On the Geological Shores of the World's Largest Freshwater Lake

Lake Superior, or *Gi chi Gamiing* ("Great Lake") to the Ojibwa, is the world's largest freshwater lake by surface area, and the deepest of the Great Lakes. Lake Superior Provincial Park protects a magnificent wild landscape along the lake's northern shore. Here, the rocks of the Canadian Shield meet the world's greatest lake in a grand geological display. This GeoTour guide highlights the geological features of 6 popular sites in the park.

A view of Lake Superior from the Trans-Canada Highway north of Katherine Cove.

A map of stops described in this GeoTour.

Getting there

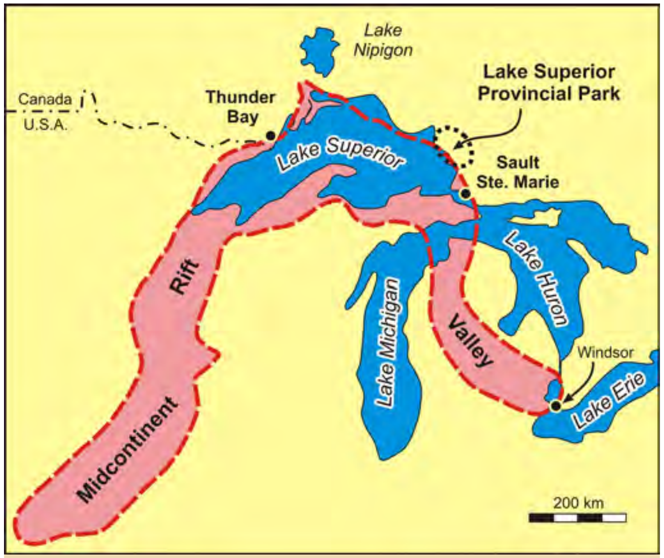
The GeoTour stops in Lake Superior Provincial Park are accessible from the Trans-Canada Highway (Highway 17) between Agawa Bay and Old Woman Bay. The park's Visitor Centre is located at Agawa Bay, 140 km north of Sault Ste. Marie.

Lake Superior Provincial Park

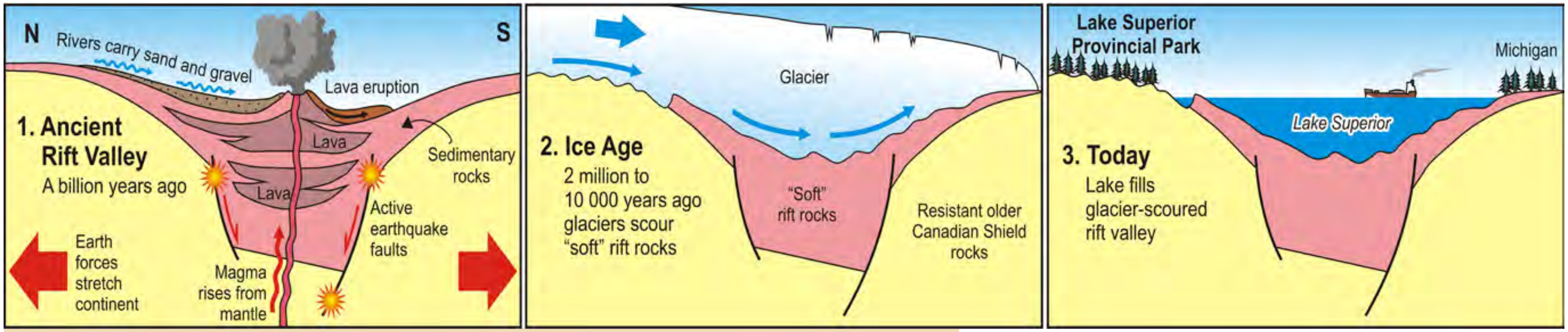
Why is the world's largest freshwater lake in northern Ontario?

Hidden beneath the waters of Lake Superior is the geological secret to its existence: a thick sequence of rocks that fills an ancient rift valley. These rocks underlie the entire lake, but only to the west and south are they well exposed on land. Between Sault Ste. Marie and the town of Terrace Bay on Lake Superior's northern shore, only small pockets of these ancient rift rocks have been preserved from erosion. Instead, this northern lakeshore is dominated by other, older and more resistant rocks of the Canadian Shield.

