

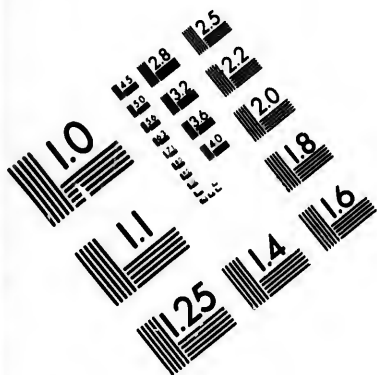
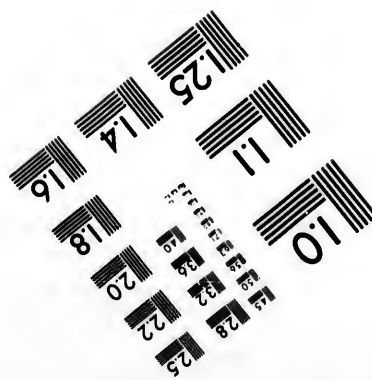
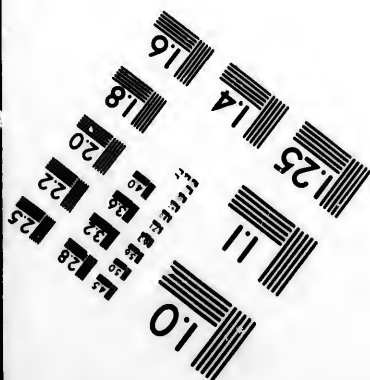
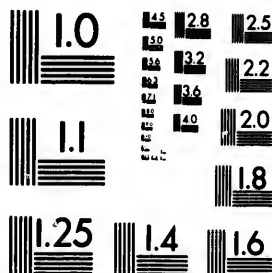
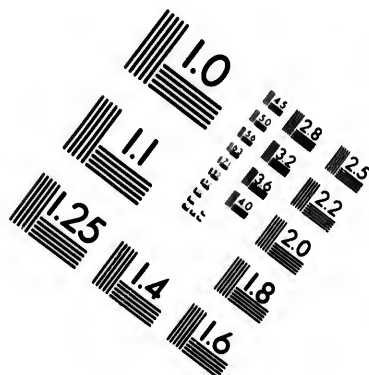


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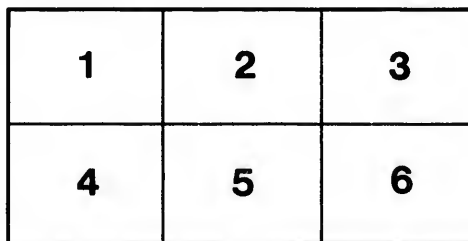
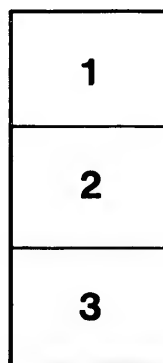
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Sir Sandford Fleming - Collector
1915-

THE IROQUOIS BEACH.

BY PROF. A. P. COLEMAN, PH.D.

(Read November 19th, 1898.)

THE effect of wave action in cutting cliffs, spreading materials as terraces, and heaping up beach sands and gravels is so easily recognised that old shore lines, where well marked like those of the Iroquois beach, quickly attract attention. Mr. Thos. Roy, a land surveyor in the early days of "Upper Canada," was the first to refer to the Iroquois beach, in a paper on the "Ancient State of the North American Continent," read by Lyell before the Geological Society of London in 1837. In this paper* Roy describes a series of "terraces or level ridges" to the north of Lake Ontario, the first at 108 feet above the lake, the second at 208 feet, and a series of higher ones, the last rising 762 feet above Ontario, or 996 feet above the sea. It is probable that the beach described as two and a half miles north of the lake and 208 feet above it must be looked on as the Iroquois beach, though later measurements make its height only 170 feet. Roy's other beaches have not been found with certainty by later observers, and it is doubtful if he was correct in his inferences, the densely wooded character of much of the country making it more difficult in those days to recognise an old beach.

In 1842 Lyell visited Toronto, largely to examine these terraces, and rode in company with Roy about twenty miles north, *i.e.*, to the old moraine of the Oak Ridges, and reports having seen in all eleven of these apparent beaches, the highest 680 feet above Lake Ontario; but he is not certain that all of them were due to wave action. He says, however, that "with the exception of the parallel roads or shelves in Glen Roy and some neighboring glens of the western highlands of Scotland, I never saw so remarkable an example of banks, terraces and accumulations of stratified gravel, sand and clay maintaining over wide areas so perfect a horizontality as in the district north of Toronto." He mentions that the second beach, the one at 208 feet, has a shore cliff rising fifty to seventy feet, and is covered with boulders; characters which we find on the Iroquois beach near Yonge street, in the northern part of Toronto.†

Roy accounted for this series of supposed beaches by the former presence of an immense lake 1,000 feet deep, dammed to the east and

* Proceedings Geol. Soc., London, Vol. II., No. 51, pp. 537 and 538.

