Appendix 1

Geology Features Inventory

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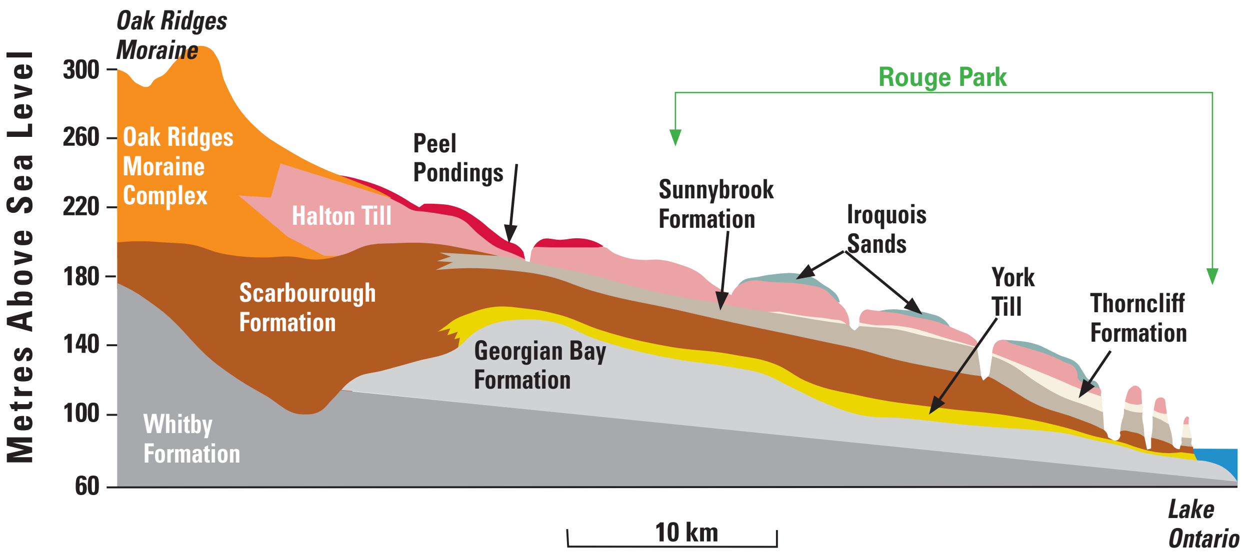
Figure A1.1: Geological North-South Cross-section from Oak Ridges Moraine to Lake Ontario

Based on Eyles and Boyce 1991



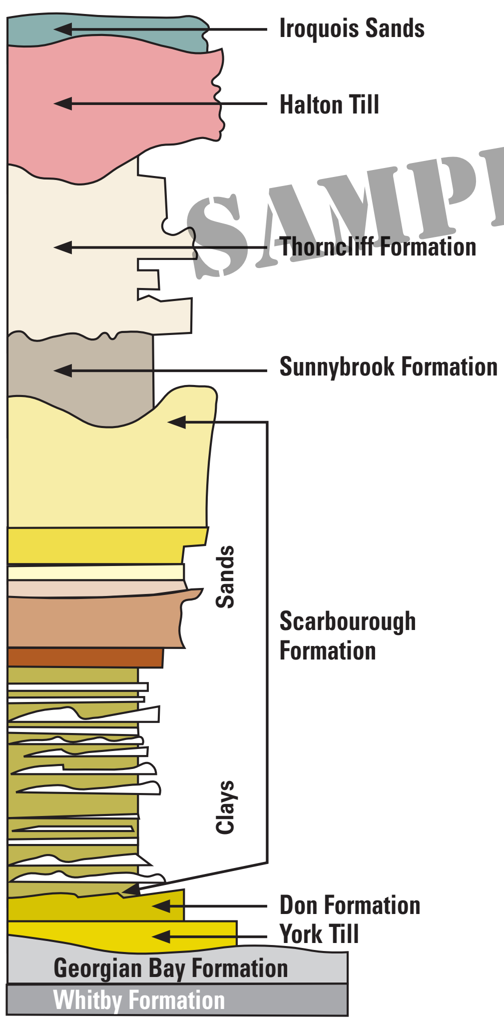


Figure A1.2: Schematic of Stratigraphy of the Toronto Area

Based on Eyles and Boyce 1991

Introduction

A resource inventory identifies in detail specific natural and cultural heritage features and processes and their locations. This can be a valuable tool for HAVE staff on which to provide accurate, meaningful HAVE services in Rouge Park, and as a planning tool for future programs.

A resource inventory can never be complete. By their very nature, the natural systems of the park are dynamic and ever changing. Past, current and future restoration work will have widespread and in some cases, unpredictable repercussions on physical (e.g., stream levels and flood control) and natural/ ecological systems (e.g., rates of forest regeneration and succession) in the Park. New studies may reveal exciting new finds about the many aspects of the park's natural and cultural heritage features.

This appendix is intentionally incomplete. It currently contains background information on the geology and geomorphology of the section of Rouge Park south of Steeles Avenue The geomorphology section is intended to be a model for Rouge Park HAVE staff who will complete the Features Inventory. In many cases, the act of researching the topics outlined in this Appendix will not only increase the knowledge of HAVE staff but also forge contacts and develop mutual respect with experts and community members, reveal new details and should be a living document When complete, this Appendix will review the key natural, cultural and historical features of Rouge Park. It looks at the areas nearby the park and the key natural and cultural features within the park.

Deep History

Geology and Geomorphology

An understanding of Geology and Geomorphology is necessary in reading landscapes, a skill called upon in most interpretation and education services. Geomorphology is the study of the character and origin of landforms, such as river valleys, hills and ridges etc.

