THESE TERMS GOVERN YOUR USE OF THIS DOCUMENT

Your use of this Ontario Geological Survey document (the "Content") is governed by the terms set out on this page ("Terms of Use"). By downloading this Content, you (the "User") have accepted, and have agreed to be bound by, the Terms of Use.

Content: This Content is offered by the Province of Ontario's *Ministry of Northern Development and Mines* (MNDM) as a public service, on an "as-is" basis. Recommendations and statements of opinion expressed in the Content are those of the author or authors and are not to be construed as statement of government policy. You are solely responsible for your use of the Content. You should not rely on the Content for legal advice nor as authoritative in your particular circumstances. Users should verify the accuracy and applicability of any Content before acting on it. MNDM does not guarantee, or make any warranty express or implied, that the Content is current, accurate, complete or reliable. MNDM is not responsible for any damage however caused, which results, directly or indirectly, from your use of the Content. MNDM assumes no legal liability or responsibility for the Content whatsoever.

Links to Other Web Sites: This Content may contain links, to Web sites that are not operated by MNDM. Linked Web sites may not be available in French. MNDM neither endorses nor assumes any responsibility for the safety, accuracy or availability of linked Web sites or the information contained on them. The linked Web sites, their operation and content are the responsibility of the person or entity for which they were created or maintained (the "Owner"). Both your use of a linked Web site, and your right to use or reproduce information or materials from a linked Web site, are subject to the terms of use governing that particular Web site. Any comments or inquiries regarding a linked Web site must be directed to its Owner.

Copyright: Canadian and international intellectual property laws protect the Content. Unless otherwise indicated, copyright is held by the Queen's Printer for Ontario.

It is recommended that reference to the Content be made in the following form:

Robertson, J.A. and Card K.D. 1972. Geology and Scenery, North Shore of Lake Huron Region; Ontario Geological Survey, Geological Guide Book 4, 224p.

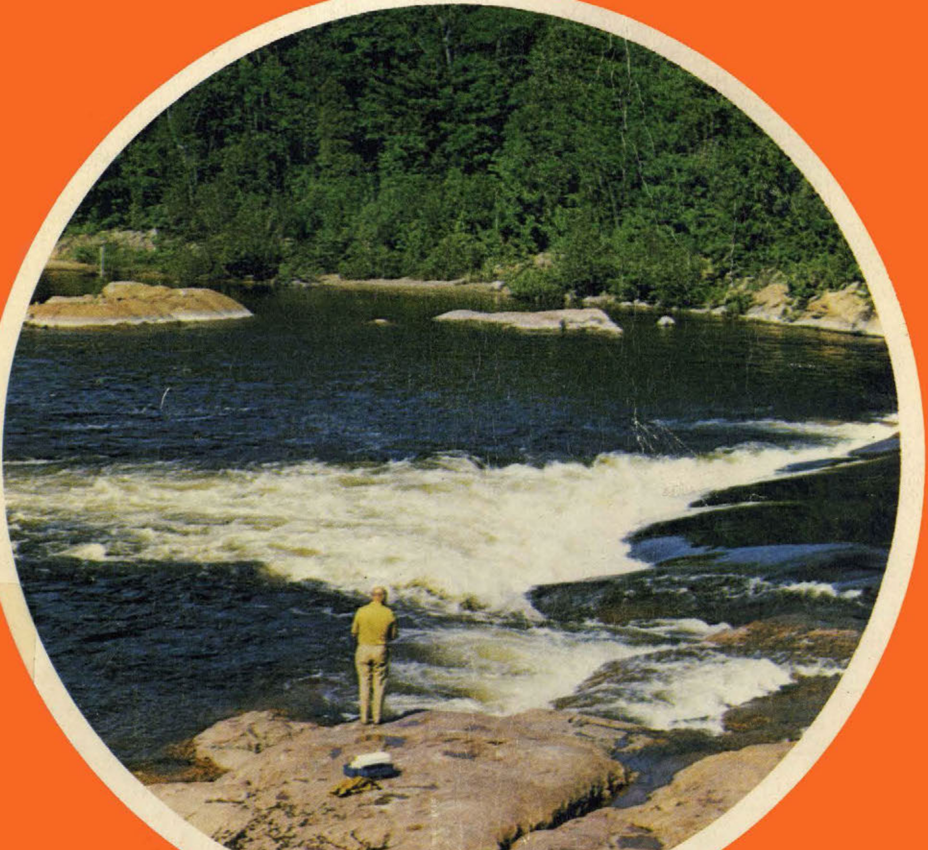
Use and Reproduction of Content: The Content may be used and reproduced only in accordance with applicable intellectual property laws. *Non-commercial* use of unsubstantial excerpts of the Content is permitted provided that appropriate credit is given and Crown copyright is acknowledged. Any substantial reproduction of the Content or any *commercial* use of all or part of the Content is prohibited without the prior written permission of MNDM. Substantial reproduction includes the reproduction of any illustration or figure, such as, but not limited to graphs, charts and maps. Commercial use includes commercial distribution of the Content, the reproduction of multiple copies of the Content for any purpose whether or not commercial, use of the Content in commercial publications, and the creation of value-added products using the Content.

