Underwater and Shoreline Features of the Rideau Canal: Smiths Falls to Westport

Introduction

This poster illustrates the important geologic and geomorphic features of the Rideau Lakes between Smiths Falls and Westport, Ontario and briefly summarizes the geological history. This part of the Rideau Waterway is one of the most scenic and heavily used recreational areas in Ontario.

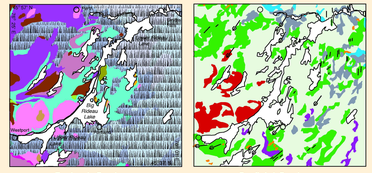
MV *J. Ross Mackay: scientific research vessel*

This area straddles the boundary between Paleozoic sedimentary bedrock and the Canadian Shield. Similar to most of Canada, it was glaciated a number of times during the last 2 million years. At the end of the last glaciation, it was covered, first, by an expanded stage of present day Lake Ontario and later, by an inland sea that formed a shallow arm of the Atlantic Ocean.

The Rideau Lakes are quiet-water settling basins for mineral and organic sediments. They received large quantities of fine-grained mineral sediment during the melting of the last glacier.

Since deglaciation they have continued to accumulate mineral and organic sediment, but at a much slower rate.

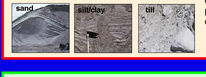
The data on bottom and sub-bottom sediments presented in this poster were collected on a scientific cruise undertaken by Geological Survey of Canada between June 29 and July 6, 1999. Information on the bedrock and surface materials along the shores of the Rideau Lakes was extracted from existing Geological Survey of Canada maps and reports.



Landscape History

The rocks and surface sediments in the Rideau Lakes area represent three major time intervals in the Earth's history since its formation 4.6 billion years ago. The oldest rocks are Precambrian (middle to late Proterozoic-age) gneisses, marbles, and granites. These rocks formed 1350 to 1065 million years ago and were intensely deformed 900 million years ago. They mostly lie to the west of the Rideau Lakes and belong to the Central Metasedimentary Belt of the Grenville Province of the Canadian Shield. Next oldest are Paleozoic (Cambrian-to Lower-Ordovician-age) limestones, dolomites, shales and sandstones that were deposited between 520 and 460 million years ago. These rocks formed from coral reefs, beaches, and bottom sediments in the warm shallow seas that covered large areas of North America at this time. After the Precambrian and Paleozoic rock-building episodes there were long periods of erosion marked by gaps in the geological record. The youngest deposits are late Cenozoic (Quaternary) unconsolidated sediments that lie on top of the bedrock. In the landscape, areas underlain by Precambrian rocks have rugged relief compared to areas with fine-bedded flat-lying Paleozoic rocks.

Quaternary sediments from the last glaciation mask most of the bedrock here. Thick ice sheets covered the area 25 000 years ago. Materials eroded and carried by the glaciers were later deposited as a story mixture of sand, silt, clay, and boulders known as till. Pebbles and boulders derived from the Paleozoic rocks in the till blanketing the Precambrian bedrock west of the Rideau Lakes offer evidence of the transporting power of the glaciers.



Till commonly takes the form of a thin, featureless, discontinuous veneer (0-1.5 m thick). Thicker till in places occurs as elongated low-relief ridges (drumlins) and in two discontinuous belts which trend east-southeast near northern Big Rideau Lake and Upper Rideau Lake. These belts mark the position of brief pauses in the retreating ice front.

By 12 500 years ago the glaciers were disappearing. At this time the land surface was still depressed from the great weight of the ice. As a result, ancestral Lake Ontario (glacial Lake Iroquois) was able to expand northwards against the retreating ice margin, at least as far north as Perth and Smiths Falls. Deposits of bouldery sand and gravel formed at or near the ice margin as water in subglacial channels flowed into the lakes fronting the glacier. Farther offshore, in the quieter, deep-water environments, blankets of finely bedded silty clay and fine sand were deposited.

Glacial lakes covered the area until about 12 000 years ago when the ice sheet retreated from the Montreal area. This opening of the upper St. Lawrence allowed drainage of the glacial lake and the invasion of marine water up the St. Lawrence Valley into eastern Ontario. The Champlain Sea extended as far west as Perth and occupied the Lower Rideau Lake and Big Rideau Lake basins as far south as Nobles Bay. Some gravel and finely bedded silt, clay and fine sand deposits within this region may be of marine origin. Whale bones, buried in sand, have been discovered near Smiths Falls. As the land surface gradually uplifted, the sea withdrew eastward, leaving the Smith Falls area uncovered by 11 100 years ago.

In the last 10 000 years since the drainage of the glacial lake and marine waters, peatlands have developed in some poorly drained areas.

