TORONTO'S GEOLOGY
(including history, biota and High Park)

by Frank Remiz

INTRODUCTION

The last period of glaciation dramatically changed the landscape of Ontario and the adjacent US states. When it ended, massive quantities of till that had accumulated under and beside the ice lobes were left, though sometimes moved further by meltwater. The resulting landforms, including the shore of old Lake Iroquois, were then eroded by rivers & creeks, and then altered by urban development and industry. *(Sincere thanks to Professor Nick Eyles and geologist Ed Freeman for reviewing drafts.)*

BEDROCK AND MOUNTAIN-BUILDING

To reconstruct the longer history of Toronto, one needs to properly consider the *bedrock*. One way to reach it would be to strip away tens of metres of glacial till, and excavate many layers of rocky sea-bottoms, to a depth of nearly 400 m.[1] Another way, *used here*, is to jump back in time, about 1.6 billion years,[2] and then begin a journey forward. Figure 1 identifies the 'periods' on the time-line.

That bedrock, also found in Muskoka, Haliburton and south into the US, is the *southern* (Grenville) portion of the Canadian Shield (see Figure 2). It was formed under conditions of enormous heat and pressure within the earth, resulting from a slow but massive collision. The original North American continent (the *northernmost* portion of the Shield: it is 3 billion years old and occupies much of north-central Canada) folded against what would much later become South America. The Grenville mountain range extended from Labrador to Tennessee, and was as high as the Himalayas.[3]

Figure 1: Geological time-line with names of 'periods.' (Geological Survey of Canada, 2007).

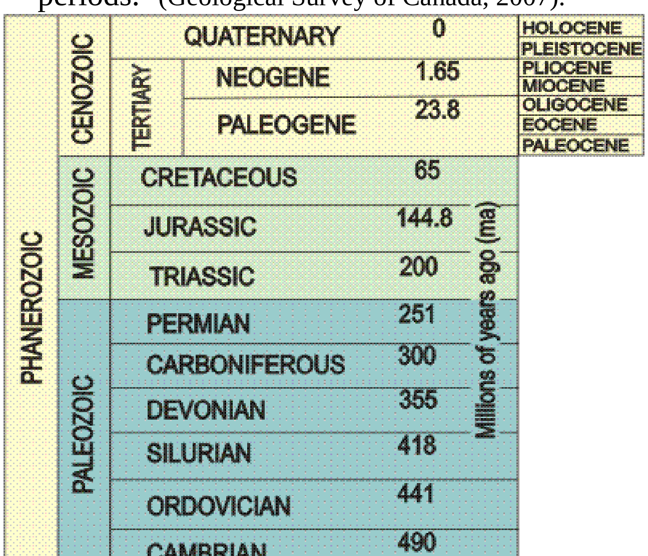
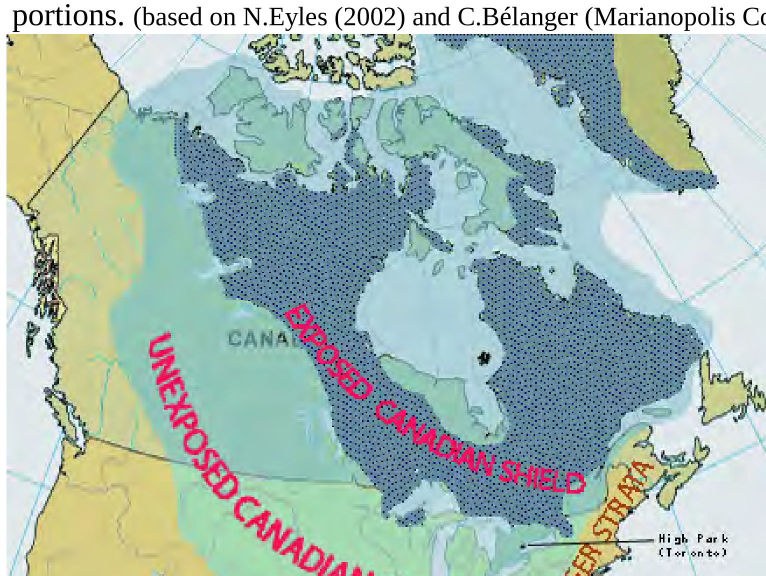


Figure 2: Canadian Shield showing exposed & unexposed portions. (based on N.Eyles (2002) and C.Bélanger (Marianopolis Coll.)).



Molten material from within the earth (magma) erupted from volcanoes, and penetrated fissures in subterranean rock. The high temperatures within the earth changed much of the original granite and sandy sediments to gneiss, and some of the periodically-formed limestone into marble.

