

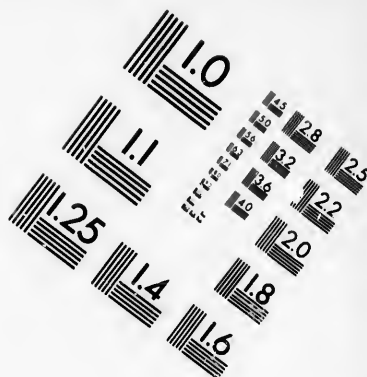
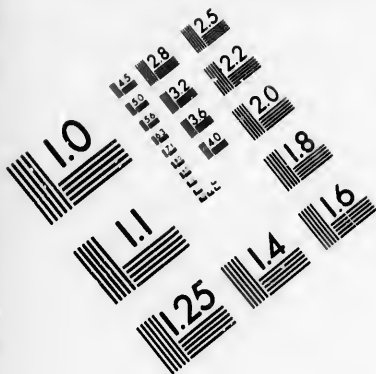
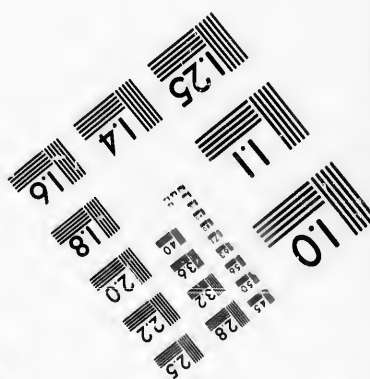
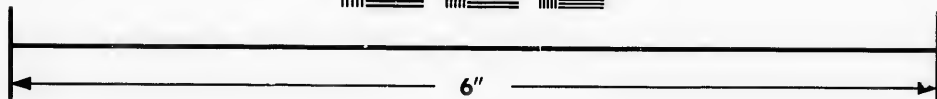
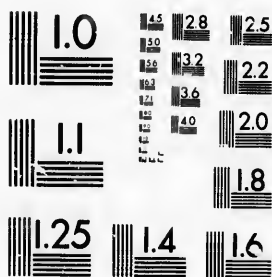


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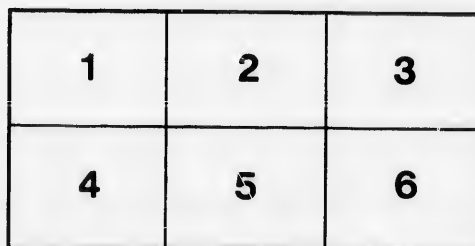
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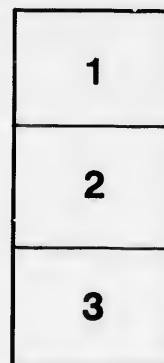
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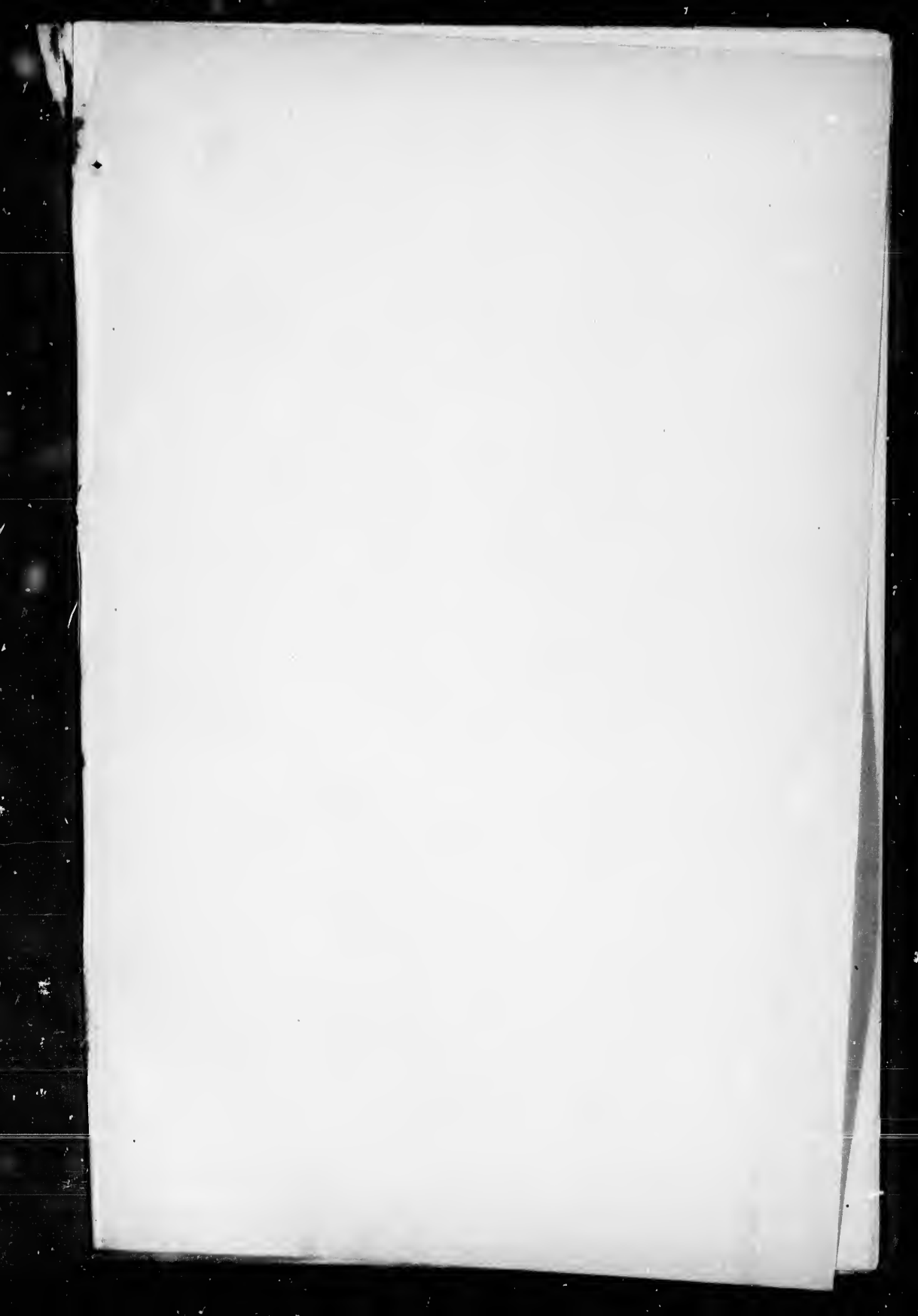
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NOTES ON THE ABANDONED BEACHES OF THE
NORTH COAST OF LAKE SUPERIOR.

