Society for the Preservation of Natural History Collections
17th Annual Meeting, May 8-13, 2002
Redpath Museum/McGill university

"Hazardous collections and mitigations"

Co-hosts:
Canadian Museum of Nature and the Redpath Museum

Field trip guidebook

Fossils in the vicinity of Montreal

Thursday, May 9th, 2002

Mario Cournoyer
PaléoVision, Montréal

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Introduction

The St. Lawrence lowlands region is a geological zone shaped like a triangle. It is delimited to the north by the Laurentian mountains (Canadian shield), and to the southeast by the Appalachian mountains. It straddles the St. Lawrence river between Ottawa and Quebec City. Of sedimentary origin, the rocks date back from 520 to 440 million years ago (from the Cambrian period to the end of the Ordovician period).In southern Quebec, the Ordovician rocks of the St. Lawrence valley hold a great variety of fossil remains. These are mostly shelled invertebrates. The deposits cover nearly all of the temporal extent of the Ordovician.

At the end of the Pleistocene epoch, sand and clays from the Champlain Sea (a vestige of the last ice age) were deposited on the older sedimentary rocks mentioned above. This inland sea stretched from Quebec City to Ottawa, between the Laurentians and the Appalachians, and its deposits contain remains of an arctic fauna.

The present trip will lead you to two localities located within the St. Lawrence valley. Both are on the south shore of the Island of Montreal. These two localities represent completely different aged deposits. The first stop (St-Césaire) is of Late Pleistocene-Holocene age (approx. 10 000 years Before Present) and tells the story of the last marine incursion in North America after the end of the last great ice age. The second stop (Laprairie) will bring the participants to a quarry containing shales and limestones of Upper Ordovician age (approx. 445 million years B.P.). Here we will be collecting invertebrate fossils such as molluscs, brachiopods and trilobites, an extinct group of arthropod. A third stop (Charron Island), containing middle Ordovician rocks, may be visited depending on time remaining.

Schedule

9h30 : departure from the Redpath Museum
10h15 : arrival at stop #1 St-Césaire
30 min. talk and 1 hour of collecting
12h00 : lunch
13h00 : departure from St-Césaire
13h45 : arrival at stop #2 Laprairie
30 min. talk with 1h30 of collecting
15h45 : departure from Lapraire
16h30 : arrival at Redpath Museum

The Pleistocene

Glaciations

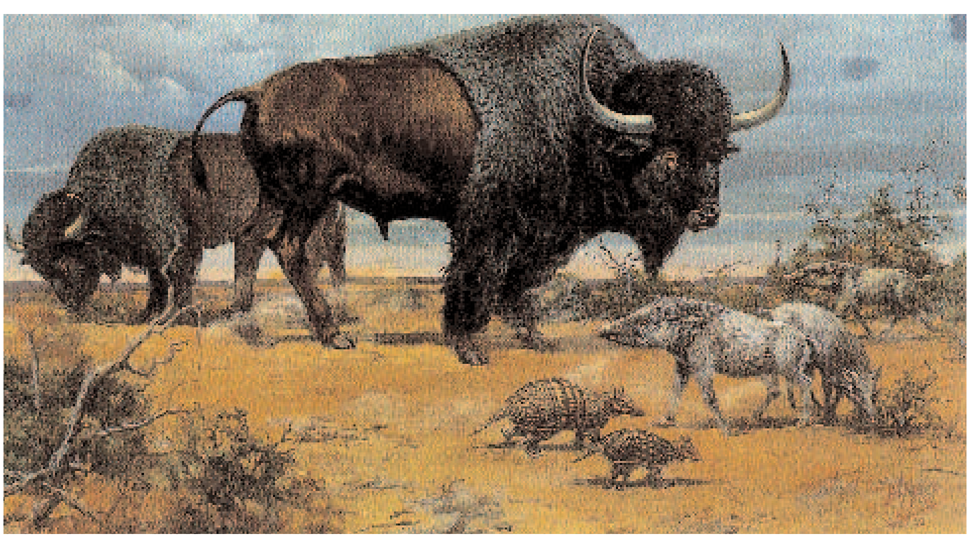
The glaciations together form the most important event of the epoch. This is why the Pleistocene has also been called the « Great Ice Age ». The outcome of a global cooling trend started many million years earlier, the glaciations develop in successive phases (glacial periods) interrupted by warmer episodes where the glaciers wane and the conditions become milder (interglacial periods).

The glacial periods are characterized by a global cooling of temperatures favoring the development of great continental glaciers (a phenomenon which is particularly obvious in the northern hemisphere). During glacial maxima, the glaciers (also called ice sheets or caps) can cover up to 30% of land areas. In North America, at the height of the last glaciation 18 000 years ago, the ice covered most of Canada and many parts of the northern United States. This blanket could reach a thickness of up to 3 kilometres in some places. The ice-covered land subsided under the immense weight of the glaciers.

The exact causes of glaciations are still being debated. Some scientists invoke variations in the amount of radiation emitted by our Sun and astronomical variations in the Earth's orbit. Others think that the advance and retreat of polar ice changes ocean currents. Recent work on polar ice and sea floor sediments clearly show that the first effect of melting ice sheets, 11,700 years ago, was to cool much of the planet! The warming interval since then has been unusually long. According to the cycles of the last 2 million years, we should be on the brink of the next 100,000 year-long ice age.