Two key sources used for this review were ***Earth Science Survey of the Rouge Valley Park*** by N. Eyles and J.J. Boyce (1991) and ***Toronto's Ice Age*** www.lostrivers.ca/points/BrickworksNorthwall.htm. Eyles and Boyce look at the geology of the lower Rouge River and Little Rouge Creek watersheds. Their report has four valuable large format single colour maps which feature:

- ***Map 1: Physiography and Geomorphology of the Rouge Valley Park***
- ***Map 2: Surficial Geology of the Rouge Valley Park***
- ***Map 3: Location of Outcrops in the Rouge Valley Park***
- ***Map 4: Terrain Sensitivity and Significant Earth Science Features***

Toronto's Ice Age focuses on the Don Valley Brickyard site located near the Rouge River system.

History as told by the Region's Bedrock and Depositional Strata

Rouge Park has numerous erosional features that reveal some of the layers of bedrock and many of the glacier related depositional strata laid down over thousands and millions of years. These layers of rock, boulders, gravel, sand, mud and silt tell the story of the many changes of climate, landscape, flora and fauna that have occurred in what we today call the Rouge River, Petticoat Creek and Duffins Creek watersheds. Each layer can tell part of this long on-going story. See Figure A1.1 for the geological strata found in Rouge Park. The diagram is designed to correspond with the layering found along river banks and road cuts with the oldest strata at the bottom and the youngest at the top.

The progressive down-cutting of the Rouge River and Little Rouge Creek during the postglacial period has exposed some Paleozoic bedrock and much of the overlying Quaternary strata of the park area. Eyles and Boyce (1991) have made an extensive review of the geological features that can be seen along the lower Rouge River system south of Steeles Avenue There is no extensive review of the geology of the upper Rouge River system or the Petticoat and Duffins creek systems. As a result most of the viewable geology described in this plan is located in the lower Rouge River area.

The exposures discussed by Eyles and Boyce (1991) are windows into the subsurface below and can be used to help visitors learn and discover some of the geologic development and deep history of the park landscape. Eyles and Boyce's (1991) *Map 2: Surficial Geology of the Rouge Valley Park* and *Map 3: Location of Outcrops in the Rouge Valley Park* featuring the area's surficial geology is especially useful for locating important features.

Bedrock

Whitby Formation

This is the oldest rock exposed in Rouge Park and one of the oldest types of rock in the Toronto Area. It dates from the Paleozoic era before dinosaurs, mammals and birds. More specifically, it dates from the Ordovician Period, when bony fish first appeared, invertebrates such as trilobites and nautiloids thrived and plants first made it onto dry land. The Whitby Formation consists of crumbly black, gray and blue calcareous (calcium-bearing) and bituminous (coal-bearing) shales. These rocks are exposed along the banks and streambeds of the lower reaches of the Rouge River, Little Rouge Creek and Duffins Creek and rise to the surface near Collingwood and at several locations on the Lake Ontario shoreline between Whitby and Oshawa.

Bedrock in the area studied by Eyles and Boyce is exposed intermittently in cut bank sections along a 2 km stretch of the Rouge River and Little Rouge Creek south of Twyn Rivers Drive.

The Whitby rocks are brown and grey-blue shales of the Upper Ordovician Whitby Formation (Figures A1.3 and A1.4). Most bedrock is covered by thick Quaternary sediments. However, outcrops can be observed along the streambeds and banks of the Rouge River and Little Rouge Creek between Twyn Rivers Drive and 3.5 km downstream at the confluence of the two streams.

There are two provincially significant sites in the park south of Steeles where the Whitby Formation is well exposed:

Site R023—Western Bank of the Rouge River

- 1.2 km downstream of the Twyn Rivers Bridge
- see Figure (A1.2)
- both the upper and middle members of the Whitby Formation are exposed
- (Eyles and Boyce, 1991 Map 3 site R023)
- 1.5 metre high outcrop exposes the brown and black fossiliferous shales of the middle Whitby member at river level
- mud cracks and ripples can be observed
- is the type locality for the middle Whitby member
- middle member grades transitionally upward into blue-gray shales of the upper Whitby member near the top of the section

Site LR015—Northeastern Side of Little Rouge Creek

- approx. 450 metres downstream of the Twyn Rivers Drive crossing
- see Figure (A1.3)
- (Eyles and Boyce, 1991 Map 3: site LR015)
- only the upper member is represented
- about 2.4 metres of the upper Whitby Formation
- a small stream which intersects the outcrop midway along its length

Both bedrock outcrops form a vertical face above river level and are relatively difficult to reach.

Other Whitby Formation Exposures

Eyles and Boyce identified several minor bedrock outcrops along Rouge River and Little Rouge Creek south of Twyn Rivers Drive (these include: Eyles and Boyce, 1991, Map 3: sites R024, LR016, LR018). These exposures are less than 1 metre high and can be obscured by riverbank slumping.

Other very restricted bedrock outcrops are exposed on the western side of the Little Rouge Creek just above the confluence with the Rouge River. Other minor bedrock outcrops occur at various locations along the Rouge and Little Rouge south of Twyn Rivers Drive (Eyles and Boyce, 1991 Map 3; R023, LROI6, LROI8). These are generally less than 1 metres in height and are mostly obscured by riverbank slumping.

The Whitby Formation is a marine shale deposited in an shallow, equatorial sea which flooded the eastern continental interior of North America about 450 million years ago. The lower member is black shales arising from mud deposited in deep water. The middle member records falling sea levels. Here mud cracks and wave ripples suggest deposition in shallow, marginal waters. The abundance of broken trilobite exoskeletons in these shales suggests wave or current action. The upper member was laid down in shallow, quiet waters—shown by intact trilobite remains. For detail on the habitats that formed the Whitby Shales see the Sidebar: The Ordovician Period.

Georgian Bay Formation

Georgian Bay Formation overlies the Whitby Formation. It consists of alternating grey shales and thinly-bedded limestones. These rocks underlie Toronto as far west as Streetsville (Mississauga), and extend northward as a narrow 1–10 km. belt along the Niagara Escarpment to Georgian Bay. Surface exposures of the Georgian Bay Formation occur along the Don River at the Don Valley Brickyard site where it was once quarried as raw material for brick making.