By FRANK B. TAYLOR, Fort Wayne, Indiana.

[From *The American Geologist*, Vol. XX, August, 1897.]





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NOTES ON THE ABANDONED BEACHES OF THE NORTH COAST OF LAKE SUPERIOR.

By FRANK B. TAYLOR, Fort Wayne, Indiana.

[Plate VI.]

The month of September, 1895, was spent by the writer chiefly in searching for abandoned beaches on the north coast of lake Superior.* This coast was studied by Prof. A. C. Lawson in the summer of 1892 with special reference to evidences of submergence, and his observations are recorded very fully in his report entitled "Sketch of the Coastal Topography of the North Side of Lake Superior with Special Reference to the Abandoned Strands of Lake Warren."†

The high value of Prof. Lawson's observations was not questioned, but his methods of correlating the abandoned strands observed at different localities, and the general conclusions which he based on this correlation have been reviewed and discussed in papers already published.‡ By reference to Prof. Lawson's report it will be seen that he tabulated his results at forty-eight localities between Duluth and Sault Ste. Marie in a substantially horizontal series.§ He supposed the greatest interval between the varying heights of any single continuous strand to be about thirteen feet.|| His conclusion in substance is that the abandoned strands of the north Superior coast are almost as perfectly horizontal, when compared with the present lake surface, as they were when they were made, and therefore, that, although this coast has been greatly uplifted relatively, it has not suffered any notable irregularity or deformation. That is to say, the region appeared to have been greatly uplifted, but so evenly over the whole area that the strands retained their horizontality after elevation. This was not the case on the south coast of lake Superior nor on any other coast of the upper lakes so far as known to the writer. It seemed to the writer that in his detailed description Prof. Lawson has not shown facts that could form an ade-

*The results were briefly stated in a letter published in the *AMER. GEOL.*, for April, 1896, p. 253.

†Twentieth Annual Report of the Geol. and Nat. Hist. Survey of Minn.

‡*AM. GEOL.*, vol. XIII, June 1894, pp. 380-383; same, vol. xv, March 1895, pp. 119-120; same, vol. xv, May 1895, pp. 304-314.

§Table opposite page 280.

||Table on page 285.

quate basis for his scheme of correlation or his conclusions. Indeed, some of his observations seemed to indicate a considerable slope for the highest strand in the west end of the basin. Later a closer study of his description of the lower beaches seemed to show quite clearly that the Nipissing beach is in its normal place on that shore, rising about 125 feet from Duluth northeastward to Peninsula Harbor.*

In discussing Prof. Lawson's conclusions the writer admitted in the earlier papers referred to that on general principles the lower shore lines, which are the youngest and newest, might still be substantially horizontal, but maintained that the higher lines, and especially the highest one, which is the oldest of all, must express in the position of its plane the composite results of all the movements which have occurred since it was made, and further that on this account it could hardly be expected that it would be left finally in a horizontal position. These contentions seemed sound enough on general principles, but were in part curiously reversed in the results attained in 1895.

The Nipissing beach was found in its normal place, rising from about 55 feet above lake Superior on the eastern base of Mt. McKay near Fort William to about 115 feet at Peninsula Harbor at the extreme northeast angle of the lake. But so far as observed the highest beach that extends continuously along the north shore was found to be nearly, but not perfectly, horizontal.