By 700 million years ago, powerful convection currents in the earth's mantle were forcing magma into pre-existing rock, and tearing supercontinent Rodinia apart.[4] The 'North American' portion along with the Grenville Mountains then separated from it, whereupon the southern Ontario area was inundated by the newly-created Iapetus Ocean. In the tropical climate, coral reefs developed, which later turned to limestone. Later, that ocean became progressively smaller as the plate on which it sat was drawn down under the east side of the North American plate. This was accompanied by volcanic activity, and the creation of the Taconic Mountains.[5] At this period, 'Toronto' lay south of the equator.

INLAND SEA

By 450 million years ago, a large network of rivers flowed across 'southern Ontario' into a vast inland sea covering much of what would become North America. It almost completely eroded the land that had been forced up.[6] Clay-rich sediments beyond the deltas were compacted to form layers of shale. Similarly the lime-rich muds formed limestone,[7] including the particularly resistant, magnesium-rich dolostone that would later define the 'cap' of today's Niagara Escarpment (40 km west of Toronto). The warm, shallow waters supported a large variety of life (see Figure 3), including corals, sponges, clams, crinoids (sea-lilies), brachiopods, cephalopods and trilobites (ancient shrimp). Gradually, their skeletal remains accumulated, and under pressure turned into stone, leaving cast & impression fossils (see Figure 4). The rock layers underlying the area from Kingston to London are shown in Figure 5.

Figure 3: Typical marine animals in Toronto, 450 million years ago. (based on diorama at Royal Ontario Museum, 1978).

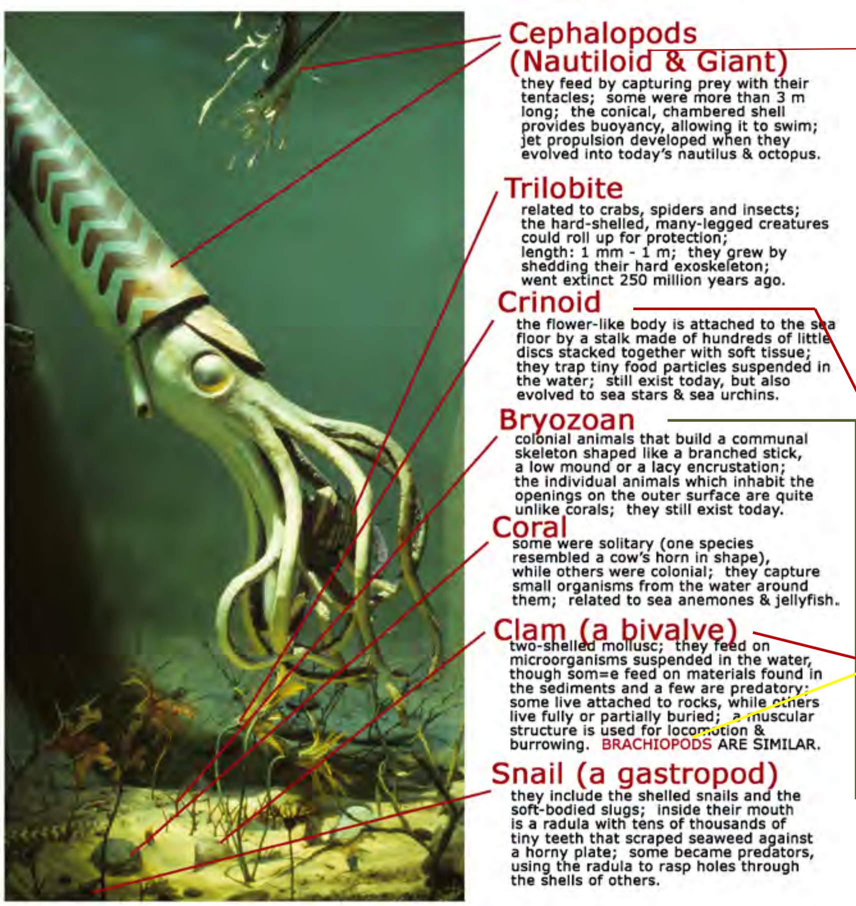


Figure 4a: Some common Toronto fossils, 450 million yrs ago (not to scale). (ROM,1967).

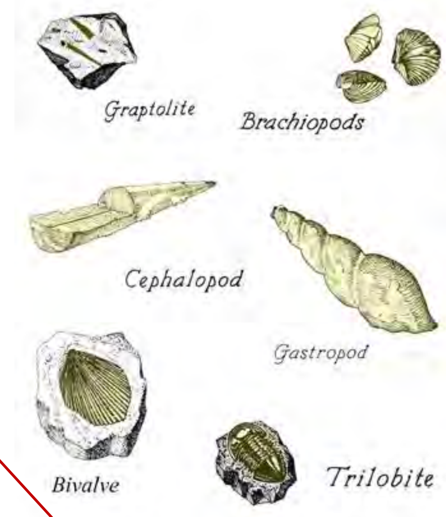


Figure 4b: Toronto rock with fossils. (ROM).

