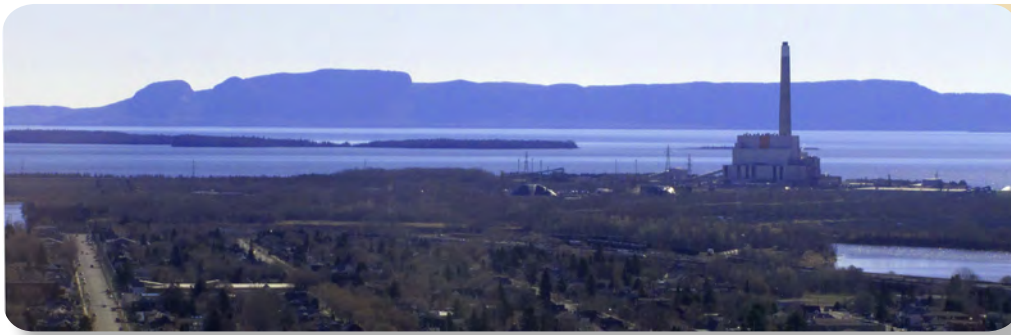


Thunder Bay

Geology of the Lakehead Region

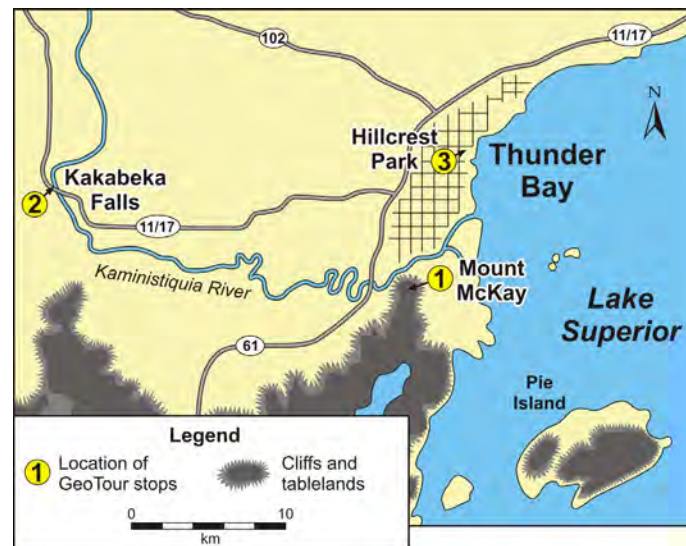
Thunder Bay is the hub of northwestern Ontario. Sitting near the western end of Lake Superior, it is often referred to as the “Lakehead” region. This GeoTour guide highlights 3 stops in the Thunder Bay region, all with fascinating geological stories: a mountain-top view of the city, a famous waterfall and a downtown park that contains evidence of an ancient meteorite impact. Along the way, the ancient origins of Lake Superior and the iconic tableland—flat-topped mountain—landscapes that surround the city are addressed.



The Sleeping Giant is an iconic landmark that rises from the waters of Lake Superior east of Thunder Bay. This cliff-bound tableland is eroded from a flat-lying and resistant layer of igneous rock known as diabase. Its sheer 240 m high cliffs are the highest in Ontario. *Photo courtesy of the Ontario Geological Survey.*

Setting the stage: The ancient origins of the world’s largest freshwater lake

Lake Superior, the world’s largest freshwater lake by surface area, has a unique geological origin that has led to its enormity. About 1.1 billion years ago, the North American continent almost split into 2 landmasses. Forces in the Earth’s mantle at that time stretched the continent, breaking the hard Canadian Shield rocks along geological faults. The land sagged between these faults, forming a rift valley similar to the modern Great Rift Valley in Africa. Melted rock, or *magma*, rose from the mantle and erupted as fiery lavas for tens of millions of years as the rift valley floor continued to sink. At the same time, rivers carrying sand and gravel drained into this valley. Seismic surveys indicate that over 35 km of volcanic and sedimentary rock lie buried in this ancient rift.



A map of the Thunder Bay area showing the location of the GeoTour stops. Thick diabase layers form long and high cliffs, or “escarpments”, that dominate the landscapes around Thunder Bay.

