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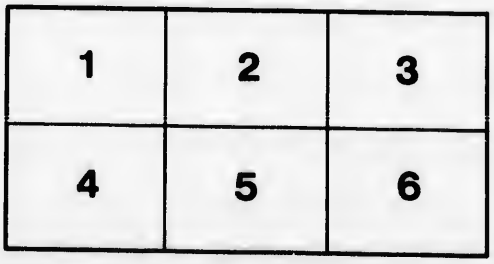

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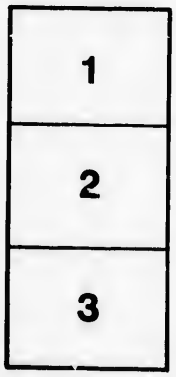

SUPERFICIAL GEOLOGY

OF

DUNDAS VALLEY AND WESTERN ANCASTER.

Read before the Hamilton Association on May 11th, 1882, by Wm. Kennedy.

In 1879, Mr. J. F. CARLL, of the second Geological Survey of Pennsylvania, presented a report on the pre-glacial and post-glacial drainage of the Lake Erie country, in which it was shown, that a great number of the streams of the northern part of Pennsylvania. in pre-glacial times, flowed into Lake Erie.*

The great difficulty with Mr. Carll's deductions, was the finding a necessary outlet for Lake Erie.

On 18th March, 1881, Professor Spencer, of King's College, Windsor, Nova Scotia, read a paper on "the discovery of the pre-glacial outlet of the basin of Lake Erie into Lake Ontario," before the American Philosophical Society, and on the 8th December last, Professor Spencer read a paper on the same subject, before the Hamilton Association. On the formation of the Geological Section of this Association, it was understood that the Geology of the district, and indeed the whole of Wentworth County, should be worked out by the Section and the report presented to a full meeting of the Association.

The following pages are intended to form a part of this report, when the Geological Section has completed its work. The question primarily discussed, is the Superficial Geology of that part of the Country, lying in Dundas Valley and the parts of Ancaster Township around the head of the valley.

Dundas Valley lies at the western end of Lake Ontario, in the form of a rude triangle, having for its base, the beach, spanning the mouth of Burlington Bay, and for its two sides, the Niagara escarpment. The valley may be divided into three parts. First, the lower portion, occupied by Burlington Bay, a deep body of water, bordered by a low sandy shore, much broken by inlets on the southern side, and a shore rising almost precipitously to the plain above, on the northern side. (This north shore consists of sand and other drift materials.) The bay is enclosed from Lake Ontario by a low semicircular beach of sand and gravel, and is separated from the second or middle third, by Burlington Heights, an old beach containing fossils of the Hudson River period. Second, the middle division, or lower portion of the valley proper, extending from Burlington Heights to within the vicinity of the town of Dundas. And the third or upper portion of the valley, comprising all that broken and hilly region at the head of the valley, and extending from Dundas to the village of Copetown, where the valley proper ends.

* Report Second Geological Survey of Pennsylvania, III. page 330 *et Seq.*

DUNDAS VALLEY.

In this present paper, I shall not take into consideration the first or lower division, containing Burlington Bay, but confine myself to the two upper divisions of the valley. The division containing Burlington Bay had other, and later causes at work in its formation, than those concerned in the construction of the upper two divisions of the valley.

Beginning at Burlington Heights, we have then a narrow canyon shaped channel, lying in a position about N. 70, E., and a little more than eight miles long, cut out between the two walls of rock forming the escarpments. This channel is about four miles wide at the lower end, and gradually narrowing until at Binkley's Corner, on the Hamilton and Ancaster road, the valley is three miles wide, a width it maintains for more than two miles, or until after passing Dundas, when the more westerly escarpment turns slightly east, to the village of Copetown, where it approaches within a mile and a quarter of the eastern side of the valley. From Copetown this western escarpment turns in a westerly direction and disappears. These measurements are from a map made by Mr. T. C. Keefer, in 1859. This map is on a scale of two inches to the mile.

Where, or at what elevation, these escarpments join each other, has not yet been determined. Sir William Logan in his Geology of Canada, published in 1863, says, "It is not, however, certain where it (the Niagara Formation) folds over the Dundas anticlinal, there being no exposures whatever upon the axis. The most western appearance of the upper part of the formation, on the south side of the anticlinal occurs in the vicinity of Ancaster; the most western on the opposite side, about two miles north of Ancaster, on the third lot of the first range of Flamboro' West. It may be inferred from the trend of the formation on each side, and from the general shape of the country, that its summit would fold over the axis of the anticlinal, on the line between the townships of Ancaster and Beverly, at about the thirty-fourth lot."

The portion of the valley from Burlington Heights to the town of Dundas, is to a considerable extent, occupied by Dundas Marsh. Between the marsh and the detritus at the foot of the escarpment on both sides, there is a tract of raised level country lying at a general elevation of about eighty feet above the level of the lake on the eastern side, and, a perhaps somewhat higher elevation on the western side. The level plain on the eastern side, is here and there cut through to the blue Erie clay, by streams of recent origin. On the western side, the country rises by broad successive steps to the foot of the escarpment. The western side is also peculiar in the absence of streams of any size, and also their fewness in number. The composition of this level plain appears to be chiefly beds of clay and silt in alternate layers, with patches of conglomerate in places.

The division from Dundas to Copetown, lies on a much higher plain, rising by steps to the summit of the valley.

Passing up the valley we come to the second elevation about a quarter of a mile beyond Binkley's Corner, on the Hamilton and Ancaster road. This elevation, which is about twenty feet higher than the general level of the second division, stretches in a semicircular form with its concave side looking down the valley, from the Hamilton or eastern side, crossing the public road, passing through Mr. Hatt's farm and coming to an end in the heavy clay beds near Dundas. This level is very much cut up by deep ravines; showing on their sides in many places, gravel terraces or levels of resting places of

the waters of the lake in former times. From this point to the upper end of the valley thedistrict rises in quick stages. This district towards the head of the valley, is much cut up by streams, and showing a generally broken surface. The hills between the streams lie in positions so that their long axis points in the direction of the long axis of the valley. Several, and indeed most of these hills, show distinct traces of two or more terraces or old beaches, and being in every case rounded on the top. Some of the hills are cone shaped, and this the more so, the nearer the head of the valley is approached. In composition, these hills are for the most part, clay of a whitish yellow color, lying upon beds of stiff blue clay, or bluish sand. The yellow clay shows little or no signs of stratification in any manner. The cone, or rounded hills, near the head of the valley, consist to a great extent, of drift sand or silt, and some few being of fine gravel mixed with reddish colored silt. Many of them have all the characteristics of sand dunes, the sand being apparently blown sand. A number of the these hills in this division contain beds of conglomerate.

The height of land closing the head of thevalley proper, and separating the drainage system of Dundas valley, from that of Fairchild's Creek, and the Grand River, is composed largely of coarse, washed or beach sand, with broken shales in some parts. On the road leading from Ancaster to Jerseyville, on the farm of Mr J. Crysler, there is a fine exposure of these gravel or sand beds. Here, the sand is distinctly stratified, lying at a high angle and dipping eastward, or down the valley. The angle of beds to the west, or towards the head of the ridge, being the highest (about 40 degrees). Passing east, the beds gradually assume a more horizontal position until they merge into the general level. Again, on the line of the next concession road to the north, and about a mile and a half, or two miles further west, there is an exposure of beds of the same material dipping at a low angle to the west. This second exposure is on the southern border of a large swamp. On the northern border of this swamp, and still on the western side of the height of land the ridge is composed chiefly of dark colored broken shale, having, where noticable, a western dip. This broken shale can be traced for nearly a mile along the road leading into the village of Copetown. That these two exposures (the one at Crysler's and the one at the swamp) are on the opposite sides of the height of land is obvious, both from the dip of the beds of sand and shale, as well as from the course of the different streams having their rise in the district—all the streams on the western side running in a southwestern direction to the Grand River or Fairchild's Creek, while the eastern side sends all its streams down the valley to Dundas Marsh. This swamp lies on the top of the ridge, and its outlet (if outlet it can be called) is through the gravel to the southwest.* The depth of this swamp has never been properly ascertained, but, it is generally estimated to be somewhere between fifty and sixty feet. From a series of measurements made by aneroid, I made this swamp 520 feet above the level of Lake Ontario. The hills around the swamp rise to a considerable height above it. This ancient beach, for it is without doubt an old beach, is flanked on both sides by high, long shaped and rounded hills, of reddish sand, heaped up apparently by glacier or water action, and showing no signs of stratification, beyond that here and there the underlying sand assumes a bluish tint.

