IMAGE EVALUATION
TEST TARGET (MT-3)

CIHM/ICMH
Microfiche
Series.

CIHM/ICMH
Collection de
microfiches.

Canadian Institute for Historical Microreproductions

Institut canadien de microreproductions historiques

1980

Technical Notes / Notes techniques

The Institute has attempted to obtain the best original copy available for filming. Physical features of this copy which may alter any of the images in the reproduction are checked below.

- ☐ Coloured covers/ Couvertures de couleur
- ☐ Coloured maps/ Cartes géographiques en couleur
- ☐ Pages discoloured, stained or foxed/ Pages décolorées, tachetées ou piquées
- ☐ Tight binding (may cause shadows or distortion along interior margin)/ Reliure serré (peut causer de l'ombre ou de la distortion le long de la marge intérieure)
- ☐ Additional comments/ Commentaires supplémentaires

L'Institut a microfilmé le meilleur exemplaire qu'il lui a été possible de se procurer. Certains défauts susceptibles de nuire à la qualité de la reproduction sont notés ci-dessous.

- ☐ Coloured pages/ Pages de couleur
- ☐ Coloured plates/ Planches en couleur
- ☐ Show through/ Transparence
- ☐ Pages damaged/ Pages endommagées

Bibliographic Notes / Notes bibliographiques

- ☐ Only edition available/ Seule édition disponible
- ☐ Bound with other material/ Relié avec d'autres documents
- ☐ Cover title missing/ Le titre de couverture manque
- ☐ Plates missing/ Des planches manquent
- ☐ Additional comments/ Commentaires supplémentaires

- ☐ Pagination incorrect/ Erreurs de pagination
- ☐ Pages missing/ Des pages manquent
- ☐ Maps missing/ Des cartes géographiques manquent

The images appearing here are the best quality possible considering the condition and legibility of the original copy and in keeping with the filming contract specifications.

The last recorded frame on each microfiche shall contain the symbol ⟶ (meaning CONTINUED"), or the symbol ▽ (meaning "END"), whichever applies.

The original copy was borrowed from, and filmed with, the kind consent of the following institution:

National Library of Canada

Maps or plates too large to be entirely included in one exposure are filmed beginning in the upper left hand corner, left to right and top to bottom, as many frames as required. The following diagrams illustrate the method:

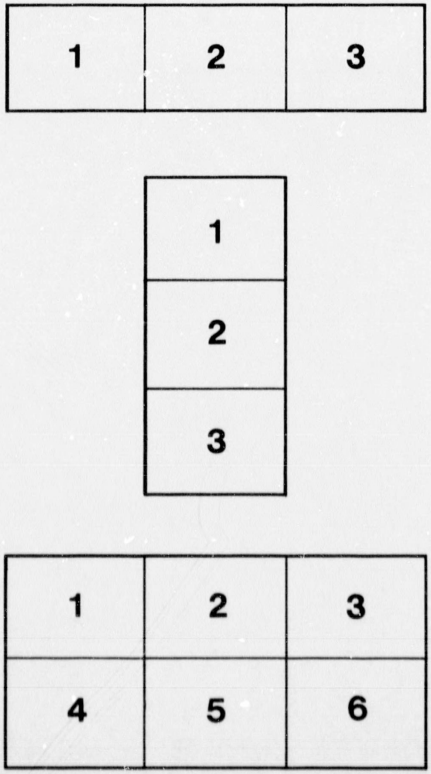
Les images suivantes ont été reproduites avec le plus grand soin, compte tenu de la condition et de la netteté de l'exemplaire filmé, et en conformité avec les conditions du contrat de filmage.

Un des symboles suivants apparaîtra sur la dernière image de chaque microfiche, selon le cas: le symbole ⟶ signifie "A SUIVRE", le symbole ▽ signifie "FIN".

L'exemplaire filmé fut reproduit grâce à la générosité de l'établissement prêteur suivant :

Bibliothèque nationale du Canada

Les cartes ou les planches trop grandes pour être reproduites en un seul cliché sont filmées à partir de l'angle supérieure gauche, de gauche à droite et de haut en bas, en prenant le nombre d'images nécessaire. Le diagramme suivant illustre la méthode :



Reprinted from THE JOURNAL OF GEOLOGY, Volume III, Number 6
September–October, 1895

GLACIAL AND INTER-GLACIAL DEPOSITS NEAR TORONTO

BY A. P. COLEMAN

CHICAGO
The University of Chicago Press

GLACIAL AND INTER-GLACIAL DEPOSITS NEAR TORONTO.

A LONG line of yellowish white cliffs to the east of the city forms a striking feature of the voyage across Lake Ontario from Niagara to Toronto; and a closer examination of the Scarboro' Heights discloses a most interesting section of the drift. At the highest point the cliffs rise more than 300 feet above the lake, and the thickness of the deposits is probably considerably greater than this, for the solid rock nowhere crops out in a distance of twenty miles. Along many parts of the Heights, which are in all nine and a half miles long, reaching from a point three and a half miles east of the River Don to the mouth of Highland Creek, the undermining action of the lake provides for a constant series of fresh exposures; and at other points the deep V-shaped valleys of small streams, afford almost as good sections. From Scarboro' westwards to Toronto also, the cuttings for railroads and streets, and the ravines of the Don and its tributaries display more or less complete sections of the drift, some of them more than 150 feet in height.

The Scarboro' Heights were an object of interest to engineers and geologists more than forty years ago as the source of the sand which, driving westwards along the lake shore, is arrested by the current of the River Don, thus forming the island which protects the harbor of Toronto;[1] but no serious geological study appears to have been made of them except by Dr. George Jennings Hinde, who published an admirable account of them in 1878.[2] The results of his observations seem little known, probably from the fact of their having been published in a journal not very widely circulated and at a time when glacial studies did not

[1] Reports on the Improvement and Preservation of Toronto Harbor, Prof. Henry Youle Hind, p. 1; Sandford Fleming, p. 15; Appendix to Canadian Journal, 1854–5.