Contact:

FOR FURTHER INFORMATION ON	PLEASE CONTACT:	BY TELEPHONE:	BY E-MAIL:
The Reproduction of the EIP or Content	MNDM Publication Services	Local: (705) 670-5691 Toll-Free: 1-888-415-9845, ext. 5691 (inside Canada, United States)	Pubsales.ndm@ontario.ca
The Purchase of MNDM Publications	MNDM Publication Sales	Local: (705) 670-5691 Toll-Free: 1-888-415-9845, ext. 5691 (inside Canada, United States)	Pubsales.ndm@ontario.ca
Crown Copyright	Queen's Printer	Local: (416) 326-2678 Toll-Free: 1-800-668-9938 (inside Canada, United States)	Copyright@gov.on.ca

GEOLOGY AND SCENERY

NORTH SHORE OF LAKE HURON REGION



ADDENDA

The discussion of the discovery in Guidebook 4 is incorrect (p. 177 - 178). This version is based on Leslie Roberts account in 'The Algoma Story' which has been repeated in Federal Government publications and subsequently in reports of the Ontario Geological Survey. It was in 1948 that the (re)-discovery of Theano Point took place. In April 1949, the identification of the radioactive sample in the Mining Recorders office by Aimé Breton was recorded. Gunterman was involved in the discovery and in possible staking in Long Township, and was the initial contact with Franc Joubin.

The relationship between Breton, Gunterman, and Joubin has become shrouded in mystery and conflicting statements, particularly with respect to the precise history after the original staking.

After publication of Geological Report 4, and the death of Breton, correspondence in the Northern Miner and the Sault Star was followed by discussion with contemporaries. This, and accumulation of early articles led to the revised account given in 'The Pronto Mine' Canadian Institute of Mining and Metallurgy Special Volume 33, p. 36-7 published in 1986.

Since this guidebook was originally written, there have been changes to the highway configurations and designations, as well as changes in detail of local construction and topography. The major changes include development of the Sudbury bypass, the four lane section of Highway 17 west of Sudbury, the relocation of the southern portion of Highway 144, and the inclusion of the Espanola–Little Current–South Baymouth Road in Highway 6. The improved ferry service between South Baymouth and Tobermory and the creation of Science North in Sudbury have added to the tourist attractions in the area and have contributed to the strengthening tourist industry. A four-lane-section of Highway 17 was completed during the summer of 1977 from the village of Echo Bay to St. Joseph's Island.

First printing 1972
Reprinted 1975
Reprinted 1988

ISSN 0375-7323
ISBN 0-7729-3596-3

Designed and produced by the staff of the Ontario Division of Mines, Ministry of Natural Resources. / Authors: J.A. Robertson, K.D. Card./Photographs not otherwise credited: J.A. Robertson, K.D. Card./Editing, layout, typography, general production, J.A. Haddon./Maps and illustrations, C. Cashin, D. Laroche./Set in Baskerville with Optima headings and Goudy italic captions./Lithographed in Ontario on Georgian Offset.

Caution: *Most of the geology and scenery described in this guidebook may be seen from public roads. When stopping, visitors are asked to park safely off the road and use proper care when walking nearby. The Official Road Map of the Ontario Department of Transportation and Communications lists police headquarters, travel information centres and first aid posts, should they be required.*

Much of the country away from the roads is not public property. Visitors must respect the rights of property owners and permission should be obtained from them before entering private property.

In respect of unpatented or unleased mining claims, permission should be obtained from the recorded holder of the claims. Without such permission, the visitor could be charged with trespassing.

Please do not smoke or light fires in the bush because of the hazard of forest fire.

Canadian Cataloguing in Publication Data

Robertson, James A., 1931 —
Geology and scenery, north shore of Lake Huron Region

(Geological guidebook, ISSN 0375-7323; 4)
Reprint. Originally published: Toronto : Ontario
Ministry of Natural Resources, 1972.
ISBN 0-7729-3596-3

1. Geology — Huron, Lake, Region (Mich.) and Ontario.

I. Card, K.D., 1937- II. Ontario. Ministry of Northern Development and Mines. III. Ontario Geological Survey. IV. Title. V. Series.

QE191.R62 1988   557.13'2   C88-099621-8

Parts of this publication may be quoted if credit is given to the Ontario Geological Survey, Ministry of Northern Development and Mines. It is recommended that reference to this report be made in the following form:

Robertson, J.A., and Card, K.D.
1972: Geology and Scenery, North Shore of Lake Huron Region;
Ontario Geological Survey, Geological Guide Book 4, 224p.