The belt of sand to the west of this ridge is much broader and is less broken than that on the eastern side. On the west, the hills as a general rule are long rolls stretching first in a southwesterly direction, but to the westward, gradually assuming a more northerly and southerly position. The margin of this sand

* This outlet can only be of any effect when the swamp is swollen by the heavy rains of Fall or Spring.

belt beginning to the west of Jerseyville, passes easterly in a semicircular form around the height of land, and borders a large district of stratified clay. On the eastern side the hills are in a great measure cone shaped and broken, passing into clay mounds within a short distance down the valley. In many places I have noticed these cone shaped hills to contain conglomerate. In continuation of this ridge a broad belt of sand and silt, more or less broken and rolling, passes towards the southeast to the line between the townships of Ancaster and Glanford, where it thins out and is replaced by stratified beds of stiff clay containing inter-stratified beds of quicksand. These beds of clay gradually deepen to the banks of the Grand River. At Middleport on the Grand River, the clay beds are between ten and fifteen feet above the surface of the river, and at Onondago, a few miles further up the river, the beds are above thirty feet higher. At both places, there are inter-stratified beds of sand, containing shells of recent species. At Onondago the drift is 78 feet thick, and the river flows through it about 35 feet above the rock bed.

In addition to the large swamp already mentioned as lying on the top of the height of land, there are numerous small cup shaped swamps lying among the sand hills on the eastern side of the ridge. On Fairchild's Creek, at Mud Run, I found shells of recent species in a small bed of sand enclosed in heavy beds of clay. The sand occupies a position between the white colored and bluish clays. The white is twelve feet thick, and the blue four feet before reaching the water level.† There is, therefore, twelve feet of clay above this six inches of sand. This clay and sand is apparently the bottom of an old lake. In the bottom of Lakes Superior and Huron, beds of clay and sand, containing shells of recent species, are being formed. *

WALLS OF THE VALLEY.

The escarpment forming the walls of the valley, is composed principally of Medina shales (250 feet, according to Professor Spencer)‖. These are succeeded by thin beds of the Clinton formation, and the whole surmounted by the beds of the Niagara formation. Sections of the escarpment near Hamilton, Ancaster and at West Flamboro, are given in Logan's "Geology of Canada." § The eastern escarpment presents in many ways, an aspect considerably different from the western. From Hamilton to Ancaster, this escarpment shews a clear face of hard Niagara limestone, and Niagara shales, lying upon the shale beds of the Clinton and Medina formations, and surmounted for the greater part of the distance, by a thick band of broken material containing considerable quantities of chert. The talus, of which there is only a moderate quantity, is largely composed of pieces of this broken band, and can be seen in the ravine, or channel, formed by every brook flowing over the escarpment. The section given by Sir Wm. Logan, in his Geology of Canada, ‡ places the Niagara beds in the vicinity of Hamilton, at fifty-eight feet, three inches in thickness. This section, beginning at the pentamerus bed, gives five beds; three of limestone, and two of shale. The other twenty feet of this section will be found, I think, back on the limestone ridge, near the town-line between Barton and Glanford. This upper escarpment can be traced through Barton Township into Ancaster Township, and to within a short distance of the lower

† These measurements were made in December after a long season of heavy rains.
* See LYELL'S Principles, pages 254 and 768; and DR. BIGSBY Jour of Science, No. XXXVII, pages 262 and 263.
‖ Ancient River by Prof. Spencer; page 2.
§ Geology of Canada, pages 313 and 325.
‡ Geology of Canada, page 323.

escarpment at Tiffany's Falls, on the farm of Mr. Robb, within one mile of Ancaster village.

Over the escarpment, between Hamilton and Ancaster, a number of streams flow into the valley beneath. These streams mostly flow in channels cut at right angles, or nearly so, to the face of the escarpment. Amongst the largest, is the stream at Chedoke. This stream has cut for itself, a channel about two hundred yards wide at the mouth, and back into the the face of the escarpment, nearly five hundred yards. The walls show a clear section of the broken upper band, and in places, the heavy bed of limestone on which the broken band rests. This limestone is from six to eight feet thick, and the broken material, eighteen or twenty feet. The lower beds apparently red and bluish colored shales, are hidden by the debris falling from the sides of the ravine, and brought down by the stream. At the head of the ravine the water has cut through the broken material to the solid rock, and falls over a face of fifty feet into a pool excavated in the underlying shales. In Nicholl's quarry on the right hand side looking up, and close to the mouth of the ravine, within thirty feet of the level of the bed of the stream, there are exposed the blue and red shales and sandstones of the Clinton group. From the horizon of these shales, I do not doubt but that they are a continuation of the same beds as are to be found at Dundas, with an elevation of one hundred and twenty feet above the lake level. There are exposed in the cutting of this stream, several fractures crossing the ravine at various angles; all nearly right angles; and one of these fractures nearly half way up the stream, on the right hand side looking up shows an opening of from eighteen inches to two feet, passing down through the broken band to the heavy limestone bed. Here the fracture seems to have divided, and passes down through this limestone bed in the shape of two close jointed fractures, with a distance of twelve feet between the joints or lines of fracture. This fracture if continued westward, should come out on the face of the escarpment a little further up the valley. I have not yet seen the outcome of it. It may, however, in its course, have met other fractures running in the other direction, or passing back into the country. This would be by no means an uncommon occurrence, as this eastern escarpment is full of fractures running from the face back. Indeed, I am inclined to think from the curved and broken appearance of the Chedoke ravine, that that stream has in its course, followed the lines of several such fractures. Such a course would enable the stream to cut out the channel it has done at a much more rapid rate than it could otherwise do. Several other streams further west, have also succeeded in cutting for themselves channels, and forming ravines quite as large, and have their courses filled with drift in much the same manner as Chedoke. The stream near Ancaster forming Tiffany's Falls, flows through a ravine not so wide nor as long as Chedoke; but, when the gravel hills lying close to its edges are taken into account a great many feet deeper. Tiffany's Falls flow over a sheer precipice of over eighty feet. The cliff is broken into two divisions by a heavy four or five feet band of limestone. This band is underlaid by blue shales containing in many places, patches of an earthy iron ore. The shales overlying the thick band are Niagara shales. Some distance up (about one hundred yards) the stream flows over a smaller fall, or linn, of sixteen or eighteen feet in height, entirely composed of thin shales containing patches of chert. This second fall is the continuation of the second escarpment, seen at Guest's lime-kiln. The overlying beds of the Barton Lime Ridge and Guest's quarry being exposed a few yards further inland. Between the falls and the linn, the stream

has hollowed out the shales so as to give them the appearance of being set on edge. There are other smaller streams, dry in summer, but foaming torrents in Fall and Spring, and most of them have formed considerably sized channels for themselves through the broken band forming the top of the escarpment and drift material filling the bottom of the valley, but have not, as yet, succeeded in doing much towards forming a channel through the harder beds in the face of the escarpment. The channels of the streams crossing the lower, or second escarpment, near Ancaster, also form large ravines of the same general form as those in the upper ridge.

The lower escarpment crosses the Ancaster and Hamilton road about a mile to the northeast of the village of Ancaster, at an elevation of three hundred and seventy feet above Lake Ontario, and passing along in a westerly direction, crossing the road from Ancaster to Dundas at the Red Mills, and coming to a general level at Mr. Leith's gate, near the Sulphur Springs road. The lower escarpment is probably joined by the upper in Mr. Leith's farm; and at Mr. Leith's gate both form a single escarpment about three hundred and sixty feet above Lake Ontario. Of this, however, I am not at all satisfied, as I have not been able to trace the upper escarpment any further than into the farm of Mr. William Farmer, where it is completely hidden by gravel hills. However, from the nature of the rock, trend, and elevation, I would not be surprised to find it on Mr. Leith's farm. So far as I have examined it, the rock bedding, both at Leith's and Chapman's, have the characteristics of the lower escarpment. On Mr. Forbes' farm, the lower escarpment is comparatively covered up by a large quantity of debris of the same material as the escarpment, and which has apparently been thrown down from the face of the cliff by the action of the weather, or some other agency undermining the softer beds lying underneath—from the texture of the escarpment where seen, I should think, by the action of water. This lower escarpment is composed chiefly of shale rock. Sections of them can be seen in the channels of any of the streams flowing over it into the valley. This escarpment is lost in the drift on Lot 38, of the first Concession of Ancaster.