[2] Glacial and Inter-glacial Strata of Scarboro' Heights, Can. Journ., 1878, p. 388, etc.

attract so much attention as they now do, since the rise of a body of able and ardent glacialists in America as well as the Old World.

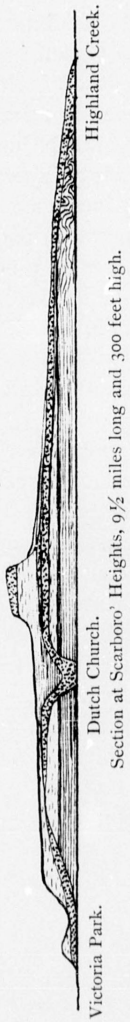
The inter-glacial beds of the Don have been described briefly by the present writer[1]; but beyond these two papers little has appeared as to the drift in this part of Ontario. It seemed so difficult to correlate the results obtained from these two localities only a few miles apart, that it was decided to connect the two by a careful study of the whole ground. This has now been carried out with tolerable completeness, and it is proposed here to give a short account of the results. In doing the work great assistance has been received from the authorities of the Grand Trunk and Canadian Pacific Railways, who provided profiles of all the lines near Toronto; from the city engineer, who provided maps; and from several specialists who have determined fossils obtained from inter-glacial beds; and I desire to express my heartiest thanks for their great kindness.

It will be well to begin with an account of the Scarboro' Heights which afford the thickest and most complete section in the region. For this my own observations, which in general accord well with those of Dr. Hinde, will be made use of chiefly.

The drift deposits show themselves first, after a long stretch of gravel beach, about three and a half miles east of the Don, as a low cliff of stratified sand and sandy clay, below which blue till appears. The first outcrop is just west of Victoria Park, and the escarpment, which is only ten or fifteen feet high at the beginning, rises rapidly, after a break caused by the valley of a stream, to one hundred and sixty or eighty feet. About three and a half miles east of the Park the cliff suddenly rises to a height of more than 300 feet, but soon drops down to its old level, after which it sinks gradually to a height of twenty or thirty feet, six miles farther east, where it is interrupted by the valley of Highland Creek.

At its best exposures the escarpment displays, beginning at the level of the lake, about ninety feet of stratified clay, followed

[1] Inter-glacial fossils from the Don Valley, Am. Geol., Feb. 1894, p. 85, etc. In this paper references are given to the literature on the subject, which is very scanty.



Section at Scarboro' Heights, 9½ miles long and 300 feet high.

by fifty feet of stratified sand, covered by a bed of till varying from forty feet to nothing in thickness. Three miles from Victoria Park this layer of till suddenly dips down to the lake, thickens to sixty or seventy feet, and rises as suddenly a quarter of a mile farther east. The hollow left on its surface is filled with stratified clay to a depth of ninety feet, and this is followed, where the escarpment is highest, a half mile farther east, by from seventy to one hundred feet of stratified clay and sand, capped by twenty or thirty feet of an upper till. About one hundred feet of stratified sand overlying the western end of the lower sheet of till, should perhaps be correlated with this, though possibly of post-glacial age. These sands thin out to nothing where the upper stratified clay shows itself. The accompanying diagram, in which the heights are exaggerated tenfold, will give a general idea of the section and make a more elaborate description unnecessary. It will be noticed that the lower bed of till dips down to the lake at each end of the section; while the upper till, forming the surface of a table land which comes out to the escarpment for a short distance only, is cut off abruptly at each end.

Examining the members of this section in ascending order, we find at its base a series of bluish-gray clays rising out of the lake. They lie perfectly horizontal, are often finely laminated with sandy partings, having sometimes twenty laminæ to an inch, but at other times forming beds several feet in thickness. Narrow bands of flat green concretions of impure carbonate of iron occur at various levels; and at others thin layers of peaty matter. Some beds of clay richer than others in plant food may be followed long distances by the eye as bands of rich, green vegetation, while other parts are bare.

The peaty matter varies from a mere film to a thickness rarely greater than half an inch, and is made up sometimes chiefly of mosses, but more commonly of fragments of bark, wood and twigs, waterworn and mingled with flakes of mica. Quite seldom one may find a larger knot or broken branch, but never trunks of any size. From these insignificant peaty layers Dr. Hinde obtained three species of diatoms, a chara, five mosses, Bryum, Fontinalis, Hypnum commutatum, H. revolvens (?) and another species of hypnum, spores of lycopodium, pieces of pine and cedar wood, portions of leaves of rush, etc., and seeds of various plants. Among animals he found two or three species of Cypris, a Planorbis and a Zonites (doubtful), as well as the elytra of beetles.[1] The insect remains were submitted to Dr. Scudder, who reports as follows:[2]

"Among the material . . . . . was a considerable number of the elytra and other parts of beetles, an assemblage, indeed larger than has ever before been found in such a deposit in any part of the world, and they are mostly in excellent condition. Twenty nine species have been obtained, some of them in considerable numbers. Five families and fifteen genera are represented; they are largely carabidæ, there being six or seven species each of Platynus and Pterostichus and species also of Patrobus, Bembidium, Loricera, and Elaphrus. The next family in importance is the Staphylinidæ, of which there are five genera, Geodromicus, Arpedium, Bledius, Oxyporus, and Lathrobium, each with a single species. The Hydrophilidæ are represented by Hydrochus and Helophorus with each one species; and the Chrysomelidæ by two species of Donacia. Finally a species of Scolytidæ must have made certain borings under the bark of juniper.