There are no known exposures of the Georgian Bay Formation in the Park.

Figure A1.3
Provincially important shales of the Upper and Middle Whitby Formation. Site R 23 on the Rouge River.
a) b) views of the cut face.
c) close-up of shales

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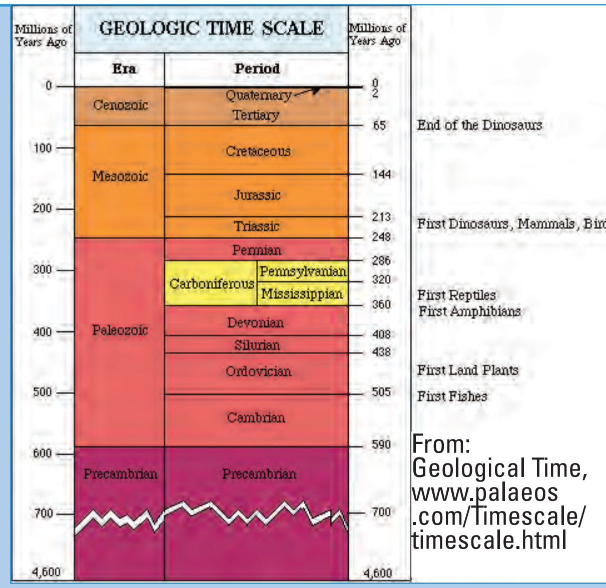
Figure A1.4 Shales of the Upper Whitby Formation. Site LR0 15 on Little Rouge Creek. a) view of the cut face. b) view of the tributary creek that cuts through the face.

Sidebar: The Ordovician Period

The Ordovician Period is the second geological period of the Paleozoic Era. It occurred after the Cambrian Period between 500 and 435 million years ago (see Geological Time Line). Major biological advances during this period include the appearance of bony fish and possibly land plants during the late Ordovician. This important period saw the origin and rapid evolution of many new types of invertebrate animals which replaced their Cambrian predecessors. Primitive plants move onto land, until then totally barren. The supercontinent of Gondwana drifted over the south pole, initiating a great Ice Age that gripped the earth at this time. The end of the period is marked by an extinction event.



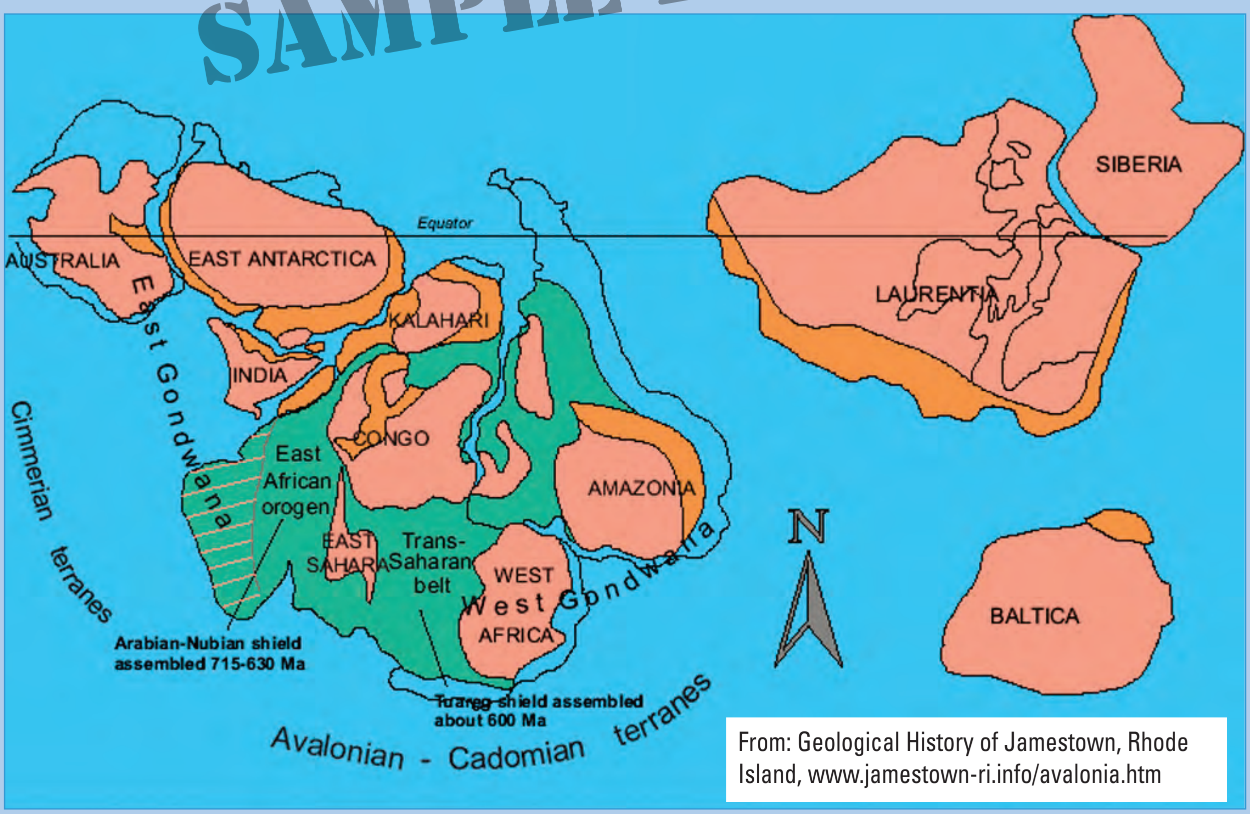
From: Geological Time, www.palaeos.com/Timescale/timescale.html

Paleogeography of Ordovician Times

During the Ordovician, the tectonic plates that included Southern Europe, Africa, South America, Antarctica and Australia remained joined together into the supercontinent of Gondwanaland, which had moved down to the South Pole. North America (named Laurentia by geologists) straddled the equator, and was about 45 degrees clockwise from its present orientation. Western and Central Europe (the continent of Baltica) were separate from the rest of Eurasia, and were rotated about 90 degrees counterclockwise from their present orientation, and was in the southern tropics. Ordovician rocks are mostly sedimentary. They are mostly marine in origin because most of the earth was covered with shallow oceans and land masses were small and low-lying—there were very few sources of land-based sedimentation. Ordovician sedimentary rock consist chiefly of limestone, shale and sandstone.