† Lyell, Travels in North America, Vol. II., pp. 103-106.

south by ranges of mountains. As the dam was cut away the water fell step by step to its present level. Lyell prefers to think that these ridges and other marks of ancient water levels were formed by the sea, since he cannot imagine where the barrier assumed by Roy could have existed.* It is evident that in 1842 the long discussed question as to the marine or fresh water origin of the Iroquois and other raised beaches had already taken its place as one demanding solution.

On the south shore of Ontario this beach was clearly recognised in 1843 by Hall, who describes the gravel ridges used as roads, and states that these beach gravels contain wood, and, as he was informed, shells also; the first fossils noted from beds of Iroquois age.

It was sixteen years later before much further attention was directed to this old beach, A. C. Ramsay mentioning briefly the Iroquois terrace north of Toronto in 1859;† while in the following year Charles Robb, C.E., of Hamilton, Ontario, describes a succession of ridges of sand and gravel, seven in number, seen as one goes inland from Lake Ontario. He refers particularly to the old Burlington beach and heights, stating that they rise 110 feet above the lake, a more correct estimate than Roy's of the same beach at Toronto. He looks on the drift as due to iceberg action.‡ In 1861 Professor E. J. Chapman, of Toronto University, describing the drift deposits of Western Canada (meaning Ontario), mentions the fresh water shells found on old beaches near Collingwood and elsewhere, and thinks that an immense fresh water lake formed these beaches in succession as it gradually fell, evidently holding a view somewhat like Roy's.§

In the same year Sandford Fleming gave a good account of a portion of the Iroquois beach northwest of Toronto in a paper read before the Canadian Institute, describing the terrace plain at the foot of Davenport ridge (which is an old shore cliff), and the gravel spit near Carlton station. He gives a rough but fairly correct map of the spit, and of a bay of old Lake Iroquois to the north.||

In 1862 Newberry described "the ice wall of the retreating glacier as forming the northern shore of the fresh water inland sea,"** and so introduced an entirely new element into the discussion. In 1882 Dr. Spencer published his work on the Iroquois beach north of Lake

* Lyell, *Travels in North America*, Vol. II., p. 108.

† *Quart. Jour. Geol. Soc.*, 1859, p. 203; and *Can. Nat. and Geol.*, Vol. IV., p. 328.

‡ *Can. Jour. New Series*, Vol. V., 1860, p. 509.

§ *Ibid.*, Vol. VI., 1861, p. 228.

|| *Ibid.*, pp. 247-253.

** Prof. Fairchild's presidential address before the Geol. Sect. of the Am. Assoc. Proc. Am. Assoc., Vol. XLVII., 1898, p. 33.

Ontario, giving the beach its name, and bringing out clearly its differential elevation toward the northeast, crediting G. K. Gilbert with similar work on the south shore of the lake, and furnishing for the first time a correct idea of the shores of this old body of water.* Spencer looks on the Iroquois water as having been a prolongation of the Gulf of St. Lawrence, and so reverts to the theory of marine origin. Gilbert, on the other hand, prefers the lake theory, and places an ice dam across the wide stretch toward the northeast, where no beach can be found.

The work of Spencer and Gilbert practically settled the area and general character of the shores of the Iroquois water, and settled also that the region has been elevated toward the north-east, so that the old beach is now 115 feet above Lake Ontario at Hamilton, 170 at Toronto, and 385 at Trenton. The rate of increase in elevation per mile toward the west end of the lake is 1.6 feet, while in the neighborhood of Watertown, N.Y., according to Spencer, it is five feet.† The rate of elevation per mile as shown on the north shore is 1.8 feet between Burlington and Toronto, two between Carlton and Scarboro', and 2.3 between Scarboro' and Trenton, showing that the deformation increases toward the northeast. Beyond the Ottawa and St. Lawrence valleys it has not been found, but there is no land high enough to receive it, even if there were no ice dam at the north-east end of the lake to close its work at that point.

In order to represent graphically this increase of deformation toward the northeast, the following curve of elevation of the beach has been prepared by Dr. Ellis and myself, the heights of the beach above sea level, taken mainly from Spencer's History of the Great Lakes, being used as ordinates, and distances from Hamilton at the west end of the lake as abscissæ. After numerous trials, it was found that the direction north 17° east harmonized the elevations on the two sides of the lake most satisfactorily, and this has been adopted in the diagram. In reality, as shown by Gilbert,‡ the isobases or lines of equal uplift are not straight, but gentle curves, concave towards the north-northeast.

The shore of Lake Iroquois lies outside the area of Lake Ontario everywhere except for half a mile at Scarboro' Heights, where a promontory extended south beyond the cliffs of the present shore.

THE IROQUOIS SHORE AT TORONTO.

