Art. III.—*Crustal Warping in the Temagami-Temiskaming District, Ontario;* by L. V. Pirsson.*

The gradual rising of the great Ontarian shield, upon whose southwestern flank the great lakes are being slowly tilted to the southwestward, presents a geologic problem of primary importance. We may reasonably expect that fuller knowledge concerning it will throw much light on secular continental movements.

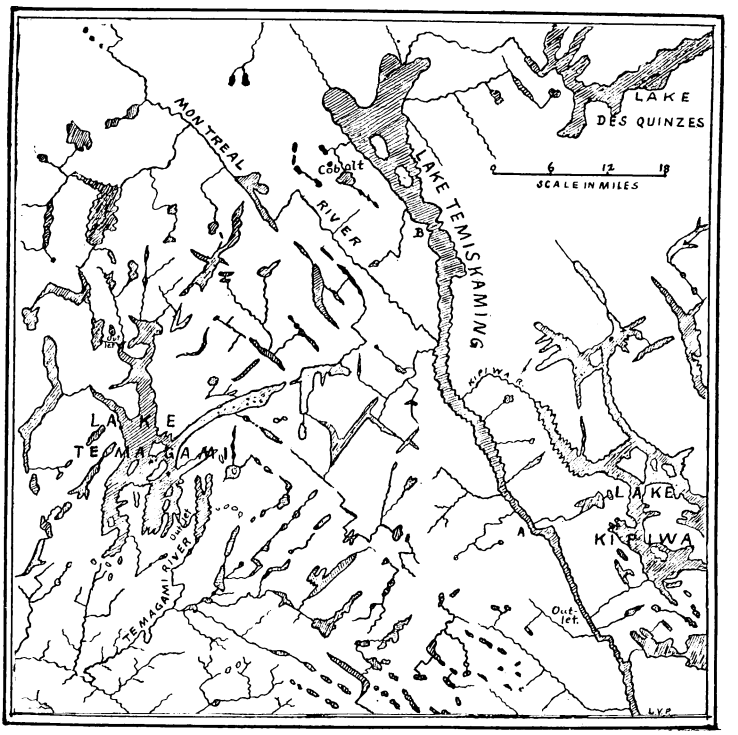
This tilting and the various phenomena to which it has given rise have been the subjects of study by various geologists, particularly Gilbert and Taylor, whose results have been published in a notable series of articles. The latter has especially studied the sequence of events arising along the north shores of the Great Lakes from their southward canting, and, in his paper on the former Lake Algonquin stage of the lake system, he presents a map upon which the node lines, or axes of tilting, are given.† It is of great importance that this work should be carried to the northward, and especially to the northeast, so that ultimately the crest and extent of the rising shield may be determined. So far not much work in this direction has been undertaken with this object in view, and in this brief paper the writer desires to point out a region whose topographic features appear to offer much of interest and significance in connection with this matter. His attention was first called to it in the summer of 1907, on a visit to the mining region of Cobalt, during which Lake Temagami was traversed and Lake Temiskaming and the Ottawa valley descended. No detailed studies were carried out, but the observations made en route on journeys lasting a couple of weeks in this area aroused his interest in it, and this has been deepened by a study of what has been written upon it, and especially by the excellent report and geologic maps of Barlow‡ and of the Provincial geologists on the mining district. The facts given in this article are taken mostly from these sources, supplemented in a few cases by original observations.

Lake Temiskaming.—This lake is nearly 70 miles long from the point where the River des Quinzes enters it to the outlet at the head of the Long Sault Rapids. While in the upper portion it is several miles wide, this width soon diminishes and the greater part of the lower portion is not over a mile broad, or is even less; in some stretches it is not wider than the Ottawa River to which it gives rise. There is a difference of water

* Abstract of a paper given before the Yale Geological Club, April, 1909.
† F. B. Taylor, Amer. Geol., vol. xv, p. 116, 1895.
‡ Ann. Rep. Geol. Surv. of Can., vol. x, 1897, Rep. I.

level between the head and foot, at times, of one or two feet and this gives a distinct current through the lake, which at the narrower constrictions becomes quite pronounced. The general direction of the lake is south-southeast. While the upper part of the valley occupied by the lake is more open, the greater part, where the lake is narrow, is a deep trench cut in the gneisses of the old upland. Thus from the shores rise

FIG. 1.