Climate

The Middle Ordovician featured widespread shallow, warm epicontinental seas. Thus, most of the Ordovician was favorable for marine life, particularly in Europe and North America. However, the Ordovician ended in a brief (300- 500 thousand years), but severe, ice age. Gondwana, particularly Africa, straddled the South Pole and became extensively glaciated. During this ice age, about 60% of animal genera became extinct, making this the second or third most deadly mass extinction of the Paleozoic.



From: Geological History of Jamestown, Rhode Island, www.jamestown-ri.info/avalonia.htm

Paleontologists and climatologist have spent a lot of time trying to understand the causes of the Ordovician Ice Age. It is not easy to see how an ice age could have occurred. Atmospheric carbon dioxide levels are believed to have been 8 to 20 times their current levels. This should have prevented anything approaching an ice age.

Sea levels were high through most of the Ordovician. They dropped, dramatically—about 50 metres—during the ice age.

Ordovician Fauna and Flora

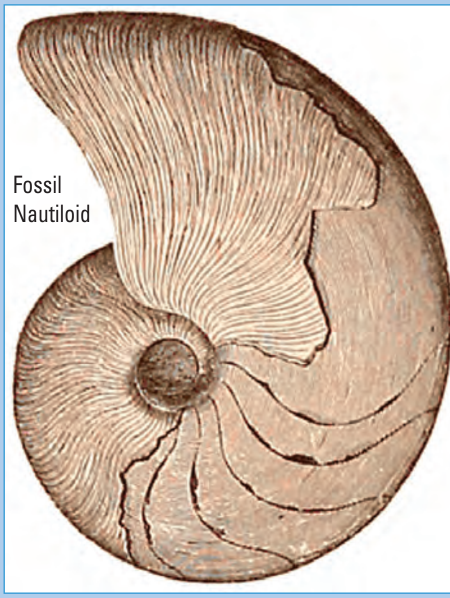
The Ordovician was an age of evolutionary experimentation, in which new organisms evolved to replace those that died out at the end of the Cambrian. It was also one of the largest adaptive radiations in the Earth's history. The number of families of known marine hard-shelled invertebrates—soft-bodied types rarely left fossils— increases from about 200 at the end of the Cambrian to around 500 in the early Ordovician. The widespread shallow, warm continental seas were the perfect environment for many groups of organisms. Micro-organisms such as colonial blue-green algae - stromatolites - are widespread. Foraminifera (marine amoebas which build tiny shells) evolve for the first time. Organisms called acritarchs, although existing during the Precambrian, become more common. Stromatoporoids (possibly sponge-like organisms) also appeared.

Among the molluscs were newcomers such as bivalves (clams)—not common during this time. Nautiloid cephalopods were a spectacular success story. These ancestors of octopi and squids were rare in the late Cambrian. In the Ordovician, nautiloids evolved quickly along many different lines—at least ten different orders flourished at this time—including straight-, curved, loosely coiled, and tightly coiled shelled types, and even one group that lost most their shell altogether. These carnivorous molluscs were a dominant life form and top predator of the world's ocean.

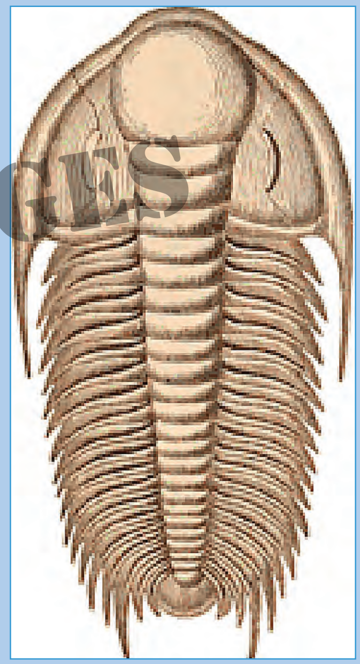
Trilobites and brachiopods in particular were rich and diverse. The trilobites were quite different from their Cambrian predecessors. Many evolved bizarre spines and nodules.

The first jawed fish appeared in the late Ordovician.

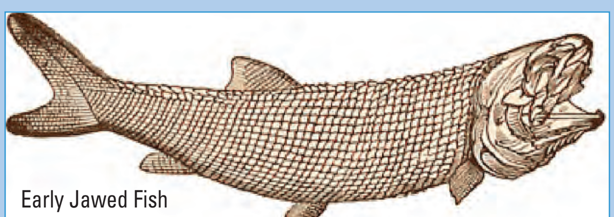
Finally, a humble start to what would eventually become the divers flora of the Carolinian Forest, the first creeping lichens and hepatophytes moved onto land, the beginning of a great new experiment of life.