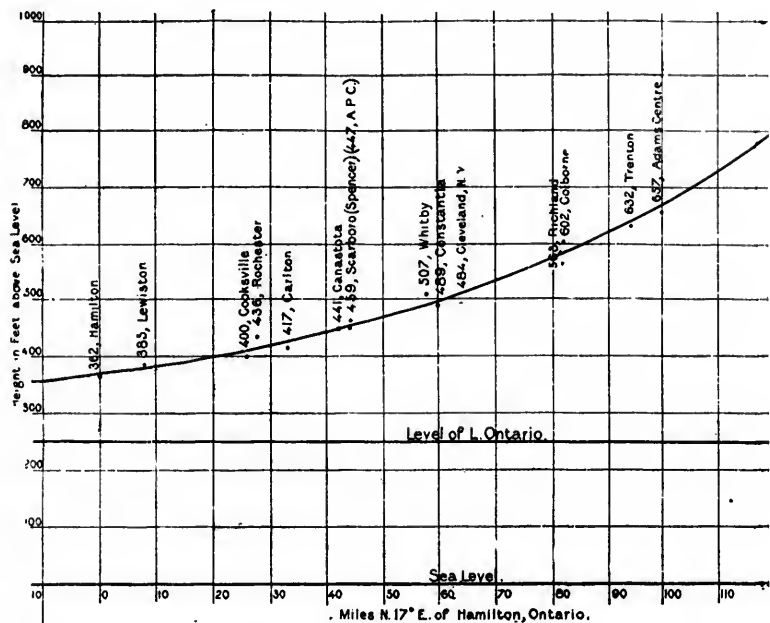
During the past two years the increase in building operations in Toronto has caused the opening of a number of sand and gravel pits

* The Iroquois Beach, Trans. Roy. Soc. Can., Section IV., 1889, p. 121, etc.

† History of the Great Lakes, pp. 47 and 48.

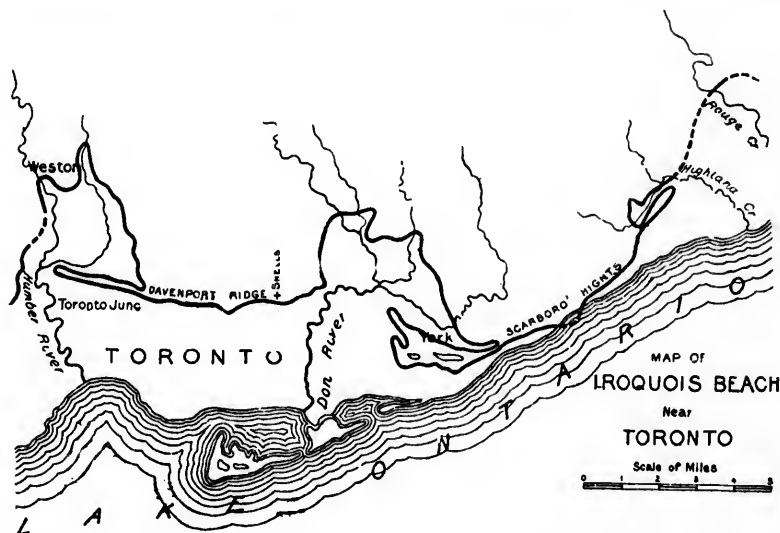
‡ Recent Earth Movements in the Great Lakes Region, U. S. Geol. Sur., 1898, p. 624.

in beach deposits of Iroquois age, and the finding of fossils in some of them has made it worth while to give this part of the Iroquois shore more careful study than it has hitherto received. The results are shown in the accompanying map of the beach in the County of York. It will be seen that north and northwest of Toronto it keeps a distance of about two and a half miles from the present shore, but toward the east approaches the lake until, as mentioned above, it is cut off for half a mile at the highest part of Scarboro' Heights, and then withdraws to the northeast.



Two large bays project to the north, one in the valley of the Humber and its tributary Black Creek, three miles long and about the same in width; the other in the Don valley, with a length of two miles from north to south, and a width of about four miles. A bar of coarse sand and gravel, often crossbedded, stretches from the east side of each bay towards the west, leaving a wide opening on that side, like the present arrangement of Toronto island and bay. A smaller gravel spit is found extending northeast of Scarboro' Heights, enclosing a small bay, now the valley of a tributary of Highland Creek. As mentioned before, the bay in the Humber valley and its gravel bar were briefly described and mapped by Sandford Fleming in 1861. Both the Humber and Don bars are mentioned by Spencer, but not particularly described.

As one approaches Lambton from the west by the Dundas road, the old shore cliff of boulder clay rises fifty feet or more, and is very well marked. It then turns north as far as Weston, keeping about half a mile west of the Humber river, but is less distinct than before, wave action being of course much less effective in a bay than on a large lake. The shores are mainly low and of gently rolling till on all sides of this bay. The bar or gravel spit commences at Carlton station, rising fifteen or twenty feet above the level plain, and extending in a north-westerly direction two-thirds of the way across the mouth of the bay. It is easily distinguished by the pine and oak trees growing on its gravelly soil, which is unsuited for farming, and has been left wooded. Beach gravel of much the same kind is found resting on Hudson shale,



near the right shore of the Humber at Weston, probably a deposit formed before the spit began to close the bay and prevent wave action.

The valley cuttings of Black Creek and the Humber give evidence that the bay was deep at first, but was afterwards filled in with stratified sand overlain with clay, the whole being in places sixty feet in thickness, the upper ten feet of clay. Much of the loose materials which filled the bay during Iroquois times, have since been removed by the Humber and its tributaries, but the river leaves the old bay by a narrow ravine cut down about thirty-five feet into the Hudson shale and at points to the south show hills of shale sometimes rising ninety feet above the river. No doubt the former stream passed out much to the east of the present one; which was crowded to the western side of the bay by

the growth of the bar and so had to cut a steep walled channel through the shale with its layers of limestone.