"Looking at them as a whole and noting the distribution of the species to which they seem to be most nearly related, they are plainly indigenous to the soil, but would perhaps be thought to have come from a somewhat more northern locality than that in

[1] Can. Jour. 1878, p. 399.

[2] Fossil Insects of North America, Vol. II., Tertiary, p. 40.

which they were found; not one of them can be referred to existing species, but the nearest allies of not a few of them are to be sought in the Lake Superior and Hudson Bay region, while the larger part are inhabitants of Canada and the northern United States, or the general district in which the deposit occurs. In no single instance were any special affinities found with any characteristically southern forms, though several are most nearly allied to species found there as well as in the north. A few seem to be most nearly related to Pacific forms, such as the Elaphrus and one each of the species of Platynus and Pterostichus. On the whole, the fauna has a boreal aspect, though by no means so decidedly boreal as one would anticipate under the circumstances."

It will be seen that this remarkable assemblage of insects is of great importance in coming to a conclusion as to the climate of the time when these deposits were laid down; and Dr. Scudder's wide experience in regard to the geographical range of North American insects gives special value to his views on the subject.

By washing, drying, and examining with a lens peaty matter from Scarboro' the present writer has succeeded in obtaining a large amount of additional material, consisting of wing cases and other parts of the chitinous armor of insects, all of which has been submitted to Dr. Scudder, who has very kindly consented to determine them and thus add to the data available for judging of the climate.

A considerable number of determinable parts of plants, such as leaves, seeds, mosses, etc., obtained in the same way, was sent to Dr. Macoun of Ottawa. The small collection of mosses was forwarded by him to Mrs. E. G. Britton of Columbia College, New York; and I am much indebted to both of them for the trouble they have bestowed on the determinations. Dr. Macoun gives the following list of the species determined by him in the material sent: Larix americana (?), Abies balsamea, Salix, alder, Carex aquatilis and C. utriculata, Equisetum, Oxycoccus vulgaris and vaccinium uliginosum. Of the last two he is quite certain.

Mrs. Britton determines the mosses as follows: Limnobium

palustre (?), L. montanum (?), Hypnum lycopodioides (?), H. aduncum, H. fluitans (?). Professor Penhallow of Montreal has determined two specimens of wood from Scarboro' as probably Picea nigra.

It will be noticed that the plants obtained by myself differ considerably from the list given by Dr. Hinde, perhaps because taken from different levels in the clay. Doubtless the number of species could be greatly added to by careful search.

Looking at the plants as a whole Dr. Macoun is of opinion that the climate was like that of the northern part of the Gulf of St. Lawrence or southern Labrador, cool and wet. He states that all the species are represented in the herbarium of the Geological Survey at Ottawa by specimens from the regions mentioned; and thinks that the deposit was formed in a pool surrounded by trees, such as we find in our northern woods today. Dr. Macoun's conclusions regarding the climate as determined from the plants correspond fairly well with those of Dr. Scudder; so that the question may be looked upon as settled. There are, however, no evidences of the action of ice. Dr. Hinde remarks the complete absence of pebbles or bowlders from these clay beds, a point which the present writer also has been struck with, suggesting no transport and dropping of materials by floating ice. One may infer from the uniform lamination and fineness of the clay that it was deposited in quiet water some distance from the shore. Leaves and bits of bark and mosses drifted in by the wind or brought down by a stream gradually waterlogged and sank along with the slowly settling flakes of mica and fragments of insects. It appears that forest fires raged in Ontario then as now, for fragments of charcoal or of chips charred on one edge are not infrequently found mixed with quite uncarbonized woody material. This, of course, does not necessarily imply the presence of man; for doubtless many fires have originated by natural causes, such as lightning.

Resting conformably on the clay we find about fifty feet of fine, yellowish or grayish sand, sometimes having thin layers reddened with garnets or blackened with magnetite. Very

marked transverse bedding is often observed, indicating more troubled water than during the deposit of the underlying clay. Some parts of these sands contain many nut-brown concretions of a much rounder form than those from the clay. A large number of these were broken, but only two or three contained traces of vegetable matter or portions of insects as a nucleus. Peaty matter may be found in small amounts in the sand, and at a few points fresh-water shells were found along with the concretions, Sphærium striatinum and Succinea obliqua, according to determination of Mr. C. T. Simpson. The Succineas seem almost too fresh and well preserved to be of inter-glacial age, but they are found nowhere except in the sand beds below the lower till, and the evidence of their age seems pretty conclusive.

The beds just described were deposited in water having a level at least 140 feet above that of the present Lake Ontario; and they may have been considerably thicker than we find them now, for there is clear evidence that they were greatly eroded before the overlying till was spread out. At the Dutch Church not only the sands but the stratified clays also were cut through by a stream valley, for we find the bowlder clay filling a hollow that reaches below the level of the lake. Hinde supposes that the ice of the glacier ploughed out this deep valley; but there is no reason to suppose that this portion only should have been excavated by the ice front while the same materials were left untouched on each side. The bedding of the clay is scarcely disturbed right up to the contact with the till, which would be impossible if the snout of the glacier had ploughed its way through, but is intelligible if it simply filled a preëxisting valley.

The till which follows is of the usual description, a blue calcareous clay charged with polished and striated pebbles of limestone and black Utica shale, with a few Laurentian bowlders. This bed of till is continuous from end to end of the section except at a point about one mile and a half east of Victoria Park, where probably by subsequent erosion, it is thinned out to nothing for about 300 yards. There is a deep hollow in the till at the Dutch Church, where it dips down to the lake, perhaps an

original depression of its surface, now filled with ninety feet of stratified clay, very like the lower beds, but more calcareous and apparently free from fossils and concretions.

