Roadside Geology of Ontario

North Shore of Lake Superior

KakabekaFallsSleepingGiantSilverIsletOntarioAmethystOuimetCanyonPictographsMountMcKay

Roadside Geology of Ontario

North Shore of Lake Superior

E.G. Pye

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Introduction

In 1960, the last link of the Lake Superior section of the Trans-Canada highway (Highway 17 in Ontario), between the towns of Marathon and Wawa, was completed. For the first time, it was possible to drive around the largest of the Great Lakes. Because the scenery of the north shore of Lake Superior is not only spectacular, but also unique to eastern Canada, the official opening of the highway by the Hon. Leslie M. Frost, Premier of the Province of Ontario, in Wawa on 17 September, 1960, heralded an unprecedented increase in the tourist industry of northwestern Ontario.

Each year since the highway opened, many thousands of people have visited the area. This, however, reflects not only an awareness of the many scenic attractions of the area, but also the growing interest among naturalists and hobbyists in the other opportunities a trip to the area provides. Visitors can examine some of the oldest and most interesting geological formations in the world, walk amidst unusual assemblages of plants in unique ecosystems, and take advantage of opportunities for rock and mineral collecting. Sportsmen and campers find the facilities of the region unequalled.

A Source of Information

As a result of the increased tourism, a demand arose for general information pointing out some of the area's most significant scenic attractions, and explaining these in the simplest terms possible. This demand resulted in the publication of a guidebook by Dr. E.G. Pye of the Ontario Department of Mines, in 1969. Sales of the book proved it to be successful in meeting the demand for information, and three printings were made before the guidebook was finally allowed to go out-of-print in the late 1970s.

Since the 1960s, a great deal of new information has become available owing to the efforts of the Ontario Geological Survey, the Geological Survey of Canada, and Ontario universities. Further, new mines have been discovered, old parks expanded and new parks established. As a consequence, this edition of the guidebook has been significantly revised and expanded.

How to Use This Guidebook

The guidebook is divided into five distinct parts, each with a common theme or purpose. The numerous maps, diagrams, and photographs found throughout the volume complement the text, and will help readers to recognize and learn about points of geologic, ecologic, and scenic interest.

Part 1 is a summary of the general geology of the region. It provides, in the simplest terms possible, general descriptions of the principal rock formations found north of Lake Superior, and includes the most up-to-date interpretations of the origins and relationships of the rock formations to one another. Because the geological history of the area is long and eventful, it is subdivided into what happened during each of the three great eons of geologic time.

Part 2 of the guidebook subdivides the route from the U.S. border, past Thunder Bay to Sault Ste. Marie into twelve sections, and lists the principal features of geological and scenic interest along or close to the main highways in each section. The locations and means of access are indicated, and descriptions and explanations of the salient features are given. Although the various points of interest are easily reached, and most have safe parking facilities, visitors are advised to use every precaution when examining roadside outcrops, to avoid traffic hazards.

The third part of the guidebook is intended expressly for amateur mineralogists, lapidaries, and mineral collectors. It provides a list of the more common rocks and minerals that may be found in the region, a reference to another publication that offers more detail for collectors, and a list of "rock" shops and amethyst mines and their addresses. Visitors are reminded to seek permission of owners of mineral and/or surface rights before visiting or collecting from properties not owned by the Crown.

Every effort has been made to avoid using technical terms wherever possible, but some such words must be used in a volume of this type. Part 4 of the guidebook, a glossary of the technical terms used, will help readers understand unfamiliar words and provide more detail for those who want it.

Part 5 of the guidebook includes addresses where more information can be obtained, and has a list of selected references to some of the extensive geological literature of the area used in the preparation of this guidebook. Readers who wish to view or obtain any of these references might find them at the offices listed at the start of the section, or at libraries at colleges or universities.

The region along the north shore of Lake Superior is vast, and ancient. This guidebook should enhance your enjoyment and appreciation of what is one of Canada's most magnificent areas.

General Geology of the Lake Superior Region

PART 1

Geologists study rocks, their structures, their mutual relationships, their contained fossils, and their radiometric age determinations. Through many years of these efforts, they have succeeded in working out a reasonably complete and accurate history of the earth from the time the first rocks were formed until the present. To make their work easier, they have divided the earth's chronology into several distinct time periods. From the youngest to the oldest, these are as follows.

Cenozoic - The era of recent life, from the present to 66 million years ago, when mammals inherited the planet and the first humans appeared.

Mesozoic - The era of middle life, from 66 million to 245 million years ago, when the reptiles reached the zenith of their development.

Paleozoic - The era of old life, from 245 to 570 million years ago, when invertebrate creatures dominated the scene, and amphibians emerged from the seas.

Precambrian - The time of primitive life, it preceded the Cambrian, the oldest subdivision of the Paleozoic. The Precambrian is divided into two eons, the Proterozoic, from 570 million to 2.50 billion years ago, and the Archean, more than 2.50 billion years ago.

The rocks and unconsolidated sediments found along the north shore of Lake Superior vary greatly in age, and record the exciting and turbulent history of a wide span of Precambrian and Cenozoic time. The oldest rocks, and the most abundant, were formed during the Archean. In places along the north shore of Lake Superior, they are overlain by thick layers of a variety of volcanic and sedimentary rocks, whose formation spanned much of Proterozoic time. Both the Archean rocks and their Proterozoic cover are cut by intrusive igneous rocks of Proterozoic age.

The consolidated rocks throughout the region are covered in places by gravel, sand, and clay lain down during the last 1.6 million years of the Cenozoic Era, during the so-called Pleistocene Epoch—or Great Ice Age—when continental glaciers spread across the country.

The Precambrian

The following pages take the reader on a journey through an abbreviated history of the Precambrian in the Lake Superior region. They span the time between the appearance of the earliest-formed rocks of the area, about 3.00 billion years ago, when the country was barren of vegetation, and the beginning of the Paleozoic Era 570 million years ago, when life first started to become aboundant in North America. The journey begins with violent volcanism, rapid erosion and sedimentation. It passes through a time of plate tectonic movement and mountain building followed by a prolonged period of quiescence when the land surface was eroded to a peneplain, and witnesses a time when the peneplain was innundated by inland seas and draped with sediment. The journey then leads through the period of extensive volcanism and intrusive igneous activity that accompanied the birth of the majestic Superior basin, and concludes with the erosion that left the numerous high cuestas and mesas characteristic of the western Superior region.

The Canadian Shield

The Precambrian rocks of the Lake Superior region make up part of the Canadian Shield, an extremely large area underlain by ancient sedimentary, igneous, and metamorphic rocks. The Shield is centred about Hudson Bay, and from there it stretches westward to the plains of Alberta, eastward to Greenland, and southward to, and in places beyond, the Great Lakes. It has a total exposed area of over five million square kilometres (two million square miles); in Ontario, it covers 565,000 square kilometres (220,700 square miles). Along much of its outer boundary, its surface slopes gently to form a platform on which younger formations rest, so it constitutes the nucleus of the North American continent.

The rocks making up the Canadian Shield have been divided into a number of geological provinces according to their type, age, and history of deformation *(Figure 1)*. In the Lake Superior region, all the rocks that formed more than 2.50 billion years ago, in the Archean Eon, have been placed in the Superior Province, while all the rocks that formed between 570 million and 2.50 billion years ago, in the Proterozoic Eon, have been assigned to the Southern Province.

The Archean Eon and the Superior Province

The Superior Province is by far the largest of all the geological provinces of the Canadian Shield. One might expect that such a large and ancient area would have a great variety of rock types, and a complicated geological history. This is indeed the case. There are volcanic rocks that formed in settings equivalent to the modern settings of the mid-oceanic ridge, Hawaii, the volcanic islands of the Western Pacific, and the Andes. There are sedimentary rocks that were deposited in deserts, lakes, and the depths of the oceans. And, there are places where thin dikes to massive bodies of molten rock have intruded the older rocks. In addition, each of these rock types formed at numerous times and in many different places, and all of them have been deeply buried, folded, faulted, and heated, in places to the melting point *(Photo 1)*.

PHOTO 1: These highly metamorphosed and deformed dark-coloured volcanic rocks east of White River have been intruded by pale pink granite.

Imagine what the environment was like in those long-past times. There was no vegetation or life of any kind. The earth's surface was an irregular patchwork of black rocks and dull grey dust. It was a rugged land, punctuated here and there by large and small impact craters formed when meteorites came crashing down. Numerous volcanoes, along deep fissures that tapped the earth's interior, belched ash and rock with explosive violence high into the primitive atmosphere, and rivers of red-hot lava flowed swiftly down their flanks. Lava fountains illuminated the dark, cloudy skies. Violent storms, accompanied by loud crashes of thunder and flashes of lightning, precipitated heavy downpours of rain that rapidly eroded the surface rocks and dumped great masses of debris into low-lying areas. As molten material or magma worked its way upward toward the surface, the crustal rocks were cracked, buckled and faulted. Earthquakes constantly rumbled across the land and violently shook and ruptured the ground. It must have been eerie and frightening indeed!

Greenstone Belts in the Superior Province

The volcanic rocks of the Superior Province formed between 2.69 and 3.00 billion years ago. They occur in irregular to easterly-trending areas known as "greenstone belts", which include the volcanic rocks, along with sedimentary rocks and subordinate intrusive rocks. On recent geological maps, they are often referred to as metavolcanics and metasediments: the prefix "meta" indicates that they have been metamorphosed or altered. The fact that layers within the rocks, which were originally horizontal or nearly so, now stand vertically or at steep angles indicates that the rocks have been intensely deformed and folded.

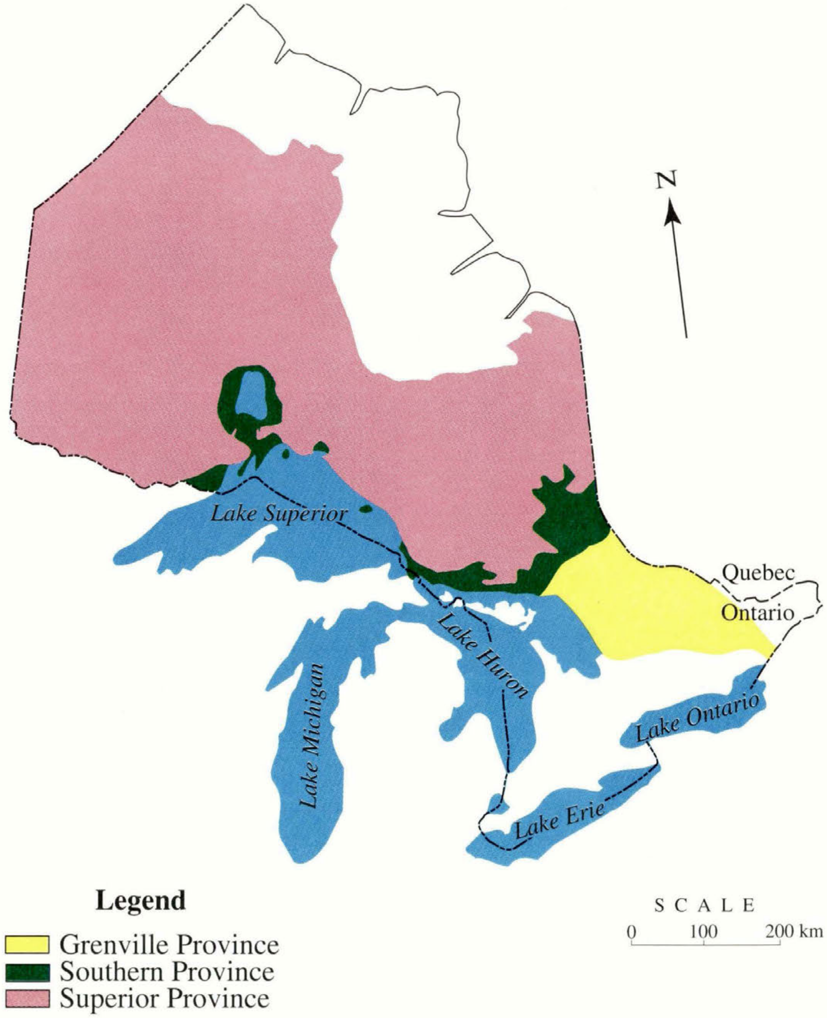


FIGURE 1: The locations of the Superior, Southern, and Grenville provinces, the three geological provinces that make up the Canadian Shield in Ontario.

The Volcanic Rocks

The volcanic rocks largely formed from lava flows. Two principal types occur, mafic (or basic), and felsic (or acidic). By far the most common are the mafic volcanic rocks, which are relatively poor in silica, but rich in magnesium- and iron-bearing minerals. These generally have been highly altered, with secondary minerals such as green chlorite and amphibole replacing the original mineral constituents. As a result, they are dark greenish in appearance, hence the term "greenstone". Typical greenstones are found along or close to Highway 17 in several localities: in the vicinity of Schreiber; between 26 kilometres (16 miles) east of Terrace Bay and the Steel River; and between Kabenung Lake, 48 kilometres (30 miles) north of Wawa and the Baldhead River, 48 kilometres (30 miles) south of Wawa *(Photo 2)*.

Felsic volcanic rocks are much less common in the Superior Province than are mafic ones. They are rich in silica, and are similar to granite in composition. They are hard, fine-grained, greenish grey rocks. Although they are not very abundant, excellent examples are exposed along the lakeshore just north of the town of Wawa.

The volcanic rocks of the Superior Province are exceedingly important economically, as significant deposits of gold, iron, copper, nickel, lead, and zinc have been found within them. The mining camps of Winston Lake, Hemlo, Manitouwadge, and Michipicoten, for example, are found in areas underlain in large part by Archean volcanic rocks.

The Sedimentary Rocks

The principal sedimentary rocks found in the greenstone belts are slate and greywacke. Slate is the metamorphic equivalent of a compacted mud or shale, while greywacke is a variety of sandstone characterized by an abundance of tiny angular fragments of rock. Greywacke results when material rapidly eroded from pre-existing rock is deposited suddenly. The slate and greywacke are usually found together in large units, some of which rival the volcanic rocks in thickness and prominence. They are exposed along Highway 17 in the 19 kilometres (12 miles) east of the Steel River, and east of Marathon between Hemlo and Highway 614. They may also be observed at intervals along Highway 11 north of Nipigon. Like the volcanic rocks, they have been highly altered or metamorphosed. Indeed, if it were not for their banded appearance due to their original bedding or layering, they would be difficult to distinguish from some of the other rocks in the area.

In a few places, conglomerate is associated with the slate and greywacke. It is not a particularly abundant rock, but it is distinctive and easy to recognize because of the pebbles, cobbles, and boulders it contains. The pebbles, cobbles, and boulders of most of the conglomerates are of volcanic rocks, slate, and greywacke. They were likely eroded from the surrounding volcanic pile. In the youngest conglomerates, however, there are also fragments of granitic rocks. Because granite forms when magma cools and solidifies beneath the earth's surface, the granite fragments suggest that deep erosion must have taken place before the conglomerate containing the granite was deposited. An example of conglomerate can be seen 3.8 kilometres (2.4 miles) east of the Marathon turnoff, along the south side of Highway 17.

PHOTO 2: Altered mafic volcanic rocks near Wawa show the colour that earns the nickname "greenstone". The lumpish shapes in the volcanic rocks typically form when lava is erupted into water.

One of the most conspicuous and important sedimentary rocks in the Superior Province is iron formation *(Photo 3)*. It consists largely of very fine-grained quartz, or chert. Some contains little other material and is pale grey or even white. Much of it, however, is coloured owing to the presence of one or more other minerals, including iron-bearing minerals such as red or black hematite, black magnetite, and pale brown or grey siderite.

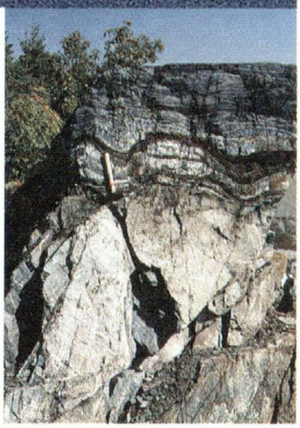


PHOTO 3: Alternating layers of magnetite-rich and magnetite-poor chert form the striking unit of banded iron formation that overlies mafic volcanic rocks south of Wawa.

Because the quartz-rich and impurity-laden rocks tend to be arranged in different layers, the iron formation is strikingly banded in appearance. Exposures of typical iron formation, with well-defined layers of red chert (also known as jasper), are found along Brulé Creek and the Canadian National Railway line near Mokomon, about 10 kilometres (6 miles) north of Kakabeka Falls. Exposures with layered white chert and black magnetite are located along Highway 17, about 11 kilometres (7 miles) south of the turnoff to Wawa. These occurrences are too low grade, or too limited in size to be of economic value. At Wawa, however, large masses of siderite are associated with the banded silica-rich iron formation. Because siderite can be roasted, or sintered, to yield a product suitable for blast furnace feed, the siderite masses contain workable orebodies, and are of great economic significance to this part of Ontario.

PHOTO 4 Large blocks of grey gneiss have been engulfed by coarse-grained granite at Katherine Cove.

Intrusive Rocks in the Superior Province

Many different types of Archean igneous rock intrude the older volcanic and sedimentary rocks in the Superior Province. They include: syenite, found at Rainbow Falls Provincial Park; diorite, exposed between Fungus and Kabenung lakes south of White River; feldspar porphyry found at Rossport Provincial Camp Grounds and at Sand River; and quartz porphyry, exposed at Michipicoten Falls near Wawa. The most abundant and widespread igneous rock type, however, is granite.

Granites can be observed along Highway 17 at several convenient places: Red Rock cuesta just west of Nipigon; Cavers Hill, 18 kilometres (11 miles) west of Rossport; 21 to 31 kilometres (13 to 19 miles) south of White River; the Agawa Bay scenic lookout; and Hiawatha Park at Sault Ste. Marie.

Like granites generally, they are typically pale pink or greyish rocks made up principally of the minerals quartz, feldspar, and mica or hornblende. In some localities, the granite is quite massive in appearance, while in others it is foliated or gneissic due to the parallel alignment of the dark minerals present. Some of the granites contain no inclusions; others contain abundant fragments of highly altered pre-existing rocks *(Photo 4)*. The variety of granites is indeed surprising. Even more impressive is the extent of the areas throughout which some of them are exposed. The conclusion that they make up extremely large masses, or batholiths, is inescapable.

Folding, Faulting, and Gold!

The layers in the volcanic and sedimentary rocks were originally horizontal or near-horizontal. Now, however, they stand vertically or are inclined at steep angles. It is at once apparent that they must have been subjected to intense compression within earth's crust. Large-scale folds and faults, and mountainous ridges, perhaps rivalling those found today in western North America, were the result. The intense compression affected the granitic rocks too: it caused the layered appearance that many of the most highly deformed granitic rocks now have.

The period of great deformation, metamorphism, and extensive development of granite batholiths which affected all of the Superior Province about 2.70 billion years ago is called the Kenoran Orogeny. It was of great economic importance to the region along the north shore of Lake Superior, for it was at this time that most of the area's gold deposits were formed. Valuable gold-bearing quartz veins were first discovered in 1897 near Jackfish east of Terrace Bay, and at Wawa. Numerous finds have been made since then, and several mines have been brought into production: near Schreiber; near Wawa *(Photo 5)*; between Beardmore and Geraldton along Highway 11; and most notably, in the Hemlo area.

Subdividing the Superior Province

As noted earlier, the various types of rock found in the Superior Province each formed at numerous times and in many different places within that huge area. Major advances in sorting out the complex geological history of the assorted Superior Province rocks have, however, been made using sophisticated laboratory methods to determine the radiometric age dates of the various rocks.

The Superior Province has been subdivided into twelve subprovinces, which for the most part form east-west trending belts. Each subprovince contains rocks with distinctive compositions, structures, ages and metamorphic conditions, and each is characteristically linear and divided from adjacent subprovinces by faults. Plate tectonic activity joined the subprovinces together like pieces in an immense crustal jigsaw puzzle during a series of crustal collisions. Similar collisions continue imperceptibly slowly even today.

Rocks from two of the Superior Province's twelve subprovinces are exposed along the north shore of Lake Superior *(Figure 2)*. The Montreal River marks the boundary between them. West of the Montreal River are rocks of the Wawa Subprovince, while east of the river, the rocks make up the western part of the Abitibi Subprovince. Within each subprovince is a complex array of Archean volcanic and sedimentary sequences cut off from each other by innumerable intrusions of granitic rocks. Although there are many similarities between the rocks of the two subprovinces, they had distinct geological histories. Even much of the deformation and metamorphism recorded in the rocks of the Wawa and Abitibi subprovinces is distinct, although some did occur after plate movements brought the two together about 2.70 billion years ago.

PHOTO 5: Grace gold mine near Wawa, shown here in 1908, operated for only a few years. It was beset by problems including fire, flooding, and lack of wood for power.

In general, the rocks in the Wawa Subprovince exposed along the north shore of Lake Superior can be summarized as listed in Table 1. The youngest rocks are at the top of the table and the oldest are at the bottom, in the manner customarily adopted by geologists.

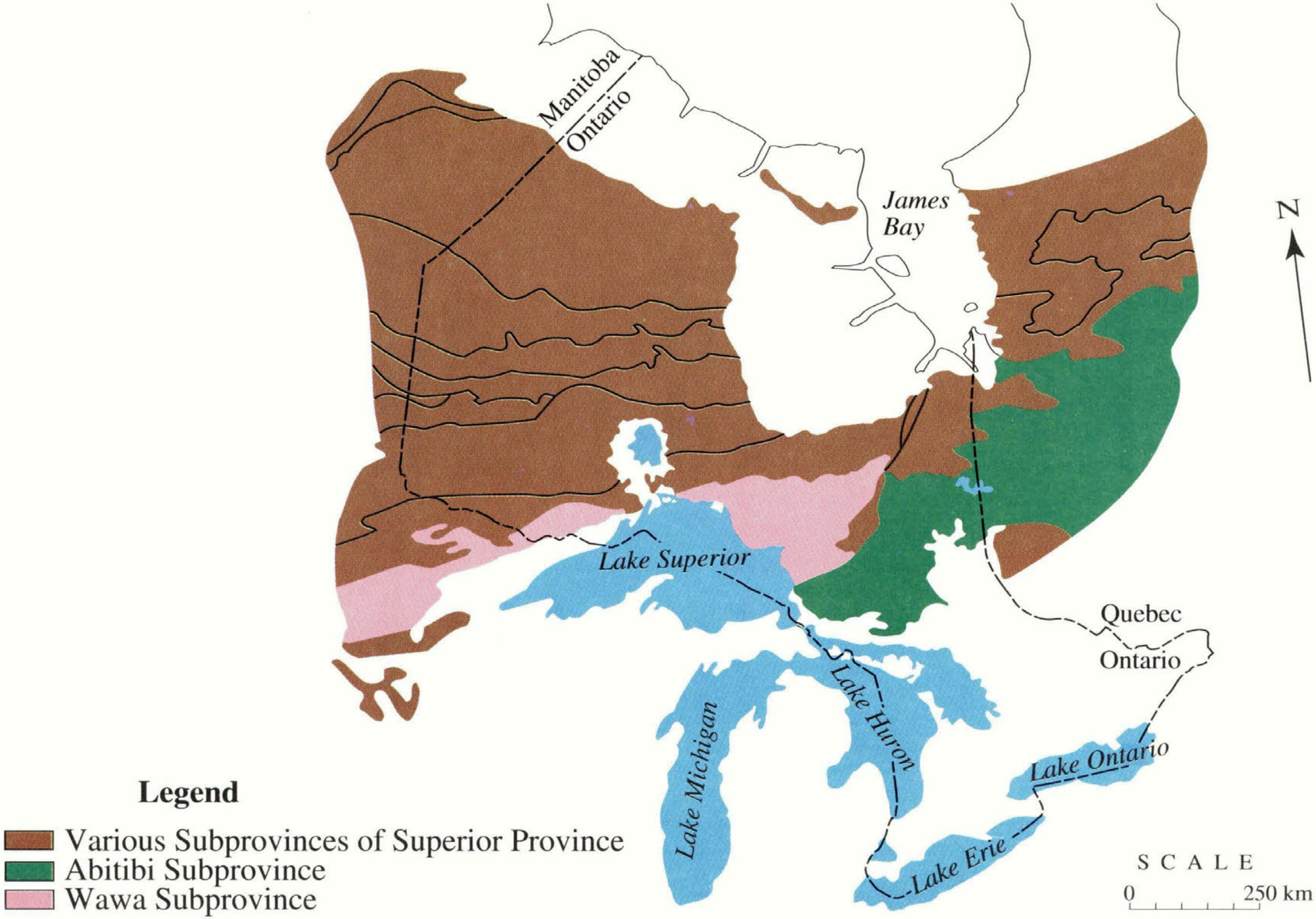


FIGURE 2: The 12 subprovinces of the Superior Province in Ontario. Rocks of the Wawa Subprovince are exposed along the north shore of Lake Superior west of the Montreal River. Rocks of the Abitibi Subprovince are exposed east of the Montreal River.

Table 1. Rocks of the Wawa Subprovince.

2.67 to 2.68 billion years	intrusive rocks	massive to foliated granodiorite and granite
2.70 to 2.72 billion years	intrusive rocks	massive to foliated and gneissic granodiorite
2.70 to 2.72 billion years	volcanic and sedimentary rocks	basalt, rhyolite, conglomerate, sandstone, mudstone
2.75 billion years	volcanic and sedimentary rocks	basalt, rhyolite, greywacke, conglomerate, iron formation
2.89 billion years	volcanic rocks	basalt

The rocks that make up the parts of the Abitibi Subprovince exposed along the north shore of Lake Superior can be summarized in a similar table *(Table 2)*. Once again, the youngest rocks are at the top of each table and the oldest are at the bottom.

Table 2. Rocks of the Abitibi Subprovince.

2.67 to 2.68 billion years	sedimentary and volcanic rocks	conglomerate, sandstone, trachyte, tuff, and agglomerate
2.67 to 2.69 billion years	intrusive rocks	syenite
2.68 to 2.70 billion years	intrusive rocks	granodiorite
2.68 to 2.70 billion years	sedimentary rocks	greywacke
2.69 to 2.74 billion years	intrusive rocks	granodiorite
2.70 to 2.72 billion years	volcanic and sedimentary rocks	basalt, rhyolite tuff, greywacke, and conglomerate
2.72 to 2.75 billion years	volcanic and sedimentary rocks	basalt, andesite, rhyolite tuff, and iron formation

Much work remains to be done before the geological history of the Superior Province is completely understood, but a good start has been made in sorting out this very complicated sequence of events. More knowledge about the various rocks present will help solve the mystery; a better understanding of the ore deposits will aid in the discovery of more of the valuable minerals the region supplies to make all sorts of consumer products.

The Proterozoic Eon and the Southern Province

The Southern Province lies along the southern flank of the Superior Province, and extends from Minnesota along the north shores of lakes Superior and Huron, and northeast to the border of Quebec. It consists of a number of distinct sequences of volcanic and sedimentary rocks, all of which date from the Proterozoic Eon.

Although the formation of the Southern Province rocks took even longer than the formation of the Superior Province rocks, the rocks of the Southern Province are much better understood because the Proterozoic Eon was much less geologically active than the Archean Eon. Instead of the colliding crustal plates, explosive volcanism, mountain building, and major episodes of intrusive activity that took place in the Archean, there were passive continental margins, crustal rifting, and relatively few intrusions during the Proterozoic. The rocks of the Southern Province have therefore been much less deformed and metamorphosed than the rocks of the Superior Province *(Photo 6)*.

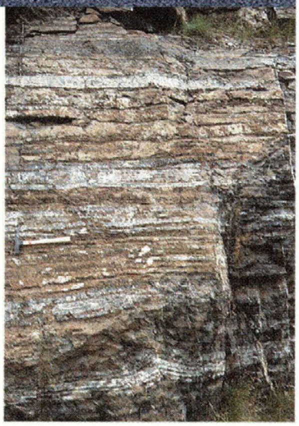


PHOTO 6: Delicate depositional features are well-preserved in these 2.10 billion-year-old sedimentary rocks north of Sleeping Giant Provincial Park.

PHOTO 7: The topography north of Lake Superior may once have been a completely barren version of this scene in Canada's arctic, where the soil has been blown or washed away from the low-lying, stony surface wherever there is no vegetation.

Setting the Stage

During and after the Kenoran Orogeny, when the rocks of the Superior Province were deformed and metamorphosed, the newly-formed mountains were subjected to weathering and erosion. Over a 200 million year period, the mountains were gradually worn down. The granitic batholiths of the Superior Province, once at the roots of the mountains, were eventually exposed to view. The older volcanic and sedimentary rocks that are found as relatively small, widely separated remnants in a vast granitic sea survived only because the mountain building events tucked them down into pockets that weren't reached by erosion.

The eroded countryside became a vast plain similar to that found today along Highway 17, inland from Lake Superior, between Marathon and Wawa. The major difference between then and now was that then, there was no vegetation, and hence little deterent to soil being blown or washed away by wind, rain, or melting snow *(Photo 7)*.

After this period of profound erosion, the large area north of the present Great Lakes was repeatedly inundated by the sea. Sedimentary rocks were deposited in rivers, lakes, and oceans of varying depths. Glaciers advanced repeatedly, and left behind deposits like those from the end of the last ice age. Crustal rifting, similar to what is happening now with the formation of the Red Sea, took place from time to time, and resulted in the formation of thin to immensely thick sequences of volcanic rocks. All these various sedimentary and volcanic rocks make up the various sequences of the Southern Province.

Subdividing the Southern Province

The rocks of the Southern Province have been subdivided into several clearly-defined sequences. These sequences are, however, not like the ones in the Superior Province. In the Superior Province, each sequence is considered on its own terms and the interrelationships between them are not well understood: in the Southern Province, the sequences are obviously stacked on top of one another, and the interrelationships between them are clear.

Some of the subdivisions are quite broad, while others encompass only rocks with very specific characteristics. Nevertheless, some of the units with the most specific characteristics are hundreds to thousands of metres (yards) thick in places. The most well-defined subdivisions are called formations. An uninterrupted succession of several well-defined formations, or a less well-defined sequence of rocks of similar age, makes up a group. And, an uninterrupted succession of groups, or groups and formations, can be combined to form a supergroup.

The units that make up the Southern Province are listed in Table 3. Periods of time when one sequence was eroded before the next one was deposited are indicated in the table by the word "unconformity". As in the previous tables, the youngest rocks are at the top of the table, and the oldest are at the bottom.

Table 3. Rocks of the Southern Province.

1.09 billion years			
	Keweenawan Supergroup:		**Sedimentary rocks**
		Jacobsville Group	**Quartz sandstone**
		Oronto Group	**Quartz sandstone, conglomerate, shale**
		Unconformity	
1.09 to 1.10 billion years			
	Keweenawan Supergroup:		**Volcanic and sedimentary rocks**
		Michipicoten Island Formation	**Basalt, rhyolite**
		Mamainse Point Formation	**Basalt, rhyolite, conglomerate**
1.10 to 1.11 billion years			
		Osler Group	**Basalt, rhyolite, conglomerate, sandstone**
		Unconformity	
1.34 to 1.54 billion years			
	Sibley Group:		**Sedimentary rocks**
		Kama Hill Formation	**Red shale and mudstone**
		Rossport Formation	**Sandy to clayey dolostone, with stromatolites**
		Pass Lake Formation	**Quartz sandstone, conglomerate**
		Unconformity	
1.85 to 2.10 billion years			
	Animikie Group:		**Sedimentary rocks**
		Rove Formation	**Shale, greywacke**
		Gunflint Formation	**Conglomerate, shale, carbonate rocks, chert-carbonate rocks, chert, taconite, volcanic tuff**
		Unconformity	
2.21 to 2.49 billion years			
	Huronian Supergroup:		**Volcanic and sedimentary Rocks**
		Lorrain Formation	**Sandstone**
		Gowganda Formation	**Conglomerate, siltstone**
		Aweres Formation	**Conglomerate, sandstone**
		Thessalon Formation	**Basalt, rhyolite**

The Huronian Supergroup

The rocks of the Huronian Supergroup occur only at the very eastern end of the north shore of Lake Superior *(Figure 3)*. There, in the area between Hayden and Bellevue, outcrops of the 2.21 to 2.49 billion-year-old Thessalon, Aweres, Gowganda, and Lorrain

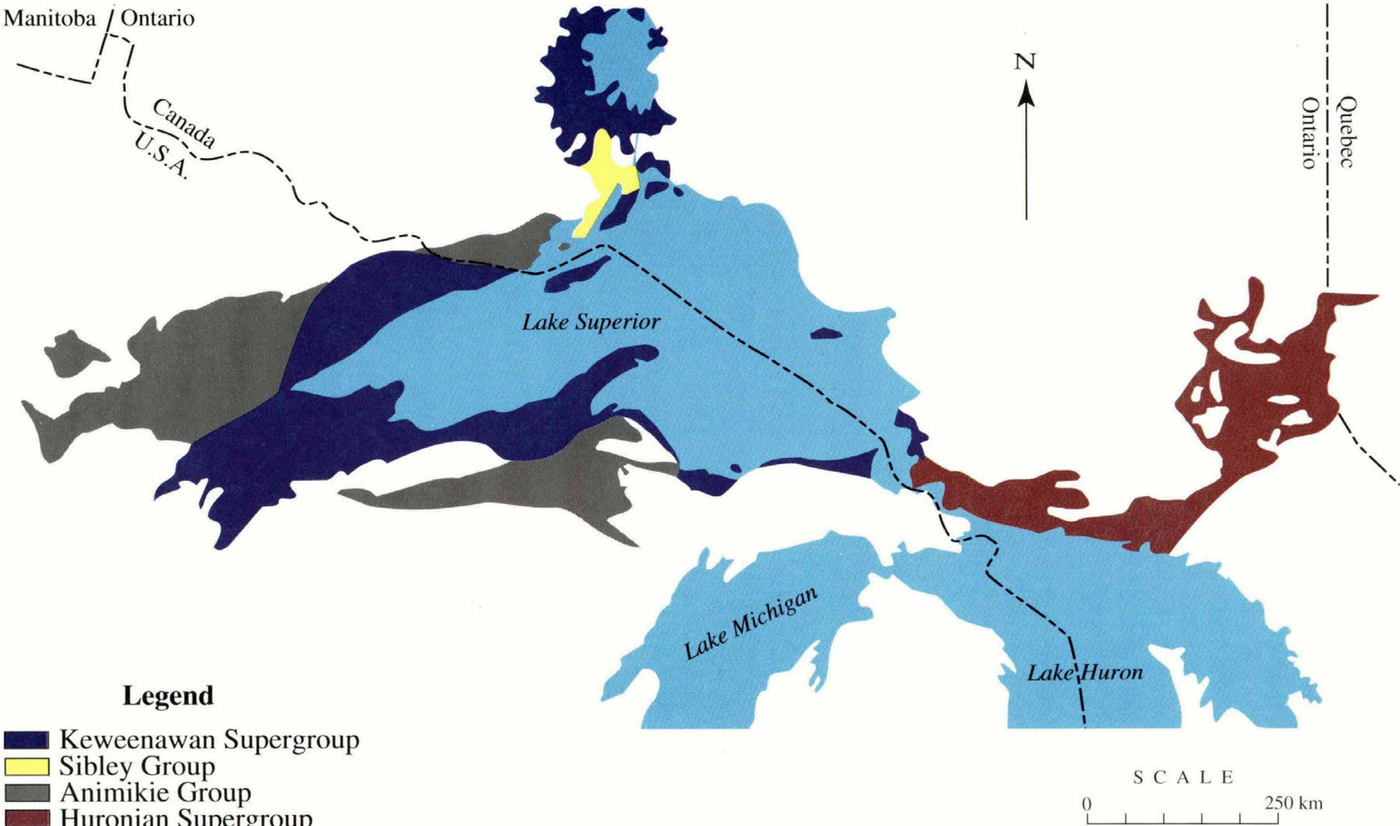


FIGURE 3: The distribution of the Proterozoic groups and supergroups in the Lake Superior area.

formations are exposed. The Thessalon Formation, at the bottom of the pile, consists of volcanic rocks including basalt and rhyolite. The Aweres Formation, which overlies the volcanic rocks, includes a thick sequence of sandstone and conglomerate that appears to have formed in rivers and alluvial fans. The Gowganda Formation, overlying the Aweres Formation is of special interest as its conglomerates and laminated siltstones contain clear evidence that they were deposited during a period of glacial activity more than 2.21 billion years ago! The Lorrain Formation, a quartz-rich sandstone, was once quarried for silica just north of Bellevue. It is quite resistant to erosion.

The sequence of rocks found between Hayden and Bellevue contains only some of the formations found within the Huronian Supergroup farther to the east. The area at the east end of Lake Superior is on the margin of the basin in which the Huronian rocks were deposited. The Huronian Supergroup stretches eastward along the north shore of Lake Huron and northeast to the Quebec border, and is important in determining much of the scenery in the area it underlies.

The Animikie Group

About 100 million years after the Huronian Supergroup was deposited, deposition of the Animikie Group began. In Ontario, the rocks of the Animikie Group are restricted to the area in and around the city of Thunder Bay (*see* Figure 3). They are exposed at numerous localities within and near the city, and extend northeastward for about 40 kilometres (25 miles), and southwestward to just south of the international boundary. They also cover a large area north and west of Duluth in Minnesota. Although mostly made up of sedimentary rocks, the Animikie Group also includes a few layers of volcanic rocks. It is subdivided into the Gunflint and Rove formations.

The Gunflint Formation

The Gunflint Formation is only about 130 metres (500 feet) thick in Ontario, but it is full of interesting rocks including conglomerate, shale, limestone, dolostone, chert-carbonate, chert, taconite, and volcanic tuff. The conglomerate, which consists of pebbles of quartz, chert, jasper, granite, and greenstone in a coarse, sandy matrix, is found at the base of the formation resting directly on Archean granite and greenstone. It is the compacted equivalent of a gravel. The surface between the Archean rocks and the conglomerate marks a gap of 800 million years in the record of the area's geological history! Typical exposures may be observed at the bottom, and near the south end, of an outcrop at the junction of Highway 11&17 and Highway 590 at Kakabeka Falls, and in the bed of the Whitefish River near the bridge, about 2.9 kilometres (1.8 miles) west of Nolalu along Highway 588.

PHOTO 8: The layers within exposures of Gunflint Formation shale found beside the parking lot and along the gorge at Kakabeka Falls break apart easily, making the rock susceptible to rapid erosion.

The shale is a fine-grained black rock that breaks very easily along its closely-spaced bedding planes *(Photo 8)*. It is therefore exposed only where interbeds of more resistant rock have hindered erosion. It lines much of the gorge at Kakabeka Falls, where a capping of tough chert-carbonate rock has kept the waterfall from eroding the escarpment away, and can be examined in exposures along the parking lot adjacent to the falls.

The carbonate rocks are layered sediments in which the beds consist of such carbonate minerals as calcite, dolomite, and siderite. Less common than calcite and dolomite, siderite is an iron carbonate. It weathers to form a brown hydrous iron oxide called limonite when it is exposed to the atmosphere, so the surfaces of rocks that contain it are distinctly rusty.

Typical carbonate rocks are exposed in the city of Thunder Bay at Hillcrest Park and at Boulevard Lake Park. At Boulevard Lake Park, they contain lenses and occasional thin layers of chert *(Photo 9)*. In places, the chert layers are numerous, and the rock becomes strongly banded in appearance, forming chert-carbonate. Chert-carbonates are also found at Kakabeka Falls, where they lie upon the shales; at Trowbridge Falls Park in Thunder Bay; and at Blende Creek north of the city.

PHOTO 9: At Boulevard Lake Municipal Park, Thunder Bay, the erosional remnants of a discontinuous layer of grey-weathering chert lies atop a rusty-weathering limestone layer.

Taconite can be seen in Thunder Bay along the bed of the McIntyre River and at Boulevard Lake Park. It is a peculiar sedimentary rock made up, not of sand grains, but of tiny round grains or granules of iron-bearing minerals or chert. Because of its high iron content, it is the most important member of the Gunflint Formation. In Ontario, it does not contain enough iron to justify mining, but in Minnesota, it forms the rich orebodies of the famous Mesabi Iron Range.

Associated with the taconite in places are layers and lenses of chert with oolitic and algal structures. Oolitic cherts contain small, round bodies called oolites. They are much like the granules in taconite, but contain radial or concentric structures or both. They are generally less than 3 millimetres (0.1 inch) in diameter, and collectively resemble the roe of fish. The algal cherts are thinly laminated, and contain cabbage-like or biscuit-like structures, or irregular patches with peculiar concentric markings. These structures, called stromatolites, formed from mats of algae and bacteria that grew in shallow water along a lakeshore or seashore in Proterozoic time. They include some of the oldest well-preserved fossils of algae found anywhere. Oolitic and algal chert both occur at Boulevard Lake Park. Particularly fine exposures can be examined in the bed of the Whitefish River 2.9 kilometres (1.8 miles) west of Nolalu, and along the shore of Lake Superior at the Schreiber Channel Nature Reserve.

Layers of volcanic tuff, formed from the deposits of explosive volcanic activity, are interbedded with the shale at Kakabeka Falls. Most of the layers are near the bottom of the gorge, but one is found upstream of the falls beneath the highway bridge. They formed when airborne ash was blown out to sea from some unknown distant volcanic eruption, and settled to blanket the sea floor.

The Rove Formation

The Rove Formation overlies the Gunflint Formation, and consists of a lower section of black shales, which grades upward into shales interbedded with siltstone and greywacke. In Ontario, it is as much as 600 metres (2,000 feet) thick, but it thickens to the south, and in Minnesota is approximately 1,000 metres (3,300 feet) thick. Rocks of the Rove Formation are found in a number of localities between Pigeon River and Thunder Bay along Highway 61, and along the western shore of Sibley Peninsula. Good exposures can be seen at Middle Falls and High Falls on the Pigeon River, at Mount McKay, and in Sleeping Giant Provincial Park.

Like the rocks of the Gunflint Formation, the rocks of the Rove Formation are flat-lying, or slope gently to the southeast. The shales are thin-bedded, dark coloured, and fissile rocks very similar to the shales in the underlying Gunflint Formation. In places, the Rove Formation shales contain large concretions, or nodules, formed when minerals dissolved in groundwater precipitated for some reason at one spot, and engulfed the clay and silt particles of the shale.

The siltstone and greywacke of the Rove Formation form relatively thick, massive brownish grey to black layers *(Photo 10)*. They contain numerous depositional features, such as ripple marks and flute casts, which are thought to be characteristic of deposition by turbidity currents. Such currents are chaotic mixtures of clay, silt, sand and water that form when immense piles of sediment along the continental margin, often at the mouths of rivers, overbalance and churn their way down the continental slope. When the currents slow, the sediments they have swept along are deposited.

The Sibley Group

The sedimentary rocks of the Sibley Group, like the underlying Animikie strata, are flat-lying or gently sloping. The Animikie rocks, however, must have suffered considerable erosion before deposition began anew in Sibley time, for in various places the Sibley rocks are found in contact with the Rove Formation, with different members of the Gunflint Formation, and even with Archean granitic rocks. Radiometric age dating tells us that this erosion took place over an extended time period of approximately 310 million years.

The Sibley Group is found east of Thunder Bay in an area extending east from the Sibley Peninsula to approximately 45 kilometres (28 miles) east of the town of Nipigon, and north to Lake Nipigon (*see* Figure 3). It is more than 400 metres (1,300 feet) thick, and is divided into three formations, which from bottom to top are the Pass Lake Formation, the Rossport Formation, and the Kama Hill Formation. All three units are believed to have been deposited in a shallow, seasonal lake or playa in an arid or semi-arid region comparable to the present interior basin of Australia.

The Pass Lake Formation

The Pass Lake Formation consists of massive white quartz-rich sandstone, with locally-derived conglomerate lenses at the base of the unit. The conglomerates are reddish coloured and consist of pebbles and boulders of Animikie and Archean rocks in a sandy matrix. Typical exposures of the conglomerate occur along the West Loon Road at the north end of the Sibley Peninsula, while prominent cliffs of quartz sandstone occur on the Sibley Peninsula itself at Pass Lake, and along the east shore of Thunder Bay.

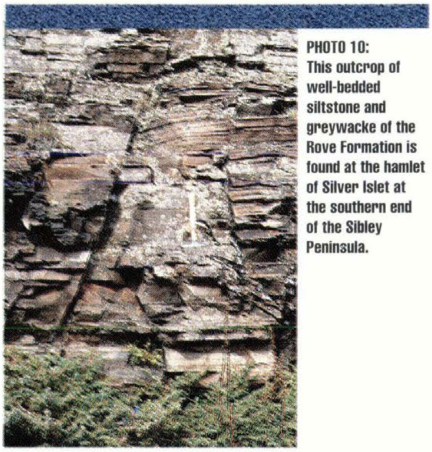


PHOTO 10: This outcrop of well-bedded siltstone and greywacke of the Rove Formation is found at the hamlet of Silver Islet at the southern end of the Sibley Peninsula.

The Rossport Formation

The Rossport Formation, a red fine-grained sandy to clayey dolostone unit, overlies the Pass Lake Formation. There is a stromatolitic layer in the middle part of the Rossport Formation. The dramatic red colour of these rocks *(Photo 11)*, and those of the overlying Kama Hill Formation, is due to the presence of earthy or ocherous hematite. The hematite formed, it is thought, when hydrous iron oxides were exposed to the atmosphere and the drying action of the sun. Outcrops of Rossport Formation dolostone are exposed along Highway 587 south of Pass Lake in Sleeping Giant Provincial Park and along Highway 17 east of Nipigon.

The Kama Hill Formation

The Rossport Formation grades upward into the Kama Hill Formation, a unit of red shale and mudstone containing sedimentary structures such as mud cracks, which indicate the rock was deposited in shallow water that periodically dried up. Good exposures of the Kama Hill Formation can be seen close-up along Highway 17 at Kama Bay.