Fossil Nautiloid



Fossil Trilobite



Early Jawed Fish

All images on this page from:
Ames D. Dana. 1896. Manual Of Geolgy, American Book Company, www.geology.19thcenturyscience.org/books/1896-Dana-ManGeol/htm/doc-full.html

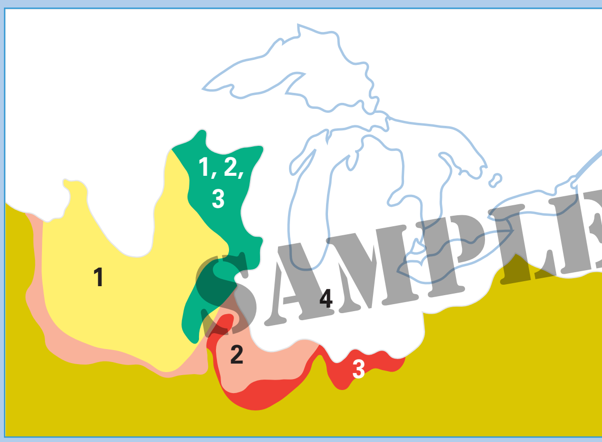
Sidebar: Glaciation Basics

The Furthest Extension South

Glaciation has played a central role in forming and shaping southern Ontario including the Rouge, Duffins and Petticoat watersheds. There is physical evidence on the ground of four major advances of the continental glaciers. It is not possible to know much if anything at all about the early ice advances; because later glaciers destroyed much of the evidence. Much of our geological history been annihilated and then shaped by glaciers. Much has been learned by looking near the edge of the furthest extension of ice sheets at the moraines and other deposits from earlier stages have escaped destruction. From these artifacts we can get a glimpse of what happened.

Beyond the greatest extent of the Wisconsinan Ice Sheet, the last major advance, are found older moraines.

The map below shows the maximum coverage around the Great Lakes of the four named advances or stages. The present Great Lakes are shown in light blue outlines—however they were not present before the ice ages (see the Formation of the Great Lakes).



The greatest extent of the four known ice advances are shown in different colours listed below in order of youngest to oldest:

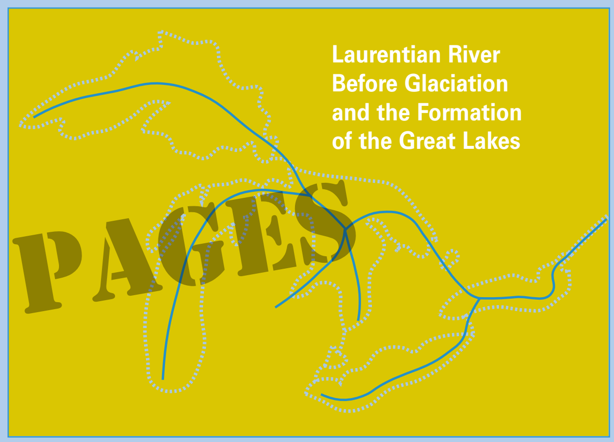
1 Nebraskan—800,000 [±300,000] years BP (yellow and green)
2 Kansan—600,000 [±200,000] years BP (salmon)
3 Illinoian—from 250,000 to 135,000 years BP (red and green)
4 Wisconsinan—from 100,000 to 5,000 years BP (white)

Illustration on this page are based on: Lake Iroquois and its shore cliff or bluff: www.lost rivers.ca/points/Lake_ Iroquois.htm

The Formation of the Great Lakes

In the late Tertiary, the St Lawrence rift system had opened up and the Great Lakes Basin drained to the Atlantic. Before the Ice Age there were no Great Lakes, only shallow basins, except for Lake Superior which had originated aeons earlier as a rift valley lake in the Central North American Rift System.

The Laurentian River drained the basin. It's source was near Lake Superior and it flowed though the Lake Huron Basin, the Georgian Bay Basin and, through a valley in bedrock, now hidden by the Oak Ridges Moraine, to the Lake Ontario Basin and drained through the St. Lawrence Valley to the Atlantic Ocean. The Laurentian River system carved out valleys through the softer sedimentary shales. With the coming of the ice ages the advancing ice sheet carved out the soft bedrock of the Laurentian River system. When the ice finally retreated, these deep erosional cuts became the beds for the Great Lakes.



How the Scarborough Formation Came to Be

During most of the first half of the last glaciation the Wisconsinan Ice Sheet did not cover the Toronto area. The ice front was located a bit to the north-east. The glacier blocked the St. Lawrence, causing a high level lake similar to Lake Iroquois. Each summer, a large river fed by the melting ice flowed into this lake and dropped material that formed the Scarborough Formation (115-106,000 years ago) the Pottery Road Formation (106-75,000 years ago) and the Sunnybrook Drift (60-75,000 years ago). This delta was big enough that the Wisconsinan Ice Sheet was not able to destroy it completely during its advance to its maximum extent. This protected the Don Beds and so preserved the evidence of the warm interglacial stage.

Paleoclimatic reconstructions suggest a climate some 2 C° warmer than today during the deposition of the lower Don Beds, with a shift to cool, temperate conditions near the top of the sequence and during deposition of the Scarborough Formation clays.

The Scarborough Formation contains a wide diversity of floral and faunal remains including:

- over 60 plant species
- 10 molluscs species
- over 70 insect species. Species composition of these finds indicate a marked cooling trend especially to a boreal climate with mean annual temperatures 2–5 C° cooler than today.

The Scarborough formation had another interesting effect. After the final retreat of the Wisconsinan glaciers, the Don River and the Highland Creek began to flow again, their direct flow was blocked by the delta sands forcing them to flow east or west before heading toward Lake Ontario (see Figure A1.8).

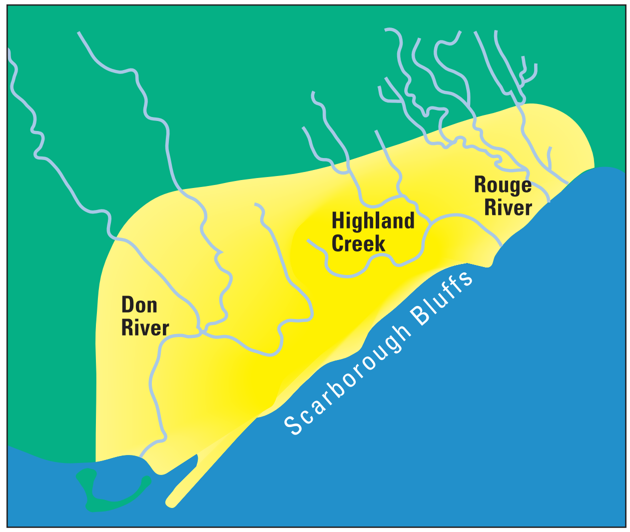


Figure A1.8 The Scarbourough Formation (yellow) deflects the course of the Don River and Highland Creek. Based on The Great Delta: www.lostrivers.ca/points/delta.htm

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Figure A1.9 An excellent exposure of the Scarborough Formation. Site R020 near the first bridge on Twyn Rivers Drive. Here this formation is overlain by Newmarket Till and Iroquois Sand.

