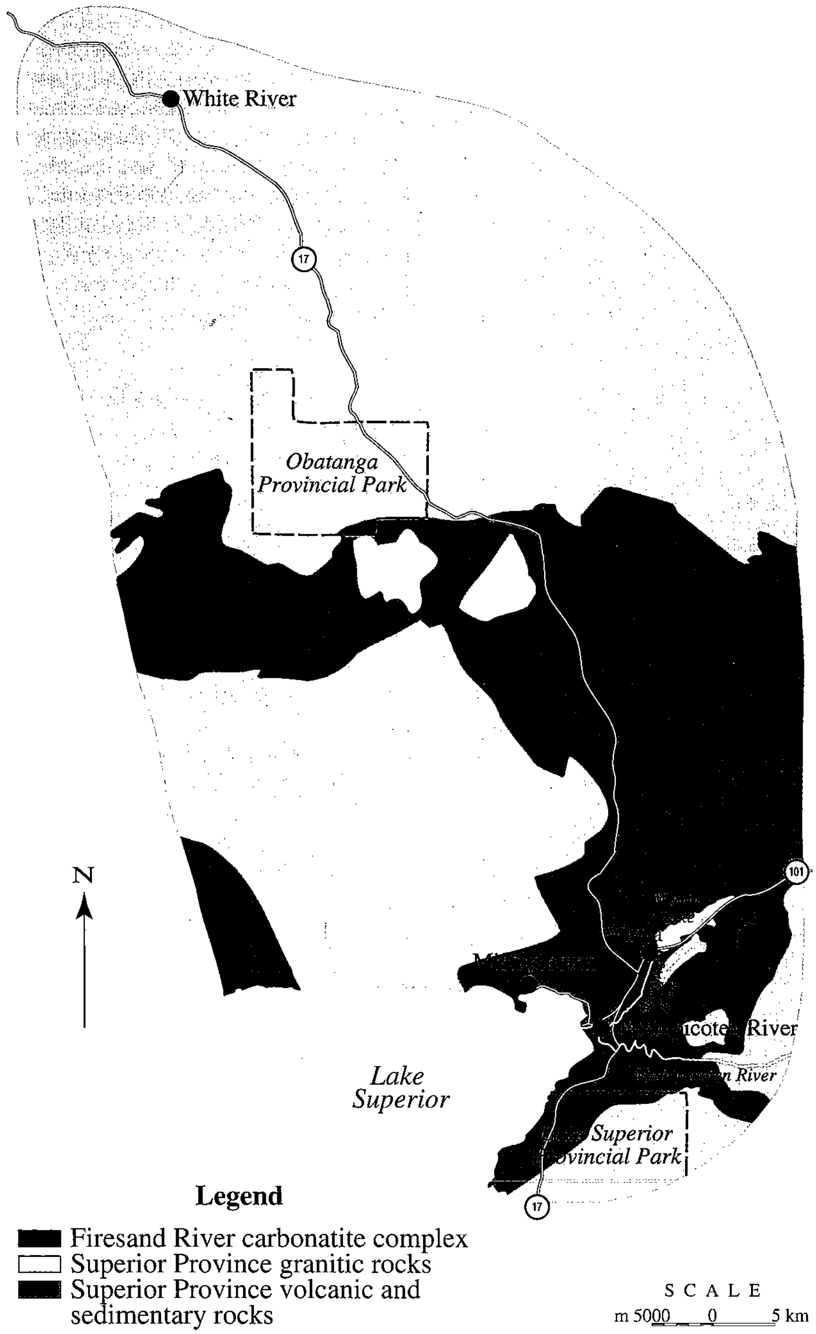


FIGURE 16: Generalized geology of the White River–Wawa area. The northern part of the area is underlain by granitic and migmatitic rocks, while the southern part is underlain by metavolcanic and metasedimentary rocks.

WHITE RIVER TO WAWA

TRIP 9

The route from White River to Wawa crosses an area that is similar in many ways to the area between Marathon and White River. The half of the route closest to White River is underlain by granitic and migmatitic rocks, while the half of the route farthest from White River is underlain by a mixture of metamorphosed volcanic and sedimentary rocks *(Figure 16)*. The volcanic rocks near Wawa are of similar age and composition to those near Marathon, and like those near Marathon, host important economic mineral deposits.

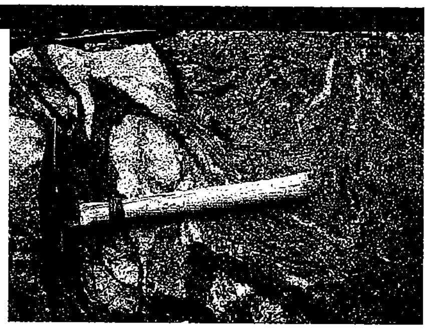


PHOTO 88: The swirls in this migmatite from east of White River are evidence of the intense deformation that it has undergone.

The topography of the region typically consists of low, broad, hills covered by mixed forest. Various deposits of gravel, sand, and silt, left at the end of the Great Ice Age, help to shape the contours of the land.

White River to Obatanga Provincial Park

The road log for the trip from White River to Wawa begins at the junction of highways 17 and 631. Between 15 and 16 kilometres (9 and 10 miles) south of White River, Highway 17 passes a series of sand and gravel ridges. These features, called eskers, were left behind when the glaciers melted away from the area at the end of Great Ice Age. They formed when meltwater from the waning glacier created channels through the ice or at the base of the ice sheet, and then laid down deposits of sand and gravel. When the ice melted away, the long, sinuous deposits left by the ice-bound streams remained.

Outcrops in the area between White River and Obatanga Provincial Park include a variety of granitic rocks, as well as migmatite and agmatite. The granitic rocks are pink to grey in colour. In some places they form entire outcrops, while in other places they form narrow dikes that cut across other rock types.

The migmatite and agmatite are similar in composition and colour to the granitic rocks, but show the effects metamorphism. The migmatite is characterized by layers of slightly different colour and composition. Chaotic swirls in the layering of some outcrops *(Photo 88)* are interesting both aesthetically and technically; they make the rock very attractive, while at the same time telling us that the rock was once so hot that it flowed like plastic. The agmatite is similar, but instead of having layers of slightly different colour and composition, it has angular blocks of one rock type surrounded by rock of another rock type. It, too, is attractive. Although it tells us nothing about deformation, it does tell us that while hot, the rock was under pressure from all sides.

Obatanga Provincial Park

This beautiful park lies just north of the midway point between White River and Wawa. At almost 100 square kilometres (more than 36 square miles) in area, it is one of Ontario's largest provincial parks. The park campground is at Burnfield Lake on the north side of Highway 17, 36.1 kilometres (22.6 miles) south of White River, but the park contains a total of 32 lakes, and an intricate network of connecting rivers and streams.

The Burnfield Lake Campground

The whole area that is now Obatanga Provincial Park was covered by glacial meltwater when the glaciers retreated at the end of the Great Ice Age. It left behind extensive deposits of sand and gravel, which form an outwash plain extending all the way across the park. Some lakes in the area are just shallow depressions in the outwash plain, and their shores are rimmed by boulders. Others are surrounded by sand flats. The 1,000 metre (1,090 yard) long beach at the Burnfield Lake Campground is part of one such sand flat.

Another notable feature of the Burnfield Lake Campground is the mature stand of jack pine trees, all about the same height. This stand established itself after a major forest fire swept the area in 1910. Jack pines thrive after forest fires because the fires clear the ground and leave it ready for new growth, while the heat of the fire causes the cones of existing jack pines to open and spread their seeds.

Where jack pines predominate, they inhibit the growth of other plants by creating a sort of umbrella that prevents the sun from shining through to the ground. Falling pine needles also make the soil highly acidic. The result is that jack pine stands typically have little undergrowth, and instead are clean and open. Two types of plants that do thrive in shady areas and acidic soil, nevertheless, are blueberries and the moccasin flower (also known as the pink lady slipper orchid). Both grow in profusion in the campground area.

Bogs and Swamps

Approximately 200 metres (220 yards) south of the park entrance, on the west side of the highway, is an excellent example of a black spruce bog. The shorter, slow-growth black spruce of the bog are flanked by the taller black spruce trees of the adjacent swamps, with their understorey of speckled alder. Swamps are rich in mineral nutrients, whereas bogs are nutrient poor; hence the difference in growth rate of the black spruce in the two areas.

Obatanga Provincial Park to Wawa

The pink and grey granitic, migmatitic, and agmatitic rocks found between White River and Obatanga Provincial Park extend only a few kilometres (miles) to the south of

PHOTO 89: Different degrees of deformation can be seen in fragmented volcanic rocks north of Wawa. These rocks are relatively undeformed.

the park. About 7 kilometres (4 miles) south of the entrance to Burnfield Lake Campground, the first outcrops of volcanic rock begin to appear. Over the next three kilometres (2 miles), the volcanic rocks become more and more common and the granitic rocks less so, until no more outcrops of granitic rocks appear. From then on, the topography is slightly more rugged than it was farther to the north, and there are fewer streams and lakes.

Typical "Greenstones"

The volcanic rocks between Obatanga Provincial Park and Wawa are mostly dark green in colour due to the presence of iron- and magnesium-bearing minerals. They qualify for the general name "greenstones", and form parts of two sequences of volcanic rocks that are 2.70 and 2.75 billion years old respectively. Some of the rocks in each se-

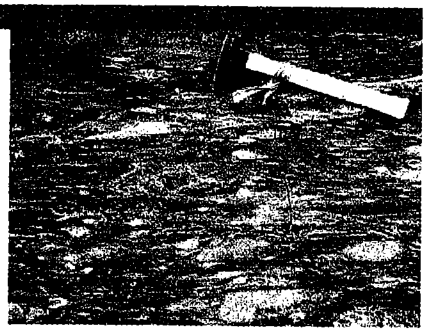


PHOTO 90: These highly strained fragmental volcanic rocks come from the same outcrop as the rocks shown in Photo 88! They show that deformation in weakly metamorphosed rocks can be quite localized.

quence are basalts with well-developed pillows that formed during fairly quiet, underwater volcanic eruptions. Others are fragmental rocks, with a jumble of angular fragments surrounded by volcanic ash, that formed during explosive volcanism either in shallow water or on land.

Regardless of the type of rock, all have been metamorphosed and deformed to some extent. Different amounts of deformation can even be seen within a few individual outcrops of fragmental rocks, called tuff breccias. In such outcrops, fragments in some parts of

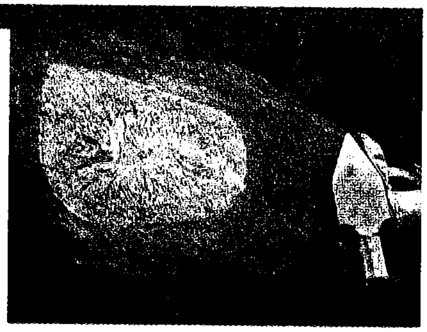


PHOTO 91: Fragments of rock contained within an unusual lamprophyre dike exposed south of the junction of highways 17 and 519 are intensely altered. This is just one of a number of similar dikes in the area.

the rock are relatively undeformed while fragments in other parts of the rock have been stretched almost flat *(Photos 89 and 90)*.

An Unusual Outcrop

The rocks exposed along the sides of Highway 17, 3.2 kilometres (2.0 miles) south of its junction with Highway 519, are quite different on the east side of the highway than they are on the west. On the east side of the highway, there is a low outcrop of dark greenish black basalt, with well-developed pillows clearly visible. Although not abundant, the sulphide minerals between the pillows are of note because sulphides associated with pillow basalts such as these are found near some base metal orebodies.

The rock exposed on the west side of the highway is, surprisingly, very different from pillow basalt. Although fragmental, it is also different from the fragmental volcanic rocks in the area. It is massive, and greyish brown in colour, and has rounded, rather than angular, fragments. Called a lamprophyre, it formed when an iron- and magnesium-rich magma intruded the volcanic rocks in the area, and enclosed and partly digested fragments of them *(Photo 91)*. The fragments range in size from less than a centimetre (half an inch) to more than 50 centimetres (20 inches) across.

The effects of chemical reactions between the fragments and the magma can be seen both inside and outside their margins. Inside the fragments, there are bright green needles of the mineral actinolite, all pointing toward the centre of the fragment that contains them. Outside the fragments are thin, pale brown "bleached" zones surrounded in turn by thicker dark green alteration zones. Features like these can be found only where rocks of one composition have been intruded by magma of a very different composition.

Explosive Volcanism

An example of the more common fragmental rock found in the area, which resulted from explosive volcanism, can be seen a further 7.7 kilometres (4.8 miles) to the south or 10.9 kilometres (6.8 miles) south of the junction between highways 17 and 519. Here, a jumble of light- and dark-coloured fragments of various compositions is packed in

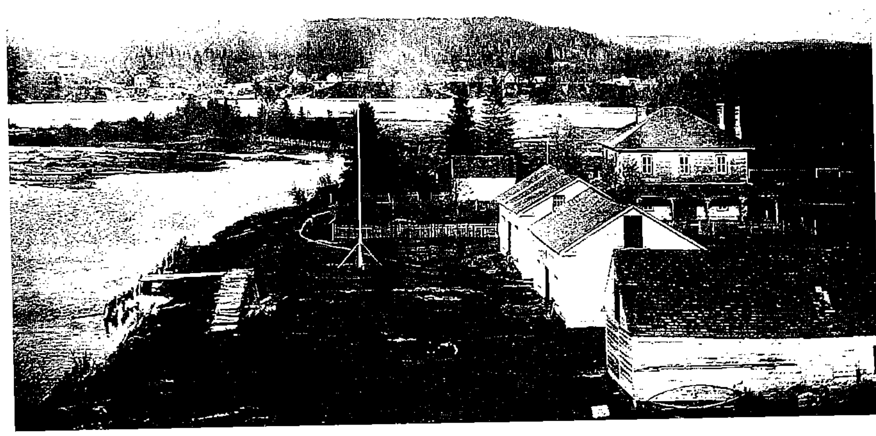


PHOTO 92: The first Mining Recorder's office in Ontario was opened in 1897 at the Hudson's Bay Company post at Michipicoten. It was located in the building with the flagpole in front of it. The developing town of Michipicoten Mission can be seen in the distance in this photgraph, taken about 1899.

a matrix of volcanic ash. Considering that these rocks are about 2.70 billion years old, they look remarkably like they would have looked shortly after they formed.

The Michipicoten Area and Wawa

The Michipicoten area, so-called because the word "Michipicoten" is found in many of the place names in the area, includes the region surrounding Wawa. The name "Michipicoten" was first recorded in 1622 by Étienne Brulé, and has since been used for a bay and an island in Lake Superior, and a river, a waterfall, a harbour, a mission, a township, and several townsites in the area. It has also been used to describe parts of the region where numerous occurrences of gold or iron have been found. The name means "place of old promontories".