The Continent Rips Apart

Between 1.09 and 1.11 billion years ago, a major event in the geological history of North America took place. It was caused by tectonic forces like the ones that make the plates of the crust move about the earth's surface today. Such forces are currently slowly ripping the African continent apart along the Red Sea. Then, they caused a 2,000 kilometre (1,250 mile) long arcuate trough to split the ancient North American continent. The trough extended from southwest of Lake Superior, under the lake, and south across present-day Michigan to Detroit *(Figure 4)*.

PHOTO 11: The red colour of this clayey dolostone is characteristic of the Rossport Formation. Here, the brightly-coloured dolostone contrasts with very pale grey interbeds of quartzite.

The trough is called the Midcontinent Rift. Seismic reflection studies have shown that the volcanic and sedimentary rocks that fill the rift are up to 30 kilometres (19 miles) thick, making it the deepest known rift in the world. And, the volume of basalt in the rift probably exceeds one million cubic kilometres (245,000 cubic miles), making it one of the most voluminous basaltic sequences preserved on earth! The volcanic rocks, almost without exception, slope or dip from the shore inward under Lake Superior, or into the rift. The period of time when the rift formed is referred to as the Keweenawan: all the rocks that formed then are often called by the same name.

The Keweenawan Supergroup

The sedimentary and volcanic rocks (but not the intrusive rocks) that formed when the Midcontinent Rift opened make up the Keweenawan Supergroup. It consists of two parts separated by an unconformity, and is separated from the underlying rocks of the Sibley Group by another unconformity. The upper part of the sequence is made up of sedimentary rocks; the lower part is made up of an immensely thick succession of volcanic rocks.

The rocks of this supergroup are exposed at various places along the north shore of Lake Superior (*see* Figure 3), but most of the outcrops are very difficult to reach. At the west end of the lake, rocks of the Keweenawan Supergroup are exposed on the peninsula and islands south of Black Bay and Nipigon Bay. Farther east, they underlie Michipicoten Island and the islands of Agawa Bay. Only at the far east end of Lake Superior, in the area between Mica Bay (south of Montreal River) and Sault Ste. Marie, are these rocks easily accessible.

The Volcanic Rocks

The lower part of the Keweenawan Supergroup is made up of the Osler Group at the western end of Lake Superior. In the central and eastern parts of Lake Superior, it is made up of the Mamainse Point and Michipicoten Island formations.

Rocks of the Osler Group are from 1.10 to 1.11 billion years old, and include basalt and rhyolite with minor amounts of conglomerate and sandstone. The basalt is massive in places, and in places it contains abundant

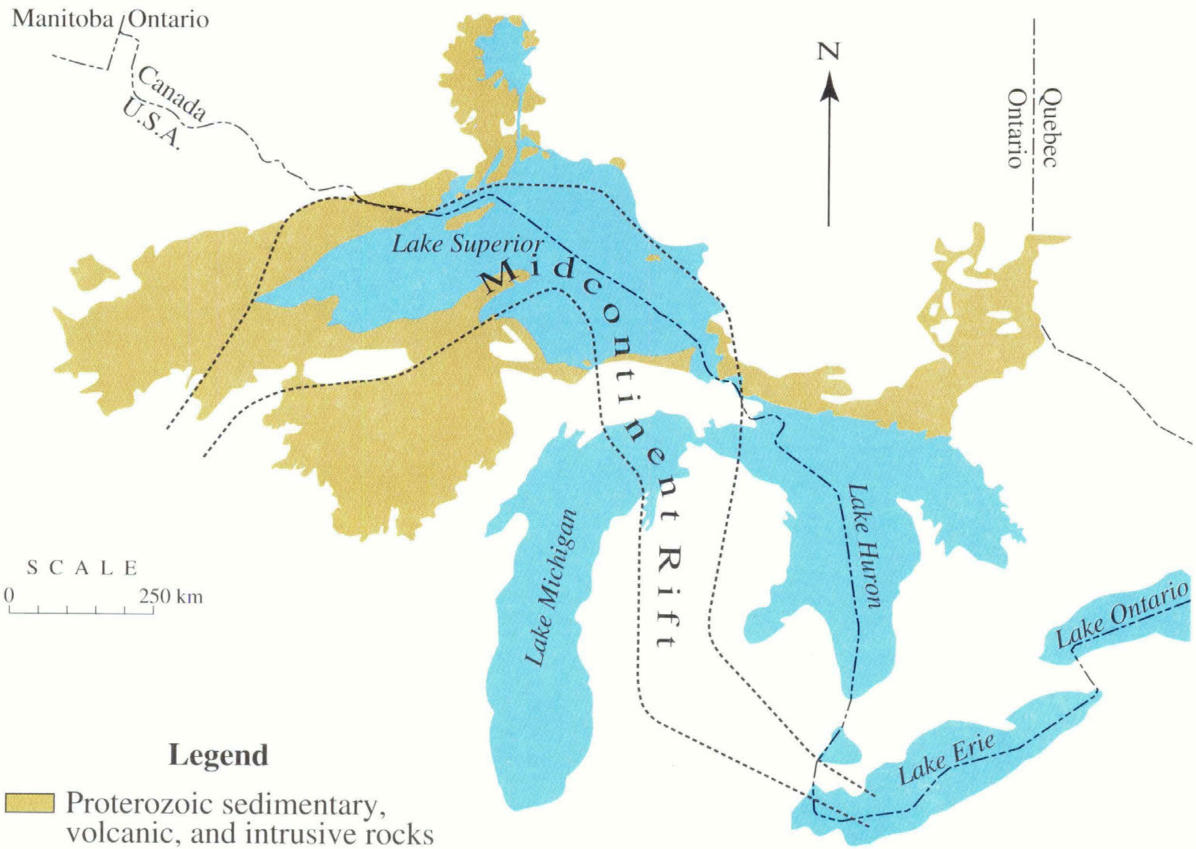


FIGURE 4: The location of the Midcontinent Rift. Some of the Proterozoic sedimentary, volcanic, and intrusive rocks found in the Lake Superior area today formed as a result of the opening of the rift.

tiny pockets of a variety of minerals including calcite, agate, zeolites, prehnite, chlorite and quartz. The pockets are called amydgules, and form when gas bubbles frozen into the cooling lava are subsequently filled with one or more of these late-formed minerals. Ropy flow tops similar to the ones found in modern lava flows in Hawaii can be found at the top of some of the basalt flows *(Photo 12)*.

PHOTO 12: Ropy flow tops, volcanic structures identical to this billion-year-old example in rocks of the Osler Group on Wilson Island, can be seen on modern lava flows in Hawaii.

The Mamainse Point Formation is a 1.09 to 1.10 billion-year-old sequence of over 300 basalt flows, each from 1.5 to 30 metres (5 to 100 feet) thick. It also includes some rhyolite and conglomerate *(Photo 13)*. Altogether, the formation is between 4,300 and 6,000 metres (14,000 and 19,500 feet) thick. The basalts formed subaerially, not under water, and contain abundant vesicles, or trapped air bubbles. Some have ropy flow tops.

PHOTO 13: Conglomerate of the Mamainse Point Formation is typically a jumble of poorly layered cobbles and boulders.

Recent studies have determined an interesting fact relating to the rocks of the Mamainse Point Formation, and the North and South Poles. During the time the Mamainse Point Formation was deposited, the positions of the North and South Poles reversed three times! They were reversed at first, then normal, then reversed, and then normal again. Reversals continue even today, with the positions of the poles reversing every million years or more. These reversals are shown by modern analytical techniques that examine the orientation of the rock's natural magnetization. Such magnetization, frozen into igneous rocks as they cool and solidify, indicates the position of the North Pole at the time the rocks formed.

The Michipicoten Formation, exposed on Michipicoten Island, overlies the Mamainse Point Formation. It consists of a variety of volcanic rocks including basalt, andesite, and rhyolite flows, along with volcaniclastic rocks formed during explosive eruptions. Minor amounts of sedimentary rocks are also present. This 1.09 to 1.10 billion-year-old sequence is unusual among the Keweenawan volcanic piles because of its abundance of volcanic rocks other than basalt.

The Keweenawan volcanic and associated sedimentary rocks exposed on the North Shore islands have been estimated to have an aggregate thickness of 4,300 metres (14,000 feet); those on Mamainse Point, 4,300 to 6,000 metres (14,000 to 20,000 feet); those in Michigan, about 6,000 metres (20,000 feet); and those in Minnesota between Duluth and Tofte, about 8,200 metres (25,000 feet).

The immense volume of lava represented by these deposits is thought to have originated from deep crustal fissures that penetrated to the earth's mantle. In this regard, it is significant that, almost without exception, the rocks slope or dip from the shore toward and under the lake, forming a large basin or trough. Because similar rocks appear on the south shore of Lake Superior, it was suggested before plate tectonics was recognized as a crustal phenomenon that the basin may be a huge syncline resulting from crustal foundering upon the withdrawal of magma that poured out at the surface to form the lava flows. It is believed at present, however, that the dips of the Proterozoic volcanic and sedimentary rocks of the Lake Superior Basin reflect late-stage faulting associated with the Midcontinent Rift, which took place after the great outpourings of the basaltic lavas, instead of foundering.

The Sedimentary Rocks

The upper part of the Keweenawan Supergroup, made up of flat and gently folded 1.09 billion-year-old sandstone, conglomerate, and shale, is found in outcrops near the east end of Lake Superior. It rests unconformably on weathered Archean granitic rocks, and on the eroded, upturned edges of the Keweenawan volcanic rocks. It is believed to have been deposited during regional subsidence following the end of volcanic activity in the area. Although much thinner on land, it is shown by seismic techniques to be up to 8,000 metres (26,000 feet) thick under the lake. The sedimentary rocks of the Keweenawan Supergroup are divided into two groups, the Oronto on the bottom, and the Jacobsville on the top.

The Oronto Group includes quartz sandstone, conglomerate, grey shale, and red sandstone and mudstone. Exposures of these rocks are scarce, but there are some at Mica Bay, near Mamainse Point.

The Jacobsville Group is a feldspar- to quartz-rich sandstone, which formed from sand that was likely left behind by a major river system. Because of its relatively undeformed state, it was originally thought to be Cambrian, or between 505 and 570 million years, in age. New evidence suggests, however, that it is instead about 1.09 billion years old, or Keweenawan in age. It is exposed on the headlands around Batchewana Bay, and in the Goulais Bay and Sault Ste. Marie areas.

Southern Province Intrusive Rocks

The history of deposition of volcanic and sedimentary rocks over a span of 1.40 billion years is not the complete geological history of the Southern Province. The rest of the story involves the intrusion of several distinct types of igneous rock, which, like the Keweenawan volcanic rocks, formed in response to the opening of the Midcontinent Rift. Outcrops of these intrusive rocks are commonly bounded by sheer cliffs, and thus they provide northwestern Ontario with some of its most magnificent scenery.

PHOTO 14: The distinctive mesa on Pie Island in Lake Superior south of Thunder Bay is one of numerous landmarks in the area underlain by diabase sills.

Most of the intrusions formed in the Thunder Bay and Nipigon areas between 1.10 and 1.11 billion years ago, or about the same time and in the same place as volcanic rocks of the Osler Group. One notable exception formed at the same time, midway along the north shore at Marathon, while a second formed about 20 million years later in the Wawa area. The main intrusions in the Thunder Bay and Nipigon areas are divided into two groups called the Logan sills and the Nipigon sills. Other, smaller intrusions are also found in the same areas. The intrusion that formed at Marathon is known as the Port Coldwell alkalic complex, while the one near Wawa is called the Firesand River Carbonatite Complex.

The Logan Sills

The Logan sills were named after Sir William Logan, first director of the Geological Survey of Canada, who described them in his

1847 report. They formed when mafic magma was forced outward from feeder dikes, and squeezed between the layers of sedimentary rocks of the Animikie Group in the Thunder Bay region. The magma cooled to form diabase, a dark rock that is highly resistant to erosion. It formed 6 major subhorizontal sheets, or sills, each up to 45 metres (150 feet) thick, plus a number of thinner sills. It also formed a number of vertical sheets, or dikes up to 200 metres (650 feet) wide, particularly in the Pigeon River region, where molten rock flowed up conduits from the magma chamber on its way to form the sills.

Today, the sills form the caps of many of the high hills in the Thunder Bay district. Such hills, called mesas and cuestas, typically reflect the dips of the sills. The mesas are flat-topped, and occur where the sills are horizontal, whereas the summits of the cuestas form ramps that slope gently to the southwest, parallel to the dips of the sills. In both cases, their flanks are marked by steep escarpments where erosion has cut down through the diabase sheets. Other hills in the Pigeon River area, which are underlain by the diabase dikes form long, straight, steep-sided ridges that project as rugged headlands into Lake Superior. Prominent landforms caused by the Logan sills include Mount McKay at Thunder Bay, Pie Island *(Photo 14)*, and the Sleeping Giant.

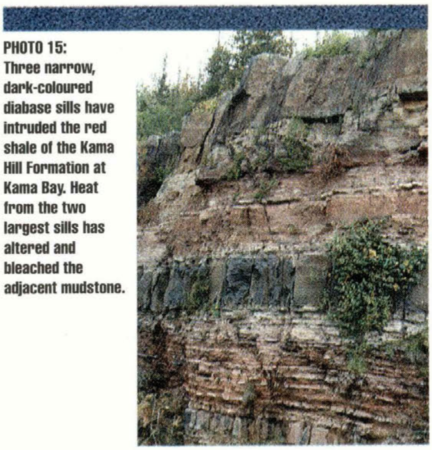


PHOTO 15: Three narrow, dark-coloured diabase sills have intruded the red shale of the Kama Hill Formation at Kama Bay. Heat from the two largest sills has altered and bleached the adjacent mudstone.

The Nipigon Sills

The Nipigon sills, found east of the Sibley Peninsula, formed in much the same way as did the Logan sills. This time, however, the diabase intruded the sedimentary rocks of the Sibley Group, and Archean basement rocks. Numerous sills can be found, and include those exposed at Kama Bay *(Photo 15)* and Red Rock, but the dominant one is 150 to 200 metres (500 to 650 feet) thick and extends across the Nipigon area. Erosional remnants of an overlying sill of comparable thickness can also be found. Most of the sills are broken along vertical cracks and joints, and as a result weather to form precipitous cliffs, including those at Ouimet Canyon.

The Moss Lake Intrusion and the St. Ignace Island Complex

On Black Bay Peninsula and St. Ignace Island, offshore from Black Bay and Nipigon Bay, the Moss Lake Intrusion and the St. Ignace Island Complex intrude volcanic rocks of the Osler Group. Both intrusions are characterized by circular structures associated with ring-shaped fractures, and both include the mafic rocks gabbro and anorthosite along with more felsic rocks such as quartz-feldspar porphyry. These rocks formed at the same time as the Nipigon sills, and are believed to mark the conduits up which magma flowed to form the sills.

The Port Coldwell Alkalic Complex

The Port Coldwell alkalic complex is located at Marathon, some distance from the other Keweenawan intrusive rocks. Its composition is different from that of the Logan sills and the Nipigon sills, even though they formed at about the same time, and is quite varied from place to place within the complex. It intrudes Archean granitic and volcanic rocks of the Wawa subprovince.

Notable on geological maps is the circular shape of the Port Coldwell alkalic complex. It is, however, not made up of just a single ring of intrusive rocks. Instead, it represents the superposition of three ring complexes that become progressively younger in a southwest direction. The oldest is an outer ring of gabbro, and an internal sheet-like cone of syenite; the second is an outer ring of gabbro to diorite and a core of syenite, and the youngest, centred on Pic Island just offshore from Neys Provincial Park, is made up of arcuate sheets of various types of syenite. To further confuse the picture, there are patches of country rock that dropped down into the complex along ring fractures, and breccias that formed where gases released from the magma exploded through solidified rock.

Although different from the rocks that make up the diabase sills, the rocks of the Port Coldwell alkalic complex are also quite resistant to erosion. Precipitous cliffs are not particularly common, but steep slopes, rugged hills, brightly coloured outcrops, and a change from the vegetation found in other places along the north shore of Lake Superior make the region an exceptionally scenic one *(Photo 16)*.

The Firesand River Carbonatite Complex

Located about 8 kilometres (5 miles) east of Wawa, the Firesand River Carbonatite Complex formed somewhat later than all the other Keweenawan intrusive rocks, and is quite different in composition from them. In fact, the composition of any carbonatite is very unusual for an igneous rock. Carbonatites are made up largely of carbonate minerals, including calcite, dolomite, and others, which are normally found in sedimentary rocks! The Firesand River Carbonatite Complex consists of a vertical pipe approximately 3 kilometres (2 miles) across, and numerous dikes that crosscut the surrounding rocks.

Keweenawan Mineral Deposits

Numerous mineral deposits were formed in the Lake Superior region in Keweenawan time. They include copper deposits near Mamainse Point, copper-nickel deposits near Pigeon River, uranium deposits near Montreal River Harbour, and amethyst and lead-zinc deposits northeast of the city of Thunder Bay. Also included are silver deposits southwest of the city and at Silver Islet *(Photo 17)*, a barite deposit on Little McKellar Island, and deposits of nepheline syenite, iron, copper, and platinum group metals in rocks of Keweenawan age near Marathon. And, sedimentary and igneous rocks from the Marathon and Sault Ste. Marie areas have been used as building stone.

Some of these deposits have played an important role in the development and economic well-being of the north shore of Lake Superior in the past; some play a significant part today; some will be important in the future. Rocks of Keweenawan age are important on the south shore of Lake Superior too. In Michigan, on the Keweenaw Peninsula, deposits of native copper have been mined since 1847. Since then, 100 mining companies have paid dividends totalling almost $350 million!

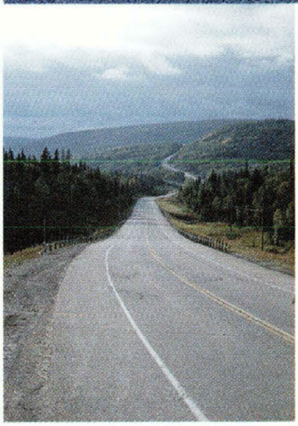


PHOTO 16: The area around Marathon, which is underlain by the Port Coldwell Alkalic Complex, has its own characteristic topography, scenery, and vegetation. It clearly illustrates the interrelationship between geology and scenery.

The Phanerozoic Eon

After the development of the Midcontinent Rift, and the large-scale intrusion of the earth's crust by diabase and related igneous rocks, the Keweenawan period came to an end. Then began a long period of erosion. Like the erosional interval at the close of the Archean Eon, the post-Proterozoic erosional interval lasted for millions of years. It marked the end of the Precambrian time in northern Ontario. After the Precambrian came the Phanerozoic Eon, or that part of geological time in which the evidence of life is abundant. It includes the Paleozoic, Mesozoic, and Cenozoic eras, and spans the period from the present to 570 million years ago. Deposits from all three eras are found in Ontario *(Figure 5)*, but only those from the most recent part of the Cenozoic Era find widespread distribution along the north shore of Lake Superior.

The Paleozoic Era

The erosional interval that marks the end of the Precambrian was terminated by the deposition of the oldest rocks of the Paleozoic Era, the so-called era of old life, when invertebrate creatures dominated the scene, primitive fishes evolved, and amphibians emerged from the sea. In the Lake Superior region, there are no Paleozoic rocks. This may be because whatever rocks were deposited have since been completely eroded away, or, more probably, because the land stood high and dry, and no rocks were deposited during Paleozoic time. If the latter case is true, then the period of erosion that affected the area north of Lake Superior lasted for over a billion years, until the continental glaciers of the Pleistocene Epoch deposited their tills and clays at the end of the Great Ice Age.

PHOTO 17: This steam-powered diamond drill, at work on the mainland opposite Silver Islet in 1876, was apparently the first diamond drill ever used in mineral exploration.

Paleozoic rocks were deposited not far from the north shore of Lake Superior, however: travellers driving south from Sault Ste. Marie through Michigan leave Precambrian rocks behind, and pass into an area underlain by Paleozoic rocks only 16 kilometres (10 miles) south of Sault Ste. Marie! These Paleozoic rocks are part of a sequence 4,000 metres (13,000 feet) thick that filled the Michigan Basin between 350 and 550 million years ago. The rocks of the Michigan Basin tell a story of non-marine deposition of sandstone, shale, and conglomerate, followed by flooding, formation of a shallow sea in a depression some 535 kilometres (335 miles) across atop the continental crust, and deposition of limestones, dolostones, and other types of rocks including salt and gypsum.

The Mesozoic Era

No rocks from the Mesozoic Era are found anywhere near the north shore of Lake Superior. In fact, the only such rocks found in Ontario lie in the far northern part of the province, in parts of the James Bay and Hudson Bay lowlands. It seems likely that most of Ontario was high and dry between 66 and 245 million years ago. One can only wonder what strange and impressive creatures wandered the province at that time. Did *stegosaurus*, *triceratops*, or *tyrannosaurus* roam where we pass today? Did oversize dragonflies flit between flowering shrubs, and spindly pteranodons with enormous wingspans soar over gigantic ferns? Did the first mammals hide amongst palm fronds, seeking protection from predators?

The geological record for most of the province during this time is blank. Where Mesozoic rocks were preserved, they contain very few fossils. Instead, they record a time when the land was not covered by water, and erosion of older rocks was actively going on. Widespread deposition of sediments did not begin until 65 million years after the end of the Mesozoic Era—or about a million years ago.

The Cenozoic Era

The Cenozoic Era, or era of recent life, began 66 million years ago and spans the period of time right up to the present. It consists of two periods, the Tertiary, from 1.6 to 66 million years ago, and the Quaternary, from the present to 1.6 million years ago. It was during the Tertiary that mammals began to flourish, but humans did not make their first appearance until the Quaternary.

There are no rocks of Tertiary age in Ontario, but there are extensive sedimentary deposits of Quaternary age. They are

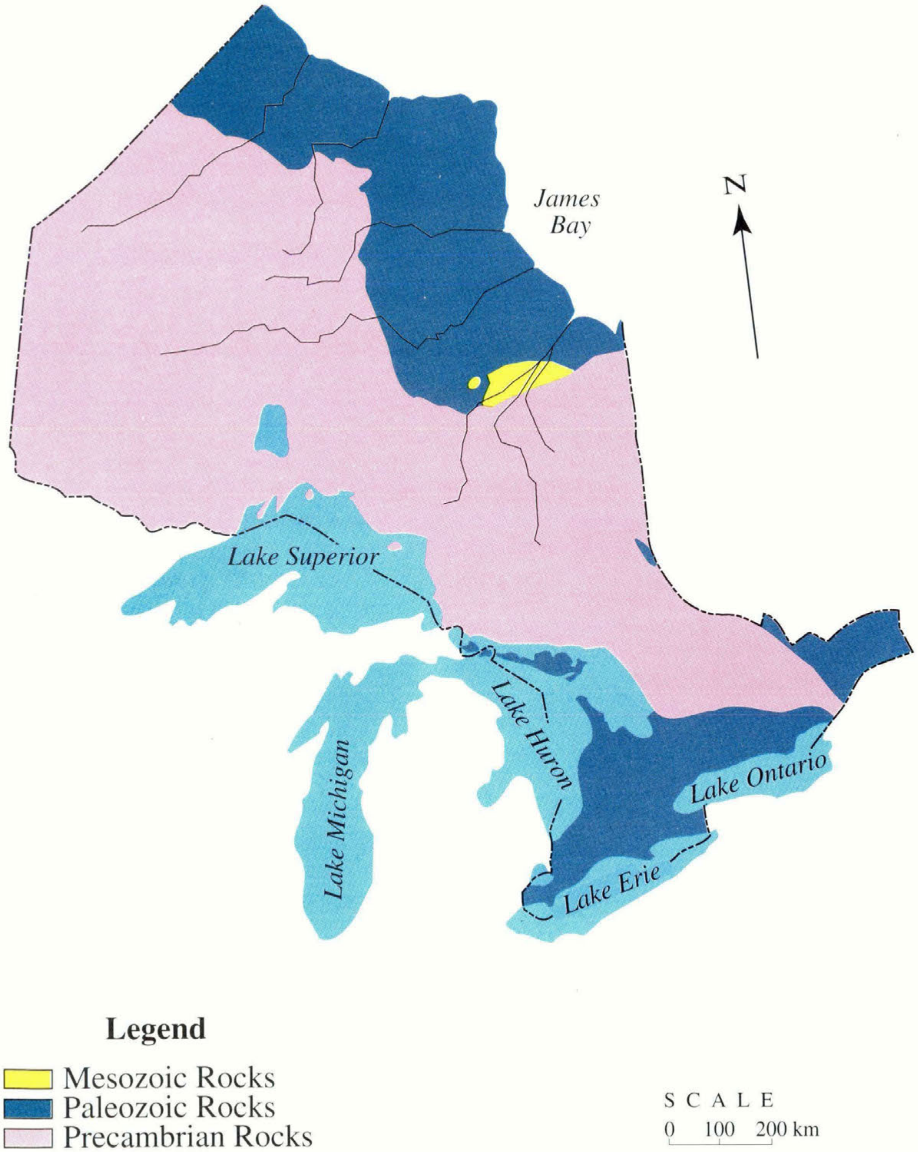


FIGURE 5: Distribution of Precambrian, Paleozoic, and Mesozoic rocks in Ontario. The Paleozoic and Mesozoic rocks drape the margins of the Canadian Shield. Cenozoic deposits are not shown on this map, but a discontinuous layer of such deposits was left behind by retreating glaciers over much of the province.

"unconsolidated", meaning they have not yet solidified to form rock. Most formed during the part of the Quaternary called the Pleistocene Epoch, which lasted from 10,000 years ago to 1.6 million years ago, and is also known as the Great Ice Age. Some of the best Pleistocence deposits are located along the north shore of Lake Superior. Their formation was related to the advance and retreat of the immense continental glaciers of the time. A few Quaternary deposits are also known from the Holocene Epoch, which extends back 10,000 years from the present.

The Great Ice Age

Although the geological record of the Pleistocene in Ontario is quite extensive, it is very incomplete. This is primarily because Ontario is located in the center of the North American land mass, a terrestrial location where erosion is constantly removing parts of the geological record. Pleistocene deposits in Ontario appear to represent only the last 190,000 years, but that time span includes the two main glacial stages of the Great Ice Age.

PHOTO 18: These glaciers have melted somewhat, leaving jumbled mounds of gravel along their edges, but it is clear that tongues of ice flowed from the mountain peaks to join the main valley glacier as it inched downhill.

The first glacial stage was a relatively cold period when most, if not all, of Ontario was covered by a massive continental glacier which may have been several thousand metres (more than a mile) thick. It appears that temperatures were on average 9°C colder then than now. The interglacial period, between 115,000 and 135,000 years ago, was as warm as, or warmer than it is today. The second period of glaciation followed the interglacial period, and ended about 10,000 years ago. During it, a number of advances and retreats of the glacial ice sheet followed fluctuations in temperature. Parts of southern Ontario were ice-free at times, but about 20,000 years ago, all of the province was once again covered by ice. By about 15,000 years ago, the ice sheet began to melt northward, and by 10,000 years ago, it had retreated some distance northward, although a large part of northern and central Ontario were still ice-covered *(Figure 6)*. Not until less than 8,000 years ago had the ice sheet in Ontario entirely melted.

Glacial Flow

Ice is generally considered to be hard and unyielding, and anyone who has fallen while ice skating can attest to the truth of that perception! Yet, geologists say that glacial ice actually flows. How can that be?

Glaciers form when annual accumulations of snow do not melt before being covered by the next year's snowfalls. When the blanket of snow becomes deep enough, the weight of the overlying snow exerts such great pressure on the snow at the bottom of the pile that the snowflakes change into ice granules. If this process goes on long enough, a thick sheet of ice results, and the weight of the overlying ice exerts even more pressure on the ice at the bottom of the pile. The additional pressure causes changes in the ice granules: the changes are reflected by the flattening and spreading of the ice sheet *(Photo 18)*. Flow in glacial ice might be compared to flow in the children's toy Silly Putty®. When a ball of that "solid" material is placed on a flat surface, it spreads out under its own weight to form a flat puddle.

Glaciers continue to spread, or advance, as long as new snow is added to the top of the pile as fast as, or faster than, the ice at the edge of the ice sheet melts away. When glaciers retreat, they do not move back

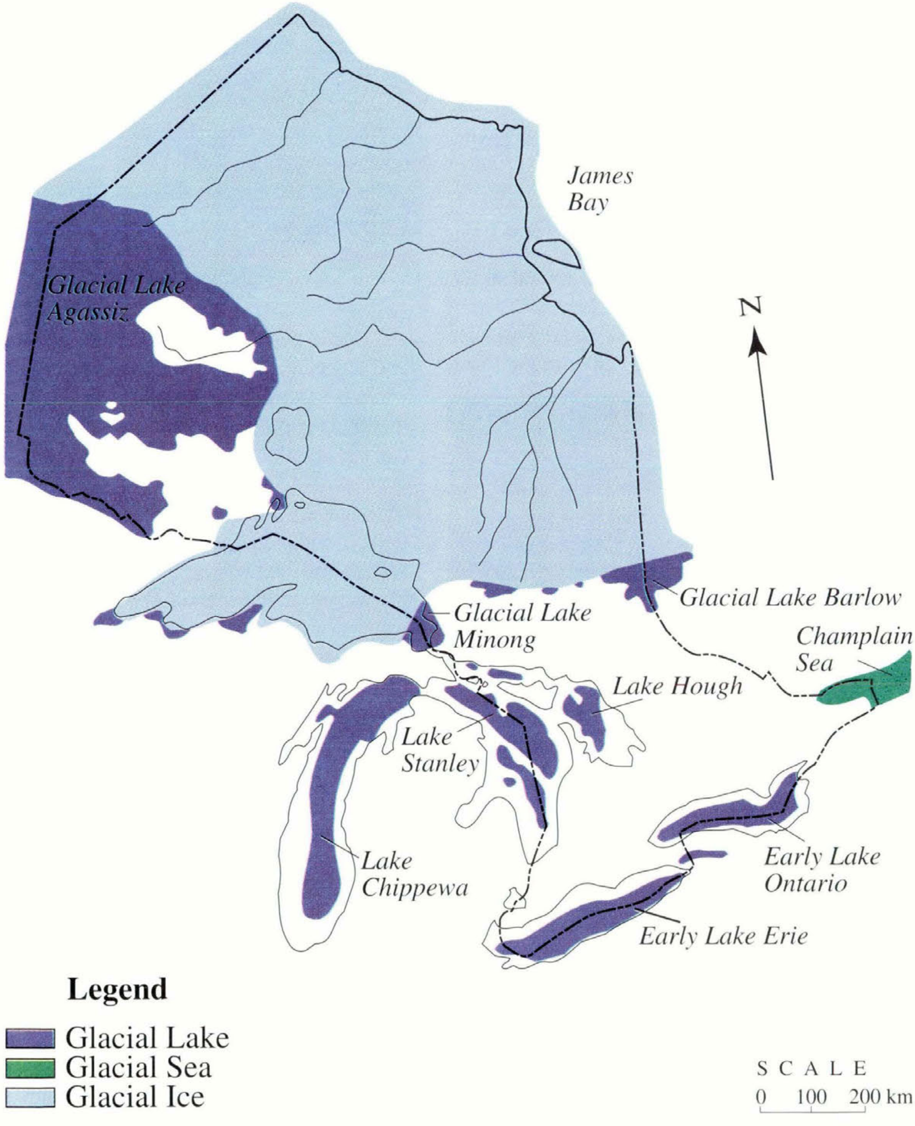


FIGURE 6: Distribution of glacial ice, glacial lakes, and glacial seas in Ontario 10,000 years ago. Note that much of northwestern Ontario was flooded, while water levels in the Great Lakes other than Lake Superior were lower than at present. Seawater reached inland as far as Ottawa.

whence they came: the glacial ice simply melts faster than it is replaced.

Ice Sheets in the Lake Superior Region

The ice sheets in the Lake Superior region advanced in a general southwesterly direction and, in doing so, profoundly modified the surface of the land. The bedrock was stripped of a mantle of weathered debris that had been accumulating since Precambrian time. Outcrops were grooved and scratched in some places, and in others they were smoothed and polished. Elevated areas in general were severely abraded, and old river valleys and canyons that happened to be parallel to the direction of ice movement were gouged and deepened.

PHOTO 19: This gravel was left at the margin of a glacier on Ellesmere Island as the ice melted away. Meltwater later cut the channel, still partially filled by the previous winter's snow, through the gravel.

Pleistocene Deposits

The climate eventually warmed toward the close of Pleistocene time, and the great ice sheet melted away. As it melted, the debris that had been picked up by the advancing ice was left behind in a helter-skelter jumble. Sand, silt, and clay mixed with pebbles, cobbles, and boulders of all sizes to form a discontinuous, fairly flat sheet of gravel covering much of northern Ontario. Topographic relief on these deposits, called ground moraines, ranges from 2 metres (6 feet) to 10 metres (33 feet).

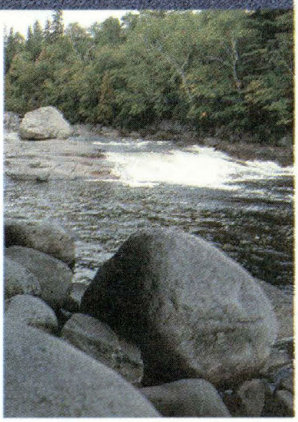


PHOTO 20: Stranded oversized boulders like these near the mouth of the Sand River in Lake Superior Provincial Park are a sure sign that the stream once had much more water, flowing much faster than at present.

In places where the glacier advanced at about the same rate it melted, the glacial retreat was stalled for some time, and the deposits are somewhat different. Called end moraines, they formed because the ice acted like a conveyor belt, continuously moving its load of debris forward and dumping it all in the same spot. Some end moraines have quite irregular surfaces, and stand as much as 30 metres (98 feet) above the surrounding countryside *(Photo 19)*. Excellent examples of such deposits can be seen north and east of Kakabeka Falls.

Complete disorganization of the preexisting drainage system was effected by these deposits; an intricate pattern of innumerable lakes, either large with indented shorelines, or long and narrow with short rapid rivers and spillways, characterized the new landscape. Some old rivers were reestablished and new streams were formed by the abundant, rapidly flowing meltwater *(Photo 20)*. Extensive deposits of well-washed sand and gravel were left behind in many channels, some of which bear little more than a trickle of water today.

Huge volumes of glacial meltwater were also ponded in the Superior basin, forming a succession of lakes. The first was much larger and deeper than the present lake. Because its lake water was held in on the north and east by glacial ice, it drained through an outlet along the valley of the present St. Croix River that separates parts of Minnesota and Wisconsin. As the ice continued to melt, and the glacial front receded, new drainage patterns developed and water levels in the Lake Superior basin changed accordingly. The water levels lowered: old shorelines were abandoned; more recent lake deposits became progressively exposed to view; and new shorelines were established.

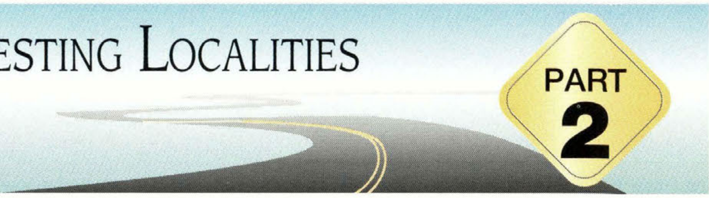
Broad, flat expanses underlain by laminated clay *(Photo 21)* mark areas that were flooded by precursors of Lake Superior. Much of the region crossed by Highway 11&17 between the Sibley Peninsula and Nipigon is underlain by such deposits: many of northern Ontario's farms are found in this and other such areas.

Flat, stepped terraces and abandoned beaches made up of cobbles, gravel, sand, and clay are also found at numerous localities surrounding the present Lake Superior shoreline. They are separated from one another by rather abrupt escarpments or shore cliffs, cut by wave action when the lake level was higher than it is now. They are particularly well developed in the Thunder Bay, Nipigon, Terrace Bay, Marathon, Wawa, and Sault Ste. Marie areas. Terrace Bay even derives its name from its prominent series of ancient beaches.

Aside from the detritus being laid down today by rivers and streams, and the beds of peat forming from decaying vegetation in modern swamps, the Pleistocene deposits constitute the youngest geological formations in the north shore of Lake Superior region.

PHOTO 21: Laminated deposits like these were laid down in glacial and post-glacial lakes throughout the north shore region. One pair of the alternating clay and silt layers that make up these sequences was deposited each year.

Interesting Localities



Localities having some special interest can be found all along the north shore of Lake Superior. Some are of interest because of their exceptional scenic beauty, while some are of interest because of their unique natural history. Others are of interest because of the part they played in the settlement and development of the region. Part 2 of this Roadside Geology volume identifies many of these sites and links their descriptions to short trips along the north shore of the lake.

Twelve Trips from West to East

The route from the United States border at Pigeon River, past Thunder Bay and east to Sault Ste. Marie, is divided into twelve sections or trips, each approximately 65 to 100 kilometres (40 to 60 miles) long. Distances are indicated in both miles and kilometres, in order to accommodate the two systems of measurement used by North American travellers.

A generalized geological map outlining the rock types present in the area is included at the beginning of each trip. The map is complemented by general descriptions of the rocks in the region, along with significant details concerning when, where, and how the rocks formed. Also included are references to the glacial history of the region, and explanations of how the present-day topography, vegetation, and scenery are derived from the bedrock and glacial geology.

Points of Interest

The trips may be taken individually, or several can taken together, making up a day's travel. The principal features of interest along or close to the main highways are described for each section, as are their locations and means of access. Such features include waterfalls, panoramic vistas, unusual rock types and structures, uncommon micro-environments with assemblages of rare flora and fauna, and sites celebrated in Ojibwa legends. Many of them are illustrated by photographs. Historical anecdotes relating to the various historic and modern communities round out the information included for the points of interest.

Most points of interest are located in parks, at scenic lookouts, or at other such developments. A few, however, are located alongside the Trans-Canada highway or other roads. Readers are cautioned to take care when stopping at these points of interest to ensure that they park well off the road surface in a spot that can be seen by traffic coming from both directions, and that they cross the highway only when it is safe to do so.

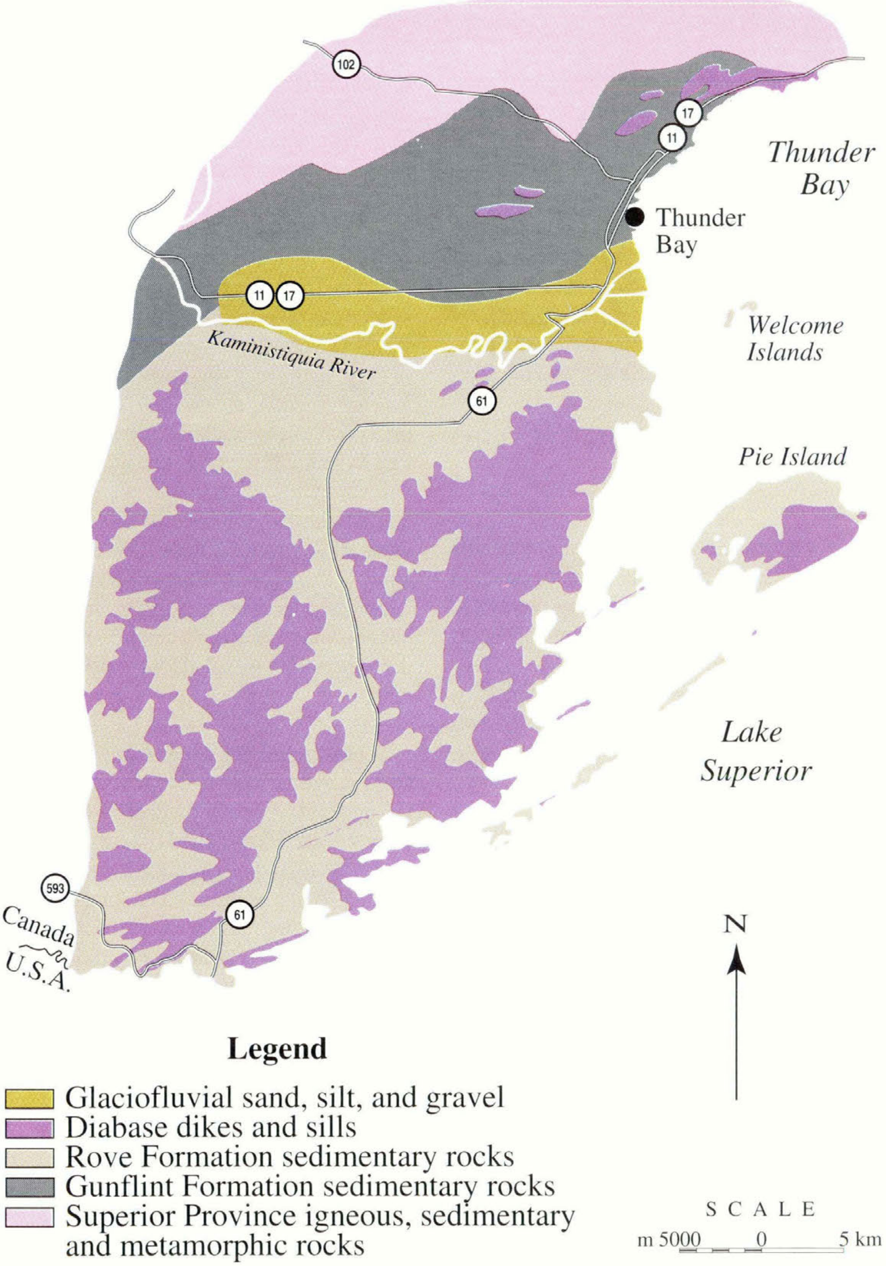


FIGURE 7: Generalized geology of the Pigeon River–Thunder Bay area. The areas underlain by diabase dikes form the long narrow ridges, while those underlain by diabase sills form the stocky flat-topped hills.

PIGEON RIVER TO THUNDER BAY

TRIP 1

The short route followed by Highway 61 between Pigeon River and Thunder Bay *(Figure 7)* crosses three distinctly different sets of landforms. There are long, narrow ridges separated by deep valleys, stocky flat-topped hills rising from relatively flat surroundings, and broad, flat plains with incised creeks and rivers. Each of these landforms is a reflection of the underlying bedrock, and together they provide a clear illustration of the interrelationship between geology and scenery.

Highway of the Fur Trade

The Pigeon River, which marks the boundary between the Province of Ontario and the State of Minnesota in the U.S.A, was the route used from 1722 to 1797 by fur traders travelling between Lake Superior and Lake of the Woods. The first portion of the Pigeon River voyageur route was known as "Grand Portage", largely because of the staggering 13.6 kilometre (8.5 mile) uphill trek from Lake Superior to the most important inland fur-trading post on the 684 kilometre (428 mile) route. The post, established at Grand Portage in 1778, was relocated to Fort William at the mouth of the Kaministiquia River after the American Revolutionary War (1776-1783).

PHOTO 22: At Old Fort William, visitors can travel back in time more than 175 years to a reconstruction of a fur trade era landmark, complete with palisades, farm, jail, hospital, and living and storage areas.

Today, a U.S. national historic monument is located at the site of the first post, where several of the original buildings have been reconstructed. Grand Portage State Park follows the southern shore of the Pigeon River several kilometres (miles) upstream from its mouth.

In Ontario, a campground named Middle Falls Provincial Park was created along the Pigeon River in 1956. Since then, it has been expanded to a 965 hectare (2,385 acre) natural environment park, including a substantial portion of land along the Pigeon River to Lake Superior, and 8 kilometres (5 miles) of lakeshore. As a complement to the park along the Pigeon River, the provincial government operates Old Fort William at the mouth of the Kaministiquia River in the city of Thunder Bay *(Photo 22)*. It is a historic reconstruction of the 40 buildings of the complete trading post as it stood in the year 1821.

The Pigeon River

The Pigeon River drops about 90 metres (300 feet) in its last 16 kilometres (10 miles) before entering Lake Superior. Rapids are numerous and there are three waterfalls. The most westerly falls is known as Horne Falls; the most easterly, as High Falls or Pigeon Falls. The third occurs roughly midway between the others. It has been appropriately named Middle Falls, although on many maps it is shown as Little Falls.

High Falls (Pigeon Falls)

High Falls is located approximately 1.5 kilometres (1 mile) west of the Tourist Information Centre on Highway 61. The waterfall is one of the most impressive physiographic features in the Pigeon River region, and visitors are well advised to include it on their itineraries.

A trail starting at the northwest corner of the parking lot at the Tourist Information Centre leads to the falls. It passes along the south side of the highway for several hundred metres (yards), crosses under the highway, and then leads back toward the Pigeon River. At the site of an old homestead—where nothing remains but the ruins of a stone chimney—the trail turns away from the highway, and upstream toward High Falls.

Below the falls, the Pigeon River flows through a narrow steep-walled gorge that has been cut into gently sloping shales and greywackes of the 1.86 billion-year-old Rove Formation. These rocks are also exposed next to the trail where a set of stairs bypasses some cliff faces, and at the lookout point, just downstream from High Falls.

The shales and greywackes are easily eroded, and one would naturally expect the gorge to persist upstream for a considerable distance. This is not the case, however, for the face of High Falls looks like a solid wall *(Photo 23)*. The wall is formed by a prominent vertical diabase dike, which cuts the sedimentary rocks. Having resisted erosion, the dike stands up as a 28 metre (92 foot) high barrier, and abruptly terminates the gorge.

Middle Falls (Little Falls)

Middle Falls is located on Highway 593, 2.2 kilometres (1.4 miles) from the intersection of highways 593 and 61. It is situated on a floodplain of the Pigeon River. The clay and sand of the floodplain were deposited on the underlying shales of the Rove Formation when, following continental glaciation, the level of glacial Lake Agassiz was higher than the level of Lake Superior is today.

While Middle Falls itself is the central point of attraction, the visitor's attention is also drawn to the rock outcrop found along Highway 593 opposite the falls. It provides evidence of what caused Middle Falls to form.