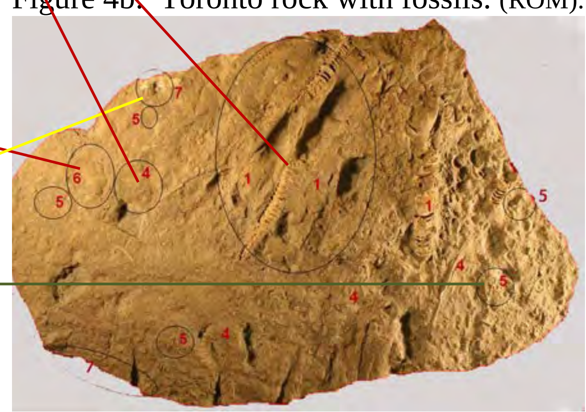
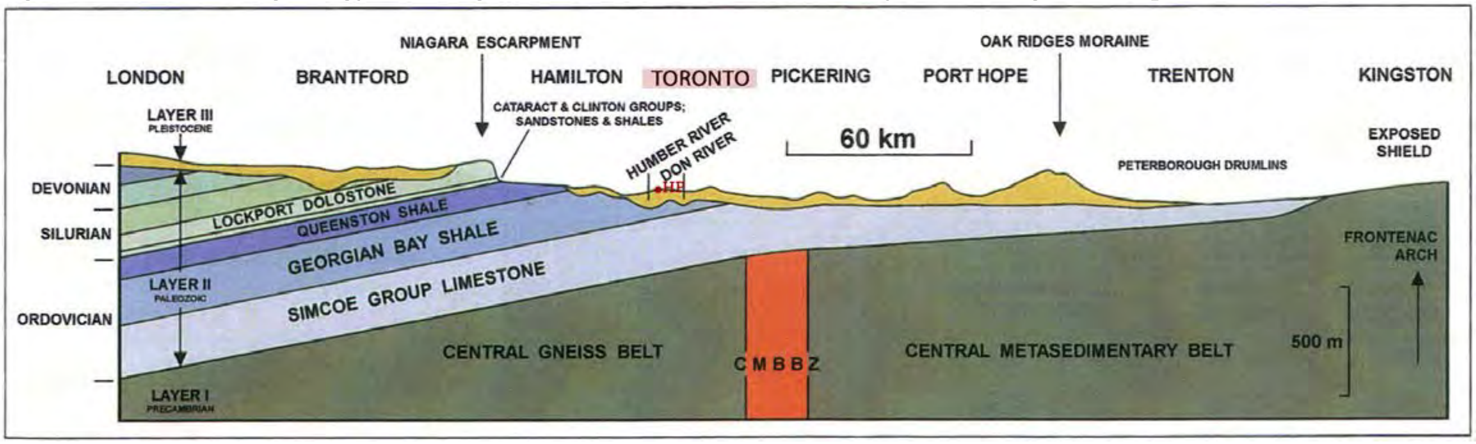


Figure 5: Subsurface geology showing bedrock (dk green), sedimentary rock and glacial deposits (tan). (N.Eyles,2002).



By 300 million years ago, North America and Africa were a new continent, called Pangea. As layers of rock were thrust over bedrock, the Appalachians were formed.[8] The now-deeper seas supported more fish life; their fossils have been found at Port Colborne (70 km south of Toronto). Amphibians became abundant in many parts of the world, and reptiles a hundred million years later. But there is no evidence of them in Ontario's geological record. When the seas finally evaporated, large amounts of salt were left behind (e.g. at Goderich, 180 km west of Toronto). Further west, in Michigan, were swamps with ferns, scale trees (Lycopodiophyta), horsetails (10 m high) and seed-ferns.

By 150 million years ago, Pangea was breaking up, with the widespread occurrence of 'graben faults.' Not only did these lead to the creation of the Atlantic Ocean, but also the St. Lawrence and Ottawa valleys.[9] Finally, North America assumed its present shape.

LAURENTIAN RIVER AND BEGINNING OF 'GREAT LAKES'

Perhaps 3 million years ago,[10] water began to cut channels in the bedrock. The biggest ones created the axes of today's four lower Great Lakes. The channels, once connected with the earlier rift in the 'Superior Valley,' would have been the first manifestation of the ancient St. Lawrence River system.[11] One part of it, called the Laurentian Channel, flowed south from today's Georgian Bay between the Niagara Escarpment and Lake Simcoe, passing very close to where Aurora, Nobleton and Bolton are located.[12] From there it approached the Toronto area, not as a single river but multiple ones, sometimes as much as 20 km apart, tracing the origins of today's Humber and Don valleys[13] as well as the nearby Rouge and Credit. The water continued 20 km beyond today's Lake Ontario shore (that lake didn't yet exist), before connecting with the Erigan River (flowing east across today's Erie basin and through a valley *west* of today's Niagara River (Dundas V. was J.W. Spencer's surmise)). From there, the Laurentian River system continued east along the middle of the Lake Ontario basin, its surface 100 m lower than that of today's lake.[14] The water then entered the St. Lawrence rift valley, and finally emptied into the ocean. Figure 6 has maps of the Laurentian Channel and the ancestral St. Lawrence River system.