Geophysical Surveys Reveal the Underwater Geology

Production of echosounder and sidescan acoustic records is based on the same sound echo location principle that allows a bat to sense surrounding objects. Transducers hanging from or being towed by the boat send out sound pulses and receive their echoes. Pulses sent from the echosounder systems penetrate unconsolidated sediment and bedrock lying below the lake floor, while those from the sidescan stop at the lake bottom. Echosounder signals travel through different subsurface sediment types at different speeds and return at different times, creating distinct reflection patterns. For both the echosounder and sidescan systems, the returned sound pulses are captured digitally to form an acoustic record that can be transformed into images.

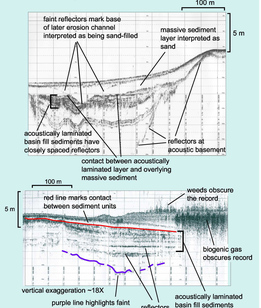
Only shallow boreholes (metres) have been drilled to explore the sequence of sediments lying beneath the Rideau Lakes. Interpretation of the acoustic records was aided by information from earlier onshore mapping and sampling projects. At the bottom of the lake it is usual to find modern soft organic sediments (gyttja) up to around 2 m thick underlain, in places, by sand. Below these are layers of bedded silt, sand, and clay that overlie bedrock which may or may not be covered by till.

The lowest reflector on the echosounder image is referred to as the acoustic basement and generally marks the contact of relatively impenetrable till or bedrock with the overlying sediments. In contrast, the sound pulses so easily penetrate the uppermost organic sediments that they are not visible. Reflections are generated at boundaries between sediment layers with contrasting densities. In places, however, the acoustic record is obscured completely by gases generated from decaying organic matter on the lake floor.

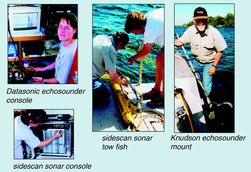
A sidescan record is displayed on the Big Rideau Lake panel below (A_1). The image produced from this system shows the surface topography of the lake floor.

- *The boat was equipped with the following:*
- *Knudson 320 M echosounder (sub-bottom profiling system; paper record)*
- *EG&G Model 260 sidescan sonar (lake bottom imaging; paper record)*
- *Datasonics Chirp II echosounder (sub-bottom profiling system; digital profile)*
- *Trimble GPS Pro XR DGPS (navigational positioning)*
- *Fugawi Moving Map software (navigational tracking)*

Interpreting the echosounder subbottom record



Geophysical equipment used on the Rideau Lakes

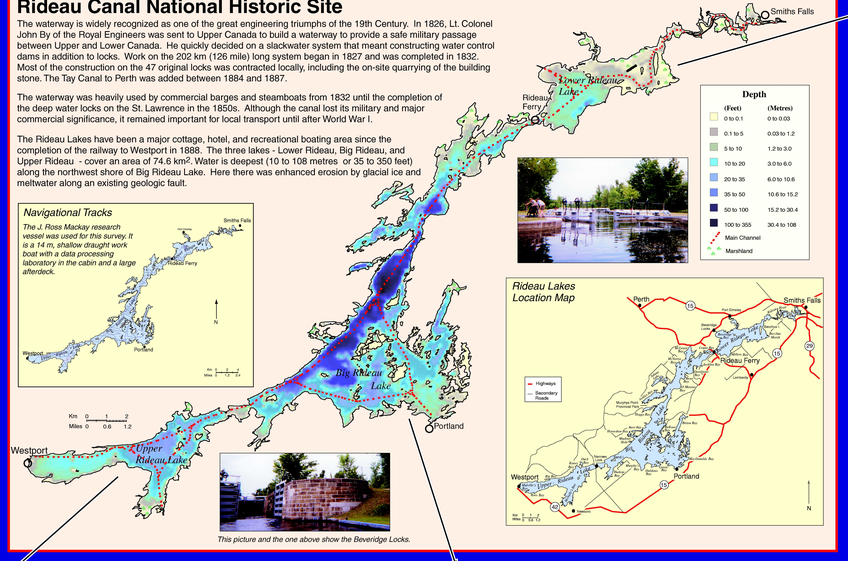


Rideau Canal National Historic Site

The waterway is widely recognized as one of the great engineering triumphs of the 19th Century. In 1826, Lt. Colonel John By of the Royal Engineers was sent to Upper Canada to build a waterway to provide a safe military passage between Upper and Lower Canada. He quickly decided on a slackwater system that meant constructing water control dams in addition to locks. Work on the 202 km (126 mile) long system began in 1827 and was completed in 1832. Most of the construction on the 47 original locks was contracted locally, including the on-site quarrying of the building stone. The Tay Canal to Perth was added between 1884 and 1887.

The waterway was heavily used by commercial barges and steamboats from 1832 until the completion of the deep water locks on the St. Lawrence in the 1850s. Although the canal lost its military and major commercial significance, it remained important for local transport until after World War I.