Errata p. 72, Map 3.
The Worthington Offset is norite, not granophyre as shown on Map 3

Cover: *Falls on the Mississagi River west of Blind River. The rock is red granite of Algoman age.*

2000-1988-Ainsworth

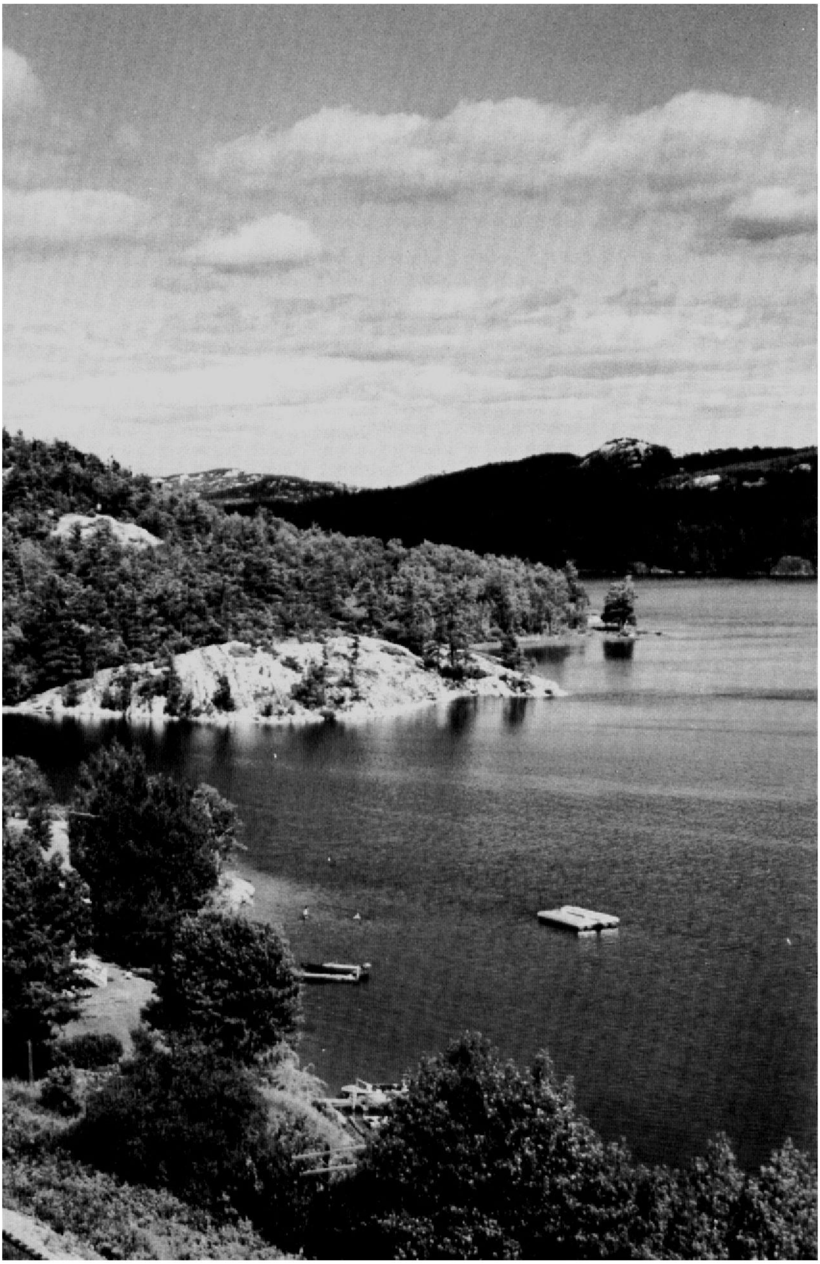


Photo 1. *Lake Charlton, Willisville, near Highway 68. (Photograph courtesy the Ontario Ministry of Industry and Tourism)*

GEOLOGY AND SCENERY

NORTH SHORE OF LAKE HURON REGION

J. A. Robertson and K. D. Card

Geological Guidebook No. 4

ONTARIO DIVISION OF MINES
MINISTRY OF NATURAL RESOURCES

PREFACE

In recent years rock and mineral collecting have aroused the interest of many North Americans. At the same time they have become increasingly aware of our scenic attractions and the part geology has played in the development of the landscape. Their desire to preserve the environment and their love of camping and the outdoors have led to a greater yearning for the North and a wish to understand it in all its aspects. Others have recognized both the drama of mineral exploration and the impact of the mining industry on our provincial and national economies and have requested geological information to help them better understand the nature of our mineral resources. In response to this demand the former Ontario Department of Mines (now the Ontario Division of Mines of the Ministry of Natural Resources) commenced the publication of these "Geology and Scenery" guidebooks covering various parts of the province in the hope that they will help satisfy the needs of amateur geologists and, at the same time, stimulate similar interests among the general public.