The outcrop is made up largely of flat-lying, rusty-weathering black shales of the Rove Formation, but dikes and sills of diabase are also present. At the top of the outcrop, the sedimentary rocks are capped by a sheet or sill of diabase, made conspicuous by its rusty-coloured weathered surface. A second, thinner, diabase sill about 1 metre (3 feet) thick, lies below and is separated from the first sill by 6 metres (20 feet) of shale.

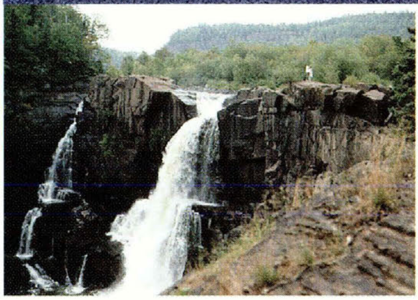


PHOTO 23: A diabase dike that crosscuts easily-eroded shale and greywacke stands like a rampart at High Falls (Pigeon Falls), resulting in the dramatic waterfall.

The shale and the two diabase sills have been cut by faults, and by three diabase dikes. The faults slope steeply to the north. The dikes are vertical or nearly so in attitude, and being more resistant to erosion than the shales, they form promontories extending outward from the cliff face. There is one about midway along the outcrop, and one at each end. The diabase dike at the south end of the outcrop can be traced

PHOTO 24: Middle Falls occurs where the Pigeon River flows over a resistant vertical diabase dike that cuts the less resistant sedimentary rocks of the Rove Formation.

across the highway to the Pigeon River. A hard, resistant rock, it stands up as the vertical escarpment over which the waters of the river tumble to form beautiful Middle Falls *(Photo 24)*.

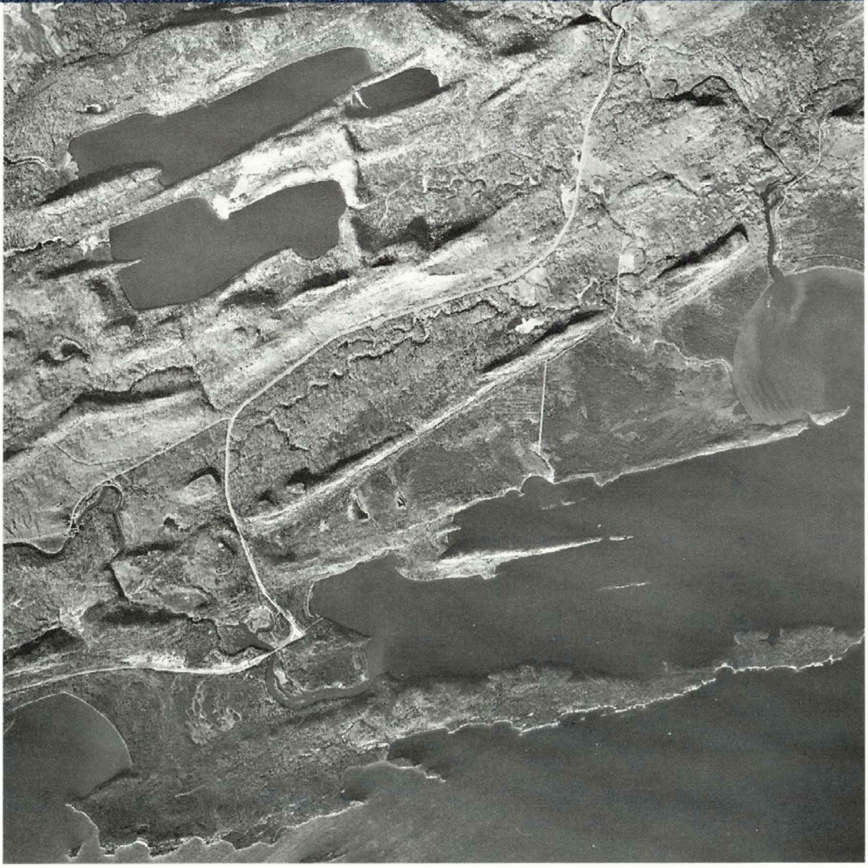
Middle Falls campground lies just downstream from the waterfall. It offers an attractive camping area, in a beautiful stand of mature pine and other trees.

Pigeon River to Thunder Bay

The terrain crossed by Highway 61 for 18.5 kilometres (11.5 miles) east of the Pigeon River is characterized by high ridges separated by deep linear valleys filled with clay, sand and silt; only in a few places have quarry operations exposed sedimentary rocks of the Rove Formation. The ridges, some of which rise in places to 120 metres (400 feet) above the highway, are the topographic expressions of northeast-trending, vertical diabase and gabbro dikes.

The highway extends 5.6 kilometres (3.5 miles) northeast of the Pigeon River along the side of one of these dikes, turns north for about 4 kilometres (2.5 miles) and crosses at least four dikes, and then follows another dike for a few kilometres (miles). The parallel diabase ridges, separated by deep valleys, are conspicuous from the shore of Pine Bay, one of the more picturesque bays along this portion of the Lake Superior shoreline. Their

PHOTO 25: Northeast-trending diabase dikes that cut the relatively soft sedimentary rocks of the Rove Formation can be seen forming sharp ridges in this vertical aerial photograph of the Pigeon Bay–Pine Bay area. The irregular white line crossing the photograph is Highway 61; the photo is approximately 6 km (4 miles) across.



prominence as a topographic feature of the region is also evident in air photographs *(Photo 25)*.

Pine Bay Lookout

Just east of the Pine River Bridge, the Memory Lodge Road leads south from Highway 61 to Pine Bay. Approximately 4.5 kilometres (2.9 miles) from the junction, an old dirt road leads up a moderate grade on the left to a large veiwpoint overlooking Pine Bay. The road is blocked by large boulders, so visitors must walk to the lookout by following the road up the hill for about 400 metres (440 yards) to an open area, and then taking a short footpath to the viewpoint.

The viewpoint is perched on one of the northeast-trending diabase dikes which form the prominent topographic ridges in the area. The round bay below is Pine Bay. The headlands that form the bay, as well as the offshore islands, are also dikes of the same swarm. To the southwest, if not obscured by foliage, another such dike can be seen in cross section: it resembles a gigantic wall cutting across the country. The flat-lying areas between the dikes are underlain by shales and greywackes of the Rove Formation.

Lake Superior's Oldest Mine

At the Cloud River, Highway 61 passes some 12 kilometres (7.5 miles) west of an important site on the shore of Lake Superior. It was there, at a location on Spar Island in Prince Bay, that a vein carrying significant amounts of copper and silver was discovered. The vein was tested by underground work during 1846 and 1847, in the first "modern" mining operation known on the Canadian shore of Lake Superior.

A little silver is known to have been recovered. No production records are available, however, and there is some doubt that the venture was successful. Nevertheless, the Prince Mine is of special significance in that it represents the beginning of one of northwestern Ontario's most important industries. The mine, and the bay where it was found, were named after Colonel John Prince, developer of the property and one of the first entrepreneurs of Ontario's fledgling mining industry.

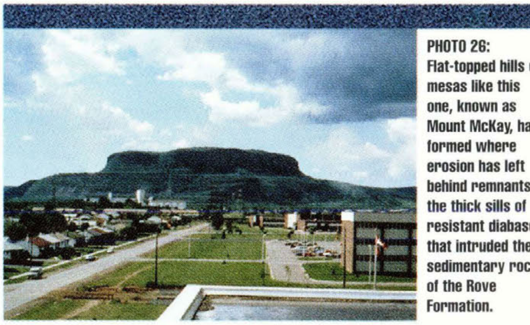


PHOTO 26: Flat-topped hills or mesas like this one, known as Mount McKay, have formed where erosion has left behind remnants of the thick sills of resistant diabase that intruded the sedimentary rocks of the Rove Formation.

Ridges to Mesas

Approximately 1.5 kilometres (1.0 miles) east of the Cloud River, the dominant topographic features change from steep-sided liner ridges to flat-topped hills, or mesas. The layering in the bedrock is horizontal or nearly so, and the hills have flat upper surfaces and are bounded on one or more sides by precipitous slopes. They are found along the highway for many kilometres, and are particularly prominent within 16 kilometres (10 miles) of the south end of the city of Thunder Bay. They are best developed at Mount McKay *(Photo 26)*.

The hills are made up of shale and greywacke, overlain and protected by hard cappings of diabase. The diabase cappings are remnants of sills that were intruded into the Rove sedimentary rocks about 1.11 billion years ago, and were once continuous across the whole region. They were fractured and faulted, and eroded by streams and atmospheric agencies. Isolated flat-topped hills were left, in which only small remnants of the once-extensive sills remain.

Excellent examples of vertical columnar jointing can be seen in the diabase in many places. These large columns formed when the diabase contracted and fractured while cooling from its once-molten state.

Uplands and Lowlands

Near the city of Thunder Bay, the hills are made even more prominent by contrast with the flatness of the lowland that Highway 61 crosses. The flatness reflects the presence of an extensive deposit, up to 27 metres (90 feet) thick, of layered clay. This clay was deposited in glacial Lake Agassiz, the huge lake of glacial meltwater that occupied the Lake Superior Basin at the end of the Great Ice Age more than 8,000 years ago. This lake stood more than 200 metres (650 feet) higher than present-day Lake Superior, and it extended many kilometres inland from the present shoreline along flooded valleys between the mesas.

PHOTO 27: This large nodule, resembling an oversized curling stone enclosed in flat-lying shale, is typical of the concretions found in the Rove Formation shales. It is about a metre (3 feet) across.

Grown in the Rock!

Because of the thick layers of clay deposited by glacial Lake Agassiz, there are few good exposures of the bedrock underlying the lowlands west of the city of Thunder Bay. Much of the lowlands are underlain by greywacke and shale of the Rove Formation, such as are found in outcrops farther to the west.

Of particular interest are the thin-bedded dark shales, which in this area contain large, well-developed concretions. The concretions are much like curling stones in shape; they are oblate spheroids, with diameters up to 1.9 metres (6 feet) and thicknesses up to 0.5 metre (1.5 feet) *(Photo 27)*. They are harder and less likely to split into layers than the shales enclosing them, and contain abundant fine-grained calcite, thus differing somewhat in composition from the shales.

The concretions have a distinctly layered structure; when viewed from above, the boundaries of the layers appear as concentric circles. In cross section, their layers are found to be parallel to, and coincident with, the bedding or stratification of the shales. The layers thicken slightly from the margins of the concretions inward, and the shale strata immediately above and below the concretions are distinctly bulged, upward and downward, respectively.

These features indicate that the concretions are not simply pieces of foreign material that were somehow included in the enclosing rock. Instead, they must have formed in place, and in their development they must have incorporated, and partly displaced, original rock material.

Although the mechanism of the process has not been completely explained, it is generally believed that concretions, like those in the Rove Formation shales, form when a minor, slightly soluble rock constituent such as calcite dissolves in groundwater. The mineral then moves with the water through the rock, and eventually precipitates and accumulates near and around some nucleus such as a pebble or grain of sand.

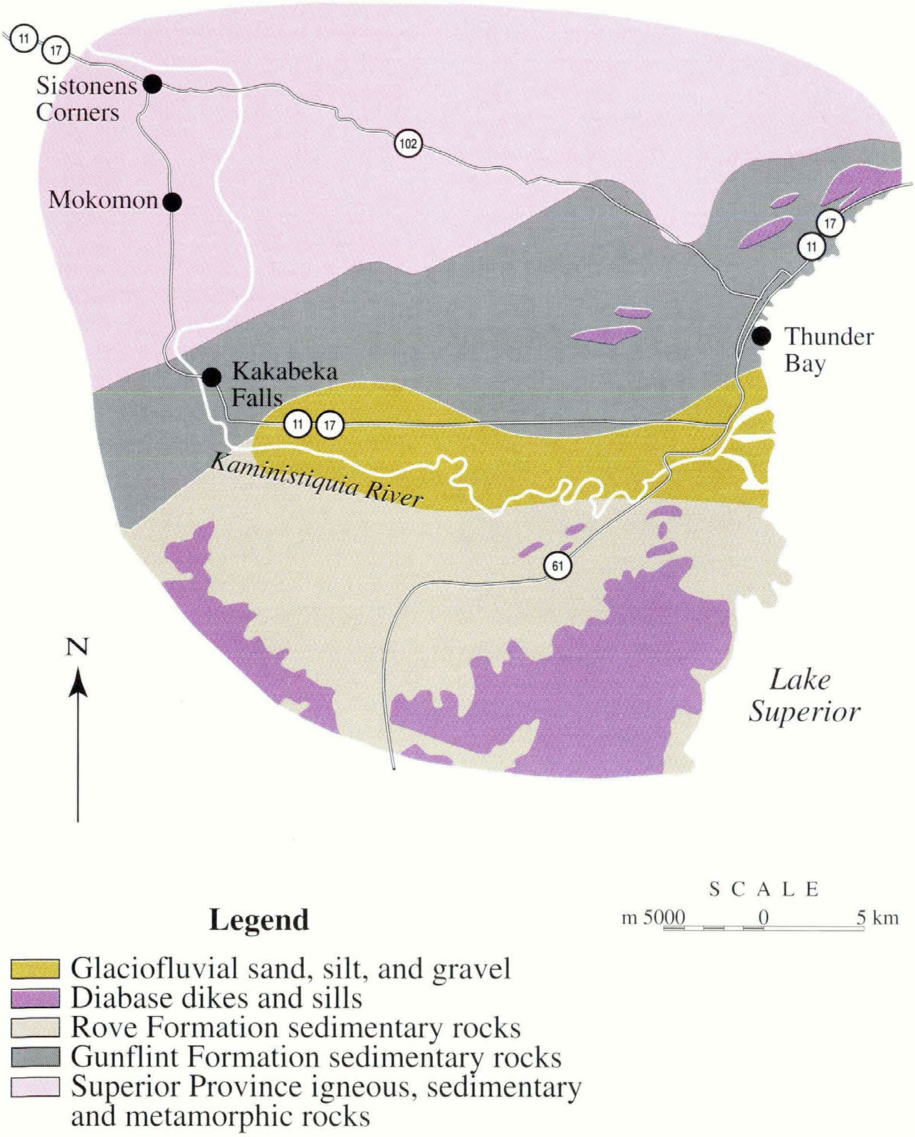


FIGURE 8: Generalized geology of the Thunder Bay–Kakabeka Falls area. The bedrock of much of the area has been covered by extensive deposits of sand and gravel, although high hills capped by diabase sills rise to the south.

KAKABEKA FALLS CIRCLE TOUR

TRIP 2

This tour leads west along Highway 11&17 from the south end of the city of Thunder Bay, past the well-known "Niagara of the North", Kakabeka Falls. It returns to the north end of the city by way of Highway 102 *(Figure 8)*. The best rock exposures along the way are at Kakabeka Falls, but in the Thunder Bay–Kakabeka Falls area, the material covering the rocks is as interesting as the rocks themselves. In this chaotic jumble of sand, silt, clay, and gravel is written a story of repeated glacial advances, inundations by post-glacial lakes, and erosion by powerful rivers.

Thunder Bay to Kakabeka Falls

The flat area that extends many kilometres to the west of the city of Thunder Bay marks the location of extensive deposits of sand, gravel, and silt deposited by the ancient Kaministiquia River. The sediment came from the debris left behind by the retreating glaciers; the water in the powerful river was meltwater from the glaciers themselves.

In places, these glaciofluvial deposits have been modified by later events. Younger streams have cut through the sand and gravel, and have themselves later abandoned their channels. Lake sediments, such as the layers of clay and silt around Neebing, were left on top of the river deposits at times when the level of Lake Superior was higher than it is now. Evidence that the level of Lake Superior was, at times, higher than it is now, can also be seen in the beaches and escarpments left behind by the ancient lake.

Highway 11&17 crosses one such escarpment about 2.6 kilometres (1.6 miles) west of the junction with Highway 130. This terrace can be traced for more than 20 kilo-

PHOTO 28: Beautiful Kakabeka Falls, the "Niagara of the North" lies just downstream from the Highway 11&17 bridge of the Kaministiquia River. Viewpoints and walkways have been constructed along both sides of the gorge since this photograph was taken.

metres (12.5 miles) along the ancient lake shore. It marks a higher lake level than does another prominent terrace, found at Hillcrest Park in Thunder Bay.

Kakabeka Falls

Kakabeka Falls is situated about 30 kilometres (18 miles) west of the city of Thunder Bay, where Highway 11&17 crosses the Kaministiquia River *(Photo 28)*. From 1800 to 1820, the falls presented the major obstacle on the fur trader's transportation route between Montreal and the northwest. From the Athabaska country and beyond, the voyageurs of the North West Company travelled downriver in canoes laden with furs. At the annual Great Rendezvous at Fort WIlliam, they exchanged their furs for iron wares, cloth, and trinkets brought from Montreal.

Explorers, soldiers, settlers, and missionaries all followed the voyageurs. Their accounts speak of the arduous passage over the portage around the gorge, and of the power and beauty of the "kah-kah-pee-kah" (sheer cliff) falls. One account, written by W.H. Keating in 1825, relates "As we passed...we could feel...the earth quaking under us from the great concussion produced by the fall of water."

Today we can only imagine what Keating saw. Since 1904, a hydroelectric power station has used water from the Kaministiquia River to produce electricity for the region. Although this has tamed its tremendous power somewhat, Kakabeka Falls is still one of the most spectacular physiographic features in northwestern Ontario.

Kakabeka Falls Provincial Park

A park with facilities for camping, picnicking, swimming and hiking has been established at Kakabeka Falls by the Province of Ontario. A trail approximately 2 kilometres (1.3 miles) long traces the steps of the voyageurs as they portaged around the falls, while a 3.6 kilometre (2.3 mile) long trail leads through the distinctive landscape of the area. There are also walkways and viewing platforms on either side of the river gorge, offering excellent views of the waterfall. The walkways are often bathed in mist from the falls, and rainbows can sometimes be seen arching through the mist from one side of the river to the other.

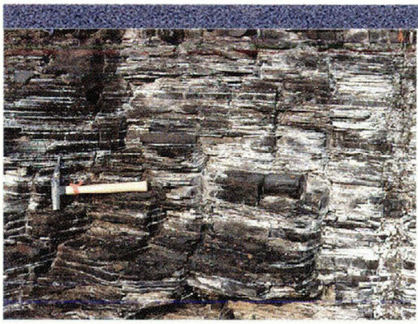


PHOTO 29: Delicate streaks of white, made up of minerals left behind by evaporating groundwater, mark the boundaries between layers of the easily-eroded shale at Kakabeka Falls.

Two points of geological interest at Kakabeka Falls are the outcrop at the south end of the parking area adjacent to Highway 11&17, in which the rocks are the same as the ones that form the brink of the falls, and the falls themselves.

The Rocks that Form the Falls

Outcrops of Gunflint Formation rocks exposed at the southeast corner of the parking lot adjacent to Highway 11&17 offer visitors an excellent opportunity to examine the layer that forms the Kakabeka Falls precipice. The lower part of the outcrop consists of thin-bedded, platy, fissile black shale which breaks up easily *(Photo 29)*. The powdery white deposits that highlight the boundaries between some of the beds formed when water flowing through the rock dissolved some of the minerals in it, seeped out along the bedding planes, and evaporated. The dissolved minerals were left behind as delicate white grains.

In marked contrast to the shales is the massive unit which caps the outcrop. It is made up of bands of brown chert-carbonate and black chert, and is so hard that it can't be scratched with a knife. Layers can still be seen within the sediments, along with slump structures and other deformation features formed before the rock solidified. Unlike the shales, the chert-carbonate does not break apart along the layers, and there is no evidence that water flows along the boundaries between the beds in this unit.

These two rock types, and their different response to the scouring action of rushing water, are the reason Kakabeka Falls formed. You are asked to not take samples from this outcrop or damage it in any way, so that it will be available for future visitors to study and enjoy.

The Waterfall

Having a width of over 60 metres (200 feet) at its crest, and a near-vertical drop of 39 metres (128 feet), there is no doubt that

– Kakabeka Falls –

The Indian "Legend of Greenmantle" tells of an Ojibwa princess, captured by the Sioux, who pretended to guide them to her tribe, and instead guided them straight over the falls.

Her peace-loving father, the chieftain White Bear, learned that the Sioux were about to attack his tribe. Too old to go to battle, he was greatly distressed. This led his daughter, Princess Greenmantle, to devise a plan. She paddled her canoe upstream, well above the waterfall, and walked into the camp of her enemies. They captured her and planned to put her to death. Pretending to be lost and frightened, she bargained with them to spare her life. In exchange, she agreed to lead them to her camp.

The next morning, the young Princess was placed in the lead canoe and the great band of Sioux set out. They turned the bend of the swiftly flowing river, and were plunged into the great gorge of the falls. The Princess lost her life, along with the Sioux warriors, but she spared her tribe. Now it is said that the spirit of Greenmantle lingers in the mist as a rainbow, a monument to her courage, while the voices of the angry warriors cry from the roaring waters below.

PHOTO 30: The bed of resistant chert-carbonate rock at the brink of Kakabeka Falls has protected the underlying shales, and prevented them from being eroded.

Kakabeka Falls is aptly nicknamed "Niagara of the North". Like Niagara Falls itself, it is a typical example of a waterfall that has developed where easily-eroded rocks are fortified by hard, resistant material in the riverbed.

Here, the rocks are flat-lying sediments; a thick sequence of soft, black shale and tuff is protected by a thin layer of resistant chert-carbonate. The chert-carbonate layer is about 0.6 metres (2 feet) thick where exposed at the lip of the falls *(Photo 30)*, and is the same layer as the one exposed at the top of the outcrop alongside the parking lot.

Had the shales been the only rock present, the original waterfalls would have been destroyed early in the river's history, for the running water would have scoured out the river bottom to produce a bed sloping gradually towards Lake Superior. The chert-carbonate layer above the shales, however, prevented the scouring from taking place.

Because the underlying shales wear away at a faster rate than the chert-carbonate, the latter tends to be preserved as a projecting lip, thereby maintaining the sheerness of the escarpment. This escarpment was originally much closer to Lake Superior, but, through the gradual erosion of the shales and the attendant undercutting and piecemeal collapse of the cap rock, it receded slowly upstream, leaving a deep gorge downstream to mark the watercourse. Of special interest in this regard is that, when the site of the falls was somewhere to the southeast, the river was wider. It slowly wore down the bedrock above the receding falls. This reduced the cap-rock's thickness and formed the lower terrace in the park above the gorge.

Kakabeka Falls to Highway 102

North of Kakabeka Falls, Highway 11&17 passes over more deposits of sand, gravel, and silt left by the ancient Kaministiquia River, and by post-glacial lakes. In places, small outcrops of Archean granite and metavolcanic rocks poke through the blanket of sediments. About 6 kilometres (4 miles) north of Kakabeka Falls, however, the character of the sand, gravel, and silt begins to change.

PHOTO 31: Glacial till is typically made up of pebbles, cobbles and boulders that were plucked from the bedrock crossed by the advancing ice sheet, and mixed with a featureless matrix of clay, silt, and sand.

Chaotic Glacial Debris

Here are deposits left behind at the edge of a melting glacier. A lobe of the ice sheet advanced to the west and southwest across the area approximately 11,500 years ago, and, about 1,300 years later, began to melt away. For a while, the body of ice pushed forward at about the same rate as its leading edge melted back. The huge volumes of debris carried forward by the ice were dumped where the ice melted, much as material carried along by a conveyor belt forms a pile where the conveyor belt ends.

The debris left by the glacier formed a long, narrow band with hummocky topography. Today, the band is known as the Marks Moraine. It consists of a 1.6 to 4.8 kilometre (1.0 to 3.0 mile) wide belt of gritty till *(Photo 31)*. The till dries to a light reddish brown colour, as a result of material eroded from the Gunflint and Rove formations that is incorporated within it. Other glacial features including kames—hummocky domes of sand and gravel formed when sediment-laden meltwater flowed into a crevasse or poured off the edge of the melting ice—are also found in the area.

The Marks Moraine, along with other nearby glacial deposits, was at least partially overridden by minor readvances of the ice sheet in the area. These modified the existing features, and in places deposited a layer of clayey till, this time with a pinkish red colour. In addition, meltwater channels and the Kaministiquia river cut across all these deposits, changing them even more.

Sistonens Corners

The junction of highways 11&17 and 102, at Sistonens Corners, lies north of the Marks Moraine. Glacial meltwaters ponded by the edge of the ice sheet and the moraine formed glacial Lake Kaministiquia here about 10,200 years ago. The sediments now found in the area were deposited in the lake, or were left behind by fast-flowing streams when the Kaministiquia River breached the moraine, and the glacial lake drained. The gravel being extracted from the large deposit 7.1 kilometres (4.4 miles) east of Sistonens Corners comes from an ancient channel of the Kaministiquia River.

Highway 102 to Thunder Bay

Between 8.5 and 11.5 kilometres (5.3 and 7.2 miles) east of Sistonens Corners, Highway 102 crosses over the eastern extension of the Marks Moraine. The features which can be seen in it here are much the same as those seen farther west from Highway 11&17.

Less complex glacial deposits cover the area between the edge of the Marks Moraine and the city of Thunder Bay. They consist of a discontinuous layer of gritty silt till, called "ground moraine", that was left behind as the glaciers moved across the country. Hills and valleys in the ground moraine tend to reflect the topography of the underlying bedrock. Here the ground moraine is draped over knolls of highly resistant rock. In places, the knolls protrude as outcrops; in places they are covered. West and east of Highway 589, Archean granitic and metavolcanic rocks can be seen in the outcrops which poke through the till, while near the junction of Highway 589, the less resistant bedrock of the Gunflint Formation is covered.

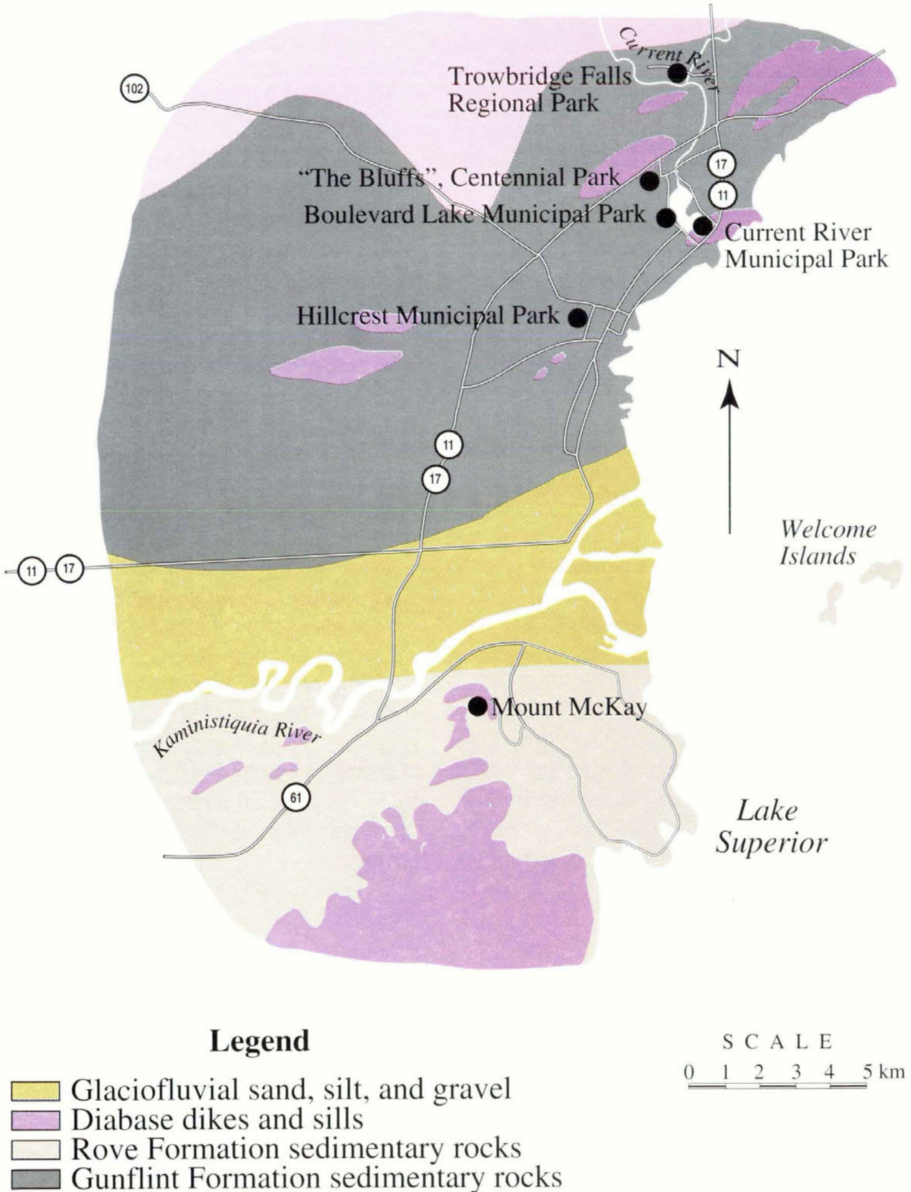


FIGURE 9: Generalized geology of the City of Thunder Bay area. Local parks where features of geological interest can be seen are indicated on the map.

Thunder Bay and Vicinity

TRIP 3

The former cities of Fort William and Port Arthur, and the surrounding municipalities were incorporated for administrative purposes on January 1, 1970, to form the city of Thunder Bay. The city lies on the western shores of the magnificent bay of the same name. The port of Thunder Bay—with its 17 elevators—is the largest grain port in the world, shipping over 600 million bushels of grain each year.

Numerous interesting geological features can be seen at Thunder Bay. Outcrops of a number of rock types are exposed at city parks, glacial features can be seen throughout the city, and massive landforms reflecting different degrees of erosion of different rock types provide dramatic scenery visible from several viewpoints in the city *(Figure 9)*.

The Kaministiquia Delta

One of the most notable features of the southern half of the city of Thunder Bay is

PHOTO 32: Early traders took advantage of the flat terrain and easy water access when they built their impressive trading post, Fort William.

the extreme evenness of the land upon which it has been built *(Photo 32)*; it is on the forefront of a huge delta. Deltas form where rivers laden with sediment flow into bodies of standing water such as lakes. The rate of flow is checked, and the material being transported is dropped rapidly from suspension and settles near the river's mouth to form a triangular-shaped piece of land. The land is called a "delta" because of its resemblance to the Greek letter Δ.

The delta at Thunder Bay was formed by the Kaministiquia River and its precursors. It extends inland, to and beyond the village of Stanley, a distance of over 25 kilometres (16 miles), and is the largest and most impressive delta found along the north shore of Lake Superior.

The delta deposits are chiefly sand, silt and clay. They were laid down at the mouth of the ancestral Kaministiquia River thousands of years ago, when the level of Lake Superior was higher. With the lake lowered to its present level, the Kaministiquia River is now cutting deeply into these old deposits, forming an entrenched channel. It is also contributing material to help build up a new delta that includes the two small islands at the mouth of the river. Other evidence of the change of water level within the Lake Superior basin can also be seen elsewhere in the city.

Hillcrest Municipal Park

Hillcrest Park, located on High Street between Oliver and Red River roads, stands about 50 metres (160 feet) above the level of Lake Superior. As its name implies, it is at the top of a steep embankment, so affords a splendid panoramic view of the waters and harbour of Thunder Bay, and of the city itself.

Along the escarpment at the park are outcrops of limestone. This limestone is a peculiar fragmental rock; it is made up of numerous small, rounded to angular pieces of chert in a matrix of coarsely crystalline iron-bearing carbonate. Interrupting it at close intervals are thin layers of chert. In places, these layers separate and join in an irregular manner, enclosing lenticular masses of limestone. When traced for any distance, however, they are found to be persistent, crudely parallel bands, and it is probably that they represent an original sedimentary stratification. The fragmental character of the limestone and the irregular chert layers are best observed in outcrops beneath the footings of the flagpole at the middle of the park, beneath the bell at the south end of the park, and in the small outcrops in areas which have not been landscaped downslope from these monuments (*Photo 33*).

Because the limestone is exposed along the escarpment, it might be assumed that it controls the nature and height of that feature. However, the limestone trends northeast at a slight angle to the escarpment, and dips or slopes 20 degrees southeast, or toward Lake Superior, opposite to the direction one might anticipate!

The clue to origin of the escarpment lies in the fact that it separates two terraces. The upper terrace is of water-lain sand; the lower terrace is an old beach. They formed when, after the glaciers that once covered the area melted, the waters of Lake Superior stood higher than they do now. The escarpment is a cliff formed largely by wave action along an old shoreline after the lake level had dropped to the elevation of the lower terrace. This cliff can now be traced almost 4 kilometres (2.5 miles) to the northeast to Current River Park.

The Welcome Islands and The Sleeping Giant

Directly in front of Hillcrest Park, and 4.8 kilometres (3.0 miles offshore) are the Welcome Islands. To the left of the Welcome Islands, commanding the entrance to Thunder Bay, is the 335 metre (1,100 foot) high Sleeping Giant, the part of the Sibley Peninsula so named because of its superficial resemblance to a reclining human figure *(Photo 34)*. To the right some 19 kilometres (12 miles) away is Pie Island, with a crudely circular, pie-shaped hill at its west end. Between Pie Island and the Sleeping Giant, and more than 50 kilometres (31 miles) away, Isle Royal in the State of Michigan can be seen on a clear day. On the extreme right is Mount McKay and the range of hills known as the Nor'westers, which stretch toward Pigeon River and the International Boundary.

The Welcome Islands are made up of sedimentary rocks of the Rove Formation. They slope gently to the southeast and form outcrops that attain elevations of almost 30 metres (100 feet) above the lake. Rocks of the Rove Formation also underlie the Sleeping Giant, Pie Island, and Mount McKay. In all these places, however, the sedimentary rocks are overlain and protected by cappings of diabase. Together they form large, flat-topped, steep-sided hills, rising hundreds of metres (feet) above the lake.

PHOTO 33: This unusual fragmental limestone with discontinuous thin layers of white chert is exposed downslope from the flagpole at Hillcrest Municipal Park.

Of particular interest is the Sleeping Giant, in which can be seen four flat-topped mesas known, from north to south, as the Head, Adam's Apple, Breast, and Triangle. A fifth mesa, Thunder Mountain, lies east of the Breast and Triangle, but is not visible from Hillcrest Park. On the west side of the Sleeping Giant, facing the city of Thunder Bay, is a sheer cliff about 245 metres (800 feet) high. This cliff is the highest in Ontario!

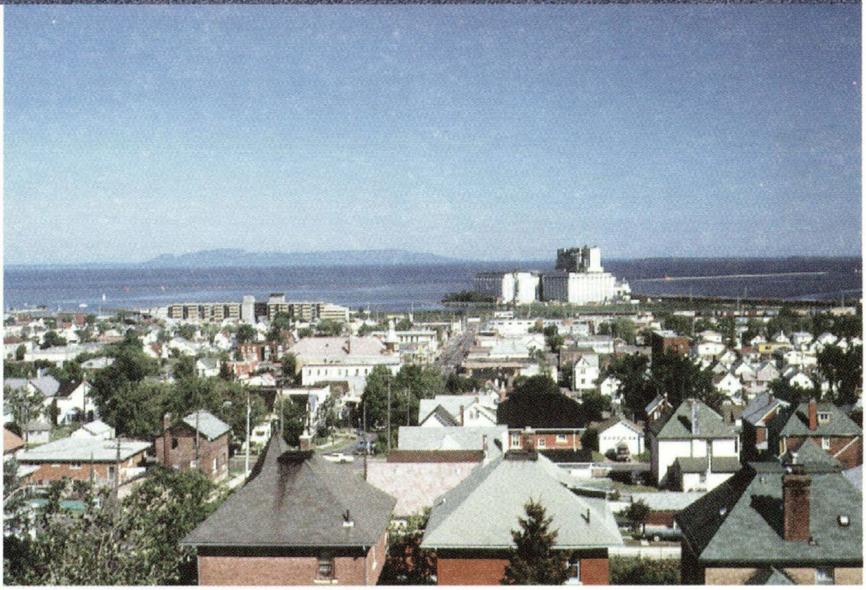


PHOTO 34: **The view from Hillcrest Park encompasses two of Thunder Bay's most famous landmarks, the Sleeping Giant, and some of its giant grain elevators.**

The Parks of the Current River

A series of parks lines the banks of the Current River in the city, from north of the Thunder Bay Expressway (Highway 11&17) to the shore of Lake Superior. Run by the municipal government or by service groups, each of the parks has its own special geologic and scenic features to offer the visitor.

Trowbridge Falls Regional Park is farthest upstream of the parks of the Current River. Its entrance is from Copenhagen Road, 2.0 kilometres (1.3 miles) north of the junction of highways 11&17 (Thunder Bay Expressway) and 11B&17B (Hodder Ave.) with Copenhagen Road. Centennial Park, Boulevard Lake Municipal Park, and Current River Municipal Park all lie south of Highway 11&17. They can be reached by travelling south on Hodder Ave. (Highway 11B&17B) for 1.7 kilometres (1.1 miles) from Highway 11&17, and then turning west on Arundel Street. Note that Hodder Avenue leads across a series of terraces immediately south of its junction with Highway 11&17. These terraces are, like the one at Hillcrest Park, remnants of a time when the waters of Lake Superior were higher than they are at present.

Trowbridge Falls Regional Park

Trowbridge Falls Regional Park was established in 1957 by the Kinsmen Club of Port Arthur as a community recreational site. It offers tent and trailer camping in a birch and pine forest, many walking and hiking trails (including one which leads south to Centennial Park), and swimming in the pools and cascades of the Current River.

The Formation of the Falls

Two small but scenic waterfalls occur about 300 metres (1,000 feet) apart along the Current River in the park. At each of the falls, the river does not tumble over a single escarpment, but rather drops over the ends of a number of flat ledges up to 1.5 metres (5 feet) in height. Unlike most waterfalls, however, these are not due to the protection of soft, easily eroded rocks by other, more resistant ones. Some of the flat ledges are capped by thin layers of carbonate, and others are capped by beds of shale or chert.

Because the bedrock splits easily along the flat bedding and is interrupted in places by vertical cracks or joints that extend across the outcrop, and because the river water readily works itself into these cracks and widens them, blocks of rock are removed from the stream bed. When the blocks are removed, small vertical cliffs are left behind, and a low waterfall is initiated. In the step-like cascades in Trowbridge Falls Park *(Photo 35)*, the treads of the individual steps are flat layers of rock, and the risers are the cracks or joints.

The Thin Edge of the Wedge

The rocks at Trowbridge Falls Park are part of the Gunflint Formation, the older of the two formations that make up the Animikie Group. Together with the Rove Formation, the Gunflint Formation forms a thick prism of 1.85 to 2.10 billion-year-old sedimentary rocks that laps onto the much older rocks of the Superior Province. It could be said that the rocks at Trowbridge Park form the "thin edge of the wedge" of Animikie Group rocks, for the Archean rocks of the Superior Province emerge from under their blanket of Animikie Group rocks just 1.0 kilometre (0.6 miles) north of the park!

The dip of the rocks themselves, and the slope of the topography of the region north of Boulevard Lake combine to present a section through the Gunflint Formation that moves deeper into the sequence the farther south one proceeds.

At the upper falls, rusty carbonate beds alternate with thin layers of chert. They mark the base of the chert–carbonate member of the formation. At the lower falls, approximately 300 metres (1,000 feet) downstream and lower within the sequence of rocks, dark coloured, fine-grained, and thin-bedded shale makes up about two-thirds of the exposure, while interbeds of rusty-weathering carbonate make up the remainder. Because

PHOTO 35: The lower falls on the Current River at Trowbridge Falls Park form a step-like cascade due to the vertical joints that cut the flat-lying beds of Gunflint Formation sedimentary rocks.

the brown surfaces of the carbonate beds contrast sharply against they dark shales, they are easily recognized in the outcrops. The bedrock at the south end of the park is from deeper still within the sequence of rocks. It is mainly gently-dipping shale, and is typical of the area, being dark coloured, fine-grained, and thin-bedded. Thin beds of

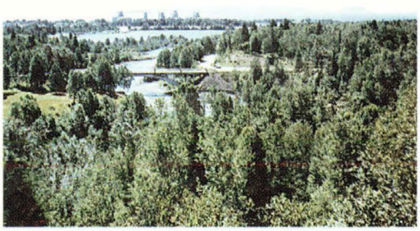


PHOTO 36: The view from the lookout at Centennial Park looks downstream along the Current River past Black Bay bridge to Boulevard Lake. Sleeping Giant and Pie Island are visible offshore.

iron-bearing carbonate are present at only widely spaced and irregular intervals.

Centennial Park

Located along the shores of the Current River north of Arundel Street, Centennial Park covers 343 hectares (847 acres) of natural wilderness. A feature attraction is a 1910 logging camp with rebuilt blacksmith shops, bunkhouse, saunas and camp cookery (restaurant). There's also a log playground, a barnyard full of animals, and a logging museum with a fine display of logging artifacts dating from the turn of the century. Access to the logging camp is by way of Centennial

Park Drive, which leads north from Arundel Street, approximately 300 metres (0.2 miles) east of the Current River.

– Sleeping Giant –

This unusual rock formation is surrounded by mystery and legend. It is said to be the Ojibwa Spirit of the Deep Sea Water, Nanabijou. One day, Nanabijou scratched a rock and discovered silver. Frightened for his people, he made them bury the silver, and swear never to reveal its whereabouts. He warned that if the white man ever found out about it, he would be turned to stone.

The secret was out when vanity got the best of a chieftain who made himself silver weapons, and was killed soon after in a battle with the Sioux. A Sioux scout, disguised as an Ojibwa, learned the location of the mine. A few days later, Nanabijou saw the scout canoeing across the lake, leading two white men to the silver. To save the secret, Nanabijou raised a terrific storm that drowned the white men and crazed the Sioux scout. Nevertheless, he was turned to stone, and today lies, majestic in his repose, across what was once a wide opening to the bay.

Separate from the logging camp, but still within Centennial Park, is a lookout which offers a superb view of Boulevard Lake, the city, and the waters of Thunder Bay, and the best view of the Sleeping Giant available in the area *(Photo 36)*. Lower-lying portions of the Sibley Peninsula, and the Welcome Islands and Pie Island can also be seen from this vantage point.

The lookout is at the top of a local landmark called "The Bluffs", and can be reached by way of a short road which leads north from Arundel Street, just west of the Current River. The Bluffs are formed by a cliff about 27 metres (90 feet) high. As many of the other flat-topped hills in the area are, this one too is made up of shales of the Rove Formation overlain and protected from erosion by a layer of diabase. The 8 metre (25 feet) thick diabase sill is flat-lying, and forms the prominent ledge which caps the hill.

Boulevard Lake Municipal Park

Boulevard Lake Municipal Park is a spacious park of 263 hectares (650 acres) surrounding Boulevard Lake at the northeast end of the city of Thunder Bay. The park extends south from Arundel Street to the dam on the lower Current River. It was established as a "park drive" in 1913. Now it also offers walking and biking trails, picnic areas, and two beaches for swimming. An early feature in the park was the Black Bay bridge on Arundel Street; a reinforced concrete span bridge built in 1911, it was the first of its type in North America.

Outcrops of Gunflint Formation rocks can be seen along the east bank of the Current River, below and near the Black Bay bridge at the north end of Boulevard Lake. They are older, and hence occur lower within the sedimentary sequence, than the rocks exposed at Trowbridge Falls Regional Park. Near the bridge, they slope north, but farther south, they slope gently south. The youngest rock exposed at Boulevard Lake Municipal Park is shale; it is found just north of the Black Bay bridge. Downstream towards Boulevard Lake, the river cuts deeper and deeper into the sequence, through rocks occurring progressively lower in the stratigraphic section. The oldest rock exposed is a dark green, thick-bedded rock called taconite; it is found along the river bank below the low falls at the south end of the rapids, about 150 metres (500 feet) south of the bridge.

An Unconformity Exposed

The contact between the shale and the underlying limestone is worthy of special note. Exposed on the east side of the riverbed just north of the bridge, it records a break in the deposition of the sequence. The upper surface of the limestone is hummocky, while the layers in the shale resting upon it tend to conform to the irregularities of the surface, and undulate gently.

The hummocky surface is referred to by geologists as an unconformity. It represents an interruption in the deposition of the sedimentary rocks in this locality, and indicates that a period of uplift and erosion took place after the limestone formed but before the mud that ultimately formed the shale was deposited. It is easy to recognize here, as the lowermost 20 centimetres (8 inches) of the shale are particularly rusty-weathering, while the shale farther above the unconformity is black and has flat, platy layers.

Some unconformities represent breaks in time of hundreds of millions to billions of years. This one likely represents a fairly short period of time, however, as no unconformity can be seen in other areas at the equivalent level within the formation.

Transition Zones

Instead of having unconformities marking breaks in their depositional history, some sequences of sedimentary rocks record continuous deposition. In places, they contain sections between rocks of two different types where the two types are interbedded. These sections are called "transition zones".

At Boulevard Lake Municipal Park, a transition zone between the limestone and the underlying taconite is exposed south of the bridge *(Photo 37)*. In it, the limestone is interrupted by small lenses and thin layers of taconite and chert that stand up in relief on exposed surfaces, and form conspicuous irregular-shaped patches (*see* Photo 9). As the limestone is iron-bearing like the taconite, it reacts to form the brown hydrous iron oxide mineral limonite when exposed to the atmosphere. The characteristic rusty weathered surfaces of the limestone are in sharp contrast to the grey of freshly-broken rock. This transition zone is comparable to the one higher in the Gunflint Formation that can be seen between the lower and upper falls at Trowbridge Falls Regional Park. There, a gradational contact between a chert-carbonate unit and shale is exposed.

Iron-Rich Rocks

Taconite, an unusual iron-rich rock and the oldest part of the Gunflint Formation exposed at Boulevard Lake Municipal Park, can be seen about 150 metres (500 feet) south of the bridge. Its principal distinguishing feature is its granular texture, best seen when the rock is examined through a magnifying glass or hand lens. This granular texture is due to the presence of innumerable tiny rounded bodies or granules made up largely of iron-bearing minerals, chiefly greenalite. It makes up a large part of the Gunflint Formation. In the states of Minnesota, Wisconsin, and Michigan, where the Gunflint Formation and its equivalents are thicker than they are in Ontario, the taconite has been the basis of extensive iron-mining industries for many years.