Michipicoten Gold Mining District

Development in the area got a boost in 1883 and 1884, when rails and other equipment were unloaded at Michipicoten Harbour. From there, they were transported to railway construction sites near Missinabi, almost 75 kilometres (47 miles) to the north-east. The biggest boost to development in the area was, however, the discovery of gold along the south shore of Wawa Lake in 1897. News of the find was published by the Associated Press, and a staking rush followed; it was not long before other gold-bearing deposits were located south of the lake.

The Ontario Bureau of Mines quickly established itself in the area by creating the Michipicoten Mining District, the first of its kind in the province. The first Mining Recorder's office in Ontario was opened at the Hudson's Bay Company post near the mouth of the Michipicoten River *(Photo 92)*. Almost overnight, the population of the district grew to about a thousand people, and in 1898 a townsite was registered at the nearby Michipicoten Mission as Michipicoten City. By 1899, the town had prospered so much that the site of present-day Wawa was surveyed and plotted into a townsite, and registered with the Sault Ste. Marie land office as Wawa City.

The First Mines

Prospect shafts were sunk on some of the deposits discovered in the area; subsequently, two mines, the Grace (*see* Photo 5) and the Manxman (Norwalk) were brought into production. Gold was found in quartz veins, along with some pyrite, pyrrhotite, and chalcopyrite, but the ore bodies were found to be either too small or of too low grade, and by 1908 mining activity had ceased. There is no record of how much gold was recovered.

A Closer Look

Interest in the gold deposits was renewed in the 1920s, doubtless because of successful exploratory results in areas of similar geological conditions elsewhere in Ontario, particularly in the Timmins and Kirkland Lake areas. Several new veins were discovered. The Grace mine was reopened in 1926, and by 1931 three new mines, the Jubilee, the Minto, and the Parkhill, had begun production. From 1930, when milling was started at the Grace mine, until 1939, when the Jubilee was shut down, the area yielded gold and silver with a gross value of $3,329,369.

Further exploration in the area occurred in the 1960s, when Surluga Mines Limited produced 96,357 grams (3,098 ounces) of gold and 2,364 grams (76 ounces) of silver, and again following the discoveries at Hemlo to the northwest in the 1980s, although no other production has been reported.

The sites of three of the old abandoned gold mines, the Mackey Point, the Wawa Gold Fields, and the Stanley, are located along Highway 101 east of Wawa. There is little remaining at these mine sites; except for the old dumps and, in the case of one, an adit or tunnel into the hillside, they would be difficult to locate.

Michipicoten Iron Mining District

The first discovery of iron ore in the Michipicoten area was made by Alois Goetz and Benjamin Boyer in 1897 near the site of the present-day George W. MacLeod Mine. The discovery was accidental; Goetz and Boyer were among the many gold-seekers taking part in the gold rush of that time.

The iron formation at the discovery site consists of two principal members, which trend east and dip vertically or steeply to the south. The main unit is made up of massive siderite. A thinly banded chert–magnetite unit lies along the northern margin of the siderite unit. Together, the two units attain a width of 305 m (1,000 feet) north of the shaft of the George W. MacLeod Mine.

The iron formation separates two groups of volcanic rocks. One, stratigraphically below the iron formation, is about 2.75 billion years old; the other, stratigraphically above the iron formation, is about 2.70 billion years old. The iron formation thus represents a distinct time break in the volcanic activity in the area. Other evidence suggests that biological activity, likely involving bacteria or algae, played a role in the deposition of the iron formation.

The First Mines

Mining operations began at the open pit Helen Mine, adjoining the present George W. MacLeod mine, in 1899. It ceased in 1918 when the then-known ore was mined out. Between 1900 and 1918 the Helen Mine was the largest iron-ore producer in Canada. During that time, it yielded more than 2,527,000 tonnes (2,780,000 tons) of "direct-shipping" ore. Only high-grade ore, consisting largely of the minerals goethite and hematite (both iron oxides) was recognized at that time. It was found to terminate at a depth of about 200 metres (650 feet). Similar ore was mined at the nearby Magpie Mine, which opened in 1909 and closed in 1921 for the same reason as the Helen.

More Ore!

In 1939, workers in the area recognized that the goethite and hematite resulted from deep weathering of the siderite, and merely formed a surface deposit, or gossan, over the siderite member of the iron formation. Innovations in production methods meant that the low-grade siderite ore could now be upgraded. Mining was revived.

Since then, the Michipicoten iron mining district has enjoyed continuous production. Ore has come from a number of open pits and, since the mid 1940s, from underground *(Photo 93)*. The underground mining operations are notable. The George W. MacLeod Mine is the only underground iron mine in North America! Current production from the mine is about 1,000,000 tonnes (1,100,000 tons) of siderite ore each year.

Roasting the Rock

The ore at the George W. MacLeod Mine is made up mainly of siderite, an iron-bearing carbonate mineral. It is light grey in colour on fresh surfaces, but after exposure to the elements it turns a characteristic rusty red colour. It does not contain sufficient iron to be used directly in the blast furnace, so must be upgraded or beneficiated. This is done by roasting the ore with coal and limestone in a sinter furnace. The roasting process drives carbon dioxide off from the ore, and raises the iron content of the remaining sinter to about 50 percent, making it a desirable product for blast furnace feed. Sinter from the furnaces at Wawa is used in the manufacture of steel at the Sault Ste. Marie mill of the Algoma Steel Corporation Limited.

Wawa

The town of Wawa at the west end of Wawa Lake is the business and community centre of the Michipicoten area. Interesting topographically is the flat sand plain on which it has been built; the plain lies between high hills composed of ancient volcanic rocks to the north and southeast. This sand plain is the highest of several terraces found between the town and Michipicoten Harbour on Lake Superior about 10 kilometres (6 miles) to the southwest.

The terraces are lake deposits formed when, after the retreat of the Pleistocene glaciers, the water in the Lake Superior basin

PHOTO 93: This 1955 aerial view looks south across the Helen open pit and past the headframe at the George W. MacLeod mine to Wawa Lake. The headframe is at the crest of the hill, just up from the buildings where the ore is processed.

stood higher than it does today. The terraces occur at different elevations, the highest being about 110 metres (360 feet) above Lake Superior, and represent successive drops in the water level. Excellent vantage points for viewing these terraces are at the parking area at the monument of the Wawa goose, along the road to the town, and along Highway 17 north of the turnoff and south of the bridge over the Algoma Central Railway line. From the Wawa goose, the view looks out over the valley of the Magpie River.

The name "Wawa" means "wild goose" in Ojibwa. The original Wawa goose statue *(Photo 94)* was built in 1960 to celebrate the opening of the Trans-Canada Highway between Wawa and Agawa to the south. Until then, the only access to Wawa was by ship, or by rail via the Algoma Central Railway. The original goose was replaced by the present steel structure in 1964.

The Wawa Volcano

The Wawa area lies within what is known as the Michipicoten greenstone belt, a zone approximately 140 kilometres (88 miles) long, and up to 45 kilometres (25 miles) wide underlain by volcanic rocks. The volcanic rocks were deposited during three separate volcanic events, 2.70, 2.75, and 2.89 billion years ago.

The 2.75 billion-year-old volcanic rocks are situated in the immediate Wawa area. They show a gradation in composition from the bottom to the top of the sequence that is the same as a gradation found in many volcanic sequences throughout the world. At the bottom of the pile are mafic, or iron- and magnesium-rich volcanic rocks. They grade in composition through rocks of intermediate composition to felsic, or silica-rich volcanic rocks at the top of the pile.

PHOTO 94: This statue of a goose was the original built at Wawa in 1960 to commemorate the opening of the Trans-Canada Highway.

The 2.75 billion-year-old volcanic rocks also contain other features of more local interest. The sequence of intermediate and felsic volcanic rocks is more than 2,000 metres (6,500 feet) thick near Wawa, but less than 300 metres (1,000 feet) thick only 10 kilometres (6 miles) away. Also, the volcanic pile is cut by a small body of intrusive rock of approximately the same age as the volcanic rocks. Together, these features suggest that the source of the volcanic rocks around Wawa was a volcano situated almost exactly where the town is located today.

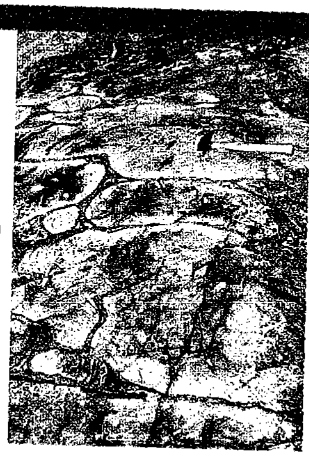


PHOTO 95: These well-developed pillow structures in basalt along Highway 101 indicate that the lavas were likely erupted under water. They are so well preserved that even tiny gas bubbles, called vesicles, can be seen frozen in the rock.

Interesting Outcrops

A short side trip from Wawa visits several outcrops of 2.75 billion-year-old rock that show exceptionally well-preserved volcanic structures, as well as some other sites of interest. The trip centres on Highway 101, the road from Wawa to Chapleau. It starts 11.1 kilometres (6.9 miles) north of the junction of the highway and Broadway Avenue in Wawa, at the bridge over the Firesand River. From there, the trip leads back to Wawa. Use the side road just before the bridge to turn around at the beginning of your trip. Be aware as you examine rock exposures along the road that the road is a main highway.

Pillow Lava

The dark green to black rocks exposed in the outcrops 1.2 kilometres (0.8 miles) south of Firesand River are volcanic rocks called basalts. They were deposited on the seafloor about 2.75 billion years ago. On the shallow slope at the north end of the outcrop, numerous circular or semi-circular shapes can be seen *(Photo 95)*. Called "pillows", they formed when lava was pushed out of fractures in the crust of submarine lava flows, much like toothpaste being squeezed from its tube. The surface of the fresh lava cooled quickly when it contacted the cold sea water, and formed a tough, elastic skin around the blob of molten rock. As the volcanic eruption proceeded, the pillows piled up on the ocean floor. They accumulated, and were compressed under their own weight, to form their characteristic shapes.

A close examination of the pillows reveals that the "margins" or skins of each pillow are made up of very fine-grained rock, and that in some cases, they have trapped gas from the original lava in the form of bubbles or vesicles within the rock. The "tails" that can be seen on some of the pillows mark places where the bases of younger pillows were pushed down between older pillows during compression. They are a valuable guide to the original top and bottom positions of a deformed volcanic rock.

Although these rocks are very old, pillow basalt just like this is forming today on the seafloor near Hawaii and Iceland, and along the mid-oceanic ridge.

The Firesand Pothole

The large outcrop 1.6 kilometres (1.0 miles) south of Firesand River is made up of volcanic rock similar to the rock at the previous stop. Here, the interesting feature developed since the volcanic rock formed. Almost directly opposite the east end of the net on the outcrop, a 2 metre (7 foot) wide, 3 metre (10 foot) deep circular indentation in the top of the rock outcrop has been cut during road construction. Several large, rounded boulders lie in the bottom of the indentation.

This feature is a glacial pothole, and was carved into the bedrock about 10,000 years ago, likely by the very boulders that now lie in the bottom of the depression. Other potholes in the area, like the ones found 42 kilometres (26 miles) farther east on Highway 101 at Potholes Provincial Park, likely formed at the same time. The huge continental glaciers that had covered the region were melting, and swiftly flowing rivers were carrying the glacial meltwater away. When rocks carried by the rapidly moving current were caught in eddies, they swirled around on the streambed, abraded the bedrock, and ground out the potholes.

Firesand Carbonatite

Farther along the same outcrop, opposite the west end of the net, a streak of light brown rock cuts across the dark green volcanic rocks *(Photo 96)*. Features of this sort, where a younger rock cuts through an older rock, are called dikes. Most are sheet-like. Here, the sheet-like structure is evident because the same dike can be seen cutting across the outcrop on the other side of the road.

The brown rock is carbonatite, an unusual and somewhat perplexing type of igneous rock. Carbonatites contain minerals like calcite and dolomite that are usually found

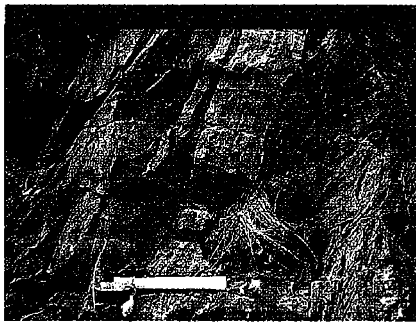


PHOTO 96: This light brown dike, which cuts across the dark metavolcanic rocks north of Wawa, is part of the suite of unusual intrusive rocks that makes up the Firesand River Carbonatite Complex.

in sedimentary rocks, but carbonatites are igneous in origin. In addition, they contain more rare elements than any other known rock type. This dike is about 1.08 billion years old, and is a part of the Firesand River Carbonatite Complex.

Deltaic Deposits

At 2.2 kilometres (1.7 miles) south of the Firesand River bridge, a gravel road leads right (north) from Highway 101, along the north shore of Wawa Lake. Turn onto this road and proceed 0.6 kilometres (0.4 miles) to the flat area beside the gravel pit on the right side of the road. The gravel in the pit is a good example of coarse deltaic sediments. It was deposited as part of a delta at the mouth of a river flowing into the highest level of ancestral Lake Superior. Here, the swiftly flowing river entered the lake, and the current slowed drastically. The sudden loss of energy meant that the water could no longer carry its heavy load of sediment, so the sediment was deposited to form the delta.

The steeply dipping layers visible in the face of the pit are called foreset beds *(Photo 97)*. They are inclined downcurrent from the

PHOTO 97: **The layers in this gravel were not tilted during some upheaval of the ground. Instead, they formed at this orientation. Angled layers like these are common in sediments deposited by flowing water or blowing wind.**

front of the delta. This is a small-scale example of what is happening today at the mouths of rivers like the Mississippi and the Nile, where modern deltas are forming.

A few marine fossils and fossil fragments can be found in limestone fragments in the gravel. They have been transported within the glacial ice, and by meltwater streams, from the area around Hudson and James bays, a distance of more than 800 kilometres (500 miles). They, and the other cobbles and boulders in the gravel, are very weakly cemented to the surrounding sand. If left undisturbed, this gravel might eventually solidify to form a conglomerate.

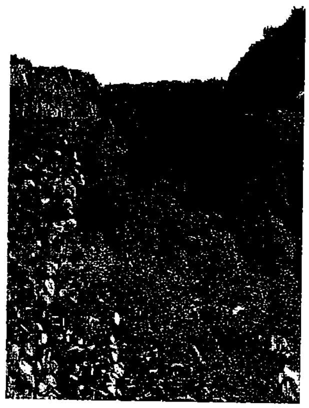


PHOTO 98: **The Sir James Dunn open pit was mined between 1958 and 1967. It yielded more than 7,000,000 tonnes (7,700,000 tons) of iron ore, which was used in steel production at The Algoma Steel Corporation Ltd. mill in Sault Ste. Marie.**

"Fire-Fragment" Rocks

Proceed an additional 1.1 kilometres (0.7 miles) along this gravel road to an outcrop on the right side of the road. Here is evidence of some very violent volcanic activity. It is the type of rock formed from eruptions such as the explosive 1980 eruption at Mount St. Helens in Washington State. The rock is a type of "fire-fragment", or pyroclastic rock. Called lapilli tuff, it consists of fine-grained volcanic ash and larger fragments of volcanic rock blown out of the volcano during the eruption. In some places, the larger fragments or bombs are as large as a small car. The fragments in this outcrop are rimmed with a reddish weathering product.

