if cut away by currents yet the low tracts around these mesas are pitted with basins. Boulders are found in a few places on this pitted gravel plain but, as a rule, it is comprised of fine, gravelly material. This plain expands toward the northwest to be 2-3 miles across at a level about 860 feet.

The Trap range north of the Allouez Gap is a very bold ridge on the west as well as east slope where highest near Cliff Mine. It seems to drop down to about 1,000 feet on the west. I went west far enough to look down onto a tract of dunes that borders Lake Superior in the recess opposite the Allouez Gap. The contour map shows them clearly. I then took a byroad southwest, rising over shore lines until I got to the hill north of the Calumet brewery. For position of beaches see topographic sheet. There is some complexity here owing to conglomerate outcrops that give abrupt banks.

Across a valley from here, on east side of a rock ridge, there are peculiar narrow drift ridges parallel with the rock ridge, that drop down gradually northward. They cause deflections in the contours. Mr. Wood examined them a few days ago and found till. Perhaps they are only veneered rock ridges. I saw an outcrop of rock toward the south end of one. Mr. Wood reports that ridges on the west slope of this rock ridge, running parallel with it, have considerable drift in them but probably a rock nucleus. From Calumet I took electric car back to Houghton.

August 14, 1909.

Houghton to South Range. I examine the shore lines on Six Mile Hill south of South Range and find a good display; one at 1,170 feet, one at 1,195-1,200 feet, one at 1,235-1,240 feet, then a faint cut at about 1,260 feet that shows on northeast face of a knoll on north side of a ravine. I can only trace it 15-20 rods, just where the knoll is best developed. The 1,235-foot cut is very strong with a bluff 15 feet ± high back of it. The 1,195-1,200 foot has a bluff about 10 feet. The 1,170-foot has a bluff 15 feet or less.

I come out to the railroad by the Baltic Mine and go down to the bench mark, 489.99. My aneroid here reads 1,110 feet, or an error of 20 feet in about an hour. The altitudes above given were taken in less than 1/2 hour from time of leaving South Range, so the error may be scarcely 10 feet. Returning west to the Six Mile Hill I get benches at 1,160, 1,190, 1,225, and reach upland at 1,255 feet. There is a small gravelly, sandy knoll here at 1,260 feet and I find several others at about this altitude scattered around on Six Mile Hill. Farther west, the altitude increases to nearly 1,300 feet and the drift becomes bouldery and seems less likely to mark shore action than at 1,260 feet.

Mr. Wood's work today was along the Copper Range Railroad from Mill Mine to Toivola. He thinks there is a 1,260-foot cut bluff near Messner which he traced along the border of the railway for over a mile in vicinity of Messner. Ravines interrupt it but it is notched into projecting spurs.

Near Toivola is a pitted plain with some features suggesting shore action at about 1,240 feet. There is a bluff rising from 1,260 to 1,275 feet running westward from the station. There are deep basins below the level of the base of the bluff a short distance northwest of Toivola. One has a lake whose surface is 60 feet below bordering plain. This pitted plain had hardwood timber. There is strong morainic topography along the railway from Messner to Toivola and it extends west 1/2 mile or more. There is morainic topography east, past Painesdale.

I returned to Houghton at noon and took boat to Portage Entry and back in afternoon. There is a remarkably large number of granite boulders on west side of Portage Entry near a poultry farm in Section 13, T 53 N, R 33 W and contorted gneiss. They seem to show a westward transportation from north end of Huron Mountains.

Mr. Wood found striae bearing 15-20° north of west on west side of Portage Lake 1 mile north of Chassel and 1/2 mile from the lake at altitude 110 feet above the lake.

The ridge along west side of Keweenaw Bay south from Portage Entry rises scarcely to 700 feet A.T. and is worked smooth by lake action. It seems to be a drift ridge but rock is likely to underlie it up to or above lake level.

Sandstone is quarried just north of Portage Entry at 15-20 feet above Lake Superior. There seems to be no land in T 53 N, R 32 W and south part of T 54 N, R 32 W that rises to 700 feet, much of it being between 620 and 660 feet. West of a swamp that runs southwest across sections 21, 20, 29, 30, and 31, T 54 N, R 32 W is a higher district with morainic topography filling the space between the swamp and Portage Lake. It reaches 750 feet or more, and knolls on it are plainly visible from the boat. The swamp just noted seems to be below Lake Nipissing, but there may be a Nipissing bar at its northeast end.