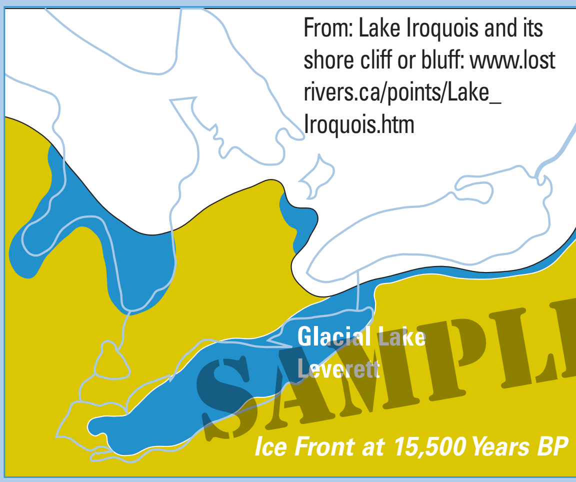
Sidebar: More Glacial Facts

The Formation of the Oak Ridges Moraine

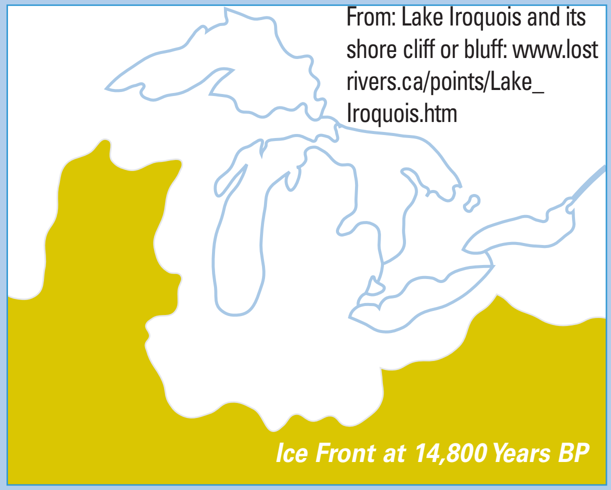
The Oak Ridges Moraine plays an important role in the hydrodynamics of the Rivers in Rouge Park. The Moraine is the headwaters of Rouge River and Little Rouge Creek. And is also the main groundwater recharge area for the numerous springs that provide year-round sources of water to the rivers and creeks in these watersheds via seeps and springs.

The retreat of the Laurentian Glacier from southern Ontario was a complicated process. The evidence and of how this happened is not always clear. At times the ice advanced in the west when it retreated in the east. There were pauses and readvances.

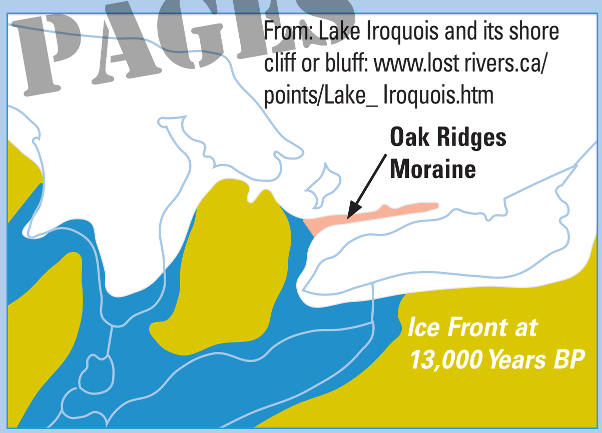
About 15,500 years ago, the ice front had cleared the Lake Erie basin, but advanced again to recover that area and more by 14,800 years ago.

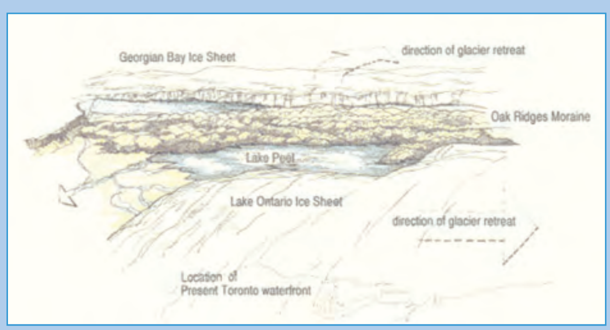


During this period of advances and retreats a space opened up between the Lake Ontario lobe and the main sheet to the north. Into this gap flowed meltwater from the glacier loaded with debris. The sands and gravels dropped out in this gap, while the finer particles escaped into a high level lake then filling the Lake Erie basin and the south end of the Lake Huron basin. This large water body probably fed the Ohio River. The sands and gravels that were dropped in the gap became a major ridge, that blocked the direct route of the Laurentian River, and which is now known as the Oak Ridges Moraine.



The Lake Ontario Ice Lobe came down the lake basin from the north-east, but it fanned out at the end of the basin so that in the Toronto area it was pushing in a north west direction up towards the moraine. Thus it left the ridges and grooves oriented north-west to south-east, that our steam valleys and ravines have followed. Resulting in the general south-eastern flow of most streams. The ice front apparently pushed forward and melted back at least twice, because its till deposits override the Oak Ridges sands and gravels in many places.