The rock at this stop is slightly younger than the pillow basalt at the first stop south of Firesand River bridge. Its light green to grey colour, somewhat different from that of the basalt, is a reflection of the fact that the compositions of the two volcanic rocks are different. This rock contains less iron and magnesium and more silica than the pillow basalt. It is one of rock types that is transitional between the mafic and felsic rocks within the volcanic pile.

Continue along the road until you find a good place to turn around, and return to Highway 101. If you reach large piles of broken rock, you have found the waste, or uneconomic, rock removed from the Sir James Dunn open pit *(Photo 98)*. One of several open pits in the Wawa area, it operated between 1958 and 1967, and yielded more than 7,000,000 tonnes (7,700,000 tons) of siderite iron ore and 5,000,000 tonnes (5,500,000 tons) of waste rock. Please note that this area is private property.

Surluga Gold Mine

From the junction of the side road with Highway 101, proceed south along Highway 101 for 6.5 kilometres (4.1 miles). A gravel road on the left leads 1.0 kilometres (0.6 miles) to the site of the former Citadel, or Surluga, Mine. Please exercise caution on this road, and obey all signs. Do not go past the fence at the mine, or trespass on the mine property.

This mine is just one of fifteen mines that produced gold in the immediate Wawa area. In 1968, it was developed on seven underground levels to a depth of 290 metres (950 feet). The mine produced 52,470 grams (1,687 ounces) of gold and 1,340 grams (43 ounces) of silver that year. There are reportedly still more than 300,000 tonnes (330,000 tons) of rock grading about 6.67 grams of gold per tonne (0.24 ounces per ton) at the site. Note that although the grade of the remaining rock is sufficient to be economic at many mines, it still contains less than seven parts of gold in a million parts of rock. To make a comparison, that would be less than five-eighths of a second out of a day!

At the end of operations in 1968, the headframe (tall building over the shaft), mill, ore conveyor, crusher house, mine office, machine shop, dry (miners' locker room), and the assay lab were all left on the property in anticipation that mining operations might resume at some time in the future.

Also left behind was a pile of broken rock, called muck, brought up from underground. It is unlikely that you would actually see any gold in this rock, however, since there is so little gold present, and where it does occur, it is as exceedingly small grains. The outcrop opposite the ore pile is of granodiorite, an intrusive igneous rock. It formed in the roots of the volcano that supplied the 2.75 billion-year-old volcanic rocks in the Wawa area. The narrow quartz veins in the granodiorite are typical of the ones that host gold mineralization in the area.

William Teddy Park

From the mine site, return to Highway 101, turn south, and proceed 0.4 kilometres (0.3 miles) to the trailer park on the shores of Wawa Lake. Here is the site of the original gold discovery in Wawa. It is said that one day in 1897, William Teddy and his wife, a couple from Michipicoten Mission, paddled across the lake to Mackey Point to camp for lunch. While Mrs. Teddy was getting water, she noticed some bright material in the rock at the lakeshore. The bright material proved to be gold. When her husband took samples to entrepreneurs he succeeded in selling the discovery. Some reports say that he received $500 for his claim, while others say that the sale price was $1,200. Gold fever quickly swept through the area. Many prospectors on their way to Canada's Yukon Territory, where the famous Klondike gold rush was taking place, detoured to the Michipicoten area to make their fortunes.

From the park you can see the high hill capped by iron formation to the north of the lake. You might also be able to see some irregular outlines on the crest of the hill that mark the sites of several of the open pits high above the town. The tall building, or headframe, visible on the crest of the hill is the George W. MacLeod Mine.

Spherulites and Flow Banding

Return to Broadway Avenue in Wawa via Highway 101, turn right, and drive through town. From the waterfront park at the north end of town, continue a short distance north along the main street to the triple junction in the road. Follow the right fork of the road along the lakeshore for about 200 metres (660 feet), and park in the small lot next to the water. Walk north to the outcrops opposite the lake.

PHOTO 99: Tiny rounded structures like these, called spherulites, may develop in volcanic rocks that were initially chilled so quickly that volcanic glass formed.

These outcrops are made up of rhyolite from the upper part of the sequence of 2.75 billion-year-old volcanic rocks. The rhyolite is much lighter in colour than the pillow basalts or pyroclastic rocks exposed north of Wawa, and contains less iron and magnesium, and more silica than they do. It also contains different structures from those in either the basalt or the pyroclastic rocks.

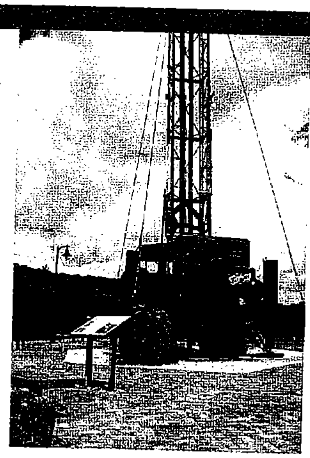


PHOTO 100: The large drill at Wawa's waterfront park is one of the drills that was used to prepare blastholes at Wawa's open pit iron mines.

In the 10 metres (33 feet) at the south end of the outcrop, the rock appears to be massive, while in the next 5 metres (16 feet), the first of a number of structures can be seen. Tiny round "beads", and very thin laminations can be seen in the rock. The "beads" are called spherulites. They occur in volcanic rocks that were chilled so quickly after they erupted that they originally formed volcanic glass. The spherulites develop when clusters of microscopic crystals form around a nucleus of some sort, such as a mineral grain, or even a gas bubble, within the glass. The thinly laminated structure has a different origin, however. Called flow banding, it forms when the quickly cooling lava is in a plastic state, and continues to flow or be stretched. It develops in much the same way as the bands that form in taffy when it is pulled.

After a covered interval about 5 metres (16 feet) long, an outcrop 10 metres (33 feet) long contains abundant examples of spherulites from 0.5 to 2.5 centimetres (0.3 to 1.0 inch) in diameter. These spherulites, some of which are hollow, are exceptionally good examples *(Photo 99)*. Beyond this outcrop is a covered interval about 10 metres (33 feet) long, and another outcrop, also about 10 metres (33 feet) long.

The rock in the third outcrop is different from those in the first two. Although similar in colour and composition, it contains angular fragments of volcanic rock, and not spherulites or flow banding. Instead of forming from lava which flowed out of the volcano, it formed during more explosive volcanism, in much the same way as the pyroclastic rock north of Wawa Lake formed.

Wawa's Mining History

From the outcrops with the spherulites and flow banding, return to the park at the north end of town. The huge drill on display at this pleasant viewpoint *(Photo 100)* commemorates the importance of mining to Wawa's history and development. It is one of the drills that was used to prepare blastholes at the open pit mines in the area.

The drill bit in the large block of rock is the same as the ones that were used with this drill. As its purpose is simply to create a large hole into which explosives can be packed, its "tricone" drilling action breaks the rock into tiny chips. This drill bit is quite different from the ones used in mineral exploration. Those drill bits are much smaller, and look more like doughnuts. Their purpose is to cut a cylindrical core of rock that can pass up the centre of the drill rod, or pipe, after drilling, and later be pulled up to surface for careful examination.

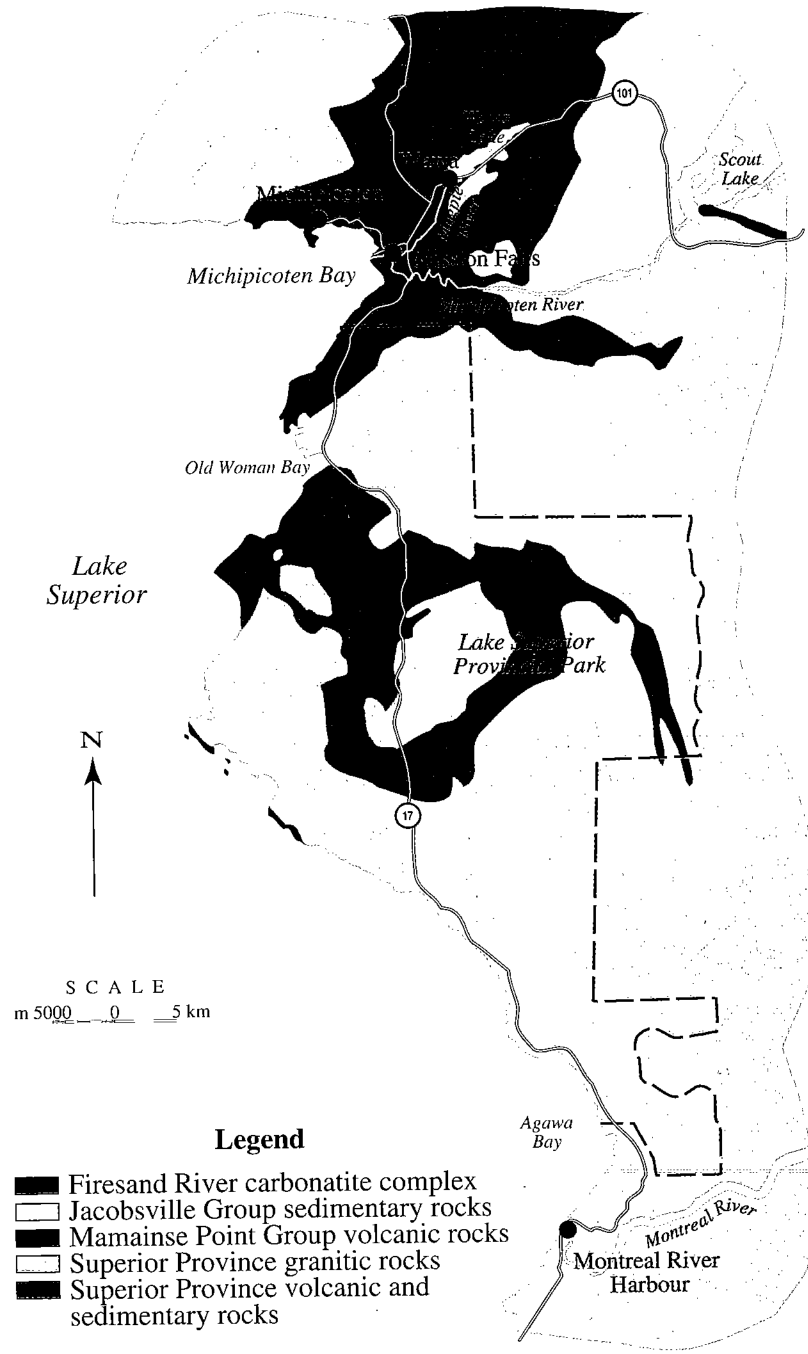


FIGURE 17: Generalized geology of the Wawa–Montreal River area. Most of the northern part is underlain by volcanic rocks, while the southern part is almost entirely underlain by granitic and migmatitic rocks.

WAWA TO MONTREAL RIVER

TRIP 10

The route from Wawa to Montreal River passes through rolling hills. The northern half of the route is underlain by volcanic rocks, although some granitic rocks are exposed in the area around Old Woman Bay, and the southern half of the route is almost entirely underlain by granitic and migmatitic rocks *(Figure 17)*. Numerous small lakes are found in the area; many are not interconnected, but occur as pockets nestled in depressions in the Archean rock.

Michipicoten Falls, Magpie River

Michipicoten Falls on the Magpie River is shown on some maps as Magpie Falls,

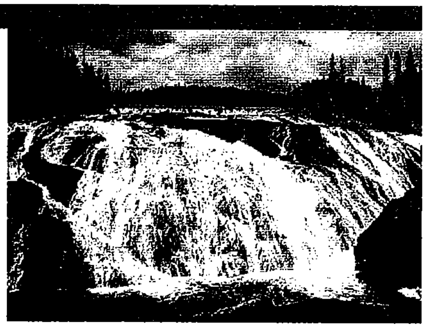


PHOTO 101: Visitors to the Michipicoten Falls park, which was established by the Rotary Club and the Great Lakes Power Company Limited, are treated to a close-up view of the face of the waterfall.

and is sometimes referred to locally as Magpie High Falls. It is easily accessible by automobile, and is well worth the trip. The access road leads west from Highway 17, 1.7 kilometres (1.1 miles) south of the junction of highways 17 and 101. Turn onto the gravel road, and almost immediately, turn left at a junction in that road. The road crosses a sand plain for 3.2 kilometres (2.0 miles), and then descends to the river valley at the foot of the falls. There, an attractive picnic park with barbecues, picnic pavilion, hiking trails, and interpretive panels has been developed.

The road passes a large turnaround area for buses, and a boat launching area at 2.9 kilometres (1.8 miles). Visitors towing heavy trailers may wish to park in this area and follow the trail from the crest of the falls to the picnic park.

Having a height of 24 metres (80 feet) and a width of 60 metres (200 feet), Michipicoten Falls is the most spectacular physiographic feature in the vicinity of Wawa. One of the things that makes it so dramatic is the abrupt right angle in the river channel at the foot of the falls *(Photo 101)*. It allows visitors to come very close to the face of the falls while staying on dry land, and gives the impression that a massive curtain of water is falling into a hidden underground river.

Fractures Cause the Falls

Most waterfalls occur at the boundaries between rocks having different degrees of hardness. In particular, they often occur where resistant rock overlies and protects relatively soft, easily eroded rock, as at Kakabeka Falls. At Michipicoten Falls, however, only a single rock type, a variety of granite, is present. This being the case, one wonders why the falls do not occur downstream where the hard granitic rock is in contact with comparatively soft volcanic rocks.

Close examination of the granitic rock at the falls shows that it has closely-spaced joints or fractures. Some, 15 centimetres (6 inches) or more apart, trend east and dip steeply to the north. Others, which are more numerous and prominent, trend northeast roughly parallel to the face of the falls, and dip 65 to 75 degrees to the northwest. They are spaced 2 to 5 centimetres (1 to 2 inches) apart. Because they have greatly facilitated erosion of the bedrock at this locality, they control the location and attitude of the escarpment that forms the waterfalls. In addition, they control the downstream course of the river, with its abrupt turn at the base of the falls and flow direction at a right angle to its previous course.

A Small Granite Intrusion

The reddish granite at the falls is porphyritic; it is made up of crystals or phenocrysts of grey quartz grains 1 to 5 millimetres (.04 to .20 inch) across in a comparatively fine-grained matrix. Known locally as "tapioca rock", it forms an irregular body enclosed by volcanic rocks. It may be an upward-projecting tongue of a much larger mass or batholith of granite at depth. The granitic rocks in the Michipicoten area are very complex and are thought to span a great period of time. Radiometric age determinations indicate that they formed about 2.75 billion years ago.