PHOTO 37: Rusty-weathering chert–carbonate rock, exposed along the banks of the Current River south of the Black Bay bridge, marks the transition from taconite to limestone within the Gunflint Formation.

PHOTO 38: At Current River Municipal Park, the Current River flows over a sill of diabase. Because the diabase is broken by flat-lying and vertical joints, the falls are steplike.

Current River Municipal Park

Current River Municipal Park is located along the shores of the Current River, south of Boulevard Lake. Cumberland Street (Highway 11B&17B) crosses the park near the north end of the city of Thunder Bay. There are two features of geological interest in Current River Municipal Park; the southeast-facing embankment that crosses Gibson Avenue 0.1 kilometre (330 feet) north of Cumberland Street and extends northeast behind the park nursery, and the river bed downstream from the dam at the south end of Boulevard Lake.

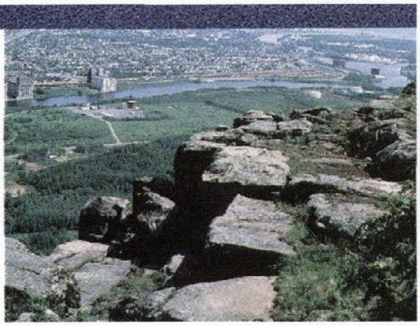


PHOTO 39: A resistant diabase sill caps Mount McKay, south of Thunder Bay. Panoramic views of the city, the Kaministiquia River, and its delta can be had from lookouts at the top of the mountain.

The southeast-facing embankment is an old shore cliff, continuous with the one at Hillcrest Park. There are, in fact, several such shore cliffs in the city of Thunder Bay. They separate abandoned beaches, the highest of which has an elevation of 72 metres (235 feet) above the present lake level. The shore cliff in Current River and Hillcrest parks is the most prominent. It separates terraces having elevations of 26 metres (85 feet) and 18 metres (60 feet) above the current lake level, and can be traced across the city and beyond for a distance of more than 27 kilometres (17 miles).

Below the dam, the Current River drops about 12 metres (40 feet) in a horizontal distance of 180 metres (600 feet). Here the bedrock is diabase. The diabase is interrupted by a large number of cracks or joints. The most prominent are vertical; others are flat-lying or dip gently to the south. They cause the rock to break into rectangular-shaped blocks. Because of this, the surface of the bedrock is steplike rather than of uniform slope, and when water is released below the dam, it tumbles over a series of flat ledges, forming a rather pretty cascade *(Photo 38)*. When the water is held back by the dam, the diabase forms an impressive broad natural pavement with a series of shallow steps marking the cracks or joints which cut it.

Mount McKay

South of the city of Thunder Bay, on Fort William Indian Reserve No. 52, Mount McKay towers about the Kaministiquia River delta. It rises to a height of about 500 metres (1,600 feet) above sea level, or about 300 metres (1,000 feet) above Lake Superior. A large mesa, Mount McKay is made up of shale and greywacke of the Rove Formation, overlain by a hard, protective capping about 60 metres (200 feet) thick of diabase.

The diabase capping is the erosional remnant of a flat sheet or sill that once extended without interruption across the entire area. A second sill, about 5 metres (15 feet) thick, also an erosional remnant, is found in the Rove Formation sedimentary rocks about 60 metres (200 feet) below the first sill, and about 120 metres (400 feet) below the top of the hill. Like the upper sill, it is also more resistant to erosion than the enclosing sedimentary rocks; it forms the base of a wide and prominent terrace.

Fort William First Nation has developed a lookout park on the terrace. There is also an easy hiking trail from the lookout park to the top of the mountain. Access is from City Road, via Highway 61B. Both vantage points offer visitors a magnificent view of the city of Thunder Bay and the extensive delta of the Kaministiquia River on which the city is built *(Photo 39)*.

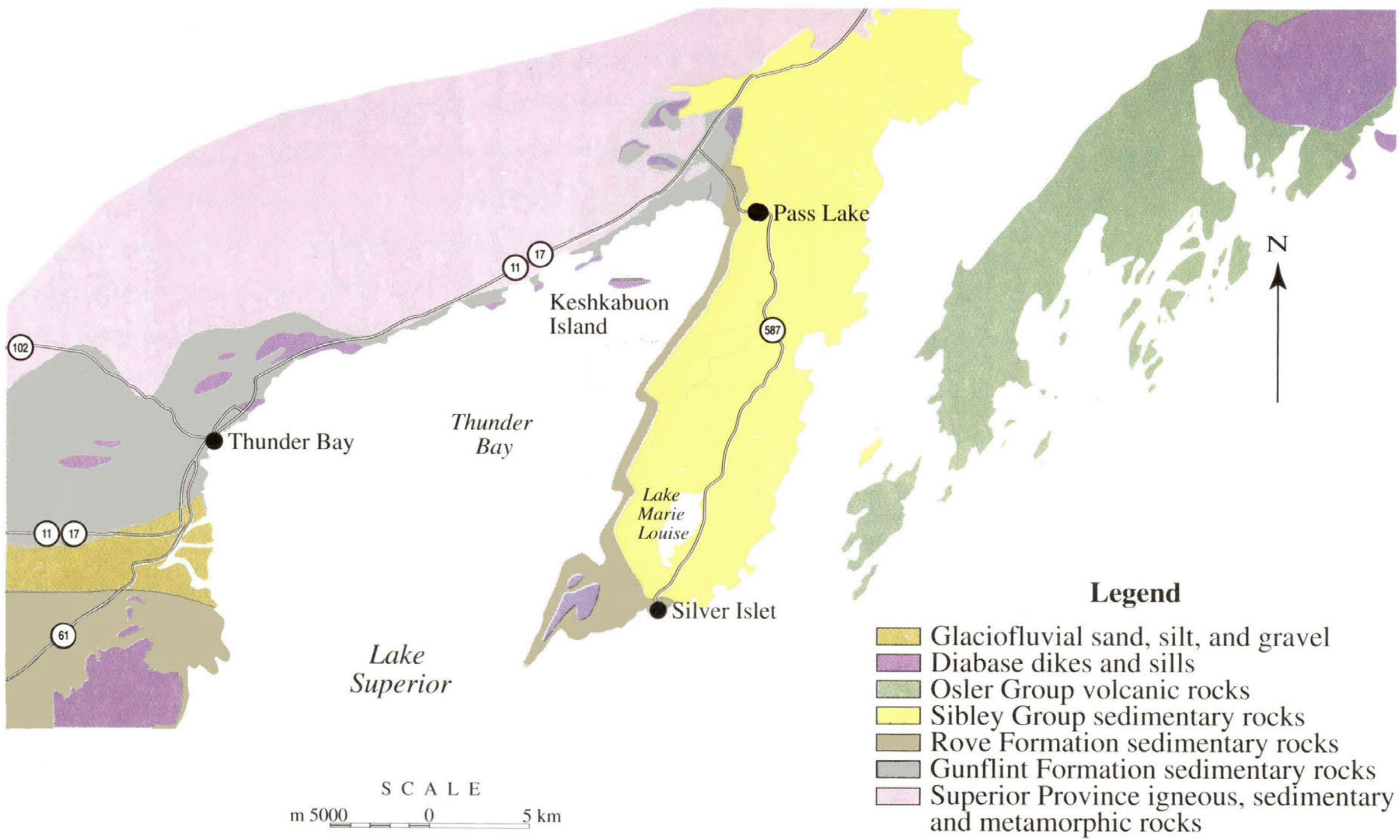


FIGURE 10: Generalized geology of the Thunder Bay–Silver Islet area. A wide variety of geological features can be seen along highways 11&17 and 587.

Thunder Bay to Silver Islet

TRIP 4

The area between Thunder Bay and Silver Islet offers some spectacular scenery, including one of Ontario's most famous landforms, the Sleeping Giant. It also has excellent exposures of the sedimentary rocks of the Animikie Group (made up of the Rove and Gunflint formations) and the Sibley Group (made up of the Pass Lake, Rossport, and Kama Hill formations), and outcrops of the 1.11 billion-year-old diabase sills which dominate the Thunder Bay region *(Figure 10)*. In addition to all of that, it has one of the most important sites in the province's early mining history.

Terry Fox Monument

A breathtaking view overlooking the Sleeping Giant and the waters of Thunder Bay greets visitors to the Terry Fox Monument. The monument is located adjacent to the Visitor Information Centre 1.1 kilometres (0.7 miles) east of the junction of Highway 11&17 with Highway 11B&17B. It was built to honour Terry, the courageous young Canadian who raised money for cancer research by running half way across the country after losing his leg to the disease. He was forced to end his "Marathon of Hope" very near here when his cancer returned. Terry died on June 28, 1981. A Terry Fox Run is now held annually in his honour in communities across Canada, raising many millions of dollars for cancer research.

PHOTO 40: The massive light brown diabase that caps the hill at the Terry Fox Monument cuts the layered sedimentary rocks in some places, and intrudes between the layers in others.

The monument is also a showcase for Ontario building stone. The 2.7 metre (9 foot) high bronze rendering of Terry is mounted on a 41 tonne (45 ton) base of grey granite, over a foundation containing local amethyst. Paving stones along the walkway leading to the monument are of red granite from Vermilion Bay.

An Intrusive Contact

The monument itself is not the only feature of geological interest at this location, however. The bluff on which the Visitor Information Centre is built is underlain by a diabase sill which, like the sills capping other landmarks in the area, such as Mount McKay and the Sleeping Giant, has resisted erosion. The contact between the sill and the sedimentary rocks of the Gunflint Formation that it intrudes can be seen along Highway 11&17 at the junction with the access road to the site.

In this excellent exposure, magma has forced its way between the layers of thin-bedded black and grey chert and siltstone of the Gunflint Formation and cooled to form massive brown diabase. The shrinkage cracks typically found in diabase in the area can be seen here, cutting across the sill and breaking the rock into columns.

The strict definition of the term "sill" requires that the intrusive rock forms a sheet parallel to the layers of the rocks which enclose it. Here, close examination of the contact shows that in places the diabase has cut across the sediments at a very low angle and truncated some of the layers of chert and siltstone *(Photo 40)*. Elsewhere in the outcrop, though, the contact and the layers are parallel. The overall placement of the diabase and sediments is such that most geologists would consider it to be generally conformable to the enclosing rocks, and hence a "sill", rather than a crosscutting body, or a "dike". The local penetration of the Gunflint Formation by the diabase, however, clearly emphasizes that the diabase crystallized from an igneous magma.

Keshkabuon Island

Noteworthy among the many physiographically striking islands in Lake Superior is Keshkabuon (Caribou) Island in the northern reaches of Thunder Bay. The best viewpoint of the island is at Perry Point, bounding Amethyst Harbour on the east. Perry Point can be reached by the east branch of the Amethyst Harbour Road, which intersects Highway 11&17 about 22 kilometres (14 miles) north of Thunder Bay's city limits, and 10 kilometres (6 miles) south of Highway 587.

The island lies about 1.5 kilometres (0.9 miles) south to southeast of the point. It is composed principally of diabase. The diabase is the erosional remnant of a large flat-lying sheet, which, like the ones at Mount McKay, intruded gently dipping shales of the Rove Formation. Its principal characteristic is that it exhibits numerous cracks or joints, which stand upright and bound thin columns of rock *(Photo 41)*.

These cracks, called columnar joints, formed when the diabase shrank as it solidified and cooled. Contraction cracks form at right angles to the boundaries of a sheet of diabase. Since they change in attitude at the west end of the island, it is apparent that the diabase cuts obliquely across the strata of the Rove shales there. This is a strictly local exception from the rule that in general, diabase sheets in the region are parallel to the stratification of the older sedimentary rocks, and thus formed as sills.

Sibley Peninsula

The Sibley Peninsula, projecting into Lake Superior from its north shore, is a large land mass 52 kilometres (32 miles) long and 10 kilometres (6 miles) wide. It separates Thunder Bay on the west from Black Bay on the east. Except for diabase dikes and for the large diabase sill forming the upper part of the Sleeping Giant near the southern tip of the Sibley Peninsula, the peninsula is underlain entirely by layered sedimentary rocks.

The sedimentary rocks strike northeast and dip or slope gently, in most places at angles of 5 degrees or less, to the southeast. They form a huge cuesta, the west margin of which is a vertical escarpment rising in places to as much as 137 metres (450 feet) above the level of Lake Superior. This cuesta is

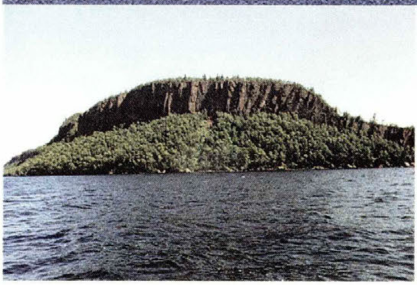


PHOTO 41: Keshkabuon (Caribou) Island has excellent exposures of diabase with columnar joints that are perpendicular to the upper and lower margins of the diabase sheet.

made up of two sequences of sedimentary rocks of the Southern Province, the 1.85 to 2.10 billion-year-old Animikie Group, and the overlying 1.34 to 1.54 billion-year-old Sibley Group.

The Animikie Group

The Animikie Group, at the bottom of the stratigraphic section, is represented by the Gunflint Formation and the overlying Rove Formation. The Gunflint Formation is approximately 130 metres (425 feet) thick. It consists of a unit of conglomerate, chert, and iron formation, overlain by a middle unit of argillite, carbonate and chert, and an upper unit of thin-bedded chert and iron-bearing carbonate. The formation is particularly interesting because of the presence of very old fossil algae found in beds of the lower chert horizons, and because of the importance of its iron-rich layers as a possible source of iron ore.

The Rove Formation consists of a lower sequence of black shales, which grades upward into shales interbedded with greywacke. The Formation is approximately 500 metres (1,650 feet) thick north of the Sibley Peninsula, but thickens southward to approximately 1,000 metres (3,300 feet) in Minnesota. Sedimentary structures in the Rove Formation suggest that it was deposited by turbidity currents flowing southeast, downslope along the sea floor, away from an ancient ocean shoreline.

PHOTO 42: Breccia exposed in an outcrop along Highway 587 consists of broken and jumbled fragments of white chert in a matrix of rusty-weathering carbonate.

The Gunflint Formation—Bent and Broken

Rocks of the Gunflint Formation are exposed in several outcrops along Highway 587. One particularly interesting rock cut is found along the east side of the highway, 1.3 kilometres (0.8 miles) southeast of the intersection of Highway 587 with Highway 11&17. Here, the formation consists of thin alternating beds of dark green to grey, rusty-weathering carbonate and pale grey to white beds of chert. Whereas most of the rocks of the Gunflint Formation in the area are relatively flat-lying, these have been somewhat deformed. The chert layers have been broken or brecciated, while the carbonate beds have squeezed into the spaces between the fragments of the ruptured chert layers.

Various degrees of deformation in both rock types can be seen in the outcrop. Near the north end of the outcrop, the beds strike to the northwest and dip or slope 30 degrees to the northeast. The effects of deformation increase to the south, where the rock has been folded, and displays a series of anticlines and synclines with amplitudes of several metres. Several quartz-calcite-barite veins have developed in fractures parallel to the axial planes of the folds. The degree of deformation increases even more close to the south end of the outcrop. At one point, the beds are vertical. At the extreme south end of the exposure, the rock has been broken into a chaotic breccia with layered chert-carbonate blocks up to 30 centimetres (12 inches) across lying at every orientation *(Photo 42)*.

The remarkable difference between what happened to the chert and the carbonate beds during deformation reflects the different ways in which the two types of rock respond to stress: chert behaves in a brittle fashion and breaks; carbonate rock behaves in a plastic fashion and "flows". This "flow" may take place by movement along minute fractures and crystal glide planes within individual mineral grains. It may take place by recrystallization or by partial dissolution followed by reformation of crystals in response to pressure. Or, it may take place by a combination of the two.

Evidence such as the deformation in this outcrop and in other outcrops within a few kilometres (miles) of this site suggest that fault zones cut the rocks in the area. One such fault zone is thought to lie under the north-south bed of the nearby Blende River.

Rocks of the Rove Formation

Rove Formation shale can be seen in a small overgrown quarry on the east side of Highway 587, 3.5 kilometres (2.2 miles) southeast of the intersection with Highway 11&17. There, it is thinly laminated and highly fissile, and black in colour due to the presence of carbon. At irregular intervals in the area, large concretions up to 3.5 metres (11.5 feet) in diameter can be found. They are similar in many ways to those found in outcrops of the Rove Formation northwest of the city of Thunder Bay (*see* Photo 27).

At Silver Islet Landing, the Rove Formation consists of somewhat harder slaty rocks interbedded with relatively thick layers of massive brown greywacke.

The Sibley Group

Sedimentary rocks of the Sibley Group overlie those of the Animikie Group, and form the bedrock of most of the Sibley Peninsula. The rocks of this group are exposed continuously in the escarpment extending along the west side of the peninsula.

Three formations make up the Sibley Group. The lowermost, the Pass Lake Formation, consists of quartz sandstone, and locally derived conglomerates. It is this sandstone which forms the escarpments overlooking the waters of Thunder Bay.

The Pass Lake Formation is overlain by the Rossport Formation, a sequence of red, fine-grained, sandy to clayey dolostone. Stromatolites, or thinly laminated sedimentary rocks left behind when sticky mats of algae growing in shallow water trapped particles of sediment, can be found in the middle part of the Rossport Formation.

The Rossport Formation is in turn overlain by the Kama Hill Formation, a sequence of red shale and mudstone. The shale and mudstone contain sedimentary structures such as mud cracks. They indicate that the sediments dried out after they were deposited, and suggest that the formation was deposited in shallow water which periodically dried up.

The rocks of the Sibley Group were deposited in a fault-bounded basin. The brilliant red colour of some of the rocks of the group is taken as evidence that there was oxygen in the earth's atmosphere at the time the rocks were deposited, and that the rocks were deposited at least partly on land rather than in the sea. One interpretation of the clues supplied by the rocks of the Sibley Group is that they were deposited in a land-locked lake environment, somewhat like that of the present interior basin of Australia.

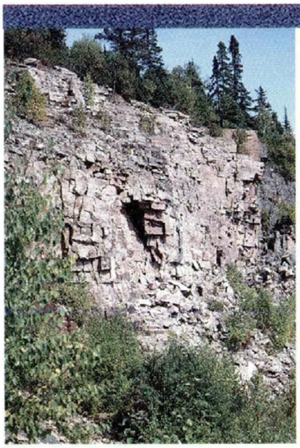


PHOTO 43: The sandstone that makes up the quarry wall at Pass Lake is from the lowermost part of the unit that forms the high white escarpment along the west side of the Sibley Peninsula

The Pass Lake Quarry

Good exposures of the Sibley sediments can be seen along Highway 587 at Pass Lake, where a large quarry lies north of the lake and the CNR railway tracks. This is an active railway line, so take care when crossing it or examining the rocks near it. The scarp at the quarry *(Photo 43)* is the "type section" of the Pass Lake Formation.

At the base of the scarp, partly hidden by large blocks of talus, shales of the Rove Formation are exposed. The contact between the shales and the overlying rocks is an unconformity, or break in the sequence of deposition, which here marks the more than 300 million years of erosion that took place between when the rocks of the Rove Formation, and those of the Pass Lake Formation were deposited.

Above the unconformity, there is a thin layer of conglomerate. It is exposed best behind the railroad shack. More than 90 per cent of the fragments or clasts in the conglomerate were derived from the Gunflint Formation. They range in size up to boulders, and are enclosed in a sandy matrix. The conglomerate in turn is overlain by sandstone. The sandstone is made up of grains of quartz, chert, and feldspar, and forms thick massive beds at the base of the cliff, and thin beds at the top of the cliff. This is the same sandstone that makes up the white cliffs of the Sibley Peninsula's west side.

Red Rocks

Outcrops of reddish, impure dolostones and dolomitic limestones of the Rossport Formation are exposed in the middle of the peninsula along Highway 587, for several kilometres (miles) south of Pass Lake. Gentle folds can be seen in the layered sedimentary rocks of some of the outcrops.

More outcrops of Rossport Formation rocks can be seen south of the turnoff to Thunder Bay Lookout. Here, however, the brick red to tan and grey sedimentary rocks are buttressed against erosion by dikes of rust-brown to black diabase.

PHOTO 44: Sleeping Giant Lookout, midway along the west side of the Sibley Peninsula, offers a magnificent view of Lake Superior and Keshkabuon (Caribou) Island.

Sleeping Giant Provincial Park

In 1944, the Ontario government established parts of the Sibley peninsula as Sibley Provincial Park. A large part of the peninsula has now been developed as a recreational and wilderness park, with full facilities for camping, hiking, nature study, picnicking, and swimming. The park was renamed Sleeping Giant in 1988.

While the park is centred on Lake Marie Louise, about 44 kilometres (27 miles) south of Highway 11&17 on Highway 587, its most impressive physiographic features is the Sleeping Giant. The famous landmark lies at the southwest margin of the peninsula, and is made up of erosional remnants of a diabase sill overlying Sibley sedimentary rocks.

There are numerous nature trails in the park. One, the Sawyer Bay–Sawbill Lake Trail, leads from the south end of Lake Marie Louise to the top of the "Head" of the Sleeping Giant. The Nanabosho Lookout at the "Head" provides a magnificent panoramic view of the city of Thunder Bay to the west, Isle Royale to the south, Lake Marie Louise, Black Bay and Edward Island to the east, and the whole length of the Sibley Peninsula to the north. Farther north, the Thunder Bay Lookout offers a spectacular view of Lake Superior and Keshkabuon (Caribou) Island 137 metres (450 feet) below *(Photo 44)*.

Following the dip of the Sibley Group sedimentary rocks of the peninsula, Sleeping Giant Parks's eastern lowlands rise gently from the lake. The western shore is dominated by huge cliffs over 250 metres high in places, which cut across resistant layers of the same rock. Deep valleys, sheer cliffs, and fast-running streams characterize the terrain there.

The peninsula was at one time almost completely submerged. At the end of the last Ice Age, the waters of Lake Minong—ancient Lake Superior—were more than 60 metres (200 feet) higher than they are today. Many traces of the beaches left by this ancient lake can still be found among the park's hills.

Sleeping Giant Park is renowned for its wildlife. Along the roads or the trails, visitors frequently see red fox, porcupine, and white-tailed dear. Moose and bears are sometimes seen, while sightings of wolf and lynx are less common. Remember, however, that these are wild animals. They should be viewed from a safe distance, and should not be fed under any circumstances.

As well as having abundant wildlife, the park also has a wide range, and exceptional mix of plants. It is part of the northern boreal forest, but lies in a unique position, with the result that many western and southern plants can also be found. As well, holdovers from the Ice Age, such as cloudberry, arctic bistort and butterwort grow hundreds of kilometres (miles) south of their usual arctic habitat.

The Sea Lion

Waves have great erosive power. As they pound against a shoreline, they pluck out rock fragments and hurl them back and forth. The bedrock is gradually worn away, and as the shoreline retreats landward, steep wave-cut cliffs are formed.

Such wave-cut cliffs, in places over 9 metres (30 feet) in height, have been carved into rocks of the Rove Formation along the coast west of Silver Islet Landing. In places, however, the sedimentary rocks are interrupted by vertical, east- and northeast-trending diabase dikes. Because the dikes are harder and much more resistant to erosion than are the sedimentary rocks, the dikes were left to project into the lake as thin, wall-like headlands when the sedimentary rocks were eroded away.

The most conspicuous of these headlands is called the "Sea Lion". It lies along the east shore of Perry Bay, about 1 kilometre (0.6 miles) northwest of Silver Islet Landing. One of the most interesting geological features on the Sibley Peninsula, it is a tabular mass of rock, not more than 1.5 metres (5 feet) thick. It forms a wall about 7.5 metres (25 feet) high that juts 15 metres (50 feet) into the lake. Through it, the waves of Lake Superior have cut a small tunnel *(Photo 45)*.

Silver Islet

Silver Islet, a small rock island situated 1.2 kilometres (0.8 miles) southeast of the dock at Silver Islet Landing, is the site of one of the more interesting stories in the history of Canadian mining. Today, there is little evidence, other than the village that sprang up to serve the mine, that the mine ever existed.

The islet was taken up as a mining location by Joseph Woods in 1846, but aside from an examination by W.E. Logan of the Geological Survey of Canada in the following

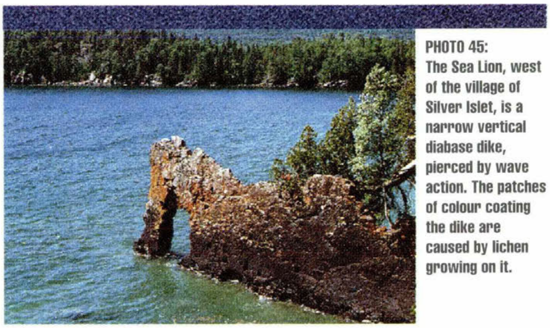


PHOTO 45: The Sea Lion, west of the village of Silver Islet, is a narrow vertical diabase dike, pierced by wave action. The patches of colour coating the dike are caused by lichen growing on it.

year, it was largely neglected for 22 years. It is worth noting that while Canadian confederation was still twenty years away at the time of Logan's visit, the Geological Survey of Canada was already 5 years old. Logan was its director and one of its three employees. At the time, less than a thousand settlers lived at Fort William and Prince Arthur's Landing, as the communities that later joined to make up the city of Thunder Bay were called.

The Discovery

There was renewed interest in the property after silver was found at, and west of, the present city of Thunder Bay in 1868, and the island was acquired by the Montreal Mining Company. Prompted by the imposition of a new mining lands tax, the company proceeded to make a systematic examination. Thomas Macfarlane was put in charge of the field party, and shortly after his arrival on the scene, silver was discovered on July 10 when his crew landed on the islet to erect a survey post.

At the time, the islet measured 25 metres (82 feet) long, and 20 metres (66 feet) wide, and rose only 2.5 metres (8 feet) above the level of the lake. Exposed on the islet was a quartz-carbonate vein over a metre (3 feet) wide, containing good values of native silver and the silver-bearing mineral argentite. The vein was located along a northwest-trending fault, where the fault cuts and displaces a diabase dike. The richness of the vein was immediately apparent. And, where the rock dropped off under water, the vein could be seen extending in both directions away from the islet.

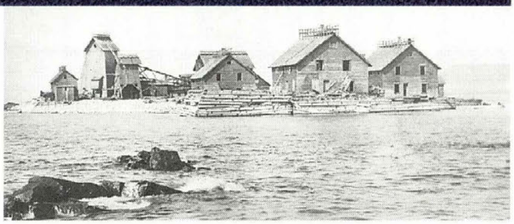


PHOTO 46: This photograph shows much of the development on Silver Islet. By the time it was taken ca. 1911, work at the mine had ceased.

The crew immediately blasted out some of the vein, using dynamite. One blast was sufficient to break up all the rich ore present above the surface of the lake. The crew continued working at the islet for the rest of the summer, however, wading into the cold waters of Lake Superior to pry off chunks of the rich silver ore.

Macfarlane's party managed to ship 607 kilograms (1,335 pounds) of rich silver ore valued at $1,200 during 1868. Realizing the potential value of the vein, the crew then began to blast out a shaft, and to construct a boarding house, warehouse, and shaft house, all on the tiny islet.

A Challenge to Mine

Spending the winter on the islet was dangerous because the spot was exposed to all the storms of Lake Superior. Waves commonly smashed right over the tiny patch of land, and it was obvious that if mining was to continue, the islet would have to be built up and fortified. The following summer, Macfarlane's crew covered the shafthouse with 5 centimetre (2 inch) thick wooden planks to protect it, but storms washed over the islet and filled the shaft with water. In spite of their problems, however, they removed 5,000 kilograms (5.5 tons) of ore from the water around the islet.

Macfarlane recommended to head office that $50,000 should be spent to fortify the islet to make it safe for mining. This was a very large sum of money at the time, so the Montreal Mining Company sold the property to Major Sibley of Detroit for $225,000.

The Silver Islet Mining Company was born, and W.B. Frue was placed in charge of the mine. On September 1, 1870, he began construction. His priority was to build wooden cribbing alongside the islet to serve as a breakwater, and as a foundation for the mine's buildings. The cribbing was made of a framework of timber, held together with massive steel bolts, and filled with large pieces of broken rock transported from the mainland. The cribbing built along the southern, most exposed, side of the island was 140 metres (460 feet) long, 6 metres (20 feet) high, and 4 metres (13 feet) thick *(Photo 46)*.

In addition, a solid wall of cement and stones, or coffer dam, was built around a 21 metre (68 foot) length of the vein. Twenty miners worked within the coffer dam, creating an open pit, and mining out silver ore worth $108,000 that summer.

Throughout the autumn, fierce storms washed away all of the cribbing and buildings on the islet. It was a see-saw battle between construction and the waves. The waves kept winning. Frue rebuilt the cribbing, this time twice as thick as it was before. By 1871, the islet had been built up to just under one hectare (2.5 acres), or sixteen times its original size. This foundation was needed to support the eleven buildings that were there, including the first lending library in all of Ontario! In addition to 20 miners, there were 150 people employed at various support jobs such as carpentry, warehousing, construction, blacksmithing, log hauling, food preparation, office work, and provision of lodging.

Mining Brings Prosperity

Good silver ore continued to be mined throughout the early 1870s, and a community grew steadily on the mainland. In fact, the growth of Silver Islet made it the centre of commerce for the entire north shore. The road along the shoreline, called "The Avenue", stretched for over 2 kilometres (1.2 miles).

Six or seven large, ornate homes were reserved for the company president and the bosses. Forty smaller log homes sheltered the miners with families. Single miners lived in boarding houses on the islet. All had a spectacular view of the lake. Other buildings along The Avenue included a doctor's house, a customs building, a post office, and all the other buildings one might expect in a prosperous community, including Methodist and Roman Catholic churches. The Methodist Church doubled as the school and community centre. The mining company also put up and operated a massive three storey frame building with a full basement, to serve as a general store. Extensive docks, and even a dry dock, provided the best harbour along the north shore of Lake Superior.

The Rich Ore Runs Out, But Mining Goes On

Except for interruptions caused by storm damage, the mining went well at first. Unfortunately, however, the mineralized vein had a habit of pinching out. By the mid 1870s, it became apparent that the quality of the ore was significantly reduced. Mining continued in spite of this.

Superintendent Frue designed and built a concentrating machine to more effectively extract silver from the lower grade ore. His design worked well, and twenty units were installed in a mill on the mainland. The mill was an enormous structure, with a capacity to process 55 tonnes (60 tons) of rock each day *(Photo 47)*. Tug boats pulled scows laden with

PHOTO 47: Silver Islet Mining Company built this stamp mill on the mainland in the mid 1870s to process the lower grade ore from its mine on Silver Islet. Shown here ca. 1890, the mill cost $100,000 to construct.

ore from the mine to the mainland. The ore was then loaded into cars, which were pulled along a railway track from the scow landing to the upper storey of the mill by a wire cable.

Frue left the company in 1875, and the former mine captain, Richard Tretheway, became the superintendent. With only low-grade ore being found in the mine, he shifted the focus to exploration. The extension of the Silver Islet vein was traced across Burnt Island and onto the mainland, in an unsuccessful search for ore. The first diamond drill ever manufactured supported these efforts.

By 1877, the shaft was about 200 metres (650 feet) deep, and there were 152 metres (500 feet) of lateral workings. The efforts to find new ore continued. In 1878, those efforts were successful, when a new discovery of rich ore was made. A second headframe was built, and an underground inclined shaft, or winze, was extended to surface on the islet, now 45 times its original size.

The town was bustling. The general store was stocked with the finest imported silks and teas, while the residents enjoyed piano recitals, musicals, and concerts put on by a forty-piece band! Among the distinguished visitors who stopped by were Sir John A. MacDonald, Canada's first Prime Minister.

Silver Islet Mine Runs Out of Steam

By the early 1880s, the mine at Silver Islet was in decline. The ore grade had fallen. The price of silver plummeted when the United States deregulated the price of silver in 1883. But the final blow was most critical. A large shipment of coal for the steam furnaces failed to arrive before the close of navigation in 1883.

The coal was vital. It produced steam to power the pumps which kept the mine dry, as well as to run all the hoists and drills. When the coal ran out, buildings were taken down for their wood. By the spring of 1884, all the available fuel had been burned, and the pumps stopped. The mine filled with water, and the producing life of Silver Islet Mine was over.

Altogether, $3,250,000 of silver ore were mined over 14 years. The shaft reached a depth of 384 metres (1,260 feet). The Lakehead region had prospered during this time, by servicing the mine and acting as a hub for transportation. The phenomenal success of Silver Islet Mine also spurred on a great deal of exploration and some development, particularly to the west of Thunder Bay.

PHOTO 48: The cribbing built to protect Silver Islet from Lake Superior has been flooded along with the footings of the shafts and some of the buildings on the islet, but all remain visible beneath the surface of the lake.

Because of the forced suspension of work at the mine, rumours persisted for many years that considerable ore remained. These rumours, however, were finally dispelled. In 1920 a Duluth company took an option on the property. The mine was pumped out, and during 1920 and 1921 considerable exploratory work was carried out at great difficulty because of flooding, without finding any additional ore. The mine was finally closed and allowed to fill with water on August 15, 1922.

New Life for Silver Islet

Gradually, Lake Superior reclaimed the islet. All that can be seen today are the two shaft openings, which appear as black patches in the water, and sections of cribbing and building foundations under 3 metres of water *(Photo 48)*. A few scrawny trees and bushes have managed to beat the elements and revegetate the exposed rock.

In spite of everything, the town has not disappeared. After the mine closed, the entire community was vacated, but residents of the Thunder Bay area kept returning to the spot for their summer vacations. The picturesque appeal of the site has led to its development as a tourist resort area. The miners' homes were sold to the public, and even the jail was converted into a cottage. The original homes can still be recognized by their brick chimneys.

Many new cottages have also popped up. The stamp mill is gone, replaced by a cottage. The hotel still stands, and the original store is still operated as a general store, but there are few indications left of the vast and important industry that took place. However, the mineralized fault that cut across Silver Islet appears to cross Burnt Island opposite the dock at Silver Islet Landing, and to persist for a considerable distance inland on Sibley Peninsula. There may, then, still be the possibility that rich pockets of ore await discovery where the fault cuts through one of the many other diabase dikes in the area.

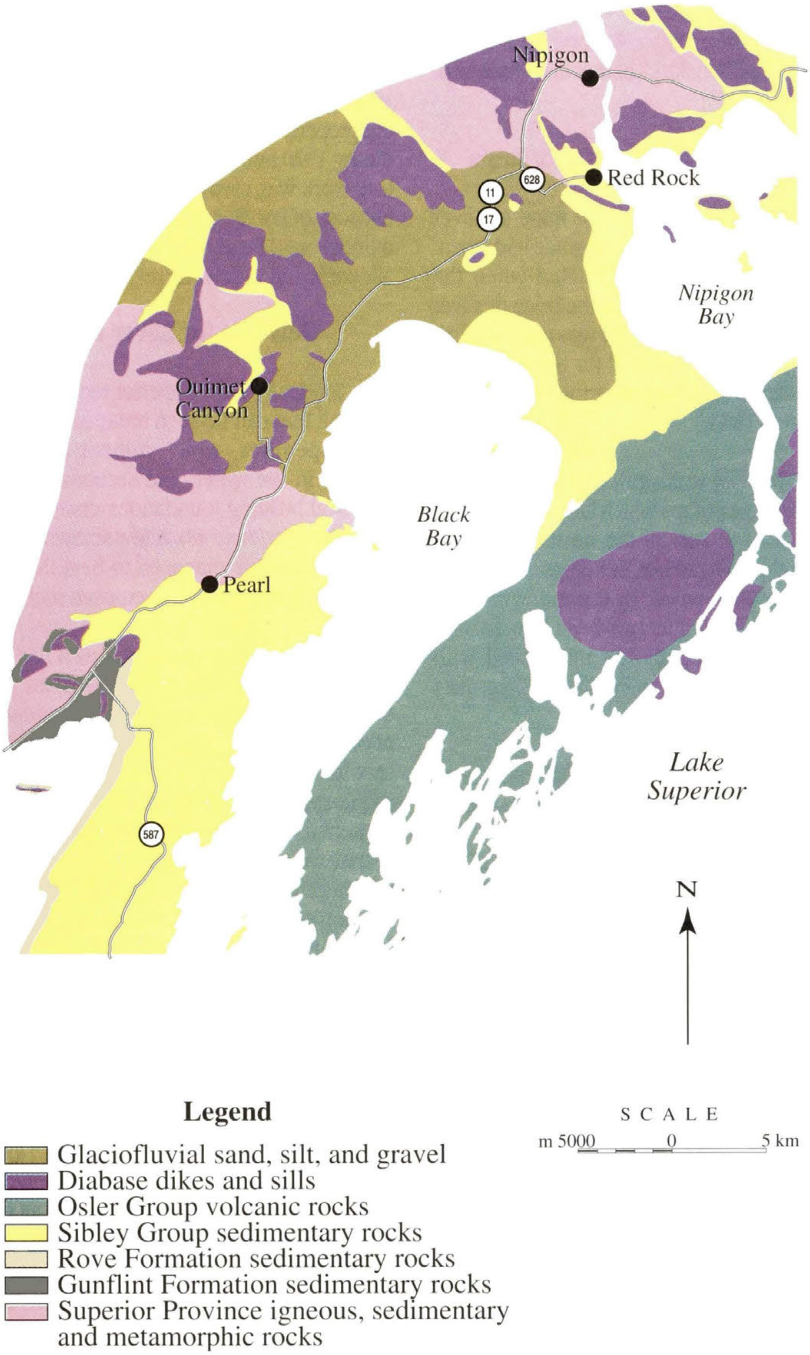


FIGURE 11: Generalized geology of the Highway 587–Nipigon area. Numerous occurrences of amethyst, Ontario's provincial mineral, are found in the Pearl area.

HIGHWAY 587 TO NIPIGON

TRIP 5

The region between Highway 587 and Nipigon *(Figure 11)* has much to offer visitors. It is the home of Ontario's world-famous amethyst deposits, and boasts a wide range of scenery. The relationship between geology and topography is clear here, especially at Ouimet Canyon and Red Rock Cuesta, and on the flat plains and stepped terraces left behind by post-glacial lakes.

Amethyst: Ontario's Provincial Mineral

Amethyst, the purple variety of the mineral quartz, is a common constituent of quartz–carbonate veins found northeast of the city of Thunder Bay. Now valued for the amethyst itself, these veins were once investigated as a potential sources of lead and zinc. Amethyst is generally rare in other parts of Ontario, but it was declared Ontario's official mineral emblem by an act of the Provincial legislature on May 14, 1975 because of the deposits in the Thunder Bay area. It is eagerly sought by mineral collectors and lapidaries as a semi-precious gem, and thousands of visitors come to the area annually to obtain specimens. The mineral is also used to some extent for industrial purposes.

PHOTO 49: Amethyst crystals with red-hued tips like these are just one of the many colour varieties of the semi-precious gemstone found in the area east of Thunder Bay.

The colour of much of the amethyst from this area is banded parallel to the crystal faces, with the layers varying from colourless to deep shades of purple. Citrine, a yellow-coloured form of iron-bearing quartz, occurs with the amethyst at some properties. The varied colour in the amethyst and citrine results from the presence of different amounts of iron in the crystals, and from very weak irradiation of the veins by natural, very slight radioactive emissions from the surrounding rocks. In places, excess iron causes brick red patches in the crystals, creating a type of amethyst unique to the Thunder Bay area *(Photo 49)*.

The Curious Lore of Amethyst

The name amethyst comes directly from the Greek word *"amethystos"*, meaning not-drunken. Greek legend relates the story that Bacchus, the god of wine was angered at an insult and vowed to set tigers on the first person he encountered. This person happened to be Amethyst, a young girl on her way to the shrine of the goddess Diana. Attacked by the tigers, the girl cried to Diana, and the goddess turned her into a statue of rock crystal to protect her. Ashamed at his display of anger, Bacchus poured an offering of wine over the figure, turning it a deep purple colour.

The Greeks drank their wine from amethyst cups in the belief that the amethyst would prevent drunkenness, but the legend of the effectiveness of the mineral in this regard may relate more to the fact that water served in amethyst cups had the appearance of wine, yet could be consumed in quantity without causing inebriation!

Other powers were attributed to amethyst as well. It was believed to control evil thoughts, to promote love, to increase intelligence and shrewdness in business, to protect soldiers from harm, and to assist hunters. The stone had religious symbolism as well. In the Bible, the Book of Exodus describes the breastplate of the high-priest Aaron (*ca.* 1300 BC) as containing twelve gems. There was one stone for each sign of the zodiac, and one of them was amethyst. By the 17th century the myths began to lose credibility, but the twelve stones are still recognized today as the birthstones, with amethyst the stone for February.

Early Reports of Amethyst

Early reports from explorers and missionaries posted along the north shore of Lake Superior mention the use of amethyst and copper by native people. Indeed, the French explorers Radisson and Groseilliers referred to amethyst in the area in 1662. There was little mineral exploration in the area for almost two centuries, but by 1840, ore reserves at Ontario's first copper mine (Bruce Mines east of Sault Ste. Marie) were running out. Because of this, the Thunder Bay area was systematically surveyed by parties from several mining companies between 1840 and 1850.

This work resulted in the discovery of several small silver deposits in the Thunder Bay area, which were subsequently developed. Amethyst was found as an associated mineral in most of the mines, and attracted the interest of a few prospectors. In the early 1860s, the McEachern brothers prospected for amethyst in the Thunder Bay and Black Bay areas. In the fall of 1862, they mined 1820 kilograms (2 tons) of amethyst, which they loaded into a small boat and sailed to Toronto. Docking at the city's wharf, they sold the amethyst through the winter. Much to their delight, their sales exceeded their expectations, largely because of the novelty of the amethyst. Similar success met a shipment to Montreal.

The success of the mineral as a valued item for sale, even in an unprocessed state, and the ease of mining encouraged other prospectors and developers to search for and produce amethyst. The Amethyst Harbour area, west of the Sibley Peninsula, was mined in the late 1880s, with samples marketed at Niagara Falls and at noted tourist spots in the United States such as Pike's Peak.

PHOTO 50: The walls of fissures and pockets, or vugs, in this fractured granite are lined by amethyst crystals. The opening of one large pocket can be seen in the floor of this trench at Diamond Willow Amethyst Mine.

The discovery and export of high-quality, inexpensive amethyst from Brazil dampened interest in amethyst from the Thunder Bay area, however. It was not until the mid 1900s that amethyst was once again produced from occurrences along the north shore of Lake Superior.

The Amethyst Deposits

Amethyst deposits along the north shore of Lake Superior can be found within a broad band some 40 kilometres (25 miles) wide, beginning approximately 60 kilometres (37 miles) northeast of the city of Thunder Bay, and extending about 200 kilometres (125 miles) east to the village of Rossport. The best developed of the amethyst deposits are found in the area around Pearl, just east of the Sibley Peninsula.

All the various rocks in the area, Archean granites and greenstones, and Sibley and Animikie group sedimentary rocks alike, host amethyst deposits. They were all fractured, leaving open channels, about 1.11 billion years ago when North America began to split apart along the Midcontinent Rift. Warm, mineral-laden water flowed up these open channels, and amethyst crystallized out of the water and lined the walls of the fractured rock as the water neared surface and cooled. Some fissures and cavities were completely filled by the purple mineral; others were simply encrusted with sharply terminated crystals *(Photo 50)*.

The main deposits occur as parallel to subparallel vein systems, themselves parallel to major northeast-trending faults. Some veins are also found along smaller north-south fractures that formed at the same time. The best crystals are found at intersections of two fault systems.

The Amethyst Mines

Several amethyst mines operate on a seasonal basis in the Pearl area. Some offer massive and crystalline amethyst for sale at sites away from the mine, some offer material for sale at the mine, and some allow visitors to pay a fee to collect their own specimens at the mine. Material from some of the mines is also being facetted and fashioned into high-quality jewellery.

The story of each of the mines differs a little, but that of the Thunder Bay Amethyst Mine Panorama serves as an example of the combination of luck, hard work, and perseverance needed for the successful operation of a small mine.

PHOTO 51: Ontario amethyst is being cut into gemstones and set into jewellery. Both this large crystal and the facetted stone set in the ring are from Thunder Bay Amethyst Mine Panorama.

The occurrence that was eventually developed into this mine was originally discovered in 1935 along the east shore of Elbow Lake, about 56 kilometres (35 miles) northeast of the city of Thunder Bay, by enthusiastic fishermen. It was rediscovered in 1955 when roadbuilders putting in a tractor road to haul steel for construction of the nearby fire lookout tower uncovered it. In the early 1960s, the area was staked, and trenches exposed the veins in what is now the open pit at the mine. The mine is open to visitors from mid-May to mid-October. It offers a gift shop and amethyst display from which samples may be purchased.

The amethyst here is found in four closely-spaced faults, which cut across Archean granitic rocks. The faults make up a zone, in places up to 24 metres (80 feet) wide, that trends east-west and dips steeply south. The zone has been opened up along its length for more than 150 metres (500 feet).

Each of the faults has an associated breccia body up to 5 metres (16 feet) wide, consisting of angular blocks of granitic rock up to 2 metres (6.5 feet) across cemented by quartz–carbonate vein material. The quartz–carbonate vein material cementing the breccias varies in width from a few millimetres (0.25 inch) to a meter (three feet) or so.

There are also numerous cavities or vugs lined with mauve to purple amethyst crystals. The vugs are up to 3 metres (10 feet) high and wide, and up to 1.2 metres (4 feet) deep. Well-formed pyramid-shaped crystals, each bound by the six faces which characterize all forms of quartz, line the cavities; most vary from a few millimetres (0.25 inch) across to 15 centimetres (6 inches) across and 23 centimetres (9 inches) long *(Photo 51)*. One of the largest crystals mined at the property was 25 centimetres (10 inches) across, and 38 centimetres (15 inches) long. This giant crystal weighed 16 kilograms (35 pounds).