Another view of the formation of Oak Ridges Moraine from Healing an Urban Watershed: The Story of the Don.

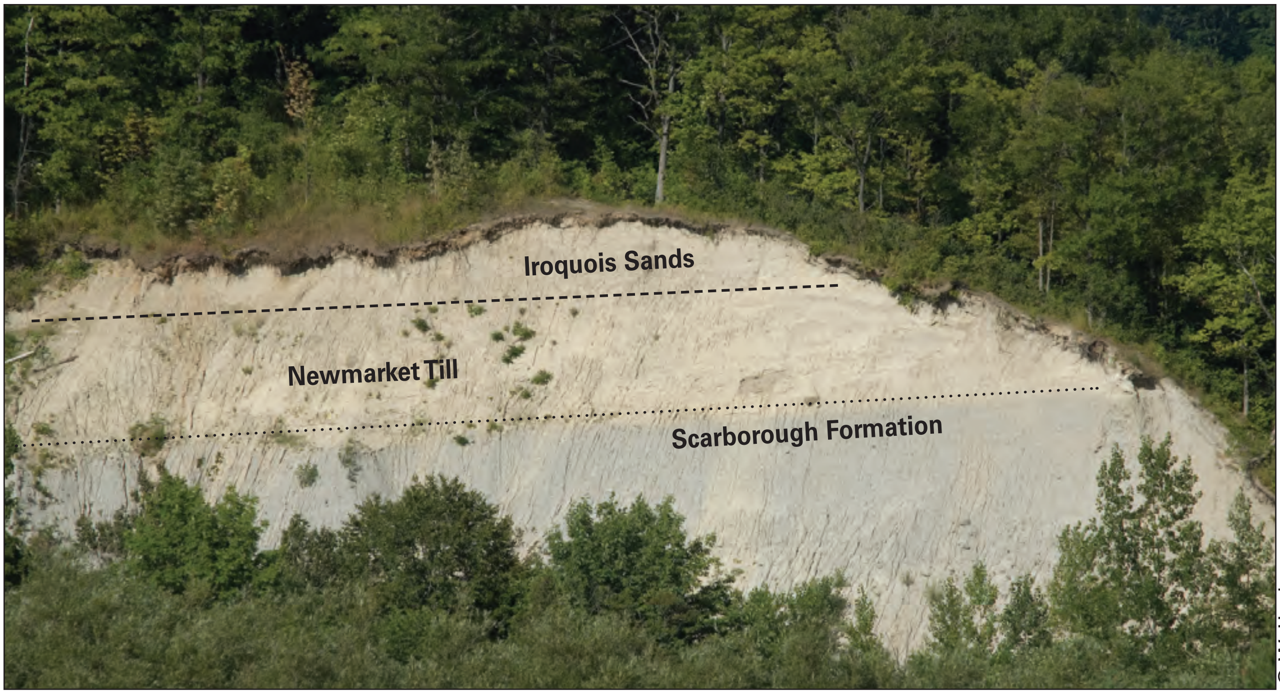


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Figure A1.15 Halton Till and Iroquois Sands exposed at Site R020.

lake) sediments which record melt stream sedimentation and the ponding of shallow lakes at the edges of the melting glacier.

This is the youngest glacial unit in the Rouge Park area. It composes the upper subsoil of most of the Rouge River watershed. In the Park south of Steeles Ave, it is widely exposed in bluffs along the Rouge River and Little Rouge Creek. The best exposure is a 40 metre bluff on the northeastern side of the Rouge River (Eyles and Boyce, 1991 Map 3, ROI5) in the vicinity of the Toronto Zoo. At this locality the Halton and Sunnybrook tills have been eroded in to a series of hoodoos.

The surface is drumlinized and fluted; several good examples of these streamlined landforms occur on the tableland in the northern part of the park south of Steeles Avenue

Glacial Features

The Wisconsinan glaciation has been the most dominant factor in shaping the landscape of the Park and the rest of Southern Ontario. It has produced a suite of landforms and associated features in the Halton Till that are artifacts of the growth and decay of the Laurentide Ice Sheet and the development of large glacial lakes in the Ontario basin.

Drumlins and Flutes

Drumlins and flutes are the principal landforms on the Halton Till plain. They record the movement of glacial ice across the region. Drumlins are elongated hills, with a profile, when seen from above similar to an aircraft fuselage or a fast-water fish such as a salmon. One end that faced the direction of ice-movement, is blunt. The tail of the hill is gently sloping in a down-ice direction. Flutes are usually a series of linear ridges which run parallel to ice flow and are separated by shallow troughs in the till plain.

A wide range of drumlin morphologies occur within the park area and are shown on Map 1 of Eyles' and Boyce's 1991 geological report.

Most drumlins within the park and surrounding area are oval shaped, with length to width ratios which are in the range of 2:3, 300–1000 metres long, 10–30 metres high. They are spread thinly—less than 5 drumlins per 10 km$_2$. Because they are low and sparse, flutes and drumlins in the park, when viewed from ground level are hard to discern. They appear as broad, rounded swells.

The best example of a low 10 metre high, ovoid drumlin cis northwest of Reesor Road, 250 metres north of Old Finch Avenue.

Glacial Erratics

An erratic is a boulder transported and deposited by a glacier having a different origin than the bedrock of the area upon which it is sitting. Erratics are useful indicators of patterns of former ice flow. They can be observed in various parts of the Park.

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Figure A1.16 Drumlin near intersection of Meadowvale Road and Plug Hat Road:

a) approach from the west.

b) View from on the west slope.

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Figure A1.17 Glacial Erratics:
a) located adjacent to Orchard Trail near the Beare Landfill site.
b) located in the Rouge River near the Twyn Creek Area.

Iroquois Sands and Clays

Lake Iroquois was formed during the early phases of regional deglaciation in the Ontario basin after 12,500 BP because the -retreating Laurentian glacier was still blocking Lake Ontario's natural outlet into the St Lawrence River.