The history of these ancient rift rocks began a little more than a billion years ago when Earth forces stretched the North American continent, cracking the bedrock along faults and creating a rift valley nearly 2000 km long. The land sagged, volcanoes erupted, and over 35 km thickness of sedimentary (sandstone, conglomerate, shale) and volcanic rock accumulated in the deepening valley. During the Ice Ages, glaciers scoured deeply into the rift rocks because they were much less resistant to erosion than the older granite and metamorphic rocks of adjacent portions of the Canadian Shield. When the glaciers retreated, water filled this great basin, forming Lake Superior. Thus the unique history of glacier scour of an ancient rift valley has created the giant basin that holds the lake.



Map of the Midcontinent Rift.



Cartoon cross-section showing a simplified three-stage evolution of the Lake Superior basin.

Stop 1: Agawa Bay, Visitor Centre and beach

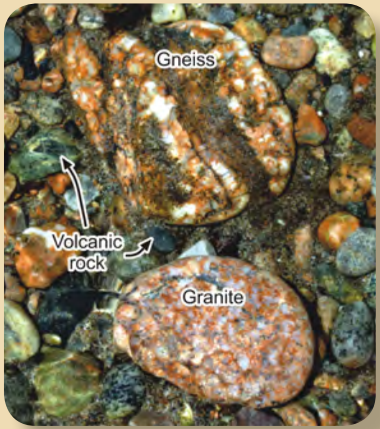
GPS co-ordinates: N47° 20.876′, W84° 37.559′

Agawa Bay is the site of the park's Visitor Centre, its largest campground, and one of the longest beaches on the north shore of Lake Superior. Take time to tour the excellent displays in the Visitor Center and then walk to the nearby beach.

Shorelines rock!

The shorelines of Lake Superior are a great place to see geology. Whether the shoreline is rocky bedrock or beach, storm waves and shifting blocks of winter lake ice scour away any plants that try to grow. Beaches form in bays where there is a good supply of sand and gravel carried to the lake by rivers. The Agawa River, which flows into Lake Superior about 2 km to the north of the Visitor Centre, is the source of the abundant sand on Agawa Bay beach. Lake waves then push the sand both north and south along the shore, forming the beach.

Stop 1: The Visitor Centre and campground are built on a flat sand terrace slightly above and behind the sandy beach at Agawa Bay. This terrace was itself a beach thousands of years ago when the lake level was higher. A small stream beside the Visitor Centre carries sand and gravel to the lakeshore, eroded from other beach terraces further inland.

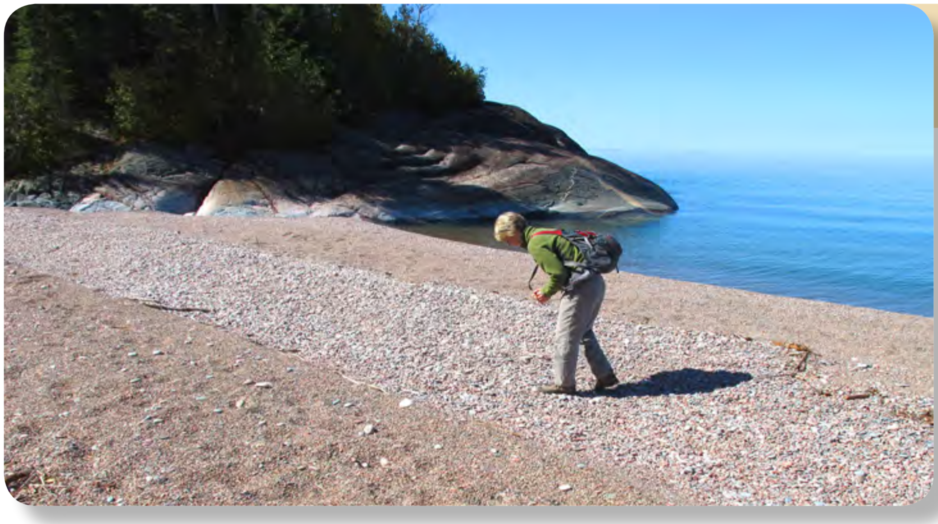


Stop 1: (Left) Sand is made up of grains of different rocks and minerals that have many different colours. (Middle) Sand grains display their colour best when wet. Common sand grains include pale grey quartz, cream to red-orange feldspar, burgundy garnet, green volcanic rock and black amphibole. (Right) Cobbles of granite, gneiss and volcanic rock show the rock types from which the sand grains were eroded.