At the point where the upper terrace comes out to the shore these stratified clays are covered conformably by a series of stratified sands with some clay beds, in all seventy feet thick. Several of these beds at different levels are remarkably crumpled and contorted, while the beds immediately above and below appear quite undisturbed. They have perhaps been folded by

Upper part of Section at Scarboro' Heights, showing two upper layers of till and the crumpled strata. After photograph by Dr. Ellis.

the grounding of ice floes, and in appearance they remind one of examples figured in *Geikie's Great Ice Age*.[1] No fossils have been obtained from these inter-glacial beds.

The upper till, which overlies the country to the north of the Scarboro' Heights, forming a gently rolling table-land, described by Professor Chamberlin in conversation as a mild form of moraine, is seen at this section to consist of yellowish-brown clay with well striated pebbles and larger stones, fragments of black Utica shales, often falling to pieces, limestones apparently of Trenton age, and archæan rocks, such as gneisses. It differs from the lower till in being somewhat more sandy, and especially in hav-

[1] P. 271–2.

ing been greatly weathered, some parts at the bottom alone showing the original blue color of the clay.

West of this highest part of the escarpment a series of rather coarse, cross-bedded, stratified sands and gravels, in which no fossils have been found, overlies the lower till, at first in a a thin layer, but rapidly thickening as the bed of till descends toward the lake near Victoria Park, where it expands to a thickness of more than one hundred feet. Hinde looks on these sands and gravels as post-glacial, but similar deposits a few miles to the west and north are covered by the upper till; and at a cutting on the Scarboro' street railway a little north of the Park crumpled strata of the kind previously referred to are well exposed, suggesting an inter-glacial age for these beds. However up to the present their position must be looked on as not positively settled.

A comparatively thin layer of coarse gravel and well-rounded stones, followed by loamy soil covers these sands and forms the surface of the Iroquois terrace.

From the description just given it will be seen that at the Scarboro' Heights there are two beds of till separated by a deposit of unfossiliferous stratified clay and sand amounting in thickness, if we add the depth of stratified clay at the Dutch Church to that of sand and clay at highest points a little farther east, of 160 feet. Below the lower till the fossiliferous sands and clays have a depth of at least 140 feet, their lower limit being covered by the lake. Dr. Hinde assumes a third till below the lower clay, nowhere exposed along the Scarboro' escarpment, but cropping twelve miles to the west at Humber Bay, where till overlies the Hudson River shales, and is covered by stratified clay not unlike that at Scarboro'. The Humber clays, so far as I have observed, do not contain peaty matter nor the plate-like concretions of clay-iron stone; however, they are so far separated that the conditions under which they were deposited may have differed greatly from those at Scarboro'.

Whether the underlying till be found or not, there is every reason to think the lower Scarboro' sands and clays inter-glacial; for they contain a series of minerals including garnet, magnetite,

hornblende and biotite, thoroughly characteristic of Laurentian rocks and not found in the adjacent Hudson River or Utica shales. The transport of these materials for a distance of not less than seventy miles is best accounted for by glacier ice.

The extent of these deposits has not yet been worked out in detail, though the lower stratified clay was apparently widespread. Twenty feet of clay very like it, containing thin layers of peaty matter, may be seen on the shore of Lake Ontario four miles to the east of Highland Creek, here also covered by a bed of till. Exactly similar clay occurs about four miles to the northwest of Victoria Park in the brickyards of Messrs. Price and Logan. The exposures are excellent, one presenting a face of sixty feet; and the top of the clay, which rises about one hundred feet above Lake Ontario, is covered with a few feet of stratified sand. One finds the greenish plate-like concretions, and peaty matter containing mosses, pieces of bark and wood, elytra of beetles, flakes of mica, etc., just as at Scarboro'. The layer of till is wanting at these brickyards, but is found a few hundred yards farther north near the corner of Danforth avenue and Greenwood lane.

If we include the Humber clay in the series, this lacustrine deposit has a length of twenty two miles, by a breadth of at least one and one half miles. Omitting the Humber beds, it has been traced for about sixteen miles.

The upper, unfossiliferous clay from the Dutch Church seems also very widely distributed. It may be found as suggested by Dr. Hinde, in the north of Toronto (formerly Yorkville), where it is used to make gray brick. It seems to occur also at the Don Valley brickworks, and other points along the Don ravines. Similar stratified unfossiliferous clays making white or buff or gray brick occur at various points a few miles to the north and west of Toronto; and beds very like them underlying an upper till are well exposed on the lake shore between Newcastle and Newtonville, more than forty miles to the east. The upper unfossiliferous clays appear then to be even more widely spread than the lower peaty clays, though one can hardly make sure

that the deposits at all the localities mentioned were laid down in the same body of water and at exactly the same time.

The inter-glacial deposits on the Don, best shown at the brickworks owned by the Messrs. Taylor, were described a year ago,[1] but will be referred to again, giving the results of a careful reinvestigation under better conditions.

When it was examined in the preparation of the paper referred to, the quarry consisted of two parts, a lower one showing about forty feet of drift, including nearly three feet of till resting on Hudson River shale, twenty-five feet of stratified sand with one or two clay beds, and, above this, ten feet of stratified clay making red brick. A slope of grass extended from this part of the quarry for about one hundred yards to the upper portion, where about forty feet of stratified clay making buff brick were to be seen, the top of the exposure reaching almost to the level of the plain formed by the Iroquois beach of Spencer. The part covered with grass was stated by the men at work in the quarry to consist of the same clay as that worked for buff brick, and was included with the upper stratified clay in the section given. About a third of a mile northwest of the quarry the Davenport Ridge, a morainic tract of gently rolling highland, composed of somewhat sandy till containing bowlders and striated stones, comes to a sudden stop and forms a cliff fifty to seventy feet high at the Iroquois beach. That the Davenport till stretched much farther south before the Iroquois water had encroached upon it is clear, not alone from the steep cliff but from the immense bowlders scattered over the terrace, evidently left behind when the finer materials were washed away by wave action. Such bowlders lay on the surface just above the quarry, until removed a year ago. The fact that the upper stratified clay of the quarry may be traced here and there up the ravine to the north, until, about half a mile above the brickyard, it underlies the till of the Davenport ridge, confirms the conclusion.