This guidebook is the fourth of the series. The North Shore of Lake Huron Region is served by the Trans Canada Highway and many other excellent highways. Since the completion of the Trans Canada Highway north of Sault Ste. Marie and of the International Bridge at Sault Ste. Marie, the volume of tourist traffic through the area has increased enormously. The better access and the increasing geological knowledge of the area following development of its uranium and nickel-copper resources have led to many universities and colleges using the area for geological field trips and other instructional purposes. This guidebook has been prepared for publication in 1972, the year of the 26th International Geological Congress in Canada in anticipation of visits by many overseas geologists who will wish to study this classical geological area.

The first part of the guidebook is a résumé of the general geology of the region. It provides a summary of the relationships between the principal elements of the regional geology and also gives the reader an account of the geological history of the area. The authors have written primarily for the novice, although they have assumed that the reader will have some knowledge of rocks and minerals. For further reading, many excellent textbooks on elementary geology and mineralogy are available in most libraries and larger book stores. Rocks and Minerals of Ontario (Geol. Circ. No. 13), published by the Ontario Division of Mines, Ministry of Natural Resources, provides a suitable companion to this and the other guidebooks of the series.

The second part of the guidebook lists the various points of geological and scenic interest along or close to the principal highways. Descriptions and explanations of the salient features are given and their locations and means of access are indicated with the help of simple maps. Although the authors have tried to restrict their descriptions to easily reached sites with safe parking facilities nearby, the reader is advised to use every precaution against possible traffic hazards.

The third section contains a list of the minerals and rocks which occur within the guidebook area and locations where these may be obtained. There is a glossary of the technical terms used in the guidebook, and a brief list of references covering the most important geological reports, papers and maps dealing with the area. The bibliographies in these reports and papers will provide information on further sources for the more specialized reader.

ACKNOWLEDGMENTS

The initial field work and compilation of material for this guidebook was largely undertaken by two persons —J. A. Robertson, who covered the Elliot Lake, Sault Ste. Marie, and Manitoulin Island areas, and K. D. Card who covered Sudbury and Highway 68 from Highway 17 to Birch Island. Both authors contributed to the section on regional geology. J. A. Robertson, as senior author, was responsible for checking, preparation of the original manuscript and the subsequent revision and editing of material. In these tasks he was assisted by David Cape, Mrs. Lenore Fordyce and Miss Lynne Ackerman. The authors wish to acknowledge the many courtesies extended by the staff of Denison Mines Limited, Falconbridge Nickel Mines Limited, the International Nickel Company of Canada Limited and Rio Algom Mines Limited. The assistance rendered and the general interest shown by many residents of the area is gratefully acknowledged.

In addition to the principal authors, the following significant contributions were made: T. E. Bolton and M. J. Copeland of the Geological Survey of Canada prepared the plates illustrating Paleozoic fossils of Manitoulin and St. Joseph Islands; the Geolog-

ical Survey of Canada contributed the photographs of possible fossils near Flack Lake taken by Hans Hofmann; G. J. Burwasser contributed data on the surficial geology of the Sudbury Basin particularly in the selection and description of points of interest; J. Hughes of the Ontario Division of Mines provided data on the history of certain mining activity in the area; W. Kenyon and P. Storck of the Royal Ontario Museum helped with data and illustrative material on the archeological site at Sheguiandah, Manitoulin Island; S. Lumbers advised on the description of the Grenville Front and of the rocks of the Grenville Province; Miss Siemiatkowska provided the description of the fenite localities on the Whitefish Indian Reserve; T. Kwak provided information on part of the Grenville Front Zone; the National Air Photo Library furnished aerial photographs. The courtesy of these persons and organisations is greatly appreciated.

Much of the material covering Highway 17 near Sault Ste. Marie has already appeared in "Geology and Scenery of the North Shore of Lake Superior" (Guidebook No. 2 of this series) by E. G. Pye to whom the authors are indebted for permission to re-use and adapt.

Many Department personnel helped with advice, criticism or, in some cases, in obtaining illustrative material. These included J. E. Thomson, E. G. Pye, F. Chandler, P. E. Giblin, S. Lumbers, D. Innis, H. Meyn, R. Rupert, K. Siemiatkowska and L. Carson Brown. Particular thanks are due to E. G. Pye for initiating the project and for the constant assistance given throughout its preparation.

The Ontario Department of Lands and Forests (now part of the Ministry of Natural Resources) contributed information on Provincial Parks and campsites and supplied aerial photographs. The Ontario Department of Tourism and Information (now Ministry of Industry and Tourism) was most helpful in providing photographs.

Finally the authors wish to acknowledge the contribution of the members of the cartography section of the Geological Branch: J. A. Haddon for research, design and editing the publication; Carl Cashin and Dennis Laroche for the preparation of the maps and illustrations.

CONTENTS

Page

PART 1 General Geology of the Region.