The Rideau Lakes have been a major cottage, hotel, and recreational boating area since the completion of the railway to Westport in 1888. The three lakes - Lower Rideau, Big Rideau, and Upper Rideau - cover an area of 74.6 km^2. Water is deepest (10 to 108 metres or 35 to 350 feet) along the northwest shore of Big Rideau Lake. Here there was enhanced erosion by glacial ice and meltwater along an existing geologic fault.



This picture and the one above show the Beveridge Locks.

Navigational Tracks

The J. Ross Mackay research vessel was used for this survey. It is a 14 m, shallow draught work boat with a data processing laboratory in the cabin and a large afterdeck.

Rideau Lakes Location Map

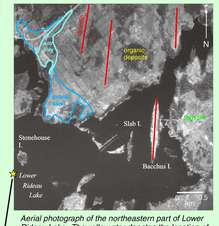
Lower Rideau Lake

The diagram below shows the echosounder record for an area west of Stonehouse Island. The records from most other parts of this lake are poor, reflecting only the presence of gas or weeds. The abundance of gas is likely caused by decaying organic matter associated with the widespread weed cover on the bottom of this lake.

West of Stonehouse Island, deposits of acoustically laminated sediments fill deeper parts of the basin and mask the topography of the underlying till-covered bedrock. It is likely that these deposits are composed of thinly bedded silt, sand and clay deposited in a glacial lake or Champlain Sea at the end of the last glaciation.

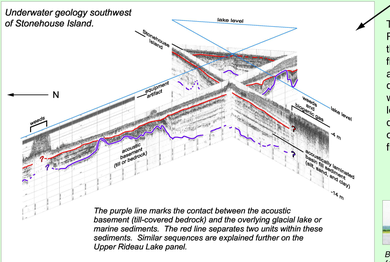
Large marshlands lie along the channel leading from Lower Rideau Lake to the Beveridge Locks.

This style of house, built in the 19th Century from local Paleozoic sedimentary rock, is common along the shores of the Rideau Lakes.



Aerial photograph of the northeastern part of Lower Rideau Lake. The yellow star denotes the location of the echosounder data record shown at bottom left.

Underwater geology southwest of Stonehouse Island.



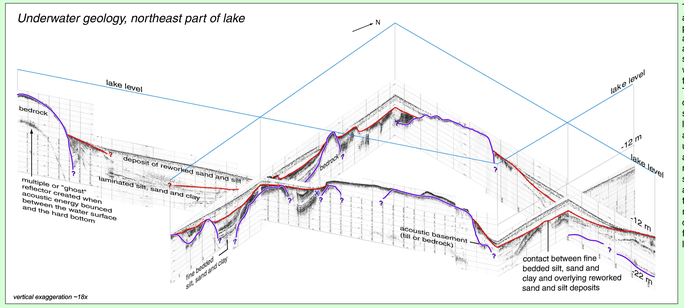
The purple line marks the contact between the acoustic basement (till-covered bedrock) and the overlying glacial lake or marine sediments. The red line separates two rock units within these sediments. Similar sequences are explained further on the Upper Rideau Lake panel.

The till cover is thin (0 - 1.5m) over most of the Rideau Lakes area. In some places where it is thicker, it takes a streamlined form, known as a flute or drumlin. Bacchus Island, shown on the airphoto above, is an example of a well developed drumlin; most others, including those indicated with red lines north of Bacchus Island, have very low relief. They are detectable on airphotos but difficult to observe on the ground. The orientation of the drumlins reflects the direction of glacier ice flow, in this case south-southwestwards.

Bacchus Island: a drumlin. Note the long narrow form of this feature which was moulded by flowing ice.

Upper Rideau Lake

Underwater geology, northeast part of lake

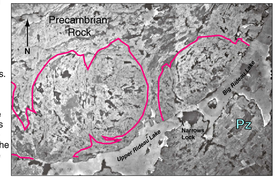


This diagram shows slices through the sediments and rock beneath the bottom of the lake. The purple line marks the boundary between the acoustic basement, characterized by a lack of acoustic reflectors (dark lines), and the overlying sediments. The basement is bedrock with or without a thin cover of till. A red line separates the two main units in the overlying sediments. The lower unit has wavy or parallel, laterally continuous reflectors that are typically closely spaced. This unit takes the form of a sheet where layers of sediments evenly drape the underlying acoustic basement, mimicking its topography. This unit is interpreted to be thinly bedded silt, sand, and clay, deposited in the lakes that fronted the melting glacier. At the boundary between the two sediment units, truncated layers (denoted with"X") are evidence of an erosional period. The origin of the upper sediment unit, characterized by fewer reflectors, is not well understood. It is likely composed of sand and silt that were reworked from the underlying sediments as the glacial lake occupying this basin drained to lower levels.