The Voyageur hiking trail leads approximately 3.5 kilometres (2.2 miles) to the south from the park at the foot of Michipicoten Falls. It crosses granitic rocks at first, but within a few hundred metres (yards) of the start, is underlain by volcanic rocks. It then passes a hydroelectric generating station *(Photo 102)*, and eventually reaches a series of waterfalls at Michipicoten Harbour Road.

More of Michipicoten

There are other interesting sites in the area besides the waterfalls, however, so visitors are advised to take a short side trip from Highway 17 to explore the region more fully. From Michipicoten Falls, return to Highway 17, turn south, and travel 3.1 kilometres (1.9 miles). Then, turn west on Mission Road for the short drive to Michipicoten Mission.

Michipicoten Mission

A French trading post was built on glaciofluvial outwash deposits at the mouth of the Michipicoten River, some time between 1714 and 1725. A Jesuit mission followed. After the British conquest of 1763, the French left the posts in the Lake Superior area to private fur traders. Competition from the Hudson's Bay Company prompted the independent traders to join together in 1783 to form the North West Trading Company. Several decades of rivalry between the two companies followed. The Hudson's Bay Company twice tried to operate a post across the river from the North West Company fort. The rivalry ended in 1821, however, when the North West Company was absorbed into the Hudson's Bay Company as a result of dwindling fur supplies and poor markets in Europe.

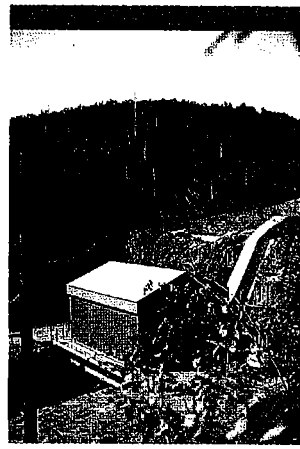


PHOTO 102: This hydroelectric generating station is located downstream from Michipicoten Falls (Magpie High Falls) along the Voyageur trail. It is built on volcanic rock, which can be recognized by its characteristic greyish green colour.

Very little evidence of the historical activity in the area remains today, as the last post was closed in 1904, and the last building demolished in 1952. Instead, Michipicoten Mission (known officially and on most maps as Michipicoten River) is today a small residential community at the confluence of the Magpie and Michipicoten Rivers. A marina takes advantage of a protected bay in the wide Michipicoten River channel, only 1.5 kilometres (0.9 miles) from the open waters of Lake Superior.

Michipicoten Harbour Road

Michipicoten Harbour Road branches from the Mission Road 0.9 kilometres (0.6 miles) west of the intersection with Highway 17. This well-maintained gravel road leads to several sites of geologic, scenic, and historic interest, and offers a number of scenic lookouts over Lake Superior. As the road includes some junctions, visitors are advised to follow first the signs for Silver Falls, and then the signs for Michipicoten Harbour. On returning, visitors should take care to retrace their path, especially when entering the community of Michipicoten Mission.

Mission Falls, Magpie River

The Michipicoten Harbour Road crosses the Magpie River 0.9 kilometres (0.6 miles) west of Michipicoten Mission, where there are three small but picturesque waterfalls referred to collectively as Mission Falls. The middle falls, with a drop of 4.5 to 6.0 metres (15 to 20 feet), is located about 150 metres (500 feet) north of the bridge over the river and can be seen from the road *(Photo 103)*. It is known locally as Silver Falls. The upper falls, 6.0 to 7.5 metres (20 to 25 feet) high, is a short distance farther upstream, and can be reached by following the Voyageur trail. The lower falls, of about the same height, occurs 30 metres (100 feet) south of the bridge. It is best viewed from vantage points along the east bank of the river, reached by way of a trail that starts about 50 metres (165 feet) before the bridge. Take care when approaching the water near any of these falls. The water level may rise considerably over a short period of time when adjustments are made to the flow rates of water coming from dams upstream.

PHOTO 103: The middle of the three cascades that make up Mission Falls, known locally as Silver Falls, can be seen from the road to Michipicoten Harbour.

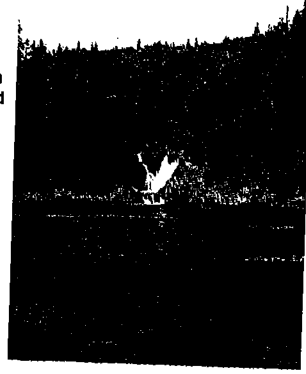


PHOTO 104: The gabbro dike that cuts across a basalt flow downstream from the lowermost of the Mission Falls cascades may have been the feeder dike for another flow, higher in the sequence of volcanic rocks.

The rock exposed at the three falls is a hard, fine-grained greyish-green volcanic rock. It is highly fractured throughout, and probably has been eroded at a much more rapid rate than its hardness would indicate. As at Michipicoten Falls farther upstream on the Magpie River, there is no change in rock composition at the sites of the individual escarpments. One is inclined to suspect that the falls are again localized where the bedrock is cut by prominent joints. Well-developed, closely-spaced vertical joints exposed in outcrops south of the bridge, and trending roughly parallel to the face of the lower falls support this idea.

In the bedrock along the east bank below Lower Mission Falls, the volcanic rock is cut by a narrow vertical dike of material that is similar to the host rock in both appearance and composition *(Photo 104)*. This dike, 75 centimetres (30 inches) wide, likely represents an injection of magma from the same source as that which had previously erupted at the surface to form the volcanic rock itself.

Claim posts, which can be found in places along the river, help tell a story of changing perceptions of mineral potential. The Michipicoten region has long been known as an area of iron and gold deposits—but it has never been considered a place where diamonds might be found. In 1993, however, a prospector found diamonds in gravel in the area, and a major staking rush took place. Eager claim stakers hoped that the bedrock source from which the diamonds had been eroded might be found in the claims they staked. Exploration continues in an effort to locate diamond-bearing rocks in the area.

Michipicoten Beach

Michipicoten Beach lies along the northeast shore of Michipicoten Bay on Lake Superior, 4.5 kilometres (2.8 miles) along Michipicoten Harbour Road. It is known locally as Sandy Beach. About 0.8 kilometres (0.5 miles) long, it rises gently from the shore between two rocky headlands of hard, ancient volcanic rocks. The beach is very wide, and is made up of clean, granular quartz sand.

About 30 metres (100 feet) inland, the surface becomes strikingly hummocky, with knolls and curving ridges rising as much as 10 metres (33 feet) above lake level. Many of them are covered by grasses, shrubs, and trees. The knolls and curving ridges are sand dunes formed by the action of strong southwesterly winds, which have picked up the sand near the shore and spread it irregularly landward. They are similar in every way to sand dunes found in desert regions, and attest to the force with which the wind, blowing without obstruction across Lake Superior, sometimes strikes this portion of the shoreline.

Michipicoten Harbour

Michipicoten Harbour lies 4.3 kilometres (2.7 miles) beyond Michipicoten Beach. It is one of the few safe harbours along the rugged shoreline of eastern Lake Superior. Between 1883 and 1884, rails and other equipment were unloaded here for transport to crews working on the Canadian Pacific Railway near Missinabi. After the establishment of the steel industry in Sault Ste. Marie, ore brought by rail from Wawa was shipped from this point. The modern docks are little used now. Lime and coal are still brought in from the United Sates for use in the sintering process *(Photo 105)*, and may be seen in piles beside the docks. From Michipicoten Harbour, visitors should return to Highway 17.

Banded Iron Formation

Approximately 6.3 kilometres (3.9 miles) south of Mission Road, and 11.1 kilometres (6.9 miles) south of the turnoff to Wawa, Highway 17 passes through a long, shallow roadcut. At the north end of the roadcut on the west side of the road, and for about 100 metres (325 feet) along the east side of the road, massive volcanic rocks are capped by black and white banded iron formation (*see* Photo 3). Rusty-weathering patches stain the iron formation in places.

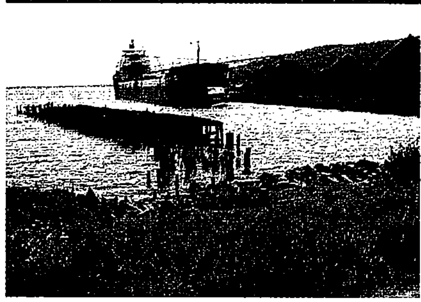


PHOTO 105: The remnants of an old wharf at Michipicoten Harbour lie alongside the modern docking facilities used by the John B. Aird to offload a cargo of coal bound for Wawa.

PHOTO 106: "Scallop" structures can be seen in the white chert and black magnetite-bearing layers of the banded iron formation where it overlies volcanic rocks along Highway 17 south of Wawa.

On the east side of the road, the banding in the iron formation appears "scalloped" *(Photo 106)*. The pattern may have formed when the layers of white chert and black magnetite were draped over irregularities in the top of the volcanic rocks as the iron formation was deposited. Alternatively, it may have resulted if later deformation affected the two different rock types in different ways.

Even though this iron formation is close to Wawa and is very similar in age to the iron formation mined there, this rock differs from the one mined at Wawa. It contains minerals made of oxides of iron; the minerals in the ore from Wawa are made of carbonates of iron. The minerals in this rock will attract a magnet, while those in the iron ore from Wawa will not. Rock like this is the source of much of the iron ore mined elsewhere in Ontario.

Lake Superior Provincial Park

The northern boundary of Lake Superior Provincial Park lies 12.8 kilometres (8.0 miles) south of the turnoff to Wawa. The park was created on January 13, 1944, but was not accessible by road in its entirety until Highway 17 opened in 1960. Major developments took place over the next six years, and included the completion of two additional campgrounds, five new picnic areas, a new Park Headquarters building, the Agawa Bay Scenic Lookout and the Pictograph Road.

PHOTO 107: The beach at Old Woman Bay is just one of many beautiful beaches in Lake Superior Provincial Park. A picnic site has been established here.

Today, Lake Superior Provincial Park covers an area of 1,540 square kilometres (601 square miles) of rugged terrain wooded with pine, spruce, birch and maple. The route across the park by way of Highway 17 is 84 kilometres (52 miles) long. Along the way, motorists are presented with magnificent vistas of the Lake Superior shoreline. There are more than a thousand lakes and many rivers within the park, and picnic, swimming, and hiking areas are well distributed among them. There are fully developed campgrounds at Rabbit Blanket Lake (an inland lake), at Agawa Bay (on Lake Superior) and at Crescent Lake (an inland lake near the southern boundary of the park).

Many interesting geological features can be observed near the highway. Take note, however, that the highway has many curves and hills. Motorists should take special precautions to park well off to the side of the road when stopping at outcrops. They should also be aware that the moose population of the park is high. While it can be exciting to see moose feeding in the small lakes and swamps alongside the road, the animals present a real danger when they cross the highway. Moose appearances along the highway seem to be most frequent during spring, when the animals move into breezy open spaces offered by swamps—and, incidentally, road allowances—to get away from the torment of biting insects.

Old Woman Bay

Twenty-four kilometres (15 miles) south of the Wawa turnoff, Highway 17 descends to Lake Superior at Old Woman Bay. A picnic site has been established at a beautiful long sand beach at the head of the bay *(Photo 107)*. From the beach, there is an excellent view southward along a prominent cliff or scarp, 120 to 150 metres (400 to 500 feet) high. It marks the location of the north-trending Red Rock River Fault.

Rocks on the west side of the fault have been displaced about 7 kilometres (4.5 miles) south and downward relative to rocks on the east side. Movements along the fault took place over a long period of time, but the last movement was many millions of years ago. The northern continuation of the fault can be seen where the highway crosses the valley of the Old Woman River. Granitic rocks on both sides of the road have been highly fractured by the faulting, and are stained deep red by hematite deposited from hot aqueous solutions that once moved along the fault.

South of Old Woman Bay, the highway climbs from the lake, and travels inland for approximately 45 kilometres (28 miles). About 3.4 kilometres (2.1 miles) from the turnoff to Old Woman Bay, a big bald black outcrop is exposed on the west side of road. It consists of two different types of igneous rock. The main body of the outcrop is fine-grained, massive basalt, a volcanic rock. It is cut by an irregular greenish-black dike of diabase. Both rocks have been polished by glacial action, but the finer grained basalt has a much shinier surface than does the coarser grained diabase.

It is interesting that in polishing the outcrop, the glaciers left evidence that they advanced three times, each time from a different direction. Each advance is recorded by a set of scratches left when pebbles, cobbles, and boulders at the base of the glacier were pressed into the outcrop by the immense weight of the moving ice *(Photo 108)*. By determining which sets of scratches cut which, observers can determine the order in which the glacial advances took place.

Red Rock Lake

The headquarters of Lake Superior Provincial Park are located at the south end of Red Rock Lake, about 10.9 kilometres (6.8 miles) south of the turnoff to Old Woman Bay. The headquarters offer information services concerning the park, as well as interpretive panels and a safe place to park while examining a very interesting sequence of ancient volcanic rocks.

The rocks themselves lie along the east side of the highway, in a high road cut that begins approximately 800 metres (2,600 feet) north of the park headquarters. The roadcut is approximately 220 metres (720 feet) long, and includes volcanic rocks of very diverse character and composition. Radiometric age dating indicates that they are 2.71 billion years old.

Two Types of Volcanic Rock

The southern 100 metres (330 feet) of the outcrop consist of light-coloured ash-flow tuff *(Photo 109)*. This type of felsic volcanic

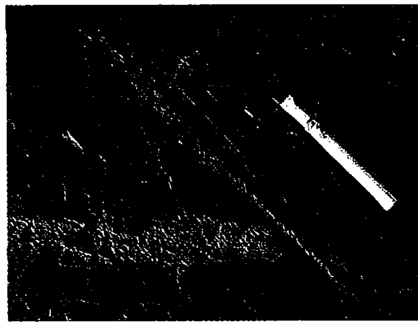


PHOTO 108: These striae record three glacial advances. The first was parallel to the hammer handle, the next was almost parallel to the hammer head, and the last was from right to left.

rock forms when lava, rendered very fluid by a high gas content, spreads widely and rapidly from a volcanic vent. Here, it contains large crystals, or phenocrysts, of quartz and feldspar, and is similar to some types of granite. The presence of other volcanic rocks in

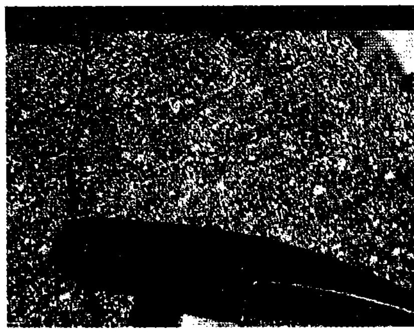


PHOTO 109: Phenocrysts, or relatively coarse grains, of greyish quartz and cream-coloured feldspar can be seen along with wispy flattened rock fragments in ash-flow tuff at Red Rock Lake.

the sequence exposed in the outcrop confirms, however, that these rocks are volcanic and not intrusive.