The Davenport ridge is a continuation of the mild moraine

[1] Inter-glacial fossils from the Don Valley, Am. Geol. Vol. XIII., February 1894, p. 85–95.

forming the upper plateau at Scarboro', the two being separated only by the deep bay-like depression of the Don Valley; and it seemed to me probable, last year, that the layer of till overlying the shale at the brickyard was a continuation of the lower Scarboro' till, which sinks beneath Lake Ontario near Victoria Park three or four miles to the east. This implied that the fossiliferous beds at the Don, with the overlying stratified clay in which no fossils occur, were equivalent to the upper, unfossiliferous beds at Scarboro'. This spring, however, new excavations at the brickyard have completely overturned this theory by disclosing a thick bed of till in the slope formerly covered with grass. This overlies the fossil-bearing strata which correspond, therefore, to to the lower, fossiliferous bed at Scarboro', so far as position is concerned.

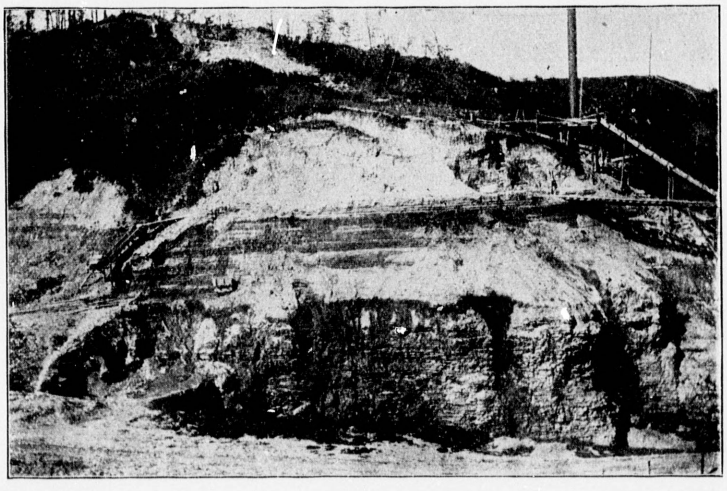
At present the quarry presents the following section as measured by aneroid and steel tape:

	Feet.
Soil and stratified clay, making buff brick (unfossiliferous)	43
Till (partly covered with grass) about	35
Stratified clay with peaty matter, making red brick	13
Stratified sand with some clayey beds (fossiliferous)	24
Till	2
Hudson River shales, about	60

The Hudson River shales rise about thirty-five feet above the level of Lake Ontario. At the Don Valley brickworks we have, then, a lowest till resting on the rock and overlaid with fossiliferous beds; a second till corresponding to the lower Scarboro' till; but no uppermost till, though one probably existed before the formation of the Iroquois beach, and the upper stratified clay passes beneath the upper till at the Davenport ridge a half-mile away. So far as I have observed the three tills are nowhere all disclosed in a single section; but a shaft sunk through the Davenport ridge or the highest part of the Scarboro' Heights would probably cut through all three.

Since the paper on the Don fossils was published three new localities have been found in the same valley; one of them, which was opened to give employment to the convicts at the gaol

near by, proving especially interesting; since thin layers of matted deciduous leaves occur in it. One of these localities is at the shore of a pond a mile above the brickyard, so that the fossil-bearing sands and clays have been shown to extend for three miles along the valley of the Don. Judging by the position of these beds with reference to the lake, the stream in which they were formed had a much more rapid fall than the present sluggish river. The lowest fossil bed in the upper part of the valley



Quarry at Taylor's brickyard, Don Valley, Toronto. The section shows the Hudson River shale; the lowest till resting on it (dark); the fossiliferous stratified sand and clay; the middle till just beneath the grass at the staging; and the upper stratified unfossiliferous clay in the much foreshortened upper quarry. The photograph is by Dr. Ellis, of the School of Practical Science, Toronto.

is about forty feet above the lake; at the Convict Cutting ten or fifteen feet; while at the cutting for the Don improvements, near the mouth of the present river, fossils were found several feet below the level of Ontario.

The localities most productive in fossils are the brickyard and the Convict Cutting, and a brief description of them may be of

interest. At the brickyard unios, retaining their dark epidermis and having the valves united, are often found embedded in a few inches of blue clay immediately overlying the till. The sands above this contain more or less waterworn unios, pleuroceras, sphæriums, etc., while the overlying stratified clay beneath the middle till holds a little peaty matter, but nothing well enough preserved to be determinable.

At the Convict Cutting, too, the unio bed is disclosed, but some stratified, sandy clay beds in the upper part of the section have proved much more interesting, that patient collector, Mr. Townsend, having obtained from them a large number of leaves, among which he thinks are leaves of the oak, beech and willow. It is very difficult to preserve these leaf fragments, since the clay dries up and the brown traces of the outline and veining shrivel up and become almost unrecognizable.