There was a strait about a mile wide at Portage Entry in Nipissing times. The beach is not well defined on either side here, nor did I find well defined beaches at higher levels when I went back southwest to the upland plain. There was more sandy and gravelly soil at about 65-70 feet above the lake than at a little lower elevation, but 25-30 feet ± above the lake is quite sandy. The sand is on a stiff red clay at a pit 1/4 mile northwest of the poultry farm.

August 16, 1909.

Houghton to Toivola on train. Morainic from Messner to Toivola with knolls in places 30-40 feet high on west side of track where track reads 1,270-1,280 feet. There is a pitted plain at Toivola with deep basins 1/2-3/4 mile northwest, one of which contains a lake. The bluff noted by Mr. Wood as a probable beach seems instead to be the bank of a glacial drainage channel. The channel has basins in it. The north bank drops down a little west of the railway but we followed the south bank clear out to the lake. It is, in places, 25-30 feet high. Its top has the level of the plain on which Toivola stands--1,275 feet.

A cut along railway just north of the station (Toivola) shows some cross bedding in the gravel with dip to northwest or north. This is near the brow of

the south bluff of the channel. The channel is 50-60 rods ± wide. We return to Toivola to set barometers (1,275 feet) and then take a road northwest that leads down to Lake Superior.

We find a flat tract for a full mile west with very gradual slope to 1,250 feet, at top of a cut bank. There is a drop to 1,235-1,240 feet in a few rods. This may be a shore line. Paces 2,000 from station. 300 paces west, on north side of road, altitude is still 1,240 feet, but south of road is a lower and eroded district. There is also an eroded tract a little farther north, so this looks like a broad bar. This is 400 paces east of a store at a homestead and clearing in NW¼ Section 7, T 53 N, R 35 W. There are so many basins here that shore action will be difficult to map. The aneroid was 1,225 feet at store at 11:30 a.m. and read 1,215 feet at 12:15 p.m.

We drive west and reach, on a ridge at 156 wheel revolutions, 1,560 feet ± on which aneroid read 1,225 feet. This may be a shore line but it is too irregular surface to be developed far. We descend rapidly to a lake at 1,180 feet at 275 more wheel revolutions. At 175 revolutions more we leave the rough land and enter a plain that reads 1,210 feet at east edge. This is probably the edge of Lake Duluth, and is near corner sections 1, 2, 11 and 12. 100 revolutions farther, the west edge of this terrace is reached at altitude 1,200 feet; 19 revolutions more, altitude is 1,188 feet. This seems to be a shore. 36 revolutions farther to west edge of flat, altitude 1,170 feet. Descent in 19 revolutions to 1,155 feet. In 100 revolutions we come to sand dunes at altitude 1,140 feet.

At 104 revolutions, altitude 1,105 feet, is a good gravel beach with sag back of it. At 77 revolutions, very bouldery strip entered at 1,085 feet with a sharp descent west of it at 12 revolutions. Then a descent of 5 feet to base of a bank. In 29 revolutions a descent to 1,060 feet to sandy plain--slope very strong. This is about 5/8 mile east of Elm River. The plain is gullied from here to river but not any definite beaches.

At Elm River, altitude is 975 feet. At 106 revolutions west of River, 1,010 feet at a sandy ridge at east edge of a flat. This may be the 1,040-foot beach of the Isle Royale ridge. Very flat, 178 revolutions, altitude still 1,000 feet, sandy at this place; 320 revolutions more to a new farmhouse, altitude 965 feet. Clay plain all the way with some sandstone outcrops in ditches. Time, 1:30 p.m. At north-south road, 196 revolutions west, 970 feet. Time, 1:37 p.m. Same altitude 100 revolutions farther west. At 190 revolutions we come to gate at homestead, altitude 925 feet, at 1:50 p.m. This is in NW$\frac{1}{4}$ Section 8, T 53 N, R 36 W.