At its full extent, the lake was approximately 60 metres above the present level of Lake Ontario. With the St. Lawrence blocked Lake Iroquois drained southward into the Mohawk Valley via an outlet near what is now Rome in New York state. Continued retreat of the ice led to the opening of the St. Lawrence outlet and a step-wise fall in lake levels after 12,000 BP, producing a series of lower lake phases. Lake Ontario's lowest post-Iroquois level occurred about 11,400 BP Water levels at this time were between 100 to 120 metres below the present level of Lake Ontario.

The crustal block that underlies most of Quebec and north-eastern Ontario, together with the eastern end of Lake Ontario and the St. Lawrence valley had been under as much as 2 km of ice for over 100,000 years. The tremendous weight of the ice over an extended time period had pushed the crust hundreds of metres down into the mantle. The western end of the lake was freed from the ice several thousand years earlier than the eastern end, and probably had only been under the ice sheet for a small part of the Wisconsinan ice age. As a result it rebounded first, tilting the western end of the Lake Ontario basin up at the time of Lake Iroquois—and for some time after. The eastern end of Lake Ontario and the St. Lawrence valley, having been depressed more, have rebounded more. As a result, the present remnants of the Lake Iroquois shoreline is tilted upward as you travel east.—e.g., at the Humber River the shoreline is located at an elevation of 55 metres above sea level and near the Rouge River it is located at approximately 68 metres.

Evidence for this lower-level phase is recorded by a 30 metre high, submerged bluff lying parallel to the present shoreline about 3 km offshore. This formed about 8,500 years ago by shoreline erosion at a time when lake level was some 60 metres below the modern level. Water levels continue to rise in western Lake Ontario by about 0.23 metres per 100 years as a result of ongoing uplift of the eastern part of the basin.

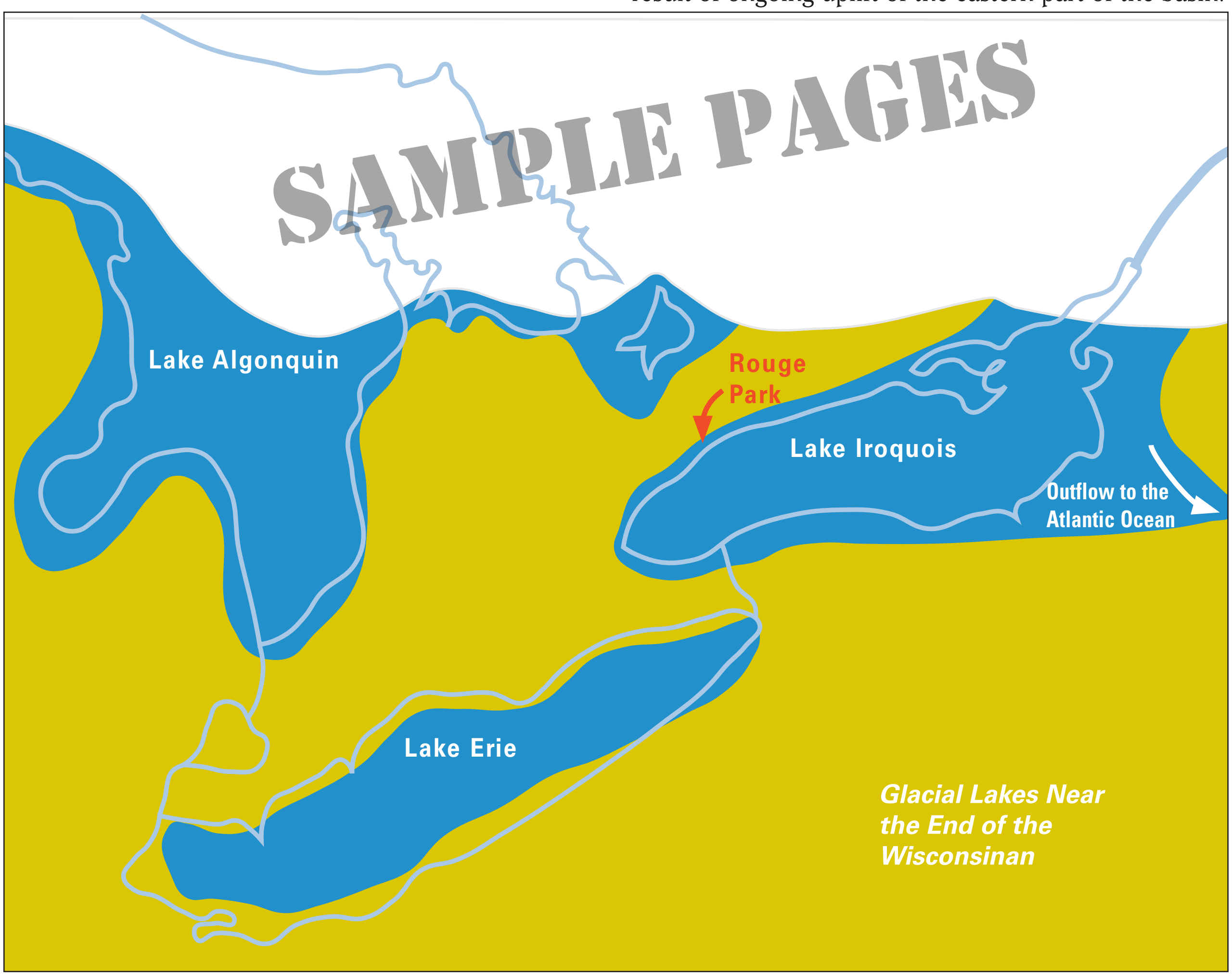

Figure A1.18 Size and location of Lake Iroquois. From: Lake Iroquois and its shore cliff or bluff: www.lostrivers.ca/points/Lake_Iroquois.htm