The extinction of large mammals in North America

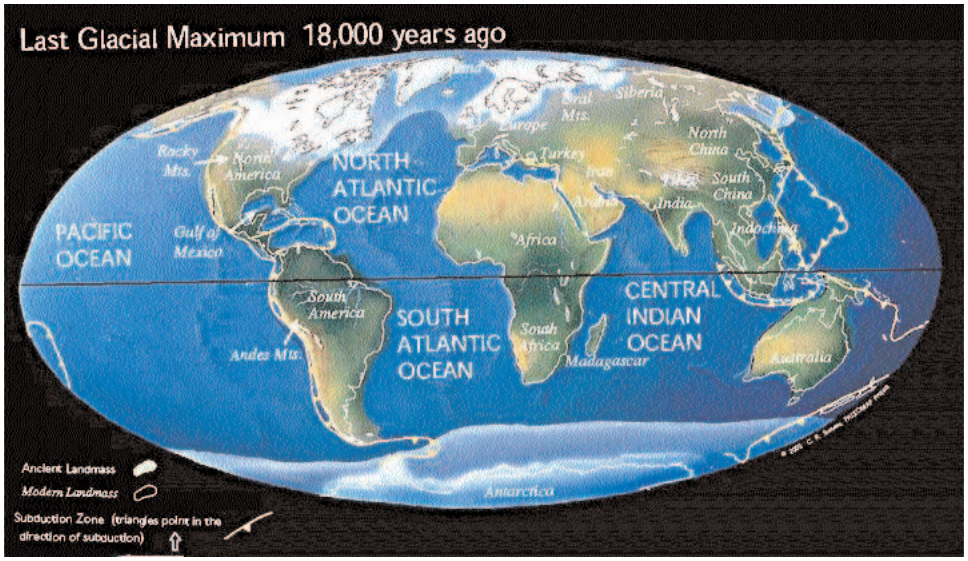
The end of the Pleistocene (10 000 years before present) corresponds to another important event in the history of life: its large terrestrial mammals went extinct. Many species of large mammals (the megafauna) disappear suddenly, while others survive for a few more millenia as small, isolated populations. The North American megafauna is particularly affected. Among the mammals that went extinct, we will mention the woolly mammoth, the American mastodon, the giant ground sloth, the glyptodont, the American camel, several species of native horses, the giant beaver, the dire wolf, the sabertooth cat, and the American lion, to name a few. Two main hypotheses, which are not mutually exclusive, are invoked to explain the megafaunal extinction. One calls upon climatic changes coinciding with the end of the last glaciation, and associated habitat alterations. The other attributes extinction to excessive human hunting (overkill hypothesis). The debate rages on.



Some representative pleistocene mammals of Canada. Illustration Ely Kish

Paleogeography

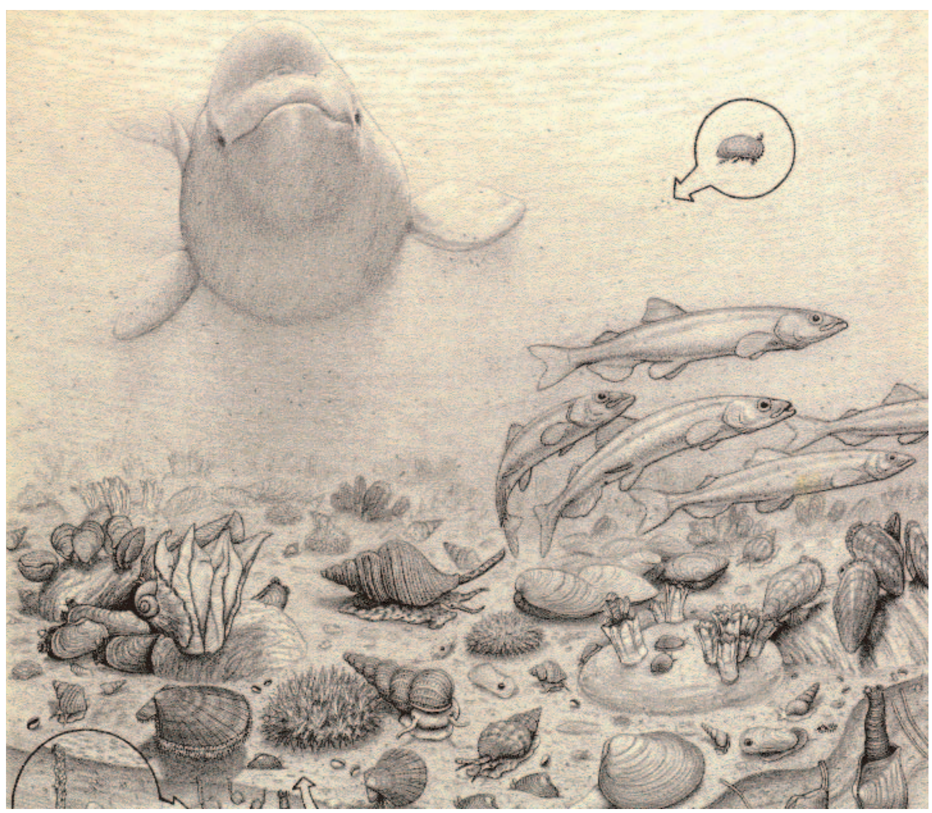
In the Pleistocene, the continents are positioned essentially as they are now. However, the shape of the land masses varies as the great continental glaciers move back and forth. The world map shows the shape of the continents and the extent of ice caps (white) during the last glacial period, 18000 years ago. At that time, many areas of the world, which are now submerged, lie above sea level. For example, we can see a land bridge, called Beringia, connecting Alaska (North America) to Siberia (Asia). This situation was brought about by the massive accumulation of water (in the form of ice) on the continents. Locking up so much water in the ice caps provoked a lowering of the sea level (approx. -100 metres), and the subsequent extension of the continental margins.



The globe during the last glacial maximum, 18 000 years ago. Illustration Paleomaps

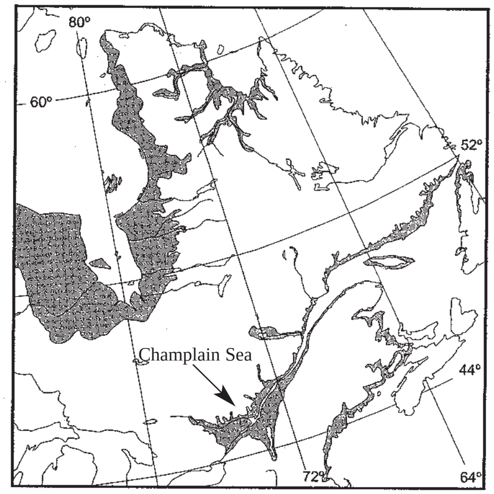
The Champlain Sea

The last marine invasion in the province of Québec, called the Champlain sea, took place in arctic conditions. Formed by the melt waters of the Inlandsis Laurentidia (one of the two great continental glaciers), the Champlain sea submerged the Saint-Lawrence Lowlands region about 12 000 years ago. It retreated around 9 000 years ago at the time of the rising of the continent caused by the lack of weight from the vanished glacier. The major deposits left by this sea are marine clays and sands. We observe on this painting many organisms who have survived until today (Molluscs, Capelin, White whale).