We follow an old road north-northwest down a sag and open into a plain at 835 feet at 2:15 p.m. We went down to lake shore and found aneroid only 10 feet too high. Returning, beach at 35, 170. Foot of a bouldery rise, 185 feet; another at 205 feet at back side of narrow shelf. We return to horse at the homestead gate in NW$\frac{1}{4}$ Section 8 and find reading 890 feet where it was 925 feet 1-3/4 hours ago. Present time, 4:00 p.m.

There is some morainic topography in this vicinity; knolls and smooth ridges. There is one like a drumlin on a homestead on south side of road across river 1/2 mile west from where we left the horse (probably in NE$\frac{1}{4}$ Section 7) that is elongated north-south and rises 20 feet above the plain east of it. We found some sandstone outcrops west of there at 850 feet $\pm$ and on down nearly to lake level.

Returning, we rise to a flat at 950 feet that reads same at north-south road between sections 8 and 9 where it read 970 feet going down. The flat as noted on way out runs 100 revolutions west of here. The reading where a road leads north between sections 9 and 10 is 975 feet. This is at middle of section line 9 and 10. About 1/4 mile east is a sandy ridge at 980-985 feet, where 1,010 feet coming down.

The west bluff of Elm River reads 1,000 feet. The river reads 950 feet, where 975 feet going down. The east bluff is also 1,000 feet. At base of strong bluff nearly a mile east of Elm River, 1,045 feet. This read 1,060 feet going down. Top of strong bluff now reads 1,065 feet.

The next beach reads 1,085 feet (1,105 feet going down). The strip of dunes east of it rises to 1,120 feet where it read 1,140 feet going down. The next higher one is 1,145 feet at crest. It has a shallow sag back of it. The next one east rises from 1,160 feet at base to 1,175 feet at top. The reading is 1,185 feet at east edge of the lake plain where basins set in. It read 1,210 feet here going west--probably correct. The reading is 1,205 feet at range line between sections 7 and 12.

It reads 1,215 feet at road intersection west of the store in Section 7--same as when we started. At store it reads 1,210 feet at 5:40 p.m. The plain 1 mile northwest of Toivola is 1,240 feet by aneroid and the station 1,265 feet. It should be 1,275 feet. A ridge southeast of the station has points 60-70 feet higher, or 1,340 feet ±. It is bouldery and hummocky.

East from Toivola is a basin tract as far as I can get a view--a mile or more. There are small lakes in it. This seems to be a place where glacial waters were escaping westward. The morainic ridges are very gravelly here also.

The well at south section house at Toivola is 58 feet to water and was driven to 66 feet. This is about the level of water in the lakes around Toivola.

August 17, 1909.

7:00 a.m. Toivola to Stonington through moraine. Some cuts are in red till--so is the one 1,318 feet, just north of Stonington. Stonington is 1,303 feet on a flat tract.

We take a wagon road west across Elm River. My aneroid reads 1,245 feet and Mr. Wood's 1,260 feet at river. Mine 1,265 and Mr. Wood's 1,275 feet on west bluff at 7:45 a.m. This is a terrace. We rise westward over a succession of low bluffs to 1,320 feet by my aneroid and 1,330 feet by Mr. Wood's at 1/3 mile beyond river about west.

At about 3/4 mile west of Elm River we come to north end of a clearing with a moraine on it that rises to about 1,370 feet. This is near line sections 30 and

25--probably in Section 30. Its northwest face is undulating till with no sign of shore features down to the road at 1,325 feet by my barometer and 1,335 feet by Mr. Wood's. The morainic topography continues strong for a mile farther, some points reaching about 1,400 feet.

We come out to a plain at 1,260 feet by Mr. Wood's aneroid and we come into sandy gravel and a slight bank at 1,240 feet by Wood's and 1,215 feet by my barometer. We then continued for a mile and descend to where Mr. Wood's reads 1,120 and mine 1,100 feet without finding definite shore features. Much of the slope is clayey. About 60 rods farther we come to a real gravelly beach, 1,090 feet by Wood's and 1,065 feet by my aneroid. It is up 8-10 feet above a flat 50 feet west. We come to a weaker sandy gravel shore at 1,055 by Wood's and 1,035 feet by mine about 1/4 mile farther west. The next, about 1/8 mile west, is 1,040 by Wood's and 1,035 feet by mine. This is just east of a stream flowing north that reads 1,035 by Wood's and 1,030 feet by mine at 9:35 a.m.