Up to the present the unios have proved the most important finds along the Don. They include the Unio phaseolus, U. clavus, U. pustulosus, U. pustulosus, var. schoolcrafti, U. occidens (?), U. luteolus, U. undulatus, U. rectus, U. trigonus, and U. solidus. The other shells obtained are Sphærium striatinum, Pleurocera subulare, P. elevatum, an undetermined species of the same genus and a single specimen which may be P. pallidum, Physa ancillaria and Amnicola limosa. I am indebted to Dr. Dall and his assistant, Mr. C. T. Simpson, for the determination of the above species, all of which occur at the brickyards and several of them at the other points. A few other fossils, including one or two species of ostracods, a number of elytra of beetles and one or two teeth, the latter found by Mr. Townsend, have been obtained at the Convict Cutting with the leaves, but have not yet been determined.

The plants include fragments of tree trunks, leaves, a very few mosses and chara. The specimens of wood have been determined by Professor Penhallow of McGill to be Fraxinus quadrangulata, Quercus obtusiloba, Ulmus americana, Maclura aurantiaca and Picea sitchensis (?). Some leaves sent from the Convict Cutting he considers to be of willows and poplars. Pro-

fessor Penhallow had previously found in material sent by Mr. Townsend from the Don Improvements, Asimina triloba, Ulmus racemosa, Taxus baccata and a new maple leaf, which was named Acer pleistocenicum.[1] In respect to the woods, Professor Penhallow says that they are usually badly decayed, but that he has referred them to the nearest living species.

If we compare the inter-glacial fossils of the Don with those of Scarboro' we find them surprisingly different. Up to the present only one species of animal, Sphærium striatinum, a form having a wide range, has been shown to be common to both localities. It will be of great interest to learn if Dr. Scudder finds insects from the Convict Cutting the same as those from Scarboro' or not. No two trees are undoubtedly alike, though Picea nigra of Scarboro' is not far removed from Picea sitchensis of the Don; and willow leaves of undetermined species have been found in both places.

It will be remembered that both the insects and plant remains of Scarboro', in the opinion of such good authorities as Dr. Scudder and Dr. Macoun, point to a cool climate like that of Lake Superior or Labrador; while the Don fossils, on the other hand, point equally conclusively to a climate as warm as that of Toronto at present, if not considerably warmer. The numerous unios, some of them no longer found in our lakes, though common farther south in the Mississippi drainage system;[2] the forest trees including three species (Asimiana triloba, the osage orange and Fraxinus quadrangulata) now belonging to the portions of Ontario along Lake Erie and the states to the south,[3] hint at a climate very far from glacial, probably comparable to that of Ohio at present.

There seems no doubt also that both of these deposits are inter-glacial and included between the same sheets of till; though the lowest till is out of sight below the lake at Scarboro'. These two series of beds can hardly have been formed contempora-

[1] Bull. Geol. Soc. Am., Vol. I., p. 328.

[2] C. T. SIMPSON, Proceedings U. S. National Mus. Vol. XVI., pp. 591–5.

[3] DR. MACOUN, Forests of Canada, Trans. Royal Soc. Can., Sec. IV., 1894, p. 11.

neously; one must have preceded the other; but which came first is not easy to decide.

One might assume that the Scarboro' clays were formed first, a cold climate continuing for a long period of time after the departure of the earliest ice sheet; that the water was drained off or the land elevated afterwards, and the Don of those days excavated its comparatively wide and deep valley apparently not greatly different from the present one. Meantime the climate had become warm, and southern forms of life pushed their way northward and occupied the river and its shores until the second advance of ice destroyed them. This hypothesis seems to agree with many of the facts, particularly if Dr. Hinde is correct in his belief that the stratified clay resting on till near the mouth of the Humber is a continuation of the fossiliferous Scarboro' beds. The quite similar clays at Price's brickyard would then be a remnant of a wide sheet of such lacustrine deposits afterward eroded by the Don. There is an appearance of interbedding of a thin layer of the peaty clay at the Taylors' brickyard with the bowlder-clay above; while the upper fossiliferous beds at Scarboro' were much eroded before this sheet of till was laid down, facts which perhaps point in the same direction. If this hypothesis be correct the Don beds, being much later than those of Scarboro', may somewhere be found resting unconformably on their eroded surface. Up to the present, however, no such section has been observed.

On the other hand one might suppose that the Don beds are the older; that after the till was laid down there was a sudden change of climate, and that southern forms of life quickly followed up the retreat of the ice-sheet as it vanished under the action of warm sun and winds. The fact that Mississippi unios lived and died right on the unweathered surface of the blue till at the brickyard fits best with this assumption. If there had been a long period of erosion before they arrived, one would expect to find the till weathered brown and its enclosed pebbles of shale crumbled to pieces, instead of being fresh and sharply striated. Taking this view, the layer of peaty clay just beneath the middle

till at the Don is the equivalent of the ninety or more feet of peaty clay at Price's brickyard and Scarboro'; and one might expect to find the unio bed, or its equivalent as to climate, beneath the level of the lake at Scarboro'. It should, however, be observed that up to the present no species has been shown to be common to the peaty beds of the Don and those of Scarboro', except one ubiquitous shellfish. It may be that future excavations will settle which hypothesis is correct; if, indeed, some entirely different interpretation may not be put upon the facts described.

Two very interesting articles have appeared recently, one by Professor Chamberlin in the JOURNAL OF GEOLOGY, the other by Mr. Warren Upham in the *American Geologist*, referring to the succession of glacial deposits in America, and mentioning the Toronto inter-glacial beds in that connection. Professor Chamberlin gives the "Toronto Formation" tentatively an independent position as the possible equivalent of Geikie's Neudeckian,[1] and places it in the interval between the Iowan and Wisconsin sheets of till. Mr. Upham places the Toronto inter-glacial beds in a somewhat similar position, but looks upon them as only in a limited sense inter-glacial, "since they lie between deposits of glacial drift; but they seem better referred to moderate oscillations of the ice boundary during its general retreat after the Iowan stage, that is, to a time during the Wisconsin or moraine-forming stage rather than to distinct glacial epochs."[2] He supports this view by a statement as to thinning out of the beds of till between Scarboro' and Toronto, suggesting the nearness of the ice border; and finds the deposits "quite inexplicable on the hypothesis that these till formations record great readvances of the ice, as either to the Iowan stage or to the Wisconsin moraines."[3]

In regard to the thickness of the sheets of till it may be mentioned that they vary greatly in this respect within short

[1] JOURNAL OF GEOLOGY, Vol. III., No. 3, pp. 273–275.