Common fossils of the Champlain Sea. Illustration Ghislain Caron

Life and death of an inland sea: The Champlain Sea

The marine invasion of the Champlain Sea, at the very end of the Pleistocene epoch, constitutes, for southern Québec, the last chapter of a lively geological history. Let’s retrace the evolution of this great inland sea.



The province of Québec 10 000 years ago. Dark areas show the extent of the marine invasions.

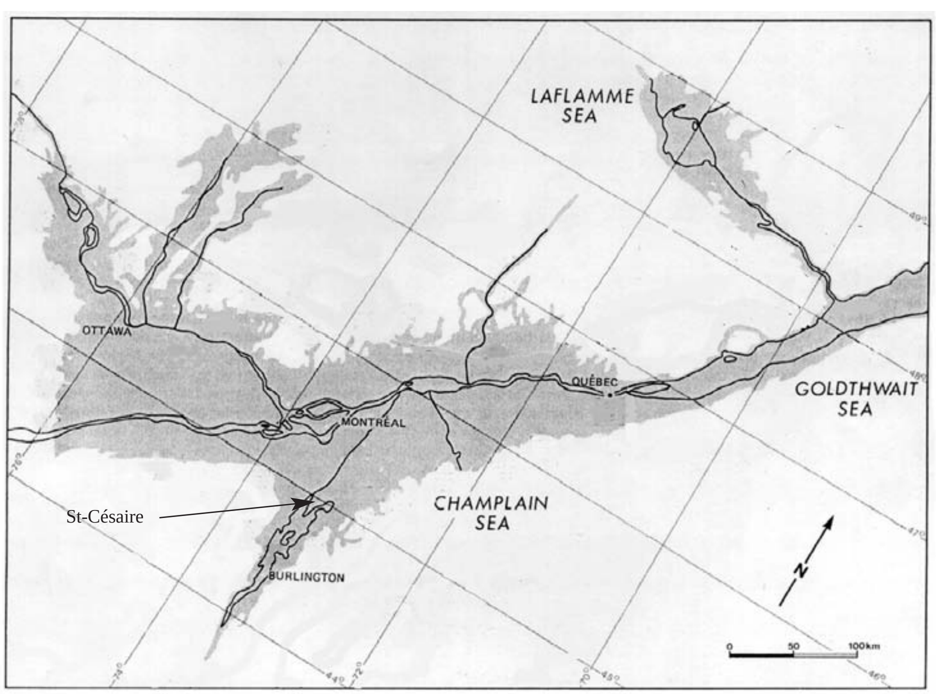
12 500 years before present - Most of Québec is still covered with ice. However, the inlandsis is retreating, and a few valleys on the north slope of the Appalachians (newly uncovered) are flooded with glacial meltwaters, thus creating ‘’proglacial’’ lakes.

11 000 years before present - One millenium earlier, the retreat of the Laurentide ice sheet north of the St. Lawrence Lowlands had allowed the sea to penetrate deep inland. This marine incursion was made possible by the fact that the continent has subsided under tons of glacier ice and was slow to "bounce back" to its former level (a phenomenon called isostatic rebound). During several centuries, the glacier meltwater and seawater mix to form a brackish Champlain Sea which becomes increasingly salty and reaches its maximum extent around 11 000 years ago.

10 000 years before present - The Champlain Sea has been regressing for a few centuries already, and its salinity is progressively falling. This regression is directly tied to the slow rise of the continent, combined with an overall drop in sea level.

9500 years before present - The Champlain Sea makes way to a freshwater lake called Lake Lampsilis, named after a freshwater mollusc found in its sediments. The continent is still slowly rising above sea level.

8000 years before present - The St. Lawrence valley is starting to assume a modern appearance. The large post-glacial water bodies have all dispersed, with the exception of the ancestor of Lac St-Pierre. The continent keeps on rising, but at a much slower rate than in preceding millenia.

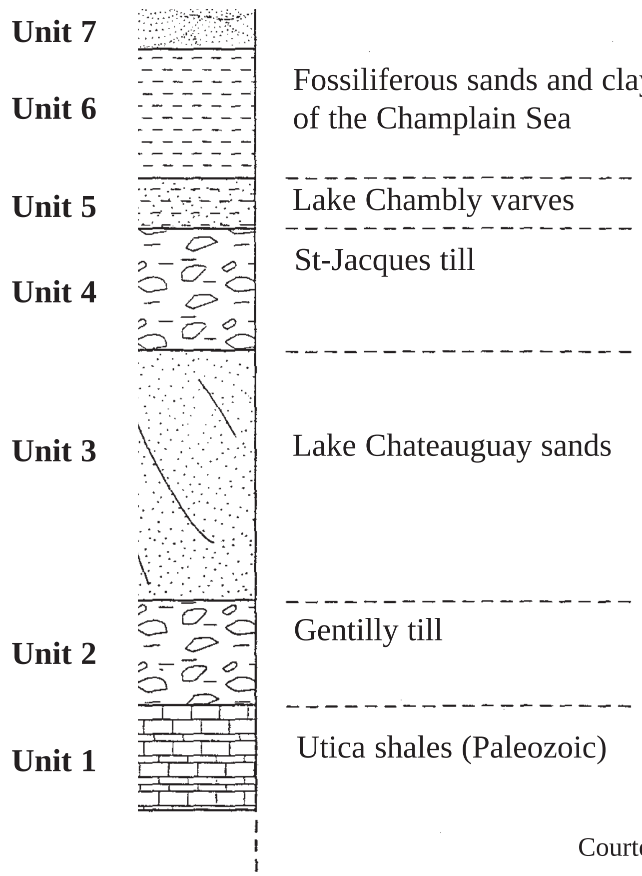


Maximum extent of the Champlain Sea in southern Québec, eastern Ontario, northern Vermont and northern New York. Illustration Serge Occhietti

Stop 1 : St-Césaire

The St-Césaire sandpit is located about 10 km south of Mount Rougemont, Monteregian hill, in the middle of the Champlain Sea basin. The site is located ‘’downstream’’, or in the glacial ‘’shadow’’ of Mount Rougemont.The sandpit is in a plain were the surface sediments are mainly regional till consisting of bedrock material crushed and transported at the base of the glacier. Towards the east, the surface sediments is composed principally of clays, commonly called Champlain Sea clays.