The upper escarpment comes to the road at Guest's lime-kilns. From the lime-kilns it follows the road to the village of Ancaster, where it rises to an elevation of about five hundred feet above Lake Ontario, and turning in a westerly direction, it passes along the southern end of Mr. Egleston's farm, and round behind the village until it meets the lower escarpment near Mr. Leith's gate. The upper escarpment is, in this vicinity, considerably broken. There is an old channel at the northern end of the village, of considerable depth, but of no great width or length. This break or channel, is filled with clay and sand drift with large flag shaped boulders of limestone and sandstone, tilted at high angles, some of them being set on edge. The upper bed is of limestone, weathered into pits or honeycombed, and corresponds to Number Six, of the section given by Sir Wm. Logan, in his Geology of Canada.* The head of this ravine behind the village, is crossed by the honeycombed rock which the stream has cut through, and is now passing over the underlying shales which the water has worn off into small steps. This stream has worn a large channel in the shales of the lower escarpment at the Red Mills, on the road leading from Ancaster to Dundas. The head of this channel is five hundred and ten feet above Lake Ontario. Passing along the northern end of the village this escarpment shows a bold face looking north, a short distance, when it is again broken by a stream having a channel of considerable width, but of no great depth. Here, the upper beds of the escarpment are very much broken by fissures of considerable width, and in

* Geology of Canada, page 324

many places present a series of steps. At other places the drift completely covers the escarpment only allowing the rock to appear here and there on the side of the stream. After crossing this stream the upper escarpment passes into the sandhills of the neighborhood and disappears. The honeycomb bed can be seen on the surface west of the village, and also on the farms of Messrs. George Farmer and A. Book, a distance of something like four miles to the south of the village of Ancaster. From these exposures, we might be inclined to infer that the upper escarpment turned south from Ancaster village, leaving a basin to the west between it and the Onondago group. The beds of the upper escarpment are made into lime by Messrs Guest, and are also quarried for building purposes, on both sides of the stream at Ancaster. The top bed at Guest's lime-kiln runs out before reaching the quarry on the adjoining farm.

Between the top of the lower escarpment and the foot of the upper, there is a considerable tract of level rocky floor covered with drift of considerable depth. A well bored by Mr. Guest, to a depth of thirty-five feet, passes through sandy loam the whole way and finishes in quicksand. This well is only within a few hundred yards of the upper or lime ridge.

The Drift covering this rocky floor is heaped up into long shaped hills on the outside, leaving a valley between them and the talus of the upper escarpment. Through this valley, the stream from the northern end of the village passes and shows in its banks, beds of gravel and boulders in patches. The hills are mostly of clay, with pebbles and streaks of sand, and where cut by streams, shew no signs of being stratified. This cutting away of the upper beds, I would refer to ice action, as, on a sheet of rock exposed where the lower escarpment crosses the road, there are striae running in a direction of N. 60, E. It is interesting to note that on the road, at the lime-kilns, there is an exposure showing the black shales of the Niagara formation, with several contorted beds of thin shale, lying immediately above them. These contorted beds are surmounted by other beds of a uniform level with the black shales underneath.

The quarry close to the Woollen Mill, belonging to the Egleston estate, and lying on the other side of the ravine, shows several large perpendicular fractures passing from the surface down through the several beds in the face of the quarry so far as exposed. At one place, two of these fractures run parallel to each other at a distance of three feet apart, and giving the enclosed rock the appearance of a dyke. That it is not a dyke, however, can be seen from the enclosed material being of the same texture, and having the same bedding in uniformity with the rest of the quarry.

At Guest's lime-kiln, just above the exposure of the black shales, the top beds, where not quarried, show a cut-away edge, somewhat as if a mighty agency had passed along and bevelled them off. This cutting away has the appearance of being due to the action of the waves, whether it was done by the ice and the markings afterwards obliterated by the action of water, I cannot say. It is, however, probable that such is the case, as the upper beds are not of such a nature as to retain any but very deep marks. In no place in this vicinity have I seen ice-markings on this upper escarpment.

The escarpment on the more westerly, or West Flamboro' side of the valley, differs in some respects from the Hamilton side. There are fewer streams on the west, there being only three or four large brooks, contrasted with the numerous small streams on the other side. The quantity of talus or detritus is much greater on the West Flamboro' side of the valley, than on the Hamilton. So extensive is this detritus in some places, that it completely covers the rocky escarpment.

The division from Copetown to Dundas is to a great extent, covered by heavy clay drift, the rock bedding only breaking through here and there, and showing mostly the upper strata of the Niagara group. In this division the drift is composed of two heavy unstratified clay beds. The clay of the upper bed is of a light color, and lies unconformably upon the blue clay of the lower division. The light-colored clay is very thick, in some places showing an exposure of between eighteen and twenty feet.

"Colour is of little value in determining the division of clays into beds, as many of the dark brown and blue clays when exposed to the air and dry, assume light tints." In this district, however, the blue and the light clays are separated by a strongly marked line of a broken or waving form. The shape of the dividing line looks as if the upper surface of the blue beds had been exposed for some length of time, and had been subjected to the ac ion of running water before the upper bed of light clay was laid down.

In some places there are considerable quantities of gravel and small boulders; mixed with the clay in others, both the beds are comparatively free from stones of any description. The gravel is mostly found at the junction of the two beds, and particularly where the blue bed is cut into stream-like hollows or gulches. In the upper bed, on the sides of these depressions I have found fragments of rock, rounded and water worn, and containing fossils of the Hudson River period.

Section of clay beds near Copetown showing old channel in the blue clay.

A. Yellowish clay.
B. Blue clay.
C. Gravel.
This section is contorted to shew more clearly the position of the gravel.

Mr. Weir's quarry, on the first lot of the first Range of Flamboro' West, is overlaid by over ten feet of the light-colored clay, containing angular blocks. The blue clay is absent, but in one place, a small patch of red till appears, lying close to the rock. The top stratum is of a hard, light-colored limestone. This bed looks extremely like as if there had been part of it cut away before the ice action set in. It has only been quarried in places; and the parts untouched, where exposed, present an edge smoothed and rounded off, and showing the glacial grooves in a beautiful condition and running in a perfect parallelism with this part of the escarpment. In the quarry I found no shells, but a few specimens of the coral favosites gothlandica, and several crystals of galena, from an inch to two inches in diameter.

The band of broken material capping the Hamilton escarpment, is wanting in Mr. Weir's quarry. The precipice at West Flamboro', according to the Geological Survey, is capped by blue and grey limestone, including bands of

white buff and grey chert, and thickly studded with chert nodulus, to a thickness of twenty feet.

Last year an attempt was made to bore an Artesian well at Dundas, and through the kindness of Mr. Bertram, I am enabled to present here, a section of this boring. The mouth of the well is in the talus of the mountain, and one hundred and fifty feet above lake level.

Section of Dundas Artesian well :

1	Broken Stone	25 feet
2	Clay	48 "
3	Clay and Fine Sand	5 "
4	Medina Group (Red Shale)	341 "
5	Lorrain Shales (Blue Shale)	550 "
6	Utica Black Shales (Shale and black slate very friable	330 "
7	Trenton Limestone to bottom of well	430 "
	Total	1,729 feet.

The well did not pierce the Trenton to its base. Below the Trenton we have the Potsdam and Sienite, and above the mouth of the well the Clinton and Niagara Groups. This section is drawn from N. E. to S. W. The beds dip at about 30 feet to the mile. The Medina Group runs out at Oakville. The strike of this group being in an E. and W. direction, it appears, in the section of the Eastern Escarpment from Niagara to Ancaster, on the same horizon, or 120 feet above the level of the lake. From this section the Medina Group appears to be only 367 feet thick at Dundas, 120 feet of which is above the lake level, thus leaving 247 feet under that level. The clay beds in the same neighborhood have, however, been pierced to a depth of 60 feet below the level of Lake Ontario, thus showing the absence of the Medina Group to that depth.‖

On the Sydenham road, on the 16th and 17th lots of the first range of Flamboro' West, the Clinton Group is 100 feet 11 inches thick. This is overlaid by 127 feet thickness of beds of the Niagara Group. †

The rocks of the section in the neighborhood of Dundas, form two separate and distinct terraces. The lower and more marked escarpment presents the strata beneath the band of chert and limestone, which caps the precipice at Flamboro West.

The upper escarpment, composed of the dark colored bituminous and magnesian limestones, and their accompanying beds, rise more gradually in a succession of steps, terminating at the summit in a wide extent of Table land.

The elevation of the top of the escarpment at Dundas, is 520 feet above lake level.

OLD BEACHES.

Dr. Robert Chambers, in his Ancient Sea Margins, in speaking of the region of the great American lakes, says: "This district presents some memorials of ancient sea levels which are not, perhaps, exceeded in interest in any part of the globe. To the north of the lowest lake, Ontario, which is 232 feet above the ocean level, the gentle slope, composed of a deep bed of clay enclosing scratched boulders, is traversed lengthways by a series of ridges, nine in number, at a rising series of levels."