Over the next few hundred thousand years, well before the latest Ice Age, the portion of the Laurentian river system between Georgian Bay and Toronto (as well as other portions) was extensively altered and infilled by multiple glacial processes, including the action of the associated melt-water. The Laurentian Channel still exists today, buried deep below a thick cover of glacial sediments. Water, squeezed against the bedrock bottom, seeps very slowly through this mass, south across the Toronto region. It is a remnant of the Laurentian River; some call it an aquifer. In High Park, it 6 m deep, 38 m below ground (23 m below Lake Ontario's surface). In 2003, during the course of some drilling work near Spring Creek, it erupted 20 m into the air.[15] Reddish stains are also visible, the result of oxygen reacting with the small amount of iron from hundreds of kilometres away.

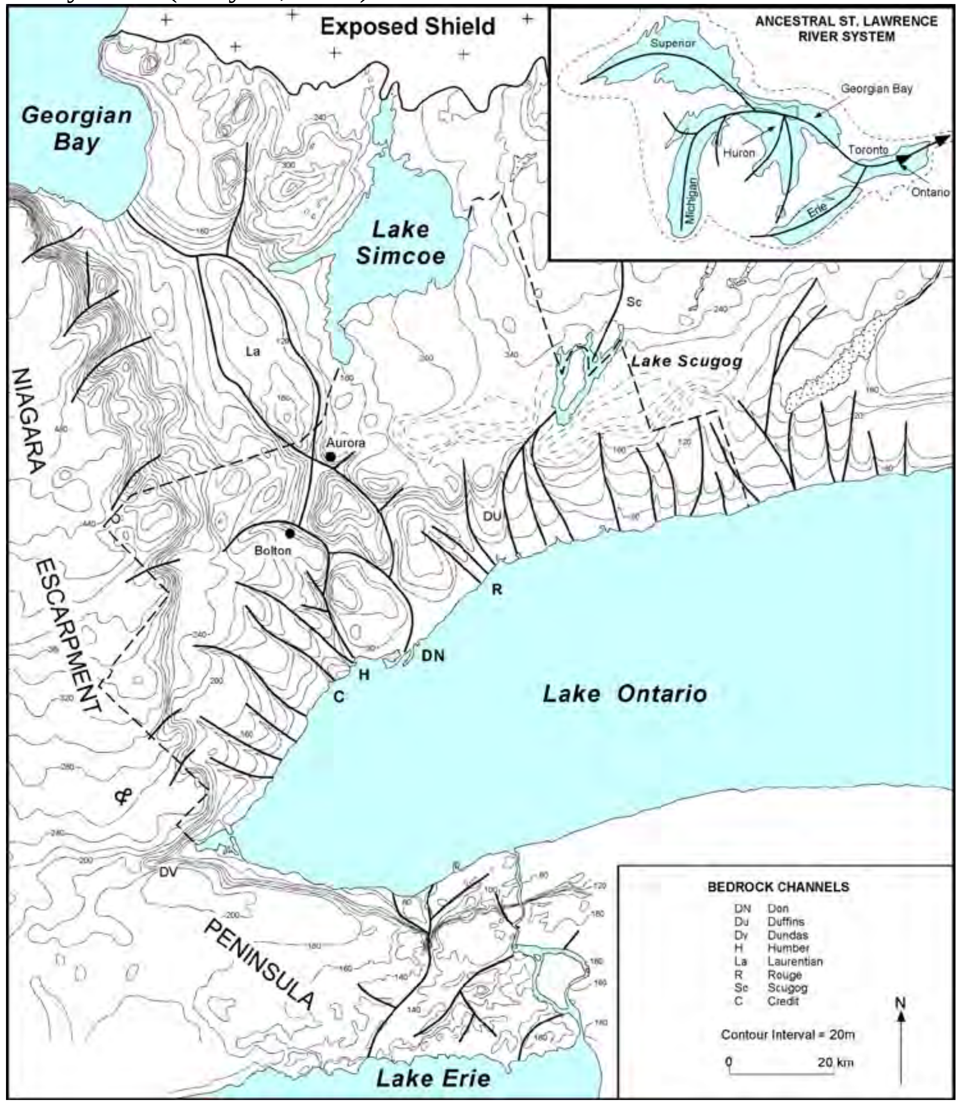
THE LAST ICE AGE AND LAKE COLEMAN

About 2.5 million years ago, the climate once again became much colder for an extensive period of time, heralding the most recent of the planet's numerous Ice Ages. Snow and ice accumulated annually, creating an ever-larger ice-sheet across northern Canada. Soon it began to creep south, gouging out lake basins along the way, including those that would become the Great Lakes.