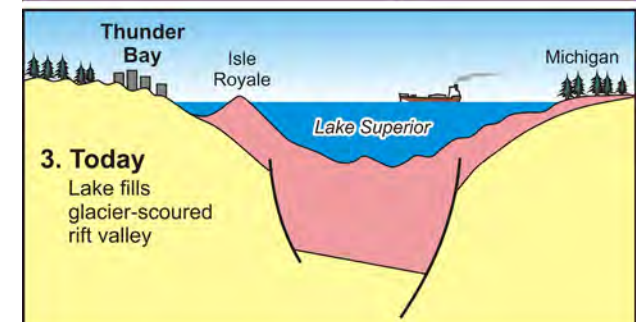
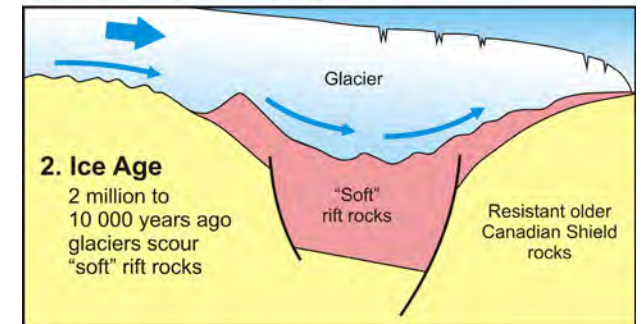
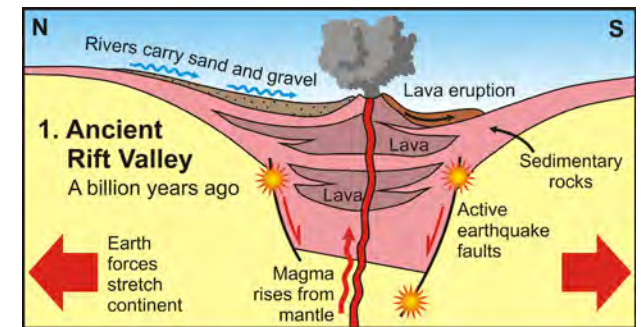
Thunder Bay

Many giant lakes, such as Lake Tanganyika in East Africa and Lake Baikal in Siberia, lie within active rift valleys, where the Earth's crust sags and forms a deep basin. Other giant lakes, such as those of the Great Lakes, and Great Bear and Great Slave lakes, fill large depressions scoured by Ice Age glaciers.

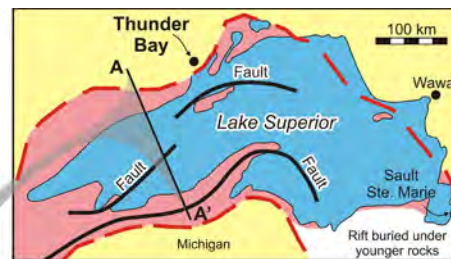
Lake Superior, the largest of all, lies in a basin that was both an ancient rift valley and was scoured by glaciers. Before the Ice Age, the basin that is now filled with Lake Superior was a river valley carved into the soft Canadian Shield rocks filling the ancient rift valley. During the Ice Age, glaciers flowed into the valley, scouring it deeper. When the glaciers melted, the deep basin was a giant trap for water carried by streams, and it filled to create the great lake that it is today.



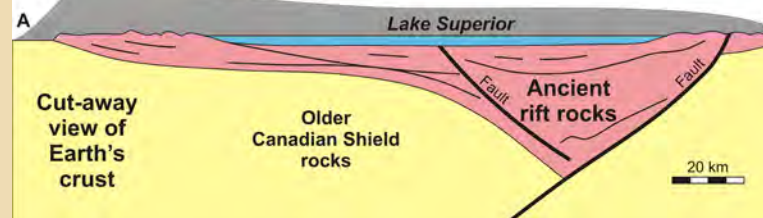
The rocks filling an ancient rift valley extend about 2000 km from the state of Kansas, USA, to Windsor, Ontario, and lie buried below younger sedimentary rocks for much of their extent. However, they are exposed along the shores of Lake Superior and underlie the lake.



The evolution of Lake Superior.



Thunder Bay sits at the edge of the ancient rift valley. The cross-section shows the underground extent of the ancient rift rocks.



Thunder Bay

Stop 1: Mount McKay Scenic Lookout

GPS co-ordinates: N48° 20.754', W89° 16.700'

Our first GeoTour stop is a scenic lookout on Mount McKay, the striking mountain on the southern edge of the city. The mountain is sacred to the local Ojibwe people of the Fort William First Nation and is known as *Animikii-wajiw*, or “Thunder Mountain”.



Stop 1: An aerial view looking south across Thunder Bay to Mount McKay. The mountain is a promontory on an irregular escarpment known as the Nor'Westers, which separates a tableland to the south from lowlands to the north.

Photo courtesy of the Ontario Geological Survey.