Port Arthur. In passing the north end of Isle Roynle and between Thunder cape and Pie island a low terrace could be seen quite distinctly in several places. It is a plain feature on the north end of Pie island, and is probably a fragment of the Nipissing beach. Lawson reports a broad terrace there which abuts against a talus of great blocks at 43.5 feet. Probably the back of the terrace was covered up, for the Nipissing beach was clearly identified on the main shore in or near Port Arthur at about 60 feet. (61.4 feet as levelled by Lawson.)

Mt. McKay was ascended up to the "first level" or great shelf which is about 500 feet above the lake. In the two miles of swamp between the Mission and the eastern foot of the mountain several sandy ridges of a littoral character were crossed

**AM. GEOL.*, vol. xv, May 1895, page 313.

at a height of 50 to 60 feet. In the ascent of the mountain a great beach ridge of shingle was found at an altitude of 155 feet. It is composed mostly of small slabs and flat fragments of the Animikie slate which underlies the columnar trap of the mountain. The stones are pretty well worn by wave action, most of them having a rudely lenticular form. Some of them are as much as eight or ten inches wide, and two or three thick. This ridge has a distinct lagoon hollow behind it, although it lies on a very steep slope. The ridge is not unusually wide, but its lower edge is about fifteen feet below its crest. It is probably compound, but no distinct evidence of this was noticed. This strong ridge appeared to be the lowest one of a series extending up to about 210 feet, several of which are well developed. Much of the mountain slope seemed unfavorable for any permanent record. It is too steep, the rock fragments are too large. Besides, a large amount of talus of later origin has fallen down over much of it. A beach ridge of shingle, quite distinct, but not so strong as some of those lower down was found at a height of about 440 feet. It is so heavily overlain by talus at the point observed that it is not certain that the part seen is the highest mark of wave action, but none higher were observed.

The central part of the great shelf on the mountain is a swampy thicket, but the northern and eastern edges are more accessible. No evidence of wave action was found on this level, nor any of still-water sedimentation, unless a thin, light yellow loam that appeared to cover gravelly drift in some places might be taken as such. The floor of the shelf along the north edge is bare and has the appearance of having been polished smooth by glacial action. No striae of entirely certain identity were found, but some very faint lines and the *roche moutonnée* contours of the slightly rolling, polished rock surface seemed to indicate that the ice moved toward the west, and a little to the north of west.

A drive was made to the Beaver mine in the valley of White Fish river, 24 miles west southwest from Port Arthur. On the Oliver road, half a mile or more southwest of town the Nipissing beach is finely formed with a bluff 15 to 20 feet high at its back. Beach ridges were crossed at a point six miles out about 240 feet above the lake. South of Murillo on

the Canadian Pacific railway the road crosses a sandy rolling plain which is apparently an old delta of the Kaministiquia river. The top of this plain is 240 to 260 feet above the lake and is about at the level of the top of the famous Kekabeka falls three or four miles to the west. The eastward or downstream front of this plain is distinctly cusped, having the appearance of being cut by long winding gullies. These show the composition of the plain to be mostly of sand. A little to the north of Stanley on the Duluth and Port Arthur railway the blue clays mentioned by Lawson* appear underlying the sand. In one bank they appeared to be distinctly laminated. But in several other exposures no distinct horizontal layers were detected. South of the river at Stanley the road ascends a bluff of gravelly blue clay. At about 180 feet above the lake fine wavy blue clay was found free of stones and gravel and having a humpy, rolling surface. At a point about two miles from Beaver mine the road follows a long shelf on the south side of the valley, which at this height is at least five or six miles wide, widening towards the northeast. Along the edge of this shelf there is in some places a gravel ridge which is probably a wave-made bench. Its height is approximately 450 feet above the lake. At Beaver mine, and on the hill back of it, no evidence of submergence at higher levels was seen.

In the town of Port Arthur the several features described by Lawson were easily recognized. To his report on this place† I add only such observations and conclusions as are new, or at least not mentioned by him. The lower of his terraces, backed by a sharp sea-cliff at 61.4 feet, was readily recognized as the Nipissing bench. Lawson's photographic view‡ looks northward on this terrace, with the sea-cliff on the left. The point from which the view was taken was easily found. The newness of this terrace as compared with those above it, shown by the comparative amount of erosion, where creeks and streams cross it, seems not to have been noticed by Prof. Lawson on any part of this coast. Evidence of this kind was not found quite so conspicuous in Port Arthur as at some other places to be described later. But when this quality was once

*Ibid., pp. 210-211.

†Ibid., pp. 262-263.

‡Plate IX, Fig. 1, opposite p. 262.

recognized it became a valuable aid in identifying this beach at places widely separated. Its great strength, however, is the most reliable character for its recognition. Sometimes this quality may not appear to be striking at a given locality, but it generally makes its appearance soon if the beach is followed for any distance along the shore. Back of the town the great hooked spit at 170 feet on the south side of the Dawson road was found as described by Lawson. The most of the material for the spit appears to have been drawn from a hill of drift which formed a salient point east of the road and above the town. At the top of the hill and just north of the road a lightly formed beach not mentioned by Lawson was found at about 210 feet. It takes the form of a gentle, boulder strewn slope towards the south, and it has a low sea-cliff at its back.