Contents Page

PART 2 Points of Interest.

Contents Page

Contents Page

Contents Page

PART 3 Rock Collecting, Glossary, References.

PHOTOGRAPHS

Photographs Page

MAPS

Page

FIGURES

PLATES

TABLES

PART 1

General Geology of the North Shore of Lake Huron Region

The rocks and rock materials of the region lying north of the north shore of Lake Huron were formed during three of the four major eras of earth history. The earliest was the Precambrian, which began with the development of the oldest recognizable rocks more than 3 billion years ago and ended about 600 million years ago. The Precambrian was followed by the Paleozoic era, the period in which life first became abundant and which ended about 220 million years ago. The most recent era which reaches down to the present day is known as the Cenozoic, the period characterized by mammals, especially man, and by glaciation which began about 7 million years ago. There are no known deposits in the region from the Mesozoic era, the time of middle life which occurred between the Paleozoic and the Cenozoic eras. The major subdivisions of geological time are listed in table 1.

The region described in this guidebook extends from Sudbury to Sault Ste. Marie. It lies at the southern edge of the exposed Canadian Shield, an area of some 2,000,000 square miles which stretches westward to northern Alberta, and northward to Greenland and the Arctic islands. This vast area is underlain by ancient igneous, sedimentary, and metamorphic rocks formed in Precambrian time. Around much of its outer boundary, and in the centre around Hudson Bay, its surface is covered by younger formations which were deposited when shallow seas covered these areas during the Paleozoic and subsequent eras. The Canadian Shield constitutes the nucleus or basement of the North American continent. During the Pleistocene Period, the North Shore of Lake Huron, like much of northern North America, was covered by continental glaciers which stripped away the soils, eroded the bedrock, and left behind local deposits of sand and gravel.

Table 1.

GEOLOGICAL TIME-SCALE

Era	**Time Unit**	**Time Unit commenced Years before Present**
Phanerozoic		
Cenozoic		
	Recent	
	Pleistocene	1,000,000
	Tertiary	20,000,000
Mesozoic		
	Cretaceous	135,000,000
	Jurassic	180,000,000
	Triassic	220,000,000
Paleozoic		
	Permian	275,000,000
	Pennsylvanian	330,000,000
	Mississippian	355,000,000
	Devonian	410,000,000
	Silurian	430,000,000
	Ordovician	490,000,000
	Cambrian	550,000,000
Precambrian		
Proterozoic		2,500,000,000
Archean		4,500,000,000 ?

Precambrian Rocks

AGE RELATIONSHIPS

Although the Precambrian encompasses more than three quarters of the entire history of the earth, relatively little is known about it. Precambrian rocks are difficult to classify and decipher because of the general absence of fossils, the prevalence of orogeny (mountain building) as indicated by the greatly disturbed and metamorphosed condition of the formations, and the abundance of large granitic intrusions. However, with the advent of radiometric age dating (a technique which utilizes the known rate of radioactive breakdown of certain isotopes of potassium, rubidium, and uranium in rocks, and special analytical methods to measure the amounts of the breakdown products and thus permit the age of the rock to be calculated), considerable progress has been made in unravelling Precambrian history.

Photo 2. *Cutting relationships. Gabbro (dark grey) is cut by porphyritic quartz monzonite (speckled grey), which is cut by aplite (light grey) filling a fault with a left hand displacement. Field evidence of this type permits geologists to establish the sequence of geological events but not the absolute timing.*

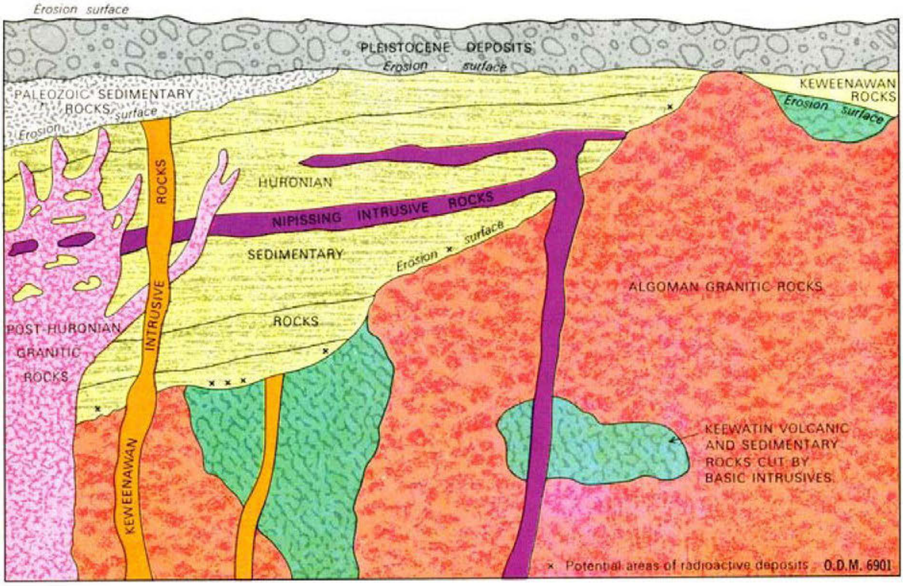


Figure 1. *A diagrammatic summary of the classification of the main rock units in the guidebook area.*

Table 2 lists the major Precambrian rock units and the orogenic events in the Sudbury – Sault Ste. Marie area, while these relationships are shown diagrammatically in figure 1.