A story of 2 landscapes

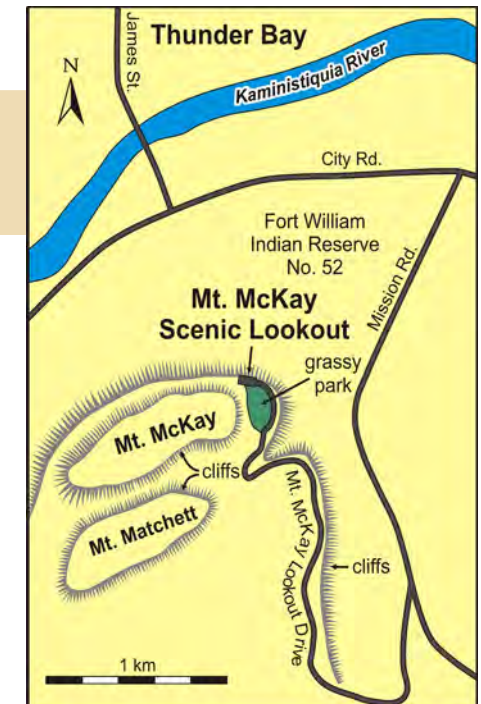
The scenic lookout on Mount McKay provides a remarkable panorama of the Lakehead region. To the west and north is the relatively flat, undulating landscape that characterizes much of the Canadian Shield. In contrast, to the east and northeast, along the shores of Lake Superior, are rugged flat-topped mountains bounded by vertical cliffs. What causes this dramatic change in scenery?



How to get there

Mount McKay Scenic Lookout is just south of the city of Thunder Bay on Fort William First Nation's lands. An access fee is charged.

A map showing access to Mount McKay Scenic Lookout.



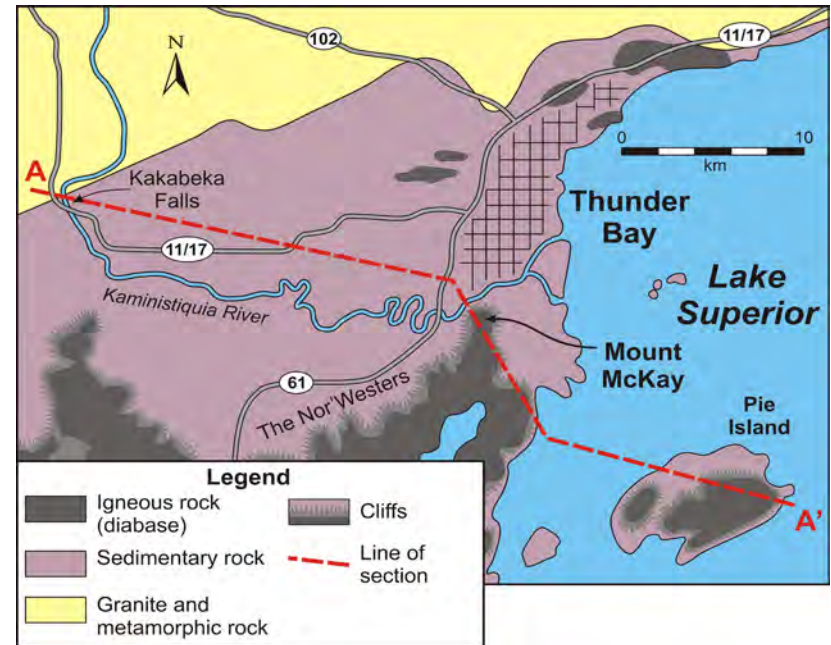
Stop 1: Looking northwest from the lookout across the Kaministiquia River to the flat landscape of the older Canadian Shield.

Thunder Bay

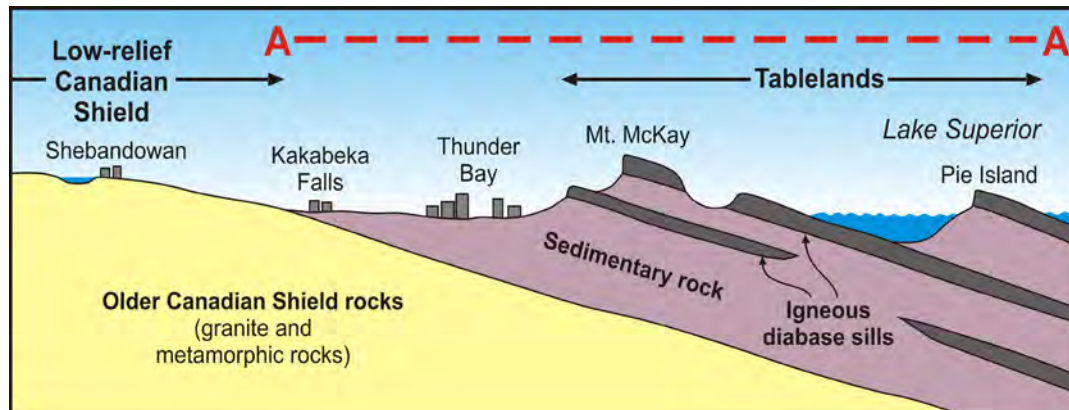


Stop 1: Looking southeast from the scenic lookout at tablelands on Pie Island, offshore from Thunder Bay. These tablelands lie on the outer edge of the rift valley, which is filled with younger Canadian Shield rocks.