Eastward of the Carlton gravel bar the beach is once more very sharply defined with a shore cliff of stratified sand capped by till rising seventy feet at some points, the so-called Davenport ridge, really the edge of a rolling plain of ground moraine. The Davenport road skirts the west end of this escarpment and the Canadian Pacific railway the eastern end as far as Leaside junction. The greater part of the city of Toronto stands south of the Davenport ridge on the gently sloping sub-aqueous plain of Lake Iroquois, once thickly strewn with boulders washed out of the promontory of till by wave action, as mentioned by Lyell and Ramsay many years ago. At present few of these boulders are left, most of them having been used for building material or road metal, and soon all will have disappeared. Most of them were Archæan and some were of large dimensions.

At Leaside Junction there is a short bar of gravel pointing eastwards and then the wide Don bay opens toward the north with low shores of till showing little wave action. It seems that this bay was never very deep, for the ravines of the Don and its tributaries cut below its plain show very little stratified material, but thick sections of till. The eastern end of the Don bay comes within a quarter of a mile of Lake Ontario, where the Kingston road climbs Scarboro' Heights; and from here gravel ridges extend with an outward curve for three miles to the northwest, well shown at York Station on the Grand Trunk railway. There are two main ridges with hollows between, ancient lagoons; and the greatest width of the gravel beds is about a mile, the towns of York and Norway being on the old island. In form this group of ridges much resembles Toronto Island in Lake Ontario, and the mode of formation was doubtless the same, gravel and sand being drifted westwards along shore from the Scarboro' cliffs. The map shows that the outlet of the Don, like that of the Humber, has been crowded to the western side of its bay by the growth of the gravel bar in that direction.

Beyond the Don bay the shore becomes more marked, until at the highest point the old cliff is cut off by the undermining action of Lake Ontario, which has formed here the highest cliff on its whole circumference, with an elevation of 350 feet above the water. The Iroquois terrace once more shows itself half a mile beyond with a fine shore cliff, at one point 170 feet high. From this toward the northeast the Iroquois beach deserts the shore of Lake Ontario, and is sometimes hard to follow owing to the wooded ravines of Highland Creek and its tributaries. At the crossing of the river Rouge however, it is distinctly shown; but has not been traced in detail beyond this, although its

elevation and general direction have been determined at a number of points toward the east by Dr. Spencer.

From the sketch just given of the Iroquois beach within York county it is evident that the old shore is a quite mature one, almost as much so as the present shore of Ontario, and probably implies as long a time for its formation.

The beach deposits vary greatly in thickness and character, according to the circumstances of the shore. The greatest thickness observed is about 100 feet, just west of the Hunt Club at Scarboro', where the materials are coarse and fine sand with a little gravel; but thicknesses of fifty or more feet are not uncommon. The two bays described above were almost completely filled with sand and silt behind the gravel bars, so that now they present the appearance of plains greatly dissected by the ravines of the present watercourses. That large quantities of materials were deposited at other points on the shore of Lake Iroquois is proved by the stratified gravels of this age at Burlington and on the Niagara river.

FOSSILS OF THE IROQUOIS BEACH DEPOSITS.

In general the Iroquois beach is very barren of fossils as might be expected where loose sand and gravel uncovered by an impervious layer of clay are exposed to the weather for thousands of years. It is only at comparatively low levels, or where the gravel has been cemented by lime that fossils are likely to be preserved. The earliest finds recorded are those mentioned in 1843 by Hall in New York State, where wood and, as he was informed, shells also were found in gravel ridges of this age.* The Geology of Canada states that the shells were unios. The cutting of the Desjardins canal at Burlington Heights, where the Iroquois beach deposits, chiefly coarsely stratified gravel, partly cemented by carbonate of lime, have a thickness of 107 feet with Erie clay beneath, disclosed a number of bones of mammals, including *Euelephas jacksoni* (the mammoth), horns of *cervus canadensis* (wapiti) and the jaw of *castor fiber* (beaver). The mammoth bones occurred seventy feet above the present lake and the other remains seven feet higher;† or from thirty to forty feet below the level of Iroquois beach.

A few years ago the Toronto, Hamilton and Buffalo railway made a deep cutting on Hunter street, Hamilton, in order to obtain convenient access to the centre of the city. This cutting has since been covered over and is called the Hunter street tunnel. When examined by the writer the cutting passed through thirty feet of coarse stratified gravel,

* Loc. cit.

† Geology of Canada, 1863, p. 914.

often cross-bedded, sometimes containing boulders two feet in diameter, the equivalent of the Iroquois beach gravels at the Desjardins canal a mile or two northeast. Below this there were two feet of brown unstratified clay followed by eight feet of blue till containing few stones. Considerable quantities of rather decayed wood occurred in the brown layer, probably an old soil, the upper weathered portion of the blue till beneath; and specimens kindly examined by Professor Penhallow were determined as *Larix Americana* and a *Picea*, probably *nigra*. The workmen in the cutting found a number of bones, so far as could be ascertained, in the same layer of brown clay; and it was stated that shells were obtained in the clay a little distance off.