Precambrian rocks of the Sudbury – Sault Ste. Marie area belong to two major eras of the Precambrian, the Archean which ended about 2,500 million years ago, and the Proterozoic which ended about 600 million years ago. Geologists also consider these rocks in three major divisions or provinces of the Shield; the Superior Province, which is characterized by Archean rocks last affected by mountain building during the Kenoran orogeny about 2,500 million years ago; the Southern Province, characterized by Proterozoic rocks which were affected by the Hudsonian orogeny some 1,700 million years ago; and the Grenville Province whose rocks were last affected by mountain building during the Grenville orogeny about 1,000 million years ago. Map 1 is a generalized geological map of Ontario on which the boundaries of the geological provinces are shown.

Table 2.

SEQUENCE OF GEOLOGICAL EVENTS
NORTH SHORE AREA

Era	Geological Event	Radiometric Age Date (millions) of years)
Cenozoic	Continental glaciation (Pleistocene).	.01-1.0
	Erosion Interval	
Paleozoic	Deposition of Paleozoic sedimentary rocks.	400-600
	Lipallean Erosion Interval	
Proterozoic	Orogenic (mountain building) activity in the Grenville Province.	900-1200
	Intrusion of diabase dikes and Keweenawan volcanic activity.	1200
	Orogenic activity and intrusion of granitic rocks in the Grenville Province.	1300±100
	Intrusion of the Croker Island igneous complex and the Mongowin pluton or stock.	1450±50
	Intrusion of granitic rocks in the Grenville Province.	1600±100
	Late deformation.	
	Intrusion of the Sudbury Nickel Irruptive.	1730±50
	Intrusion of the Cutler and Killarney granites.	1750±50
	Deposition of the Whitewater Group sedimentary and volcanic rocks.	1800
	Orogenic activity (Hudsonian), involving thermal metamorphism and deformation of pre-existing rocks.	1900±100
	Intrusion of Nipissing Diabase.	2160±50
	Orogenic activity (Penokean); intrusion of the Creighton and Murray granites.	2200
	Deposition of the Huronian Supergroup of sedimentary rocks.	2200-2500
	Eparchean Erosion interval	
Archean	Orogenic activity (Kenoran); intrusion of large masses of Algoman granitic rocks.	2500
	Formation of a thick sequence of ancient sedimentary and volcanic rocks.	2500+

Archean Rocks

The earliest rocks of the Lake Huron area which have been dated are granites, at least 2,500 million years old, which were intruded into a pre-existing assemblage of volcanic and sedimentary rocks. These older volcanics and sediments, which were moderately to strongly disturbed and altered, form the "greenstone" belts found throughout the Canadian Shield and often referred to as Keewatin, particularly if basic volcanic rocks predominate. The predominant Archean rock types are the granites, named Algoman granites because of their abundance in the administrative district of Algoma which covers much of the territory being described. The Algoman and Keewatin rocks were strongly eroded before the Huronian sedimentary rocks were laid down on them in Proterozoic time. Basic intrusive rocks, some pre-Algoman and some post-Algoman in age, are found locally.

KEEWATIN ROCKS

Volcanic and Sedimentary Rocks

The rocks of the greenstone belts of the Superior Province are basic and acid volcanic rocks, and associated sedimentary rocks. Typically in any completely preserved greenstone belt there is an upward progression from basic or basaltic and andesitic lavas at the base, through intermediate and fragmental volcanic rocks, to acid or rhyolitic fragmental volcanic rocks at the top. These volcanic piles were eroded, leaving deposits of detrital sediments within, around, and on top of, the volcanic sequence.

The Archean volcanic rocks are chemically similar and were originally mineralogically similar to lavas which have been erupted throughout geological history. Metamorphism converted their original minerals, mixtures of pyroxene, olivine, quartz, and plagioclase, to assemblages typically consisting of amphibole, chlorite, epidote, quartz, and plagioclase. For the composition of minerals see the glossary. Shearing and other types of deformation associated with mountain building transformed them locally into schists. However, despite metamorphism and deformation, many original structures and textures are locally well preserved. Pillows, which are balloon-like masses of lava thought to form when lavas are in contact with water; phenocrysts, large early formed crystals; and amygdules, which represent gas cavities later filled by minerals, are common in the greenstones (photo 115). Flow banding occurs in the rhyolite.