The answer lies in the underlying geology. Thunder Bay lies at the boundary between 2 major subdivisions of the Canadian Shield: older (>2.5 billion-year-old) granite and metamorphic rocks and overlying younger (1.8 to 1.1 billion-year-old) layers of an igneous diabase and sedimentary rock. The older rocks, being more uniform in hardness, have eroded at similar rates and form a relatively flat landscape. In contrast, the resistant diabase and soft sedimentary rock erode at very different rates, resulting in a landscape of cliffs and flat-topped mountains called tablelands. Mount McKay is a promontory on an irregular escarpment of these tablelands. Tablelands extend from southwest of Thunder Bay to Rosspoint, about 200 km to the northeast along the northwest margin of the ancient rift valley. The Sleeping Giant is a tableland that rises to the east across the waters of Lake Superior on the Sibley Peninsula.



Stop 1: A geological map of the Thunder Bay area showing the location of the cross-section displayed in the figure below. Thick layers of igneous diabase rock form the high cliffs near Thunder Bay.



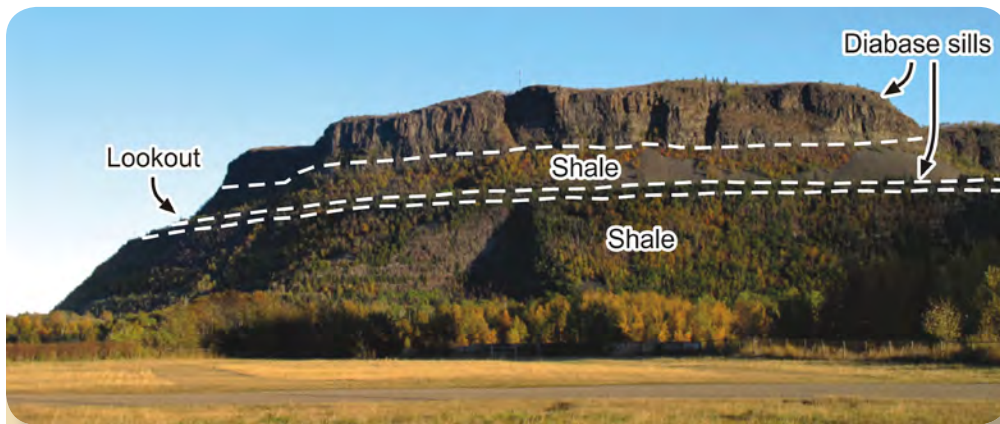
Stop 1: Underlying geology explains the different yet adjacent landscapes.

Thunder Bay

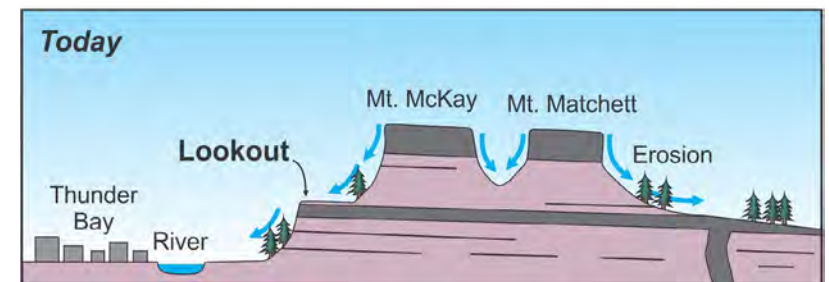
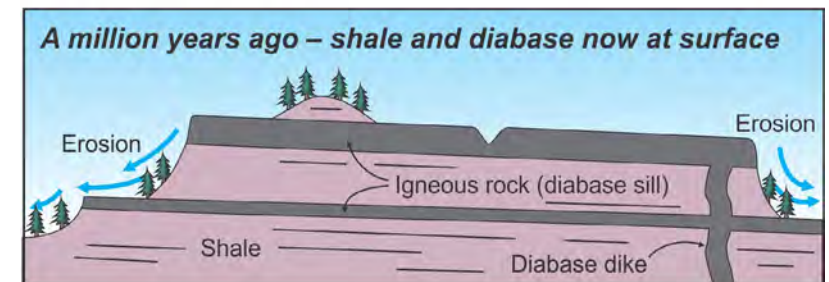
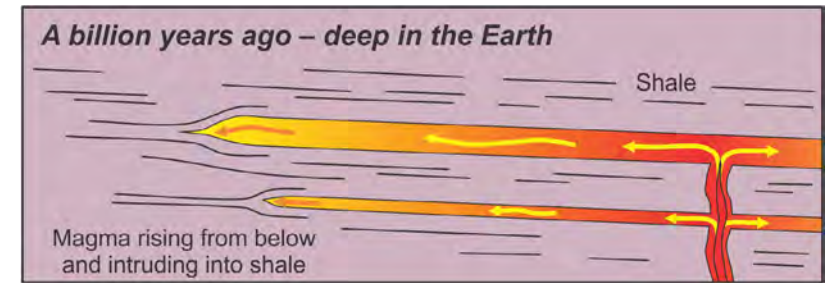
Creating Mount McKay

The rocks exposed at Mount McKay are gently tilted layers of sedimentary shale and igneous diabase. The diabase formed about 1.1 billion years ago during the formation of the ancient rift valley, when magma rising from the mantle spread laterally between the layers of shale deep within the Earth, cooling and crystallizing into thick sheets of igneous rock known as *sills*. Sills lie parallel to layers of rock that magmas intrude, while *dikes*, which also form by magma intruding into rock, cut across rock layers.