Drainage map of the Temagami–Temiskaming Region.

abruptly bold rocky hills with heights ranging from 350 to 600 feet, which in many places pass into towering cliffs. Thus the aspect of the lake is like that of a fiord, and it is in truth a miniature Saguenay. At the same time, considering its narrowness, the lake is remarkably deep. From the Opemika Narrows at the point marked A on the map, Barlow found that the depth gradually increased until it reached 470 feet near the mouth of the Kipiwa* River. This is near the middle of

* This name is spelled in a variety of ways; even on the same official map more than one appears. The spelling selected seems the simplest and to express the sounds as the inhabitants pronounce it; the writer, however, disclaims any attempt to fix usage.

the lake; from here it gradually shallows and opposite the mouth of Montreal River is 350 feet deep. At the point B on the map, old Fort Narrows, there is a very marked contraction, owing to a heavy deposit of sand and gravel in the trench at this place. The depth on this is perhaps 50 feet and the lake again deepens to the north but does not reach the great depths of the lower part. It is also to be noted that where these great depths were obtained it was not only in the middle of the channel but close up to either shore.

From what has been stated it will be seen that the total depth of the trench, or rather canyon occupied by the lake, from the surface of the old upland to the lake bottom, is about 1000 feet at the deepest point. shallowing gradually either way, north and south. At the deepest point the former canyon is about one-half filled with water.

What is the origin of this lake? For one of its size and nature in this region three possibilities present themselves: it may be a rock basin cut by the ice sheet; it may be a river valley dammed by glacial drift, or it may be a warped valley. In regard to the first, since the general direction of flow of the ice sheet was toward the southwest or more accurately S. 14° W., as given by Barlow, it is inconceivable that it could have cut such a deep and narrow gorge transverse to its direction of flow. Barlow's list of glacial striæ shows, as might be expected, that in the upper, wider portion of the lake valley the topography exercised enough control to produce an undercurrent in the ice, trending to the southeast. As the valley contracts this becomes less evident and the western bank, with striæ in the direction of southwest flow, shows it was receiving the impact of the general moving ice sheet. In such a narrow, constricted gorge the local sub-current might be expected to die out, the trench would become packed with nearly motionless ice, up to the average level of the plateau, which would support the ice-sheet moving transversely across it. It seems improbable, therefore, not only that the basin was cut by the ice, but even that the pre-glacial valley was to any great extent deepened by its scour. The general appearance of the gorge, and the lack of truncated spurs, seems also to indicate no great amount of glacial control of its topography. It probably existed pretty much as it is to-day before the advent of the continental ice-sheet.

The explanation of a morainal dam also seems improbable when one considers the depth of the lake, the fact that the deepest part is not near the outlet but near the middle, and the character of the river bed below the outlet. There is no direct evidence of such a dam, and, as Barlow* remarks of the river

* Loc. cit. p. 171.

bed below the outlet: "Very little rock *in situ* can now be seen, although it is evident from the topography that the detritus was deposited in a pre-existing shallow narrows." Even were it admitted that the valley was dammed with glacial drift to a depth of 500 feet at this point, there would still be a rock barrier at the Mountain Rapids at the foot of the next stretch of still water, known as Seven League Lake, whose surface is about 50 feet lower than that of the main lake above, and which discharges down a rapids obstructed by rocky reefs and islets. Thus, even if a morainal dam exists of the great depth postulated, it can only be regarded as a secondary affair, forming a sort of facing on the downward slope toward the lake center of the bed-rock barrier beneath and giving at the most a height of some extra 50 feet to the lake.

It is not intended, of course, to deny in this that morainal deposits may not lie on the floor of the old canyon. They probably do, and the real rock floor may lie considerably deeper than the present bottom of the lake. At old Fort Narrows (B, on map) the gorge in large part is filled with a glacial deposit nearly choking the pre-existing narrows at this point. This very probably represents material accumulated by the local southeastward sub-glacial current in the ice which would be checked at this point. Only, as Barlow remarks, it could not have been originally much greater than it is now since on the down-stream side it slopes off with great sharpness to the depths of the lake. If it once projected somewhat above the present lake surface it was rapidly cut away until a grade was established between the two parts of the lake, and since then no great change in it has occurred.