Sir Charles Lyell says: "With the exception of the parallel roads or slopes in Glen Roy and some of the neighboring glens in the Western Highlands of Scotland, I never saw so remarkable an example of banks, terraces and

* Geology of Canada, page 327.
‖Geology of Canada, page 903.
†Geology of Canada, page 326.

accumulations of stratified gravel, sand and clay maintaining over wide areas so perfect a horizontality as in this district of Ontario." *

Sir Charles Lyell regards them as referable to some ancient beaches and lines of cliff formed on the margins of channels of the sea; others including some of the loftiest of the ridges, as having originated in banks and bars of sand, formed not at the extreme edge of a body of water, but at some distance from the shore, in proportion as the water attained a certain degree of shallowness from the upheavel of the land."

The height of these ridges above the sea have been given by Mr. Roy, in a paper presented to the Geological Society of London, in 1837, as : ‡

A	.....	.....342 feet.
B	.....	.....442 "
C	.....	.....514 "
D	.....	.....542 "
E	.....	.....576 "
F	.....	.....634 "
G	.....	.....654 "
H	.....	.....734 "
I	.....	.....790 "
J	.....	.....858 "
K	.....	.....914 "
O	.....	.....996 "

To these Dr. Chambers adds two others at § .

	.....	.....242–7 "
	.....	...392 "

Between Lake Ontario and the head of Dundas valley proper, there are indications of at least five of these ancient sea beaches. Two of these, Burlington Beach and Burlington Heights are clearly defined. The one at the head of the valley, although the evidence in support of it is pretty well decided, is not so easily traced. Of the other two the evidence is not so clear, as only parts of them are to be found. These beaches so far as can be traced are all rudely parallel to each other, crossing the valley in a circular form and having their convex sides looking north-east towards the lake.

Taking these beaches in serial order, we have 1st, Burlington Beach, a low sandy and gravelly bar about five miles long, varying from a few hundred yards to half a mile in width, and in no part elevated more than a few feet above the level of the lake.

This, I would assume from its position and elevation to be the most recent of the series of beaches to be found in the valley. Its elevation corresponds pretty nearly with the lowest beach given by Dr. Chambers, or about 242 feet above sea level.

2nd. Burlington Heights. This is a beach of much older origin than Burlington Beach. It forms the barrier between Burlington Bay and Dundas valley proper. This beach with its broken strata of sand, gravel and conglomerate, begins close to the escarpment on the south of Hamilton, about the end of Catherine street, and can be traced through the city of Hamilton along the road leading to Burlington village. It is separated from the raised level country lying along the escarpment at the northern end by a deep channel, at one time the mouth of the old canal and outlet of the waters flowing through the marsh into Burlington Bay.

*Ancient Sea Margins.
†Geology of Canada, page 915.
‡Ancient Sea Margins, Appendix, Table I.

A very fine section of this beach can be seen on the line of the G. W. Railway from Dundurn grounds to where the line passes around it at the old mouth of the canal.

From levels kindly supplied to me by Mr. Haskins, the city Engineer, I am enabled to give here the heights of this old sea margin at various points in its course through the city.

	FEET.	INCHES.
Reservoir, at commencement	272	
Catherine Street	187	6
John Street	117	4
James Street	110	9
McNab Street	110	6
Park Street	108	
Bay Street	113	4
Caroline Street	115	7
Hess Street	116	
Queen Street	114	
York Street, Cor. of Dundurn	102	6
Kent's [Paradise] Park	109	
Desjardins Canal	109	
Old Mouth of Canal	109	

Leaving out of our calculation the elevations at Catherine and John streets, we might give this beach an average elevation of 110 feet. This added to the elevation of Lake Ontario, 232 feet, would give an average elevation above sea level of 342 feet, thereby making Burlington Heights a Beach equivalent to A in Mr. Roy's table.

Sections of Burlington Heights show a series of strata consisting of fine sand, coarse sand, gravel and pebbles, in alternate order. The beds are much broken and give several angles and directions of dip.

A section of an outlying spur of this beach in Beasely's Hollow on measurement last fall, gave a section in descending order of

	FEET.	INCHES.	
1. Soil			
2. Clay	3		
3. Coarse Conglomerate	14		
4. Sand fine	3		
5. Stratified Course Sand		3	
6. Stratified fine Sand	1	4	
7. Silt	4	6	(dips 1 deg.)
8. Clay	6		
9. Silt		8	
10. Clay	6		
11. Sand partially concealed		8	(dips 4 deg.)

The dip of the beds in this section is to the west, or towards the marsh. Bed No. 5 dips at an angle of one degree and No. 9 has a dip of four degrees.

At the time of my making the measurement the face of the pit shewed four bands of carbonate of lime running through it; three, in a vertical position and the fourth, running in the direction of the dip but not parallel to the beds, but in a broken line crossing and recrossing two or three of the beds. The three vertical bands were from three-fourths of an inch to one inch in thickness; the broken band being only about one-half of one inch in thickness and in places fretted.

These bands apparently had their source in an overlying mass of the same material.

Another section of the same spur gave underneath the brick clay :

1. Sand, with broken top..... 4½ inches.
2. Clay 18 inches, thinning out to..... 8 or 5½ inches.
3. Sand, coarse..... 10 inches.
4. Sand, fine ..... 2 inches.
5. Conglomerate.....2 feet 6 inches.

The beds beneath the conglomerate are concealed here.
The dip of this section is also in a western direction.
The section of the Heights at the present mouth of the canal gives :

1. Soil,
2. Fine Sand,
3. Gravel,
4. Coarse Sand,
5. Gravel.

} Horizontal.

6. Coarse Sand,
7. Gravel,
8. Coarse Sand,
9. Gravel,
10. Coarse Sand,
11. Coarse Gravel,
12. Sand and fine gravel,
13. Coarse Gravel,
14. Coarse Sand,
15. Silt
16. Stratified Sand.

} Some beds wedge-shaped across the Heights and all dipping slightly towards the old mouth of the canal.

17. Beds of alternately fine and coarse sand.

These beds are underlaid by the Erie clay lying upon the Medina formation. In this section the underlying beds are mostly dipping towards the North-East with horizontal beds overlying them. These beds are not, as a rule, of uniform thickness throughout, many of them being wedge-shaped, particularly those immediately underlying the horizontal beds. The underlying strata are concealed at the canal and are rarely visible at any part of the Heights.

The pebbles contained in the gravel composing these beaches, (Burlington Beach and Burlington Heights) are mostly from the rocks of the Hudson River formation, granites and other crystalline rocks, and the Niagara limestones.

Although Burlington Beach and Burlington Heights are usually denominated beaches, the evidence they offer can hardly warrant them being properly so called. Beaches, strictly speaking, are the margins of the land, and an examination of these two will show that they can hardly ever have been in that position. They might, more properly, be considered as banks, ridges or shoals, derived from the debris of the old shores of the lake, when the water level was at least 120 feet higher than at present.

The position, composition and shape of Burlington Beach, points out conclusively that it never was a beach, but since its formation, has continued to be what it is at present, a low sand bar. *

Of Burlington Heights, the disposition of the materials composing it, answers the question of its origin. Different parts of the heights dip in different directions. It has already been shown that in Beasely's Hollow and

*See paper by Mr. P. S. Vanwagner for further information concerning Burlington Beach.

to the south-east, the beds dip in a western direction or away from the lake, while at the canal the dip is to the east or towards the lake, some of the beds also having a slight inclination towards the old mouth of the canal.

Had the Heights been a beach, with the terrace closing up behind, I do not see how the beds could have been given this western slope. After studying this phenomenon, only two very likely causes can be offered for the formation. These are, first, that Burlington Heights are the remains of a morraine of the last glacial period, afterwards stratified by the action of the lake. This, I do not think tenable, as a morraine, even although of a second period and derived in a great measure from the relics of the first, could hardly escape having some large angular blocks; but here, the stones are all small, rounded and water-worn, and corresponding specimens can be found in patches in different parts of the valley.

The second cause for the formation of the Heights, appears to be much more reasonable and in accordance with the observed facts.

At the time when the lake stood about 120 feet or so higher than at present, the waters would be washing away the clay and gravel beds in the neighborhood of Dundas. The softer materials, such as silt and clay, forming these beds, would be carried down to the lake, while the pebbles and gravel, being heavier, and requiring a greater force to move, would be gradually rolled down towards the mouth of the valley, afterwards to be heaped up into the position they now occupy, by the storms affecting the lower and less sheltered waters of what, at that time, would be Lake Ontario.