The high cliffs of Mount McKay are the retreating edges of layers of diabase and shale that once covered a much larger area. More rapid erosion of the soft shale undercuts the overlying cap rock of diabase, causing it to break and topple. In this way, erosion maintains a vertical cliff. Erosion of soft shale overlying the diabase has exposed the flat top of the once-buried diabase sill.



Stop 1: A view of Mount McKay from the northwest.



Stop 1: The origin of Mount McKay and the tablelands of the Thunder Bay region.

Thunder Bay

Stop 2: Kakabeka Falls Provincial Park

GPS co-ordinates: N48° 24.170', W89° 37.414'

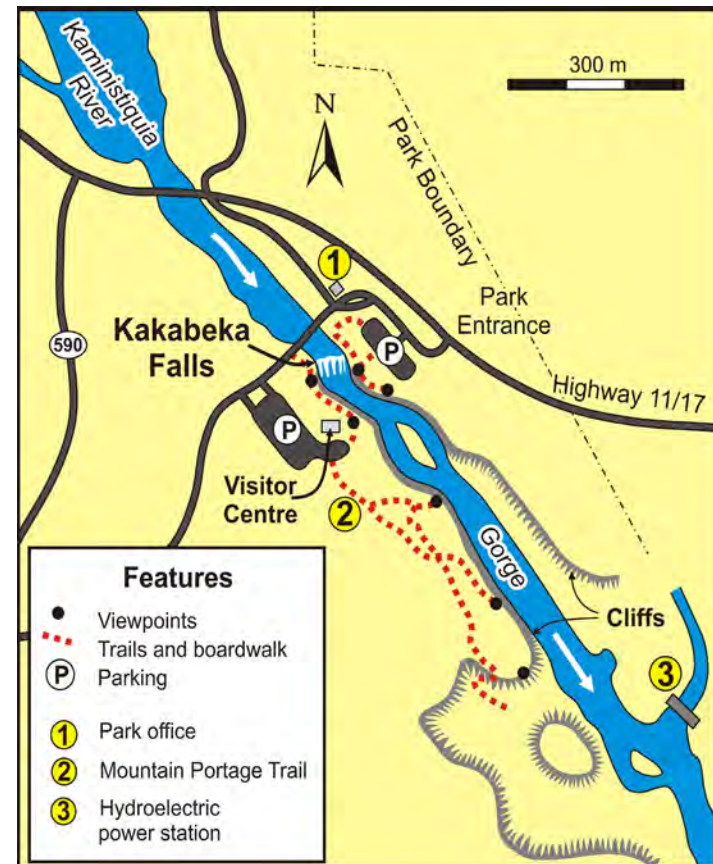
Kakabeka Falls, on the Kaministiquia River, is an awe-inspiring wonder in a popular provincial park along the Trans-Canada Highway west of Thunder Bay. The name “Kakabeka” comes from the Ojibwe word *gakaabikaa*, meaning “waterfall over a cliff”. For the Voyageurs in the 1800s, the Kaministiquia River was a major route westwards from historic Fort William, located on the edge of Lake Superior, and a major portage was built to bypass these falls. Exhibits at the visitor centre tell the geologic story of the falls, its famous fossils and the history of Ojibwe and fur traders.

How to get there

Kakabeka Falls Provincial Park is 27 km west of Thunder Bay on the Trans-Canada Highway (Highway 11/17). There is a fee for day parking and for use of the campground.



Stop 2: Boardwalks and trails provide a number of different viewpoints of the falls and gorge at Kakabeka Falls Provincial Park.



Stop 2: Map of Kakabeka Falls Provincial Park.