The discovery and development of the deposits at the Thunder Bay Amethyst Mine

Panorama led to increased interest in the area. Prospectors attracted to the potential of the purple mineral discovered more showings east of the first deposit, and by the late 1960s a fledgling amethyst mining industry boasting several operators had been born. Visitors will certainly find a visit to any of the mines in the area—whether to view semi-precious gemstones still embedded in the rock, to purchase samples collected or fashioned into jewellery by others, or to do their own collecting—an interesting and rewarding experience.

Topography and Geology

Between Thunder Bay and a point approximately 16 kilometres (10 miles) east of the junction of Highway 587 with Highway 11&17, the topography is characterized by low, broad hills, covered with birch, poplar and pine bush. For the next 5 kilometres (3 miles) to the east, the topography is more hilly, and roadcuts through rock outcrops are common. Then, the scenery changes abruptly. Gone are the hills and outcrops, and in their place is flat land, covered by a thick forest of poplar and aspen, with some pine and birch.

The changes in topography can be readily ascribed to the bedrock geology. In the area from Thunder Bay east, the bedrock alternates between metamorphosed sedimentary, volcanic, and granitic rocks of the Superior Province, and sedimentary rocks of the Southern Province. These rocks are all moderately resistant to erosion, and so over the millennia have been sculpted into the low broad hills we see today.

Farther east, these rocks are capped by a sill of diabase, which is quite resistant to erosion. It has provided us with more rugged topography, and forced roadbuilders to blast roadcuts through the rock.

Where the hills give way to flat land, the road crosses into an area that was flooded at the end of the Great Ice Age. Deposits of silt and clay left behind by the post-glacial lake blanketed the bedrock, and left us with the flat plain we see today.

Similar examples of how geology controls topography, and ultimately vegetation and scenery, can be seen in many places all along the north shore of Lake Superior.

Ouimet Canyon

A dramatic illustration of the relationship between geology and topography can be seen at Ouimet Canyon *(Photo 52)*. It can be reached by following a well-marked road extending 10 kilometres (6 miles) westerly from Ouimet, 24.1 kilometres (15.0 miles) north of the junction of highways 587 and 11&17. Ouimet is shown as Quimet on some maps.

Named after the nearby Ouimet Station on the Canadian Pacific Railway, it honours Joseph Alderic Ouimet, Canadian Minster of

PHOTO 52: The steep cliffs of Ouimet Canyon, and the prominent vertical jointing in the thick diabase sill the canyon transects, are clearly visible in this aerial view.

Public Works from 1892 to 1896, and a highly-regarded lieutenant-colonel in charge of the 65th Mount Royal Rifles. That regiment worked on the transcontinental railway while en route to quell the 1885 North West Rebellion.

Ouimet Canyon Provincial Park

Ouimet Canyon lies within Ouimet Canyon Provincial Park, a 777 hectare (1,920 acre) nature reserve, and is one of the most impressive topographic features in the region.

The road from Ouimet leads to the rim of the canyon, but the last 2.3 kilometres (1.4 miles) of the road are quite steep. For that reason, visitors are asked to leave any trailers they might be towing at a parking area at the base of the steep section. At the end of the road, there is another parking area, a picnic area, a hiking trail, and lookout pods offering breathtaking views of the canyon.

PHOTO 53: Huge talus piles of bouldery rubble skirt the base of the cliff along both sides of Ouimet Canyon. In places along the canyon walls, columns of resistant rock form isolated pinnacles such as this one, called "Indian Head".

A gentle walking trail 1.4 kilometres (0.9 mile) long leads from the upper parking lot to two viewing pods which extend over the edge of the precipitous canyon wall. The walls of the canyon fall 100 metres (325 feet) straight down beneath the lookouts. On the far side of the 150 metre (500 feet) wide gap left by the canyon, huge columns of diabase form a spectacular rock wall. To the north, the canyon pinches and twists into the surrounding hills. To the south, it folds open to a broad valley and a grand vista of Lake Superior.

The oldest rocks in the area, exposed at the north end of Gulch lake in the south part of the park, are granitic in character and of Archean age. These are overlain by near-horizontal layers of sedimentary rocks of the Proterozoic Sibley Group. To the north, the Sibley sediments are overlain by a sill of diabase, which forms the cap rock of a large flat-topped mesa. The canyon slashes across the diabase-capped mesa. It trends northerly for most of its length of 2.4 kilometres (1.5 miles) and then turns abruptly to follow an easterly direction. A few small, flat outcrops of diabase can be seen along the hiking trail between the viewing pods at the canyon rim.

How the Canyon Formed

The north-trending portion of the canyon has been said by some observers to reflect the occurrence of a great fault in the earth's crust. This, however, is not the case. Because the diabase occurs as a flat sheet, and because the two walls of the canyon have the same elevation, there is little evidence that any displacement of rock has occurred. The canyon is instead a deep erosional feature, carved out of the diabase by glacial and post-glacial processes along two major vertical cracks or joints.

Also contributing to this erosion has been the well-developed closely-spaced columnar jointing in the diabase, much like that at found on Keshkabuon Island (*see* Photo 41) and in the diabase at Red Rock Cuesta. Rain and melting snow run down into the tiny cracks left by the joints, and during the spring and autumn, are repeatedly frozen and thawed as the daily temperature swings below and above the freezing point.

Each time the water freezes, it expands, and wedges apart the crack ever so slightly. When it melts, it runs farther down the newly-enlarged crack, to begin the process over again. Over the centuries, great blocks of rock are broken away from the canyon walls, and crash to the canyon floor. Shattered boulders as much as 10 metres (33 feet) across now litter the canyon floor, and form huge talus piles below the cliffs. Some columns resist breaking, and remain standing as isolated rock pinnacles separate from the walls of the canyon. The one near the north lookout is known is the "Indian Head" *(Photo 53)*.

The park's managers advise visitors to stay in designated viewing areas, and to walk only along marked trails as there is the risk of rock collapse at the upper edge of the canyon. They also request that visitors refrain from hiking along the canyon floor because of the danger of rock slides, and to prevent damage to the unique vegetation found there.

A Unique Habitat

Because the canyon is so narrow, sunlight rarely hits its floor. Ice stays from one winter to the next without melting, and the climate at the canyon floor is chilled so that it is reminiscent of the arctic. This creates a unique habitat that is the most southerly in Ontario of at least three species of arctic plants, and is home to a number of other uncommon arctic and sub-arctic plants. Even the common pussy willow, normally an upright shrub, grows in the peculiar, low, mat-like habit characteristic of arctic plants. The arctic plants are relics, stranded in their localized environment when the Great Ice Age ended about 10,000 years ago.

– Ouimet Canyon –

A long time ago there were giants. Most were evil, and were slain by Nanabijou. One called Omett was a good giant, however, and was allowed to remain on earth. He helped Nanabijou when he wished to raise a mountain or make a new lake.

Omett fell in love with Naiomi, Nanabijou's daughter. Naiomi liked Omett and encouraged him to display his strength. One day Omett was moving a mountain when a peak broke off, struck Naiomi and killed her. Greatly frightened of the wrath of Nanabijou, Omett hid Naiomi's body in a shallow lake and covered it with a rock shield.

Searching for Naiomi, Nanabijou was striding over the great shield when he felt vibrations from under the rocks. Reaching into the sky, he grasped a thunder bolt and drove it into the rocks, splitting them open. In the wide canyon he discovered his daughter's body.

Nanabijou buried Naiomi in at the bottom of the canyon. From her grave grew the rare and beautiful flowers found only there. To punish Omett, Nanabijou turned him to stone and placed him on the canyon wall to watch over the grave for all eternity.

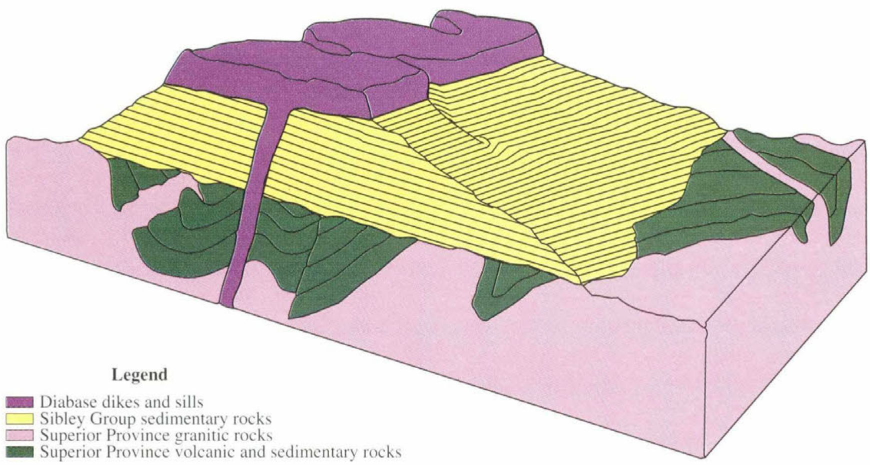


FIGURE 12: Schematic diagram of Red Rock Cuesta. The layers that form the hill, with granitic and other rocks of the Superior Province overlain by sedimentary rocks of the Southern Province and capped by resistant diabase sill, are clearly shown.

Red Soil

Between Thunder Bay and Nipigon, there are a number of small farms. Most of them have the tan to rich brown soil normally associated with Ontario's farms. At the junction of Highway 11&17 with the western end of Highway 582, however, the soil is noticeably different. It has the deep red colour more typical of Prince Edward Island's soil.

PHOTO 54: At Red Rock Cuesta, here viewed from Highway 11&17 south of Nipigon, sedimentary rocks rest on granitic rocks, and are capped by a flat sill of diabase.

Here, the area is underlain by the iron-rich sedimentary rocks of the Sibley Group. The soils are derived in part from the erosion of those rocks, and so have the same characteristic colour as the rocks.

The influence of bedrock geology on the overlying soil is apparent to the naked eye in this case. In other cases the influence is not so obvious, but it is sufficient that geologists routinely take samples of soil during mineral exploration programs. The samples are then analyzed for trace amounts of metals such as lead, zinc, copper, silver, and nickel, in an effort to find mineable concentrations of those metals where the bedrock is covered by soil.

Red Rock Cuesta

A prominent landmark along Highway 11&17 is the large cuesta located about 11 kilometres (7 miles) south of Nipigon. This hill rises more than 125 metres (400 feet) above the surrounding country and can be seen from a considerable distance *(Photo 54)*. Most conveniently studied from the intersection of Highway 11&17 with Highway 628, the road leading to Red Rock, its geological features can surprisingly be summarized as flat *(Figure 12)*.

At the base of the hill are low rounded knolls almost 15 metres (50 feet) high. These knolls mark a relatively flat—geologically speaking—erosional surface. The granitic rocks which form the knolls were covered between 1.34 and 1.54 billion years ago by 60 to 90 metres (200 to 300 feet) of flat-lying sediments of the Sibley Group. These in turn are capped by an erosional remnant, 30 metres (100 feet) or more thick, of a flat-lying 1.11 billion-year-old diabase sill. Finally, the area surrounding Red Rock cuesta was covered by flat-lying layers of mud, silt, sand and gravel about 10,000 years ago, when the water level of Lake Superior was much higher than it is now.

The Rocks of Red Rock Cuesta

The granitic rocks at the base of the hill make up part of a batholith. A batholith is a very large body of igneous rock, usually of irregular shape, that forms when hot molten material, or magma, crystallizes deep within the earth. The batholith that is exposed at the base of the hill did not form at, or even near, the present surface; it became visible only after prolonged erosion had removed a great thickness of old cover rocks. This great period of erosion between the time the granitic rocks were formed, exposed at surface, and then buried by the flat-lying strata of the Sibley Group lasted more than 1.33 billion years!

The sediments of the Sibley Group that overlie the granitic rocks are shale and impure shaly dolostone, and dolomitic limestone with interbedded sandstone. They are typically red in colour, and stand out in marked contrast to the other rocks, particularly the dark grey diabase at the top of the hill.

It is thought that the Sibley sediments were laid down in the shallow waters of a lake or inland sea of fluctuating water level, and partly by rivers as flood-plain detritus. The red colour is due to small amounts of the iron-bearing mineral hematite. Since the hematite appears to have formed from other original iron minerals in the sediments, it is likely that the sediments were exposed to the atmosphere at about the time they were deposited, and not submersed deep underwater.

The diabase at Red Rock Cuesta is characterized by the prominent vertical cracks or joints that bound long prisms or columns of rock, and give the diabase sills along the north shore of Lake Superior their pronounced columnar structure. At right angles to the upper and lower margins of the flat diabase sheets, they resulted when the diabase contracted or shrank as it cooled.

"Basement" Rock

A good example of the complexity of some of the Archean rocks in the area can be seen in the roadcut 4.6 kilometres (2.9 miles) east of the junction of highways 628 and 11&17. Here, dark-coloured, layered metamorphosed sedimentary and volcanic rocks between 2.68 and 2.80 billion years old are cut by masses of bright pink granite. Rocks such as these, which are the oldest in an area, and typically form the eroded base upon which younger rocks—whether sedimentary, volcanic or both—are deposited, are commonly called "basement" rocks.

At the north end of this outcrop, a thick diabase dike cuts across both the older rock types. Other, thin diabase dikes occur elsewhere in the roadcut. The diabase is part of the suite of 1.11 billion-year-old intrusive rocks that includes sills such as the one capping Red Rock Cuesta.

Nipigon Scenic Lookout

A scenic lookout along Highway 17 about 1.6 kilometres (1.0 mile) west of the junction with Highway 11 overlooks the town of Nipigon. Built on a high ridge of sand and gravel about 50 metres (175 feet) above the level of Lake Superior, it provides an excellent view of the Nipigon River; on a clear day the paper mill at Red Rock at the river's mouth 8 kilometres (5 miles) away is plainly visible *(Photo 55)*.

The mouth of the Nipigon River and the bay into which the river discharges are girdled by high, imposing rocky hills. One, near Red Rock, has an elevation of more than 240 meters (800 feet) above the lake. Like Red Rock Cuesta, the hills are underlain by erosional remnants of a thick sheet or sill of diabase which intruded the flat-lying sedimentary rocks of the Sibley Group, and, in places, Archean metasedimentary, metavolcanic, and granitic rocks.

PHOTO 55: The mouth of the Nipigon River and the distant paper mill town of Red Rock can be seen from the lookout on Highway 17 at Nipigon.

One of the members of the Sibley Group is a dolostone. It was quarried commercially prior to 1919 at a location on the east side of the river's mouth. When cut and polished, this rock provides a decorative material comparable in quality to many imported marbles. It was, however, not the only rock quarried in the area at that time. The red sandstone of the Sibley Group on Vert Island, offshore from the town of Nipigon, was called "brownstone" by builders. It was quarried from 1882 to 1912. Most of it was shipped to Chicago for construction purposes, but some can be seen in the supports of the Nipigon railway bridge.

PHOTO 56: **The significance of the Nipigon pictographs is unclear. A squatting figure, now missing from above the inverted brackets, was thought to represent Maymaygwayshi (Ghost or Spirit).**

Nipigon Beach Terraces

The town of Nipigon, site of the first permanent European settlement on the north shore of Lake Superior, was built on flat terraces of sand and gravel. These terraces, easily seen from the vantage point of the scenic lookout, are lake deposits that were left behind when the waters in the Lake Superior Basin were higher and extended farther up the valley of the Nipigon River than they do today. Three terraces are recognizable: one is along the river bank at the north end of the town; one is occupied by the business section and provides a level base for the Canadian Pacific Railway line; one lies just below the lookout, and has been reserved mainly as a residential area.

The terraces are separated by steep-walled embankments. The lowering of the lake to its present level was intermittent, and these embankments mark old shorelines, abandoned successively with each drop in water level.

Indian Pictographs

At the mouth of the Nipigon River, almost directly opposite the town of Red Rock, several Ojibwa Indian pictographs that might be anywhere from 400 to 1,000 years old are painted on the sedimentary rock in a rusty shade of red *(Photo 56)*. Since the site is accessible only by water, the paintings were likely done from rock ledges reached by canoe. Fingers were used as paint brushes, and fine clay mixed with red iron oxide was used as paint.

Highest on the rock face, some 15 metres (50 feet) above the nearest ledge, are lines and symbols which appear in neat order similar to the rock layers. One of the symbols is reversed brackets enclosing a vertical bar. Most of the symbol meanings are uncertain, and are open to speculation.

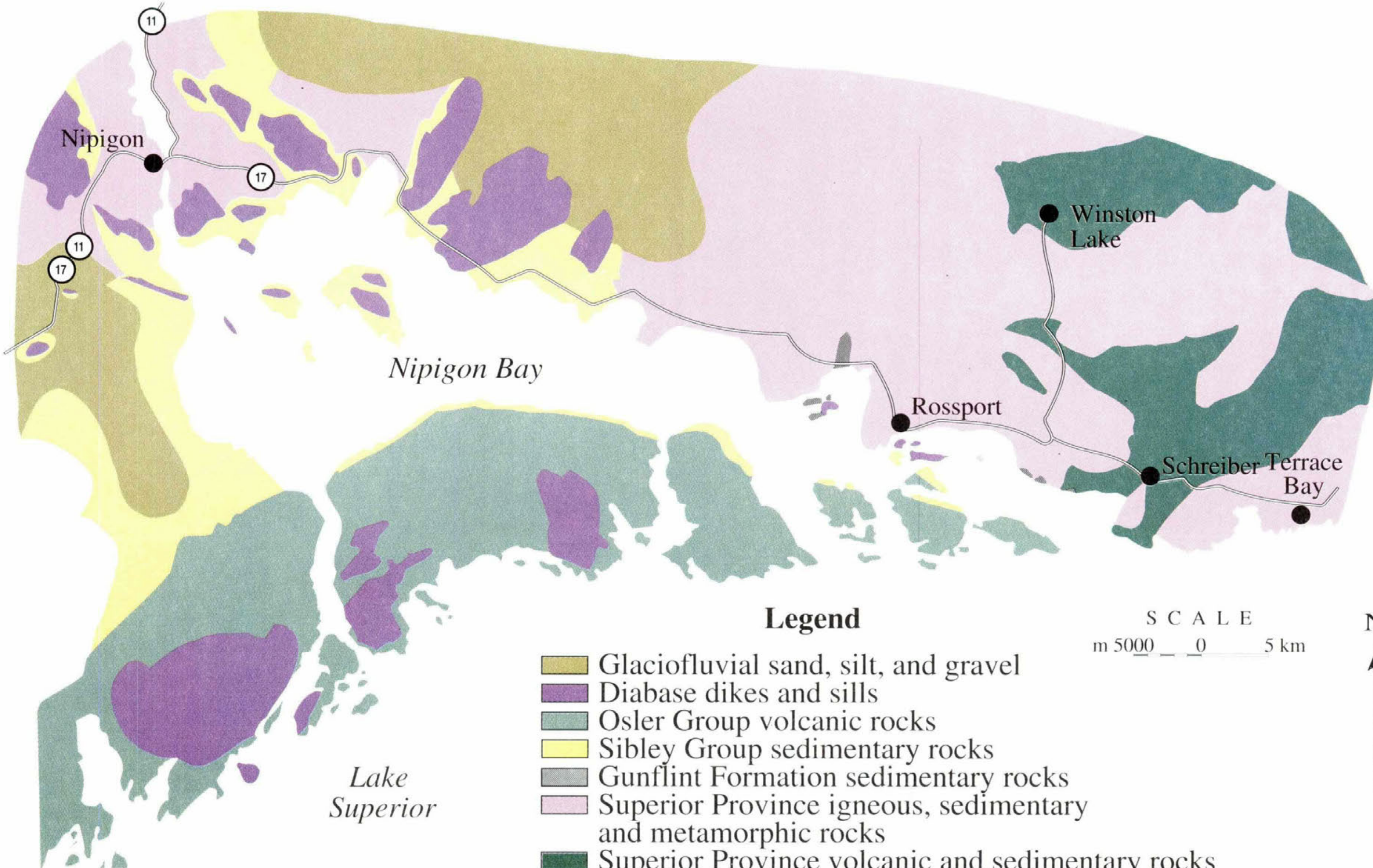


FIGURE 13: Generalized geology of the Nipigon–Schreiber area. The resistant diabase sills, along with the numerous other rock types found in the area, provide spectacular scenery for travellers.

Nipigon to Schreiber

TRIP 6

Some of the most spectacular vistas to be seen along the north shore of Lake Superior are found between Nipigon and Schreiber. Outstanding panoramas, backed by colourful cliffs revealing a long and varied geological history, are the norm *(Figure 13)*. The numerous hills and bends along the road leave visitors eagerly anticipating what each next viewpoint has to offer.

Palisades of the Pijitawabik

The Palisades, named after the bay at the south end of Lake Nipigon where they are most prominent, are found along Highway 11. To view these impressive cliffs, take a side trip about 50 kilometres (30 miles) north from Highway 17 to Macdiarmid. Vantage points for viewing the Palisades are along the way at Gorge Creek, Reflection Lake, Orient Bay, and Macdiarmid.

PHOTO 57: The abrupt cliffs at Reflection Lake along Highway 11 north of Nipigon resulted from erosion of a thick diabase sill. They form part of the Palisades of the Pijitawabik.

The cliffs mark the edges of huge erosional remnants of a great flat-lying diabase sheet that, in places, exceeds 150 metres (500 feet) in thickness. The remnants form large, flat-topped hills, bounded by abrupt, towering escarpments separated by deep, narrow valleys, and provide northwestern Ontario with some of its most magnificent scenery *(Photo 57)*. Columnar jointing, a common feature of the diabase, is the reason these topographic features have formed in response to the powers of erosion. Near Macdiarmid, one vertical column is roughly cylindrical in shape and projects into Lake Nipigon. This conspicuous feature has been named "Chisel Rock".

The diabase sheet was once thought to be a thick lava flow, largely because the general lack of any overlying rock offered no evidence to the contrary. Near Pine Portage on the Nipigon River, however, diamond drilling and mapping have shown that the diabase sheet dips below the surface, and cuts through Archean sedimentary rocks. This indicates that the diabase was intrusive; it originally formed below the surface, and was exposed to view only after its once extensive cover-rocks were removed by erosion.

A Rock Hard Layer Cake

The geology of the area is well exposed in a mesa on the south side of Highway 17, about 15 kilometres (10 miles) east of its junction with Highway 11. The highway wraps around the north side of the mesa, providing good views of the layers that make up the hill.

The overall appearance of the stack of rocks can be likened to a three-flavoured triple-decker layer cake! The bottom layer, which might be compared to marbled cake, is a mixture of volcanic, sedimentary, and intrusive rocks such as granite. These rocks formed, and were deformed, during the Archean, between 2.49 and 2.89 billion years ago. The second layer of the cake might be called strawberry. It consists of a distinctive sequence of red sedimentary rocks that was deposited on the eroded remnants of the Archean rocks between 1.34 and 1.54 billion years ago. The third layer of the cake might then be called chocolate. It is a brown layer of diabase, which intruded the other rocks about 1.11 billion years ago, and has since been exposed by erosion. After this "cake" was assembled, all three layers had chunks eaten away—or eroded—before being frosted with a covering of glacial debris and sprinkled with a forest of pine, poplar, cedar, and aspen.

Mixed Up Rocks

A series of outcrops on both sides of Highway 17, about 19.4 kilometres (12.1 miles) east of the junction of highways 11 and 17, offers excellent exposures of parts of the lowest layer of rocks in the area. As parking is only available on the shoulder of the road, care must be observed in viewing these outcrops.

The rock at this site is migmatite and gneiss. The term migmatite stems from the Greek word *"migma"*, or "a mixture". It commonly refers to a composite rock including both metamorphic and igneous components. Here, the dark layers were once sedimentary rocks, but they have been severely altered by heat and pressure. The light layers are granitic igneous rocks, which, when still liquid, were intruded into the sedimentary rocks.

The light and dark banding in the outcrops is sometimes called *"lit-par-lit"*, from the French for "bed-by-bed". It refers to the alternating dark and light layers in the rock, and implies that the granitic rocks intruded along closely-spaced layers or beds within the sedimentary rock *(Photo 58)*. Some of the granitic magma that became the light-coloured layers in this rock resulted when the rock was subjected to such great temperature and pressure at depth within the earth's crust that it began to melt.

At the east end of the outcrop, pink dikes cut the migmatite. The dikes formed from a granitic magma, which intruded the older rocks and then cooled so slowly that the minerals in it had time to form large grains. Such coarse-grained rocks are called pegmatites.

These rocks are exposed at surface now only because eons of erosion have removed the several kilometres (miles) of rock that once covered them.

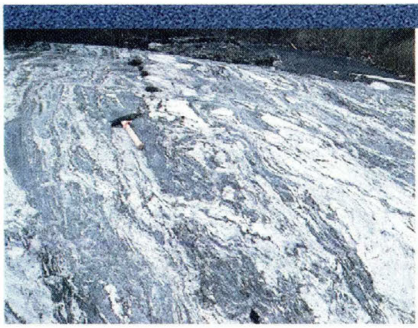


PHOTO 58: This rock, with its alternating light-coloured and dark bands, is called a migmatite. Migmatites are found where rocks were once subjected to such great heat and pressure that they began to melt.

Kama Bay

Three scenic lookouts have been established along the east shore of Kama Bay, at points 21.3 kilometres (13.3 miles), 22.3 kilometres (14.1 miles), and 26.7 kilometres (16.7 miles) east of the intersection of highways 11 and 17. Located on the flanks of, or on the top of high hills that rise to more than 200 metres (700 feet) above Lake Superior, they provide excellent views of the shoreline and the offshore islands.

From the lookouts, the layered geological character of the whole region is quite apparent. Diabase-capped mesas and cuestas rise abruptly, like sentinels, out of Lake Superior and the adjoining lowlands. The hills along the highway at the lookouts are typical of the mesas, with erosional remnants of a diabase sill or sheet overlying a thick sequence of flat-lying Sibley Group sedimentary rocks.

The Layers

The layers of Sibley Group sediments

and diabase sills can be plainly seen at the most westerly lookout. In the distance to the west, the thick diabase sill that caps the area is encircled by steep cliffs. As far away as it is, prominent columnar joints can still be seen in the diabase.

Closer to the lookout, in outcrops across the highway and just west of the parking area, dark brown diabase sills ranging from only a few centimetres (inches) to 4.6 metres (15 feet) in thickness can be seen intruding the red sedimentary rocks. For the most part, they form tabular sheets parallel to the layers in the rocks enclosing them, and can be followed along the highway for considerable distances.

In a few places, however, tongues of diabase have unsuccessfully tried to push their way between the layers of sedimentary rock, and pinch out abruptly. In others, the sill changes positions from one level within the sequence of sedimentary rocks to another *(Photo 59)*. Where this happens, the sedimentary rocks have been distorted. The distortion evidently reflects a wedging apart of the sediments, caused by the forcible injection of the molten material or magma from which the diabase crystallized.

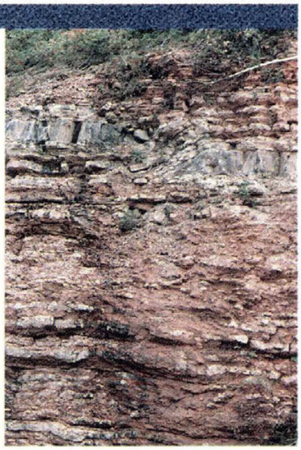


PHOTO 59: The two sections of the thin dark grey diabase sill near the top of this exposure intrude different levels within the sedimentary sequence, and distort the intervening layers.

The Sedimentary Rocks

Excellent exposures of the sedimentary rocks of the Sibley Group can be seen in the outcrops beside the road between the first and second lookouts. The best plan for examining these rocks would be to park at the middle lookout, and walk about 500 metres (0.3 mile) west, or half way to the most westerly lookout. As these outcrops are steep, and next to a busy highway, caution is advised when examining them.

Here, the sedimentary rocks are clearly layered, and off-white to reddish orange and maroon in colour. They formed when silt, mud and sand were deposited in a shallow quiet lake between 1.34 and 1.54 billion years ago. The alternating white and reddish orange beds at road level are the consolidated equivalents of sand and lime-rich mud, respectively. They were deposited during a period of fluctuating water levels; shallow water favoured the deposition of sand, while deeper water favoured the deposition of lime-rich mud.

A thin, distinct grey bed, from 80 to 140 centimetres (30 to 55 inches) thick, occurs above the orange and white beds, several metres above the highway level. It consists entirely of minerals that were precipitated in lake water, rather than being deposited as sediment. It is characterized by the presence of stromatolites, the thinly laminated or cabbage-like structures produced when the precipitated minerals were trapped by the sticky surfaces of mats of ancient algae and bacteria *(Photo 60)*.

The reddish orange to white lime-rich mudstone that overlies the stromatolites represents a return to the deposition of muddy sediment in the ancient lake. Like many of the other local rocks, these owe their reddish colour to the presence of microscopic grains of the iron oxide mineral, hematite.

Above the lime-rich mudstone is a sequence of maroon to purple siltstone. Deposited on a floodplain rather than in a lake, the siltstone tells us that the lake, which had been home to the ancient algae and bacteria, had dried up.

Deformation and Alteration

An interesting demonstration of the disparate ways in which different rocks respond to stress can be seen in these outcrops. Near the west end of the exposure, at road level, beds of white sandstone have been broken into squat blocks. The blocks are now stacked like toppled dominoes, while the enclosing red mudstone shows no effects of deformation at all.

The rigid sandstone behaved in a brittle fashion when subjected to stress, and broke into blocks. The blocks then slid along their fracture surfaces until the stress was relieved. In contrast, the stress was relieved in the less solid mudstone by innumerable tiny displacements of individual grains, leaving no obvious signs that any movement took place in that rock *(Photo 61)*.

Thin diabase sills can also be seen at intervals within the sedimentary sequence here. Note that the rocks immediately above and below the sills have, in many places, been bleached to a light tan colour by the heat of the intruding magma.

The Diabase Capping

The diabase sill, with its prominent vertical joints, can easily be seen from the middle viewpoint, capping the hills to the north and east of the highway. It can also be seen capping offshore islands from the hilltop viewpoint 26.7 kilometres (16.7 miles) east of the junction of highways 11 and 17. The best place for a close up view of the diabase is, however, at the picnic site and scenic lookout 0.5 kilometre (0.3 mile) off the highway at kilometre 27.5 (mile 17.2).

Here, the diabase is a massive, rather coarse-grained rock. It consists largely of the minerals pyroxene and feldspar, the latter occurring as small, randomly oriented, tabular crystals. As at other localities, the diabase is broken by numerous vertical cooling cracks, or joints, which appear on the rock pavements at the picnic site as sets of parallel fractures. Because these fractures facilitated erosion, the outcrop boundaries at the lookout are sheer cliffs, 90 metres (300 feet) or more in height.

A Lake Shore High Above the Lake!

Between 43 and 53 kilometres (27 and 33 miles) east of the junction of highways 11 and 17, the road crosses a number of flat terraces at various elevations above the lakeshore. Regardless of the elevation, gravel is exposed in places in the banks along the road. The abundant gravel here was commemorated by the builders of the railway, when they named the local siding "Gravel".

PHOTO 60: This structure, called a stromatolite, formed when ancient algae caused chemical changes in lakewater, resulting in minerals that were trapped by sticky organic material.

PHOTO 61: The different responses of brittle white quartzite and ductile red mudstone to stress are clearly shown in this photo.

The gravel was left behind by the forerunner of the Gravel River at the end of the Great Ice Age. The river washed huge volumes of glacial debris away from the melting ice sheet, and built a prominent delta out into Lake Superior. The waves of ancient Lake Superior then washed the material, and left behind terraced sand and gravel deposits when the water level fell.

The Scenic Rossport Area

Rossport began its life as a station along the Canadian Pacific Railway line, and still boasts a hotel that opened in 1884 to serve the railway traffic. The population of the village has fallen from its peak of about 300 in the 1940s, largely because of the decline of the once-flourishing commercial fishing industry that was based at Rossport's protected harbour. With the decline of the fishing industry, however, Rossport has found new life in tourism as it is the centre of an area with abundant scenic attractions.

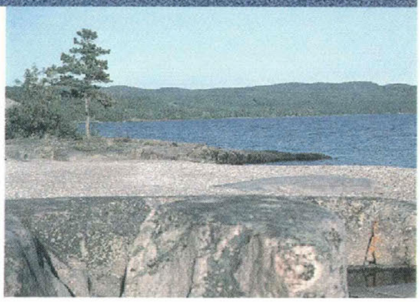


PHOTO 62: Bright pink pebbles of granite nestle in hollows between lichen-coated outcrops of the same rock along the Lake Superior shore in the scenic Rossport area.

Time Travel to an Ancient Landscape

East of the outwash deposits left by the ancient Gravel River, the various different Archean rock types that make up the lowest of the three major layers of rock in the area are exposed. In some outcrops, there is bright pink, well-jointed granite *(Photo 62)*; in some there is dark metavolcanic rock cut by dikes of granite; in some there is pink, gray and black banded migmatite.

All these rocks provide evidence of the long and complex geological history of the area. Even the topography we see today in the area is a part of its history. It is very similar to the topography left hundreds of millions of years ago by erosion of the Archean rocks, and is close to being the same surface that the sedimentary rocks of the Sibley Group blanketed some 1.54 billion years ago. If we could go back to that time, however, we'd notice one major difference: the surface would have been absolutely barren. There were no land plants on earth at that time, and, without plants, there was nothing to keep any soil that formed from being washed or blown away by rain or wind.

Rossport Provincial Campground

Rossport Provincial Campground, an affiliate of Rainbow Falls Provincial Park, is located along the shore of Lake Superior about 5 kilometres (3 miles) east of Rossport, or 15 kilometres (10 miles) west of Schreiber. It offers complete facilities for tent and trailer parking.

Excellent exposures of granite, forming prominent headlands projecting into the lake, can be seen at the campground. These exposures have been worn smooth by wave action, so the texture of the rock is remarkably well displayed. Close observation indicates that the rock is made up of tabular crystals of pale pink to cream-coloured feldspar up to 2.5 centimetres (1 inch) long in a relatively fine-grained groundmass of feldspar, quartz, and black mica *(Photo 63)*. As igneous rocks having a mix of coarse-grained minerals in a finer-grained matrix are termed "porphyritic", this rock is a porphyritic granite.

How Porphyritic Rocks Form

To determine how porphyritic rocks form, one must first look at what happens when magma cools. When magma cools slowly, few crystal nuclei form, but they gradually develop into large crystals. On the other hand, when a magma chills rapidly, many crystal nuclei are formed, and they quickly form small crystals.

It appears, then, that the granite at Rossport Provincial Campground crystallized in two stages. The large feldspar crystals resulted from slow cooling of the magma at depth, where the temperature was high; the small crystals that form the groundmass resulted from rapid chilling of the magma after it had worked its way upward into a cooler environment, closer to the earth's surface.

An interesting and unusual characteristic of this porphyritic granite is that the long dimensions of the large feldspar crystals are roughly aligned. Since logs in a flowing river line up parallel to each other as they float downstream, the alignment of the large feldspar crystals suggests that they lined up parallel to each other in a flowing crystal mush, possibly as the magma was making its way closer to the earth's surface. The magma never did reach surface, however, before completely solidifying. Instead, it was exposed after millions of years of erosion removed the great thickness of rocks it had intruded.

Hewitson Scenic Lookout

A magnificent view of the Lake Superior shoreline and nearby islands is afforded by a scenic lookout along Highway 17 at a point 7.2 kilometres (4.5 miles) east of the eastern turnoff to Rossport, or 13 kilometres (8 miles) west of Schreiber *(Photo 64)*. The rocks exposed along the shoreline are mainly granites more than 2.49 billion years old; those found on the islands are sedimentary and volcanic rocks of between 1.11 and 1.54 billion years old.

The rocks on the islands are parts of two groups, the Sibley, and the Osler. The Sibley Group rocks are the older. As at Kama Bay, they are made up of sandstone, with red impure dolomites and dolomitic limestones. The younger Osler Group, which overlies the Sibley, also contains sedimentary rocks. Indeed, at its base, it is represented by conglomerate, sandstone, and red mudstone not much different in composition and structure from their Sibley counterparts. The principal rocks, however, are basaltic volcanic rocks. With some interflow sediments, the volcanic sequence attains an average thickness of almost 3,000 metres (10,000 feet).

PHOTO 63: This granite at Rossport Provincial Campground has coarse grains of feldspar embedded in a finer-grained matrix of other feldspar, quartz, and mica. Rock like this can be used to make attractive building stone.

The Sibley and Osler group sedimentary rocks and the Osler Group volcanic rocks in this region trend east-west and dip gently to the south. Their attitudes, which reflect the fact that they occur along the northern margin of the Midcontinent Rift, are highlighted by the topography. The islands are cuestas, with abrupt escarpments that cut through the rock sequence along their north sides and gentle slopes that lie parallel to the layering within the rock facing the open lake to the south.

PHOTO 64: Hewitson scenic lookout between Rossport and Schreiber offers a panoramic view of the north shore of Lake Superior. The rocks exposed along the shore are mostly granitic.

Rainbow Falls Provincial Park

While not the most spectacular attraction between Nipigon and Schreiber, there is little doubt that Rainbow Falls is one of the prettiest. As at numerous other localities near Lake Superior, the falls does not occur where a river flows over a single vertical cliff. It is a cascade, in which the flowing water tumbles from ledge to ledge in a rapid descent where the Whitesand River drains Whitesand Lake into Lake Superior. A rainbow often rises in the mist below the thundering cascade. A provincial park has been developed at the site, about 9 kilometres (5.5 miles) east of Rossport and 11 kilometres (7 miles) west of Schreiber along Highway 17.

The bedrock at the falls is pink syenite, an igneous rock similar to granite, but made up chiefly of black hornblende and reddish feldspar. Careful examination of the well-developed joints in the syenite discloses that their orientations have controlled the course of the river, as well as the positions of the individual escarpments of the cascade. The course of the river is a zigzag one; it follows vertical or nearly vertical joints, some of which trend northwest, and some of which trend southwest. The escarpments, as one might anticipate, are most prominent in those places where the joints intersect and the river's direction changes abruptly.

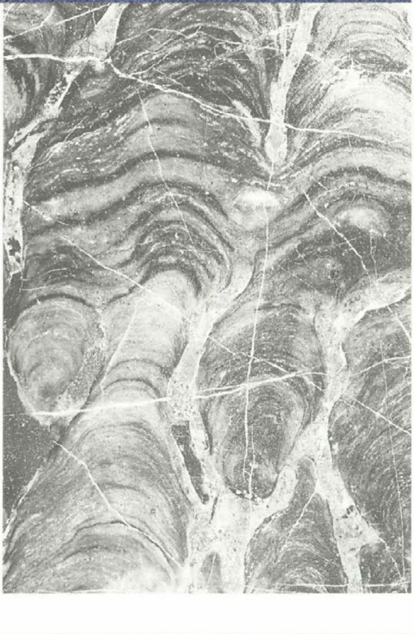


PHOTO 65: The finely laminated primeval stromatolitic structures traced in this rock from Schreiber Channel Nature Reserve, shown here at their actual size, were built up by layer upon layer of algae. Individual filaments of fossil algae can be seen if the rock is enlarged 1,000 times.

Hiking trails within the park, and the rugged 50 kilometre (31 mile) long Voyageur hiking trail which passes through the park en route from Terrace Bay to Rossport, offer panoramic views of the park and the Lake Superior shoreline.

The offshore islands in Lake Superior are underlain by several different types of rocks. Those nearest the shore to the west are underlain by diabase sills, while those directly offshore are underlain by sediments of the Sibley Group capped by a sequence of Keweenawan volcanic rocks similar to those found just north of Sault Ste. Marie. The distinctive silhouettes of these cuesta-form islands reflect the fact that all these rock units, which form thick sheets that dip gently toward the south, occur along the northern margin of the Midcontinent Rift.

Fossils and Pseudofossils

South of Rainbow Falls Provincial Park, near Winston Point, a few outcrops of Gunflint Formation rocks are exposed along the Lake Superior shore. These rocks are part of the Animikie Group, which underlies the Sibley Group. Rocks of the Animikie Group are more commonly found in the Thunder Bay–Kakabeka Falls area, but chert from the lower part of the Gunflint Formation near Winston Point is of special interest.

It contains algal structures, or stromatolites *(Photo 65)*, and the microfossil remains of other organisms. These ancient remains, which are 1.85 to 2.10 billion years old, or several hundred million years older than the stromatolites exposed at Kama Hill, represent some of the earliest forms of life discovered in the Canadian Shield. They are also among the best-preserved microfossils found in Precambrian rocks anywhere in North America. In recognition of this, the Schreiber Channel Nature Reserve was established to protect the site.

Features resembling the microfossils,

but which formed by inorganic processes, have also been found in these rocks. These pseudofossils formed when pyrite grains were propelled through the rock by the force of crystallization and left worm-like quartz or carbonate trails tracing their paths!

Zenith and Winston Lake Mines

The Zenith and Winston Lake mines lie north of Rainbow Falls Provincial Park, near Winston Lake. Significant amounts of zinc and copper have been recovered from both of these mines.

The First Discovery

The Zenith Mine site is located at the end of a 21.8 kilometre (13.5 mile) long road that branches off from Highway 17 about 2.3 kilometres (1.4 miles) east of Rainbow Falls Provincial Park. Zinc mineralization was known at the Zenith location as early as the 1860s. Between 1889 and 1901, the Grand Calumet Mining Company of Ottawa developed the deposit *(Photo 66)*, and transported 966 tonnes (1,063 tons) of ore grading 45 percent zinc over frozen rivers and lakes to the Canadian Pacific Railway line along the north shore of Lake Superior.

The property then lay idle until 1952, at which time it was taken up by Zenmac Metal Mines Limited. By 1966 this company had built the road to the mine and had constructed a mill at Selim siding. From 1966 to 1970, when the mine was exhausted, 165,300 tonnes (181,800 tons) of ore were recovered. The mine yielded more than 25,300 tonnes (27,835 tons) of zinc, 235 tonnes (258 tons) of copper, and 64 tonnes (70 tons) of cadmium.

The mineralization at the Zenith Mine consisted of irregular masses, fracture fillings, and disseminations of dark brown sphalerite with minor amounts of pyrrhotite, pyrite, and chalcopyrite. It was found in Archean rocks, near the base of a large body of gabbro that had intruded along the contact between a series of pale-coloured volcanic rocks and a younger, overlying series of dark-coloured volcanic and sedimentary rocks.

Modern Exploration Methods in Action

The Winston Lake deposit is just 1.0 kilometre (0.6 miles) southwest of the Zenith Mine. It was discovered in 1982 by Corporation Falconbridge Copper when targets identified using geophysical methods were tested by diamond drilling. The company was working on the theory that the Zenith orebody was simply a portion of a deposit that had formed by volcanic processes, and had been dislocated and remobilized when the magma that formed the Zenith gabbro was intruded.

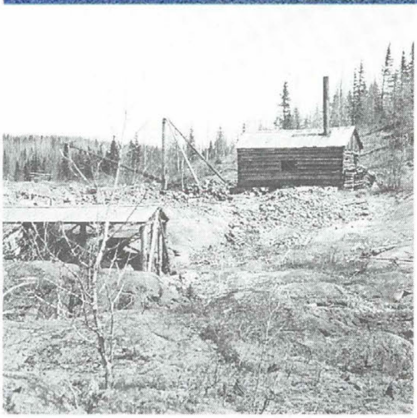


PHOTO 66: The Grand Calumet Mining Company mined 966 tonnes of high-grade zinc ore from the Zenith Mine between 1889 and 1901. This photo shows the property in 1914.

The orebody at the Winston Lake Mine forms a sheet averaging 4.3 metres (14.1 feet) in thickness, 700 to 800 metres (2,300 to 2,625 feet) long, and 300 to 400 metres (985 to 1,300 feet) wide. Drilling during 1982 and 1983 outlined 2,675,000 tonnes (2,942,500 tons) of ore containing 17.81 percent zinc, 0.94 percent copper, and small amounts of gold and silver.

The company put down a shaft to a

depth of 510 metres (1,673 feet) during 1984 and 1985. Work at the property was suspended in 1985, however, pending a company restructuring. In April, 1987, the mine

PHOTO 67: The tall building at Winston Lake Mine is the headframe. It stands over the mine shaft, and houses the hoisting equipment for the "cages" and "skips" used to move workers, supplies, waste rock, and ore.

was acquired by Minnova Incorporated (now part of Inmet Mining Corporation). Development proceeded, and mining commenced the following year *(Photo 67)*. The mine presently yields over 300,000 tonnes (330,000 tons) of ore annually, and has reserves that are expected to last until 1997. Development of the nearby Pick Lake deposit, which was begun in 1996, will mean that mining in the area will continue at approximately the same level until at least 2002.

Production during 1996 totalled 35,000 tonnes (38,500 tons) of zinc and 2,300 tonnes (2,530) tons of copper, down about

PHOTO 68: These prospectors examined samples from an interesting vein just north of Big Duck Lake, about 22 km (14 miles) north of Schreiber, in 1915.

25 percent from 1994. This is still almost twice as much in one year, however, than was produced during the lifetime of the Zenith Mine. The Winston Lake Mine is a tribute to the value of geological theory and advanced techniques in modern-day prospecting.

Schreiber

The town of Schreiber, nestled amongst steep hills of Archean volcanic rocks, was established in 1885 and developed originally about a Division point on the Canadian Pacific Railway line. Between 1915 and 1930, the town witnessed a great deal of gold prospecting and mining activity *(Photo 68)*. Several properties, including the Harkness–Hays, Gold Range, Jeddar, Johnston–McKenna, McKenna–McCann, and Schreiber–Pyramid, were explored.