After crossing the first hill-top west of town on the Dawson road and descending the west side a large sandy beach ridge was crossed at 170 feet, the level of the hooked spit just noted. About five miles out faint sandy beaches were found at 370 and 380 feet above the lake. A broad plain at 410 to 420 feet, eight miles out, may be related to a higher beach, but higher ground was not seen in that vicinity.

On a drive to the old Thunder Bay mine northeast of Port Arthur and up the north branch of Current river, several interesting evidences of submergence were observed. Starting northward from the post office the road follows the terrace of the Nipissing beach near its highest level to the outskirts of the town and then turns west through a cut in the old sea-cliff to the higher terrace. Less than a mile out a fine sandy beach running southwest is crossed by the road at about 110 feet above the lake. Clean-washed rounded gravel was found at 180 feet just south of the bridge over Current river. The gravel forms a plain and is part of an old delta, which is still more extensive on the north side of the river. Its surface slopes gradually towards the lake and is covered by a numerous series of low beach ridges of fine gravel and sand. The highest part crossed by the road is about 190 feet above the lake. About a mile northeast of the bridge an old lumber road turns off northward up the north branch of the river. This road crosses the outer edge of an old delta at about 210 feet.

Farther on it ascends a massive ridge of gravel which projects from the east, and ends abruptly as a high bluff overlooking the river. The top appears to be a beach, and the whole ridge is probably a great spit. Its height is about 260 feet. Less than two miles farther north the road crosses a great terrace, now a muskeg and cedar swamp, which has what appeared to be a sea-cliff at its back cut out of irregular morainic hills of drift. The back of this terrace is about 450 feet above the lake. From the hills above, a fine view is had of Thunder bay and Pie island in the distance. The highest point reached was 70 feet above this terrace. At a point about two miles north of Port Arthur the Canadian Pacific railway passes up over the Nipissing beach, which is here marked by a low rock cliff extending for some distance. The railroad then ascends gradually over a sandy plain with many ridges, and passes into a region of bare rocky knobs.

Two trips were made from Fort William westward up the main line of the same railroad. The first was to a point two miles north of Finmark and the second to Dexter, 55 miles from Fort William and near the top of the grade. Both trips were made on freight trains and most of the time was spent outside on top where the seeing is best. This is the best way to get a glimpse at that wild region, for there are no wagon roads. The old Dawson road is passable as far as Kaministiquia station, 20 miles west of Port Arthur. But at this point the bridge is gone and the old trail beyond is not passable. Fort William is on a low flat delta of the Kaministiquia and the tracks of the railway are only three or four feet above the lake. About three miles west of West Fort William the track crosses a series of sandy beach ridges and a sand bluff about 15 feet high. The beach is about 60 feet above the lake and is beyond a doubt part of the Nipissing beach. The plain close above and back from the edge of the bluff is deeply trenched by small streams which flow in very narrow, steep-sided trenches with meandering courses. The trenches reach back an eighth of a mile or so from the bluff. Except a few fragments of low sandy ridges, no other conspicuous relics of submergence were noted until Kaministiquia station was reached. Here is the great gravel delta described by Lawson,* at an al-

**Ibid.*, p. 262.

titude of 455.1 feet. The extensive ballast pit below the station shows the gravel in fresh exposure 30 feet high. Considering the way in which the old delta was shut in between the hills and the comparatively coarse quality of much of the gravel, it seems probable that its surface at the pit does not mark the old water level, but is somewhat higher. The structure of the delta was not very well shown except in the upper part above the talus where the layers were horizontal.

Lake Kaministiquia and the Sunshine Red Clay. A short distance above Kaministiquia the railroad crosses the river and turns away westward and within a few miles farther enters the valley of Sunshine creek which it follows nearly to its source. Three or four miles beyond Kaministiquia the cuts along the railway begin to disclose sections of fine red clay. The frequency and depth of these clay sections increase until, from a point two or three miles south of Finmark to a point four or five miles beyond this place, the clay appears to form an almost complete mantle over the drift and rocks of the valley floor and many sections 15 to 20 feet or more in depth may be seen. The color of this clay is bright red. It is fine and smooth in texture, and no evidence of stratification or lamination was found. Two or three thin layers of moderately coarse sand and several small pockets of sand were discovered. These pockets resembled the "sand boulders" sometimes found in clayey masses of glacial drift and may have been frozen or cemented when deposited. On the first trip I alighted from the train in a cut about fifty rods west of a long trestle two miles above Finmark and walked back along the track to the station. In this way I had a fine opportunity to examine the clay which is exposed in an almost continuous series of cuts in this interval. West of the trestle the clay appeared not to extend up more than 75 or 100 feet above the track, which is there about 100 feet above Finmark. (On C. P. R. profile Finmark is 1177 feet above sea level.) On account of recent caving, many of the clay surfaces in the cuts were comparatively fresh. In two places, one at the bottom of a section 25 feet deep, ditches had been dug out on that day. Weathered surfaces showed a distinct granular structure like the buck-shot soil of the lower Mississippi, but no lamination. The grains or little blocks are fine at the top of the sections, a six-

teenth to an eighth of an inch in diameter, but increase in size with depth, reaching two or three inches diameter. Old surfaces in the cuts are crusted over, and have lost their brightness of color, becoming grayish red. Underneath this crust the clay is loosened up and is soft and spongy for six or eight inches. The fresh wet clay in the ditches has the quality and fineness of cocoa butter and its purity and homogeneous composition are quite remarkable.