That indefatigable collector, Col. Grant, writes that several partly decayed bones of an elephant were found buried in the blue Erie clay at the base of the cutting, some of them being now in the museum at Hamilton, others apparently carried off by onlookers. He states also that some well preserved timber, recognized as belonging to trees still living in the vicinity, was found in the clay. "The shoulder blade of a moose or large deer was obtained from a sandy beach bed about a yard or so above the clay according to the workmen. I got a decayed rib of an elephant in a Slabtown gravel pit previously. Some years ago I paid a visit to the old gentleman who had the contract for the Desjardins canal excavation. He mentioned that horns, etc., of a buffalo or bison were carried away by a bystander in addition to the animal remains secured by Sir W. Logan for the Survey." From Col. Grant's account it is somewhat doubtful if the elephant remains from the Hunter street tunnel came from Iroquois beach deposits or from an old land surface of pre-Iroquois age. The wood obtained by myself appears to be older than the Iroquois beach deposits.

In regard to the shells reported to have been found in this cutting, it may be said that they turn out to be Silurian brachiopods from boulders contained in the till below the old lake gravels.

A description of the Hunter street section is given by Mr. A. E. Walker in the Journal of the Hamilton Association, in which he states that he obtained the lower jaw of some carnivorous animal, probably from the sand overlying the till,* and also partly carbonized wood. While the Hamilton fossils appear to be of an age greater than the base of the Iroquois beach gravels, and those from the Desjardins canal occur somewhat high up in them, most of the fossils found near Toronto occur comparatively near the surface.

Fossils have been reported from four localities near Toronto, the

* Jour. and Proc., Ham. Assoc., 1895-96, p. 150.

Carlton gravel spit, Reservoir park, the sandy plain east of the Don, and the gravel deposit at York; and there are a few other localities in which fossils occur which may prove to be of Iroquois age, but are not certainly so. The only fossil recorded from the gravel pits at York is a mammoth's tooth. The dune-like sand plain east of the Don between the end of the York gravel spit and Gerrard street east, which stands a little below the level of the Iroquois beach, but forms a part of the same gentle lakeward slope, has yielded to Dr. Wm. Brodie, of Toronto, the following shells: "*Succinea avara* (?) or near this species, *Planorbis complanatus*, *Limnea palustris* (doubtful—very much broken, but no doubt a limnea), *Unio complanatus* (?) (complanatus doubtful, but certainly a unio)." The shells, which were found in street cuttings, are bleached and fragile. There is of course a possibility that these shellfish lived in some pond later than the Iroquois stage, though there is no direct evidence to show that they were not really inhabitants of Lake Iroquois.

During the past two years a gravel pit opened just east of the Canadian Pacific viaduct at Reservoir park in Toronto, has disclosed a deposit of cross-bedded sands and gravels occupying the position of the Iroquois beach and having a distinct shore cliff of till twenty-five feet high just to the north. Two openings have been made, one just north of the railway and the other just to the south. The latter is the deepest and in it a considerable number of fresh water shells have been found, *Campeloma decisa* being much the commonest and best preserved; though pleuroceras, probably of more than one species, sphaeriums and badly worn pieces of unios occur also. It was at first thought that these gravel beds were interglacial, but the thin clay which in places overlies them has evidently slipped down from the adjoining low cliff of till, and the whole appearance of the deposit corresponds to that of the Carlton or York gravels, their upper surface occupying the right level for the Iroquois beach at that point, if below water and not raised as a bar, viz., 170 feet, five feet above the railway. The Don inter-glacial beds, half a mile away to the southeast, are about 100 feet lower down and contain a different set of fossils, campeloma being very rare, and unios very common. It has been suggested by Dr. George Dawson that the shells may have come from a stream flowing into the Iroquois water and simply have been buried on the shore with other materials washed down. The sharp clay bank rising in the rear and reaching a height of seventy feet a quarter of a mile to the east shows no sign of a stream bed, though the ravine crossed by the railway viaduct just to the west has possibly removed evidence of the sort that may have existed. Without direct proof to the contrary, however, the probabilities are strongly opposed to the supposition that these shells found from ten to

fifteen feet below the surface of the shore gravels did not inhabit the body of water in which the beds were laid down.