The northern 120 metres (390 feet) of the outcrop consist of a sequence of three units of dark-coloured basalt, alternating with two units of light-coloured ash-flow tuff.

Poorly preserved flattened pillows can be seen in the first basalt unit, while several narrow diabase dikes can be seen at the southern margin of, and within, the second basalt unit. The third basalt unit marks the end of the sequence. Of note is the thin rusty weathering banded layer at the contact between the second ash-flow tuff and the third basalt unit. It is in rocks such as these that some mineral deposits can be found.

South of Red Rock Lake, outcrops of volcanic rocks can be seen for a few kilometres (miles), along with glacial debris including glaciofluvial sand and gravel deposits. About 22 kilometres (14 miles) south of Red Rock Lake, however, Highway 17 passes through a region that contains both volcanic rocks and granitic rocks. A little farther south, it finally passes out of the area of Archean volcanic rocks and into one dominated by a variety of granitic rocks.

PHOTO 110: Large blocks of black and pink banded migmatite engulfed by coarse-grained pink granite are exposed along the riverbank at the Sand River picnic area in Lake Superior Provincial Park.

Katherine Cove

Highway 17 returns to the shores of Lake Superior about 29 kilometres (18 miles) south of Red Rock Lake. About 35.0 kilometres (21.9 miles) south of Red Rock Lake, it passes the picnic area at Katherine Cove. Katherine Cove has two scenic little beaches, and is sheltered from the main body of Lake Superior by Lizard Island. The shallow water of the cove is thus much warmer than the water at many of the other beaches in the park, and so is more comfortable for swimming.

The beaches are separated by a headland with some very interesting rocks. In the outcrops, angular blocks of banded grey gneiss are engulfed and crosscut by granitic dikes. Some of the dikes contain pale pink feldspar phenocrysts 10 centimetres (4 inches) and more across. Broken crystals on the surface of the outcrop reflect sunlight from their flat cleavage surfaces like a myriad of tiny mirrors. Boulders of a variety of rock types are stranded in a jumble on the headland, all brought to the area by glaciers and left behind when the ice melted. Boulders such as these, which came from some source far from where they are found at present, are called erratics.

Sand River

Highway 17 crosses the Sand River about 1.6 kilometres (1.0 mile) south of Katherine Cove and 24 kilometres (15 miles) north of the southern boundary of Lake Superior Provincial Park. It is noted mainly for the beautiful succession of low falls and rapids just east of Highway 17, where it tumbles quickly in its descent over outcrops of attractive pink and black migmatite.

A turnoff from Highway 17 leads 0.2 kilometre (0.1 mile) to a parking and picnic area. From the picnic area, there are scenic trails to the falls. Some of the falls are almost immediately adjacent to the picnic area, but the trail extends about 3 kilometres (2 miles) upstream along Sand River, and past a number of other cascades.

The colourful outcrops along the river bank consist of large blocks of banded black and pink migmatite, which have been shot through and engulfed by attractive coarse-grained pink granite *(Photo 110)*. The various bands in the migmatite have weathered differentially, resulting in ridges in the surface of the rock. The granite contains large crystals of reddish feldspar, some as long as 15 centimetres (6 inches), in a finer grained matrix.

Formation of a Sand Bar

An outstanding feature of the Sand River is the conspicuous sand bar across the river's mouth. It is commemorated both in the river's current name and its former one, Pinguisibi, which means "river of fine white sand". The sand bar was caused by the action of longshore currents sweeping along the margin of the lake. Such currents are usually caused by waves striking the shore at an oblique angle. They remove sand from around exposed headlands, and deposit it in more protected places such as are provided by embayments in the shoreline. Where the currents pass a particularly deep indentation (like the mouth of a river) the sand is deposited as a ridge, which grows until finally, it extends across the indentation as a long narrow bar.

Some of the sand from the bar at the mouth of the Sand River has been reworked by winds from the open waters of Lake Superior, and has formed prominent sand dunes along the beach. These dunes are similar to those found at Michipicoten (Sandy) Beach near Wawa.

Agawa Rock and Indian Pictographs

About 1.2 kilometres (0.8 mile) south of the Sand River and 4.3 kilometres (2.7 miles) north of the Agawa River, a short access road on the west side of Highway 17 leads to a parking lot and picnic area. From there, a rugged and picturesque trail leads 400 metres (1,300 feet) to Agawa Rock. Along the way, the trail passes through a narrow steep-walled canyon. Many visitors might believe that the canyon resulted from a fissure or fault in the rock. Closer examination shows, however, that it marks the site of a narrow diabase dike. Being much less resistant to erosion than the granitic rock it intruded, the diabase has been deeply eroded while the granitic rock has not. The huge boulder which lies across the top of the canyon near the lakeshore was left in its precarious perch when the glaciers melted away from the area.

Agawa Rock makes a dramatic sight as it rises sheer about 30 metres (100 feet) above the level of Lake Superior *(Photo 111)*. Scattered along its base are 35 Indian rock paintings, said to illustrate the story from about

PHOTO 111: Agawa Rock formed when a granite outcrop broke apart along vertical and subhorizonal joints, leaving a high vertical cliff with a small sloping shelf at its base. Along the base, 35 Indian pictographs are painted.

1825 of an Ojibwa war party of more than 50 men. The group left a village on the south shore of the lake and travelled in five large canoes for three days to cross the lake. Once across, they joined forces with the Agawa band of Ojibwa to do battle with the Iroquois.

The first published description of these pictographs came in 1851 from Henry Schoolcraft, a United States Indian agent, who got his information from an influential chief of the Sault Ste. Marie Ojibwa. Schoolcraft's collection of Ojibwa folklore was the basis of Longfellow's epic poem "Hiawatha". Although Schoolcraft did not visit the pictograph site, it was seen by the anonymous author of an article that appeared in an 1879 edition of *Forest and Stream/Rod and Gun* magazine. It was also well known by local fisherman. The site did not gain national attention until it was located in 1958 after a 14 month-long search by a worker from the Royal Ontario Museum.

The paintings are done in red ochre, a pigment made by grinding hematite, an iron oxide *(Photo 112)*. The powdered mineral may have been mixed with animal grease or fish oil to make it easier to apply. The paintings have proven remarkably durable, but are fading with time and exposure to the elements. Also, the 1879 account provides evidence that at least some pictographs were lost from the site when frost action broke slabs off of the outcrop during the winter of 1878.

Visitors who venture onto the rock ledge at the foot of the cliff to view the pictographs are warned to use extreme caution. The rock ledge is slippery when wet, waves from the lake can be unpredictable and dangerous, and the water beneath the cliff is deep and cold. Please refrain from touching the paintings, for they may be damaged if you touch them.

PHOTO 112: The paintings at Agawa Rock, done in red ochre, are said to commemorate the success of an Ojibwa war party. These pictographs represent the spiny-backed Misshepezhieu (the water spirit), a canoe carrying warriors (image to the left of Misshepezhieu), and two serpents.

Agawa Bay Scenic Lookout

The Agawa Bay scenic lookout provides a magnificent view of the Lake Superior shoreline and the surrounding country. It is located on the east side of Highway 17, 1.5 kilometres (0.9 mile) south of the turnoff to the pictograph trail, and 2.8 kilometres (1.8 miles) north of the Agawa River.

The area, with its hills rising high above the lake, is one of the most rugged and most beautiful in Ontario. It is underlain almost entirely by granitic rocks, such as the grey granodiorite exposed at the lookout itself. The granodiorite is of igneous origin, and is part of a large batholithic mass that formed between 2.70 and 2.90 billion years ago. The shore of Agawa Bay, below the lookout, is famous for its kilometres (miles) of driftwood-strewn and pebbled beach.

Agawa Canyon

Agawa Canyon is one of the more picturesque sites in the region. It is located along the valley of the Agawa River a short distance east of, and inland from Lake Superior Provincial Park, along the Algoma Central Railway line between Sault Ste. Marie and the town of Hearst. At the canyon, the Agawa River follows an exceptionally straight north-south course. Unlike the Ouimet Canyon, which formed when a diabase sill with well-developed jointing was eroded, Agawa Canyon formed due to erosion of a major fault zone. Movement on the fault took place hundreds of million of years ago, and was predominantly vertical. The east side moved down compared to the west side.

The canyon ranges up to about 1.6 kilometres (1.0 mile) wide, and has steep walls up to about 150 metres (500 feet) high. The rocks exposed in the canyon walls are largely granitic. They have some large inclusions of older volcanic rocks or "greenstones", and are cut by younger dikes of diabase. Along the riverbed, sheared and brecciated rocks bear witness to the faulting. Displacements as much as 2.8 kilometres (1.8 miles) have been measured along the fault.

A park with facilities for picnicking and nature study has been developed at the south end of the canyon by Algoma Central Railway. Tributary streams to the Agawa River tumble down the rocky canyon walls, and hiking trails lead to three attractive waterfalls in the park area: Otter Creek Falls; Black Beaver Falls; and Bridal Veil Falls.

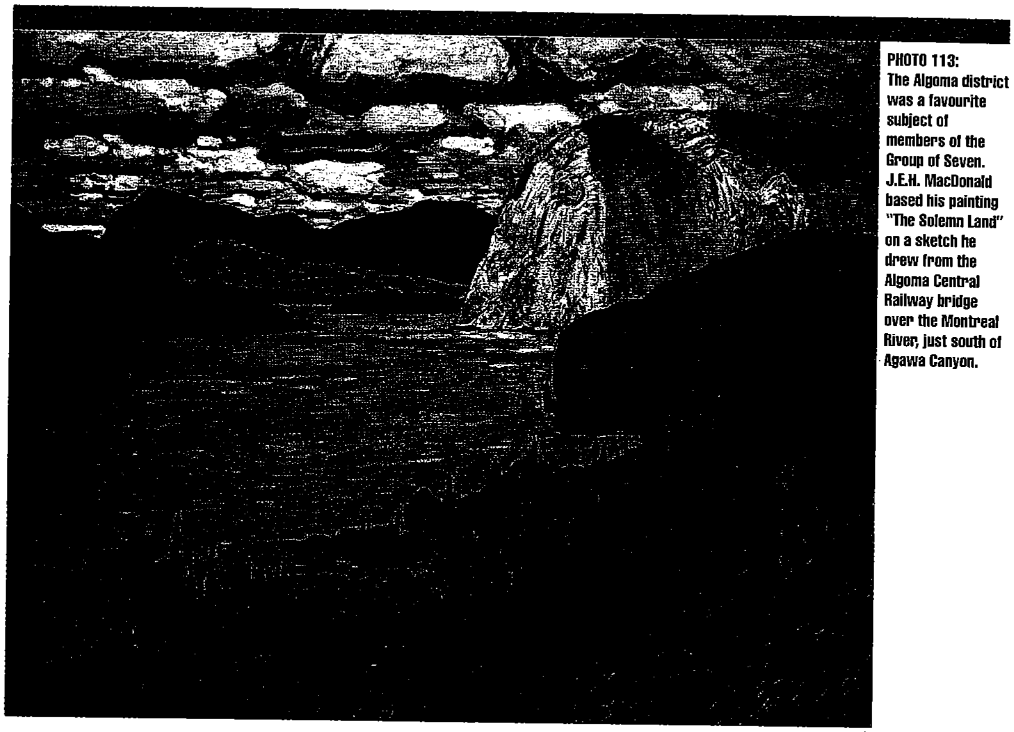


PHOTO 113:
The Algoma district was a favourite subject of members of the Group of Seven. J.E.H. MacDonald based his painting "The Solemn Land" on a sketch he drew from the Algoma Central Railway bridge over the Montreal River, just south of Agawa Canyon.

While not accessible by motor vehicle, the canyon is easily reached by way of Algoma Central Railway, which operates a daily train from Sault Ste. Marie during the months of May through October. A trip to Agawa canyon is best scheduled for the fall season, between mid September and mid October, when the Algoma countryside is ablaze with colour. Among the many visitors who have enjoyed the scenic beauty of the area are Group of Seven members A.Y. Jackson, Lawren Harris, Franz Johnston, and J.E.H. MacDonald *(Photo 113)*.

Montreal River

Where Highway 17 crosses the Montreal River, the river flows through a steep-walled canyon. Although the canyon is no more than about 30 metres (100 feet) deep, it is unusually narrow *(Photo 114)*; at first glance many visitors conclude that it represents a deep crack in the earth left after faulting caused by some violent earthquake. Like most theories based on insufficient evidence, however, this idea is far from being true.

Close examination of the bedrock shows that the walls of the canyon are made of hard granite, whereas the riverbed is underlain by black diabase. This diabase is in the form of a dike that extends along the riverbed below the bridge, and dips, or slopes, steeply to the north at the same angle as the canyon walls. Thus, after more complete examination of the facts, observers can conclude that the canyon resulted when the fast-flowing river eroded the diabase dike more quickly than the enclosing granite.

The differential erosion of the diabase dike beneath the channel of the river may be due to the fact that the diabase here is highly fractured or jointed, whereas the granite is quite massive in character. The cracks or joints are of two types. Some joints, which may be described as longitudinal, are parallel to the walls of the dike itself. Others, which are much more

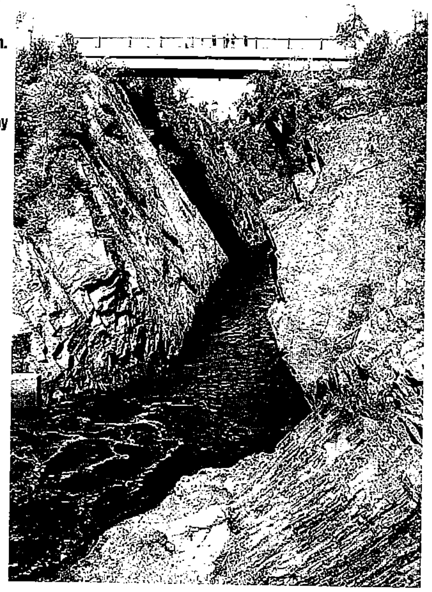


PHOTO 114:
The Montreal River canyon at Highway 17 is a result of differential erosion. The canyon walls are of resistant granite, while the floor is underlain by a steeply dipping diabase dike with closely spaced joints. The easily eroded diabase is exposed in the foreground of the photograph.

numerous and closely spaced, cut transversely across the dike. They cause the rock to break into thin polygonal prisms or columns 2 to 15 centimetres (1 to 6 inches) in diameter. The columnar jointing is remarkably well developed in this dike, and is one of the most outstanding examples of columnar jointing to be found along the north shore of Lake Superior. The diabase crystallized from a hot magma, and the columnar jointing resulted when the diabase contracted as it cooled inward from the walls of the dike, while the rock solidified.

Visitors might find it interesting to compare this canyon to the one along the trail to Agawa Rock in Lake Superior Provincial Park. The bedrock geology and history of the two sites are very similar. In contrast, the diabase dike that forms the Sea Lion near Silver Islet in Sleeping Giant Provincial Park, is more resistant to erosion than the enclosing sedimentary rocks. It projects into Lake Superior as a narrow wall!