The western slope of the beds is accounted for, by the water washing over the top of the ridge and gradually moving the materials over to the western side. This may also account for the wedge-shape of the beds, formed here and there through the ridge.

The abrupt termination of the beds at the northern end of the ridge, would lead the observer to conclude that the current down the valley at the time the ridge was being laid down, set in close to the eastern and southern shores of the valley, and gradually worked its way over to the position it holds at present, throwing the ridge and other materials close to the eastern shore, filling up the old bed with the materials derived from the new.

Another proof of this beach or ridge being laid down in comparatively deep water, is the conglomerate composing the beds and also found underlying the clay, in different parts of the valley.

This conglomerate is formed by the infiltration of the beds of gravel and sand with carbonate of lime, and as the carbonate could hardly pierce the heavy clays, lying, in some places above the conglomerate, without leaving some traces of its having done so, it may reasonably be inferred that the waters charged with the lime, were flowing through the valley and depositing their charge, before the upper clay beds were formed.

The carbonate of lime was derived, without doubt, from the continued washing of the waves against the limestones of the escarpment? some streams of the present day being so highly charged with this material, as to act upon the mosses and other vegetable matter, growing within reach of their spray. It could, therefore, only be after the action of the waves upon the cliffs had ceased, that the heavy clay deposits lying upon the conglomerate throughout the valley were laid down.

As no conglomerate has been found beneath the blue clay, it can also be reasonably inferred that the conglomerate beds, with the overlying silts and clays are the results of a period succeeding the glacial period, in which the blue clay was laid down.

These beds may be, and are, in all probability, the results of a closing up of the mouth of the stream flowing down the valley, and a general flooding of the district for a great number of years.

The breaking of the bank closing up the mouth of this stream, after the lowering of the waters of the lake, would drain the valley to the extent we now find it, and also leave the channel occupied, as we now find it, by the marsh. When we consider the great depth of the old mouth of the canal, this seems all the more probable.

The question how is it that the beds are alternately coarse gravel, mud pebbles and sand, of various degrees of fineness, naturally comes up to the observer's mind.

This variation, accepting the foregoing theory as correct, would lead to the conclusion that, then as now, the waters of the lake were subject to periods of storm and calm. In fine weather, when the waters of the lake were at rest, they would have less force of action, and as a consequence would only be able to move the finer materials, but at times of storms the force of water breaking over the shoal, would carry the pebbles high up on it and deposit them where we now find them.

Mr. Sanford Fleming, in the Canadian Journal, New Series, Vol. VI, page 247, describes another such ridge, known as the Davenport Ridge, in the Township of York. He says the gravel deposit can be traced over a considerable area, but unlike the terrace in its windings into the interior, the gravel is found only in a uniform straight direction, and that generally parallel to Lake Ontario.

The gravel is not deposited in horizontal beds as is generally the case with subaqueous formations, nor is it laid in thin beds dipping southerly or from the shore towards the water, as if they had been thrown up one over another on the inclined plane of the beach, by the storms of the former lake. On the contrary we find the gravel invariably deposited in the opposite direction, that is to say, dipping away from the lake, and in some instances, nearly at right angles to what may have been the plane of the beach.

Mr. Fleming's theory as to the formation of the Davenport Ridge is, that the gravel was washed out of the terrace into the position it now occupies, and that being at one time under and at another time above the water, the waves washing over it caused a gradual changing of the materials, and the formation of the beds of gravel and sand dipping away from the lake. He also refers to the spit or island lying in front of Toronto harbor. Davenport Ridge like Burlington Heights is underlaid by clay.

The Beach at the head of the valley has already been referred to, and it is therefore unnecessary to again refer to it beyond that its elevation being about 560 feet above Lake Ontario, or 792 feet above sea level, a height corresponding within a few feet of 790 of Mr. Roy's table.

From what has already been said concerning this beach, or ridge, it might be inferred that this was the line of division between the two lakes at some past period of the geography of the district, as at present it is the watershed of the two drainage systems of Lake Erie and Lake Ontario.

Concerning the other old beaches in the valley, little can be said. Remains of two can, I think, be shown to exist in parts only. I have not yet traced either of them sufficiently to be able to describe them.

The Geological survey * gives us information of two old water margins in the vicinity of Dundas, thus: to the west of the town of Dundas is an old water margin at an elevation which seems to coincide with that of Burlington

*Geology of Canada, page 914.

Heights, while on the north side of the town another ridge of gravel and sand attaining a height of 318 above the lake, occurs just under the escarpment of the Niagara formation. In its eastward extension it recedes from the cliff and diminishing in height disappears at the end of a mile. It approaches the face of the escarpment on the east side of Spencer's ravine, on the other side of which a still higher bank of sand and gravel connects the escarpment and was probably at one time connected with the gravel ridge, which would thus have formed a bar between the former outlet of Flamboro' Creek and the waters which then filled the Dundas valley.

This gravel ridge is, I think, the end of the one found running across the valley and forming the beach dividing the lower portion of the valley proper from the upper one, on the Hamilton and Ancaster road. At the road it is about 120 feet above lake level.

GLACIAL MARKINGS.

Had the glacial period anything to do with the formation of the valley? Professor Spencer says "that Dundas Valley is not of glacial origin is almost too apparent for consideration." The surface of the adjacent country is often covered with ice markings, but the striae are not parallel to the axis of the valley. This is Professor Spencer's view, while on the other hand Mr. George J. Hinde, in an article in the *Canadian Journal*, vol. xv, page 407, asserts that Dundas valley is altogether of glacial origin. He says, after speaking of the old channel at St. David's: "Valleys of a similar character are to be met with in other places in this escarpment of Niagara dolomite; for instance, the one at the western extremity of the lake in which the town of Dundas, Ont. is situated; another one occurs at Owen Sound; in all these cases there is no evidence of streams having been the means of forming these wide-mouthed valleys, whilst both near Dundas and Owen Sound there are plain traces of glaciers having passed up them. The fact of the existence of ancient stream beds leading from the south-west end of Lake Erie, in the direction of the Mississippi valley, and showing that the pre-glacial drainage of that area followed that direction, militates against the theory of a Niagara Falls existing of pre-glacial or inter-glacial date, to which this old valley has given rise." *

In a list of ice markings given on page 891 of the Geology of Canada, we find the following directions of striae in the neighbourhood of Dundas valley:—

LOCALITY.	LATITUDE.	LONGITUDE.	DIRECTION.
Brant	44.12	81.13	S 10 W
Sydenham	44.35	80.52	S 12 W
"	44.32	80.55	S 23 W
Beverley	43.19	80.14	S 46 E
" near Sheffield	43.20	80.13	S 72 E
" near Troy	43.15	80.12	S 76 E
"	43.18	80.13	S 59 E
"	43 19	80.10	S 79 E
West Flamboro	43.21	80. 2	S 49 E
do. (other grooves S. 69 W.)	43.16	80. 1	S 74 W
do.	43.16	80. 1	S 24 W
Ancaster	43.15	79.56	S 71 W
"	43.15	76.59	S 59 W
Barton			
York, Grand River	43 02	79.54	S 68 E

* Glacial and Inter-glacial strata of Scarboro' Helghts.

The axis of the valley is about N 70 E, and from the foregoing table we see that on the two sides of the valley the striae are in different directions. In the township of West Flamboro', of the four sets of grooves, one of them, S 69 W, is within one degree of the axis of the valley. In the same place, two other sets cross in the direction of S 74 W and also S 24 W. In the upper part of the same township the striae S 49 E largely diverge from the axis of the valley. In the Township of Ancaster, two sets of striae, one S 71 W, and the other S 59 W, have been recorded. The striae S 59 W passes along the top of the lower escarpment and apparently was a prime agent in forming this escarpment. These Townships lie on the two sides of the valley, and the direction of these markings would make them converge further up towards the head.

In the Township of Beverley six sets of striae varying from S 46 E to S 79 E are given. These two directions are the outside markings of a series, and would apparently show a divergence of a considerable amount.

Comparing the several directions of these striae, one would be inclined to draw the inference that the ice coming from the North-East passed into the valley in currents, met near the narrow part of the valley, forced itself through the gorge into the Township of Beverley and the western part of Ancaster Township, and spread over the country on its way to the South-West.

What effect the glaciers leaving these marks had upon the formation of the valley, is not so apparent. The question might naturally be asked, are these ice markings the results of a first or second glacial period? That is a question I cannot very well answer, as some of these markings I have not seen. Some of them I would unhesitatingly ascribe to the one period and some to another; whether these periods were first, or second, or third, or fourth, I do not know.