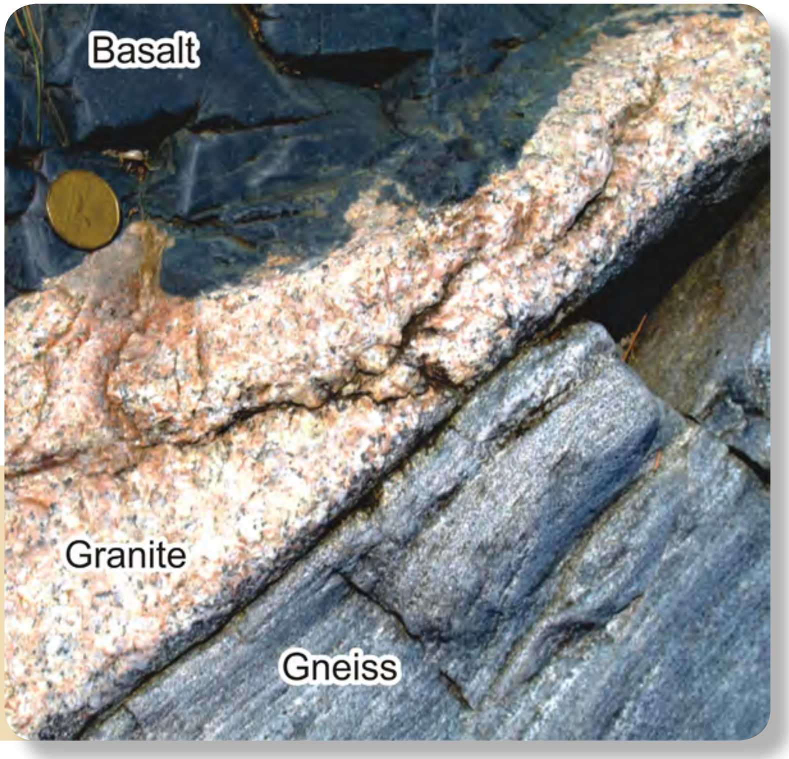
Stop 2: Rocky Point, Agawa Bay Campground

GPS co-ordinates: N47° 19.147′, W84° 36.496′

Ancient rocks of the Canadian Shield form the hills behind Agawa Bay. Rocky Point is a small headland of Canadian Shield bedrock at the southeast end of Agawa Bay Campground beach, about 2 km southeast of the Visitor Centre. A trail leads inland from the end of the beach to the headland at Rocky Point and a private beach further south. The headland's broad rock platform is swept clean by winter storm waves and provides an excellent display of the local bedrock.



Stop 2: Rocky Point forms the southern boundary of the beach at Agawa Bay Campground.



Stop 2: Three rock types are exposed where the beach meets the bedrock slopes of Rocky Point. From upper left to lower right they are black basaltic rock, pink granite (referred to as "pegmatite" if very coarse grained), and gneiss with alternating dark and pale grey bands. The granite contains visible grains of pink and grey feldspar, grey quartz and black amphibole. Loonie for scale is 2.65 cm in diameter.

Veins and dikes: what is the difference?

Veins and *dikes* are sheet-like features that form distinctive stripes across rock outcrops. Both veins and dikes were ancient fractures that have since been filled with minerals. Whereas a vein is a fracture that was filled with minerals deposited from ancient groundwater circulating through the fracture, a dike is a fracture filled with minerals that crystallized from molten rock that injected into the fracture.

Stop 2: A view of the headland at Rocky Point. A basaltic dike forms a prominent dark stripe across pink granite and grey gneiss on Rocky Point. The dike marks the location of an ancient fracture along which magma intruded and cooled to form the rock.

Stop 2: A folded dike of white granite in grey gneiss. The dike was once straight, but was folded under great pressure and temperature deep in the Earth. Loonie for scale.

Stop 3: Agawa Bay Scenic Lookout

GPS co-ordinates: N47° 21.752', W84° 40.229'