On a geological map we can only see the arrangement of the surface sediments, but in a sandpit, the cliffs gives us a glimpse of their vertical arrangement, in other words, the succession of the sediments through time. Here is an idealized stratigraphic sequence.



Courtesy Michel A. Bouchard

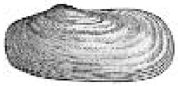
Not all sedimentary units shown in the diagram are observable in the sandpit. Some units (for example, units 1 and 2) are only seen in borings through the sand pit floor. In general the sandpit floor is located in the Lake Chateauguay sands. The St-Jacques till (Unit 4) is the surface sediment of the region west of the sandpit. Unit 6 includes the fossiliferous sands and clays of the Champlain Sea, and this is where we will be collecting invertebrate fossils.

Unit 2 (Gentilly till) and Unit 4 (St-Jacques till) represent two glaciations. We could even say that they are actually ‘’fossilized’’ glaciers since the till is the result of the erosion by glacier ice. Many type of materials are found in the till : sands, clays, silts, pebbles and rocks. All this material was caried by the glacier from the north accross the Laurentian mountains and laid down here in the St-Lawrence Lowlands. Unit 4, St-Jacques till, represents the last glaciation (Wisconsinian) about 20 000 years B.P. Unit 2, Gentilly till, is another glaciation that took place about 50 000 years B.P..

Plate 1

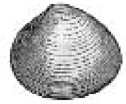
Champlain Sea invertebrate fossils

Bivalves

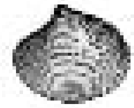


Hiatella arctica

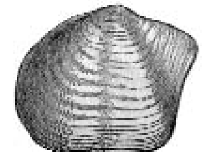
Macoma calcarea



Macoma balthica

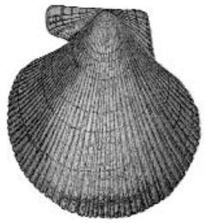


Astarte montagui

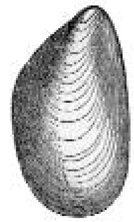


Mya truncata

Serripes groenlandicus



Chlamys islandica
Iceland Scallop



Mytilus edulis
Blue Mussel

Mya arenaria
Common Clam

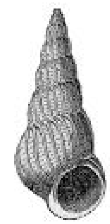
Gastropods

Natica clausa
Arctic Natica

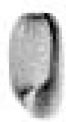
Buccinum spp.
Common Northern Whelk

Neptunea despecta
Common Northern Neptune

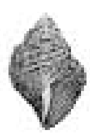
Acirsa borealis



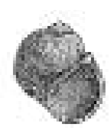
Epitonium
cf. *E. greenlandicm*



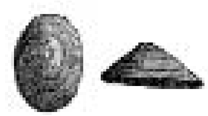
Cylichna alba



Trichotropis borealis



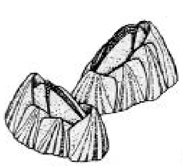
Littorina saxatilis



Lepeta cacea

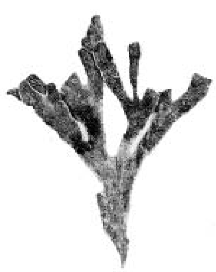
Barnacles

Balanus hameri

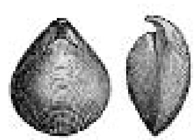


Balanus crenatus

Bryozoans

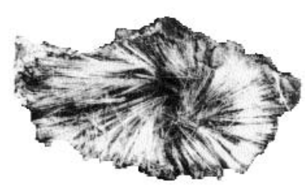


Brachiopods



Hemithiris psittacea

Sponges

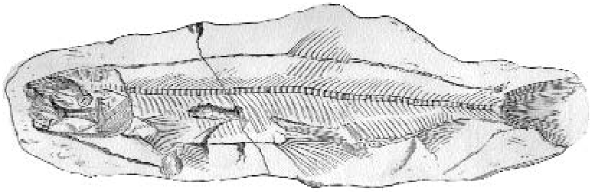


Tethya logani

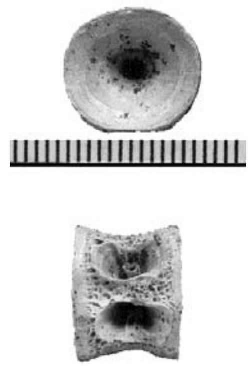
Plate 2

Champlain Sea vertebrate fossils

Fishes

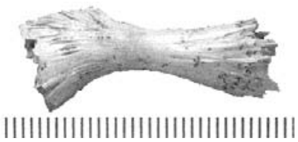


Capelin (*Mallotus villosus)*
Fish found in nodule in the vicinity of Ottawa

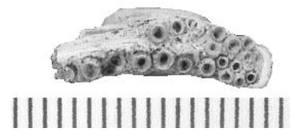


Specimen MDC1997-05
Salmonidae vertebra genus and species unknown

Specimen PV1997-10
Frontal of an indeterminate fish



Specimen MDC1996-07
Eelpout Ceratohyal (*Lycodes* sp.)