We turn back at 10:45 a.m. First beach 1,065 feet by Wood's and 1,055 feet by mine. At 900 paces we are on beach 1,105 feet by Mr. Wood's and 1,095 feet by mine--gravelly. At 1,000 paces, beach 1,118 feet by Wood's and 1,110 feet by mine is gravelly. Back of this is a bouldery till slope up to 1,135 feet at 1,100 paces. I read 1,125 feet. At 1,365 paces Mr. Wood reads 1,165 feet at base of a bank that seems to be a beach. Top of bank at 1,380 is 1,170 feet. Surface is much eroded from here east with deep ravine on south to 1,750 paces, altitude 1,195 feet. East from here it is very smooth. We pass granite boulders at 1,840 paces at altitude 1,195 feet--mine reads 1,165 feet. We come to the place where aneroids read 1,205 and 1,190 feet at 1,975 paces and have same reading at 10:20 a.m. At 2,223 paces, sections 26 and 27, near corner. At 2,760 paces we are at east side of the wet land where sandy soil begins at 1,225 feet, at 10:28 a.m. At 2,860 paces we are at highest beach, 1,233 feet by Mr. Wood's aneroid, 10:30 a.m. At 3,244 paces and altitude 1,240 feet we are at the west edge of morainic land in southwest part Section 23 or northwest part Section 26 and southwest of

Section 23. Probably edge of moraine is 1,220 feet or less.

We rise at 3,650 paces to brow of bluff to 1,300 feet. Bluff is irregular and of red till. Probably it is a morainic feature. Very flat wet clay land to 4,250 paces in northeast part Section 26. Altitude 1,305 feet. Here depressions set in each side of the road which runs on a divide that is flat to 4,790. At 4,790 paces altitude 1,303 feet at west part Section 25 at base of the large moraine that extends east past the railway. Time, 10:50 a.m. Opposite 5,200-5,400 paces the moraine south of road rises to 1,385 feet. The road at 5,215 paces is 1,325 feet. This is near center Section 25, T 53 N, R 36 W.

At 6,460 paces we reach edge of the clearing at 11:10 a.m. near range line, Sections 25 and 30. Mr. Wood ascended the high part of the moraine opposite 5,200 paces and found it to be 1,385 feet. At 7,300 paces we come to abrupt bluff-like descent to Elm River terrace. Altitude 1,325 feet at top of bluff; altitude 1,310 feet at base, 7,310 paces. At 7,540 paces, east edge of high terrace at 1,305 feet. Drop to 1,290 feet on next terrace at 7,550 paces. At 7,820 paces, at east edge of this terrace, altitude 1,290 feet. At 7900 paces, east side of river, 1,275 feet; at 7,960 paces, east side of low bottom, 1,280 feet; at 8,050 paces, altitude 1,292 feet on a terrace. East edge of terrace, at 8,195 paces, altitude 1,295 feet. At 8,210 paces, ridge at 1,305 feet. At 9,000 paces we come to the railway at Stonington and read 1,320 feet where it should be 1,303 feet.

We calculate that the road we were on took us into south part of Section 22. The highest beach we came to was not far from corner sections 22, 23, 26 and 27, T 53 N, R 36 W and is not far from 1,215-1,220 feet. We follow the railway south and pass a large striated syenite boulder 6 feet in diameter just south of Mile Post 36, 1,282 feet, in a spruce swamp. East of the railway about opposite the mile post is a high morainic ridge with northeast-southwest trend visible for 1/2-3/4 mile northeast from track. It reaches about 1,350 feet.

The drift cuts in this vicinity show much sandy and silty material, though some are a sandy gravel. The silt is of red color. Boulders are rather scarce.

Basins with small lakes are conspicuous features. The water level is usually 30 feet ± below the railway. One mile northeast of Elm River Station is a good outcrop of the conglomerate in a hill rising 30 feet ± above the track. Elm River Station is 1,239 feet.