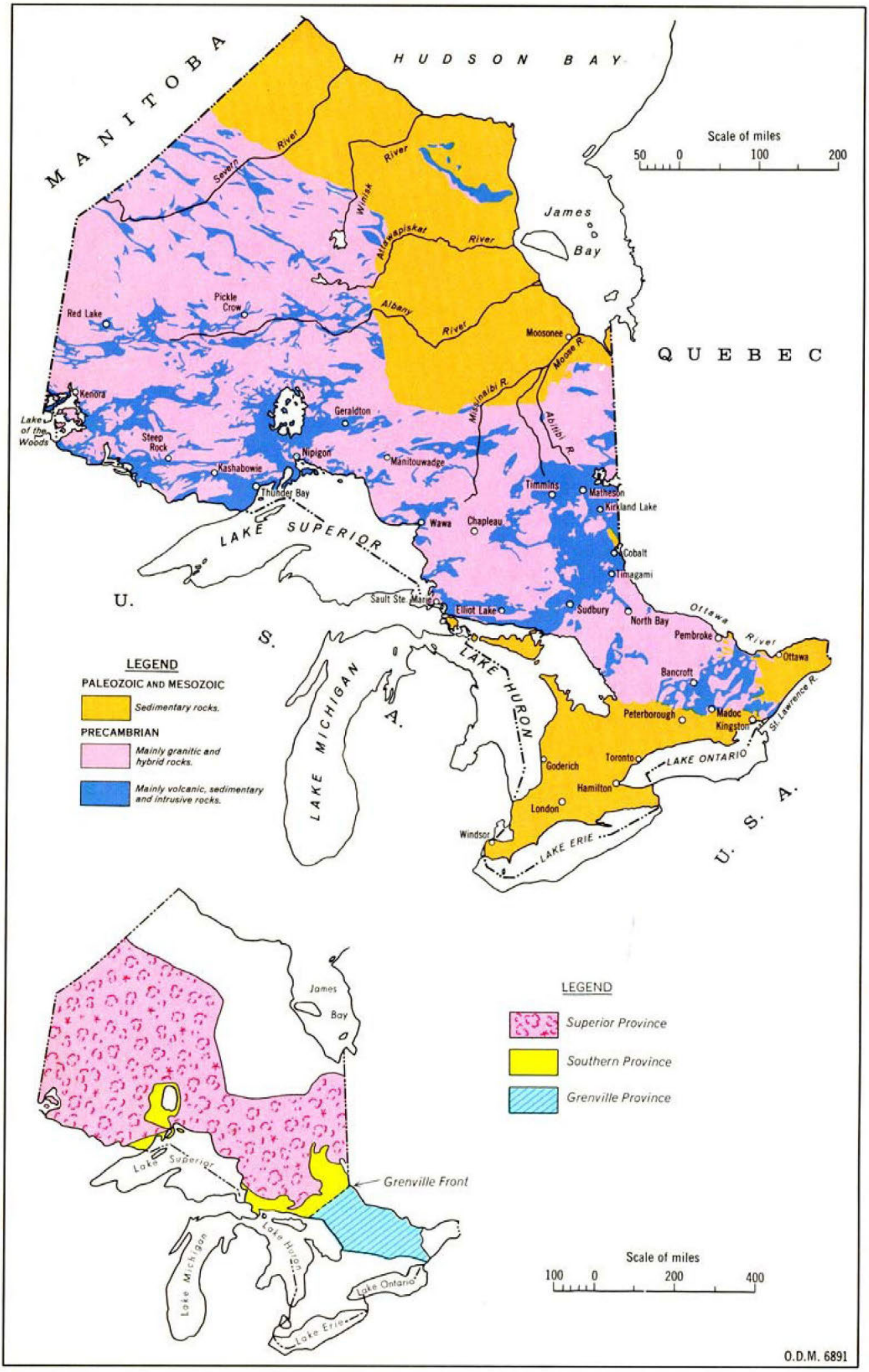
The outpourings of Keewatin lavas were periodically interrupted by explosive volcanism, and the volcanic ash and rock fragments so formed were deposited in bedded deposits called tuff, breccia, and agglomerate. Such rocks are not particularly abundant in the area.

Archean sedimentary rocks include greywacke, slate, conglomerate, and iron formation. These rocks are generally metamorphosed and may be represented by schists and gneisses. The greywacke and conglomerate are poorly sorted, rapidly deposited rocks derived from the volcanic rocks and possibly from still older basement rocks of unknown age. Iron formation, consisting of thin alternating layers of fine grained quartz and iron minerals such as magnetite, hematite, and siderite, is probably a chemical precipitate (photo 3).