Specimen MPE1997-01
Jaw fragment of an indeterminate fish

Marine mammals

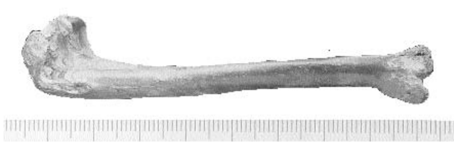
Specimen PV1995-11 Metatarsal of an unidentified seal species

Specimen PV1995-03
Seal cervicale vertebra

Specimen PV1996-02
White whale caudal vertebra
(*Delphinapterus leucas*)

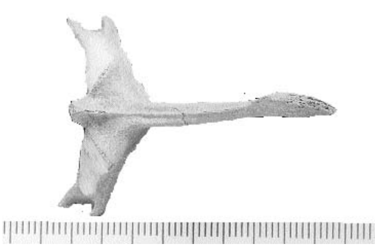
Specimen MPE1997-04
Walrus right innominate
(*Odobenus rosmarus*)

Birds



Specimen PV1994-01
Thick-billed Murre humeri (*Uria lomvia*)

Specimen PV1995-08
Rib of an unidentified bird



Specimen PV1994-02 Anterior part of a sternum of a Thick-billed Murre (*Uria lomvia*)

Specimen MDC1998-06
Indeterminate bird

The Ordovician

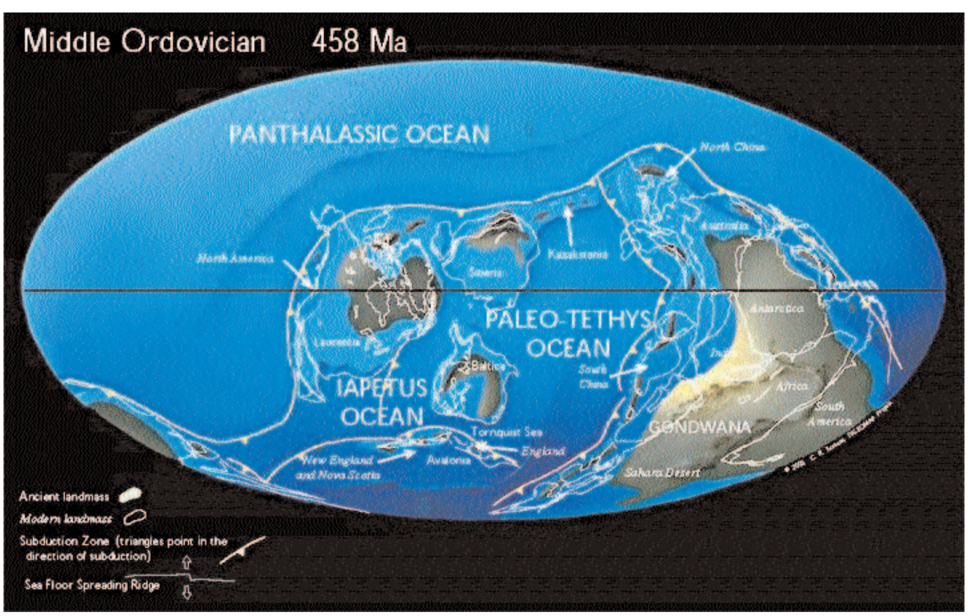
A transition period from the early life to the modern life!

The Ordovician period is a long one, lasting more than 60 million years. Early on, life was made up of primitive forms but as the Ordovician neared its end, most of the major modern marine groups were present. Some of the newcomers were the corals, the bryozoans, the starfishes, crinoids and echinoids. The molluscs went through a great diversification : gastropods (snails) became larger and more numerous, bivalves (oysters, mussels) expanded their territories on sea floors and cephalopods (octopus, squids) were at the top of the food chain. After surviving a major extinction at the end of the previous geological period (Cambrian), the trilobites experienced a new diversification. But of all the invertebrates living in the Ordovician seas, the brachiopods, shelled animals looking somewhat similar to the bivalved molluscs, are the dominant forms in the seas.

Other animal groups, less numerous but very successful, appeared during this geological period. The eurypterids (sea scorpions) were fearsome predators and some reached more than 1.5 meter in length. Finally, vertebrates, now present, were represented mainly by bony armored jawless fishes. Plant life was also an important element in the Ordovician seas, photosynthetic plankton and scum-like bacterial colonies were the basis of the marine food chain. Stromatolites (microbial colonies forming layered mounds) are not considered plants... Plants, like animals, grow from a germ and develop specialized tissues. Algae is a much looser term. One important group is the rhodophytes, or red algae, including today's most common seaweeds. Of all these groups, only members of the green algae eventually conquer land and give rise to the first terrestrial plants. At the end of the Ordovician rocks are found to contain some fossil spores and fragments of vascular tissues belonging probably to terrestrial plants.

Paleogeography

All throughout the Ordovician most of the ancient continents where located on and south of the equator. For instance, North America or Laurentia since it was quit different from today, was sitting on the equator. It was covered mostly by warm shallow seas having only the Canadian shield submerged. On the southern rim of the continent was the Iapetus ocean, which was closing slowly as ancient continents such as Baltica (northern Europe), Avalonia (part of New England and England) and Gondwana (Africa) was getting closer to Laurentia (North America). This closing of the ocean was also creating the first mountain building of the Appalachians, a chain of mountains running all along the eastern part of North America.



The globe during the Ordovician, 458 million years ago. Illustration Paleomaps

End Ordovician extinction

An important extinction happened at the end of the Ordovician, caused by a major glaciation. The sea levels lowered, eliminating many continental shelves. More than 25% of the known fossil families were eliminated, with trilobites, sponges and brachiopods suffering the most. This mass extincion is well documented in the Anticosti Island outcrops located in eastern Quebec.