If we take the Township of West Flamboro' as an instance, we have, in one place, no less than three sets of markings, running in as many different directions. These are S 74 W., S 69 W., and S 24 West. From the generally level appearance of this situation, it could hardly be inferred that it was the centre of a local glacier, radiating in these directions. We have, therefore, little option in the matter, but must ascribe these directions to two periods of glacial action, which we may call first and second. This will be more readily understood when we come to look at the drift filling the valley and covering the escarpment in many places. *

Ice, according to Mr. Carll, moves at different rates of speed at different depths and on meeting any serious obstacle to its progress would turn aside and pursue a course in the line of least resistance. This may account for the direction of the striae in the valley being in different directions from those found on the top of the escarpment. It is clear that the ice coming from the north east would impinge on the eastern escarpment, which would effectually bar any further progress of the lower strata or stream in that direction. It is also self-evident that on account of the pressure exerted from behind by the whole weight of the moving glacier, the line of least resistance would be along the face of the cliff to the westward, and this course would be the direction pursued by the lower ice current, while the upper division would pass over the top of the escarpment. To this action I would ascribe the two lines of cliff, the upper and lower, and the broken material found on the top of this lower eastern escarpment, and which is wanting in most parts of the western or West Flamboro' wall of the valley.

In the stream near Ancaster, blocks of sandstone belonging to the Medina formation have been found embedded in the sands and clays filling the old

* Report III. Second Geological Survey of Pennsylvania, page 330 et seq

ravine. This would seem to bear out the theory of the movements of the lower ice. It would thus appear that this stream is of pre-giacial date, or at least existed at a time before the glacier tearing up these blocks covered the district.

The position of Dundas Valley, however, in respect to the rock bedding of the district, is peculiar. The valley lies on the top of the anticlinal and must at one time have had an elevation of 520 feet above lake level. At the time the bedding of the escarpment formed the anticlinal, the escarpment would also be complete in the channel of the present Niagara river, as far down as Queenstown Heights. This elevation would, therefore, have to be compared with the elevation of the old channel at St. David's and at Queenstown.

This may form an objection to the theory that Dundas Valley is an old river channel. From the nature of the Niagara beds in this district and from the frequency and extent of the fractures throughout these beds it may be that at the folding over of the anticlinal, a fracture of considerable dimensions occurred and thus opened a direct passage to the streams of the district and enabled them to operate upon the softer shales lying underneath the limestones forming the surface. This theory receives some color from a large fracture extending from the ravine at Albion Mills back into the country for some miles. The fissure thus opened would gradually be enlarged by the action of the water, the frosts in winter and other atmospheric changes. At the opening of the first Glacial period this gorge would present a natural pathway to the ice, and by the grinding of the glacier along its sides would be enlarged to form an opening of considerable extent. On the retiring of the glacier, the stream would resume its sway until the return of the ice would still further widen the gorge and on retiring close up the avenue completely and leave the country to the action of the lake, when the upper beds would be gradually re-arranged into the form we now find them.

DRIFT FILLING UP THE VALLEY.

Through the agency of the sections seen in the streams running through the valley, we have a general knowledge of the upper beds of the drift, while the records of well-borings give us a pretty fair idea of what is to be found further down.

"What is the floor of the valley, and at what rate of inclination does it go up the valley? I think these questions can be answered in a partially accurate manner.

In Hamilton the hard rock of the Hudson river formation has been reached at a depth of 227 feet below lake level, and near the centre of the valley, on Lot 40, of the first concession of Ancaster, at an elevation of 232 feet above lake level, a well 30 feet deep came to the sandstones of the Clinton formation. This rock would therefore be 202 feet above lake level. These elevations would give a general inclination of about 434 feet in seven miles, or about 62 feet to the mile.

Although this is the approximate rate of inclination it cannot be the true level of the old floor. This inclination would at Dundas, five miles up the valley, give the Clinton formation an elevation of about 80 feet above lake level. The clays in the same neighborhood have, however, been pierced to a depth of 60 feet below lake level, without touching rock. Now, by adding these two—80 feet above and 60 feet below lake level—we may arrive at the conclusion that between the place where the rock has been found at 202 feet above the lake and Dundas a break of 140 feet occurs. Professor Spencer estimates the depth of Burlington Bay, from water level to rock, to be 70

fathoms, or 83 feet below the bottom of the boring in Hamilton. This 83 feet would therefore have to be added to the break of 140 feet we have seen to be above Dundas, making a total break of 223 feet. Niagara Falls are 160 feet, and if these measurements are of any value, the pre-glacial age of Dundas valley witnessed a fall of 63 feet higher than the present age has the pleasure of beholding.

The streams running through the valley have cut channels at various depths, many of them piercing the underlying blue clay. The sections of many of these channels, show the clays banded with alternate layers of red and blue clays.

A section has already been given of the stream in Beasley's hollow. Further up in the cutting, near Robinson street, the section is:—

	FEET.	INCHES.
Red clay, visible	1	6
Blue clay (almost hard as slate)	1	
Red clay	4	
Blue clay (almost hard as slate)	1	3
Red clay	5	
Total	12	6

This is overlaid with reddish yellow clay, covered by a thin layer of gravelly soil. The clays of some parts of the north eastern side of the valley have the same banded appearance.

On the stream near the Red Mills, on the Ancaster and Dundas road, the blue clay, comparatively free from stones, is visible several feet above the stream bed, and is surmounted by heavy beds of a whitish clay. Further up the valley this stream runs upon the top of the blue clay, between high banks of this whitish clay. The white clay in this neighboorhood shows no stones in the sections, although occasional fragments containing Hudson river fossils and small boulders of granite are found on the surface and in the beds of the streams. These granite boulders are for the most part small and rounded. A stream rnnning parallel to this on the other side of the line of terraced clay hills, and cuts occasionally into clumps or knolls of blue clay.

On the line of the Hamilton and Dundas Street Railway, near Ainslie's Woods, a stream has cut through the brown clay beds to the blue clay and in some places into it for a few feet The blue clay seems to have the property of forming itself into a slaty material on its exposure to the air.

In this stream near Ainslie's woods, the water has worn it off into a step like form, giving to an observer, at a casual glance, the appearance of blue slaty beds. *

On the line of the same road, where it begins to descend to the level of the marsh, there is exposed in the cutting a section of stratified whitish clay and silt, in very thin beds, none of them exceeding three inches in thickness, the surface soil being about two feet thick, but this is evidently brought about by the breaking up and mixing of several of the beds by cultivation, or the vegetation on the surface.

Again, after passing through a small corner of the marsh, and near where the road crosses Morden's creek, there is another section of the same kind exposed to view. Throughout the cutting on the H. and D. S. R., on Mr. Buttram's farm, a band of faint brown clay can be detected between the beds of whitish yellow clay.

* The red and blue clays in this stream may, upon closer examination and tracing, prove to be shales of the Medina.

On the top of the second escarpment, at Ancaster, this stratification is altogether wanting. The streams show in their sides, clay mixed with gravel and sand, in no regularity, but in patches.

A hill on the farm of Mr. R. Guest, has already been described as being composed of blue clay enclosing pebbles and patches of fine building sand. These patches of sand tempted Mr. Guest to open a pit, but it proved a failure on account of the uncertain distribution of the sand. On the same farm a well near the upper ridge, passed through 35 feet of sandy loam,

The records of the well borings which I have been able to obtain, show the state of affairs further down.

A well on the brick field of Mr. Henry New, gives a section of 50 feet:

Brick clay	8 feet.
Blue clay, filled with limestone fragments	6 feet.
Gravel and sand	32 feet.
Quicksand, or silt	4 feet.
Total	50 feet.

At Bamberger's there are two wells, each twenty feet deep, passing through clay and ending in sand

Mr J. Buttram's well is 38 feet deep and gives a section of:

Clay	27 feet.
Gravel	6 feet.
Hardpan, (conglomerate)	3 inches.
Beach shingle	5 feet.
Total	38 feet, 3 inches.

These wells are on a general elevation of about 80 feet above the lake. Farther up the valley, and within a hundred and fifty yards of the Hamilton escarpment, a well dug by Mr. Hamilton Arthur passed through 27 feet of gravel before reaching the blue clay. This well is on the edge of a stream filled with pieces of limestone and cannot be much more than eighty feet above the lake. Toward the head of the valley, and in the narrow part of the gorge, three well-borings have been obtained.

The first, on Lot 40, of the first concession of Ancaster, has already been referred to, as being 232 feet above lake level. The surface is clay loam, with a sub-soil of blue clay containing boulders and fragments of limestone. This well is 30 feet deep and ends at the sand-rock of the Clinton formation. The second well, on Lot No. 40 of the same concession, passes through the blue clay 38 feet 6 inches.