The railroad follows the creek pretty closely, but is most of the time 30 to 90 feet above it. The creek flows rapidly in a rather narrow trench cut mostly in stony drift. It frequently encounters rock ledges, and is much choked with boulders. The bottom of the clay rests generally on grayish colored drift in the bank of the stream 10 to 30 or 40 feet above the water. The red bed appears originally to have covered the bottom of the valley and extended up its sloping sides for some distance. But its whole surface so far as seen is deeply gullied, forming a series of ridges sloping down from the valley sides toward the creek. The railway cuts across the lower ends of these ridges, and it was in these cuts that all the sections were seen. No part of the clay bed was seen which presented a plane surface free from gullies, but in one or two expanded parts of the valley the even tops of the ridges indicated the former existence of such a surface. The forms of the gullies suggest a considerable period of erosion. Their sides were no doubt steep bluffs at one time, but they have been worn down to gentler slopes and appear to have attained a stable form.

The Sunshine clays, as I call them, indicate an interesting incident of the glacial recession for this region, and they point clearly to a different history from that suggested by some of the early geologists who visited it. The clays themselves, while conspicuously lacking, so far as seen, in the horizontal laminations that generally mark fine deposits laid down in still water, are nevertheless, plainly enough, waterlaid. Their extreme fineness and perfect homogeneity with entire absence of boulders, pebbles, gravel, and even of sand or silt, with the exceptions mentioned above, puts them outside of the class of boulder clay or ice-laid drift. There are places in the sections where a glance from a passing train suggests boulders in the

clay. But on closer examination the boulders were all found to be projecting upward into the clay and really resting on the subjacent floor of drift or rock. In one case the clay was found abutting against an almost vertical bank of gravel which it had apparently once covered over entirely.

The red clay extends nearly to Nordland station but grows thinner toward Dexter and appears finally in only small patches here and there. Then comes a belt of sand and above that gravel. Bordering the edges of the marshes in some places north of Buda and south of Nordland there are small low fragmentary ridges of gravel suggesting shore structure. This part of the valley appeared to be too narrow, however, to have built beach ridges by wave action. If they are shore forms they are probably made by ice-jamming as is often seen on small lakes. The altitude of these surface gravels lying next above the red clays is about 1530 or 1540 feet above sea level. (930 or 940 feet above lake Superior.) I learned afterwards from Col. Dawson in Ottawa that there are old gravel terraces of shore origin on Dog lake towards the east (head of the Kaministiquia river) at about the same level.*

Nothing whatever was learned of the boundaries of this lake, or the situation of its outlet. The contour of 1540 feet, however, would indicate a lake of considerable size, at least forty to fifty miles long and nearly as wide, and of very irregular shape, with an outlet most probably toward the southwest into the Rainy Lake valley. Its waters must have been held in by the ice-lobe that filled the Superior basin and stood as a wall across the eastward opening of the several valleys that converged to the lower Kaministiquia. The existence of a lake in this situation at this stage of the glacial retreat is quite contrary to the views of some glacialists, who would have the area of lake Kaministiquia still covered by the Kewatin ice-sheet.

Independently of these considerations I had concluded that the faint striae on the north side of Mt. McKay indicated ice-motion from east to west, slightly north of west. But according to Dr. Bell Louis Agassiz observed striae in a valley near Ft. William "running about due east."† Considering

*Possibly these are the same as those observed by Hind (1859) at Great Dog portage at 1435 feet.

†"Geology of Canada," 1863, p. 888.

what we now know of the ice-motion in the lake basins at the various stages, it is hard to see how there ever could have been motion toward the east at that place.

There is another area of red clay probably of the same kind and of the same or slightly earlier age in Minnesota west of the western extremity of lake Superior. It was probably laid down in the first glacial lake of the Superior basin, before the opening of the St. Croix outlet and hence before the time of lake Duluth. All these very red clays are evidently derived from the red rocks of the Nipigon series.*

Nipigon. In going by train from Port Arthur to Nipigon one sees a number of interesting evidences of the higher lake waters of the past. Sandy places and fragments of beaches are seen in several places. Prof. Lawson reports here a pitted terrace-plain at Mackenzie backed by sea-cliffs, altitude 497 feet, with another higher terrace. At Loon lake, 424 feet above lake Superior, sandy gravel overlies the stony clay in patches. At Pearl River, 246 feet above the lake, the surface is a mass of boulders and cobbles. East of the station there is a finely formed beach ridge of rather coarse gravel with well rounded pebbles. It runs for some distance nearly parallel with the track and appeared to spring from a rocky knob east of the station. It is cut on a long diagonal by the track just west of the rocks. Pebbles of bright red color and beautifully rounded are a large constituent. At a point about two miles east of Pearl River and 60 feet lower a narrow valley between bare hills is floored with greenish yellow silt and clay in finely laminated beds. In some places the fine sediments take on a reddish tinge. Farther east a broad plain of these sediments in beds with fine horizontal laminations, was crossed for several miles descending gradually from about 275 to 100 feet above the lake, and extending to Nipigon.