Two of these properties, the Harkness–Hays (also known as the Vimy Ridge) and the Gold Range, lie about 5.0 kilometres (3.1 miles) northeast of Schreiber along old Highway 17. They are less than 500 metres (1,640 feet) apart, and both are situated on the same vein system. The sites have been partially rehabilitated, however, and the old buildings have been removed.

The Harkness–Hays property was staked in 1918 and investigated by W.S. Jackson between 1918 and 1920. Surface and underground work in 1925 and 1926 produced gold and silver worth $5,879. The Gold Range property was explored sporadically from 1918 to 1937, but even though a small mill was erected at the site, there was little or no recorded production.

Unlike areas such as the Hemlo area east of Marathon, where exploration has resulted in the development of three of Canada's biggest gold mines, the Schreiber area is one where no major deposits have yet been discovered in spite of intensive prospecting and apparently promising geological conditions. Tantalizing rocks typical of the area are exposed just west of town in the large rock face on the north side of Highway 17. Rusty coatings, yellow stains, and powdery white deposits on the surface of the of the outcrop are all evidence that minerals that may be accompanied by gold, silver, or base metals like copper, lead, and zinc are present.

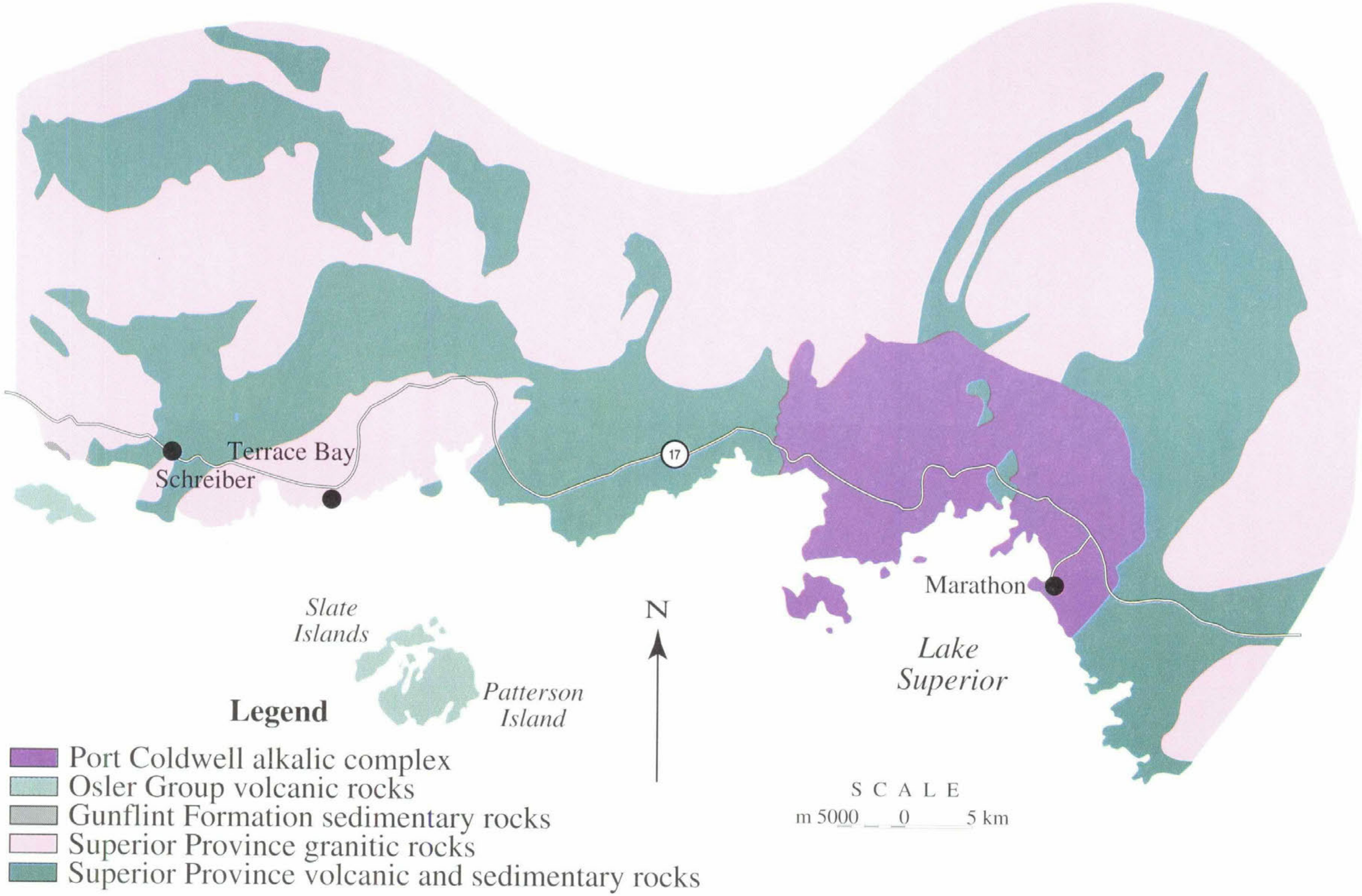


FIGURE 14: Generalized geology of the Schreiber–Marathon area. The scenery of the part of the area underlain by the Port Coldwell alkalic complex is quite different from that of regions underlain by other rock types.

SCHREIBER TO MARATHON

TRIP 7

Much of the area between Schreiber and Marathon *(Figure 14)* is characterized by low to moderately high rolling hills covered with mixed forest, alternating with flat areas covered by stands of pine. Outcrops in the western part of the area are of pink granite, dark green to black greenstone, and dark grey metamorphosed sedimentary rocks. About 60 kilometres (38 miles) east of Schreiber, however, the scenery changes abruptly. Steep, rugged hills and dramatic scenic vistas are the norm. Outcrops of massive red to black rock show that the change in scenery results from a change in the bedrock geology. Here, the highway crosses the interesting and unusual rocks of the Port Coldwell alkalic complex.

Aguasabon Gorge

The turnoff to the Aguasabon River gorge is located just west of the Aguasabon River highway bridge at the west end of the town of Terrace Bay. Parking and viewing areas are found at the end of the road, a few hundred metres (yards) south of the highway. A wheelchair-accessible boardwalk has been constructed to an observation deck.

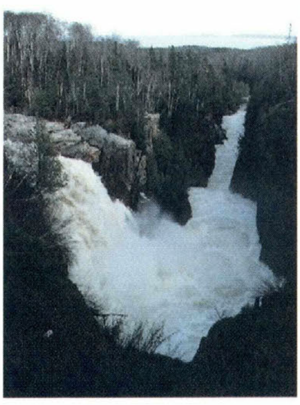


PHOTO 69: The falls at Aguasabon Gorge swell to a thundering cataract each year when spring runoff dramatically increases the flow of water. The position of the falls is controlled by jointing in the rock.

From the observation deck, you can see the water of the Aguasabon River plummet 30 metres (100 feet) over a narrow waterfall, and make a sharp turn to flow through a deep rock gorge towards nearby Lake Superior. In the spring, a dam located upstream along the river is opened, swelling the river and enhancing the spectacular waterfall *(Photo 69)*.

The rock at the waterfall is granodiorite. An igneous rock similar to granite in appearance and composition, it is approximately 2.60 billion years old. The river has eroded its channel along regular fractures or joints in the bedrock, resulting in the sharp turn in the gorge.

A Source of Hydroelectric Power

Much of the present flow in this river originates from Long Lac, which is part of the Albany River watershed. Until 1939 all water from Long Lac flowed north to Hudson Bay. Since then, water from Long Lac has been diverted southward to Lake Superior in order to increase hydroelectric power production on the Aguasabon River and at Niagara Falls. Since 1939, the average diversion from the Long Lac drainage area has been almost 40,000 litres (8,800 gallons) per second.

Terrace Bay

Bedrock is not exposed at Terrace Bay. The principal geological feature here is a succession of flat terraces, made up of deposits of sand and gravel, upon which the town has been built. Like the terraces at Thunder Bay and Nipigon, these terraces reflect changes in water levels in the Superior Basin after the retreat of the glaciers from the north shore region about 10,000 years ago. The terraces are particularly prominent at this locality (the uppermost extends for several kilometres (miles) along Highway 17), and they have provided the town with a most appropriate name.

Steel River Area

Archean granitic rocks and granite gneisses are exposed intermittently in the area east of Terrace Bay *(Photo 70)*. From about 21 to 47 kilometres (13 to 29 miles) east of the Aguasabon River, however, the bedrock consists of interbedded Archean volcanic and sedimentary rocks. The layers of rock trend easterly, roughly parallel to the highway, but dip or slope steeply north at angles of 75 degrees or more. Because the layers originally had horizontal or nearly horizontal attitudes, it is apparent that they have been steeply tilted. Geological evidence indicates that the rocks were tightly compressed into great folds about 2.67 billion years ago; mountainous ridges, now largely eroded away, may have alternated with deep linear depressions such as we now witness in the Rocky Mountains.

Because of the heat and pressure associated with the compression and folding, some of the original minerals present in the rocks changed to new minerals. This resulted in a change in appearance of the rocks. Basalt, perhaps not unlike the 1.11 billion-year-old volcanic rocks found in places along the north shore of Lake Superior, was metamorphosed to greenstone (a type of rock rich in amphibole and the green mineral chlorite). At the same time, the interbedded sedimentary rocks became slaty or schistose when their original minerals changed to platy minerals like mica, with the flat surfaces of the new mineral grains oriented parallel to each other. The metasedimentary rock now splits readily along roughly parallel, closely spaced surfaces, as a result of the new minerals.

Archean Greenstone

The metamorphosed volcanic and sedimentary rocks can be examined at a number of localities where small roadside parks have been established along the highway. A particularly interesting outcrop is found about 1.6 kilometres (1.0 mile) east of the Steel River. Here, the exposure provides an excellent three-dimensional view of greenstone formed from basalt that was extruded onto the sea floor over 2.70 billion years ago. It was originally similar to volcanic rocks that have recently erupted underwater off Hawaii and Iceland.

Piles of Pillows

The greenstone is characterized by well-developed pillow structures. Such structures are fairly common in Archean volcanic rocks, and are evidence that the rocks formed under water. Videos taken of underwater eruptions off Hawaii and elsewhere show that as lava erupts into the sea, bulbous protrusions of molten rock push into the water. The lava is chilled by the cold sea water, and a skin of hardened rock quickly forms over it. Additional lava then pushes through ruptures in the skin, to form new protrusions.

PHOTO 70: This cairn, situated on an exposure of granitic rock about 500 m (1650 feet) from the south end of Jackfish Lake, was erected May 16, 1935 to commemorate the fiftieth anniversary of the last spike on the railway between Montreal and Winnipeg.

This happens over and over again, and the protrusions or "pillows" pile up on top of one another. Newly formed pillows may sag into depressions between older pillows, creating a sharp point in the base of the pillow. Such points tell us which way was "up" when the pile of pillows formed. This outcrop gives a good exposure of pillows in cross-section. The rounded pillow tops and pointed or cuspate pillow bottoms present tell us that the "way up" on the ancient sea floor when these pillows formed was to the southeast. The pillows now lie on their sides because of the folding which has taken place since they formed.

Vesicles or Varioles

The distinct spots that can be seen, particularly in the upper or convex parts of the pillows, were once thought to be gas cavities that were frozen into the rock when it cooled, and were later filled with minerals. Such cavities are common in volcanic rocks such as these. When empty, they are called vesicles; when filled by minerals such as agate after the lava solidified, they are called amygdules.

Close study shows that these spots consist, instead, of primary rock minerals with radiating internal structure. They are believed to have been caused by undercooling, a process whereby the lava was cooled in the liquid state to a temperature below its normal crystallization temperature, and formed volcanic glass. The internal structure of the glass later changed, and the glass converted to crystals, which here radiate outward from scattered nuclei. They are called spherulites or varioles.

PHOTO 71: This young bull caribou is part of the herd of woodland caribou that occupied the Slate Islands in 1907. He was photographed early in the year, so still has "velvet" covering his antlers.

The Tracks of the Glaciers

In Pleistocene time, when continental glaciers advanced across Ontario during the Great Ice Age, the grinding action of debris carried along by the ice wore down the greenstone bedrock, and left the surface crudely polished and scratched. Where subsequent weathering has been negligible, the polished surfaces and scratches have been preserved. The scratches, called glacial striae, are roughly parallel, and mark the direction in which the glacier pushed its rock-studded base across the countryside. The striae preserved here indicate that thousands of years ago, the glaciers moved south-southwesterly over the region.

Slate Islands

The Slate Islands are located about 13 kilometres (8 miles) south of the north shore of Lake Superior, opposite the town of Terrace Bay. The flora, fauna, and geology of these remote islands are all unique. Views of the islands are available to the south of Highway 17, about 30 kilometres (19 miles) east of the Augasabon River, although there are no lookouts or other good spots to pull off the highway in the area.

The rugged topography and cool climate of the islands have resulted in the preservation of certain northern plants. Among the plants are species such as *Dryas drummondii* and mouse-eared chickweed. The low, trailing shrub *Dryas drummondii* is not found again for another 1,600 kilometres (1,000 miles) to the north, while the chickweed, a relict of the Great Ice Age in this its most southerly occurrence, is usually found in the arctic or at high elevations on mountains.

A herd of woodland caribou also occupies the islands *(Photo 71)*. The herd, numbering around 100, is the largest known to be without predators. It was established in 1907, when Lake Superior partially froze in front of Terrace Bay during a particularly cold winter. This formed an ice bridge and allowed caribou living on the mainland to cross to the islands. The caribou do well because there are no predators such as wolf and lynx, and no moose or deer to compete for food or transmit parasites.

The Rocks of the Slate Islands

The geology of the islands is as unusual as the flora and fauna found on them. Surprisingly, there is no slate on the Slate Islands. Instead, the island is underlain mainly by metamorphosed volcanic rocks more than 2.70 billion years old. Also present are 1.85 to 2.10 billion-year-old sedimentary rocks of the Gunflint and Rove formations similar to those found southwest of Thunder Bay, and 1.11 billion-year-old volcanic rocks, dikes, and sills similar to those found to the west and east along the shores of Lake Superior. It appears that about 1.11 billion years ago, there was also a volcanic centre on the largest of the Slate Islands, but subsequent erosion has almost completely removed all the volcanic rocks which erupted from it. The youngest rocks in the area are unusual rocks called diatremes that occur as dikes of irregular size and shape, and crosscut all the older rock types present.

A Possible Meteorite Impact Site

Along with these various rock types are a number of unusual geological structures normally found at meteorite impact sites. The structures include microscopic features such as parallel fractures in quartz, and larger features such as shatter cones *(Photo 72)*. There has been lively discussion amongst geologists for more than 20 years concerning whether or not the Slate Islands were the site of a meteorite impact many millions of years ago.

Port Coldwell Alkalic Complex

The Port Coldwell alkalic complex extends along Highway 17 for 35 kilometres (22 miles), from 2.9 kilometres (1.8 miles) west of the Little Pic River to 3.7 kilometres (2.3 miles) east of Marathon. It is so named because it is in the region about Coldwell, and

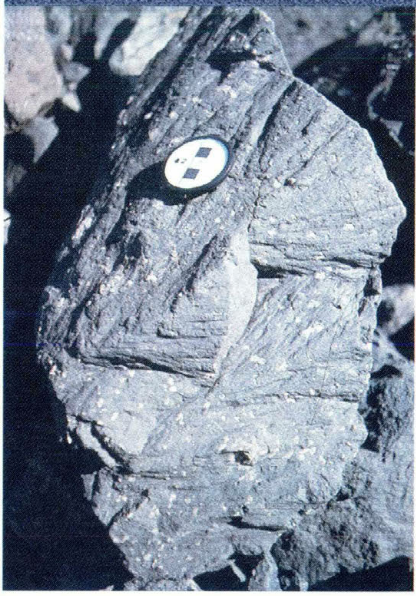


PHOTO 72: Shatter cones in 1.11 billion-year-old amygdaloidal basalt on Patterson Island, the largest of the islands in the Slate Islands group, are evidence that the islands were once the site of a meteorite impact.

it forms a great mass of igneous rocks rich in the alkali metals sodium and potassium.

The complex is characterized by rugged topography, with 100 to 200 metre (330 to 660 foot) high hills separated by steep valleys. Cliffs are common. Huge piles of talus can be seen at the base of cliffs in many places, including along the shores of some of the small, isolated lakes, streams, and swamps that lie in some of the valleys.

A Range of Rock Types

The rocks of the Port Coldwell alkalic complex are mainly syenites and gabbros. They are brick red to chocolate brown or black on fresh surfaces, and pink to grey to dark brown or rust on weathered surfaces. In some places, they exhibit spheroidal weathering, with groups of large, rounded bumps being left after the erosion of flat expanses of rock. Many of the rocks of the complex are fairly coarse-grained. In places where feldspar is abundant in the coarse-grained rocks, sunlight reflected from a myriad of flat cleavage surfaces gives the rock a spangled look *(Photo 73)*.

Most syenites are rather like granites in overall appearance, and except for the absence of the mineral quartz, they are also rather like granites in composition. Syenites are generally named after the principal minerals, other than feldspar, that are present. Thus an augite syenite contains the mineral augite; hornblende syenite, the mineral hornblende; and nepheline syenite, the mineral nepheline. Augite syenite is exposed 4 kilometres (2.6 miles) west of the turnoff to Marathon and 2.0 kilometres (1.3 miles) east of Angler Creek, while feldspar-rich red syenite outcrops 16 kilometres (10 miles) west of the turnoff on the bank of Mink Creek, and nepheline syenite is exposed at the Coldwell townsite.

The other main rock type in the area is gabbro, which is much like diabase in composition. Gabbro is exposed in roadcuts along Highway 17 east of the Marathon turnoff.

PHOTO 73: The flat cleavage surfaces left when feldspar grains in Port Coldwell alkalic complex rocks are broken are easily seen in this photograph. They act as tiny mirrors, making the rock sparkle in the sunlight.

Formation of the Complex

The Port Coldwell alkalic complex is the largest of its kind in North America. It is made up of a series of three concentric intrusions of various compositions, which become progressively younger to the southwest. The outermost bands or rings of the two oldest intrusions are made up largely of gabbro. This is succeeded upward and inward by syenite. The youngest intrusion is made up of curved sheets of various types of syenite.

For the most part the units of rock dip eastward near the Little Pic River, westward near Marathon, and southward near Bamoos Lake a few kilometres north of the highway. The assemblage of igneous rocks thus forms a huge saucer-shaped or funnel-shaped body, with the different rocks stacked as discontinuous and crudely semicircular bands, roughly concentric about the centre of the alkalic complex.

Recent radioactive age determinations indicate that the Port Coldwell alkalic complex, like the diabase sills near Nipigon, formed 1.11 billion years ago, and is amongst the youngest Precambrian rocks found along the north shore of Lake Superior. Both formed as a result of the rifting, or partial break-up of the North American continent at that time.

Economic Mineral Potential

The Port Coldwell alkalic complex contains deposits of copper, nickel, columbium, iron, platinum group elements, and other valuable metals. Although none of these appears to be mineable at present, they indicate that the area has potential economic significance.

Nepheline, an important mineral constituent of the syenite of the Port Coldwell alkalic complex, has wide application in ceramic manufacturing. While not being obtained commercially from this syenite at present, nepheline is being mined from a similar rock near Peterborough in southern Ontario.

The rocks themselves are also of considerable economic interest. The dark augite syenite and the red hornblende syenite are massive rocks of pleasing appearance, particularly when cut and polished. They have all the necessary qualities of good building and ornamental stones. Indeed, both rocks were quarried near Marathon for these purposes, and were sold as "black granite" and "red granite" respectively. In the 1880s, "black granite" was quarried for use in the Canadian Pacific Railway bridges over the Pic and Little Pic rivers, and in 1920s and early 1930s, both "black granite" and "red granite" were quarried for use in buildings in Toronto, Thunder Bay, Chicago, Detroit, and other cities in the midwestern United States. The T. Eaton Company College Street building in Toronto, now a heritage building, is one of the buildings in which the "black granite" was used.

Little Pic River

A scenic lookout located along the south side of Highway 17, 1.3 kilometres (0.8 miles) east of the Little Pic River looks out over the rugged Coldwell Peninsula, which juts into Lake Superior from the north shore. The stark beauty and turbulent waters of the area were made legendary by A.Y. Jackson, Franklin Carmichael, Lawren Harris, and other "Group of Seven" artists. One of Harris' most famous works is a painting of Pic Island; the rock wilderness he captured is just south of the Coldwell Peninsula.

Also visible from the lookout is the splendid valley of the Little Pic River *(Photo 74)*, with its steep escarpment on the west side of the river, north of the bridge. The river valley extends north for several kilometres (miles) as a deep, narrow, linear depression. This linear depression is thought to reflect the occurrence of a zone of fractured and sheared rock, developed by movements along a prominent north-south fault that cuts across the Port Coldwell alkalic complex.

Muddy Water

The name "Pic" means "muddy river", an appropriate designation because upstream from the bridge, the river flows through clay banks that were deposited on the bottom of ancient Lake Superior at the end of the Great Ice Age. The clay banks consist of thin layers, or varves, that alternate between muddy and silty units. Each pair of layers represents the deposits of one year; the muddy layer was deposited during summer when the water was relatively warm, and the silty layer was deposited during winter when the water was relatively cool. Because water is less dense when it is warm

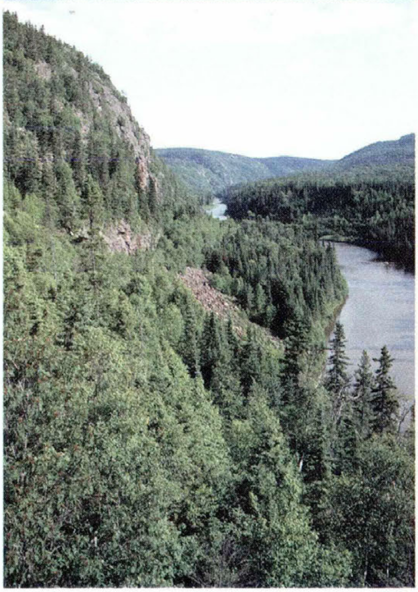


PHOTO 74: The narrow valley of the Little Pic River follows a prominent north-south fault that has cut across the Port Coldwell alkalic complex, leaving behind broken, easily-eroded rock.

than when it is cool, the warmer summer water could not keep the clay and mud in suspension, while the denser winter water could.

Red and Black Breccia

The lookout is also located within the Port Coldwell alkalic complex, near its western margin. The rock exposed at the lookout is an igneous breccia, or rock composed of angular fragments of pre-existing rocks that were fractured, broken, and incorporated into a molten igneous intrusion *(Photo 75)*. The intrusive rock is a pink to red syenite, a rock similar to granite. The fragments are of the dark, fine-grained volcanic rock that formed the bedrock of the area before the syenite was intruded. The resulting rock has a startling, dramatic appearance.

Neys Provincial Park

The entrance to Neys Provincial Park is 4.5 kilometres (2.8 miles) east of the Little Pic River. The park grounds are located on a sandy beach in the river estuary about 3 kilometres (2 miles) by paved road from the main highway. White spruce, balsam fir, white birch and trembling aspen thrive in drier parts of the park, while black spruce, larch and white cedar abound in wetter areas. Secluded campsites, good swimming, and interpretive programming facilities are available.

PHOTO 75: Igneous breccias, wherein angular fragments of rock are engulfed by a flood of magma, are found along the margins of some intrusions. In this one, the black rock has been intruded by pink syenite.

PHOTO 76: The eastern shore of the Coldwell Peninsula and Pic Island, with part of the beach at Neys Provincial Park, can be seen in this view to the south from the park.

Excellent views of the park itself, and of the shoreline and islands of Lake Superior can be had from vantage points along the three hiking trails in the park *(Photo 76)*. The complicated interrelationships between the diverse rock types of the Port Coldwell alkalic complex, which underlies the park, are well shown along the shore in outcrops of intrusive breccias, and in exposures of syenite with dikes of three or more different rock types crosscutting each other. Evidence of the passage of the glaciers is present in the sets of glacial striae left on some of the outcrops, while other outcrops have been smoothed and polished by the powerful waves of Lake Superior.

The south shore of the Coldwell Peninsula also has the mysterious "pukaskwa pits". These rock cavities along the beach are remnants of ancient native constructions. Their purpose remains a mystery, although they may have been used as canoe shelters, dwellings, fish smokehouses, places of sacred rituals, or blinds for caribou hunting.

This once-remote site served as a prisoner-of-war camp during the 1940s, although little evidence of the camp remains today.

Marathon

Marathon is sheltered in a deep-water bay behind a high rounded promontory known as "the Peninsula". The town originated as a fur trading post, but grew to its present population after a kraft pulp mill was built there between 1944 and 1946. Marathon is dominated by the high rounded hills of the Peninsula. It used to also be dominated by huge conical hills of pulp logs stored on the shores of the bay *(Photo 77)*, but these have disappeared since the James River Ltd. pulp mill began to use wood chips instead

PHOTO 77: Hills of pulp logs like these used to be a familiar site in Marathon, where they were used as the raw material for kraft paper. In June, 1985, the pulp logs were replaced by wood chips as the raw material, and the hills of logs disappeared.

of pulp logs as its raw material. Originally, the logs were floated downriver to the mill during the summer, and stockpiled to provide raw materials for steady production through the winter.

Interesting Geological Features

The Peninsula is underlain by augite syenite of the Port Coldwell alkalic complex. Black augite syenite is also exposed along Highway 17 both east and west of the Marathon turnoff. The unusual composition of some of the syenites in the area is emphasized by the fact that the rare cerium carbonate minerals parisite and bastnaesite have been reported from the road cut 1.6 kilometres (1.0 mile) east of the turnoff.

Some interesting features of post-glacial geology can also be seen at Marathon. The road into town from Highway 17 drops down over a series of sandy terraces, which mark former glacial lake beach levels. Approximately the first 0.8 kilometres (0.5 miles) of the road lies on the highest of these terraces, about 120 m (400 feet) above the current level of Lake Superior.

Pebble Beach

Pebble Beach, at the southeast end of town, a scenic beach 2.0 kilometres (1.3 miles) long, is made up of smooth, naturally polished rocks *(Photo 78)*. The rocks are of a very wide range of rock types, including virtually every type of rock to be found for a great distance north of town. They owe their presence on the beach to the action of glaciers during the Great Ice Age. Many different rock types were picked up and carried along by the ice on an 800 kilometre (500 mile) journey from the Hudson Bay Lowlands. Other rocks were scooped up by the ice just north of Marathon, and reflect the local rock types. Most surviving fragments are of igneous rocks like granite, but even fossils such as coral and trilobites from the Hudson Bay Lowlands can be found.

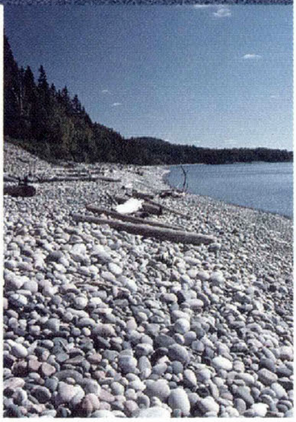


PHOTO 78:
Pebble Beach, a popular picnic site for Marathon residents, is made up of well-rounded pebbles and cobbles of a wide variety of different rock types.

Of note is the fact that virtually all the cobbles on the beach, regardless of composition, are of almost the same size and shape. The shape of the cobbles resulted when the rocks were ground against one another and the bedrock as they were moved southward by the glaciers. Flowing water in post-glacial streams then began the task of sorting the rocks by size; those that were too small were washed away, while those that were too large were left behind in the river bed. The sorting was finished by the vigorous action of waves along the shore of Lake Superior. When waves now wash the shores during stormy weather, the rocks can be heard rolling in the surf, grinding against one another and being smoothed and polished much as the stones in a rockhound's tumbler are polished.

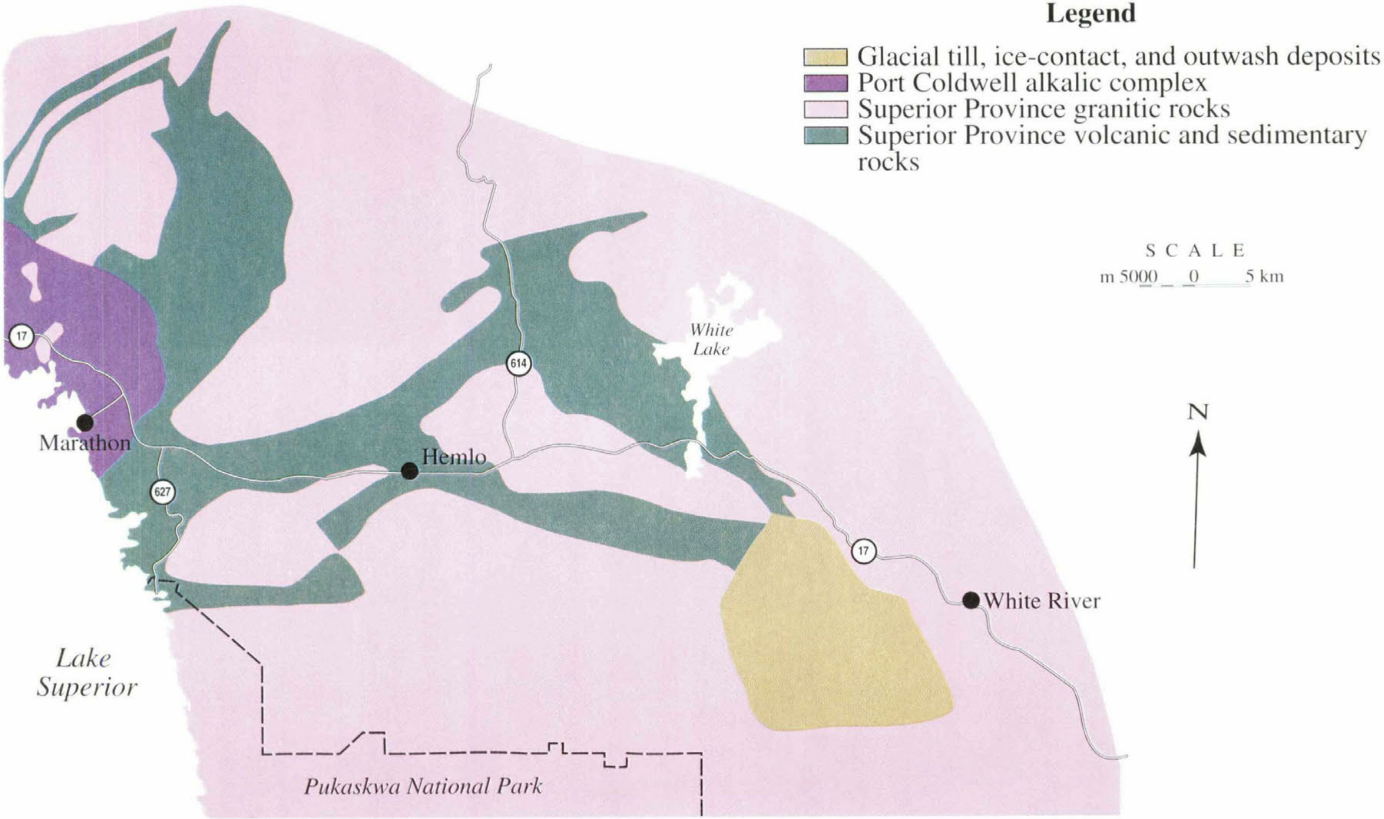


FIGURE 15: Generalized geology of the Marathon–White River area. Most of the area is underlain by Archean volcanic, sedimentary and granitic rocks, and is marked by a relatively low topography mantled in places by extensive glacial deposits.

Marathon to White River

TRIP 8

Highway 17 east of Marathon departs from the shoreline of Lake Superior and arcs inland for about 190 kilometres (120 miles) *(Figure 15)*, regaining the lake at Michipicoten near Wawa. About 3.3 kilometres (2.1 miles) east of the Marathon turnoff, an outcrop of rusty weathering, chocolate brown to black coarse-grained gabbro marks the eastern margin of the Port Coldwell alkalic complex. The highway then enters a region underlain by a great terrain of granitic rocks interrupted in places by long belts of Archean volcanic and sedimentary rocks. Highway 17 runs along the boundary between two such belts of volcanic and sedimentary rocks from the edge of the Port Coldwell alkalic complex to the junction with Highway 614, the road to Manitouwadge. From there to White River, it passes over a region dominated by a variety of granitic rocks.

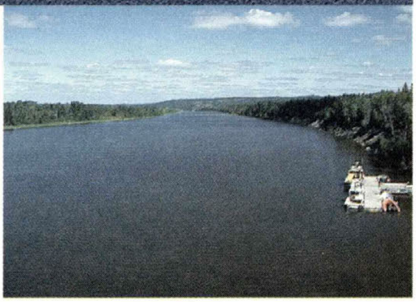


PHOTO 79: The topography of the flat-lying glaciofluvial deposits near the mouth of the Pic River contrasts with that of the distant area underlain by Archean volcanic, sedimentary and granitic rocks.

Topographic changes clearly reflect differences in the underlying bedrock. Areas underlain by the Port Coldwell alkalic complex are rugged, with steep hills and high relief, but a few kilometres (miles) east of Marathon, where the bedrock consists of volcanic, sedimentary and granitic rocks, the topography changes to low, broad, hills covered by mixed forest. Deposits left at the end of the Great Ice Age contribute to the topographic diversity too, by blanketing the bedrock and in places creating broad, flat expanses of gravel, sand, and silt *(Photo 79)*.

Pukaskwa National Park

Pukaskwa National Park, described as "the wild shore of an inland sea", was established by the federal government in 1983. Ontario's largest national park, it covers an area of 1,878 square kilometres (725 square miles) and is located along the east shore of Lake Superior south of Marathon.

Road access leads only to the most northerly part of the park, at Hattie Cove. It is by way of Highway 627, which runs south from Highway 17 for 14.8 kilometres (9.3 miles). The junction of highways 17 and 627 is 6.6 kilometres (4.1 miles) east of the Marathon turnoff. There are few outcrops along the road into the park. For the most part, the road crosses deposits of gravel, sand, silt, and clay, left behind by the Pic River at the end of the Great Ice Age.

Pic River Sand Dunes

Just north of the bridge over the Pic River, a side road leads south from Highway 627 to a campground area and beach. The sand on the beach was also deposited by the Pic River. About 10,000 years ago, the river was swollen with meltwater running off the melting glaciers, and carried a huge load of sediment. As the river entered the lake, it lost its energy and thus its carrying power. The sand was dumped near the mouth of the river. Over the years, the wind and water have shaped it into the beach and dunes.

Even today, the dune complex is active. The Lake Superior shore is wide open to the prevailing westerly winds here, and sand is picked up from the beach and blown inland.

A series of primary dunes receive some of the beach sand. In turn, they are eroded themselves.

On the beach there is no vegetation. In the fragile environment of the primary dunes, however, grasses, beach pea, and a few other hardy plants have established a foothold. Their roots help to keep the sand from shifting. Trembling aspens, normally 15 to 20 metres (50 to 65 feet) high, are stunted and twisted on the dunes, where they have managed to grow to only 1 to 2 metres (3 to 6 feet) in height because of the high winds.

From the low, primary dunes, sand is swept onto the secondary dunes. The crests of these dunes are at tree top level! The huge dunes are slowly but steadily moving inland, and encroaching upon the black spruce forest. The first line of trees has been partly buried by sand, and some of the trees have been killed *(Photo 80)*. In fact, some of the stumps and logs found along the beach are dead black spruce, smothered by advancing dunes long ago.

Hiking Trails

The Hattie Cove Campsite, at the end of Highway 627, is the centre for most park activities and services. It is also the start of the Coastal Hiking Trail, as well as several shorter trails. The Coastal Hiking Trail is a rugged trail that extends south from Hattie Cove for 60 kilometres (40 miles) along the shore of Lake Superior. It offers many beautiful vistas of both the land and the lake. The shorter trails, which take only on hour or two to complete, explore the shores and forests in the Hattie Cove area. All provide access to a variety of geological features.

In the farthest northern and southern parts of the park there are outcrops of metamorphosed Archean volcanic and sedimentary rocks, but most of the park is underlain by granitic rocks of the Pukaskwa gneissic complex. All these rocks are about 2.70 billion years old. In places, they have been intruded by diabase dikes about 1.11 billion years old *(Photo 81)*. A thin mantle of glacial deposits covers much of the area, and raised beaches and terraces like those found at

PHOTO 80: Grasses growing on the lee side of the secondary dunes help stabilize the sand. Trees that have been killed and partially buried by the advancing sand can be seen along the foot of the dune.

Thunder Bay, Nipigon, Terrace Bay, and Marathon, can be recognized at places along Lake Superior's shore.

Glaciofluvial Deposits

Just east of its junction with Highway 627, Highway 17 crosses the Pic River. About 6 kilometres (4 miles) father east, the highway crosses the Black River, a major tribu-

PHOTO 81: Diabase dikes like this one, which cuts across pale pink granitic rocks south of Oiseau Bay, can be seen at places along the Coastal Hiking Trail in Pukaskwa National Park.

tary of the Pic. The valleys of both rivers were inundated by glacial Lake Algonquin at the end of the Great Ice Age, leaving swamps, sand plains, gravelly beach deposits, and deposits of clay and silt. A result of this is that the bedrock along Highway 17 from about 9 to 28 kilometres (6 to 18 miles) east of the Marathon turnoff is almost completely covered by a blanket of sediment, resulting in flat countryside with very few outcrops to be seen.

The "Grand Canyon" of the North

An interesting erosional feature in the blanket of glaciofluvial sediments has been nicknamed "The Grand Canyon of the North" by area residents. It can be reached by way of a fairly obscure gravel road, leading north from the east end of a long curve in Highway 17, 25.7 kilometres (16.1 miles) east of the Marathon turnoff, or 19.1 kilometres (11.9 miles) east of the junction of highways 17 and 627. Although rough, the gravel road can be negotiated by car except after heavy rains. About 1.1 kilometres (0.7 mile) from Highway 17, the gravel road forks. Park off the right-of-way at the fork, and follow either branch of the road to the edge of a spectacular pit. Approach the edge of the pit with caution.

PHOTO 82: Thick sequences of sand, silt and clay can become unstable and slump catastrophically when water-laden. This relatively small slump is one of many that helped form the "Grand Canyon of the North" near Rous Lake.

What was once a small pit in a thick sequence of fine-grained sand, silt, and clay has become a crater of huge proportions. Air photos show that in 1962, the pit was about 6 to 9 metres (20 to 30 feet) deep, 180 metres (600 feet) wide, and 270 metres (900 feet) long. Although no longer being excavated by man, 1974 air photos show that the forces of nature had been at work. By then, the pit measured 23 to 30 metres (75 to 100 feet) deep, 317 metres (1,040 feet) wide, and 378 metres (1,240 feet) long. Today it is even bigger.

The enlargement of the pit engulfed a portion of two roads, and a considerable amount of forest area. Some 4.6 to 6.1 million cubic metres (6.0 to 8.0 million cubic yards) of material have been displaced, equivalent to 10 tandem trucks hauling 10 loads a day for twenty years.

The pit seems to be growing in the direction of Rous Lake, 0.8 kilometres (0.5 miles) to the east. Water from the lake apparently flows underground along the tops of impermeable clay layers in the glaciofluvial sequence, and upon reaching the pit walls it flows down and washes away sand and silt. In places on the floor of the pit, water can even be heard running beneath the surface!

Natural Environmental Hazards

Sediment washed from the pit has made the water of the nearby Black River cloudy. At times, sediment also fills the air. "Clouds" of fine silt are blown from the pit walls on windy days. Large sections of the pit walls also slump down from time to time *(Photo 82)*, carrying trees and vegetation with them. In places, however, the trees seem to be stabilizing the pit walls, and the vegetation growing inside the pit appears to be slowing the rate of pit expansion.

Other areas in Ontario and Quebec with similar deposits of glacially derived fine sand, silt, and clay have been the sites of disastrous accidents. Huge slumps have taken place, dislocating dozens of homes and businesses, and killing residents. One such land movement took place at the former townsite of Lemieux, 50 kilometres (31 miles) east of Ottawa on June 20, 1993, when 2.5 to 3.5 million cubic metres (3.3 to 4.6 million cubic yards) of sand, silt and clay slumped into the South Nation River valley.

Hemlo Gold Mines

About 37 kilometres (23 miles) east of the turnoff into Marathon, Highway 17 reaches a region of considerable economic importance. Previously known only for a sleepy hamlet along the Canadian Pacific Railway line, the area was catapulted into the international news in 1981 when the Hemlo gold deposit was discovered.

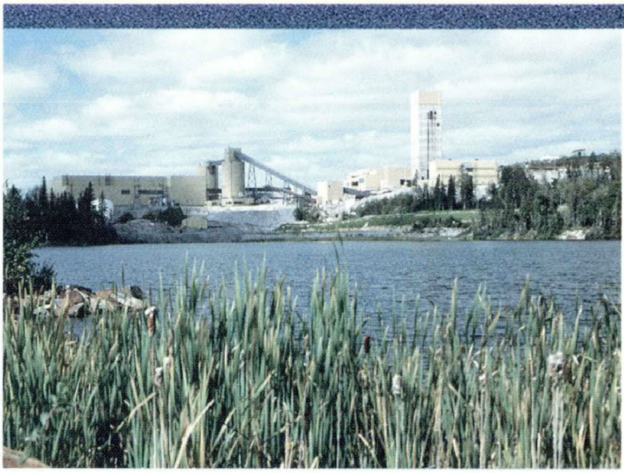


PHOTO 83: The Williams Mine, operated by a joint venture between Teck Corporation and Homestake Canada Inc., was Canada's leading gold producer for several years.

Three mines—the Williams at the west *(Photo 83)*, the Golden Giant in the centre, and the David Bell at the east—soon came into production, making the Hemlo area one of the foremost gold producing camps in North America. In 1992, the area's best year, the Hemlo mines provided approximately 50 percent of Ontario's gold production and 23 percent of Canada's gold production. From west to east, the mines were Canada's number one, number two, and number three gold producers!

The Orebody

The Hemlo deposit lies within a west-trending sequence of volcanic and sedimentary rocks rich in fine-grained white mica or sericite. The deposit forms a sheet-like structure that has a continuous strike length at surface of 2.9 kilometres (1.8 mile), and extends at least 1.3 kilometres (0.8 mile) down its dip of 50 to 60 degrees to the north. It is estimated to contain geological reserves of about 69 million tonnes (76 million tons) of ore grading 8.2 grams of gold per tonne (0.24 ounce of gold per ton), or more than 565,800,000 grams (18,190,000 ounces) of gold. The gold is found associated with pyrite, molybdenite, and other sulphide minerals.

An outcrop of the West ore zone can be seen just north of the highway about 500 metres (0.3 miles) east of the eastern end of Moose Lake. The ore at this outcrop, as well as elsewhere in the orebody, is characterized by the presence of minerals such as molybdenite, green mica, sericite, and pyrite (fool's gold). The gold itself is typically not visible to the naked eye because of its microscopic grain size. Weathering of the pyrite gives the outcrop its rusty appearance.

Old Prospects Become New Mines

The first recorded exploration of the area was in 1869. Prospecting continued on and off through the years. The history of the area was succinctly recorded by Sabina (1991, p.88). Her report, which uses the abbreviations "g" for grams, "t" for tonnes, "g/t" for grams per tonne, and "m" for metres is as follows:

> *"Interest in the Hemlo deposit was sparked by the 1944 discovery of a gold showing north of Moose Lake by Moses Fisher of the Heron Bay Reserve. He pointed out his discovery to Harry Ollmann of Heron Bay who, along with J.K. Williams of Maryland, staked the claim in 1945. Forty years later, the claim became the Williams Mine. At about the same time (1945) adjoining claims to the east were staked by a group consisting of T. Page, M. Bartley,*

Moses Fisher, A. Halliday and J.K. Williams. Between 1947 and 1959, these claims and the Ollman-Williams claims were explored first by Lake Superior Mining Corporation Limited and later by Teck-Hughes Gold Mining Limited. In 1973-1974, Ardel Exploration Limited did some drilling on the deposit. None of these investigations resulted in locating the main ore zone. In the winter of 1979-1980, John Larche and Donald McKinnon [of Timmins] staked blocks of claims which were later optioned to International Corona Resources Limited, Goliath Gold Mines Limited and Golden Sceptre Resources Limited.

The richness of the ore deposit was revealed in the summer of 1981 when the main ore zone was intersected during a drilling program directed by geologist David Bell on the International Corona property. By the end of that year, Teck Corporation undertook development of the property which became the Teck-Corona Mine, later renamed the David Bell Mine. After this company outlined a deposit of 1.18 million t grading 10.2 g/t gold in 1982, other companies became interested in the Hemlo deposit. Noranda Limited began development of the Golden Giant and Goliath properties which became the Golden Giant Mine, and Lac Minerals began open pit operations on the Ollmann-Williams claims, now the Page-Williams Mine. News of the developments at Hemlo brought a prospecting rush to the area and by the end of 1982 the entire region from Wawa to Terrace Bay was staked.

The first mine to come into production was the Golden Giant in March 1985. The David Bell Mine produced its first gold bar, which weighed 30,978.6 g, in May 1985. Six months later, Lac Minerals Limited poured its first gold bar from its open pit operation. The mines are operated from shafts to depths of 1,100 m (Golden Giant), 1,100 m (David Bell) and 350 m (Page-Williams). To the end of 1985 production of gold amounted to 3,052,915 g (Golden Giant), 652,821 g (David Bell Mine) and 322,507 g (Page-Williams Mine)".

Controversy has surrounded the deposit since its discovery. First, there was disbelief that junior, normally "speculative" mining companies could have made the fabulously wealthy discovery they claimed to have made. Then, there was amazement that such a deposit could lie exposed at surface within a stone's throw of the Trans-Canada Highway without having been recognized *(Photo 84)*. Lawsuits concerning irregularities in the rush to acquire land followed.

Today, the discussions centre on how the deposit originated. Some geologists claim that it formed at the same time as the host rock, while others contend that the deposit was formed later than the host rock. Although such discussions may seem to be academic, the answer to this question has important implications in the search for other deposits of this type.