The first two hypotheses of lake origin having been considered and dismissed there remains the third, and it now seems fairly evident that the lake represents a pre-glacial canyon which, by down-warping in its middle part, has become flooded. The total amount of down warp may be roughly estimated to be as much as 500 feet in the center of a distance of 50 miles in a general north to northwest and south to southeast direction.

Lake Kipiwa.—If such down-warping has occurred, it can scarcely be supposed that the immediate region would not be affected by it and the other drainages and lakes should show evidences of it. While not enough is known of those geologic features of the area which would offer decisive evidence on this point, there are some facts which appear to favor it. Thus Lake Kipiwa is so near to Lake Temiskaming and parallels it for such a distance that it should also be affected. It has not been seen by the writer, but Barlow describes it as filling several valleys parallel in a general way to Lake Temiskaming. These, like Temiskaming, cut across the general direction of

foliation of the gneissic rocks. The depth of the lake is not known. It has at present two outlets, the natural one by the Kipiwa River at the north end, and an artificial one produced by a dam at the outlet of the lake into the Kipiwa river and by the blasting away of the crest of a low rocky barrier by the lumbermen which causes the lake to discharge by Gordon's Creek into Temiskaming at the point marked "Outlet" on the map. Thus it would appear as if the canting of the lake to the north by the down warp had left the old outlet dry and caused it to seek a new one by the Kipiwa River. The latter, as it enters Temiskaming, is a swift, foaming torrent which plunges down over the rocks into the main lake at a point where the latter is nearly 400 feet deep, without entering through any distinct valley. As one sees it, it appears to have all the marks of topographic youth.

Lake Temagami.—This lake, some 40 miles to the west of Temiskaming, is also a many branched valley system which has been flooded and which discharges by two natural outlets, one at the north, the other at the south end. Neither of these has been seen by the writer, but from what he has been able to learn it is inferred that both are over rock rims. The greatest depth of the lake obtained by sounding near the central west shore is about 170 feet. The double outlet in connection with the warped character of the Temiskaming canyon is very suggestive, but since the direction of the axial line of the warped trough, as it would pass westward from Temiskaming, is not known, it may pass through Temagami Lake, or to the north, or south of it. In the first case the valley system would be flooded, and former water-work on shores near the central part would be drowned; if either of the latter two, the lake would have been canted north or south respectively and wave-work, such as beaches or sea-cliffs, would be elevated at the north or south ends. It should also not be forgotten that as the lake has many arms, some of them may have served as a former outlet and have been choked by a moraine dam which has caused the flooding and overflow elsewhere of the valley system. These are points which can only be settled by a careful study of its entire shore line, and it offers an attractive problem for investigation.

Drainage System.—In this connection attention is also directed to the remarkable drainage plan of the region (fig. 1). It is impossible to see it and avoid the conviction that there has been a distinct control in its production by rock structure. What is here evident on a small scale map is also striking on the large scale one of the mining district prepared by Miller.* This feature of the region has been previously commented

* 14th Ann. Rep. Bureau of Mines, Ontario, 1905.

upon. Bell,* in noting the course of Lake Temiskaming, suggests that it follows the course of a great dike which has been eroded; a suggestion which Barlow's geological map shows to be untenable. Hobbs,† in a short paper on fracture systems, briefly alludes to this drainage plan and gives a map of a part of the area showing its peculiar nature. He attributes it to joints. Miller‡ gives a more extended discussion of the systems of lines, and states that it is impossible to tell whether they follow faults or folds.

A study of Barlow's geologic maps of the Nipissing and Temiskaming sheets shows that these depressional lines of drainage are independent of the distribution of the rocks. The Montreal River, which holds a straight course through graywacke, slate, quartzite, and diabase, is a striking example of this. In a few cases, however, as plotted on the map, they appear to lie over the contact of formations. A consideration of the strike, especially of the planes of foliation of the gneissic areas, shows that they sometimes follow it, but just as often, and especially in the larger depressions, cut directly across it.