A geological boundary

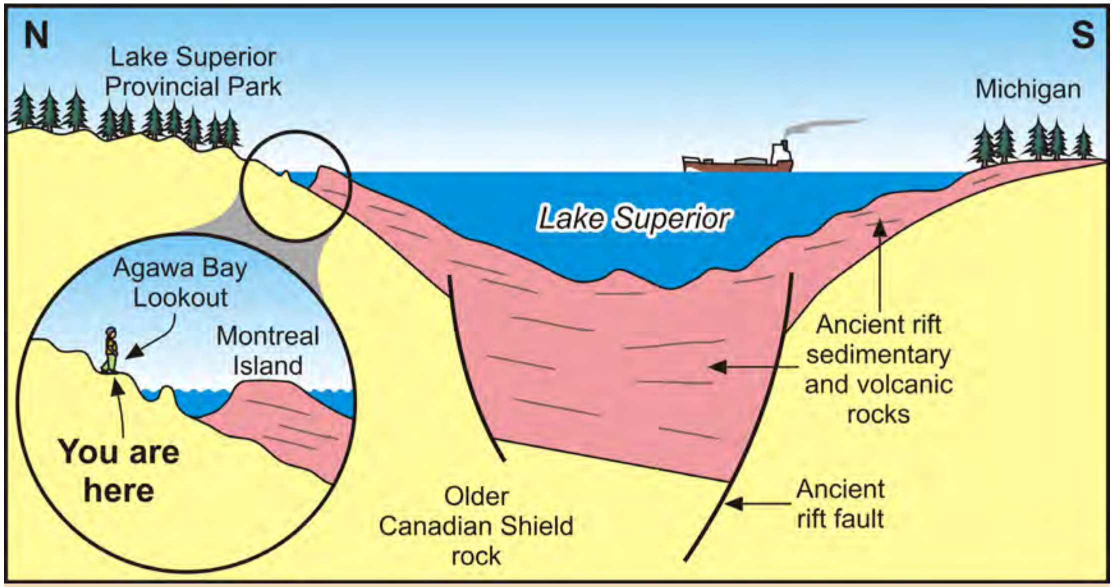
Agawa Bay Scenic Lookout is on a high rock ridge of Canadian Shield granite and metamorphic rocks about 6 km north of the Visitor Centre along Highway 17. The lookout provides expansive views across Agawa Bay, Lake Superior, the rugged hills along the shoreline and the low offshore islands. From the lookout, the flat profile of offshore Montreal Island is a surprise. Seeing rugged shorelines and hills right beside more subdued and flat island landscapes is puzzling and reflects the juxtaposition of 2 very different rock types. Montreal Island represents the eroded edge of the thick sequence of sedimentary and volcanic Canadian Shield rocks that filled the ancient rift now hidden below Lake Superior. These rocks erode much more easily than the older and harder granite and metamorphic Canadian Shield rocks on which they lie. The waters between the shore and Montreal Island mark the boundary between the ancient rift rocks and the older and harder Canadian Shield rocks.

Stop 3: The view to the southeast from the scenic lookout across the Trans-Canada Highway and Agawa Bay. The lookout is perched on hard white granite that was rounded and smoothed by Ice Age glaciers.

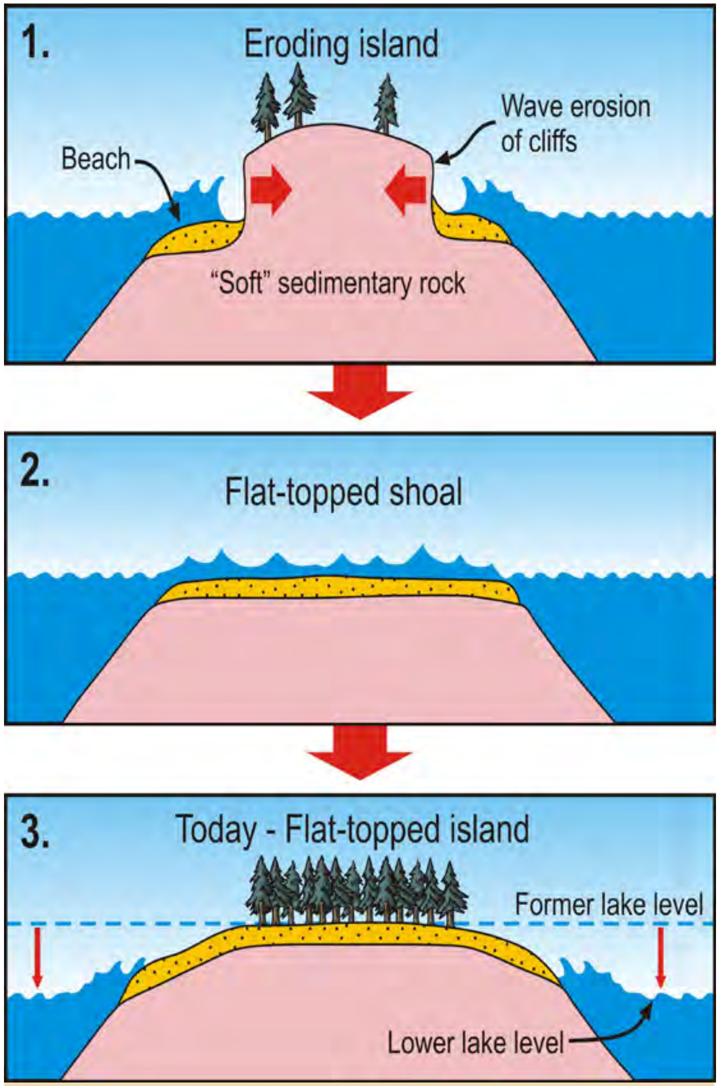
Stop 3: A view to the southwest from the scenic lookout across a rugged shoreline hill to the flat profile of Montreal Island and Lake Superior.