Thunder Bay

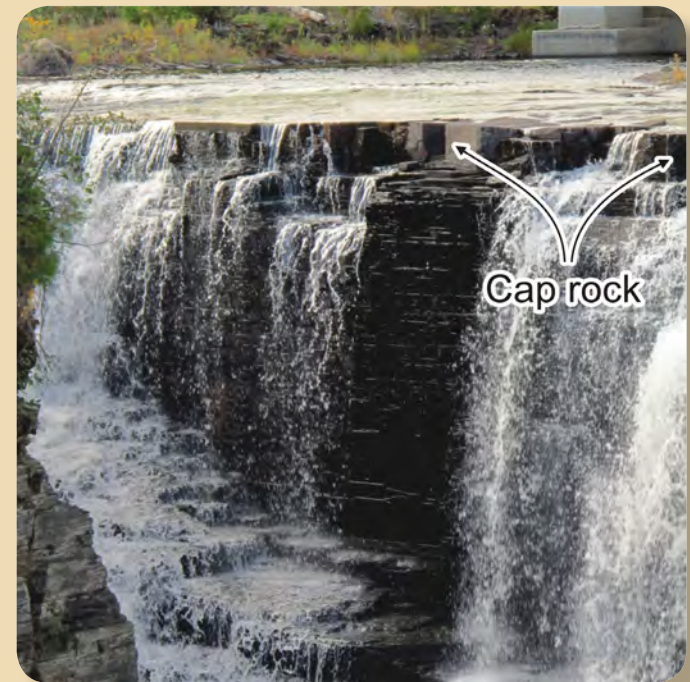
Niagara of the North

The Kakabeka Falls area is underlain by flat-lying layers of soft shale that erode easily. However, within the shale are layers of chert, a hard sedimentary rock that resists erosion. One chert layer underlies the bed of the Kaministiquia River above the falls, and forms a durable lip, or cap rock, for the falls. The underlying shale erodes easily, undercutting the cap rock and causing it to topple. In this way the falls retreats upstream while maintaining a near-vertical drop.

Stop 2: The Kaministiquia River tumbles 40 m to form Kakabeka Falls. The falls is known as the “Niagara of the North” for its similarity to Niagara Falls. Both the Niagara and Kaministiquia rivers flow across flat-lying and strongly layered sedimentary rocks, then tumble into a gorge.



Stop 2: Shale at the falls contains abundant closely spaced fractures and bedding planes that cause the rock to easily break into thin plates. Quarter is 2.3 cm in diameter.



Stop 2: The lip of the falls is protected by a metre-thick cap rock layer of hard chert.

Thunder Bay

Gorge Cutter

The thunder and mist of the falls immediately capture your attention when you arrive in the park. However, you will soon notice another dramatic feature of the park: the gorge. Below the falls, the Kaministiquia River flows through a deep canyon. What is the relationship of the gorge to the falls?

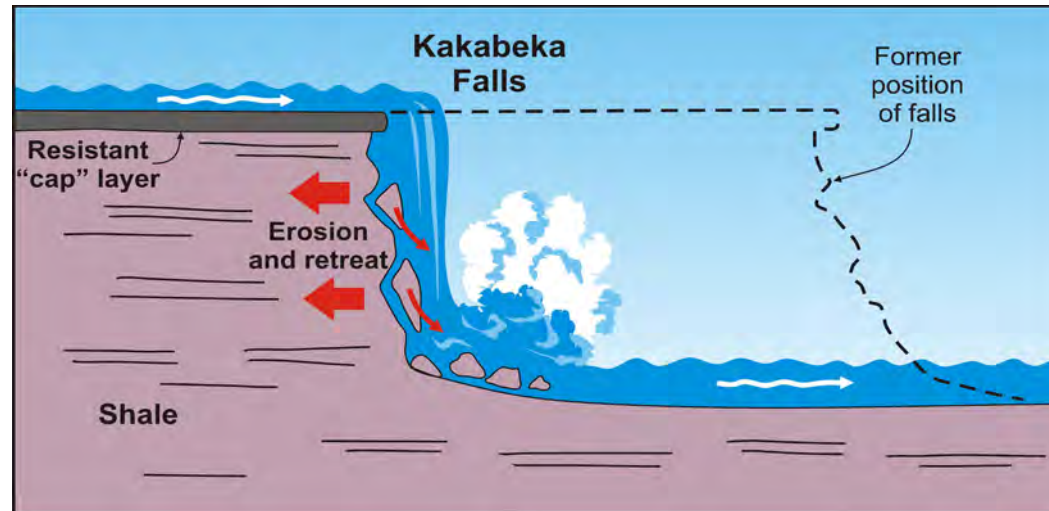


Stop 2: A view of the gorge and falls from a viewpoint along the Mountain Portage Trail.

Waterfalls will create a canyon where the rock is easily worn away. Falling water has great power to erode, particularly during floods. Shock waves from crashing water pulse through water-filled fractures, loosening rock. During cold weather, repeated freezing and thawing of water in fractures further wedges rocks apart. The river carries the loose rubble away and, over time, the position of the falls moves, or retreats, upstream.