No ground favorable for the higher beaches appeared to exist near Nipigon station. Lawson reports the apparent crest

*In a letter to the author relating to the red clays, Dr. G. M. Dawson, director of the Canadian geological survey, very kindly gave the following references: "On the Fresh Water Glacial Drift of the Northwestern States," 1864, by C. Whittlesey, Smithsonian Cont., vol. xv. "Geology and Resources of the 49th Parallel," 1875, p. 213. Red clays of Minnesota are mentioned in some of the reports of that state. Those described here are also mentioned briefly by Dr. Bell in one of his early reports in the Canadian geological survey.

of a large terrace north of the station at 198 feet. The most important observations made here relate to the Nipissing beach and the character of the bed of the Nipigon river below this level. A start was made for lake Nipigon, but the great "Wiggins storm" of Sept. 22 to 24 found us about half way up the river and it was so violent that we were obliged to stop. So much of the brief time available for this trip was thus lost that we were obliged to turn back.

The Nipigon is a large river, and is in reality the upper St. Lawrence. Being the outlet of a large lake and having no large tributaries along its course, it would be expected that this river would be clear, and so it is in its upper half except for the stain of the muskeg. Its lower course, however, is quite remarkable for its character of newness. In this part the river is cutting its clay and silt banks and is quite muddy. At the upper end of the long portage, nearly half way up to lake Nipigon, the river is clear. The banks along the west side of the river above and along the shore of lake Jessie are of gravelly glacial drift. The long portage passes around extensive swift rapids, the lower part of which were run in a canoe on the return trip. The head of the rapids is probably at least 100 feet above lake Superior, but was not accurately measured. Camp Alexander is at the foot of the long rapids. The river here crosses a ledge of gneiss with no certain evidence of recent cutting or gorge making. The rock on the north side appears to be in rather loose blocks, but on the south side the ledge is solid and smooth, though uneven. It appeared to be a glaciated surface which had not been modified much by the river. Perhaps the river has cut the ledge down five or ten feet, certainly not more, and this was done by removing blocks that were probably loose to begin with.

From camp Alexander down to lake Helen, seven or eight miles, the river is nearly straight and flows with a current of two to four or five miles an hour in a comparatively narrow bed with low banks mostly of horizontal laminated clay and silt. Along the bank two or three feet under water the laminations were distinctly seen. Besides the finer laminae, there appeared to be a harder layer every three or four inches. This projected a little over the softer layers next below, and these in turn rested on another harder layer. The bank under wa-

ter was nearly vertical and these layers gave it an appearance resembling the weather boarding of a frame house. Where the river turns into lake Helen there is a delta of considerable proportions, composed apparently entirely of sand and silt. It is only a little below the water surface and bears a growth of rushes. A well marked shore line on the east side of the lower end of lake Helen was not measured, but appeared to correspond closely in altitude with the Nipissing beach.

On leaving lake Helen the river flows rapidly for about a mile and makes a sigmoid curve, first to the east and then to the west. In this stretch the river is now cutting its banks rapidly. First from the head of the outlet to a point some distance below the railroad bridge it is cutting its east bank, then from there to the Hudson Bay Co's store it is cutting its west bank. At the time of my visit the river was unusually low, but the clear water that issued from lake Helen flowed past the store in a milky stream. Below the eastward curve and directly southward down the valley from the bridge there is an extensive modern delta much like that in lake Helen. By its great bend to the west the river avoids this and passes around its west side. The conditions presented by the river bed below lake Helen show the extreme recentness of its adjustment to its present level. At two higher levels in the vicinity of the railroad bridge there are terraces marking higher, wider channel floors, the first next west of the present bed is 20 to 30 feet above the present river and the next 50 to 60 feet. These two terraces evidently mark steps in the falling of the river from a higher level, apparently from the level of the Nipissing beach. Considering ~~the fact~~ that the barrier through which these old channels and also the present bed are cut is composed of soft clay, sand and silt with gravels above and the further fact that there is no other restricted passage on the course of the river from lake Helen to the open expanse of Nipigon bay, it seems clear that the terraces are related to former levels of lake Superior, higher than the present, but lower than the Nipissing beach; and the fresh condition of the present bed indicates very recent if not modern progressing relative elevation of this part of the coast. There are several faintly marked beaches on the slope between the station and the Hudson Bay Co's store. Lawson gives beach-

es at 61.3 feet, 28.4 feet and 13 feet. The exact correlation between the beaches and river terraces was not made out. It is evident from the eastward slope of the terraces at the bridge that the bed of the river has shifted continually eastward at that point during the falling stages.