Manitouwadge

The town of Manitouwadge lies 56 kilometres (35 miles) north on Highway 614 from its junction with Highway 17, about 40 kilometres (25 miles) east of the Marathon turnoff. This attractive little town came into being in the mid 1950s following the discovery of zinc-copper-lead-silver orebodies north of Manitouwadge Lake. Four mines have operated in the area: the Geco; the

Willroy; the Willecho; and the Big Nama. By 1994, all had ceased production except the Geco Mine, operated by Noranda Minerals Inc. Geco closed November 1, 1995 due to depletion of its ore reserves.

The Archean volcanic and sedimentary rocks at Manitouwadge have been folded into a large east-trending trough or syncline, with the sedimentary rocks towards the interior of the fold. The core of the syncline is occupied by a large mass of granitic rock, and the orebodies are located in the sedimentary rocks near the contact with the granite. Numerous faults also cut the host rocks and the orebodies. The roads to both the Geco and Willroy mines have been built in valleys along such faults.

The Geco Mine

In 1993, the Geco Mine produced 18,410 tonnes (20,250 tons) of copper, 18,176 tonnes (20,000 tons) of zinc, and 31,950,000 grams (1,027,000 ounces) of silver. From the start of milling in 1957 until it closed, the Geco Mine yielded more than 51,500,000 tonnes (56,650,000 tons) of ore grading 1.85 percent copper, 3.84 percent zinc, and 56.8 grams per tonne (1.66 ounces per ton) silver, and thus was one of Ontario's major mines. In addition to the copper, zinc, and silver, the mine also yielded lead and gold.

The deposit, located 2.0 kilometres (1.3 miles) north of Manitouwadge Lake, consisted of a tabular body of massive sulphide minerals, chiefly pyrite, pyrrhotite, sphalerite, and chalcopyrite, enclosed in an envelope of foliated muscovite-quartz schist containing scattered sulphide minerals. It trended east and dipped vertically. An impressive pit some 120 metres (400 feet) deep marks one of the original surface outcrops of the Geco orebody. The ore has now been mined out of this section, and the pit has formed by caving of the original mine workings.

A Fortune Lost and Found Again!

The Manitouwadge area was first mapped geologically by Dr. J. E. Thomson for the Ontario Department of Mines in 1931. On his map, Thomson indicated the presence of a sulphide occurrence at the site of the present Geco mine. While studying this map in the winter of 1952-1953, two weekend prospectors, Roy Barker and William Dawd of Geraldton, Ontario, decided to investigate. In May, 1953, with air transportation provided by their friend and neighbour, Jack Forster, they visited the location shown on Thomson's map. They were sufficiently impressed that they decided to stake the ground.

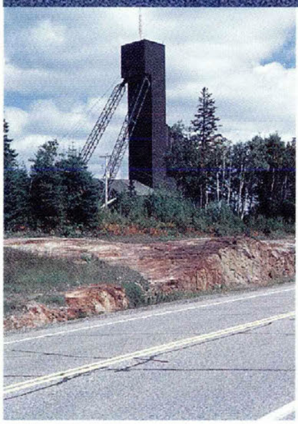


PHOTO 84: It took more than thirty-five years for the full potential of the deposits like the one at David Bell Mine to be recognized, even though they could be easily reached by way of the Trans-Canada Highway!

Before they could stake their claims, however, they had to go back to Geraldton for supplies. While in Geraldton, they found that others were becoming interested in the Manitouwadge sulphides too. When they returned to the showing on June 22, they were disappointed to find that, during their absence, the occurrence had been staked by other prospectors. Fortunately for Barker, Dawd and Forster, these prospectors were looking for nickel, and, when assays of samples failed to indicate any, the claims were not recorded.

As soon as the thirty day time limit for recording was up, Barker and Dawd restaked the discovery. In July, the property was taken up by General Engineering Company, Ltd., Consolidated Howey Gold Mines, Ltd. and H.

W. Knight and Associates. Diamond drilling by this partnership soon indicated that the deposit was of great significance. A major prospecting rush to the area followed. Over 50,000 claims were staked in a solid block extending as far away as the village of Hornepayne on the Canadian National Railway line. Exploration soon resulted in the discovery of the other orebodies to the west of the Geco deposit. The first ore was milled at the property of Willroy Mines Ltd. in October, 1956 *(Photo 85)*, establishing Manitouwadge as an active base metal mining area.

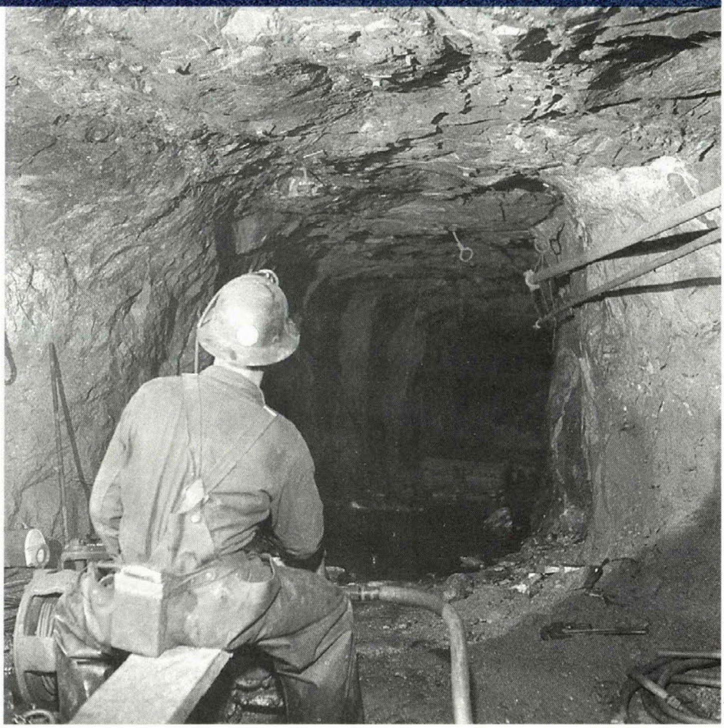


PHOTO 85: Miners at Willroy Mine used scrapers, called "slushers", like this one, when the mine began operations in 1956. The slushers were strung on cables and dragged in and out of the drift to remove the broken ore.

White Lake Provincial Park

About 59 kilometres (37 miles) east of the Marathon turnoff and about 18 kilometres (11 miles) east of the junction of Highway 614, an access road on the south side of Highway 17 leads to a recreation park of some 15 square kilometres (6 square miles) on the shore of White Lake. There are many campsites in a forest of jack pine, white birch and poplar. Across the lake from the park is a Hudson Bay Trading Post, around which much of the local aboriginal life centred. This area is the ancestral homeland of the Ojibwa and the Cree Indians, and there are many legends about the battles fought for its hunting grounds.

Although there are no outcrops in the park itself, a contact between granitic rocks and one of the volcanic-sedimentary belts has been assumed to strike east across the park. The granite lies to the south of the contact. There are also geophysical indications of a major diabase dike running northwest beneath the campground.

The sandy soil in the park was left behind when the melting ice sheets filled a depression in the rock of the Canadian Shield at the end of the Great Ice Age, and formed a large lake. Over time, the lake decreased in size, exposing beaches whose sand has a high limestone content *(Photo 86)*—evidence that much of it was transported hundreds of kilometres (miles) from the James Bay lowlands by the glaciers.

White River

White River lies 92 kilometres (58 miles) east of Marathon on Highway 17. It originated in 1885 as a Canadian Pacific Railway depot. Situated within a hill-flanked bowl in a deeply eroded section of the Canadian Shield, White River is well away from the warming influence of Lake Superior. Since cold air drains to valley floors, White River is much colder than most places in the district. It is famous for its severe winter temperatures—publicized by the large thermometer by the highway—although it is debatable if it is truly the coldest spot in Canada.

Since 1894, the White River area has also been a centre of logging, although it did not gain its present stature as a major logging community until 1977 when its first sawmill was opened. Today, logging, sawmill, and reforestation operations in the area are major employers.

The mill produces enough lumber each year to frame 50,000 three-bedroom houses! Scraps from the sawmill operations are not wasted: woodchips and sawdust are shipped to the paper mill at Red Rock, just west of Nipigon, to be made into paper, or are sold to other area pulp mills; shavings are bagged and sold as animal bedding; and the bark, which is removed from the logs in one of the first stages of the milling process, is burned to fuel the boilers of the drying kilns and to heat the sawmill during the winter!

A Bowl of Granite and Migmatite

The huge bowl-shaped depression surrounding White River is underlain by a large batholith of granitic rocks. Exposed intermittently along Highway 17 for 55 kilometres (34 miles) west of the town, some of the rocks making up the batholith are granites in the true sense of the terminology, but most are migmatites. The granites are pink, massive rocks made up of quartz, feldspar, and some black mica, while the migmatites are grey to black, white, and pink, and composed of the highly altered remnants of preexisting volcanic and sedimentary rocks mixed thoroughly with variable amounts of granite *(Photo 87)*.

There are two varieties of migmatite: breccias, in which fragments of the older rocks are cemented by dikes and veins of granite; and banded rocks, in which layers of the older materials alternate with layers of granite. In the banded type, the migmatite is said to have a *"lit-par-lit"* structure.

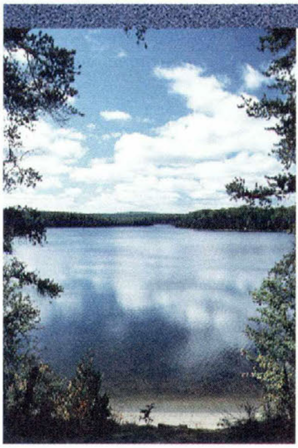


PHOTO 86: White Lake Provincial Park has no outcrops. Instead, it is characterized by sandy soil left behind in a large lake at the end of the Great Ice Age. A mixed forest thrives on the ancient lake deposits.

The granitic rocks and migmatite formed deep within the earth some 2.72 billion years ago. About 1.11 billion years ago, they were fractured and intruded by magma that cooled to form dikes of diabase. The diabase, like that near Nipigon and Thunder Bay, is a black or dark brown rock. It therefore contrasts sharply with the pink granitic rocks of the region, and, where it is present along the highway, is quite conspicuous.

PHOTO 87: The banded pink and grey migmatite and the dike of bright pink coarse-grained granite that cuts across the migmatite are typical of the rocks found in the White River area.

White River's World-Famous Bear

It is through White River's association with the railway that the world was ultimately given the well-loved bear, "Winnie-the-Pooh". In 1914, a young soldier from Winnipeg was on board a troop train heading east. When the train stopped in White River to take on coal and water, the soldier noticed a trapper with a little bear cub in his arms. The soldier bought the bear for $20 and named her "Winnipeg", or "Winnie" for short, after his home town.

Winnie was taken by train to the east coast, and by ship to London, England. In December of 1914, the troops, who were camped near the London Zoo, were called to the front lines in France. The bear was left at the London Zoo, where she became a major attraction, and the favourite bear of A.A. Milne's son Christopher Robin. In 1926, Milne published his book "Winnie-the-Pooh" based on the relationship between his son and the bear!

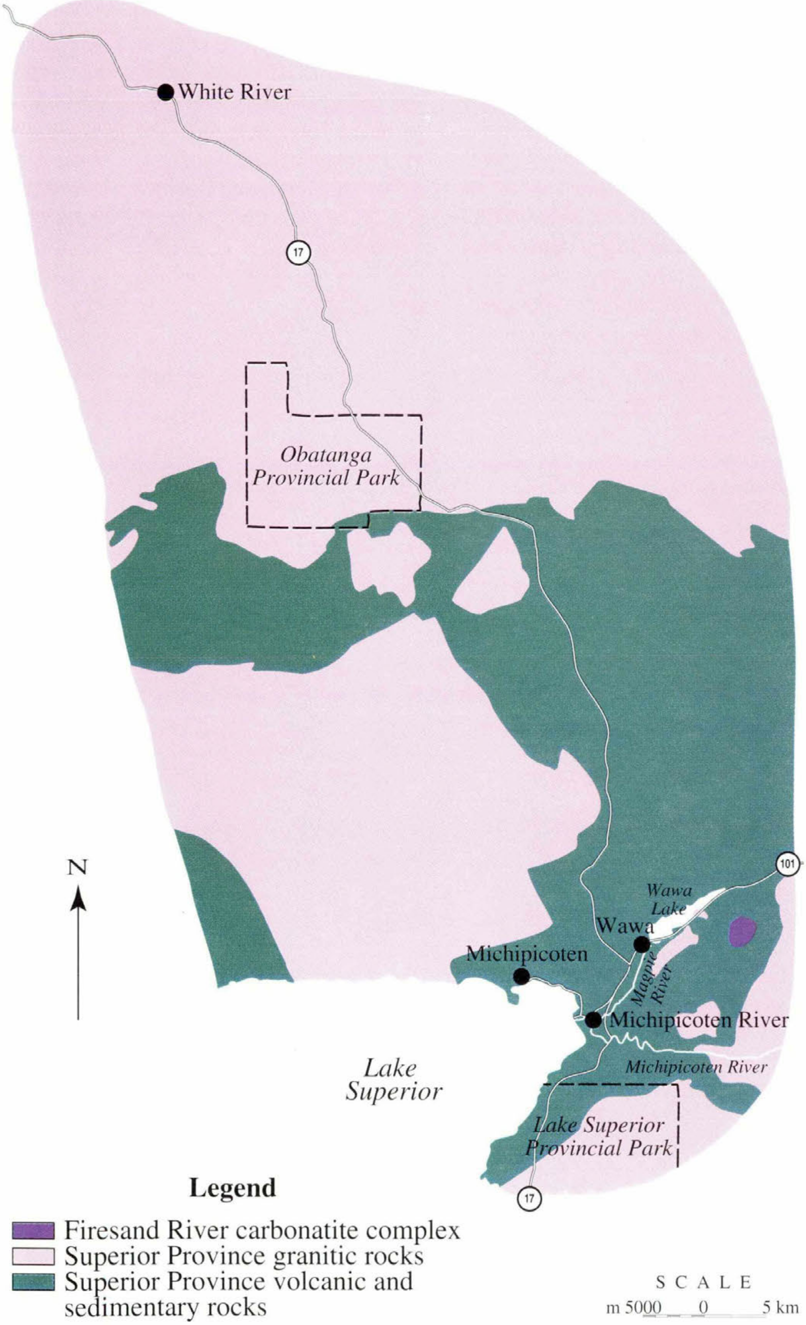


FIGURE 16: Generalized geology of the White River–Wawa area. The northern part of the area is underlain by granitic and migmatitic rocks, while the southern part is underlain by metavolcanic and metasedimentary rocks.

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 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.

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

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 sequence 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.

PHOTO 90: These highly strained fragmental volcanic rocks come from the same outcrop as the rocks shown in Photo 89! They show that deformation in weakly metamorphosed rocks can be quite localized.

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

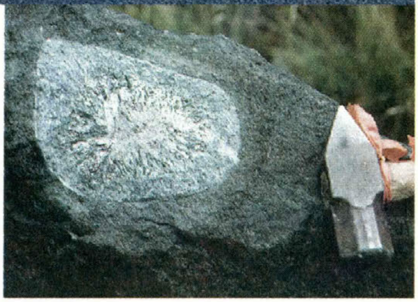


PHOTO 91: Fragments of rock contained within an unusual lamprophyre dike exposed south of the junction of highways 17 and 519 are intensely altered. This is just one of a number of similar dikes in the area.

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

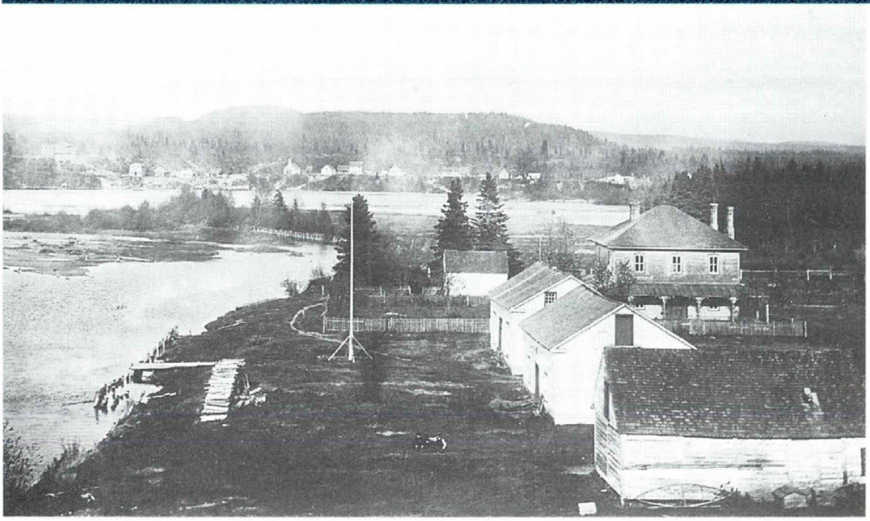


PHOTO 92: The first Mining Recorder's office in Ontario was opened in 1897 at the Hudson's Bay Company post at Michipicoten. It was located in the building with the flagpole in front of it. The developing town of Michipicoten Mission can be seen in the distance in this photgraph, taken about 1899.

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 northeast. 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 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.

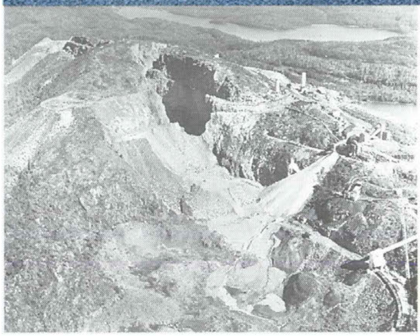


PHOTO 93: This 1955 aerial view looks south across the Helen open pit and past the headframe at the George W. MacLeod mine to Wawa Lake. The headframe is at the crest of the hill, just up from the buildings where the ore is processed.

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 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.

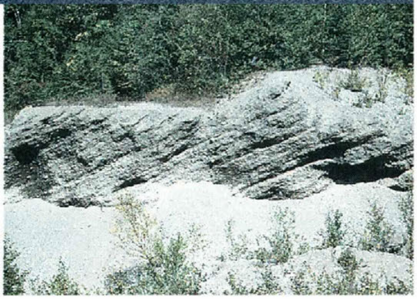


PHOTO 97: The layers in this gravel were not tilted during some upheaval of the ground. Instead, they formed at this orientation. Angled layers like these are common in sediments deposited by flowing water or blowing wind.

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.

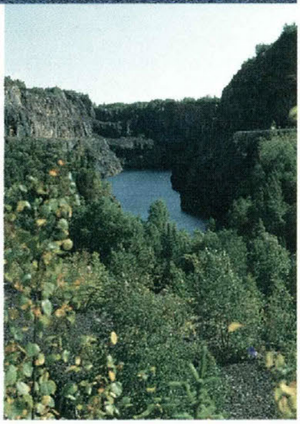


PHOTO 98: The Sir James Dunn open pit was mined between 1958 and 1967. It yielded more than 7,000,000 tonnes (7,700,000 tons) of iron ore, which was used in steel production at The Algoma Steel Corporation Ltd. mill in Sault Ste. Marie.

"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.

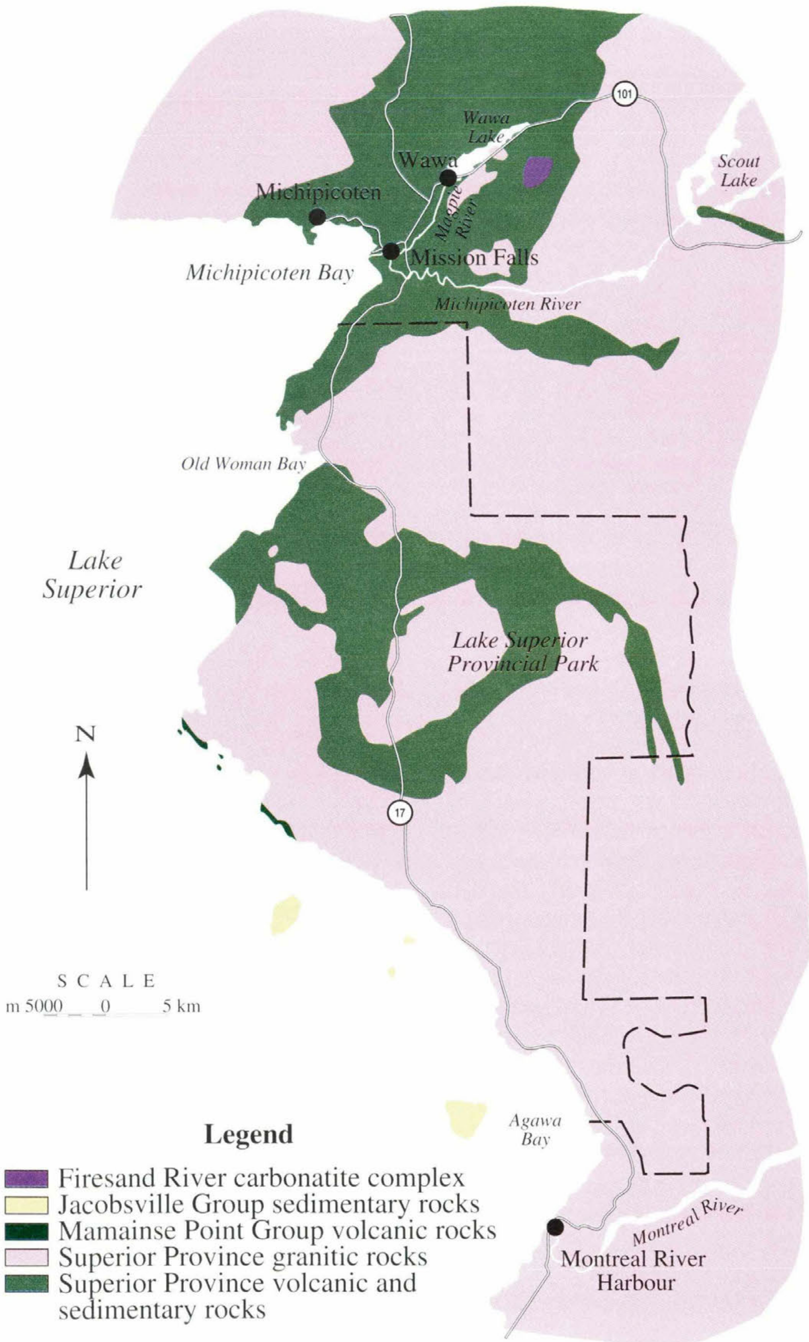


FIGURE 17: Generalized geology of the Wawa–Montreal River area. Most of the northern part is underlain by volcanic rocks, while the southern part is almost entirely underlain by granitic and migmatitic rocks.

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.

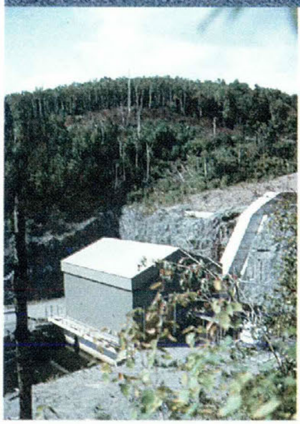


PHOTO 102: This hydroelectric generating station is located downstream from Michipicoten Falls (Magpie High Falls) along the Voyageur trail. It is built on volcanic rock, which can be recognized by its characteristic greyish green colour.

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.

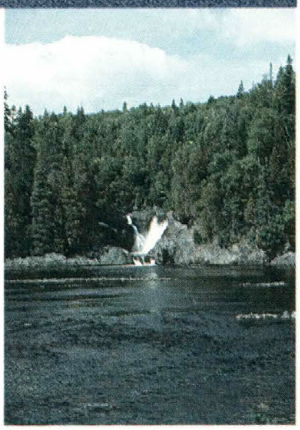


PHOTO 103: The middle of the three cascades that make up Mission Falls, known locally as Silver Falls, can be seen from the road to Michipicoten Harbour.

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.

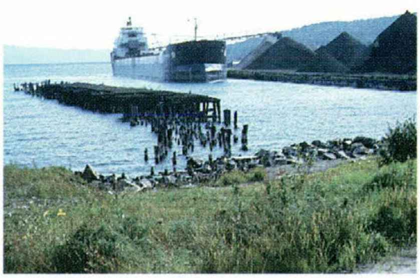


PHOTO 105: The remnants of an old wharf at Michipicoten Harbour lie alongside the modern docking facilities used by the John B. Aird to offload a cargo of coal bound for Wawa.

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

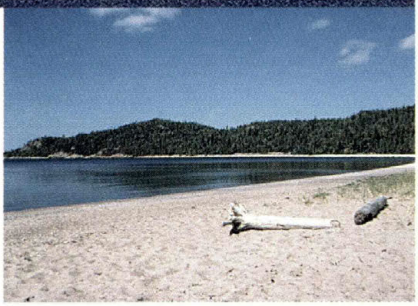


PHOTO 107: The beach at Old Woman Bay is just one of many beautiful beaches in Lake Superior Provincial Park. A picnic site has been established here.

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.

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

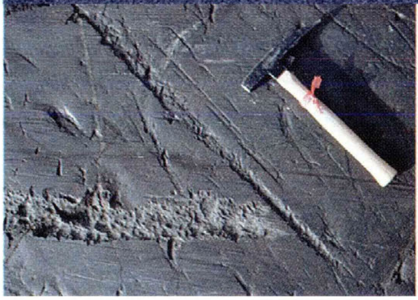


PHOTO 108: These striae record three glacial advances. The first was parallel to the hammer handle, the next was almost parallel to the hammer head, and the last was from right to left.

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 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 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.

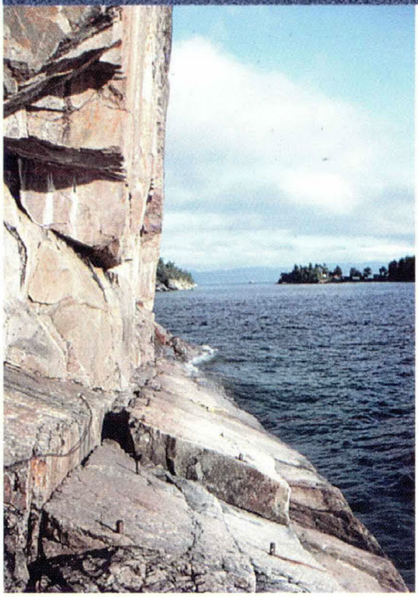


PHOTO 111: Agawa Rock formed when a granite outcrop broke apart along vertical and subhorizonal joints, leaving a high vertical cliff with a small sloping shelf at its base. Along the base, 35 Indian pictographs are painted.

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.

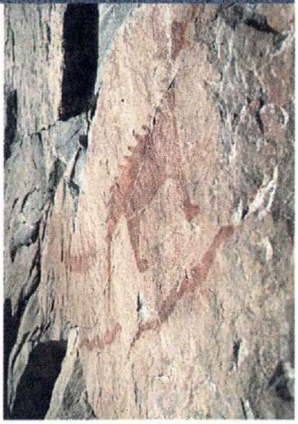


PHOTO 112: The paintings at Agawa Rock, done in red ochre, are said to commemorate the success of an Ojibwa war party. These pictographs represent the spiny-backed Misshepezhieu (the water spirit), a canoe carrying warriors (image to the left of Misshepezhieu), and two serpents.

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

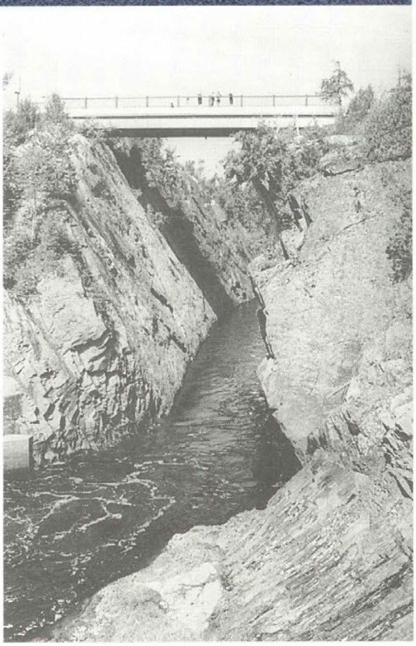


PHOTO 114:
The Montreal River canyon at Highway 17 is a result of differential erosion. The canyon walls are of resistant granite, while the floor is underlain by a steeply dipping diabase dike with closely spaced joints. The easily eroded diabase is exposed in the foreground of the photograph.

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!

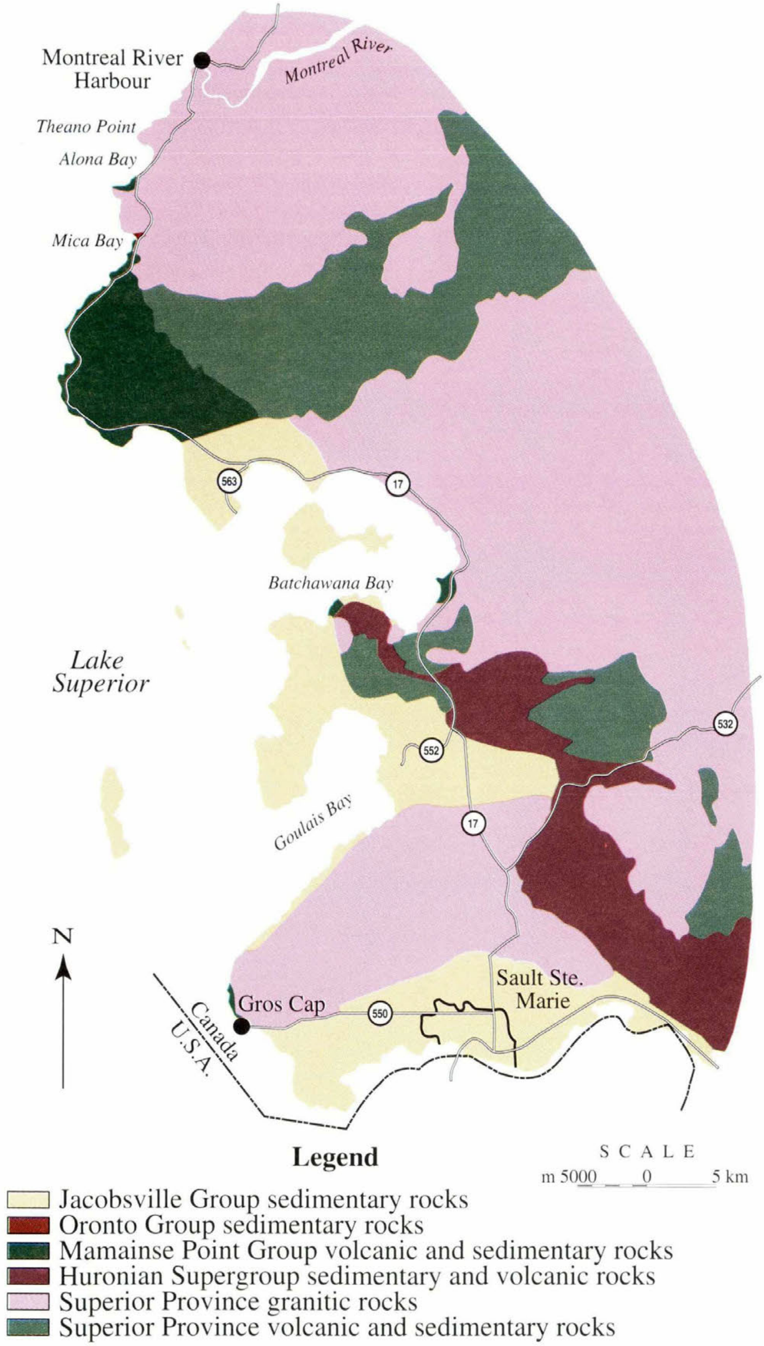


FIGURE 18: Generalized geology of the Montreal River–Sault Ste. Marie area. Exposures of Superior Province and Southern Province rocks alternate in this region, resulting in varied topography and scenery.

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

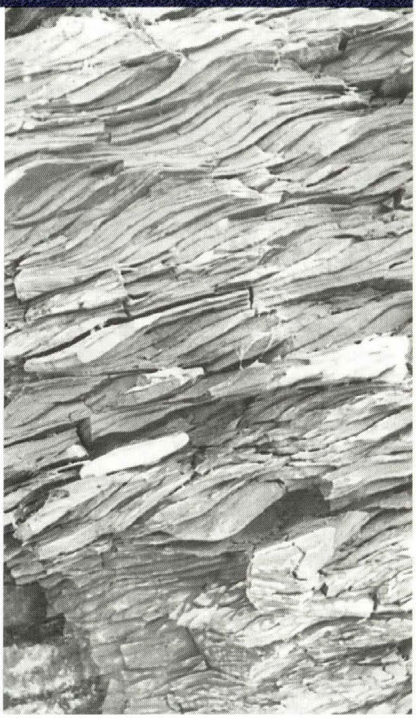


PHOTO 118: These structures in the sandstone at Mica Bay indicate that the water was flowing from right to left when the sediment was being deposited. They are typical of ripples formed by waning currents. A white jackknife near the middle of the photograph provides a scale.

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.

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 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.

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.

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

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.

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 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.

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.

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 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.

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.

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

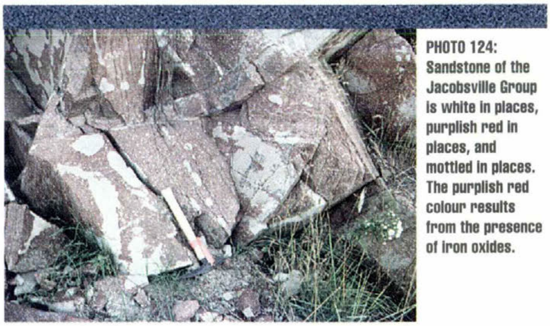


PHOTO 124: Sandstone of the Jacobsville Group is white in places, purplish red in places, and mottled in places. The purplish red colour results from the presence of iron oxides.

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

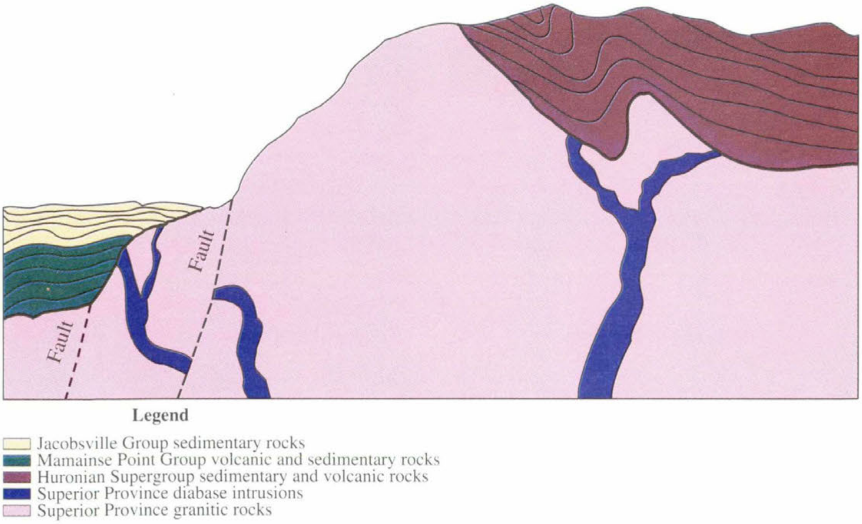


FIGURE 19: Cross section of the area between Sault Ste. Marie (at left) and Bellevue (at right). The older rocks occur at higher elevations, while the younger rocks are found at lower elevations in a down-faulted basin that formed during development of the Midcontinent Rift.

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!

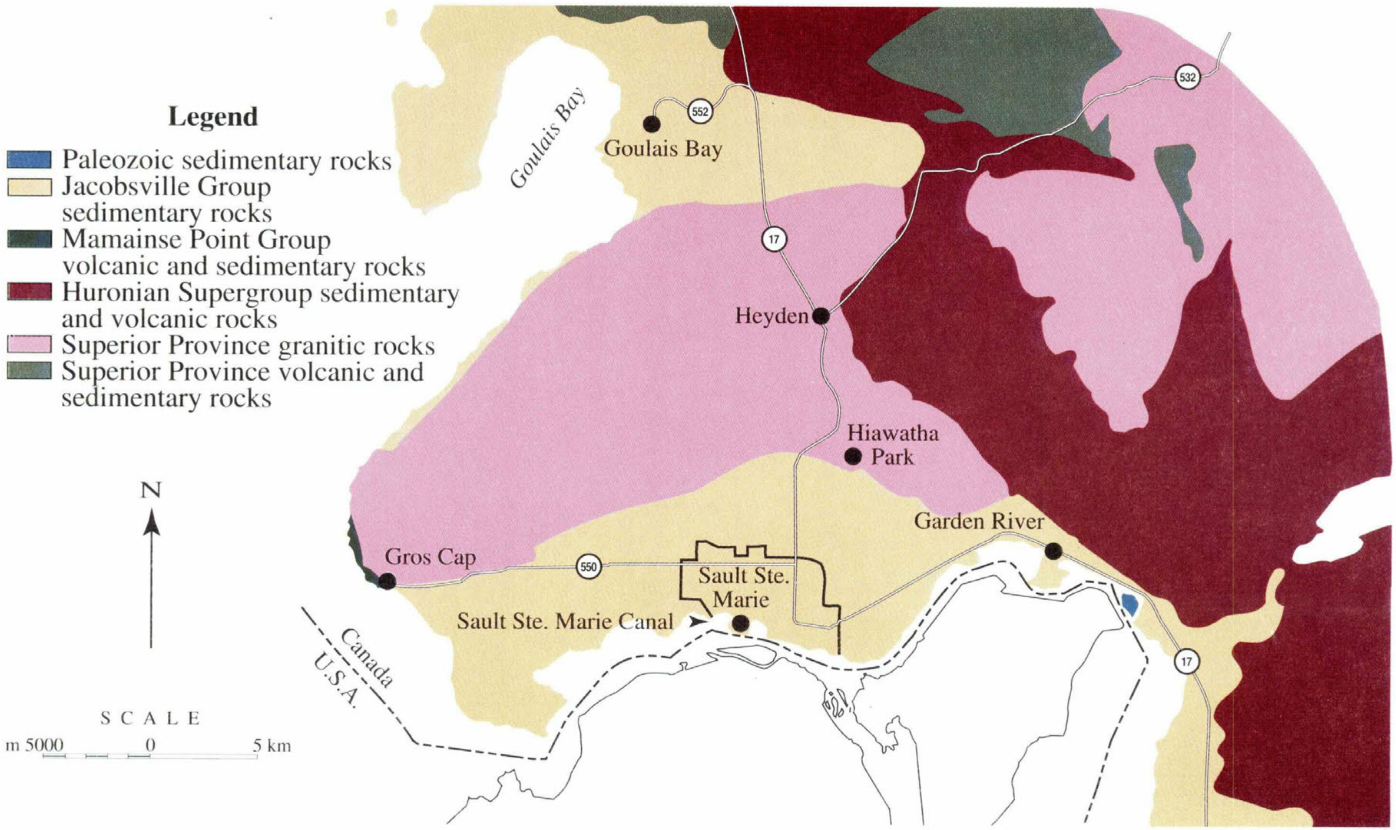


FIGURE 20: Generalized geology of the Sault Ste. Marie area. The Archean rocks of the Superior Province were blanketed by the Proterozoic rocks of the Southern Province. Both were subsequently deformed and eroded, and eventually covered by younger volcanic and sedimentary rocks, and by glacial debris.

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.

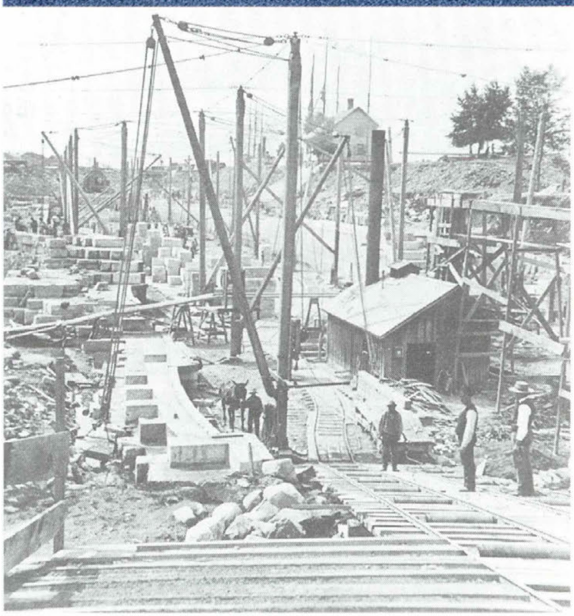


PHOTO 125: Construction on the Canadian locks at Sault Ste. Marie began after the US refused a Canadian ship passage through the American locks in 1870. The locks, shown here under construction ca. 1880, were completed in 1895.

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 126: 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)*.

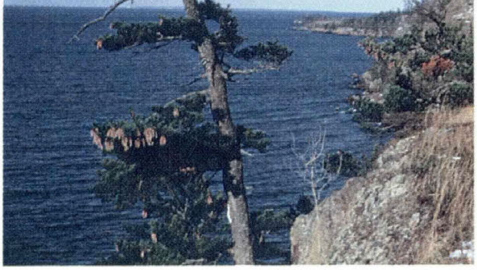


PHOTO 127: Gros Cap is popular with Sault Ste. Marie residents as a destination for family outings, and for rock and ice climbing. The promontory, home to hawks and bald eagles, offers a panoramic view across Whitefish Bay.

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

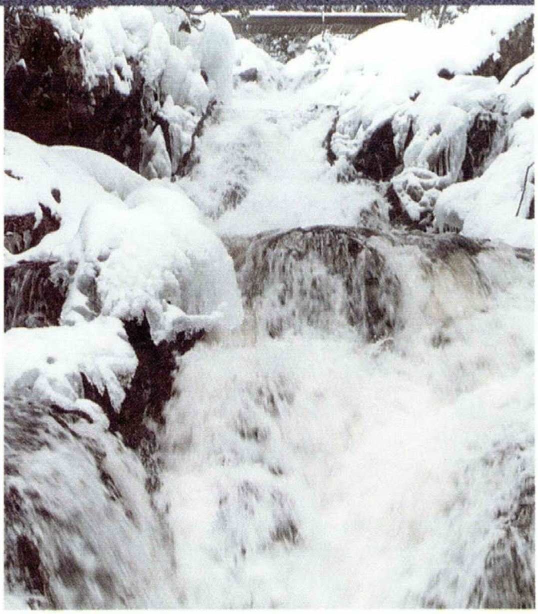


PHOTO 129: Crystal Creek tumbles over snowy ledges of lichen-covered granite at Minnie Ha-Ha Falls. The falls are one of the features that attract visitors to Kinsmen Hiawatha Municipal Park year-round for hiking and skiing.

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.

ROCKS AND MINERALS FOR THE COLLECTOR

PART 3

A large variety of minerals and rocks, some of them suitable for lapidary work (cutting and polishing) can be found along or close to highways 61, 11&17, and 17, near the north shore of Lake Superior. Names and descriptions of some of the minerals and localities where they occur follow, as do some general comments concerning access to properties in northern Ontario for the purposes of mineral collecting. The list of minerals and sites is not exhaustive, and includes only the more common minerals. For more information the reader is referred to the compilation by Ann P. Sabina (1991, p.55-134) published by the Geological Survey of Canada.

Access to Collecting Sites

Much of northern Ontario is Crown land, and thus accessible to everyone, but collectors should note that many mineral occurrences and old mines are covered by valid mining claims. In some cases, the holders of the mineral rights also hold the surface rights of the property. In other cases, the mineral rights and the surface rights have different owners. Mineral occurrences may also be on properties where the surface rights are held, but the mineral rights are not.

No mineral materials should be removed from claims without the permission of the claim holder. In addition, permission to enter privately-held properties should always be obtained from surface rights holders before accessing any property. Information concerning the ownership of mining lands can be obtained from the offices of the Mining Recorders in Thunder Bay and Sault Ste. Marie, at Suite B003, 435 James St. South, Thunder Bay, Ontario, P7E 6E3, (807) 475-1311, and 60 Church St., Sault Ste. Marie, Ontario, P6A 3H3, (705) 945-6925 respectively.

Collectors should not despair at these restrictions. There are plenty of places where minerals can be found on Crown Lands along the shores and roads north of Lake Superior. Please be aware of safety at all times, however, especially when stopping at outcrops along the highway and when challenging the ever-changing boating conditions of Lake Superior.

MINERALS

Agate - Agates with beautiful concentric colour markings are found filling cavities in Keweenawan basalts exposed on Black Bay Peninsula and on the islands in Lake Superior to the east *(Photo 130)*. Many agates have weathered loose from the bedrock, and are commonly found as pebbles in the gravel beaches along the east side of the peninsula and the south sides of the islands. Other well-known localities include Michipicoten Island, and Cape Gargantua in Lake Superior Provincial Park.

PHOTO 130: Brightly coloured agates like these examples from Michipicoten Island are left behind after Keweenawan volcanic rocks along the north shore of Lake Superior are eroded.

Amethyst - Amethyst is a variety of quartz with a distinct purple colour. It occurs in veins, and where these have open cavities or vugs, it commonly forms beautiful clusters of pyramidal crystals. Samples of amethyst can be found on old mine dumps in the region around the city of Thunder Bay, in veins at the mouth of the McKenzie River about 16 kilometres (10 miles) northeast of the city, and in narrow veins cutting shales in the bed of the Current River within the city limits. The most notable localities are, however, northeast of Thunder Bay in Dorion and McTavish townships, near the head of the Sibley Peninsula. Several localities where visitors can collect their own material for a fee are listed at the end of this section, along with shops where samples, decorative items, and jewellery made from local amethyst can be purchased.

Anthraxolite - Anthraxolite, a mineral substance resembling anthracite coal, occurs in narrow veins in rocks of the Gunflint Formation. Samples have been found at several localities in and near the city of Thunder Bay. Generally, the veins are so narrow and so erratically distributed that individual occurrences have not been recorded.