The St. Lawrence valley under the tropics: Quebec's lost world

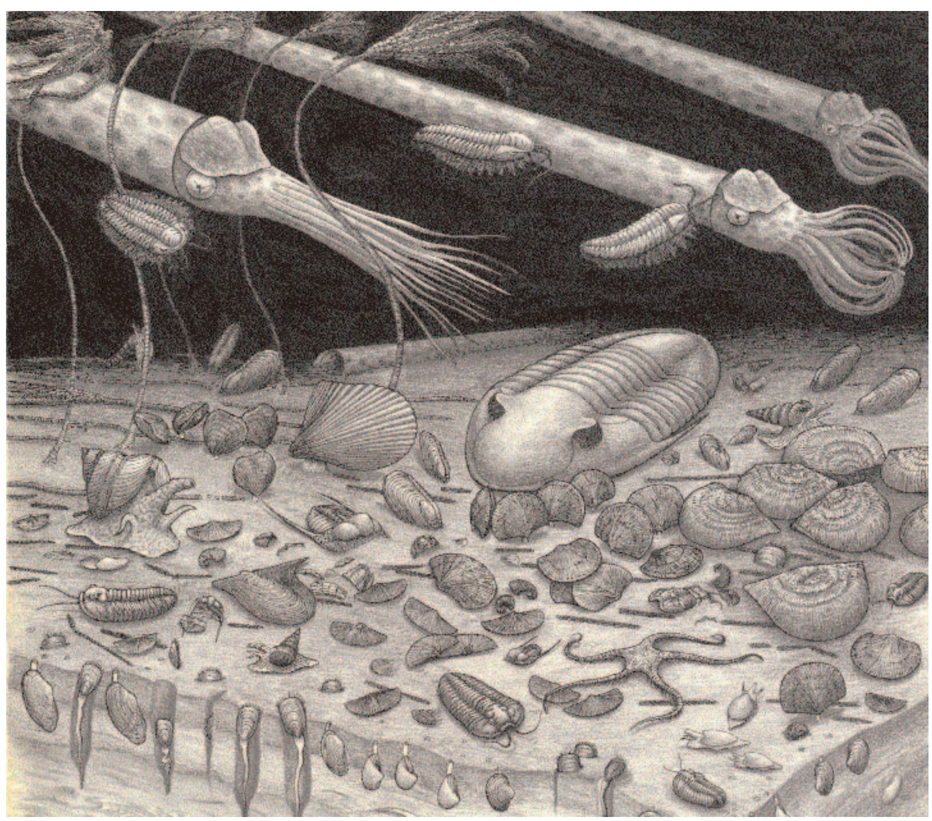
The St. Lawrence lowlands cover an area that extends, all along the St-Lawrence river, from Anticosti Island (north-east) all the way to Toronto (south-west). It is delimited to the north by the Laurentian mountains and to the south-est by the Appalachian mountains. These sedimentary rocks cover a time span of over 130 millions years, from the upper Cambrian period to the middle Silurian period.

These sediments were deposited by a warm marine sea sometimes shallow, and at other times deep. The climat and environment changing, the faunas and floras varied with these changes. In the vicinity of Montréal, the rocks of the lowlands can be divided in geological groups (from oldest to youngest) : the Potsdam, the Beekmantown, the Chazy, the Trenton, the Utica and the Lorraine. Each geological group contains distinct fossil assemblages which are visible in outcrops.

During that time, southern Quebec was located south of the tropics and was submerged by a warm shallow sea. A fauna and flora quite different from today's lived in the seas. Dry land was mostly bare rock.The marine fauna was made up of shelled animals such as bivalved molluscs (mussels and clams), gastropods (snails), shelled cephalopods (close relatives of squids) and brachiopods. Corals, sponges and bryozoans built the first reefs. Trilobites, which are related to crustaceans, were an important group in the sea. Also, crinoids (cousins of starfishes) created small "forests" on the seafloor. Finally, jawless fishes (or agnathans) appear during the Middle Ordovician.

The Lorraine formation

During the Upper Ordovician time, the St. Lawrence lowlands was covered by a sea that was rising. The sea floor became less well oxygenated and much more poorly lit. The sediments of previous levels were mostly calcareous, whereas Lorraine rocks are composed mainly of clays, the preferred environment of burrowing organisms like the bivalves. Fossils found here are usually well preserved but often compressed. Their age is about 445 million years. The fossils found in Laprairie are quite similar to the faunas found in the famous late Ordovician outcrops of Cincinnati, Ohio.



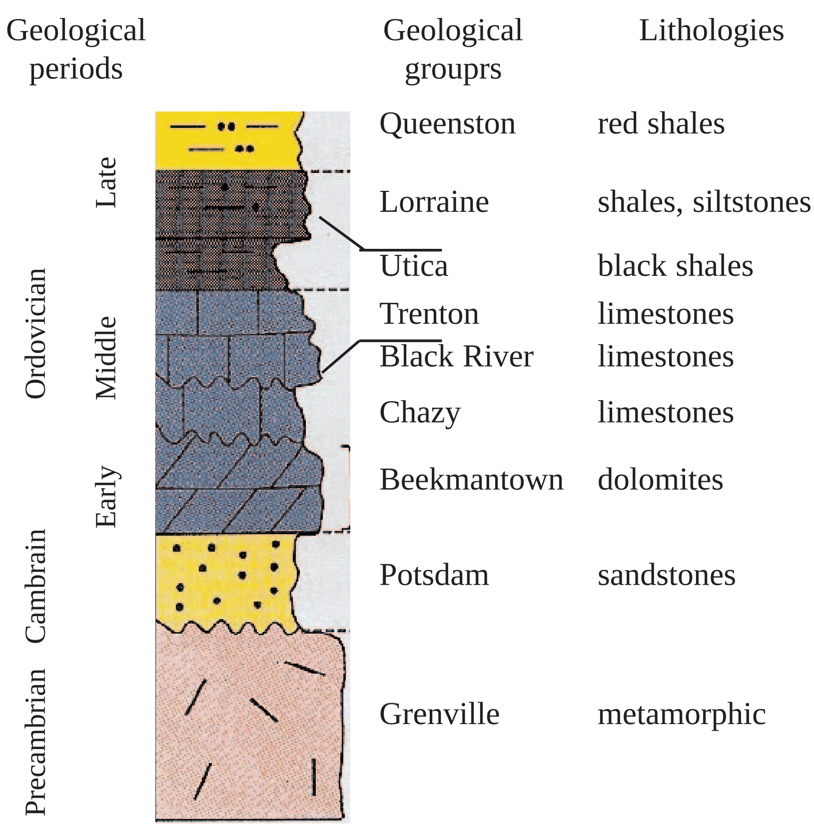
Common fossils of the Upper Ordovician sea. Illustration Ghislain Caron

Stop 2 : Laprairie

The St. Lawrence brickyard, located in Laprairie on the south shore of Montreal, is a relatively large quarry (more than 90 acres) that produces bricks. The quarry is not deep, therefore we don't see many vertical exposure of strata. It's exploitation is somewhat unusuall: once or twice a year, they turn over the quarry floor with large plough and leave the rocks lying their for several months until the rocks desintegrates with the atmospheric erosion. Once the weathering work is done, they pick up the material and bring it in the manufactory for brickmaking.