About 135,000 years ago (during the Illinoian Glaciation), the underlying, 470-million-year-old shale was ripped up, and a 1-metre-thick layer ('York Till') was laid down; it is the oldest-known glacial deposit in southern Ontario.[16] Then, during an interglacial period, 120,000 years ago, a set of sand & clay deposits ('Don Formation') was laid down. The abundant fossils, including the Osage orange and pawpaw trees as well as 10 shellfish now only found in the Mississippi River, indicate a climate much warmer than ours today.[17] These 2 layers (and 5 others) occur in localized areas, and are clearly visible at the old Don Valley Brickworks quarry (8 km northeast of High Park).

About 80,000 years ago, during the latest period of glaciation (called the Wisconsin), the Laurentide ice-sheet began to cover most of the Laurentian River valley. Sand, gravel and boulders were carried forward, and deposited along the way.

Figure 6: Maps of Laurentian Channel & ancestral St. Lawrence River system. (N.Eyles, 2002).



The ice-sheet receded on a few occasions when the climate became warmer. Each time, the glacial melt-water would create rivers which not only carried sand and silt away from the glacier, but also carved up the land in its path. So much water (and sand and silt) flowed into the basin of 'Lake Ontario' 75,000 years ago[18] that it was given a unique name: Lake Coleman. It was a precursor of Lake Ontario. It was 20 m higher[19] than today, and as a consequence its deltas were further upriver.

The ice-sheet reached its maximum extent 20,000 years ago[20] (advancing to Illinois and Ohio, and reaching from Newfoundland west to British Columbia). In the Toronto area, the ice was one kilometre thick. A layer of till (boulder clay) was laid down in the Toronto area,[21] including the High Park area. The giant 'ice-plow' scooped more material out of several big valleys, and made the lake basins even more elliptical.

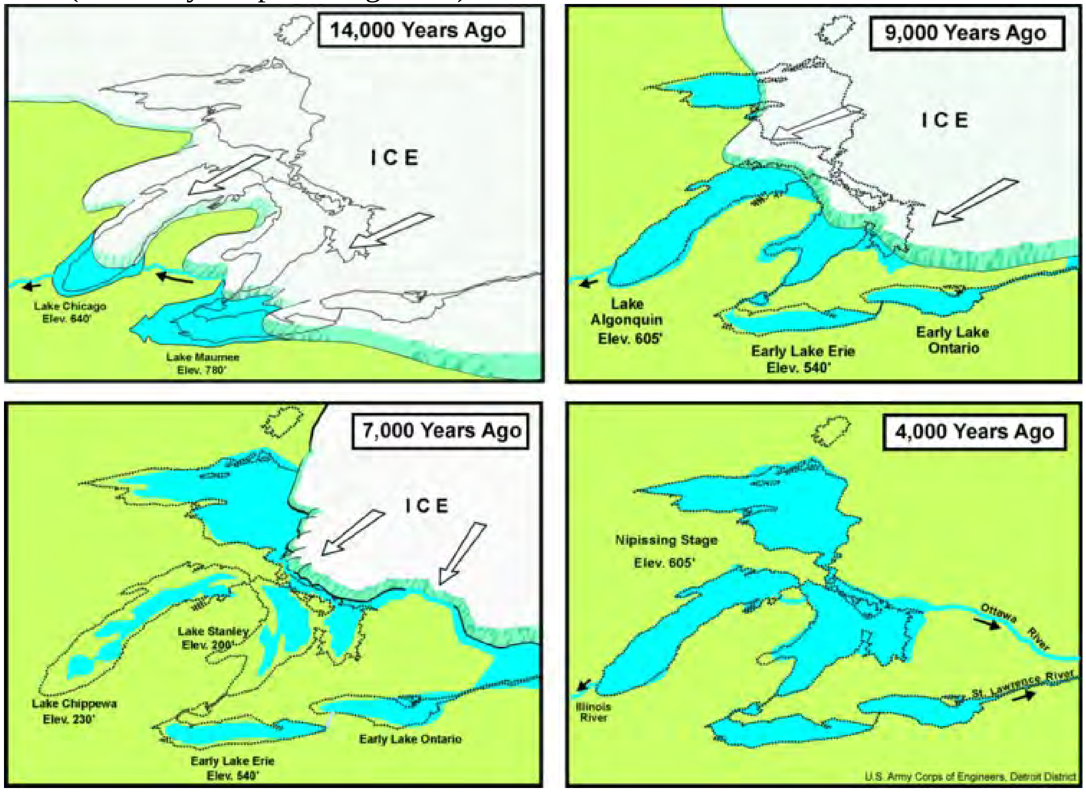
RETREATING ICE-SHEET

14,000 years ago, the ice-sheet thinned and generally retreated, while still sometimes advancing. Part of the ice lobe advancing west along the 'Lake Ontario' basin moved northwest across the Toronto area. Another lobe pushed south against it. The debris left along the facing sides of these lobes is known today as the Oak Ridges Moraine (25 km north of the city).[22]

Meanwhile, loose material carried forward *under* the ice was sometimes left in place, later appearing as whale-shaped, 40-m high, 1-km long 'drumlins,' e.g. at and near Bathurst & Eglinton Ave. Their NW-SE orientation shaped the flow of later creeks. The deeper parts of High Park's tablelands (& beyond) would date from this period, but their precise origin has not been determined.