Beheaded islands

Why is Montreal Island so flat? The island is a hill of sandstone that pokes above the lake surface. At the end of the last Ice Age, the lake level of Lake Superior was higher, and the waves eroded the top of the weakly resistant sandstone hill, forming a flat platform. Later, the lake level fell, exposing the wave-cut platform as a flat-topped island.



Stop 3: Cartoon cross-section of Lake Superior showing the thick sequence of ancient rift rocks overlying Canadian Shield rock below the lake. The boundary between older Canadian Shield rock (yellow) and younger Canadian Shield rock (pink) that filled the ancient rift valley lies along the shores of Lake Superior Provincial Park and between Agawa Bay Scenic Lookout and Montreal Island.



Stop 3: A schematic diagram showing the interpreted origin of Montreal Island.

Stop 4: Agawa Rock Pictographs

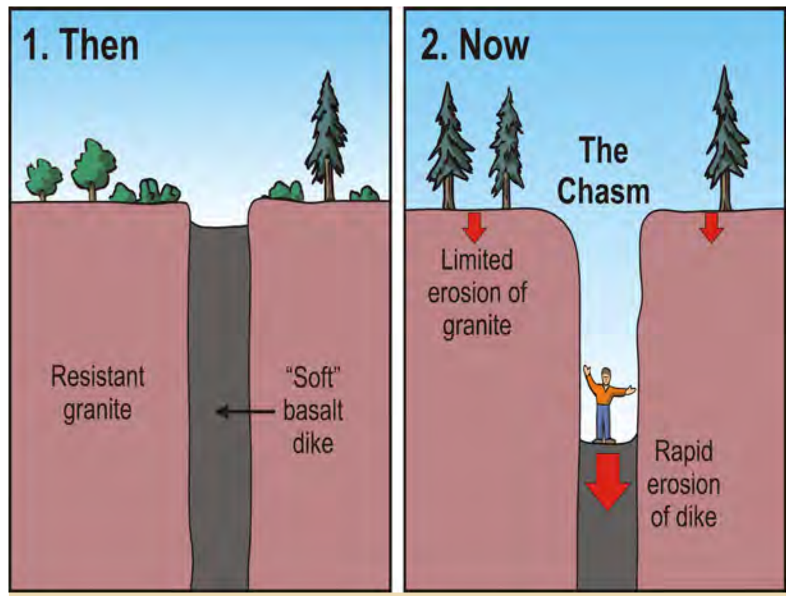
GPS co-ordinates: N47° 22.219′, W84° 41.988′

About 1.5 km north on Highway 17 from the Agawa Bay Scenic Lookout and 7.5 km north of the Visitor Centre is the turnoff to the Agawa Rock Pictographs. A kilometre and a half from the highway is a parking lot and from here, a short trail leads down to the shoreline site of the pictographs. The pictograph site can be viewed at a distance from a nearby shoreline overlook. A close-up examination of the pictographs requires caution as large waves could easily sweep a visitor into the lake.

Stop 4: A portion of the trail follows a chasm once filled with a narrow sheet-like body (or dike) of basaltic rock or diabase that has eroded more quickly than the adjacent and more resistant granite.