Either the drainage plan is directly conditioned by the present rock structures, or it is one that has been inherited; that is to say, it is superimposed upon the present surface by overlying formations, which once existed but have now disappeared. It is true that a remnant of an overlying formation, generally attributed to the Niagara, is found at the north end of Lake Temiskaming, but to restore this over the whole region would not only involve great improbabilities but would in itself give no explanation, for we should still have to account for the conditions in such an overlying series which would initiate such a drainage. It is also difficult to see how simple folding could produce such a rectangular net-work. On the whole, as suggested by Hobbs and Miller, it seems most probable that a system of nearly right-angled jointing and faulting has initiated planes of structural weakness through the region, which the streams have taken advantage of, and which has therefore exercised a directive control over them. While, as Miller remarks, it is difficult to directly prove this, since such lines of weakness in rock structure, or of displacement, are now for the most part covered by lakes, streams, and swamps, yet some corroborative evidence may be gleaned from Barlow's report where the jointed character of the rocks along the Montreal River is mentioned, and in one place of the direction of these joints as determining the course of the river.§ Many more such instances should be found when the region is more closely studied.

* Bull. Geol. Soc. America, vol. v, p. 365, 1894.
† Trans. Wisc. Acad. Sci., vol. xv, p. 19, 1905.
‡ Rep. of the Bureau of Mines, Ontario, vol. xvi, pt. ii, 1907, p. 36.
§ Loc. cit., p. 224.

If it be admitted that the drainage system is the outward revelation of an inward one of rock-fracturing, weakness, and probably to some extent displacement, then the network appears like the result of Daubrée's experiment on the induction of jointing by torsional warping.* It would seem natural to refer the lakes in part to minor warps or displacements of pre-existent channels along these lines of weakness, although in part they are probably due to morainal dams and to glacial scour.

Time of Warping.—If such warping with fracturing has taken place, the questions naturally arise as to when it occurred and if it is still continuing. The region has, as yet, not been studied in sufficient detail, with such questions in mind, to afford decisive answers. Some facts there are, however, which have a bearing on these points. Thus Miller† points out that the mineral veins follow closely the same systems as the water courses, and the deduction from this must follow that they are either contemporaneous or later than the formation of the fracture system. But the silver veins have been glaciated and consequently the fracture system is pre-glacial. Miller indeed refers it to post-middle Huronian time, this view being based on the hypothesis that the deposition of the ores was the result of the intrusions of diabase which are referred to this period. But inspection of the maps shows that the larger elements of the fracture systems, as indicated by the drainage lines, pass through these diabases as well as the older rocks. A careful study of the Niagara group, and especially of its contact with the older rocks, may throw much light on this question.

Whether the crustal movements here assumed continued after the glacial period and are still going on is a problem which demands further investigation. Miller‡ states that post-glacial faulting can be proved to have taken place. A noticeable feature of the region are the open torsion cracks and joints seen on glaciated rock-surfaces which have not been filled or eroded. They have been illustrated by Miller. While these are indications, more positive evidence would come, as has been previously suggested, from the canting of the lakes and exposures of uplifted beaches and marks of wave-work on shores. If such canting is pre-glacial these would be largely swept away, but if warping has continued into post-glacial times or been renewed, the evidence to prove it can undoubtedly be gathered.§

* Géologie Expérimentale, p. 510, 1879.

† Loc. cit., p. 38. ‡ Loc. cit., p. 38.

§ Since this paper was presented, and at the time of putting it in form for publication, the program of papers to be read at the Boston meeting of the Geol. Soc. Amer. has been received. In this is listed a paper by Dr. Robert Bell entitled the "Diversion of the Montreal River," and in the attending

Summary.—The ideas expressed in this paper may be now briefly summarized. That in this region there was first initiated by torsional warping in pre-glacial times a system of jointing, fracturing, and structural lines of rock weakness, and possibly foliation, which has controlled the drainages. That later, or continuing, warping has caused the beginning of a broad synclinal fold with the production of the larger lakes and other modifications of drainage; that this has taken place or continued into post-glacial times and may still be in progress, and that this is a minor feature of the uprise of the great Ontarian shield. It is not intended to assert that this idea or all parts of it are necessarily correct, or proven; only that the facts, so far as published and known, appear to point in this direction. For the object of this paper is not so much to state an hypothesis as to direct attention and to start an inquiry.

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short synopsis the view is advanced that the Montreal River in post-glacial times has been diverted from a former northward direction and made to flow southward by an uprise of the land which gives a southward tilt to its present course. This is in the region north of that covered by the map accompanying this article. While the writer has not heard this paper, this view, as thus stated, appears to favor the general idea expressed in this article and the southward flow of the river down the northern flank of the warp to be a local feature of the more general problem here presented.