East of Nipigon. For much of the way from Nipigon east to Winston's the railway lies on laminated silt beds, usually between 20 and 50 feet above the lake. At Gravel river there are extensive gravel beds near the station which appear to belong to a delta deposit made at a level considerably higher than the station which is 24 feet above the lake. They appeared to reach up at 40 or 50 feet above the station, but whether they belong to the Nipissing or a lower beach was not determined.

At a point about a mile west of Winston's the Nipissing beach appears in fine form and a great ballast pit has been opened in it, showing false bedding with eastward pitch and sand overlain by clean gravels. The gravels at Winston's station are at a higher level (210 feet or more, Lawson).

Schreiber. Lawson's observations at this point were verified and one additional terrace about ten feet higher than his highest was found. About a quarter of a mile northeast of the station, along the base of the hills where a small stream comes in, there is a small terrace which seems to be the modified delta of the stream. It is not wide, but is distributed some distance along the base of the hill. Its features suggest that it marks a former level of the lake at about 400 feet. A day was spent at Schreiber and an excursion was made up the flat little valley into the hills back of the town and up to the summit of those situated about two miles to the northeast, reaching a height of 270 feet above the flat. No evidence of higher submergence was found, although the little valley should apparently have afforded as favorable an opportunity for a delta deposit above 400 feet as it did below. Down toward the lake an effort was made also to locate the Nipissing beach. But the brush was so thick along the trail followed that no satisfactory result was attained. There are several faint beaches covering an interval of a few yards below the highest beach, the most prominent being at about 345 feet. Below this are clay and silt beds 35 feet deep. Only

the upper beaches of Terrace bay were seen from the railroad track east of Schreiber.

Jackfish Bay. At this place and around the point about two miles east of Jackfish station, the old shore lines were found in magnificent form and all substantially as described by Lawson. The Nipissing beach appears here in one of its strongest types—a wide beach-plain with numerous beach bridges nearly at the same level. At Jackfish this long-lived lake shore is probably represented by Lawson's beach series between 85 and 110 feet above the lake. With the limited time at my disposal at this place I was unable to determine which beach stands for the upper mark of the Nipissing, but it seemed to lie between those at 103 and 110 feet. East of the point it was also difficult, from what I saw, to make out the exact upper level. Here, too, the beaches form a great ridged plain and appear to have been built almost wholly with material brought from the east where a great terrace at a higher level has been cut away at the Nipissing and lower levels. The most prominent ridge on the plain and forming the front edge of a slightly higher plain than that which lies in front of it, is about half way between the railway track and the cabin of Duncan MacIntyre. The higher ridges of this series are often bouldery, especially on their inner or rear sides. In one place the boulders are four to six inches in diameter and they lie nearly two feet deep with no filling between them. The beach-plain back of this prominent ridge is very ridgy and uneven, with some marked basins, almost a pitted plain in some places. This area is a counterpart of the Nipissing beach-plain at Rogers City, Michigan. Ten miles east of Jackfish there is a fine series of beaches belonging probably to the Nipissing. Three miles west of Caldwell there are beds of white silt capped with sand at about 250 feet above the lake.

Peninsula Harbor. This place is at the extreme northeast angle of lake Superior. Lawson visited it, but made no measurements, on account of fog. I found the top level about two and a half miles back from the lake on the south side of an embayment, the valley of a small river that enters the lake north of the station. The whole slope has been burned over and the features of the ground are not much hidden by later growth. The deposit which covers the slope appears to be

an old delta deposit of the Big Pie river which now enters the lake a few miles farther south. The highest mark of the ancient lake was found at about 410 feet above the lake. On the upper plain two or three pits were found, one 20 feet deep and about 200 feet in diameter. From the upper level down to the Nipissing beach-plain there are several terraces and ill-defined beach ridges, the most prominent one about 260 feet above the lake. Here again, the Nipissing beach appears as a great beach plain with many ridges at altitudes close to 110 or 115 feet (aneroid) above the lake. The material was apparently derived from the cutting of higher terraces towards the south and as they were built northward across the embayment they cut off a lower tract behind and formed a shallow marshy lake. The lake feeds a water tank for the railway, and the recently excavated trench for the laying of the pipe gives a characteristic exposure of beach material, sand and well-rounded pebbles. The edge of the plain back of the station and Mr. Mudge's house is bordered by a line of dunes from which a good view is had of the beach-plain back of them. The beaches below the Nipissing were not so clearly defined here, but one is fairly plain as a cut terrace at 40 or 45 feet. Back of the station the Nipissing beach-plain is about a mile and a quarter wide. Some of the ridges on the plain are sharply and beautifully developed in long parallel lines or curves, with lagoon hollows between.

East of Peninsula. The interval from Peninsula to Melgund was passed after dark, but a return trip was made next day from White river to the latter place. The lower beaches were not seen. But at a point two or three miles west of Cache Lake station, a sand plain like several others which mark the upper limit of submergence farther west was found backed by a sea-cliff, the altitude being approximately 420 or 425 feet. East of this along the course of the rapidly flowing White river to the hight of land near O'Brien and Amyot no sign of submergence was seen.