On another part of the same Lot 40, a well 42 feet deep passes through red clay into quicksand.

At this place it may be worthy of note that beds of limestone and sandstone appear nearer the centre of the valley than the last mentioned well.

A little to the west of Ancaster, wells to depths varying from 30 to 90 feet have been dug through sand, gravel and hardpan, and in one place clay. One well near the top of the ridge was bored about 190 feet through sands, gravels and clays.

The gravel beds covering the end of the upper escarpment in this district are about 200 feet in thickness.

In the village of Ancaster, although the rock appears upon the surface in places, there is a ridge of sand more than 40 feet in thickness. It has been pierced to that depth without touching rock.

Passing over the Height of land, and toward the west, we have seen that outside of the belt of sand and gravel surmounting this Height of land, there are large beds of clay interstratified with the beds of silt. Generally these beds have a stratified appearance. In many places the beds present regular strata or whitish yellow and reddish clays, in layers of from half an inch to one inch in thickness. This arrangement is particularly marked on the banks overlooking the Grand river between Middleport and Onondaga. These clays lie at a lower level than the sand ridge. At the village of Alberton they are about 465 feet above Lake Ontario, and at a mile or so to the east they have an elevation of about 480 feet.

I regret I am not able to say accurately what the elevation of Middleport or Onondaga is, but from the general elevation and run of the streams I would estimate these places to be nearly 400 feet above Lake Ontario. They may be a few feet less, but not enough to make any material difference in our present calculations.

The records of deep wells bored in this district are very scant. Although there are numerous wells dug, they generally do not exceed 12 or 15 feet, some few being from 30 to 50 feet in depth.

One at Onondaga, 78 feet; one on Lot 32 of the sixth concession of Ancaster, over 100 feet; and one on Lot 31 of the fourth concession of the same township, 110 feet.

In Onondaga Township, a well bored 50 feet was stopped by reaching rock. Placing these wells in a tabulated form, we see at a glance what the general features of the underground portion of this district are.

TABLE SHOWING THE PARTICULARS OF WELL-BORINGS IN DISTRICT LYING TO THE WEST OF THE HEIGHT OF LAND.

LOCALITY.	DEPTH.	SURFACE.	UNDERLYING STRATA.	BOTTOM.	NATURE OF WATER.	REMARKS.
Lot 39, IV. Con. Ancaster..	30	Whitish clay, mud with sand	Whitish clay and sand....	Quicksand..	Fresh...	
Lot 39, V. Con. Ancaster...	50	do	Whitish clay and sand; beds of quicksand at 30 feet....	Quicksand..	Sulphur..	
Lot 31, IV. Con. Ancaster..	110	Whitish brown clay loam...	Beds of clay and quicksand; rock at 55 feet.	Limestone55 feet in rock.	Fresh ...	The water coming out of the rock was highly chg'd with sulphur and the boring had eventually to be plugged.
Lot 34, III. Con. Ancaster..	52	Sandy loam..	Sandy loam..	Quicksand..	Salt.	
Lot 33, III. Con. Ancaster..	35	Sandy loam..	Saddy loam..	Quicksand..	Fresh. .	
Lot 38, III. Con. Ancaster...	12	Clayey loam..	Clayey loam..	Quicksand .	Fresh....	The sand in this well rises so fast that it has frequently to be taken out to prevent the pumps choking.
Lot I. Con. Onon. three miles S W. Alberton.....	41	Clay	Clay with sand	Rock		
Alberton.....	61	Clay and sand.	Clay.....	Quicksand..		
Lot 33, VI. Con. Ancaster..	100	Clay	Clay and sand.	Rock at 85 feet		
Lot 22, I. Con. Onondaga. .	50	Clay	Quicksand at 16 feet ...	Rock.....	Fresh....	
Lot 21, I. Con. Onondaga...	22	Clay	Clay, blue clay at 40 feet....	Quicksand..	Fresh....	
Lot 21, I. Con. Onondaga...	35	Clay	Clay and sand	Sand	Fresh..	
Onondaga.....	78	Clay.....	Clay and sand	Rock	No water	The bottom of this well is 25 feet below the bed of the river.

In this table it will be seen that rock has been reached in five places, viz:

	Elevation of Rock above Lake Ont.
Three miles S. W. of Alberton, at 41 feet	
Onondaga Village at 78 feet	389 feet.
Lot 31, IV. Concession of Ancaster at 55 feet	322 "
Lot 22, I. Concession of Onondaga, at 50 feet	492 "
Lot 43, VI. Concession of Ancaster, at 85 feet	350 " ?
	490 " ?

These elevations tend to show the general uniformity of the rock bedding underlying the district; and also, I think, to show that in case, as Professor Spencer says, the Grand River at one time ran into the Dundas valley, it must have come up in a channel situated to the west. This channel, most probably, was that now occupied by Fairchild's Creek. In this district we find quicksand, or silt, at the depths of 12, 16, 20, 30, 35, 50 and 60 feet. It is, however, probable that the beds at 12 and 16 feet, and at 30 and 35 feet, are the same beds pierced twice. This would reduce the number of these sands to five distinct beds, or strata.

It has already been noticed that the sand in the section shown at Mud Run, on Fairchild's Creek, contain several species of recent fresh-water shells. At Middleport and Onondaga, the inter-stratified beds of sand also contain specimens of recent shells, most of which, however, are of different genera from those at Fairchild's creek. Only one class seems to be common to the two places.

The present lakes, notably Lakes Superior and Huron, are laying down deposits corresponding with what we see covering this district. The maps of the U. S. Coast Survey also describe the bottom of Lake Erie as mud and clay. Mr. Geikie, in his "Great Ice Age," in describing several districts of Scotland as old lake bottoms, gives sections nearly corresponding to the beds of clay and sand covering the tract west of the Height of Land at the head of the valley. Some of his sections are so near a parallel that they might almost be substituted for what is found here.

Looking at the deposits of clays and sands in this district, there seems to be little doubt but that it is the bed of a lake of post-glacial date, the Height of Land forming the barrier between it and Dundas valley. Mr. Geikie, in referring to these old lakes, says such filled up lakes are probably far more numerous than we have any idea of—for it is always difficult to prove that a wide flat of alluvial ground marks the site of an ancient lake. The barriers that formerly held the waters become obliterated, either by being swept away or buried deeply under recent deposits. Such is the case with not a few rock basins, where the lower lip of rock is often concealed below silt, sand or gravel, and it is only by boring that this fact can be demonstrated.

In this district, fortunately for the theory of its being an ancient lake bed, the barriers are not wanting. The Height of Land, we can easily see, formed the border of this lake on the north and eastern sides. In all probability the western border will be found in the upper beds of the Onondaga group, while the southern side would be partially left open for the connection with Lake Erie by the Grand river, to which, we have already seen, all the streams in the district are tributaries.

The deposits forming the upper beds of drift in the valley proper correspond very nearly to those in the region which we have just shown to be the bed of the post-glacial lake. The sands and clays, brown and blue, are present in many places in regular order, thus showing in a pretty conclusive manner that the operations concerned in the formation of the one were also actively engaged in the construction of the other.

This district has also its bounds shown—the three sides, the escarpment,

and the fourth we have already assumed to be Burlington Heights partially, or it may have been occasioned by the retiring glacier damming up the waters in the valley and forming a lake.

The valley proper has, however, several features altogether wanting in the district to the west. In the western district just described, I have not in any instance seen any boulders or fragments of native rocks. Boulders of any kind are not very plentiful and those generally found are altogether rounded and water-worn granites.

Well-diggers and the farmers of the district assure me that the underlying clays whenever pierced are absolutely free from stones. Of course, in a wide district like this and the small holes usually made by the diggers, it would be a strong assumption to say there were no stones to be found in the clays. On every farm there is at least one well, and on some farms two or three, many or most of which have entered the blue clay. When these numerous diggings fail to show stone, we may assume that stones are by no means of frequent occurrence in the district. Beds of gravel are also reported as being absent.

Now, the condition of the underlying blue clays of the valley is altogether different.

The borings in many places report the underlying clays to be literally packed with stone, and limestone fragments in nearly every case.

Beneath the upper bed of the blue clay, gravel and shingle are of frequent occurrence. These again in some places are underlaid by a lower bed of blue clay. The blue clays in the head of the valley lie upon the rock, while the beds of the same material towards the mouth of the valley are underlaid in most places by beds of shingle, gravel and silt.

Another feature of the upper blue beds is their want of uniformity throughout the valley. In Mr. New's boring we find it within eight feet of the surface, while in the boring at Mr. Buttram's, about a mile and a half further south west, its place is supplied by beds of brownish clay, inter-stratified with fine sand or silt.