Thunder Bay

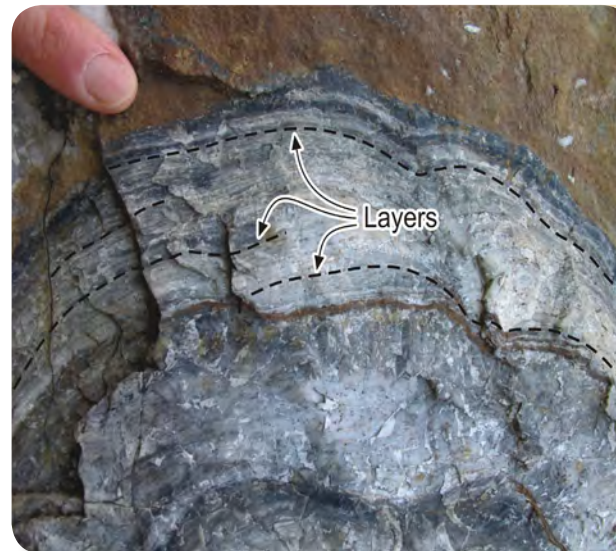
How fast is the falls cutting upstream? It is likely that the 500 m long gorge has been cut since the Kaministiquia River formed at the end of the Ice Age 10 000 years ago. The flow of meltwater from the retreating glaciers was much greater than the modern Kaministiquia River, and much of the gorge was likely cut in a few hundreds to thousands of years. Since then, the falls have continued to retreat upstream at a more leisurely pace.



Stop 2: Kakabeka Falls is formed by erosion of soft shale below a hard cap rock. When the cap rock no longer has shale underneath to support it, overhanging cap rock snaps off and falls to the base of the falls. The length of the gorge marks the distance the waterfall has retreated.

Famous Fossils

The sedimentary rocks that underlie the area near Kakabeka Falls are 1.8 billion years old and are known as the Gunflint Formation. In the 1950s, researchers discovered fossils in the Gunflint Formation that are interpreted to be ancient colonies of cyanobacteria, a community of algae and bacteria called *stromatolites* that formed mounds on shallow seafloors, and still live in several locations around the world today. This exciting discovery of stromatolites in the Gunflint Formation pushed back the age of earliest known life on Earth by over a billion years and brought international scientific attention to the Thunder Bay region. The park visitor centre has excellent displays of these fossils. Since the 1950s, older fossils continue to be found elsewhere. Most recently, bacterial fossils found in Western Australia have been dated at almost 3.5 billion years old.



Stop 2: A road cut near Kakabeka Falls Provincial Park reveals a cross section through a fossilized stromatolite the size of a large cabbage. Fine layering in the stromatolite represents successive deposits of fine sediment trapped by ancient colonies of algae and bacteria.

Thunder Bay

➤ Stop 3: Hillcrest Park, Thunder Bay

GPS co-ordinates: N48° 26.050', W89° 14.082'

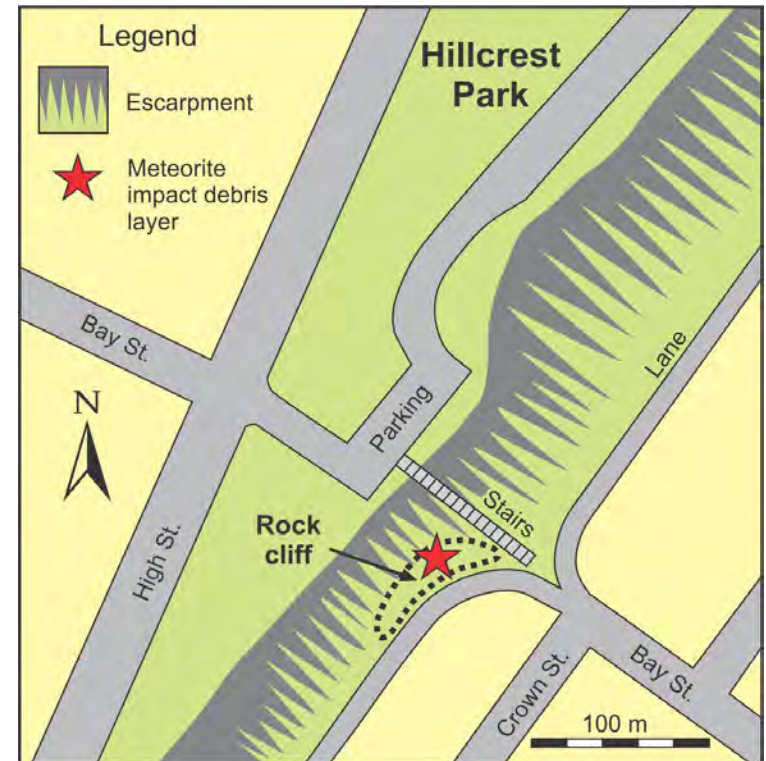
Hillcrest Park in Thunder Bay sits at the top of an escarpment and provides sweeping views. The park is popular with visitors and residents and includes gardens and a World War II memorial to a local regiment.



Stop 3: View of downtown Thunder Bay, Lake Superior and the Sleeping Giant from Hillcrest Park.