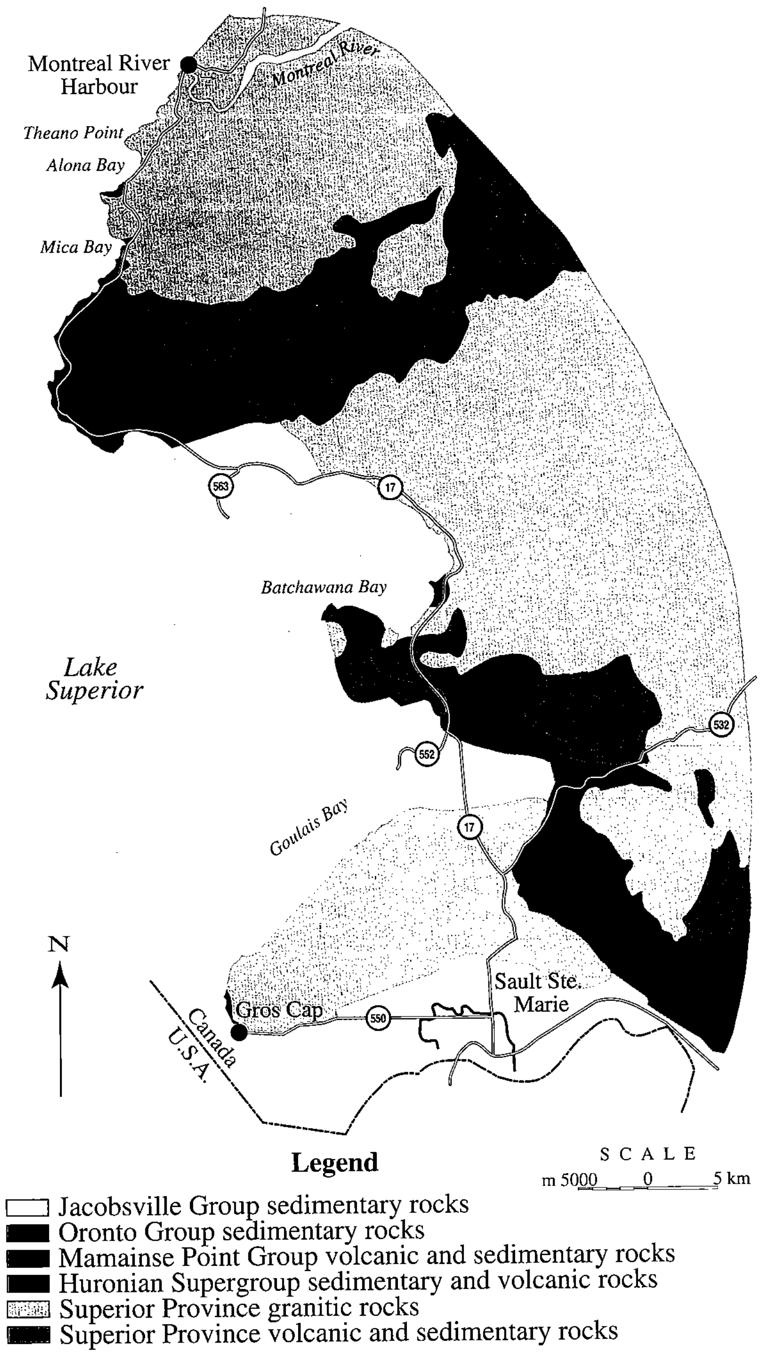


FIGURE 18: Generalized geology of the Montreal River–Sault Ste. Marie area. Exposures of Superior Province and Southern Province rocks alternate in this region, resulting in varied topography and scenery.

Montreal River to Sault Ste. Marie

TRIP 11

This portion of Highway 17 passes through some of the prettiest scenery in Ontario. High, forested hills, long sandy beaches, and wave-washed rocky headlands have made the area very popular with vacationers.

PHOTO 115: This terrace just south of Montreal River Harbour shows curved gravel ridges left along the shore of Glacial Lake Minong when the water level was much higher than at present.

The Archean granitic and volcanic rocks that underlie the area have been blanketed by a discontinuous layer of Keweenawan volcanic and sedimentary rocks. In places, the older rocks are exposed; in places the outcrops are of the younger rocks *(Figure 18).* The narrow shoulders along much of this stretch of the highway mean, however, that outcrops that can be examined are limited for the most part to parks or similar pull-off spots because there are few places where travellers can safely park alongside the road.

Montreal River Nature Reserve

Some very interesting glaciolacustrine deposits can be seen along Highway 17 at the top of the hill 2.4 kilometres (1.5 miles) south of the Montreal River bridge. Directly opposite the service centre there, a natural clearing in the forest is underlain almost entirely by rounded pebbles and cobbles of granitic and other rock types *(Photo 115).* This unconsolidated material makes up a terrace left behind when Glacial Lake Minong, a precursor of Lake Superior, dropped from its high water mark of 247 metres (809 feet) above sea level about 9,200 years ago. The present level of Lake Superior is 184 metres (603 feet) above sea level, or 63 metres (207 feet) lower than the abandoned terrace.

The terrace is of special interest not only because of its makeup, but also because of its structure and the plants that live there. The loose pebbles and cobbles form several parallel curvilinear ridges, the crests of which lie roughly 15 metres (50 feet) apart. The ridges once formed a succession of offshore bars that developed in response to the rhythmic action of waves, a common occurrence in coastal environments. Such bars generally are made up of sand. Here, however, any original sand was washed away by the undertow and shore currents, leaving the residue of rounded pebbles and cobbles.

The terrace is so porous that rain simply disappears into it, and nothing can grow on it except lichens. Lichens are mutually-benefiting associations of algae and fungi; the algae are protected by the fungi, which in turn depend upon the algae for their food. A "pioneer species" that grows where nothing else can, lichen was among the first things to grow on the Canadian Shield after the glaciers melted. The lichen mats on the terrace are as much as 30 centimetres (1 foot) thick in places *(Photo 116).*

The terrace, its bars, and its unique vegetation have been set aside as a Nature Reserve to help preserve it for the enjoyment of future generations. Visitors are requested not to walk on, or disturb the site in any way.

Alona Bay

The highway passes a series of outcrops of Archean granitic rocks, migmatite, and agmatite between Montreal River and Alona

Bay. The scenic lookout at Alona Bay, 10.2 kilometres (6.4 miles) south of Montreal River, affords an excellent view along the Lake Superior shoreline. The prominent rocky headland guarding the north side of the bay is Theano Point.

Uranium Discovery on Theano Point

Theano Point may be the site of the first uranium discovery in Canada. In a paper published in the American Journal of Science in 1847, J.L. LeConte refers to a sample of a uranium-bearing mineral collected by B.A. Stanard. It was said to have been taken from the lakeshore about 110 kilometres (70 miles) north of Sault Ste. Marie at a place where the geology is not unlike that of Theano Point. Several attempts were made by the Ontario Department of Mines and by the Geological Survey of Canada to relocate this occurrence. These efforts were unsuccessful, and it was not until 1948 that a uranium-bearing deposit was found here by prospector Robert Campbell.

Campbell's curiosity about the region around Theano Point was prompted by the sudden interest in uranium, which arose out of the development of the atomic bomb. Learning of the original discovery, he obtained a Geiger counter and set out to prospect the Lake Superior shoreline. On September 8, 1948, he was caught in a fierce storm on the lake. His boat, the Theano, was wrecked, and he was forced to take shelter in a small cove on the west side of the point that now bears the boat's name *(Photo 117)*.

Undaunted by his supposed ill fortune, he proceeded to check the rocks in the cove with his Geiger counter. Near the water's edge, in the granite face forming the south wall of the cove, he found short veins of a radioactive black mineral. It ultimately proved to be pitchblende, the chief ore mineral of uranium. Additional veins were evident deeper in the cove; Campbell staked his find, and subsequently transferred his claims to Camray Mines Limited. In 1949, a shaft was sunk on the deposit, and some underground work was carried out. Although the results of this work were disappointing and

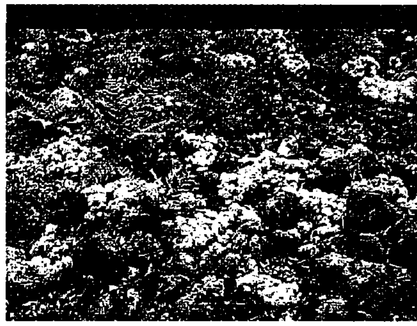


PHOTO 116: Lichens are among the few plants that can survive on the Montreal River Nature Reserve gravel ridges. Visitors are asked not to walk on the site, or disturb the delicate growth.

operations at the property were soon suspended, the search for uranium in the region continued. It was not long before mineable deposits were found by others in the Blind River and Elliot Lake areas east of Sault Ste. Marie.

The rock exposed on Theano Point is principally granite. The granite is cut in several places by diabase dikes. Indeed, the discovery cove, a narrow canyon similar to that at Montreal River, was formed by the differential erosion of a dike. The dike is 10

PHOTO 117: Theano Point, site of what was probably Canada's first uranium discovery, can be seen in this view across Alona Bay.

to 12 metres (35 to 40 feet) wide, trends west-northwest and dips steeply to the north. Along its south margin, both the diabase and the granite country rock have been highly fractured. The fractures are mineralized with pink calcite, chlorite, hematite, and pitchblende in varying proportions.

Mica Bay

At Mica Bay, 19.1 kilometres (11.9 miles) south of Montreal River, there is a small sand terrace at an elevation of about 4.5 metres (15 feet) above a 300 metre (1,000 foot) long gravel beach between two prominent granite headlands. It may be difficult to make a stop at the beach, because there are few safe parking spots in the area. The rocks exposed there are, however, exposed nowhere else along the route.

Scarce Rocks of the Oronto Group

At the base of the shore cliff formed by the terrace, and extending north about 30 metres (100 feet) from the southern headland, is an exposure of sedimentary rocks. Originally thought to be Paleozoic in age, these rocks are now considered to be part of the 1.09 billion-year-old Oronto Group. Better known from exposures south of Lake Superior, it is found in few places north of the lake. The Oronto Group formed at the end of the period of Keweenawan volcanic activity.

PHOTO 118: These structures in the sandstone at Mica Bay indicate that the water was flowing from right to left when the sediment was being deposited. They are typical of ripples formed by waning currents. A white jackknife near the middle of the photograph provides a scale.

A small patch of conglomerate is exposed at the bottom of the sequence of sedimentary rocks. It is the compacted, solidified equivalent of a coarse gravel containing pebbles, cobbles, and boulders of rock like the granite on which it lies. Above it are several metres (feet) of grey, rather soft, well-stratified shales and sandstones.

Since being deposited, the sediments of the Oronto Group have been deformed. At the south end of the outcrop, the beds dip about 15 degrees to the north; at the north end of the outcrop, they dip about 10 degrees to the south. Near the centre of the exposure, they curve abruptly and are nearly vertical.

Erosion and Deposition

A contact between the sedimentary rocks and underlying granitic rocks is exposed at the base of the outcrop. The sedimentary rocks are Proterozoic in age, while the granitic rocks below them are Archean; the surface between the two units, called an unconformity, represents a period of erosion spanning more than 1.40 billion years. During that time a great thickness of rocks was removed.

Migrating Ripples

The sandstones of the Oronto Group are particularly interesting because, in places, they have distinct cross-laminations *(Photo 118)*. These structures result from the action of water currents during deposition of the sediments. When currents sweep sand or silt along the bottom of a stream or lake, parallel ridges or ripples form in the sediment in much the same way that ripples form when wind blows along the surface of a body of water.

The ripples are asymmetric, with gentle slopes facing upstream, and relatively steep slopes facing downstream. As the currents continue to flow, sediment is washed over the ripple crests and deposited on the downstream, or lee, sides of the ripples, and the crests migrate downstream. Depending upon the grain size of the sediments and the flow rate of the current, the ripples can be anything from a centimetre (0.5 inch) or less to more than 100 centimetres (39 inches) high. The layers deposited along the lee sides of the ripples, called cross-laminations or cross-beds, can be at steep angles to the upper and lower surfaces of the unit.

Mamainse Point Area

The presence of copper in the Mamainse Point area was known in early times from its use by the local Indians. They may have worked the area as long ago as 6,000 BC. Copper ornaments from Lake Superior were traded throughout North America before the arrival of the Europeans *(Photo 119)*. Étienne Brulé, the first European to visit the area, carried news of the copper back to the King of France in 1623, but little exploration work was done for more than two centuries.

Greenish black to purplish weathered surfaces are characteristic of the volcanic rocks throughout the Mamainse Point area. When it was realized that these rocks are similar to those of the great Michigan copper district on the Keweenaw Peninsula, the region was thoroughly investigated by prospectors. Several copper deposits were discovered, and in the period between 1846 and 1894, several attempts were made by different mining companies to develop profitable operations. At least three mines, the Copper Creek , the Silver Creek, and the Mamainse, were opened, and a mill was constructed at the Mamainse Mine, but these activities met with little success. There is no record that any significant amount of copper was produced until the 1950s and 1960s, when the Coppercorp and Tribag mines came into production in the area.

Mamainse Mine

The story of the Mamainse Mine is typical of the early copper mining endeavors in the area. The mine was opened in 1889, and for 5 years a bustling

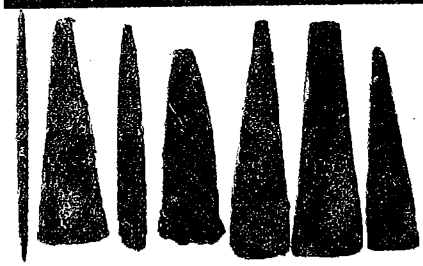


PHOTO 119: These weathered awls and spindles, made of copper from the Mamainse Point area, were found along the shores of Georgian Bay. They were probably used in canoe making.

community of 400 with a mill and upwards of 30 other buildings existed on this site. When the ore ran out, the people moved to similarly short-lived communities along the shore.

The mine site is located along Highway 17, 25.2 kilometres (15.8 miles) south of Montreal River. One shaft is located 50 metres (165 feet) southeast of the highway, while the other two are located 50 metres (165 feet) and 100 metres (330 feet) northwest of the highway. The rocks here are about 1.11 billion years old, and form part of the Keweenawan sequence. They include amygdaloidal basalt with copper in veins and as amygdule fillings. The amygdules were formed when bubbles of hot gas, which separated from the molten lava as it poured out over the surface, were frozen into the cooling basalt and later filled by copper and other minerals including agate, calcite, chlorite, and epidote.

Conglomerate of the Keweenawan sequence is present about 250 metres (820 feet) north of the mine. It consists of pebbles, cobbles, and boulders of granite and other rocks in a matrix of red sandstone; the conglomerate is simply the hard, compacted or consolidated equivalent of a coarse-textured gravel.