Again, at Mr. Arthur's the blue clay clay underlies a bed of gravel 27 feet thick, and at Dundas the blue clay under the gravel beds is more than 60 feet.

The positions of these underlying beds of clays, sands, gravels and shingle correspond in many particulars to instances given by Mr. Geikie in his "Great Ice Age."

The positions and formations of the beds of gravel and shingle underneath the blue clay can only be accounted for by assuming them to have been in that position before the blue clay was laid down.

Several reasons may be adduced in favor of the theory of these beds being already in the positions they are now found in prior to the deposition of the glacial bed:

First—If Dundas valley was an arm of a pre-glacial sea, then, from the shape of the valley, there would be a tendency of gravel, sand and other material to gather within its bounds, but in that case these beds of gravel and sand would stretch across the valley in a semi-circular form. Many of the gravel beds appear to lie in this position.

Second—If Dundas valley is the gorge or canyon of a pre-glacial river, then these gravel beds would be ranged on one or both sides of the old river bed. In the case of most modern rivers running through gravelly soil, all gravel or sand bars usually stretch down and across the stream from one side or the other. If this rule be applied to the gravels underlying the clay beds in Dundas valley, we would be warranted in ascribing these beds to an existing pre-glacial river. These gravels, if belonging to a pre-glacial age when the

valley was an arm of the sea, would not only be placed in a position across the valley, but would be likely to contain fossil shells of the species living in the waters of that time. None, however, have been obtained from any of the beds. They would also have a stratified appearance, the strata lying at a low angle and sloping down the bay towards the lake in the same manner as the gravel beds of the upper deposits. From all that is at present known concerning these beds, it is not very safe to say how they may slope, or how far their stratification may be depended on.

Third—That these gravel beds were laid down prior to the glacial period is also borne out by the position of the clay beds found on Lot 40, or on top of what must at one time have been a fall in the course of the stream passing through the valley. At the place where sandstone was struck in boring, clay containing fragments of limestone was found resting upon the rock, while in different places of the same lot this clay was underlaid by sand. The same thing occurs in the course of the Niagara, and we may assume that this place in which the clay was found resting upon the rock was subject to a strong current which prevented the sand from gathering in its course, while the comparative quiet at the banks of the river allowed accumulation or beds of sand and gravel to be formed. Near the Height of Land, at the head of the valley, these underlying sands and gravels are found in positions leading the observer to infer that, previous to the deposition of the last beds of clay at least, a stream of considerable magnitude passed down toward the valley and over the rock bedding on Lot 40.

DRAINAGE SYSTEMS.

This district appears to have two systems of drainage, an upper and lower, In the valley, both systems are draining in the one direction. In the district, around the head of the valley, the superficial system carries the water to the Grand river, while the underground or deep-seated system apparently carries its water towards the Dundas valley.

I am aware that the evidence to be adduced in support of this theory is very meagre and consists chiefly in the nature of the waters shown in the different wells and springs throughout the region.

Numerous sulphur springs are found, stretching from the Onondaga group, at Paris, down toward the head of the valley.

One peculiarity of these springs is, that they are only found in certain band-like traets, and are always more or less deeply seated springs.

The superficial waters on the margin of this band are perfectly fresh and apparently bear no relation whatever to the waters underneath.

Nor is this band lying in a straight line between the two formations—that is, between the Onondaga and Niagara—but, from what can be gathered from the position of the wells of sulphur water, they follow a line along the Grand river from Paris to Onondaga, and then branch around toward the head of Dundas valley.

These wells are found on Lots 30, 31 and 39 of the IV. Concession of Ancaster, and again a the Sulphur Springs, about two miles west of Ancaster. The analysis of this water made in 1858, by Dr. Wilson, gives :—

Chloride of Sodium	3.5476
Chloride of Potassium	.0052
Chloride of Calcium	1.3528
Chloride of Magnesium	.4190
Sulphate of Lime	.6500
Carbonate of Lime	.2035

Carbonate of Magnesia	.0160
Carbonate of Iron	.0274
Silica	.0097
Organic matters, Phosphoric Acid, Alumina and Iodine	Traces.
Total	6.2312

The carbonates are bi-carbonates. The sulphuretted hydrogen 5.6 inches to 100 inches of water. The spring is slightly thermal.

In addition to these Sulphur Springs, there are also saline springs running in a direction nearly parallel to the sulphur. On lot 34 of the III. Concession of Ancaster, a well gives brackish or salt water, and on Lot No. 39 of the I. Concession of the same Township a salt well is found. This well was considered of sufficient strength to warrant an attempt to make salt being made. Again, in the valley, a well charged with salt is reported. There is also a saline well in a brook near Dundas.

Sulphur springs are by no means rare in districts overlaid by the Niagara group, but the peculiar positions of these springs in this district seem worthy of remark.

No springs would rise from the rock unless there were fractnres or fissures in the rock enabling them to reach the surface. May not these fractures be the sides of the canyon through which an ancient stream passed, on its way from the present course of the Grand river to the outlet through the valley.

The evidence of the saline springs appears to me to show that there is a gradual underground drainage from the higher beds of the Salina or Onondaga group towards Lake Ontario, or in the direction of the lowest level.

Of the present surface drainage enough has already been said to show that, with the exception of one or two streams at the most, the present system is altogether of recent origin.

The only stream which I have observed that can really be ascribed to be of pre-glacial or inter-glacial origin is the one at Ancaster. From the drift filling its old channel, and from the position in which it enters the valley, it can easily be inferred that this stream existed at a time before the ice action set in, and that it entered the valley when a current was flowing through the valley towards Lake Ontario.

The question of the origin of Dundas valley is one of considerable importance, and if properly solved would prove valuable as a key towards the solving of many of the problems connected with Canadian Geology.

We have already seen that two theories have been put forth—one that is of glacial origin, and the other that it is due solely to fluviatile and ærial erosion.

The supporters of both theories bring forward evidence to prove their assertions.

To briefly recapitulate the evidence supporting these theories will require little space. Mr. George J. Hinde asserts that it is wholly of glacier origin and points, in support of his theory, to the ice markings found throughout the whole district, and also to the beds of blue glacial drift, or till, lying in the bed of the valley. He also points out the form of Lake Ontario and the direction of the glacial striae found at both ends of the lake. Another proof of the glacial origin of the valley is the evidence of pre-glacial outlets from the southwest end of Lake Erie towards the Mississippi valley and the absence of any outlet for the waters of Lake Ontario towards the northeast by the St. Lawrence in pre-glacial times.

The fluviatile theory is supported by Mr. J. F. Carll, of the Geological

Survey of Pennsylvania, and Professor Spencer, of Kings' College, Windsor, N. S. Mr. Carll has shown by numerous measurements of borings that the whole, or at least the greater part of the pre-glacial drainage of the northern division of the State of Pennsylvania, was into Lake Erie, and from the directions in which these streams entered Lake Erie that their course must have been down the lake towards the northeast.

Prof. Claypole, in a paper on the origin of Lake Erie, also supports Mr. Carll, by stating that the basin of Lake Erie must have existed before the advent of the glacial period. He says: "If Lake Erie had been excavated in this manner (that is, by glacial action) there would have been evidence of the beds of drift around the south end of the lake." He ascribes the formation of Lake Erie to the action of an ancient river flowing through the region in pre-glacial times. Lakes Erie and Ontario would then be a broad, open valley, worn out where the rocks were soft, and connected by deep channels where they were hard.

Professor Spencer, in his paper, assumes this theory as correct, and points out that the deep channel connecting the two lakes, Erie and Ontario, would in all probability be through Dundas valley.

The evidence gathered by personal inspection and given in the foregoing pages all tend towards the confirmation of the theory laid down by Professor Spencer that Dundas valley formed in preglacial times the connecting link between Lake Erie and Lake Ontario.

One objection to this theory might, however, be raised. There does not appear to be any outlet for the waters of this river after reaching Lake Ontario. Professor Spencer has, after examining the district to the south of the lake been unable to find a position for an outlet. I am unacquainted with this region, but from a study of the maps of the United States Coast Survey, and the frequency of rock bottom, would favor the opinion that some local elevation has had the effect of closing up the old channel, and by damming up the waters has formed Lake Ontario and forced the water to find a new channel through the St. Lawrence. Of this, however, I have no evidence to offer, and can only feel that if the evidence I have here produced has any effect towards settling the question of the origin of Dundas valley my object has been attained.

DUNDAS VALLEY.

DUNDAS ARTESIAN WELL, SHOWING UNDERLYING STRATA.

The right hand column gives the Contractor's record and classification. The left hand column is from a section by Mr. Bell. The dip of the beds is about thirty feet to the mile.