[2] Am. Geol., Vol. XV., No. 5, p. 289, etc.

[3] Ibid., p. 290.

distances both at Scarboro' and along the Don, but by no means always in the sense of thinning out towards the west. For instance, the middle till, the lowest visible at Scarboro', is there generally less than thirty feet thick and for a mile or more scarcely averages five feet in thickness; but at the Dutch Church, where the subglacial débris has been crowded into a deep valley, it reaches a maximum of seventy feet. The same bed of till at the Don brickworks is thirty-five feet thick, and a little farther south, between the Winchester street bridge and Danforth avenue, is apparently ninety feet thick.

The upper till at Scarboro', so far as I have measured it, runs from twenty to thirty feet in thickness; but at Moore Park Station, less than a mile north of Taylor's brickyard it is forty-five feet thick, and at York Mills, three or four miles northwest, is nearly sixty feet in thickness.

In reality the difference in thickness of the drift at Scarboro' and the Don is due rather to the greater or less development of the inter-glacial beds than to the thickness of the till.

If these inter-glacial deposits were formed during slight oscillation of the ice margin, one would suppose that drifting ice floes or even bergs would have been active on the waters of the time, transporting bowlders and other materials, which should be imbedded in the clays and sands of the lake bottom; but neither Dr. Hinde nor the present writer has been able to find stones of any kind in the 140 feet of fossiliferous beds at Scarboro'.

The case of the Alaskan glaciers cited in the article mentioned[1] is in reality not at all analogous to the conditions prevailing at Toronto during the earlier inter-glacial time. In Alaska the Japan current brings comparatively warm moist air right up to latitude 60°; while the highest mountains in North America rise a few miles inland, their icy flanks intercepting the moisture-laden winds from the Pacific and causing a tremendous snowfall in a region where the snowline is only 2000 feet above sea level. If Mt. Fairweather, Mt. St. Elias and Mt. Logan were leveled,

[1] Ibid., p. 278.

how long would the Malaspina and other Alaskan glaciers hold their ground?

At Toronto during one part of this inter-glacial time we had a climate, judging by the flora and fauna, far milder and drier than that of Alaska; and, nothing that can be called a mountain rises between this and Hudson Bay. The inter-glacial time was long enough not only to allow of the deposit of the thick beds of sand and clay that have been described, but to allow the great body of water in which they were formed to be drained to a depth of one hundred and fifty feet, and the new land surface to be deeply eroded. At the Dutch Church, for instance, a valley was dug a mile in width from edge to edge and a quarter of a mile wide at the lowest level exposed by Lake Ontario.[1] All of this must have demanded time and plenty of it. Can any one believe that meantime, while elms and oaks and maples, not to mention the papaw, were growing along the Don, the ice-field, with no lofty slopes to supply gathering ground for névé, was lurking a few miles off, ready to advance and overwhelm the deciduous forests?

It has been pointed out in a previous paper that Toronto lies not more than 500 miles from Hudson Bay or 700 from the center of Labrador, with no mountains intervening.[2] There seems no more reason to assume that a great ice-field existed within those distances while the Don fossils were being buried than there is to assume it at the present day. As a whole, then, the evidence at Toronto seems to support strongly the theory of Geikie, Chamberlin and others as to the distinct ice ages separated by mild inter-glacial times.

The unfossiliferous clays and sands lying between the middle and upper sheets of till and having a thickness of at least one hundred and sixty feet at Scarboro', and of forty at Toronto, indicate a second recession of the ice. The absence of fossils, the presence, though rarely of angular striated pebbles in the clay, and the corrugated and crumpled beds here and there found among the upper sandy layers suggest a cold, perhaps

[1] See Section of Scarboro' Heights.

[2] Am. Geol., Vol. XIII., p. 92.

Arctic climate, implying perhaps only a long recession of the ice, not its complete removal. The upper part, consisting of cross-bedded sand and clayey sand, seems quite widespread, for similar beds lying between the rolling surface of till and a lower sheet of till have been found on a branch of the Don seven miles north of the city, at Pickering twenty miles northeast, and on the lake shore near Newcastle forty miles to the east. It may be that fossils giving a hint as to the climate in this inter-glacial period will be found at some time. The tooth of a mammoth was found last summer on the Don eight miles north of the city at a point where the stream flows over the middle till and cuts away banks showing stratified sand and in some cases the uppe till also, but the fossil may be post-glacial rather than inter-glacia in age. The same holds of two mastodon teeth found several years ago, one on the Don, the other in a sand pit two or three miles east of the city.

If Professor Chamberlin is correct in assigning the fossiliferous beds of Toronto and Scarboro' to the interval between the Iowan and Wisconsin ice ages;[1] then the upper stratified beds imply a still later ice age, separated probably by a shorter and less genial inter-glacial time than the former one. It is however possible, as suggested by Professor Chamberlin, for the beetle-bearing beds of Scarboro' in case they should prove to belong to a lower horizon than the Don beds, that the fossiliferous beds near Toronto are of Aftonian age, *i. e.*, belong between the Kansan and Iowan sheets of till; and that the upper beds represent the interval between the Iowan and Wisconsin ice sheets. The former supposition seems to me the more probable, since there is some likelihood that the mild morainic sheet forming the Davenport ridge and upper Scarboro' Heights runs out in the neighborhood of Toronto, and hence cannot be continuous with the Wisconsin sheet to the southwest. Until the till sheet lying to the north and east of Toronto has its western boundaries traced this point cannot be settled.