The Chasm

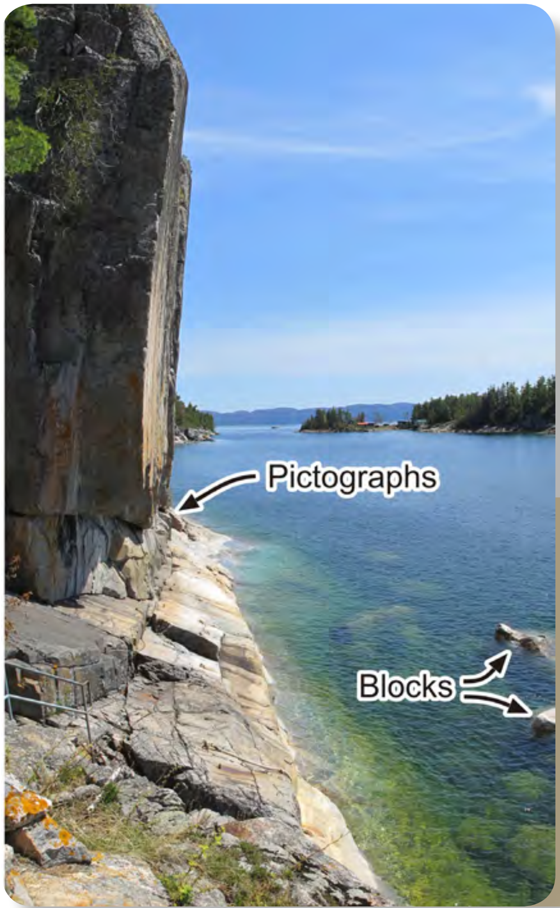
The trail to the pictographs passes through a narrow chasm in pink granite of the Canadian Shield. The chasm is striking evidence that when "softer" rocks erode more quickly than surrounding more resistant rock, a depression is created. The chasm is an example that differs only in scale from the erosion of the ancient rift rocks that created the Lake Superior basin.



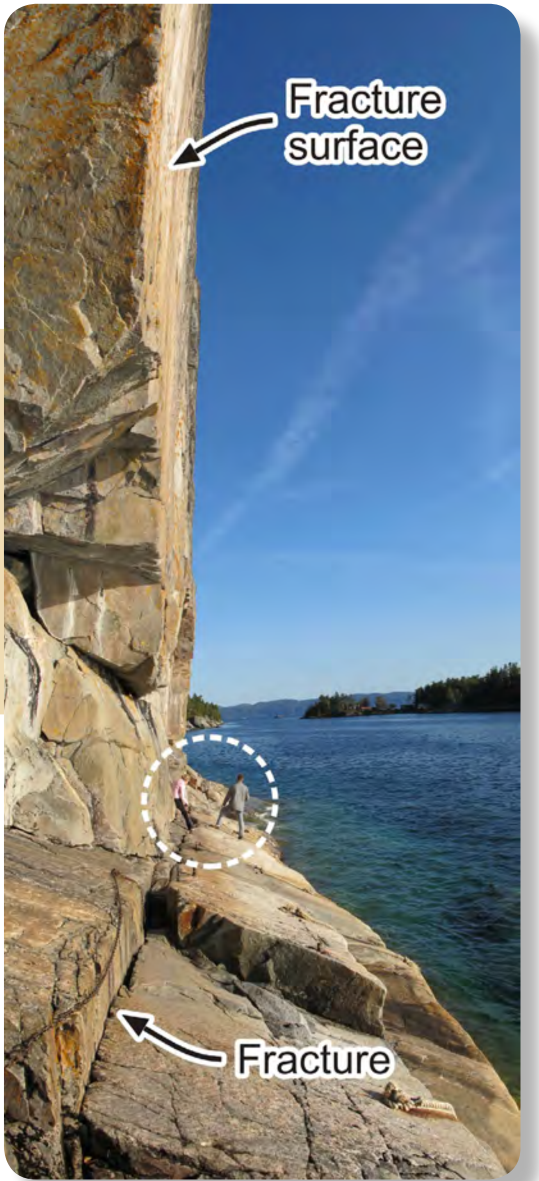
Stop 4: A schematic figure illustrates the origin of the chasm over time.

A natural place to paint

The pictograph site is on a shoreline cliff of Canadian Shield granite and is a very picturesque example of Lake Superior's north shore. It is not clear why this site was chosen by ancient people for their painting, but several geological factors may have made it favourable. The collapse of rock along vertical fractures in the cliff has created a smooth vertical wall. The granite bedrock has a pale colour and homogeneous texture that provide a favourable canvas for the drawings. As well, granite is a very durable rock and provides a stable and enduring base for the artwork. The site is readily accessible by water and may have even provided the natural ochre pigment for painting.



Stop 4: The pictographs are on a shoreline cliff above a sloping ledge. The cliff formed when granite slabs collapsed along vertical fractures parallel to the shore. Large broken blocks of rock from this ongoing collapse sit just offshore.



Stop 4: The cliff is the surface of one side of a fracture. The fracture is visible at the base of the cliff at the juncture with the sloping rock ledge. Hikers (circled) for scale.