About 13,000 years ago, the ice retreated from the 'Lake Ontario' basin. Much melt-water accumulated, more than at any previous time, so it was given a new name: Lake Iroquois. It was the largest lake yet in that basin. The shore was 4 –15 km away from where it is today. In the Greater Toronto Area (GTA), striking remains can be seen along the Highland Creek, crossing the Rouge Valley, and on the Seaton Trail in Pickering.

Figure 7: Map set showing the four stages of ice retreating from Great Lakes. (US Army Corps of Engineers).



Lake Iroquois was 35 m deeper[23] and 60 m higher[24] than today's lake. In the relatively shallow waters near the shore (the south part of Toronto), deposits would have been made. Today there are sandy and silty-sandy soils[25] there. Below those soils, and at the surface of most other parts of Toronto, are mainly clay-silt and sandy-silt soils, formed from glacial till.

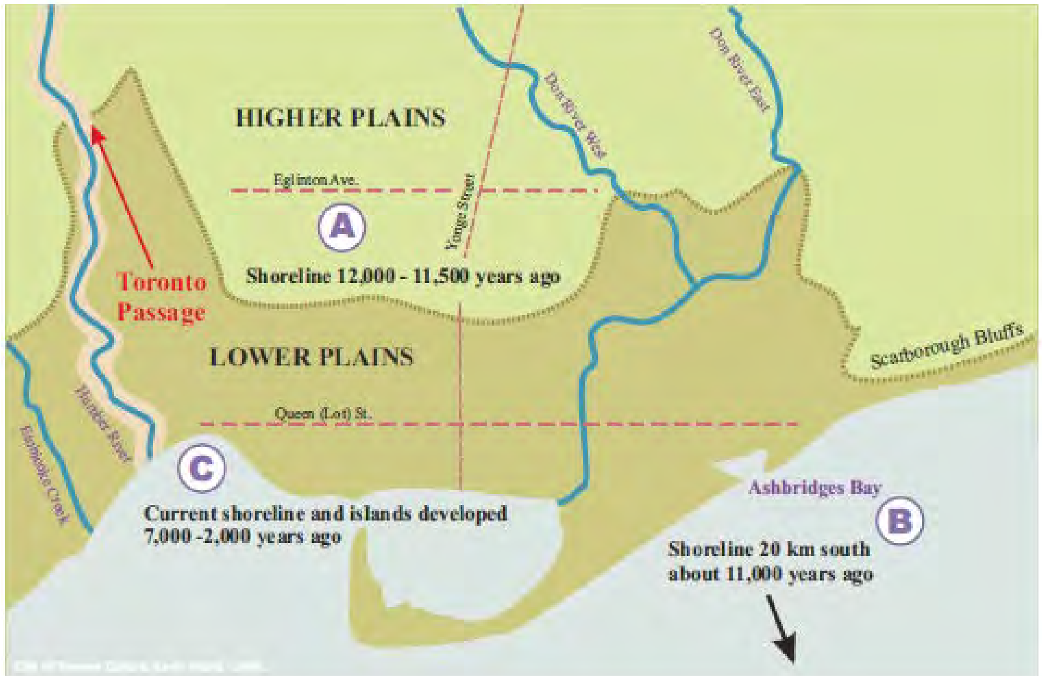
Feeding in to the lake was water from Lake Erie's predecessor (by this time, flowing over 'The Falls'). Water flowed out through the Hudson Valley via the Mohawk or Champlain Valleys, as a result of the initial retreat of the 'New York State' ice lobe. [26]

Then, 12,000 years ago[27] (or possibly earlier), the ice dam in the St. Lawrence valley broke up. Water from the lake immediately flowed through this new outlet, to the sea. The extremely low sea levels of 10,000 years ago, along with the area's somewhat depressed crust (from the sheer weight of the ice that had been resting upon it), allowed the lake to almost empty itself (this is known as the L. Admiralty phase).[28] The original river deltas and bays would have dried up, leaving sandy plains. The rivers would have followed the grade, and cut though the glacial sediments of the exposed lake-bed, creating new deltas at the receding shoreline. Watercourses would have developed in the High Park area, though perhaps not the same ones seen today. Two 5-km-long, sand & gravel bars are visible in Toronto, running east-west from Keele & St.Clair and from Danforth & Victoria Park Ave.