The basalt flows and the conglomerate bed trend northerly and dip about 30 degrees to the west. This structure is reflected in the physiography of the Lake Superior shoreline. A series of ridges project northward, along the line of strike, and into the lake as finger-

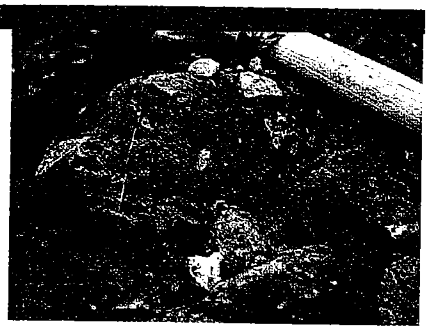


PHOTO 120: Pebbles and cobbles were swept up into the base of this basalt unit when the molten rock flowed over loose gravel. Surface weathering has caused the brownish colour of part of the basalt.

like headlands. When viewed lengthwise, the headlands are seen to be asymmetrical, with gentle dip-slopes to the west and abrupt escarpments facing east.

Fluid Lava

Situated 34.6 kilometres (21.6 miles) south of the Montreal River bridge, a large outcrop in a roadcut offers a dramatic illustration of how fluid lava can be. Here, a thick

PHOTO 121: The magnificent sand beach at Pancake Bay is 3.2 kilometres (2 miles) long. Camping and picnic sites are available there at Pancake Bay Provincial Park.

basalt flow is sandwiched between two thick layers of conglomerate. On the west side of the road, pebbles that have been swept up by the flowing lava and incorporated into the base of the basalt layer can be seen, as can "fingers" of basalt that formed when lava ran down between the boulders of the conglomerate *(Photo 120)*.

The clasts, or fragments, in the conglomerate are mainly of Archean granitic rocks. Although more than a billion years old, this conglomerate was never deeply buried and hence is much like it was when it was lain down. Seams of calcite deposited from groundwater have filled some of the empty spaces between the cobbles in the conglomerate.

Pancake Bay Provincial Park

Perhaps the longest and most magnificent sand beach along the north shore of Lake Superior in Ontario is the one at Pancake Bay, 43.1 kilometres (26.9 miles) south of Montreal River bridge. The beach offers a stretch 3.2 kilometres (2.0 miles) long of fine, pure sand, and is sheltered from the open waters of Lake Superior by the two promontories that form the bay *(Photo 121)*. The sand forms part of the extensive glaciolacustrine deposits of the area. Beach terraces, from when water levels were higher than they are now, are preserved on the promontories on either side of the bay.

Red pines are the most common trees in the well-drained sand and soil along the shoreline, while farther inland, yellow birch and sugar maples predominate. Sheltered by the trees are 338 campsites (most of them large enough to take trailers), a hiking trail 3.6 kilometres (2.3 miles) long, and numerous other facilities.

Pancake Bay got its name from the fur traders who camped on the beach en route from Fort William, at what is now Thunder Bay, to Montreal. Running low on food, they would make pancakes from their remaining flour, knowing that they could replenish their supplies the following day at Sault Ste. Marie.

Batchawana Bay Provincial Park

Batchawana Bay Provincial Park is located 10.5 kilometres (6.6 miles) southeast of Pancake Bay Provincial Park. Also located on a picturesque long sand beach, it offers free day use for picnicking and swimming, and is a pleasant place to take a break. Around the bay, remnants of former Lake Superior shorelines can be seen as terraces on the hillsides. The Batchawana Tourist Association operates a seasonal Visitor Information Centre at the park to answer questions from the travelling public and to provide information concerning nearby motels, restaurants, and attractions.

Chippewa Falls Wayside Park

Highway 17 crosses the Harmony River 10.9 kilometres (6.8 miles) south of Batchawana Bay Provincial Park. Although some people refer to this river as the Chippewa, in fact the Chippewa River flows into the Harmony River about 10 kilometres (6 miles) upstream from the bridge. To add to the confusion, some people refer to Jones Creek, about 12.2 kilometres (7.6 miles) south of the park, as the Harmony River!

Just east of the bridge, a wayside park with facilities for picnicking has been established next to Chippewa Falls. There are, in fact, two cascades about 45 metres (150 feet) apart at the park. Although both have resulted from differential erosion, wherein a mass of hard rock has resisted erosion and created the cataract, the resistant rock at the lower falls is quite different from the one at the upper falls.

The Lower Falls

The lower falls is closest to the picnic area. It drops 6 to 7 metres (18 to 21 feet), where the granite that makes up most of the bedrock of the area is capped by a thin remnant of Keweenawan volcanic rock *(Photo 122)*. This erosional remnant lies athwart the riverbed. It slopes about 30 degrees to the southwest near the top of the falls, but flattens so that at the base of the falls, it slopes at angles of 10 degrees or less. A fault running under the riverbank has cut and displaced the bedrock. As a result, the remnant block of resistant rock lies farther upstream on northwest side of the river than it does in the riverbed and along the southeast bank.

PHOTO 122: A remnant of dark grey Keweenawan basalt rests atop a 1.11 billion-year-old erosional surface at the lower waterfalls, Chippewa Falls Roadside Park.

Record of an Eruption

The patch of resistant volcanic rock is interesting not only because it controls the site of the falls, but also because of the features it exhibits and because of its relationship with the underlying granite. It is dark in colour and basic, or basaltic, in composition. It crystallized from a magma that, before eruption, contained abundant water vapour and other gases. When this magma poured out over the surface, the gases separated from it rapidly. Where they were frozen into the cooling lava before they were able to escape, they left the lava riddled with rounded bubble holes, or vesicles. Subsequently, these vesicles became filled with minerals such as dark green chlorite and pale green epidote, and the resulting rock became crudely spotted in appearance. In addition, the rock has very closely spaced joints, and its surface is exceedingly rough and jagged in appearance. It is also broken by irregular but persistent fractures. Along some of the joints and fractures, the rock has taken on a reddish colour due to the presence of the mineral hematite. Some fractures are filled with pale green epidote; others have narrow veinlets of white calcite.

Because the granite is about 2.70 billion years old while the basalt is about 1.11 billion years old, the boundary between them represents a prolonged period of erosion. The granitic rock was at the surface of the earth when the volcanic rocks were erupted. The grains in the volcanic rock where it rests upon the granite are very fine, no doubt because the lava was chilled rapidly as it flowed over the cool outcrop of granite. The contact

PHOTO 123: The upper cascade at Chippewa Falls is caused by a faulted dark grey diabase dike. The faulted continuation of the dike can be seen about 9 metres (30 feet) upstream.

between the volcanic rock and the granite appears fairly smooth at first glance. When it is closely examined, however, thin tongues of basalt can be seen projecting downward and outward from the flow, completely enclosing small blocks of granite in places.

Potholes in the Rock

An example of modern erosion can be seen near the base of the lower falls. There, numerous round depressions up to 1.5 metres (5 feet) across and 0.9 metre (3.0 feet) deep can be found in the volcanic rock and, to a lesser extent, in the granite. Round depressions, or potholes, such as these form where the water in a rapidly-flowing river is given a rotary motion by eddying currents. The eddying currents can carry pebbles, cobbles, or even boulders if the current is strong enough, and scour those stones against the underlying bedrock. When the stones are harder than the bedrock, they grind out round depressions such as these.

The Upper Falls

The upper falls can be reached by following a good trail from the parking area for about 245 metres (800 feet) along the southeast bank of the river. The escarpment at the upper falls is not caused by a remnant of volcanic rock like the one at the lower falls. Instead, it is caused by a diabase dike that cuts the massive granite bedrock. The dike is a vertical, tabular-shaped body about 20 metres (65 feet) thick. It trends northwest and stands up as a resistant wall, over which the river tumbles 6 to 7 metres (20 to 25 feet) in its descent to Lake Superior.

As with the remnant of volcanic rock at the lower falls, the dike at the upper falls has been cut and displaced by a fault. Standing on the dike and looking northwesterly along it, one can see that it terminates abruptly. Its extension on the opposite side of the river has been displaced about 9 metres (30 feet) farther upstream (northeast) *(Photo 123)*.

The trail along the Harmony River continues about 150 metres (500 feet) upstream from the upper falls. There, the fast-flowing shallow waters of the stream tumble over a bed of large boulders; all finer-grained material has been washed away by the powerful current.

The waterfalls, the structures displayed by the bedrock formations, the potholes, and the general scenic attractiveness of the area, combine to make Chippewa Falls Park one of the most interesting locations along the north shore highway.

The Jacobsville Group

Outcrops of mottled red and tan sandstone of the Jacobsville Group are exposed on the east side of Highway 17, 14.1 kilometres (8.8 miles) south of the turnoff to Chippewa Falls Wayside Park. It unconformably overlies the rocks of the Oronto Group, such as are exposed at Mica Bay. Batchawana Island (the large low island in the centre of Batchawana Bay), the broad plain surrounding the mouth of the Goulais River, and the city of Sault Ste. Marie are also underlain by rock of the Jacobsville Group. Evidence suggests that the sandstone, which has been used as a building material in some of the older buildings of Sault Ste. Marie, was deposited in a fluvial, or river, environment.

The red colour of the sandstone is due to the presence of iron oxides. Its patchy nature *(Photo 124)* probably results from the combined actions of groundwater containing trace amounts of dissolved iron, and chemical variations within the rock itself. The indistinct layers in the sandstone, which are

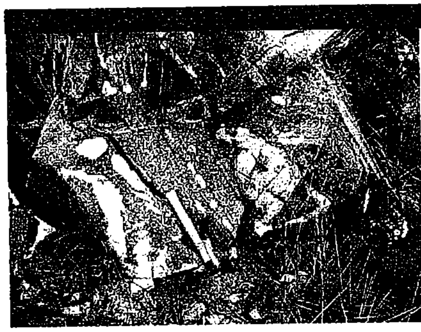
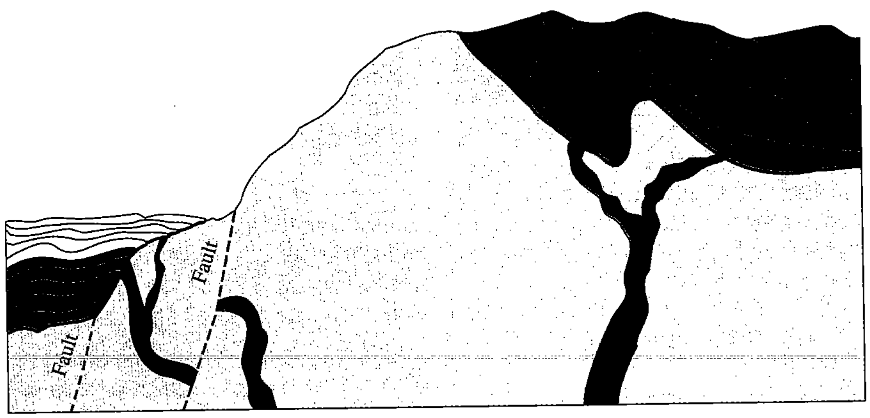


PHOTO 124: Sandstone of the Jacobsville Group is white in places, purplish red in places, and mottled in places. The purplish red colour results from the presence of iron oxides.

highlighted by the colour variations, probably represent the original layers, or beds, in the sandstone. The fact that the layers are now tilted at a steep angle suggests that they have been folded.

Goulais River Area

The Goulais River and Sault Ste. Marie areas are at the transition zone between the



Legend

- Jacobsville Group sedimentary rocks
- Mamainse Point Group volcanic and sedimentary rocks
- Huronian Supergroup sedimentary and volcanic rocks
- Superior Province diabase intrusions
- Superior Province granitic rocks

FIGURE 19: Cross section of the area between Sault Ste. Marie (at left) and Bellevue (at right). The older rocks occur at higher elevations, while the younger rocks are found at lower elevations in a down-faulted basin that formed during development of the Midcontinent Rift.

southern hardwood forest and the northern coniferous forest. Wild flowers and other plants common to both the southern and northern parts of Canada flourish here. At Mile Hill, the long hill that leads up from the floor of the Goulais River valley 5.0 kilometres (3.1 miles) south of the river, excellent examples of the effects of microclimates can be seen. The cool, moist microclimate of the valley floor provides suitable habitat for conifers such as black spruce, jack pine, and white pine, while hardwood forests abound on the surrounding hills.

Also at Mile Hill, Highway 17 climbs from the low area around Goulais River, underlain by rocks of the Jacobsville Group, onto a wide ridge of older rocks that protrudes through the blanket of 1.09 billion-year-old sedimentary rocks.

The Huronian Supergroup

Highway 566, which leaves Highway 17 11.0 kilometres (6.9 miles) south of the Goulais River bridge at the town of Heyden, and leads about 12 kilometres (7.5 miles) farther uphill to Bellevue. The area around Bellevue is underlain by rocks that are found nowhere else along the north shore of Lake Superior. These rocks mark the most westerly exposures of a sequence of 2.22 to 2.49 billion-year-old volcanic and sedimentary rocks called the Huronian Supergroup. The Huronian Supergroup rocks are the oldest rocks in the Southern Province of the Canadian Shield. They form a long belt that extends all along the north shore of Lake Huron. The trip to Bellevue is worthwhile for the spectacular view to be obtained there, as well as for its geological interest.

In a roadcut 500 metres (0.3 mile) south of the town of Heyden, light pink Archean granite and granitic gneiss are exposed. The central part of the outcrop is cut by a dark grey diabase dike about 18 metres (60 feet) wide. The colour contrast between the two types of rock is quite dramatic.

This outcrop, and the nearby exposures of rocks from the Huronian Supergroup, are both many metres (feet) in elevation above the nearby younger, and relatively underformed rocks of Jacobsville Group. They provide compelling evidence that the local topography was rugged when the Jacobsville Group sediments were deposited *(Figure 19)*. It may have been as rugged as the erosional surface in the area today—or even more so!