The Carlton sand and gravel spit has long been known to contain deer horns, though so far as I am aware they were never mentioned in print before 1884, when Samuel Thompson wrote as follows:—"While speaking of the Carlton gravel ridge, it is worth while to note that, in taking gravel from its southern face, at a depth of twenty feet, I found an Indian flint arrowhead; also a stone implement similar to what is called by painters a muller, used for grinding paint. Several massive bones, and the horns of some large species of deer, were also found in the same gravel pit, and carried or given away by the workmen. The two articles first named are still in my possession. Being at the very bottom of the gravel deposit, they must have lain there when no such beach existed, or ever since the Oak Ridges ceased to be an ocean bed." * Mr. Bain of the Toronto Public Library was good enough to call my attention to the passage just quoted. Mr. Thompson is dead, and enquiries as to the arrowhead and muller referred to have been fruitless. It is possible that the Indian remains reached their position through burial, or were covered by a land slip, though there is no proof of this. The finding of a hearth of stones with ashes and charred sticks on the Iroquois beach in New York State gives support to Mr. Thompson's evidence of man's presence in Iroquois times.†

Last summer several horns were found in a gravel pit on the north side of the same spit at a depth of from twelve to twenty feet below the surface, the best preserved, just above a layer of clay, perhaps at the base of the gravel deposit. They are horns of caribou or reindeer, and are so fragile that unless handled very carefully they fall to pieces. The specimens which have reached me have been treated with glue by Mr. Archibald Pride of the Biological museum and are preserved in fair condition. Mr. Pride reports that the large horn first found is a "shed horn of a reindeer, apparently young, from the right side, slender and delicate in form, about three feet three inches in length, measured by the curve, or two feet six inches from burr to tip, making allowance for the point of the horn which is broken off." The second, "a fragment of another reindeer's shed horn found near the former but on a different level, has the same characteristics as the almost entire antler above described."

"The last horn found, upon close examination undoubtedly that of a reindeer, is a right shed horn, worn by water and sand, and probably from a fine large male. The first, or brow antler, a palmated or

* *Reminiscences of a Canadian Pioneer*, 1884, p. 286.

† 6th An. Rep. State Res. Niagara, Dr. Gilbert, p. 84.

turned up snag, is broken off; the second, also broken off, is inclined to be flat on the inside surface. The measurement of girth between the two snags is six inches. Sufficient remains of the horn to show the sweep of the beam; and the slight flattening at the attachment of the tine is characteristic." As there was some doubt of the nature of this imperfect horn, which at first was thought to be a worn wapiti horn, Mr. Pride compared it carefully with Dr. Pike's fine set of caribou horns. He found that it corresponds closely with a pair of caribou horns from an animal shot by Dr. Pike a number of years ago in Nova Scotia. The shape is much the same, and the girth of the Nova Scotia horn is $6\frac{1}{8}$ inches between the front antler and the first branch as compared with six inches in the specimen from Carlton. It is evident from Mr. Pride's work, that caribou or reindeer differing much in character of horns frequented the Carlton bar, but he thinks the horns examined are more like those of the Barren Ground than the woodland caribou. Numerous other horns and bones of deer are reported from gravel pits of the region, but apparently none have been preserved.

The man in charge of the main gravel pit states that shells occur in the gravel, but we were unable to find any, and as the gravel is loose and uncovered with clay it may be that shells formerly present have been completely crumbled or dissolved.

The only other fossiliferous deposit which will be referred to is one found quite recently while sinking a well near the Don above Taylor's first paper mill for the purpose of determining the relationships of the glacial and interglacial beds in connection with the work of the committee appointed by the British Association for the investigation of the Canadian Pleistocene. The well was started on a hill side thirty-five feet below the Iroquois level, and penetrated sand and gravel, sometimes cemented by carbonate of lime into impervious layers, for a depth of thirty-eight feet. Below the cemented layers at a depth of about seventy feet beneath the Iroquois terrace, freshwater shells occur, portions of unios, sphæriums and pleurocera having been obtained. The stratified sand rests on what appears to be a weathered surface of interglacial peaty clay, and is perhaps of Iroquois age, though the shells are found at a lower level than those obtained in Iroquois deposits at other points near Toronto.

FRESHWATER SHELLS FROM OTHER LAKE DEPOSITS.

From the instances given above, it will be seen that a considerable number of fossils are known from the Iroquois beach gravels, but many of them are horns or bones of mammals or fragments of wood, giving no hint as to the freshness or saltiness of the water. With the exception

of the unios said to have been found in beach ridges of New York State, no shellfish have been discovered except in the neighbourhood of Toronto. It is believed, however, that the Toronto finds are fairly conclusive that the water was fresh; and the evidence is strengthened by the fact that fresh water shells are found in deposits of most of the other great bodies of water that followed the retreat of the ice.

In the beaches of Lake Agassiz Warren Upham notes *Unio ellipsis* from Campbell, Minn.; and four species of shells occurring in considerable abundance near Gladstone, Manitoba, about 875 feet above the sea, *Unio luteolus*, *sphærium striatinum*, *S. sulcatum* and *Gyraulus parvus*. I have collected a unio, probably *rectus*, and two species of *sphærium* from the stratified clay of Rainy River, Ontario; deposits laid down in Lake Agassiz, according to Upham; but belonging to a separate lake, according to Tyrrell. Dr. Bell has found freshwater shells in old lake deposits north of Lake Superior; and Professor Chapman, formerly of Toronto University, names eleven species from Angus, south of Georgian Bay, in beds probably formed by Lake Warren, but possibly by Lake Algonquin. Chapman's list includes *Unio complanatus*, *Cyclas* (*Sphærium*) *similis*, *C. dubia*, *Amnicola porata*, *Valvata tricarinata*, *V. piscinalis*, *Planorbis trivolvis*, *P. campanulatus*, *P. bicarinatus*, *Limnæa palustris* and *Physa ancillaria*.* In my own collection made in the same region Dr. Dall has named eighteen species, including *Unio luteolus*, *Sphærium sulcatum*, *S. rhomboideum*, *Pisidium novaboracense*, *Valvata sincera*, *Amnicola limosa*, *Succinea avara*, *Goniobasis livescens*, *Planorbis deflectus*, *P. parvus*, *Limnæa decidiosa*, *L. elodes*, and *Polygyra monodon*, in addition to those found by Chapman. Similar shells are found at other points near Georgian Bay, and in the latter case as well as on Rainy River the shells are very widely spread and must have inhabited the waters in which the silts and sands containing them were laid down.