Notes from Back of Notebook

Ontonagon to Pori on C.M. & St. P. Railway:

Distance 1,000'	Station	Altitude	Remarks
0	End of line	7	
2.0	Ontonagon Station	3	
4.7	Bridge	22.5	center
13.5	Top of steep grade	137.	
16.0	Back of terrace	145	
19.0	Top of steep grade (0.95)	173.	
21.0	Terrace .2 grade	177	
25.2-25.4	Ridge with sag back of it	232	
28.0	Steep grade 1.	252	
30.	Back side of .35 grade	259	Nat. surface 255
33.2	Top of .81 grade	284.	
35.5	Top of .61 grade	298.9	Nat. surface 302
37.0	Summit level to 370	298.9	
40.8-41.	Sag and culvert	290.	
44.	Top of .67 grade	310	
45	Top of .13 grade	312	
50.0	Top of .63 grade	340	Nat. surface
50.5	Steep bank up to ?	360	Nat. surface (beach)
51.4	Top of 1.25 grade	361	
52.2	Level 51.4-52.2	361	Culvert
57.0	Base of bank	410)	
	Top	427)	Intermediate points
58.2	Back side of basin	433)	on 1.3 grade
60.7	Culvert 60.6-7	470)	
62.2	Grade of 1.3	490	At top
62.7-63.4	Rockland level	490	Nat. surface 501
63.4-68.	Descent 1.3 grade	428	At bottom
68.3-.5	Ravine, nat. surface	422	
72.0	Top of 1.6 grade from 68.1	491.3	Track
		517	Nat. surface
75.	Descent 1.21 grade	455	
77.2	East end 0.5 grade	443.9	
78.5	Level	443.9	
79.7	East end 0.9 grade	433	
80.7	Level	433	
83.8	East end 0.62 grade	413.94	
84.4	Level	413.94	
85.7	East end of upgrade (1.23)	430	
86.6	Level	430	
88.2	Foot of grade .68	419	
90.2	East end grade .45	428	

Distance 1,000'	Station	Altitude	Remarks
93.0	Top of 1.5 grade	470	
95.	Top of 1.27 grade	495.4	
95.3	Level	495.4	
100.6	Steep descent	416	412' by C.M. & St. P.
102.	Mass City-foot of gradual descent	412	At Mass City-407' by CM&St.P
	Bridge level	412	407' by east part of profile
108.	Top of 1. grade	463	
112.2	Top of steep grade	500.5	
114.3-4	Culvert	507.5	508.5
118.4	Top of steep grade	542.5	
118.9-119.6	Level	544	
127.7	Base of downgrade	470	
128.1		470.5	
134.0	Base of bluff	523	
134.4	Top	542	Nat. surface
134.4-135.2		542-544	Nat. surface
137.3-6	Ravine bridge or fill	536	Bed of ravine 485'
141	Pori	545.	1140

Notes on Copper Range Railroad southwest from Mill Mine Junction. Add 500 feet for sea level.

Mill Mine Junction	625		1125	U.S.G.S. B.M. is 1128'
Messner	758		1258	
Ridge 2400' southwest of	779	Nat.surf.		
Descent for 2800 (400' beyond curve)	764		1264	
At 27½ M. Summit	806	Nat.surf.	1306	
Sag at 1000' north of M.P. 28	769	Nat.surf.	1229	
Ridge 800' north of Ricedale switch	806	Nat.surf.		
Ricedale, opposite section house	776	Track	1276	
200' south of Ricedale switch	748	Nat.surf.	1248	
M.P. 30	805	Track	1305	
800' south of M.P. 31	768	Nat.surf.		
2000' north of M.P. 32	795	Nat.surf.		
Sag north of Toivola station 1300'	744	Bed of ravine		
Toivola Station	775		1275	
Ridge 1000' south	798	Nat.surf.	1298	
M.P. 33	785		1285	
M.P. 34	805		1305	
Ridge north of Stonington	818		1318	
Stonington	803		1303	
M.P. 35	788		1288	
Stonington tank	781		1281	
M.P. 36	782		1282	
M.P. 37	780	Ridge 790'	1280	Ridge 1290'
Beaver Dam spur	783	Ridge	1283	
M.P. 38	768		1268	
Elm River Station	739		1239	
M.P. 39	752		1252	
M.P. 40	717		1217	
Spur at Brays Mill runs down to lake	720		1220	
M.P. 41	705		1205	
Twin Lake Station	705		1205	

M.P. 42	702	1202
Stack Pole Station	703	1203
Bridge on Misery River	697.84	1197
River	688	1188

1000' south of Misery River Elevation changes on profiles. 697.94 = 579.2 = Difference 118.74 feet.