The stratigraphic succession in the quarry is quite omogenous : mainly dark grey to black shales, sometimes interstatified with thin beds of sandstones, siltstones and limestone. A dyke (montegerian origine) with small branches can be seen in the middle of the quarry. These rocks belong to the Lorraine geologial group and to the Nicolet river formation, which is the basal (or oldest) part of the Lorraine. The shales are soft, and they tend to break up into lenticular fragments.

In the dark shales are found a diverse mollusc, brachiopod and trilobite fauna, thus mainly benthonic and necktonic. The limestones contain brachiopods, trilobites and crinoids that belongs to a infralittoral community. The siltstones are rich in bivalves, gastropods, cephalopods and some graptolites.

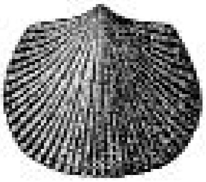


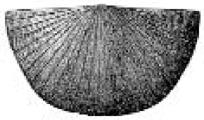
Idealized stratigraphic column of the St.Lawrence lowlands.
Adapted from Hocq, 1994.

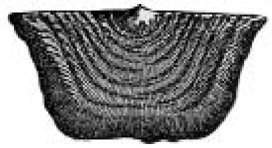
Plate 3

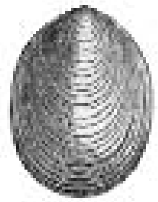
Upper Ordovician fossils

Brachiopods


Onniella


Sowerbyella

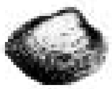

Leptaena

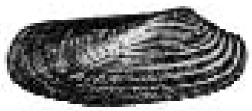

Lingula


Schizocrania

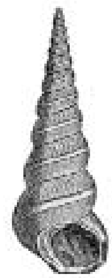
Bivalves


Nuculites


Ctenodonta

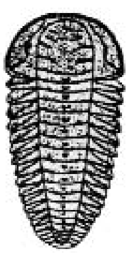

Rhytimya

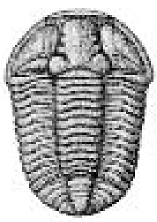
Gastropods

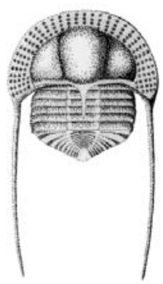

Hormotoma

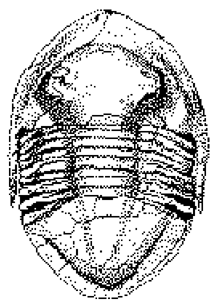

Cyrtolites

Trilobites


Triarthrus

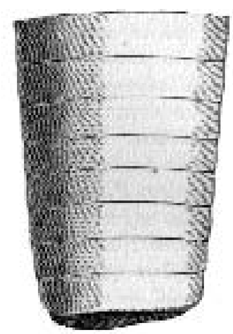

Flexicalymene


Cryptolithus


Isotelus

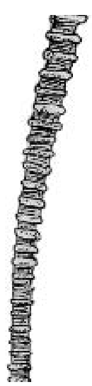
Cephalopods


Geisonoceras


Michelinoceras

Crinoids


Animal complet / complete animal


Tige / stem

Bryozoans

Ichnofossils (trace fossils)