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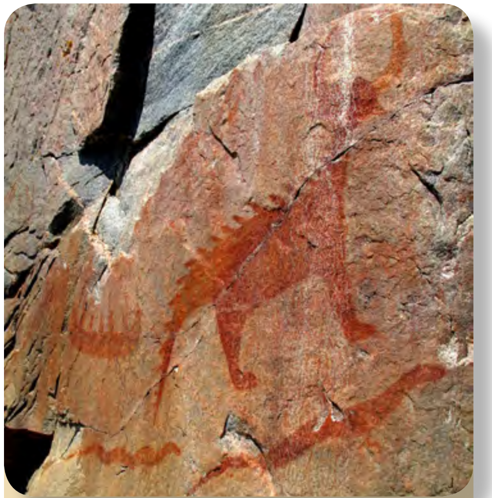
Nearby natural pigments

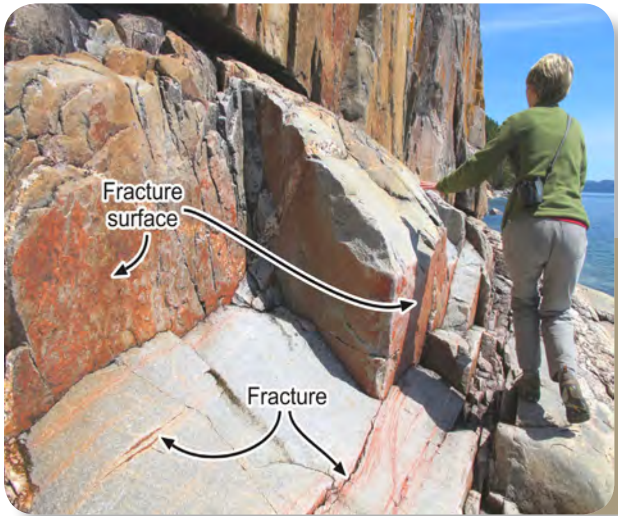
The pictographs were painted using ochre, a natural earth pigment consisting mostly of hydrated iron oxide. The red ochre was mixed with oils from fish or animal fats to form an oily paste for painting. Possible sources of ochre sites are known near Gargantua Bay, 35 km to the northwest along the coast, and also at the Agawa pictograph site, where fractures exposed on the sloping rock shelf at the base of the shoreline cliff contain red iron oxide ochre-like material.

The geological origin of the ochre may be linked to its location. The pictograph site lies within Canadian Shield granite near the boundary between the older rocks exposed along the Lake Superior shore and the younger rocks that filled the Midcontinent Rift and are now hidden under Lake Superior. The fractures exposed at the pictograph site likely formed during rifting a billion years ago as the continent stretched and cracked. Hot magma rose along faults under the rift and erupted as volcanoes. The basaltic dike on the rock ledge near the pictographs is an example of the ancient magma that was intruded into a crack and then cooled and crystallized. The rising magma heated the nearby rocks and the groundwater that circulated through them. These hot waters dissolved iron and other minerals, carried them in solution and deposited them in fractures like the ones at the pictograph site while they were still buried in the Earth. Erosion since that time has removed overlying rift rocks, exposing the present site.



Stop 4: Agawa pictographs.

Stop 4: A close-up view of fractures and a fracture surface (upper right) with ochre. Penny for scale.



Stop 4: Fractures in the rock ledge at the base of the cliff contain a brick-red, ochre-like material rich in iron oxide. The red lines in the sloping rock shelf are cross sections of the fractures, while the surfaces that look like they have a painted coating are the fracture surfaces themselves.

Stop 4: (Left) The basaltic dike that cuts across the granite shelf at the pictograph site represents a fracture along which magma rose and cooled and hardened to rock. More rapid erosion of this dike relative to the adjacent granite has created a cleft in the rock, similar to the chasm along the access trail.
(Right) Holes in the dike rock indicate that the basaltic magma was bubbling with gas as it cooled and hardened. Since the pressure must be low for dissolved gas to be released from magma, the dike was likely just below the ancient land surface and may have fed an ancient volcano, which would explain the presence of volcanic deposits in nearby rift rocks.