M.P. 43	600 or 718.74	1218
1800' north of M.P. 44, summit	630 or 748.74	1248
M.P. 44	625 or 743.74	1243
Ridge just south	638 or 756.74	1256
Winona Station	624 or 742.74	1242
Little Sleeping River, stream	580 or 698.74	1198
M.P. 45	604	1222
600' south of bridge 10, ridge	624	1242
Sleeping River, stream	558	1176
M.P. 46) swampy	592	1210
M.P. 47)	592	1210
Fire Steel River, stream	555	1173
bridge	576	1194
M.P. 48	587	1205
Scager section house	600	1218
M.P. 49, in swamp	570	1188
M.P. 50 Henwood (beaver dam here)	520	1138
M.P. 51	469	1087
Conglomerate cut, top	490	1108
M.P. 52	415	1033
M.P. 53	365	983
Fire Steel bridge grade	348	966
1st stream	273	
2nd stream	264	
3rd stream	256	
M.P. 54	365	983
Summit on laminated clay ridge	407	1025
Bohemia Creek, bridge	375	993
creek	333	
M.P. 55	379	998
Belt Station	385	1003
Greenland Junction, switch	411	1029
M.P. 56	415	1033
West Y switch, Greenland	435	1053
D.S.S. & A. Railroad, Peppard Sta.	433	1051
M.P. 57	430	1048
Junction with C.M. & St.P. toward Chicago at distance 57.93	432	1050

Bench Marks of Mining School:

B.M.	
3	93.9
6	182
7	205.5
8	244
9	305.8
10	319
22	141.5
26	180.7
27	244
28	294
29	
34	365.5
38	336
39	307
40	403
41	334
69	150.6
71	206
72	255
76	195.8
80	121.6
81	229
82	219.6

B.M.		
87	71.8	
88	305.4	
92	7.8	
98	10.8	
99	3.9	
100	31.2	
102	188	
103	247	
104	307.7	
105	347.5	
106	359	
107	270	
108	24.8	
109	63.7	
110	22.9	
111	72	
113	160	
114	82.5	
115	68.7	
116	305.3	
117	385	
118	346.2	
119	22.7	
120	327.8	
121	427.4	
122	127.6	
A.	158.5	Hubbell Hill

Bench Marks North of Portage Lake:

1	98
2	137
3	184
4	192
5	297
6	309
7	329
8	31
9	45.3
10	77.2
11	81.6
12	94.7
15	24.8
17	103.8
18	124.6
19	197.7
20	243.4
21	314
22	417
23	141.2
24	219.2
25	398
26	446.6
27	117.7
28	
29	584.287
30	568.158
31	543.192
32	499.8
33	
34	
35	

Triangulation Stations:

D or 22	328.274
C or 6	136.9
No. 8	7.9
K or 12	113.9
I or 10	167.9
No. 9	252.6
R	95.0
14	20.288
20	106.9
23	224.4
27	388.5
29	173.9
37	466
48	473.4
77	233
79	176.4
85	271.9
87	18.116
89	36.159

Azimuth Station U.S. 482.7

Franklin Train Center 484.53
Post
Helltown Quarter Post 527.524

Foster and Whitney: Part 2, 1851, pp. 246 and 247 explain occurrence of limestone on Superior shore.

Altitudes on Mineral Range Railroad west from Keweenaw Bay:

	Dist. Ch.	Alt. A.T.	
East Terminus	0	683	
Summit	91	746	Track
		753	Nat. surface
Summit	120	744	Track
Valley	270	658	
Sturgeon River, water	465	667	
bridge		679	
Pelkie	485	679	
Old beach	510		
Hazel	720	804	
Laird, track	850	930	
top of cut		958	
Otter River	1,200	1,107	
Summit	1,280	1,180	
Firesteel River		905	Water
		1,015	Bluff
Copper Range Railroad		1,057	
Adventure Creek		1,047	
Mass City		1,063	

mjdv, 9-5-56.