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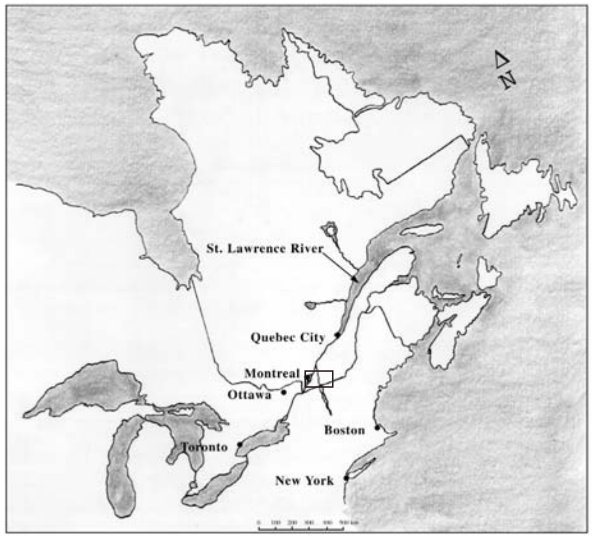
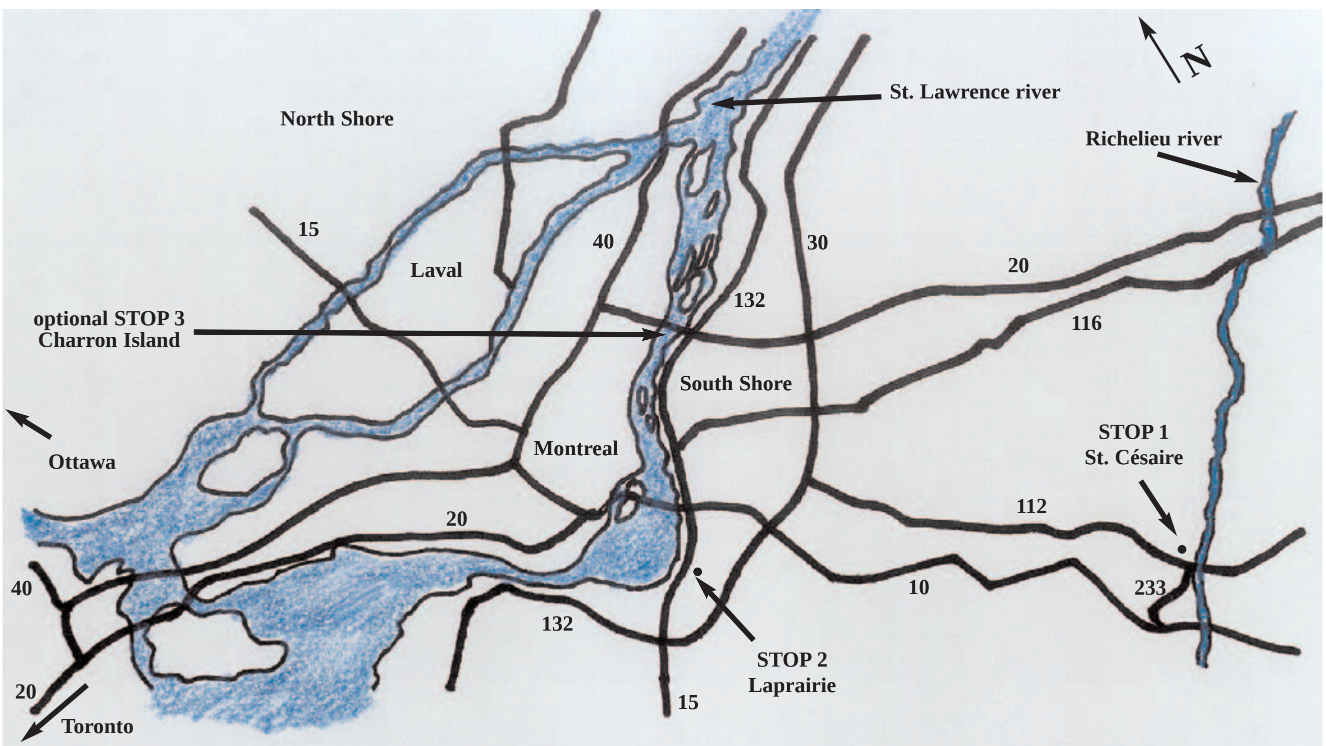
General localisation



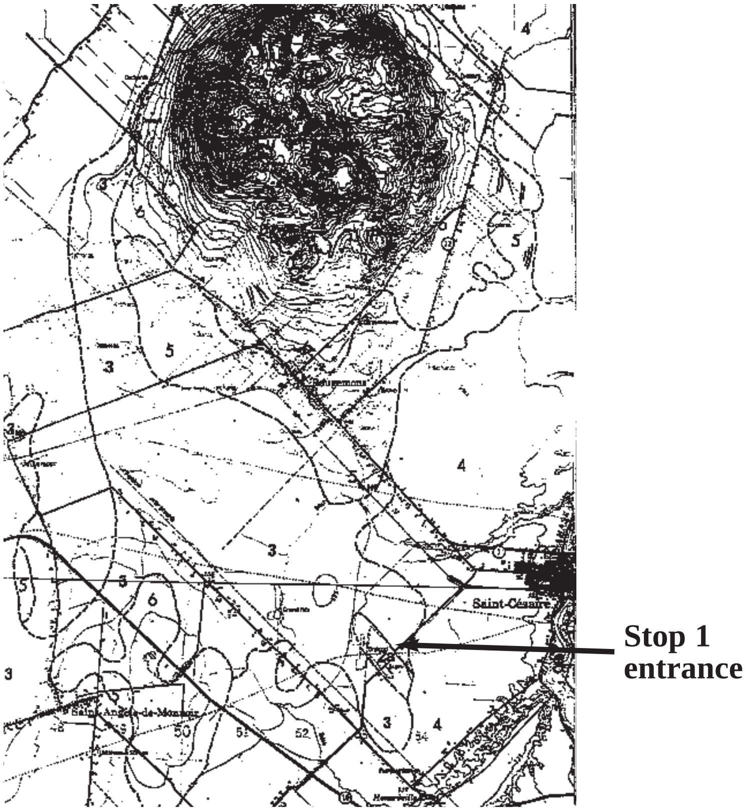
Generalized map of north-eastern North America.



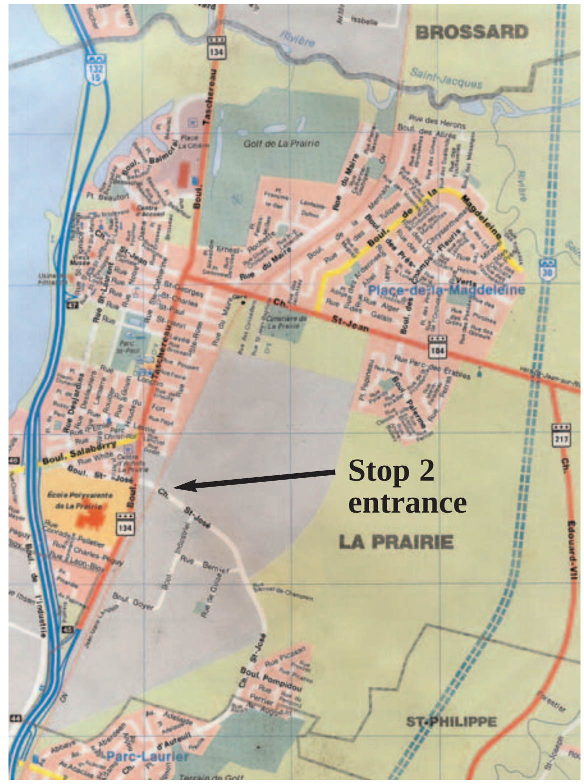
Enlarged view of the Montreal Island area with field trip stops indicated.

Localisation of stops

Stop 1 : St. Cesaire



Stop 2 : Laprairie



Stop 3 : Charron Island (optional)