How to get there

Hillcrest Park is in the north-central part of Thunder Bay. From the Trans-Canada Highway take Red River Road east and turn right (south) on High Street. Turn left (east) at the second entrance to Hillcrest Park, at Bay Street. At the bottom of the stairs that descend from the parking lot, turn right (south) and walk along the narrow lane to the small rock cliff that exposes the meteorite impact debris layer.



Stop 3: A map of Hillcrest Park showing location of rock outcrop containing ancient meteorite impact debris.

Thunder Bay

Ancient meteorite impact debris

Geologists have long recognized that the rocks exposed at Hillcrest Park are unusual. Within the cliff is a layer of rock that contains abundant fragments, and for many years these rocks were interpreted to have been deposited by a violent storm. Recently, 2 retired high school teachers with an interest in geology have provided evidence that the rocks represent debris fractured, disrupted and/or deposited by the impact of the giant meteorite that collided with the Earth near present-day Greater Sudbury about 1.85 billion years ago. This layer of ancient meteorite impact debris has since been found elsewhere west and south of Lake Superior along with evidence for a tsunami associated with the impact.



Stop 3: Rocks in the cliff contain fragments of broken rock that were ripped up by the ancient meteorite impact. Penny (1.9 cm in diameter) for scale.

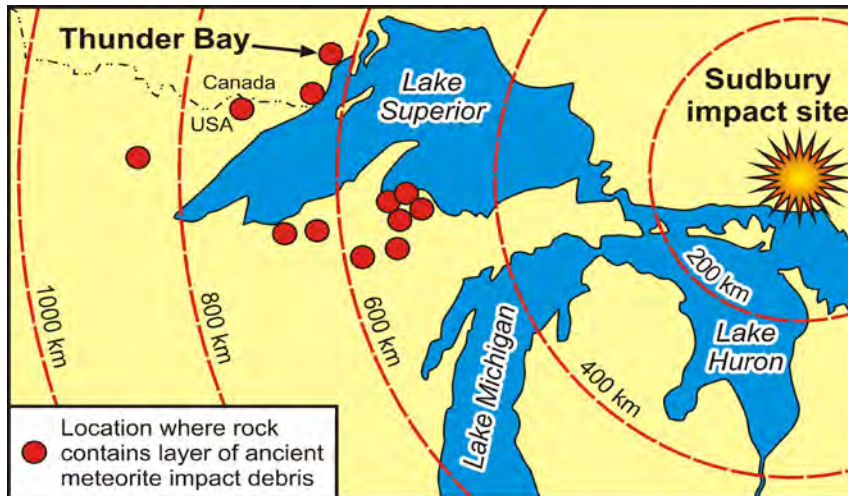


Stop 3: Geologists discuss the nature of the layer of ancient meteorite impact rocks exposed below the lookout at Hillcrest Park.

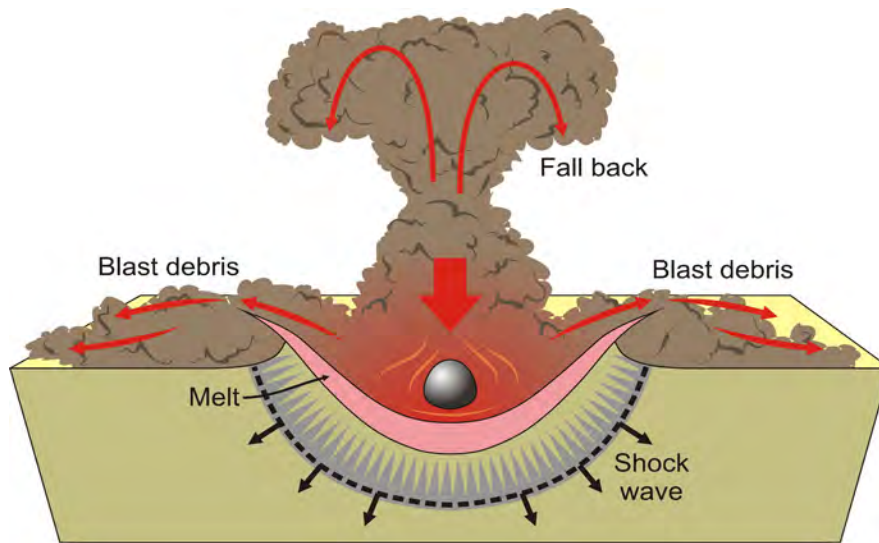


Stop 3: A rock outcrop near Hillcrest Park provides another exposure of the meteorite impact debris layer. Here, boulder-size fragments, 600 km from the site of the meteorite impact, are evidence of the power of the impact.

Thunder Bay



Stop 3: Rocks containing debris from the Sudbury meteorite impact site have been found as much as 800 km from the impact site. The absence of sites closer to the Greater Sudbury area is likely due to subsequent erosion of these rocks.



Stop 3: A cross-section of the Greater Sudbury area at the time of impact. Impact debris spread for hundreds of kilometres from the meteorite impact site, sweeping across the present site of Thunder Bay.

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