Stop 5: Katherine Cove day-use area

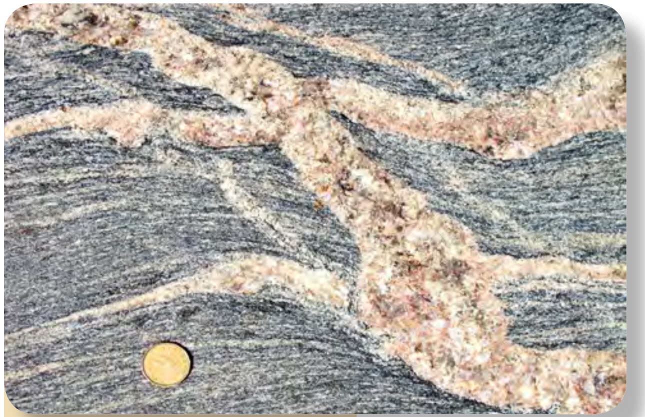
GPS co-ordinates: N47° 26.612′, W84° 44.984′

A virtual tour of the deep Earth

Katherine Cove is a very popular site along Highway 17 about 16 km north of the park's Visitor Centre. At Katherine Cove, 2 sheltered coves with fine sand beaches and waters uncommonly warm for Lake Superior straddle a small point. A short access trail leads to a broad rock platform at the tip of the point. A separate trail leads from the north end of the northern cove to a flat rock platform.

Rocks exposed on both platforms provide striking displays of textures that can only form deep in the Earth. At very high temperatures and pressures, rock will partially melt and flow like toothpaste, causing minerals to align, recrystallize and segregate into layers. The result is a banded rock with granite-like textures called *gneiss*. Some of the melted rock separated from the gneiss and squirted into cracks, forming a network of granite and pegmatite veins.

Stop 5: Pink veins of coarse-grained granite (pegmatite) cut grey gneiss on the rock platform that forms the tip of the small peninsula that separates the beaches at Katherine Cove.



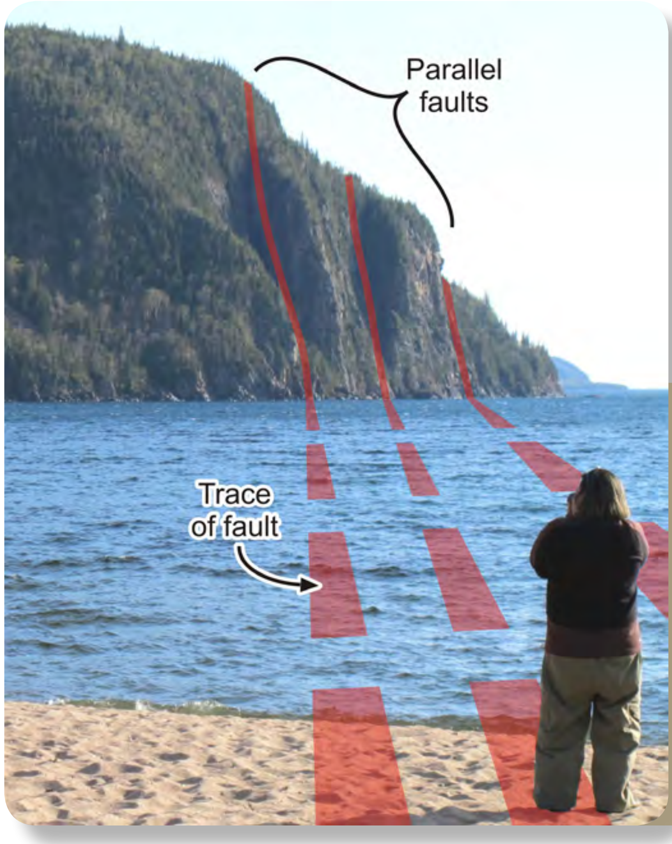
Stop 5: Pink granite veins cut across banded grey gneiss. Loonie for scale.

Stop 6: Old Woman Bay day-use area

GPS co-ordinates: N47° 47.435′, W84° 53.828′

Sixty kilometres north of Agawa Bay along Highway 17 is Old Woman Bay and its attractive beach bound by 2 prominent headlands. The Old Woman River flows into Lake Superior here after being deflected by the long beach spit, or berm, to the far south end of the cove.

Stop 5: White granite veins protrude from dark gneiss at the point north of Katherine Cove. Granite resists erosion better than the gneiss and provides another example of differential weathering.



Stop 6: Old Woman Bay was named for the shape of a woman's face displayed in the cliffs along the south shore. Deep clefts in the rock create the face and reflect differential erosion along geological faults within the headland.

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Stop 6: The view upstream of the Old Woman River from the bridge crossing on the Trans-Canada Highway. The extensive deposits of sand and gravel that underlie the Old Woman River valley were deposited as beaches when the lake level was higher and the shoreline further inland. The river erodes these deposits and carries the sand and gravel to the lake, creating today's beach.

Stop 6: The channel of the Old Woman River is deflected behind a beach berm, the result of active beach-building by the power of lake waves. The prevailing westerly winds drive waves southwards along the beach, continually damming the river mouth with sand and forcing the river water to flow towards the southern end of the bay.

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