By 8,000 years ago, as the ice cover retreated further northeastward, the St. Lawrence valley area and the eastern end of Lake Iroquois were uplifted (isostatic rebound). This caused its lake levels to rise, and many valleys to flood.

The land covered by ice during the preceding several thousand years would have progressively, but rather quickly, become revegetated. The southern Ontario landscape would initially have been a boreal forest, but, as average temperatures increased, it would have shifted to a mixed forest. In addition, certain 'southern' species like Eastern White Pine and Sassafras were able to extend their range north to the Toronto latitude.[29] On the moist ravine slopes of areas like High Park, maples and Eastern Hemlock were common. On the tablelands between the ravines, in the park and on 3,000 hectares nearby, an open-canopy forest would have developed. In particular, island-like stands of widely-spaced oak trees[30] would have been dominant, along with prairie grasses and multitudes of wildflowers. The integrity of this oak-savannah plant community would have been maintained with naturally occurring fires. This community also established itself at the mouths of Toronto's rivers, and at least another 70,000 hectares elsewhere in southern and south-western Ontario.[31]

Figure 8: Map showing the shores of the precursors to Lake Ontario. (City of Toronto).



WATERCOURSES IN HIGH PARK AND VICINITY

Figure 8 shows the changing location of the shoreline of 'Lake Ontario.' As the lake began to assume its current shape, about 3,000 years ago, the rivers as well as hundreds of creeks and streams of the GTA would have modified their watercourses, as they cut through the thick layers of sediment and gravel. Spring Creek (in High Park's eastern half) and Wendigo Creek (on its west side) would have existed by now, though not yet in their final, pre-settlement form. They would have had a much greater water-flow, extending a few kilometres north of what is now Bloor Street, with a number of tributaries. Close to the lake, the rivers would have traversed gently sloping land, moved more slowly, and meandered.

The two creeks (as well as the GTA's Humber, Don, Rouge and Credit Rivers) probably became straighter over time, as the meanders were isolated by fluctuating water levels, leaving sand and gravel bars, and sometimes marshy ponds. (This is substantiated by pollen counts from cores on the most southerly 2 km of the nearby Humber valley.[32]) At the same time, the lake levels were still slowly but steadily increasing, inundating the lower parts of the river valleys. Also, wave action on the 'new' beaches would have moved sand and gravel, sometimes adding significantly to the bars already there or blocking the outlets. The result was trapped wetlands.[33] Such was the case with Wendigo Creek, and to a lesser extent with Spring Creek (and dozens of others along the lake's north shore). Flooding would then have ensued.

This is how Grenadier Pond, largest of the park's 3 ponds, was formed. Its southern shore is, essentially, the Wendigo Creek sand bar.[34]

Grenadier Pond is surely no more than 2,000 years old, based on when Lake Ontario assumed its current form and its close proximity to the lake. Along the shores of the pond, Red Maple and willows would have been commonly seen, while Speckled Alder would have grown in the adjacent bottomlands.

Beyond Grenadier Pond's sand bar, and opening onto the lake, a large marshy area remained. From time to time, big storms or elevated water levels from either direction would have broken though the sand bar, briefly directly connecting the pond with the lake (similarly at Lower Duck Pond, which probably formed through a similar process). Such wash-outs served important ecological purposes, and helped the pond renew itself.

Today, nothing remains of Wendigo's original lakeshore marsh, and there is only an isolated portion of Spring Creek's marsh. Most of the other lakeside marshes are also gone. Also, many of Toronto's smaller watercourses would have been covered up or channelled into sewers as the land was graded for housing subdivisions. (This is why some streets, like Glendonwynne, just north of High Park, are winding and slumping.) Figure 9 shows their earlier location, as well as the park's current outline.

Figure 9: Some of Toronto's 'lost rivers' in relation to High Park. (D.Spring, 1999; courtesy of Lost Rivers, Toronto Green Community; modified).

SUMMARY AND CLOSING

The earth's continual, almost imperceptible changes can be parsed into events in a drama. Toronto has the same geological history as the area reaching 120 km north to Midland, 220 km east to Kingston, and across to the south shore of Lake Ontario. They share the billion-year old southern Canadian Shield, rock layers formed in a big inland sea, and a pre-glacial river that began to delineate the Great Lakes. In Toronto, 450-million-year-old fossils can be found along the banks of the Don, Humber, Mimico, Etobicoke and Credit valleys. By understanding the conditions at that time, one can better appreciate its natural history, and which organisms flourished. A few thousand years after the glacial ice had receded from Lake Ontario, the soil & climate conditions in parts of southern Ontario were favourable for Carolinian forests or oak-savannah meadows. The latter is still found in High Park. Its northern ravines are still relatively undisturbed, and show what Toronto would have looked like hundreds of years ago. The geomorphology of its ponds can still be discerned, even though the park is now isolated from the lake.