A long halt in the retreat of the last glacier, if not a recru-

[1] JOURNAL GEOLOGY, Vol. III., No. 3, p. 273, etc.

descence of glacial conditions after another interval, is indicated by the great morainic loops stretching from Trenton westwards to Lake Huron and passing (as the Oak ridges) about eighteen miles north of Toronto.

The post-glacial history of the region near Toronto has not yet been satisfactorily worked out, though one episode, that of the Iroquois water as described by Dr. Spencer, has left its mark very distinctly in the old beach to the north of the city, and must have had considerable importance as regards the formation of surface deposits.

Much of the somewhat loess-like fine clayey sands of the Humber valley may turn out to be post-glacial; and Dr. Hinde supposes that the upper hundred feet of sand and gravel at the west end of the Scarboro' cliffs are of the same age; but my own observations incline towards an inter-glacial position for these thick and widespread but greatly eroded deposits. Similar sands occurring at York Mills and other points north of the city are undoubtedly covered by the upper till, which may simply have been removed from the more southern parts near the lake. Unprotected by a layer of till these sands are easily attacked by wind and water and superficially rearranged, so that their original structure and relationship becomes obscured.

Of course the Don and Humber with their tributaries have formed in the lower sluggish parts of their courses alluvial deposits of clay and sand that are evidently modern, and in some instances are added to by every spring flood.

The succession of events since Pliocene times in the vicinity of Toronto may now be reviewed in order to bring to a focus the results of the observations described in this paper.

No Pliocene deposits have been found in this region, supposing the earliest advance of the ice to indicate the end of the Pliocene; but the lowest till forms a carpet over the eroded surface of the Hudson River shales. At the time the earliest glacier advanced the Scarboro' region formed a valley whose hollow is now below the surface of Lake Ontario, and there were low hills where the Don and Humber valleys now exist, the

highest observed level of the shale being about eighty feet above the lake at Lambton Mills on the Humber.

The retreat of the ice was followed by a rise in the water of the lake to a level at least 150 feet above the present lake, depositing that depth of clay and sand upon the unweathered till. The Scarboro' water, as it may perhaps be called, was then drained off to a point below the present lake level, and at some points erosion took place to a corresponding depth. It is possible that the climate became warmer during this period of erosion and that the Don beds were deposited afterwards.

At the time of the second glacial period the topography of the region had greatly changed. The Scarboro' Heights already had an elevation of 150 feet, while valleys reaching the present lake level had been cut by Highland Creek and the Don, as well as by the Dutch Church stream, which now has no equivalent. The retreat of the second ice-sheet was followed by a rise of the water to a height of 280 feet above the present lake, the water being cold and lifeless, and bearing ice floes.

Once more the lake was drained, at least partially, and erosion went on, for the upper till is found at a sand pit near the corner of Bloor and Christie streets in Toronto at a level of about 120 feet above the present lake. Either the period of dry land was short, giving no time for the cutting of deep valleys, or the level of the lake of those days was considerably above the present Lake Ontario. The contour of the land at the end of this inter-glacial period is more difficult to settle than in the former one; but it is tolerably certain that the Scarboro' Heights had almost their present height, and that the Don valley was much shallower than at present, if it existed at all.

The retreat of the third ice-sheet was followed as before by a rise of water, Lake Iroquois reaching 160 feet above the present lake to the north of Toronto, and about 190 at Scarboro'. After the draining of Lake Iroquois it is probable that the surface of the country presented much the same rolling swells of till as are now found north and east of Toronto; fo , in general, erosion has gone on to a moderate degree only, except where the more

powerful streams have cut out picturesque ravines, such as are seen along the Don and Humber.

It is probable that at the end of the first inter-glacial period the topography had almost as old an aspect as at present, indicating as long a time for erosion as has elapsed since the last ice age; but the dry land stage during the second inter-glacial period was apparently much shorter. The length of time during which high water lasted during the two mild periods must have been very great to allow the immense sedimentary beds to be deposited at Scarboro' and elsewhere, 150 feet thick in the earlier period and 160 in the later. The Iroquois high water stage after the last ice age was probably much shorter, since it has left much smaller sedimentary deposits.

It is a notable fact that each ice-sheet advanced apparently during a time of low water, and was followed by a stage of high water; whether this is to be accounted for by assuming an ice dam at the foot of the predecessors of Lake Ontario, or a change in the level of the land surface caused by the loading and unloading of its ice burden, it is very unlikely that the sea has extended inland so far as Toronto since glacial times. The numerous marine animals found as fossils lower down on the St. Lawrence and Ottawa would hardly have stopped short without reaching the Iroquois bay, if that had been a body of salt water, in communication with the Gulf of St. Lawrence.[1] However, no fresh water forms have been found on its beach, so that the evidence is only negative.

The Scarboro' beds give very instructive evidence as to the comparatively slight erosive power of glaciers. Except near the east end of the section, where, as suggested to me some time ago by Mr. J. B. Tyrrell, the ice front began to rise upon the higher ground during the second advance and crumpled and contorted the clay beds, there is no very striking disturbance even of the stratified sand, though here and there portions of the sand

[1] Two marine shells have been picked up on the Iroquois beach, but, as suggested by Dr. Dall, to whom they were submitted, they have almost certainly reached that position by human agency.

are tilted out of place. The upper layer of till rests in some places on crumpled beds of sand, but more often one sees little trace of disturbance. One might almost describe the till as a lubricant allowing the ice-sheet to glide easily over the inequalities of the surface.

A. P. COLEMAN.