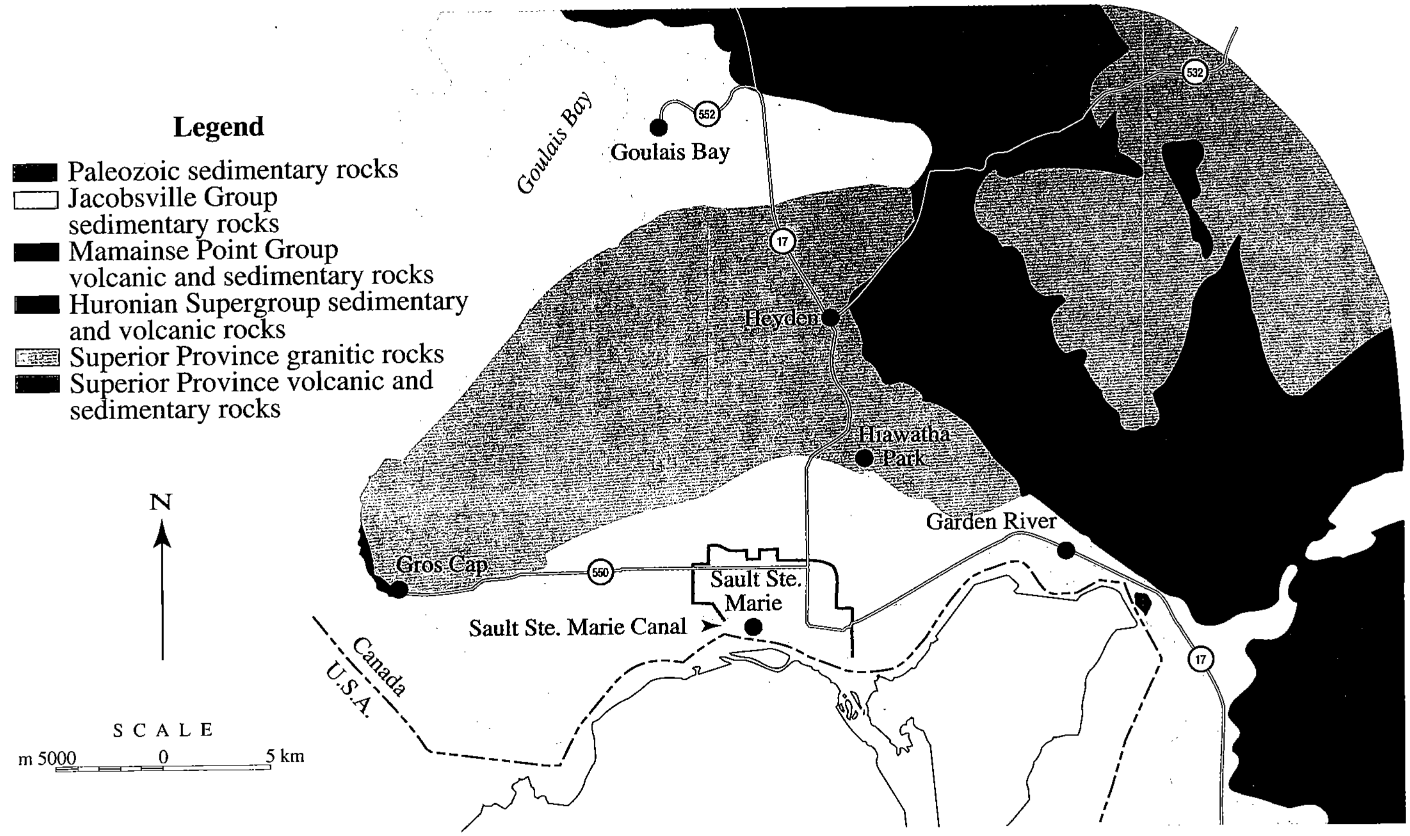


FIGURE 20: Generalized geology of the Sault Ste. Marie area. The Archean rocks of the Superior Province were blanketed by the Proterozoic rocks of the Southern Province. Both were subsequently deformed and eroded, and eventually covered by younger volcanic and sedimentary rocks, and by glacial debris.

SAULT STE. MARIE

TRIP 12

Sault Ste. Marie is a relatively young community, despite its established appearance and its long-standing status as a major transhipment point on the vital east-west Great Lakes transportation route. Originally called "Sault de Gaston" by Champlain in 1632, it was renamed Sault Ste. Marie in 1668 by Jesuits when they set up a mission. Both names commemorate the rapids with the old French word "sault".

The city, on the north bank of the St. Marys River, lies in an area with an interesting geological history. Here, Archean and overlying Proterozoic rocks *(Figure 20)* are covered by a blanket of clay, sand, and silt. All have played an important role in the development of the local topography and scenery.

A Transportation Hub

Today, Sault Ste. Marie continues to be an important transportation centre. With road and rail links to the United Sates, and the east-west shipping route, the area handles large volumes of through traffic. The canals permitting navigation between Lake Superior and Lake Huron are on one of the busiest shipping routes in the world, and regularly handle more traffic than any comparable system in the world. The concentration of canals and locks, and road and rail crossings amply demonstrate that this is a transportation hub. The International Bridge, built between 1960 and 1962 at a cost of $20 million, spans 4.5 kilometres (2.8 miles), and at its highest point is 44 metres (145 feet) above the St. Marys River. It demonstrates the importance of mineral products; 103,600 tonnes (114,000 tons) of concrete and 10,000 tonnes (11,000 tons) of structural steel were used in its construction!

The History of the Locks

The North West Company built a post at Sault Ste. Marie in 1783, and developed the fisheries in the area in support of the voyageurs working the busy east-west trade routes. By 1797 the canoes and boats of the fur traders, and their cargoes, had become so large that the portage around the rapids was impractical, so the North West Company built a sawmill, a canal, and a lock. The lock raised and lowered vessels the 6.7 metres (22.0 feet) between the upper and lower river levels.

The lock, along with the rest of the strategic, but undefended, North West Company post, was destroyed by American raiders on July 10, 1814, near the end of the War of 1812. The Americans were unable to capture nearby Fort Michilimackinac, however, and British forces retained control of Sault Ste. Marie. The post and lock were rebuilt and remained in use until 1865. Parks Canada has restored the canal and lock, and today there are historic displays and viewing areas at the scenic grounds of the site. The canal features antique stone buildings and machinery straight out of Canada's industrial revolution.

Construction of the American locks began in 1853. The first two were completed in 1855. As commerce grew, however, the need for more locks became evident. The result was that the first two locks were transferred from the state to the federal government in 1881, and two more locks were built. The last of the locks to be built was on the Canadian side. It was started after the United States refused to permit the steamer Chicora, carrying Colonel Wolseley's Red River expedition, to pass through the American locks in 1870, and was completed in 1895 *(Photo 125)*.

Industrial Development

Indications that Sault Ste. Marie was a community with a future could be seen even in the early 1800s. In 1814, fur trader Charles Oakes Ermatinger built a Georgian mansion of stone downstream from the rapids *(Photo 126)*. This, reportedly the oldest stone house in Canada west of Toronto, was fully restored in 1970 and has been preserved as a National Historic Site to portray the early pioneer period.

Development continued slowly for several decades. Large scale development began at the turn of the century with the ambitious industrial complex created by American entrepreneur Francis H. Clergue. He oversaw construction of the first pulp mill in Northern Ontario in 1896, and the building of the Algoma Central Railway between 1899 and 1914. The railway supplied logs to the mill, and iron ore to the foundries and mills of Algoma Steel, his other new endeavour begun in 1900. The rapids at Sault Ste. Marie played an important part in all this work; their head of water provided hydroelectric energy for the new industries.

Although Clergue's massive developments bankrupted his company in 1903, they also provided the foundation for Sault Ste. Marie's modern industry. Algoma Steel Corporation is Canada's third largest steel company, Algoma Central Railway still brings iron ore and logs south for local industry, and Great Lakes Power still produces hydroelectricity. Paper is still manufactured in the city, but instead of newsprint, a glossy clay-filled specialty product called "supercalendered paper" is now produced. In addition, the city hosts government offices, hospitals, and educational and research centres, including Sault College of Applied Arts and Technology and the Great Lakes Forestry Centre.

Geological Setting

Rocks from both the major time divisions of the Precambrian, the Archean and Proterozoic Eons, are found in the Sault Ste. Marie area. Although one might logically expect that the Proterozoic sandstones, lying on top of the Archean granitic rocks, would also be at the highest elevations, that is not the case at Sault Ste. Marie. Evidence preserved in the rocks of the area tells why this is so.

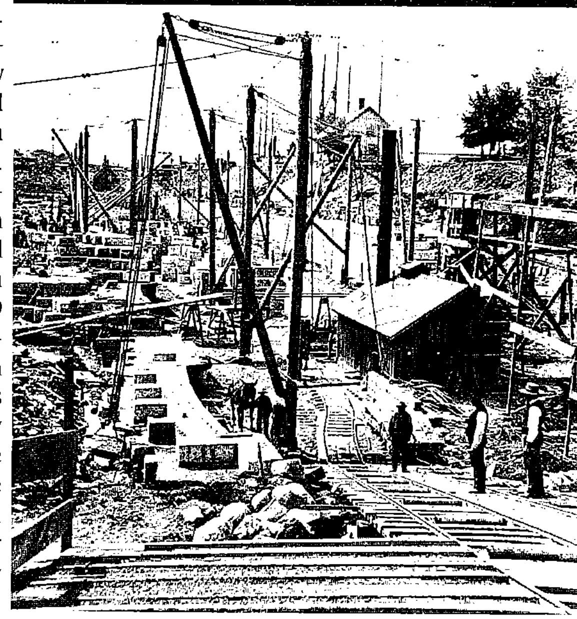


PHOTO 125: Construction on the Canadian locks at Sault Ste. Marie began after the US refused a Canadian ship passage through the American locks in 1870. The locks, shown here under construction ca. 1880, were completed in 1895.

The Gros Cap Highland

The most prominent topographic feature in the vicinity of Sault Ste. Marie is the Gros Cap highland. It rises to 120 to 180 metres (400 to 600 feet) above Lake Superior, and separates the St. Marys River lowland on the south from the Goulais River lowland on the north. It gets its name from Gros Cap, on the shore of Lake Superior,

PHOTO 128: Ermatinger House was built in 1814, the same year that American raiders destroyed the nearby North West Company depot in an effort to gain control of the waterway at Sault Ste. Marie.

which means "big headland". Highway 17 crosses the highland north of Sault Ste. Marie in the area around Heyden and Bellevue.

Gros Cap itself, the headland where the west end of the highland forms a high rock promontory overlooking Lake Superior, can be reached by following Highway 550 (Second Line) west from the city for about 20 kilometres (12.5 miles). The highway ends at a parking lot in front of a restaurant on the shore of Lake Superior. A trail leads approximately 400 metres (1,300 feet) from the west end of the parking lot to the top of the headland, 90 metres (300 feet) above the lakeshore. The panoramic view from the headland across Whitefish Bay includes lake and ocean freighters passing into and out of Lake Superior *(Photo 127).*

PHOTO 127: Gros Cap is popular with Sault Ste. Marie residents as a destination for family outings, and for rock and ice climbing. The promontory, home to hawks and bald eagles, offers a panoramic view across Whitefish Bay.

The Oldest Rocks at the Highest Elevation

In addition to being the area's most prominent geological feature, the Gros Cap highland is also its oldest. The western and central parts of the highland are made up of a large mass of 2.72 billion-year-old granite and granitic gneiss. Such rocks form deep within the earth, and are exposed to view only after a prolonged period of erosion. Most are associated with intensely folded and faulted rocks in mountain ranges. The eastern part of the highland is made up of folded and metamorphosed volcanic and sedimentary rocks of the 2.22 to 2.49 billion-year-old Huronian Supergroup. Evidence suggests that they were part of a major deformational event about 1.80 billion years ago. Thus, it is tempting to speculate that the rocks of the Gros Cap highland once formed a mountainous region, and that the highland is merely the erosional remnant of such a terrain.

The southern boundary of the highland is an escarpment that marks the location of a fault in the bedrock. The fault is one of a local set of parallel faults, each about 10 kilometres (6 miles) from the next, that extend to the east-northeast. Some of the blocks between these faults have slid down, while others have not. The net result is somewhat like a piano keyboard with some keys pressed down and some remaining in their original positions. The low-lying areas around Sault Ste. Marie and Goulais River are on blocks that have dropped down, while the Gros Cap highland is on a block that has not moved. This faulting appears to have been associated with the opening of the Midcontinent Rift, about 1.11 billion years ago.

The Jacobsville Group

The rocks of the Jacobsville Group are the ultimate reason that Sault Ste. Marie exists; they underlie both the St. Marys River rapids and the lowland area adjacent to the rapids that was eventually settled. Blocks of this attractive stone appear in many of the city's buildings *(Photo 128)*.

The flat-lying red and tan sandstones are found at lower elevations than the older rocks for a simple reason; they were deposited on the bottomlands of a region of rugged topography. The high hills that make up the Gros Cap highland today were hills 1.09 billion years ago, when the rocks of the Jacobsville Group were being deposited. The rocks of the Jacobsville Group may have once been thick enough to bury the hills. If so, they have been mostly eroded since then. It is also possible that the hills formed islands in the covering of sediments from the time they were deposited until the present day.

Glaciolacustrine Terraces

The low-lying parts of the region close to the St. Marys River are blanketed by layers of clay, sand, and gravel. Like similar units along the north shore of Lake Superior, these deposits were laid down in Lake Superior when the water level in the lake stood higher after the retreat of the Pleistocene glaciers than it does now.

Three terraces in these deposits underlie the city, each representing a stable elevation of the former lakeshore. They are prominent and distinctive features that span the entire city. The highest terrace stands about 128 metres (420 feet) above the present level of Lake Superior, while the second and third terraces are about 30 metres (100 feet) and 15 metres (50 feet) respectively above the present water level.

The oldest, uppermost terrace can be seen along Old Garden River Road, which branches to the northeast from Highway 17B a short distance north of Northern Avenue. The road descends from the terrace north of Second Line, follows along its base to the north, and then climbs back up onto the terrace north of the Root River. The clay that underlies much of Sault Ste. Marie between the uppermost and middle terrace was deposited on the bottom of the glacial lake when the water level was at its highest. The lower terraces are closer to the St. Marys River. They are marked by the short, steep hills on Pim and Bruce streets.

PHOTO 128: Distinctive red sandstone of the Jacobsville Group, quarried during excavation of the locks, was used to construct the buildings at Sault Canal National Historic Site.

Kinsmen Hiawatha Municipal Park

Hiawatha Park, noted for its nature trails and for Crystal Falls, was established as a community recreational site by the Sault Ste. Marie Kinsmen Club. It lies along Crystal Creek at the intersection of Fifth Line and Landslide Road (the northern extension of Old Garden River Road), about 4.0 kilometres (2.5 miles) east of Highway 17, and about 9.0 kilometres (5.6 miles) north of downtown Sault Ste. Marie.

Crystal Creek flows southwest across the granitic rocks of the Gros Cap highland, and over the south-facing edge of the highland to form two beautiful waterfalls. At Crystal Falls at the north end of the park, the creek drops about 30 metres (100 feet). Some 400 metres (0.2 mile) farther south, the creek drops again at Minnie Ha-Ha Falls *(Photo 129)*, this time over closely-spaced

PHOTO 129: Crystal Creek tumbles over snowy ledges of lichen-covered granite at Minnie Ha-Ha Falls. The falls are one of the features that attract visitors to Kinsmen Hiawatha Municipal Park year-round for hiking and skiing.

ledges about 3 metres (10 feet) wide and 6 metres (18 feet) high. The locations of both these falls are controlled by prominent joints or fractures in the pink granite bedrock.

Below the falls, the creek flows through a narrow valley, about 30 metres (100 feet) deep, cut into the sand and gravel terrace found there. The terrace is the uppermost of the three marking ancient lake levels in the Sault Ste. Marie area. Local erosion of the sand and gravel deposits caused the sudden and dramatic sliding away of a massive volume of this material in the landslide that gave the local road its name.