To buy the booklet or to learn more about Toronto's natural heritage visit torontofieldnaturalists.org or highparknature.org

FOOTNOTES:

[1] Freeman, E., 2008. 'Formed and shaped by water: Toronto's early landscape,' in: HTO – Toronto's Water from Lake Iroquois to Lost Rivers to Low-flow Toilets, W.Reeves & C.Palassio (eds.), p.26.

[2] Ontario Geological Survey, 1992. Chart C - Proterozoic Tectonic Assemblages, Plutonic Suites and Events in Ontario (Map 2581), (Ont. Min. of Natural Resources). (Web path: Ont. Min. of Northern Development & Mines > Mines and Minerals > Geology Ontario).

[3] Eyles, N., 2002, Op.cit., p. 102.

[4] Eyles, N., 2002, Op.cit., p. 118-119.

[5] USGS, 2004. Geologic Provinces of the United States: Appalachian Highlands Province.

[6] Eyles, N., 2002, Op.cit., p.130-134.

[7] Freeman, E., Op.cit., p.26.

[8] Eyles, N., 2002, Op.cit., p.144-145.

[9] Eyles, N., 2002, Op.cit., p.162.

[10] Freeman, E., Op.cit., p.27.

[11] Eyles, N., 2002, Op.cit., p.217.

[12] Westgate, J., P.von Bitter, N.Eyles, J.McAndrews, V.Timmer & K.Howard, 1999. 'The Physical Setting: A Story of Changing Environments through Time,' in: Special Places – The Changing Ecosystems of the Toronto Region, B.Roots, D.Chant & C.Heidenreich (eds.), p.20.

[13] Freeman, E., Op.cit., p.27.

[14] Freeman, E., Op.cit., p.27.

[15] Conserve News Archive: http://www.waterconserve.org/shared/reader/welcome.aspx?linkid=25732 (accessed 2011).

[16] Eyles, N., 2002, Op.cit., p.198.

[17] Freeman, E., Op. cit., p.29.

[18] Eyles, N. 2008. 'Ravines, lagoons, cliffs and spits: The ups and downs of Lake Ontario,' in: HTO – Toronto's Water from Lake Iroquois to Lost Rivers to Low-flow Toilets, W.Reeves & C.Palassio (eds.), p.34.

[19] Freeman, E., Op.cit., p.29.

[20] Eyles, N., 2002, Op.cit., p.189.

[21] Freeman, E., Op. cit., p.31.

[22] Westgate, J., P.von Bitter, N.Eyles, J.McAndrews, V.Timmer & K.Howard, Op.cit., p.24.

[23] Karrow, P.F., J.R. Clark & J.Terasmae, 1961. 'The age of Lake Iroquois and Lake Ontario,' in: J.of Geology, v.69, p.659-667.

[24] Eyles, N., 2008, Op.cit., p.35.

[25] Ontario Geological Survey, 1980. Quaternary Geology – Toronto and Surrounding Area (Preliminary Map P.2204 Geological Series), (Ont. Min. of Natural Resources). (Web path: Ont. Min. of Northern Development & Mines > Mines and Minerals > Geology Ontario).

[26] Woods Hole Oceanographic Institution, 2004. 'News Release: Flooding from Ancient Lake may have Triggered Cold Period.' (Results of study by J.Donnelly & team were published in Geology, Feb.2005.)

[27] Rideau Info.com: http://www.rideau-info.com/canal/history/rideau-route/shaping.html (accessed 2011).

[28] Eyles, N., 2008, Op.cit., p.37.

[29] Varga, S., 1999. 'The Savannahs of High Park,' in: Special Places – The Changing Ecosystems of the Toronto Region, B.Roots, D.Chant & C.Heidenreich (eds.), p.261.

[30] Applied Ecological Services, 1993. Analysis of Historic and Existing Ecological Conditions of Significant Oak Woodlands at High Park, Toronto, p.1.

[31] Bakowsky, W. and J.Riley, 1993. 'A Survey of the Prairies and Savannas of Southern Ontario,' in: Proceedings of the Thirteenth North American Prairie Conference, p.14.

[32] McAndrews, J., 1999. 'Humber Valley,' in: Special Places – The Changing Ecosystems of the Toronto Region, B.Roots, D.Chant & C.Heidenreich (eds.), p.278, 281.

[33] Eyles, N., 2008, Op.cit., p.38.

[34] Coleman, A.P., 1933. The Pleistocene of the Toronto Region, including the Toronto interglacial formation, (Ont. Dept. of Mines) v.41.

TO LEARN MORE ABOUT GEOLOGY & PALEONTOLOGY:

- 46 page book: Toronto Rocks - The Geological Legacy of the Toronto Region (by N.Eyles & L.Clinton, 2004).
- Web path: Indiana Geological Survey > General Geology > Fossils and Geologic Time > Paleontology Portal > Time and Space: On map click province.

Toronto Field Naturalists

HIGH PARK nature

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