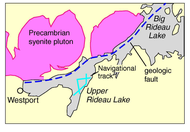
Upper Rideau Lake and adjoining areas of Big Rideau Lake are bounded on their north shores by large plutons (intrusive bodies formed at depth) of Precambrian syenite bedrock. These plutons can be seen on the airphoto to the right. The plutons formed between 1090 and 1060 million years ago when molten rock intruded the marbles and sedimentary quartzites that had formed about 200 million years earlier. Note the rounded shape of the two plutons and the contrast between the rugged Precambrian Shield rocks on the north shore and the flat-lying Paleozoic sandstone (Pz) south of the lakes. The steep bedrock cliffs, common along the northern shoreline, mark the presence of a geologic fault (a fracture along which the rocks have moved).

The cover of till is thicker overlying the Paleozoic bedrock on the south shore than over the Precambrian rocks to the north. There are at least two reasons for this difference. First, during glaciation, debris was more easily eroded by the ice sheet from the flat-lying, finely bedded Paleozoic bedrock than from the Precambrian units composed of massive, coarse-grained rock. Second, the thick till is part of an east-southeast trending belt formed during a brief pause in glacial retreat.

Exposure of syenite pluton near Narrows Lock.

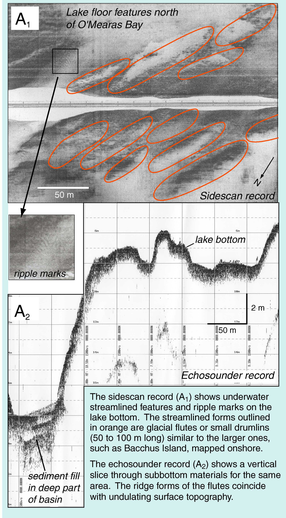


Aerial photograph showing syenite plutons (outlined in red) and an area underlain by flat-lying Paleozoic rock (Pz).



Locations of the syenite plutons and the navigational track for the perspective diagram (above left).

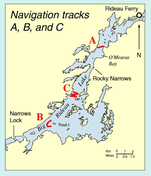
Big Rideau Lake



The sidescan record (A_1) shows underwater streamlined features and ripple marks on the lake bottom. The streamlined forms outlined in orange are glacial flutes or small drumlins (50 to 100 m long) similar to the larger ones, such as Bacchus Island, mapped onshore.

The echosounder record (A_2) shows a vertical slice through subbottom materials for the same area. The ridge forms of the flutes coincide with undulating surface topography.

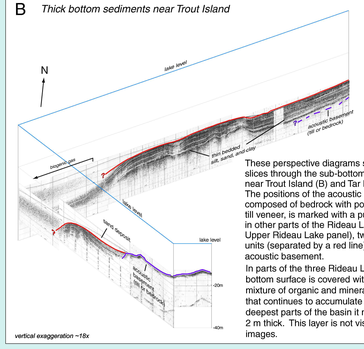
Navigation tracks A, B, and C



Paleozoic sedimentary bedrock on the south shore near Rideau Ferry. Thinly bedded units are typical of the Paleozoic rock in this area.

Precambrian bedrock near Rocky Narrows. In contrast to the Paleozoic units, Precambrian bedrock commonly has a rugged, massive appearance and coarse crystalline texture.

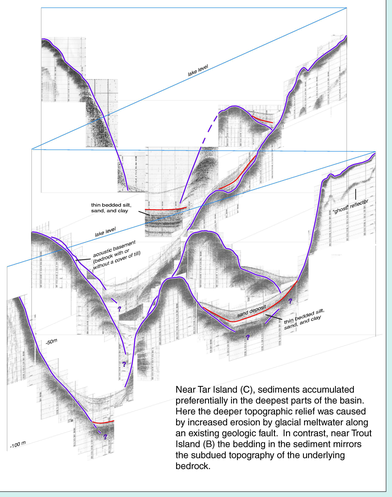
B *Thick bottom sediments near Trout Island*



These perspective diagrams show vertical slices through the sub-bottom materials near Trout Island (B) and Tar Island (C). The positions of the acoustic basement, composed of bedrock with possibly a thin till veneer, is marked with a purple line. As in other parts of the Rideau Lakes (see Upper Rideau Lake panel), two sediment units (separated by a red line) overlie the acoustic basement.

In parts of the three Rideau Lakes, the lake bottom surface is covered with gyttja - a soft mixture of organic and mineral materials - that continues to accumulate today. In the deepest parts of the basin it may be over 2 m thick. This layer is not visible on the images.

C *Rugged underwater topography near Tar Island*



Near Tar Island (C), sediments accumulated preferentially in the deepest parts of the basin. Here the deeper topographic relief was caused by increased erosion by glacial meltwater along an existing geologic fault. In contrast, near Trout Island (B) the bedding in the sediment mirrors the subdued topography of the underlying bedrock.

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