PHOTO 131: This delicately bladed barite was recovered from Coppercorp Ltd.'s copper mine at Copper Creek, near Mamainse Point.

Apophyllite - Apophyllite crystals occur in narrow quartz-calcite veins in diabase along Highway 17, 1.3 kilometres (0.8 mile) south of the south branch of the Baldhead River, in Lake Superior Provincial Park.

Argentite - Argentite was a common but valuable mineral in the silver ores mined about Thunder Bay prior to 1913. Samples in which argentite is associated with calcite can be found in the old mine dumps in and around the diabase-capped mesas along Highway 588, about 6.4 kilometres (4 miles) southwest of the village of Stanley. The quality of the material, however, is poor.

Arsenic - Native arsenic was found in a shaft 10.6 metres (35 feet) deep, sunk on a silver-bearing vein at the south end of Edward Island in 1884. Edward Island is at the entrance to Black Bay, east of Sibley Peninsula, and can be reached by seaworthy boats from Silver Islet landing.

Augite - Specimens of augite up to 2.5 centimetres (1 inch) across, can be obtained from a very coarse-textured syenite in a rock cut 61 metres (200 feet) east of the roadside table on Highway 17, 4.0 kilometres (2.5 miles) west of the Marathon turnoff.

Barite - Good samples of barite *(Photo 131)* can be found on the dumps at the Beaver Junior Mine and in the North Bluff vein on which this mine was developed. The mine site is west of Thunder Bay along Highway 588, 6.4 kilometres (4.0 miles) southwest of Stanley, at the west end of a diabase-capped mesa. Barite can also be found in veins in granitic rocks on Ozone Creek, 18 kilometres (11 miles) east of the junction of highways 11 and 17 and at Coppercorp Ltd.'s mine near Mamainse Point. The most notable location in the region is Little McKellar Island south of Pie Island, Lake Superior.

Bytownite - Bytownite, a calcium-rich variety of feldspar, is found as large crystals, or phenocrysts, in a porphyritic basalt exposed along Highway 17 in Lake Superior Provincial Park, 2.1 kilometres (1.3 miles) south of the north branch of the Baldhead River. The crystals are mostly equant and up to 2.5 centimetres (1 inch) across.

Calcite - Calcite occurs in most mineral veins found in the vicinity of the city of Thunder Bay. Particularly good samples can be found on the dump at the Shuniah mine. This mine is reached from the scenic lookout at Boulevard Lake Park by taking a single-lane road for 0.8 kilometre (0.5 mile) to the radio tower.

The calcite here fluoresces when held under an ultraviolet light. Delicately zoned crystals of calcite are also found in quartz-calcite veins in diabase along Highway 17 in Lake Superior Provincial Park, 1.3 kilometres (0.8 mile) south of the south branch of the Baldhead River.

Chalcocite - Small amounts of chalcocite occur in fractures in Keweenawan basalt along the Lake Superior shoreline between Mica Bay and Mamainse Harbour. It also occurs in a vein at the north end of a wagon road that branches from Highway 17 about 1.8 kilometres (1.1 miles) south of Mamainse Harbour. The distance from the highway to the occurrence is about 900 metres (3,000 feet).

Chalcopyrite - Chalcopyrite, a common sulphide of copper and iron, has been found in most mines in the Lake Superior region. Good samples can be collected at the Enterprise Mine, where it is associated with amethyst, quartz, calcite, and other minerals. The Enterprise Mine lies at the head of the Sibley Peninsula, 14.8 kilometres (9.2 miles) south of Dorion and 1.1 kilometres (0.7 mile) north of Pearl Lake. It can be reached from Highway 11&17 by following road No. 69-13 east for 1.1 kilometres (0.7 mile) to the Canadian National Railway line, and then by proceeding northeast (left) alongside the railway line for 300 metres (1,000 feet). Chalcopyrite can also be found in a copper deposit near Middleton, along a wagon road that extends 0.8 kilometre (0.5 mile) south from Highway 17, from a point 2.1 kilometres (1.3 miles) west of the bridge over the Little Pic River.

Chert - Small concretions, suitable for collectors, can be found in shale quarries along Oliver Road (Highway 130) in the city of Thunder Bay, about 7 kilometres (4 miles) west of its junction with Memorial Avenue (Highway 11&17).

Conglomerate - Conglomerate with pebbles small enough to make the rock suitable for private collections has been nicknamed "puddingstone". Examples of such conglomerate from the Animikie Supergroup can be found in the lower part, and at the south end of the large outcrop at the junction of highways 17 and 590, at Kakabeka Falls Provincial Park. A coarser conglomerate from the Sibley Group is exposed along West Loon Road 3.4 kilometres (2.1 miles) north of where it intersects with Highway 11&17, some 34 kilometres (21 miles) northeast of the city of Thunder Bay.

Copper - Native copper occurs as cavity fillings in Keweenawan amygdaloidal basalts along the north shore of Lake Superior. Specimens have been collected from exposures of this rock on Edward and Porphyry islands at the mouth of Black Bay, on the islands near Rossport, on Michipicoten Island *(Photo 132)*, and along the Lake Superior shoreline between Mamainse Harbour and the old Mamainse mine. During the construction of Highway 17 in 1936, a specimen of native copper weighing 67 kilograms (147 pounds) was found in a rock cut 88 kilometres (55 miles) north of Sault Ste. Marie. Copper-bearing amygdaloidal basalts have also been observed southwest of the city of Thunder Bay in Blake, Crooks, and Oliver townships.

PHOTO 132: Nuggets of native copper like this one from Bonner Head, Michipicoten Island, were widely used for tools and trade items by native North Americans.

"Daisy Stone" - An unusual porphyritic volcanic rock, "Daisy Stone" contains numerous pale grey, tabular phenocrysts of feldspar up to 2.5 centimetres (1 inch) long. The feldspars are arranged in radiating groups or rosettes, and look like flowers set in a contrasting dark green to black, fine-grained matrix. "Daisy

Stone" flows are found at Mica Bay and along Highway 17 at Mamainse Point.

Epidote - Green epidote coats joint surfaces in a hornblende diorite exposed along Highway 17 between Fungus and Kabenung lakes, 47 and 50 kilometres (29 and 31 miles) respectively south of White River. Epidote is also found associated with fluorite and quartz in veins in granite along Highway 17, 11 to 13 kilometres (7 to 8 miles) west of Rossport. Attractive green and pink pebbles of epidote with feldspar can be found along the Lake Superior shoreline at Montreal River.

PHOTO 133: These small purple cubes of fluorite, associated with tiny crystals of quartz, were found just west of Rossport.

Feldspar - Feldspar is not just one mineral; it is a group of related minerals, each with a different amount of potassium, sodium, and calcium. The potassium-rich variety spectrolite, and the calcium-rich variety bytownite are described separately here. Large crystals of other potassium-rich feldspars can be seen in the porphyritic granites exposed at Rossport and at the mouth of the Sand River.

Fluorite - Excellent specimens of fluorite occur as small cubic crystals, either coating fracture surfaces in granite, or associated with quartz and epidote in veins, in a rock cut along Highway 17 about 11 kilometres (7 miles) west of Rossport *(Photo 133)* and 3.9 kilometres (2.4 miles) west of the Pays Plat River.

Galena - Good specimens of galena as perfect cubic crystals can be found on the dump at the Enterprise Mine, described under chalcopyrite above. Galena also occurs at the head of the Sibley Peninsula in a narrow vein, 30 centimetres (12 inches) wide, on the west side of a peninsula near the west end of Silver Lake. The east end of Silver Lake can be reached by a short road that branches from Highway 11&17 about 6.1 kilometres (3.8 miles) north of the West Loon Road. Other galena occurrences include one at Ozone Creek, where the galena is associated with barite.

Garnet - Small but well-formed crystals of red garnet can be found in rock cuts on Highway 17 about 1.4 kilometres (0.9 mile) south of the north branch of the Baldhead River, Lake Superior Provincial Park. Even the syenite dikes in this outcrop contain garnet in places.

Graphite - Graphite was found during mining operations at the Silver Islet Mine, and samples can be found on the dump. A small amount of graphite has been observed in limestone along the bank of the Current River at the north end of Boulevard Lake in the city of Thunder Bay. The mineral is also reported to occur in an outcrop at the south end of the beach extending southward along the Lake Superior shore from the mouth of the Steel River, about 27 kilometres (17 miles) east of Terrace Bay.

Grunerite - Small grains of the iron-magnesium silicate mineral grunerite form the green layers in iron formation near Red Rock Lake on Highway 17, Lake Superior Provincial Park.

Hematite - Good samples of the iron oxide hematite can be found along the Canadian Pacific Railway line 3.2 kilometres (2.0 miles) west of Loon Lake station at the head of the Sibley Peninsula. Hematite also forms botryoidal masses with manganite in a calcite vein in rhyolite on Devil's Warehouse Island, off Cape Gargantua in Lake Superior Provincial Park.

Hornblende - Hornblende crystals, with cleavage faces several centimetres (inches) long, occur in a rock cut along Highway 17 about 22 kilometres (14 miles) west of the town of White River, and 1.6 kilometres (1.0 miles) east of the stream known as West White River. There are no parking facilities at this outcrop, and collectors are warned to take precautions to avoid traffic accidents.

Jasper - Oolitic jasper occurs in lenses in taconite along the bed of the McIntyre River in the city of Thunder Bay. Ordinary red jasper can be obtained in the creek bed behind Mokomon station on the Canadian National Railway line, and at a point along the track about 1.6 kilometres (1.0 mile) north of the station. Mokomon station can be reached by a motor road that branches from Highway 11&17 about 9.6 kilometres (6.0 miles) north of Kakabeka Falls.

Laumontite - Laumontite, one of a group of minerals called zeolites, is found in quartz-calcite veins in diabase along Highway 17, 1.3 kilometres (0.8 mile) south of the south branch of the Baldhead River, Lake Superior Provincial Park. The grains are very small and occur as aggregates in the veins.

Limonite - Specimens of the iron-bearing mineral limonite, formed as a weathering product of pyrite, can be found in the rock cut at the junction of highways 11&17 and 590 at Kakabeka Falls Provincial Park. Samples of lesser quality can also be found at a large outcrop along Highway 17, about 0.8 kilometres (0.5 mile) west of Schreiber.

Magnetite - Magnetite occurs in the roadcut 1.9 kilometres (1.2 miles) west of the bridge over the Little Pic River along Highway 17. It weathers to a coarse, dark, rusty, granular material, and is easily recognized in the outcrop. Fine-grained magnetite is also found in exposures of iron formation in Lake Superior Provincial Park, and 12.7 kilometres (7.9 miles) north of the northern boundary of the park.

Manganite - Botryoidal masses of manganite occur with hematite in a calcite vein in rhyolite on Devil's Warehouse Island (see hematite).

Marcasite - This common iron sulphide mineral is found at many localities along the north shore of Lake Superior, including the mines southwest of Thunder Bay that were mined prior to 1913 for their silver content. It is also found associated with pyrite in the iron ores of the Wawa area *(Photo 134)*.

Molybdenite - Molybdenite occurs in a quartz vein exposed along a motor road 1.3 kilometres (0.8 mile) east of its junction with Highway 11&17, about 5 kilometres (3 miles) north of the entrance to Kakabeka Falls Provincial Park.

PHOTO 134: Tiny cubes of pyrite coat the surface of marcasite crystals from the George W. MacLeod Mine at Wawa. Marcasite has the same chemical formula as pyrite, but a different crystal structure.

Pectolite - Excellent specimens of pectolite, in the form of sheaf-like aggregates of needle-shaped crystals, have been found in a quarry about 1.6 kilometres (1.0 mile) northeast of the Thunder Bay city limits along Highway 11&17.

Pitchblende - Pitchblende, a uranium-bearing mineral, occurs in narrow veins along the contact of a diabase dike in granite on Theano Point at Alona Bay, Lake Superior. A road, not passable to motor traffic, leads 3.2 kilometres (2.0 miles) to the occurrence from its intersection with Highway 17, about 8 kilometres (5 miles) south of the Montreal River.

Prehnite - Excellent specimens of prehnite have been found in amygdaloidal basalts and pebbles along the beaches of the islands in

Lake Superior near Rossport. Some samples contain specks of native copper.

Pumpellyite - Pumpellyite, known locally as "Nipigon Greenstone", can be found in amygdaloidal basalts on islands in Lake Superior near Rossport.

Pyrite - Samples of pyrite (*see* Photo 134) can be found at the outcrop at the intersection of highways 11&17 and 590 at Kakabeka Falls Provincial Park, and in the limonite-coated rusty exposure along Highway 17 about 0.8 kilometres (0.5 miles) west of Schreiber. Pyrite can also be found on most old mine dumps in the Schreiber region.

Quartz - Small prismatic crystals of quartz with pyramidal terminations occur in narrow veins in granite in the outcrop at the intersection of highways 11&17 and 590 at Kakabeka Falls Provincial Park. Pyramidal crystals of transparent quartz are also found associated with amethyst in many places in the Thunder Bay area. Such occurrences include veins along the Current River north of Boulevard Lake, at and near the mouth of the McKenzie River about 16 kilometres (10 miles) northeast of the Thunder Bay city limits, and at amethyst occurrences at the head of the Sibley Peninsula.

PHOTO 135: Samples of wiry native silver from the long-dormant Silver Islet Mine, like this one, are amongst the most desirable of Canadian mineral specimens.

Siderite - The iron ore currently being mined at Wawa by Algoma Steel Corporation Limited is massive siderite, an iron carbonate.

Silver - Samples of vein material containing native silver have been found on the dump at the Silver Islet Mine *(Photo 135)*. Native silver has also been found associated with native copper in the Mamainse Point area.

Spectrolite - Specimens of feldspar having an iridescent or chatoyant (cat's-eye) lustre are known as moonstone or spectrolite. On exceptional samples, a beautiful play of colours in merging patches of blue, purple and gold can be seen on certain cleavage surfaces. Spectrolite can be found along Highway 17 in a rock cut 1.9 kilometres (1.2 miles) west of the bridge over the Little Pic River, between Terrace Bay and Marathon.

Sphalerite - Sphalerite, associated with galena, is found in barite and quartz-barite veins located along Ozone Creek, about 18 kilometres (11 miles) east of the junction of highways 11 and 17 (see barite).

Spodumene - Prismatic crystals of spodumene, an ore mineral of lithium, are present in a pegmatite dike exposed along the Gorge Creek Road, 14.5 kilometres (9.1 miles) east of Highway 11. Gorge Creek Road intersects Highway 11 some 37 kilometres (23 miles) north of its junction with Highway 17 near Nipigon.

Staurolite - Well-formed crystals of staurolite occur in mica schist exposed at the same locality as the spodumene-bearing pegmatite mentioned above.

Rock Shops and Amethyst Mines

Amethyst, Ontario's provincial mineral, is found at a number of localities in the Thunder Bay area. Numerous opportunities exist for visitors to obtain some of this attractive semi-precious gemstone. Finished jewellery and decorative items are available at a number of shops in Thunder Bay and closer to the Sibley Peninsula. Mineral samples and rough rock for jewellery making are available in many of the same shops, as well as at a number of the actual mine sites. Some mines also allow visitors to collect their own samples, for either an admission fee, or a price based on the weight and quality of the material taken. All of the mines are surface mines, with the amethyst-bearing rock coming from shallow trenches or small opencuts.

The amethyst mines, and some of the shops, are open on a seasonal basis only. Would-be collectors are therefore advised to check ahead by calling the mine operators, asking at visitor information centres, or following highway signs to find out which properties are open when they visit. The compilation by Ann P. Sabina (1991, p.55-134) published by the Geological Survey of Canada, and information available from the Thunder Bay Resident Geologist, at Suite B002, 435 James St. South, Thunder Bay, Ontario, P7E 6E3, or from (807) 475-1331 may also be helpful.

Addresses and Telephone Numbers

The names, addresses, and telephone numbers of amethyst shops and mines in the Thunder Bay area are listed alphabetically below. Each entry also gives an indication of what each supplier offers.

Amethyst Factory Gift Centre Precious Purple Gemstones Ltd.
400 East Victoria Ave.,
Thunder Bay, Ontario P7C 1A5
(807) 622-6908
- mineral samples
- jewellery
- amethyst producer
- shop

Authentique Gift Shops
CN Station–Thunder Bay Marina
South Water St.,
Thunder Bay, Ontario P7B 6E8
(807) 345-4789
- mineral samples
- jewellery
- shop

Authentique Gift Shops
1 Valhalla Inn Rd.,
The Valhalla Inn–Thunder Bay South
Thunder Bay, Ontario P7E 6J1
(807) 473-5163
- mineral samples
- jewellery
- shop

Birchwood
Highway 11&17,
Red Rock, Ontario P0T 2P0
(807) 886-2440
- mineral samples
- jewellery
- shop

Blue Points Amethyst Mine
Box 8, R.R. #1,
Pass Lake, Ontario P0T 2M0
(807) 977-2600
- mineral samples
- amethyst producer
- pick your own samples

Castagne's Rocks & Minerals
420 E. Victoria Ave.,
Thunder Bay, Ontario P7C 1A5
(807) 623-5411
- mineral samples
- jewellery
- amethyst producer
- shop

Crystal Creek Amethyst Mines
238 Wilson St. #3
Thunder Bay, Ontario P7B 1M8
(807) 344-0564
- mineral samples
- amethyst producer

Diamond Willow Amethyst Mine
R.R. #1, Pass Lake, Ontario P0T 2M0
(807) 977-2782
- mineral samples
- amethyst producer
- pick your own samples

Don-Art Crafts
Venture Inn, 450 Memorial Ave.
Thunder Bay, Ontario P7B 3V7
(807) 344-9438
- mineral samples
- jewellery
- findings
- shop

Dorion Amethyst Mine
11 Knight St.,
Thunder Bay, Ontario P7A 5M3
(807) 344-2237
- mineral samples
- jewellery
- amethyst producer

Exotic Amethyst Shop
Stillwater Park, R.R. #1,
Nipigon, Ontario P0T 2J0
(807) 887-3701
- mineral samples
- jewellery
- amethyst producer
- shop

Gem Mountain Amethyst Mine
640 River St., Box 21013
Thunder Bay, Ontario P7A 8A7
(807) 345-6230
- mineral samples
- amethyst producer

Ontario Gem Amethyst Mine
Highway 11&17, P.O. Box 2120
Thunder Bay, Ontario P7B 5E7
- mineral samples
- jewellery
- amethyst producer
- pick your own samples
- shop

Pearl Lake Amethyst Mines
Castagne's Rocks & Minerals
Highway 11&17,
P.O. Box 2594, Station P
Thunder Bay, Ontario P7B 5G1
(807) 983-2047
- mineral samples
- jewellery
- amethyst producer
- pick your own samples
- shop

Purple Haze Amethyst Mine
22 Knight St.,
Thunder Bay, Ontario P7A 5M2
(807) 345-6444
- mineral samples
- jewellery
- amethyst producer

Rocksville Gift Shop
Highway 11&17
R.R. #3,
Thunder Bay, Ontario P7B 5E4
(807) 983-3102
- mineral samples
- jewellery
- shop

E. Schwendinger Mining & Minerals
P.O. Box 2194, Station P
Thunder Bay, Ontario P7A 8A7
- mineral samples
- jewellery

Thunder Bay Amethyst Mine Panorama
East Loon Lake Road,
Highway 11&17
P.O. Box 832
Thunder Bay, Ontario P7C 4X7
(807) 622-6908
- mineral samples
- jewellery
- amethyst producer
- pick your own samples

Glossary of Geological Terms

PART 4

Acidic Rock - A chemical classification that includes igneous rocks containing 60 percent or more silica. It is similar to, but not exactly the same as, "felsic rock".

Actinolite - A bright green to greyish green fibrous mineral containing calcium, magnesium, iron, and silica, and belonging to the amphibole group.

Agate - Any very fine-grained variety of quartz, commonly banded with red, brown, and other colours as a result of impurities.

Age - The smallest subdivision of geologic time, it is shorter than an epoch. "Age" is also used informally to define the time when something happened, as in "the age of the dinosaurs".

Agmatite - A rock with blocky fragments of metamorphic rock cut and separated by igneous rock. It is commonly made up of gneiss and granite.

Agglomerate - A volcanic rock made up of coarse fragmental debris resulting from explosive volcanism.

Amethyst - A variety of quartz that is purple, violet, or red. It gets its colour from iron contained as an impurity within its structure. Ontario's provincial mineral, it is used as a gem, and for decoration and landscaping purposes.

Amphibole - A group of related tabular to prismatic dark-coloured rock-forming minerals containing calcium, iron and magnesium with silica.

Amygdule - A gas cavity, or vesicle, within a volcanic rock, that has been filled by minerals such as agate, calcite, or zeolite since the volcanic rock cooled. Rocks with amygdules are called "amygdaloidal".

Andesite - A dark-coloured fine-grained volcanic rock that is similar in composition to basalt.

Anorthosite - A medium to dark grey coarse-grained intrusive igneous rock that is made up almost entirely of calcium-bearing (plagioclase) feldspar.

Anticline - A fold structure, or arch, in which layers in the rock slope down from a common crest or ridge.

Archean - The eon of Precambrian time that was more than 2.50 billion years ago.

Ash Flow Tuff - A volcanic rock, usually of acidic composition, that erupted explosively as a mixture of highly heated volcanic gases and ash, travelled rapidly down the flanks of the volcano and along the ground, and cooled to form a rock made up of unsorted volcanic dust, ash, fragments, and blocks.

Attitude - The position of a rock surface relative to a horizontal surface.

Augite - A dark green to black stocky mineral containing calcium, magnesium, iron, and silica, and belonging to the pyroxene group.

Basalt - A dark-coloured fine-grained volcanic rock of basic composition.

Base Metal - Any common metal other than iron, including copper, lead, zinc, nickel, tin and mercury.

Basic Rock - A chemical classification that includes igneous rocks containing 52 percent or less silica. It is similar to, but not exactly the same as, "mafic rock".

Bastnaesite - An uncommon, greasy looking wax-yellow to reddish brown mineral containing the rare-earth group metals lanthanum and cerium.

Batholith - A large body of igneous rock, such as granite, that covers a surface area of more than 100 square kilometres (39 square miles) and forms deep within the earth.

Bedding - The layers in which sedimentary rocks were deposited.

Botryoidal Mineral - Any mineral having an external form like a bunch of grapes.

Breccia - A rock consisting of angular fragments in a fine-grained matrix.

Calcite - A common rock-forming mineral, and the principal constituent of limestone. Its chemical composition is calcium carbonate.

Carbonate - A chemical compound or mineral that yields the gas carbon dioxide when heated (e.g. calcite, dolomite, siderite).

Carbonate Rock - A rock made up largely of carbonate minerals that formed by either organic or inorganic precipitation from aqueous solution. Carbonate rocks include limestone and dolostone.

Carbonatite - An unusual variety of igneous rock composed almost entirely of carbonate minerals.

Cenozoic - The era of geological time from the present to 66 million years ago.

Chalcopyrite - A bright brass-yellow mineral containing copper, iron, and sulphur. It is the main ore mineral of copper.

Chert - A hard, dense extremely fine-grained form of silica. It is found as nodules in limestone and dolostone, and as areally-extensive banded deposits.

Chert-Carbonate - A sedimentary rock in which layers of carbonate rock alternate with layers of chert.

Chlorite - A group of related greenish platy rock-forming minerals containing iron and magnesium with silica. Chlorite minerals are common as alteration products of other minerals like amphiboles and pyroxenes that contain iron and magnesium.

Citrine - A transparent yellow to orange-brown variety of quartz, resembling topaz in colour. Like amethyst, it gets its colour from iron contained as an impurity within its structure.

Columnar Jointing - A variety of jointing in igneous rocks that divides the rock into parallel, prismatic columns. It is formed as a result of contraction of the rock during cooling.

Concretion - A rounded or nodular mass of seemingly foreign material in a sedimentary rock, resulting from the precipitation of one or more rock constituents from groundwater about a central nucleus after the formation of the surrounding sedimentary rock.

Conglomerate - The hard, compacted equivalent of a gravel.

Craton - A part of the earth's crust that has been stable for a prolonged period.

Cross-Beds - A feature of sedimentary rocks in which a series of layers of rock more than 1 centimetre (0.5 inch) thick are confined within a given bed, while being oriented at an angle to the top and bottom of the bed. Cross-beds are remnants of ripples or dunes, and can be used to determine the flow direction of the water or air currents at the time of deposition.

Cross-Laminations - Cross-laminations are the same as cross-beds, except that the inclined layers are less than 1 centimetre (0.5 inch) thick.

Crustal Plate - One of more than a dozen rigid plates of crustal rocks that rest or "float" on the earth's mantle, and form the earth's surface.

Cuesta - An asymmetric ridge with a gentle slope on one side, and a steep escarpment on the other side.

Delta - A flat-topped wedge of sediment formed where a river enters a lake or ocean. Because the transporting power of the river water decreases when it slows on entering the lake or ocean, the sediments carried by the river are deposited to form the delta.

Diabase - An intrusive igneous rock with the same chemical composition as basalt and gabbro. It is found only in dikes and sills.

Differential Erosion - Erosion that occurs at different rates in different rocks because of differences in the hardness and resistance of the surfaces of those rocks to erosive forces.

Dike - A sheet-like body of igneous intrusive rock that cuts across the structure of the rocks it intrudes.

Diorite - An intrusive igneous rock, midway in composition between acidic and basic, or between that of syenite and gabbro. It is commonly grey in colour, and made up of feldspar with pyroxene or hornblende.

Dolomite - A common rock-forming mineral and the principal constituent of dolostone. Its chemical composition is calcium magnesium carbonate.

Dolomitic Limestone - A sedimentary rock made up of variable proportions of the carbonate minerals dolomite and calcite.

Dolostone - A sedimentary rock made up essentially of dolomite.

Eon - The largest subdivision of geologic time. There are only three eons, the Archean, the Proterozoic, and the Phanerozoic.

Epidote - A pistachio-green rock-forming mineral commonly found as a replacement of feldspar. It contains calcium, iron, and silica.

Epoch - A subdivision of geologic time that is longer than an age and shorter than a period.

Era - A subdivision of geologic time that is longer than a period and shorter than an eon. There are three eras, the Paleozoic, the Mesozoic, and the Cenozoic.

Erratic - A rock carried some distance from its source by glacial ice.

Esker - A long winding ridge of sand and gravel formed by water flowing through or under a glacier. Eskers run roughly parallel to the direction of glacial ice flow.

Fault - A fracture, or zone of fractures, along which some movement has taken place. Faults may stretch for many kilometres (miles) or may be only a few centimetres (inches) long.

Feldspar - A group of related common rock-forming minerals that range in colour from cream to deep pink to dark grey, depending upon the amount of sodium, potassium, and calcium they contain. Orthoclase, microcline, albite, and plagioclase are all varieties of feldspar.

Felsic Rock - An igneous rock made up mainly of the light-coloured minerals feldspar and quartz (silica). It is similar to, but not exactly the same as, "acidic rock".

Fissile Rock - A rock that is easily split along closely-spaced parallel or near-parallel planar surfaces.

Foliated Rock - A rock (most often metamorphic) in which the platy minerals are arranged in thin, irregular, crudely parallel layers.

Formation - A persistent body of igneous, sedimentary, or metamorphic rock that has easily identifiable boundaries, and that can be easily recognized in the field.

Gabbro - A coarse-grained intrusive igneous rock, having the same composition as basalt.

Geochronology - The science of determining the ages of rocks in years by detailed study of the chemistry of radioactive minerals.

Glacial Striae - Minute, closely-spaced parallel scratches or grooves on bedrock surfaces. Glacial striae are made by rocks dragged along by an advancing glacier.

Glacier - A large ice mass made of recrystallized compacted snow. Glaciers originate on a land surface, and flow under the influence of gravity.

Glaciofluvial - Pertaining to meltwater streams flowing from waning glaciers, and especially to the deposits and landforms produced by such streams.

Glaciolacustrine - Pertaining to, derived from, or deposited in glacial lakes, and especially the deposits and landforms made up of suspended material brought by meltwater streams flowing into lakes bordering a glacier.

Glomerocrysts - Aggregates of crystals of one type of mineral in an igneous rock.

Glomeroporphyry - An igneous rock containing glomerocrysts.

Gneiss - A banded rock formed during intense regional metamorphism due to the effects of heat and pressure on pre-existing rocks. Bands richer in granular minerals (generally light in colour), alternate with bands richer in platy or micaceous minerals (generally dark in colour).

Goethite - An ore mineral of iron, goethite is a hydrous iron oxide. It is yellowish, reddish, or brownish-black, and is the commonest constituent of natural forms of rust.

Gossan - An iron-bearing weathering product over a deposit of sulphide minerals. Made up of goethite and other iron oxides, gossans are used by prospectors as indicators of potential ore deposits.

Granite - A coarse-textured igneous intrusive rock made up of quartz, feldspar, and one or both of mica and hornblende. Usually found in batholiths, it is a felsic rock with a high silica content.

Greenstone - A geological field term applied to any fine-grained green altered or metamorphosed basic volcanic rock. Its colour is caused by its high content of the green minerals chlorite, actinolite, amphibole and epidote.

Greywacke - A dense grey sandstone with tiny fragments of rock and rock-forming minerals such as quartz and feldspar in a matrix of clay and silt. Greywacke results from rapid erosion and sedimentation.

Group - A general term for a consecutive sequence of related layers of volcanic or sedimentary rocks.

Gypsum - A widely-distributed mineral that is most common in sedimentary rocks. In places, it forms thick, extensive, and pure beds that are mined and used to produce plaster, wallboard, and other products.

Hematite - The principal ore mineral of iron. Hematite is an iron oxide, and contains 70 percent iron by weight. Powdered hematite has been used for centuries as a red pigment.

Homocline - A structure where the layers in a rock slope uniformly over a wide area. A homocline might be one limb of a very large fold.

Hornblende - A common rock-forming mineral, hornblende is a dark green or black variety of amphibole.

Igneous Rock - A rock formed by the cooling and crystallization of molten or partially molten matter or magma, either at the surface of the earth or below.

Intrusive Rock - A body of igneous rock that has forced itself into older rocks beneath the surface of the earth, either along some definite structural feature, or by deforming and cross-cutting the older rocks.

Invertebrate - Any animal that lacks a backbone. Shellfish, worms, and insects are examples of invertebrates.

Iron Formation - A sedimentary rock, typically thinly bedded, having an unusually high iron content.

Jasper - A variety of chert. Most jasper is coloured red due to the presence of small amounts of iron oxides like the mineral hematite.

Joint - A flat fracture surface in a rock, where no movement has occurred. This is different than a fault, where movement has taken place.

Lamprophyre - A type of dark-coloured, mafic igneous intrusive rock that is characterized by a high percentage of mica, hornblende, and pyroxene.

Lapilli - Small fragments resulting from an explosive volcanic eruption. Lapilli are between 2 and 64 millimetres (0.1 and 2.5 inches) across.

Lava - Molten rock, or magma, erupted on the surface of the earth.

Limestone - Any sedimentary rock made up largely of the carbonate mineral calcite.

Limonite - A general field term for a mixture of hydrous iron oxides. Limonite commonly includes goethite.

Lit-par-Lit Structure - A layered rock having alternating layers of foliated or gneissic rock and igneous rock like granite. It is pronounced "lee-par-lee".

Mafic Rock - Igneous rock made up of dark-coloured minerals containing magnesium and iron. It is similar to, but not exactly the same as, "basic rock".

Magma - A hot mass of molten, or partially molten, rock, below the surface of the earth. If the molten rock reaches the surface, it is renamed "lava".

Magnetite - A black, strongly magnetic mineral, it is an important ore mineral of iron. Magnetite is an iron oxide, and contains 72 percent iron by weight.

Mantle - The zone of hot, semi-solid rock between the crust and the core of the earth.

Marble - A metamorphic rock made of recrystallized limestone or dolostone. Polished marble has many architectural uses.

Member - A unit of related sedimentary or volcanic rock that makes up part of a formation.

Mesa - An isolated flat-topped hill bounded on one or more sides by steep cliffs.

Mesozoic - An era of geologic time, the Mesozoic extended from 66 to 225 million years ago.

Metamorphic Rock - Rock formed by the transformation of any type of preexisting rock, while it remains in the solid state.

Mica - A group of common rock-forming minerals. Mica forms flat grains that can be split easily into flexible, thin, flat sheets. Biotite and muscovite are varieties of mica.

Microfossils - The remains of organisms that are too small to be studied without the aid of a microscope.

Midcontinent Rift - A rift valley that split the North American craton about 1.11 billion years ago. It extends from Minnesota, under Lake Superior to Sault Ste. Marie, and from there under Michigan to Windsor. It is filled with a 30 kilometre (19 mile) thick pile of volcanic rocks, the thickest known in the world.

Migmatite - A banded rock made up of a mixture of igneous and metamorphic components. Most migmatite has a "stirred" appearance.

Milling - The process whereby ore is crushed and ground to a powder, prior to the next step in its processing.

Mineral - A naturally occurring element or inorganic compound having an orderly crystal structure, and characteristic chemical composition, crystal form, and physical properties.

Molybdenite - A soft lead-grey mineral. Molybdenite is a sulphide of molybdenum, and its main ore mineral.

Monocline - A local steepening in otherwise gently sloping or flat-lying layered rocks.

Moraine - A mound, ridge, or other distinct accumulation of unsorted and unlayered glacial debris deposited by direct action of glacial ice.

Mudstone - A blocky, massive sedimentary rock formed of hardened mud.

Muscovite - A common, colourless to pale green or brown platy mineral belonging to the mica group.

Nepheline - A rock-forming mineral found in some sodium-rich rocks. Nepheline can be glassy and colourless, or greasy looking and white to green or brown.

Oolite - A tiny spherical or ellipsoidal grain having a radial or concentric internal structure, or both, and found in a sedimentary rock. The term is also used to describe a rock made up of oolites.

Ore - Any type of rock from which minerals or mineral products can be extracted at a reasonable profit.

Orogeny - A Latin word used by geologists for the process of mountain-building.

Paleozoic - The era of geologic time from 225 to 570 million years ago.

Parisite - A rare brownish-yellow mineral containing the rare-earth group metals cerium and lanthanum. It forms tiny prismatic crystals.

Pegmatite - An exceptionally coarse-grained igneous rock, usually of granitic composition, that occurs in small bodies of irregular dike-like or sill-like form.

Peneplain - A low, nearly featureless, gently undulating land surface of considerable area, which was presumably produced as a result of continuous subaerial erosion over a long period of time.

Period - A fundamental unit of geologic time that is longer than an epoch, but not as long as an era. The time divisions Cambrian and Cretaceous are examples of periods.

Phanerozoic - The eon of geologic time when evidence of life is abundant, that is from the present to about 570 million years ago.

Phenocryst - A large crystal that grew as magma cooled and solidified. Rocks containing phenocrysts are called "porphyries".

Plate Tectonics - The theory relating to the rifting, movement and collision of rigid crustal plates owing to convection and flow in the earth's mantle. Virtually all geological processes can be related to plate tectonics: the formation of continents and oceans; mountain building; volcanic eruptions; earthquakes; and even how and where mineral deposits are formed.

Pillow Basalt - A dark-coloured volcanic rock formed when mafic lava oozed from underwater fissures and cooled to form an agglomeration of rounded masses resembling pillows.

Porphyry - An igneous rock in which large crystals, or phenocrysts, of early-formed minerals are embedded in a relatively fine-grained groundmass. A feldspar porphyry has phenocrysts of feldspar; a quartz porphyry has phenocrysts of quartz.

Pothole - A deep, steep-sided round hole worn in the bedrock at falls and rapids by sand and gravel spun around by water currents.

Precambrian - All geologic time before the start of the Phanerozoic, or the period from about 570 to 4,600 million years ago, it includes the Archean and Proterozoic eons and is equivalent to almost 90 percent of geologic time.

Prehnite - A pale green mineral that commonly occurs in crystal aggregates in amygdules, fissures, or joints in altered igneous rocks.

Proterozoic - The more recent of the two great subdivisions of the Precambrian. The Proterozoic Eon extended from about 570 to 2,500 million years ago.

Pseudofossil - A natural object, structure, or mineral of inorganic origin that may resemble or be mistaken for a fossil.

Pyrite - A widespread mineral found in many rock types, whether igneous, sedimentary or metamorphic. It forms small, brass-yellow cubes, and is commonly known as "fool's gold".

Pyroclastic - Fragmental rock material formed by a volcanic explosion, or by aerial expulsion from a volcanic vent is called pyroclastic. The term also refers to rocks formed from this fragmental material.

Pyroxene - A group of related stubby to tabular dark-coloured rock-forming minerals containing calcium, iron, and magnesium with silica.

Pyrrhotite - A weakly magnetic metallic bronze mineral. Pyrrhotite is an iron sulphide.

Quartz - The most common rock-forming mineral, quartz has the composition of silica, that is, silicon dioxide.

Radiometric Age - An age, in years, determined by measuring the amounts of radioactive elements and their decay products in the material being tested.

Raised Beach - An ancient beach occurring above the present shoreline and separated from the present beach, having been elevated above the high-water mark by local crustal uplift or by lowering of the water level.

Rift - A rift occurs where the crust has been stretched and fractured, forming an immense crack. Hot magma from the upper mantle pushes up into the region. If the crust continues to stretch, the crustal plate splits into two separate plates, and a new ocean develops between them. Topographically, a rift is marked by an elongated valley with steep, parallel sides.

Ripple Marks - Low, closely-spaced parallel ridges created in sand by the action of waves or currents.

Rhyolite - This common type of light-coloured volcanic rock has a composition similar to that of granite.

Rock - A consolidated aggregate of many grains of one or more minerals, or of rock fragments. Rocks containing only one mineral include quartzite (quartz), limestone (calcite), and hornblendite (hornblende). Rocks containing more than one mineral include granite, gneiss, greywacke, and basalt.

Salt - This is the general term for a naturally occurring mineral called halite, having the formula sodium chloride. It is the mineral that we add to our food, and spread on our roads in winter.

Sandstone - A sedimentary rock made up largely of compacted sand-sized grains of quartz.

Schist - A metamorphic rock that can be easily split into thin slabs due to the arrangement of the abundant flat mineral grains in it into thin, crudely parallel sheets.

Secondary Mineral - Any mineral that formed later than the rock enclosing it, most commonly at the expense of an earlier-formed mineral, through weathering, metamorphism, or solution.

Sedimentary Rock - Rock that formed by the accumulation of sediment in water or air. The sediment may consist of rock fragments, particles of various sizes, residues left after the evaporation of sea water, or the remains of animals or plants.

Seismic Reflection - A method used to determine the structure of the earth's subsurface. Vibrations are transmitted into the earth, and some bounce off of discontinuities along their paths. By measuring the times taken for the rebounds to get back to the surface, scientists can calculate how deep the discontinuities are.

Sericite - A silky white fine-grained member of the mica family. Sericite forms as an alteration product of other minerals, and is commonly found in metamorphic rocks.

Shale - A thinly layered sedimentary rock composed of compacted or cemented mud. It breaks easily into flat sheets.

Shatter Cone - A conical fracture surface in rock. Shatter cones are from a few centimetres (inches) to more than a metre (3 feet) high, with distinctive longitudinal striations. Formed as a result of very high-energy shock waves, they are thought to indicate sites of meteorite impact.

Siderite - A yellow-brown to brown-black iron-bearing carbonate mineral. Siderite is a valuable ore mineral of iron.

Silica - The chemically resistant dioxide of silicon. It occurs naturally in five different forms, but quartz is by far the most common. Combined with other elements, it is an important constituent of many rock-forming minerals.

Sill - A tabular mass of intrusive igneous rock, roughly parallel to the layering within the rock it intruded.

Siltstone - A compact, blocky sedimentary rock composed mainly of silt.

Slate - A very fine-grained rock formed by metamorphism of a shale or mudstone. It has well-developed fissility that may or may not be parallel to the original bedding, and can be readily split into thin sheets or plates.

Sphalerite - A resinous-looking yellow, brown, or black mineral. Sphalerite is a zinc sulphide, and is the main ore mineral for zinc.

Southern Province - The subdivision of the Canadian Shield made up of sedimentary and volcanic rocks between 1.09 and 2.49 billion years old. In Ontario, it extends west from Quebec, and across the north shores of lakes Huron and Superior.

Spheroidal Weathering - A form of erosion in which concentric shells of decayed rock are successively loosened and separated from a block of rock by water penetrating the bounding joints or fractures of the block, attacking it from all sides, and commonly leaving a rounded boulder.

Spherulite - A rounded or spherical mass of acicular crystals, commonly of feldspar, radiating from a central point. Spherulites may range in size from microscopic to several centimetres (inches) in size, and are particularly common in acidic volcanic flow rocks. They are similar to varioles.

Stromatolite - A layered sedimentary structure formed when bits of sediment are trapped by colonies of micro-organisms such as algae. They include some of the world's oldest fossils, and are still being formed today.

Subduction - When two of the tectonic plates that make up the earth's crust collide, one plate turns down and is submerged beneath the other. The process is called subduction.

Sulphide Mineral - A mineral characterized by the chemical linkage of sulphur with a metal. Examples are sphalerite (zinc and sulphur), molybdenite (molybdenum and sulphur), and pyrite and pyrrhotite (iron and sulphur).

Supergroup - A formal name used to link related formations or groups of volcanic and sedimentary rocks.

Superior Province - The large subdivision of the Canadian Shield lying north of the Southern Province, and made up of sedimentary, volcanic, intrusive, and metamorphic rocks more than 2.50 billion years old.

Syenite - An igneous intrusive rock that, except for the absence of the mineral quartz, is similar to granite in both appearance and mineralogical composition.

Syncline - A fold structure, or trough, in which layers in the rock slope down to a common hinge or floor.

Taconite - A variety of iron formation made up largely of tiny rounded bodies or granules of iron-bearing minerals in a groundmass of chert or carbonate.

Tectonic Plate - A rigid plate of crustal rocks resting or "floating" on the earth's mantle.

Till - A jumbled mass of unsorted and unstratified geological debris such as clay, silt, sand, pebbles, cobbles, and boulders, left behind by a glacier.

Tuff - A rock made up of dust and fine rock fragments from explosive volcanic activity.

Turbidity Current - A current formed when piles of sediment on a continental shelf overbalance, mix with water, and rush down the continental slope at speeds of up to 60 kilometres (38 miles) per hour.

Unconformity - A surface of erosion separating younger strata from older rocks.

Variole - A pea-sized spherical body composed of crystals of feldspar or pyroxene radiating from a central point. This term is generally only applied to such structures in basic igneous rocks. Varioles are similar to spherulites.

Vein - An aggregate of minerals filling a tabular or sheet-like fracture in a rock. Minerals that form veins were deposited from hot aqueous solutions, and not directly from a magma.

Vesicle - A small rounded cavity in a volcanic rock. Vesicles form when bubbles of gas exsolve from lava (much like gas bubbles separate out of soda water), but are frozen into the cooling rock before they can escape. Vesicles are most common in mafic volcanic rocks like basalt. Rocks with vesicles are called "vesicular".

Volcaniclastic - Pertaining to a rock containing fragments of volcanic origin.

Zeolite - A large group of white or colourless minerals. Zeolite minerals have interesting molecular structures, including water that is freely released on heating, and then taken up again on cooling. They are commonly found in amygdules in basalt.

Additional Information

PART 5

In the preparation of this guidebook, considerable use was made of the extensive geological literature available on the geology of the Lake Superior region. For those who wish to pursue their studies beyond the scope of this publication, the maps and reports considered to be the most comprehensive and pertinent are included in the following list of references.

All publications of the Ontario Department of Mines, the Ontario Division of Mines, the Ontario Geological Survey, and the Ontario Ministry of Northern Development of Mines that are currently in print may be obtained from the Publication Sales Outlet, MNDM, 933 Ramsey Lake Road, Sudbury, Ontario, P3E 6B5. For further information, phone (705) 670-5691, or fax (705) 670-5770.

Some of the same publications, plus additional information, may also be obtained from Resident Geologists and Mining Recorders in Thunder Bay and Sault Ste. Marie. In Thunder Bay, the Resident Geologist and Mining Recorder are located at 435 James St. South, Thunder Bay, Ontario, P7E 6E3. The office of the Resident Geologist is in Suite B002, and can be reached by telephone at (807) 475-1331, while that of the Mining Recorder is in Suite B003 and can be reached at (807) 475-1311. In Sault Ste. Marie, the Resident Geologist and Mining Recorder's offices are located at 60 Church St., Sault Ste. Marie, Ontario, P6A 3H3. The Resident Geologist can be reached by telephone at (705) 945-6931: the number for the Mining Recorder is (705) 945-6925.

Help in finding sources of information and facts concerning the geology and mineral deposits of Ontario may also be found at various internet addresses. The website of the Mines and Minerals Division, Ontario Ministry of Northern Devleopment and Mines, at www.gov.on.ca/MNDM is a good starting point for an internet search.

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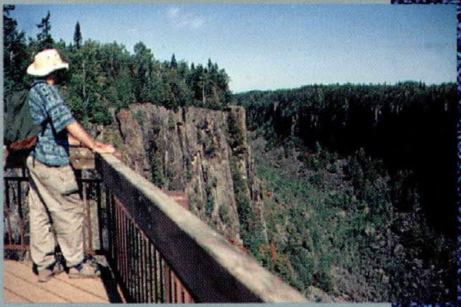
The North Shore of Lake Superior region hides many secrets. Did the Earth's crust rip apart under the lake? Were almost 20 million ounces of gold buried next to the TransCanada Highway? Is Wawa sitting on a volcano? These questions and many more are answered in this guidebook!



The highway route between the U.S.-Canada border at Pigeon River and Sault Ste. Marie is divided into twelve easily-travelled sections. Simplified maps show the general geology of each segment of the route and pinpoint the locations of interest. Detailed directions to points of interest, and descriptions of the features to be seen are given for each section of the highway, along with explanations of how the features formed. A glossary explains any terms that might not be familiar. Interesting facts, anecdotes, and examples round out the text.

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