On the other hand there is no record of a marine shell being found in any of the old beaches of the Great Lakes region, though these are common on the St. Lawrence below Brockville, on the Ottawa to the northeast, and in raised beaches along the rivers flowing into Hudson Bay on the north. If the sea had formed our raised beaches one would expect to find marine shells in these just as we do along the rivers to the east and north.

There are a few organisms living in our great lakes identical with or closely related to marine species, and this has suggested to some writers that the Canadian lakes were once arms of the sea, *Reliktenseen* of the

* Geol. Can. p. 912.

Germans ; but when this evidence is examined it proves to have little weight. Professor Ramsay Wright has been good enough to call my attention to the discussion of the whole question by Rudolf Credner in Peterman's Mitteilungen.* According to Credner, who quotes Stimpson, S. J. Smith and A. E. Verrill, two forms apparently marine occur in Lake Superior, *Mysis relicta* and *Pontoporeia Hoyeri*; and five in Lake Michigan, the two just mentioned and three in addition, *P. filicornis*, *Trigloopsis Thompsoni* and *T. Stimpsonii*. The late Professor Alleyne Nicholson found *Pontoporeia affinis* in Lake Ontario.† The two most important genera, *Mysis* and *Pontoporeia*, are tiny crustaceans which have been found also in numerous lakes in Scandinavia, and apparently easily accustom themselves to a life in brackish or fresh water, since they occur in such waters directly connected with the sea, and into which they have migrated. They or their eggs could readily be transported by waterfowl, and in fact might have passed up the canals to the upper lakes. Credner thinks that far too wide reaching inferences have been made from the finding in freshwater lakes of a very few species generally supposed to belong to the sea ; and that the decision that a given lake is a *Reliktensee* must be reached only after obtaining clear proofs of a geological character, since the fauna alone is a very uncertain guide. There are marine forms to be found in small crater lakes high up in the mountains, such as the Alban and Nemi lakes in Italy, where there is no hint that the sea has ever been in geologically recent times.‡

The fact that many freshwater shells occur in the interglacial beds of the Toronto formation is of some importance in this connection ; since the conditions under which these shell fish lived at heights of 140 or even 220 feet above the present lake must have been similar to those of the great post-glacial lakes referred to above.§

At first glance the finding of marine fossils along the St. Lawrence, e.g., at Montreal, 550 feet above the sea, seems to imply a lowering of the northeastern part of the continent sufficiently to bring the surface of Lake Iroquois down to sea level ; but an examination of the curve illustrating the differential elevation of the Iroquois beach on a previous page shows that horizontality would be reached considerably above sea level. It is probable, however, as shown by Gilbert and Taylor, that the sea entered the basin of Lake Ontario at a later time and at a much

* Die Reliktenseen, Ergänzungsheft No. 86 and 89, 1887.

† Ibid., No. 86, p. 65.

‡ Ibid., p. 107.

§ Bull. Geol. Soc. Am., Vol. 10, p. 170, etc.

lower level than the Iroquois beach,* though up to the present no marine shells have been found on these lower beaches.

AGE AND CONDITIONS OF THE IROQUOIS BEACH DEPOSITS.

Judging from the apparent maturity of the Iroquois beach as compared with that of Lake Ontario, one may suppose that the two beaches required about equal times for their production. If this be admitted, and if it be assumed that the Iroquois beach was begun at about the time Niagara Falls commenced its work, we may conclude that the waters retired from the Iroquois level about midway between the time of the retreat of the ice from the western end of the Ontario basin and the present. As this time is variously estimated at from 5,000 to 30,000 years or somewhat more, the Iroquois beach was probably abandoned from 2,500 to 15,000 years ago. Dr Spencer in conversation has expressed a belief that the beach is 17,000 years old, and this estimate may be looked on as representing the extreme limit of its age. It is possible that a more direct estimate of the time which has elapsed since the Iroquois water was drained may be made in the future, based for instance, on the present rate of erosion of the Scarboro' shore, or on the cutting of the Don or Humber valleys, and some observations and photographs have been made to serve as a starting point for such an investigation, but results that are of value have not yet been obtained.