The great hills between White river and Grasset, forming the hight of land in that part and rising 200 to 300 feet above the general plain are mostly moraines of the ice-sheet and their forms seem to show that they were made by ice coming from the northeast. Their position suggests that they

may be partially interlobate in character, but distinct proof of this was not seen. The section in the great ballast pit at O'Brien shows glacio-fluvial action quite plainly.

Missinaibi. A canoe trip was made up Dog lake to the low col which forms a part of the hight of land. The trough in which Dog lake lies is one of those curious deep rock-walled valleys that cross the wide, low crest of the Laurentide ridge at many places. Into this valley near the head of Dog lake a small stream comes in from the eastern side and the present division of the waters is determined by the low broad delta which it has built since glacial times. The lake was at a very low stage at the time of my visit, but the crest of the delta was not over three or four feet above it and the creek on the north side flows away to Brunswick lake, Moose river and Hudson bay. At the high stage of springtime it is said the water sometimes flows northward over the delta. Much of the lake is deep. But there are boulderly narrows at several points that suggest either moraines or boulder spits made by the jamming of ice-floes. The boulders are mostly quite angular. The whole region is very boulderly, gneiss and granite predominating, and the boulders are almost all sharply angular. The shore of the lake is in a few places of solid rock, but nearly everywhere it is merely a mass of angular blocks with all finer material washed out by the waves. This valley may have been the course of glacial drainage for a brief period. But I saw no evidence of a great glacial or post-glacial stream, nothing resembling the old-channel characters seen in other places. No evidence of submergence was seen in this vicinity. Striae at the station bear S. 38° W. (Mag.)

Summary and Conclusions. The higher beaches observed may be divided into two groups of localities, those clustered around Port Arthur and those near Jackfish. Not counting lake Kaministiquia, the upper limit of submergence in the first group is about 400 to 450 feet above the lake, while in the second group it is about 400 to 425 feet. Between the two groups there is an interval of about 70 miles in which high beaches have not yet been reported by anyone. (Highest reported by Lawson 360 feet at Mazokamah.) It might be supposed that the highest beach in the two groups is one continuous line, and it seems probable that this is the case, but further exploration

is needed to establish the connection. At Root river near Sault Ste. Marie Lawson's highest beach is the Algonquin, 414 feet above lake Superior. Between this place and the Jackfish group it seems hardly conceivable that there could have been a glacial or any other kind of barrier, and hence the inference seems clear that the upper beach of Jackfish group is the Algonquin. But there remains some uncertainty, of the identity of this beach in the west end of the Superior basin.

No attempt is made here to correlate the fragmentary intermediate beaches, those at horizons between the Algonquin and Nipissing. The last named beach, however, was clearly recognized at every place where the lower coast was examined. It is about 60 feet above the lake at Mt. McKay and Port Arthur, 90 feet at Nipigon station, 105 or 110 at Jackfish and two miles east of there and 110 to 115 at Peninsula Harbor. Its great length, compounded of many beach ridges forming beach-plains, gives it a physiographic prominence that is not equalled by any other shore line of the lake region.*

Several rather light but distinct beaches were found below the Nipissing, especially in the extreme north where the Nipissing beach is highest. The probable existence of at least one such beach was inferred from the observations of 1893 on the south Superior shore, and it was called the Sault beach because it appeared to hinge on the outlet at Sault Ste. Marie. On the south shore it is now all submerged and appears to lie about 50 feet below the Nipissing beach. It was estimated that it would be found somewhat more than 50 feet below the Nipissing along the north shore. The beach 28 feet above the lake at Nipigon, 33 feet at Jackfish and 40 to 45 feet at Peninsula seems to meet this expectation. The fragments so far found, however, are too few to warrant more than a provisional correlation.

Until the attainment of the results here presented the hypothesis entertained with most favor in explanation of the high shore lines of the Superior basin was that they were of marine origin. It was expected that the Algonquin beach would be found at a higher level than has been observed on the north shore and that there were straits north of Hudson bay through the passes at Kenogami lake and Jackfish

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and at Missanaibi. According to Lawson the altitude of the cols in these passes is 500 feet and 110 feet above the lake respectively. Measuring from Missanaibi station, however, the latter col proved, according to the Canadian Pacific railway profile, to be about 515 feet or 75 feet higher than the altitude given by Prof. Lawson. If the Algonquin plain is approximately even from Cache lake to Sault Ste. Marie this would leave the col at Missanaibi about 85 or 90 feet above the beach, and the col near Jackfish is nearly the same distance above the beach at that place. So the idea of straits to Hudson bay had to be given up and with it also the hypothesis of marine origin for the higher beaches. Subsequent observations in the Ottawa valley fully confirm the alternative hypothesis, namely, that the water which made the high shorelines of the northern lakes was held in place by a great ice-dam in the Ottawa valley, and that these lakes were incidental to the retreat of the ice-sheet.*

**Am. Geol.*, vol. xvii, April 1896, pp. 253-257.

Am. Geol., vol. xviii, August 1896, pp. 108-120.

Inland Educator, Terre Haute, Ind., April 1896, pp. 138-145.

"*Studies in Indiana Geography*," *Inland Publishing Co.*, Terre Haute, Ind. 1897, Chapter x, pp. 104-105.

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