The climatic conditions of the time were probably more rigorous than the present, though exact data to settle the point are not available. The two trees determined by Professor Penhallow, tamarack and spruce, belong on the whole to a relatively cool region, but both extend farther south than Toronto at present. In any case they appear to belong to an earlier time than the Iroquois beach, since they underlie its gravels. The caribou and elephants of the bars near Toronto suggest a distinctly colder climate than the present though not necessarily a glacial one; but there is not much in the structure of the beach itself to point in the same direction. Large boulders that might have been rafted by shore ice or carried by bergs have nowhere been found in the Iroquois deposits near Toronto. There are however, some crumpled beds of sand lying between horizontally bedded layers, which may have resulted from the grounding of ice floes; but it is not impossible that ice floes thirty-two inches thick, such as formed on Lake Erie last winter, may produce similar effects on beds of sand or clay along the shores of our present lakes when driven by violent storms.

Though the Iroquois climate was probably distinctly colder than that

* A Short History of the Great Lakes, Frank Bursley Taylor, 1897, p. 18.

of Toronto at present, the evidence available suggests that it was by no means Arctic, probably only cold temperate, in spite of the immense glacier generally supposed to have dammed its waters near the Thousand Islands. There are some interesting problems connected with this ice dam which held the water of Lake Iroquois for at least 2,500 years at a constant level in a climate apparently not Arctic. During the whole time its front seems to have retreated not more than fifty miles in a north-northeasterly direction, since the ice must have occupied the region near Kingston until the Iroquois water was drained to a lower level. If the Iroquois beach at Toronto required 2,500 years to form, the ice must have retreated in the direction N 17° E at the rate of about one mile in fifty years. If the time allowed for its formation is 15,000 years, the glacier retreated at the rate of one mile in 300 years. How many years were required for the ice to withdraw from its most southern point to Toronto, and how many more were needed for the retreat from the point where the Iroquois water was drained to the vanishing point in Labrador?

It is, of course, very improbable that the ice withdrew in a uniform manner. The great moraine of the Oak Ridges stretching across southern Ontario represents, no doubt, a prolonged halt in the retreat and is perhaps connected with the damming of the Iroquois water, since the moraine reaches Lake Ontario at about the point where the dam must have stood. Why should the ice have halted so long in a climate which seems not to have been Arctic? The Alaskan glaciers, it is true, present somewhat similar features, but they are Piedmont glaciers with an immense range of snowy mountains behind them as a source of supply, while the waning ice sheet of Northeastern Canada rested on a comparatively level plain.

Another point that has presented itself with considerable distinctness in the study of the Iroquois beach deposits is that their formation seems to have been preceded by a considerable period of low water. Under the thirty feet of Iroquois gravel at the Hunter street tunnel in Hamilton, the boulder clay has been weathered brown for a depth of two feet, and the time of low water was long enough for large tamaracks and spruces to grow. At that time the water must have stood at least thirty-five feet lower than the Iroquois level at Hamilton.

Near Toronto there is evidence not easily set aside suggesting that the till-covered surface was eroded into valleys and cliffs before the Iroquois water occupied its basin to the full depth. At the British Association shaft near the Don, stratified sand, probably of Iroquois age, is found resting on a brown, evidently weathered, surface of inter-

glacial peaty clay, the overlying till having been removed, apparently, in this old valley, for a few hundred yards to the east blue till is seen overlying the same peaty clay at a higher level. There are other points also, one at a brickyard in the east of the city, where the peaty clay seems to have been cut into a cliff before the Iroquois sands were spread over it, and half a mile east at Price's brickyard, the same cliff of clay buried in stratified sand may be found, though not so distinctly. If this evidence be admitted, the water stood for a long time at least 100 feet below the Iroquois terrace after the laying down of the last till sheet.

It is generally held that during the last retreat of the ice the succession of high level lakes was unbroken, and that Lake Iroquois followed Lake Warren without any dry land interval. It has been shown by Gilbert that owing to differential elevation of the basin toward the northeast the water at the southwest end of Lake Iroquois at first stood lower than the later level of the beach.* Perhaps the difference at Hamilton may be sufficient to account for the weathered till thirty feet below the top of the Iroquois gravels, for Hamilton is the farthest point southwest of the line running through Rome, N.Y., representing the axis at which the water level suffered no change. Toronto is very nearly on that line, so that there would have been little or no oscillation of the Iroquois water level; nevertheless there are indications of Iroquois erosion and weathering seventy feet or more below the Iroquois beach. Before making positive statements regarding this, however, it will be well to examine all the localities likely to throw light on the subject, and up to the present only a few of them have been studied with this point in view. If the fact should be established it may be necessary to assume the withdrawal of the ice after the time of the Warren water long enough for the erosion and weathering observed, and then an advance of the glacial lobe of the upper St. Lawrence valley to the Thousand Islands, and a halt at the northeast end of Lake Iroquois sufficiently long for the formation of the beach. It would be of great value to examine the clay beds or rock underlying the Iroquois beach gravels at other points than Hamilton and Toronto, so as either to prove or disprove the existence of a low water stage between the time of Lake Warren and that of Lake Iroquois as suggested above.

This splendid old beach, so excellently preserved in both New York State and Ontario, whose bars and gravel ridges are traversed by main roads for many miles, on whose terraces towns and cities are planted, should receive more careful study than has been devoted to it of late years so as to solve the interesting problems it presents regarding the immediate past of the region.

* 6th An. Rep. State Reservation at Niagara, pp. 70 and 71.