Basic Intrusive Rocks

Small bodies of basic igneous rocks are closely associated with the volcanic and sedimentary rocks of the basement complex which they interrupt. Like granite, these rocks crystallized from melts injected into the crust from below. The rocks making up these bodies are chiefly gabbro. These bodies possibly represent the conduits through which the Keewatin lavas rose to surface. Gabbro is similar to granite in texture, but is dark green in colour and is made up of roughly equal amounts of the minerals feldspar and pyroxene.

Photo 3. *Keewatin banded iron formation, along former Highway 612 north of Depot Lab, Proctor Township. The dark bands are rich in magnetite; the light bands are rich in silica.*



Map 1. *The generalized geology of Ontario. The inset map shows the distribution of the geological provinces.*

ALGOMAN ROCKS

The term Algoman is used to refer to a group of igneous rocks that are younger than and have invaded the igneous and sedimentary rocks of the basement complex just described. These igneous rocks mainly comprise such diverse materials as granite, quartz monzonite, syenite, diorite, quartz diorite, and quartz and feldspar porphyries. Examples of all these are common.

Granites are abundant and very widespread in the region and make up extremely large masses, hundreds of square miles in extent, called batholiths. The Algoman granites are at least 2,500 million years old, and were intruded during a period of crustal upheaval termed the Kenoran orogeny. Granitic rocks, some of which are of definite Kenoran age and some of which may be considerably older, form the bulk of the Archean rocks.

Geologists group igneous rocks on the basis of three main features: the composition of their minerals; their texture and grain size; and if before cooling and consolidating they were extruded from the surface of the earth or if the consolidation took place underground.

The definitions are complex and are dealt with in detail in Rocks and Minerals of Ontario by D. F. Hewitt, published by the Ontario Department of Mines and Northern Affairs. In general terms granites, quartz monzonites, and granodiorites are light coloured medium or coarse grained rocks which contain abundant quartz, orthoclase and plagioclase. Syenites and syenodiorites are similar rocks with less quartz. They cooled beneath the earth's crust.

The rocks discussed here consist essentially of quartz, plagioclase, potash feldspar, biotite and amphibole (hornblende). Most are medium grained with large crystals of feldspar or quartz or both. They range in composition from granite to granodiorite or syenite to syenodiorite, and structurally they are massive to gneissic, with the minerals segregated and aligned in layers.

Near the contacts between the intrusive granites and the older metavolcanic sequences, various types of migmatites or "mixed rocks" are present. These consist of various mixtures of the older and younger rocks, and commonly the older materials have been dissolved in (assimilated) and redistributed throughout the younger granitic intrusions to produce layered gneiss.

POST-ALGOMAN BASIC INTRUSIVE ROCKS

Bodies of gabbro and anorthosite which cut the granitic rocks are present in some parts of the region. Anorthosite is usually

Photo 4. *The Proterozoic–Archean unconformity on an island near the mouth of Livingstone Creek, four miles east of Thessalon. The Archean granite lies at the top of the photo.*

pale grey or greenish black in colour, and is made up largely of calcic feldspar with small amounts of hornblende or pyroxene. Numerous dikes of diabase, gabbro, and amphibolite intrude the granitic and older Archean rocks: some of these have been radiometrically dated as Archean. They were probably emplaced near the end of the period of mountain building known as the Kenoran orogeny.

EPARCHEAN INTERVAL

The Algoman mountains, formed by uplift at the end of the Archean, were weathered and eroded during the Eparchean Interval, which separated the Archean from the Proterozoic. During this time, several miles of cover rocks were stripped off to expose the mountain roots, the granitic batholiths with their infolds of older metamorphosed or highly altered volcanic and sedimentary rocks. Apparently they were worn down to a vast plain of low relief, very similar to that found throughout northern Ontario at the present time (photo 5).

The products of erosion in this region were carried mainly southward. Part of this eroded material, possibly amounting to more than one million cubic miles of sediment, was deposited during Proterozoic time around the margins of the Superior Province (map 1). At a number of localities, particularly in the Blind River – Elliot Lake area, remnants of soil formed during the Eparchean Interval are preserved below the Proterozoic Huronian rocks. The composition of this fossil soil (paleosol) indicates that it was formed under reducing conditions, suggesting that at the time of the soil's formation, the earth's atmosphere lacked free oxygen. This is discussed further on page 180.

On islands in the North Channel of Lake Huron near the mouth of Livingstone Creek, 4 miles east of Thessalon, excellent water washed exposures show granite grading through blocky disrupted granite (photo 4) into a conglomerate which is characterized by angular fragments of partially weathered granite surrounded by a ground mass of gritty feldspathic sandstone. This in turn grades upward into boulder free sandstone. This is the locality where early workers first recognized the Archean-Proterozoic contact along the north shore of Lake Huron. This abrupt change from granitic to sedimentary rocks with the evidence of the fossil soils indicating a long erosional interval is known as an unconformity by geologists.

Photo 5. *View of Quirk Lake, Township 144. Note the even skyline reflecting peneplanation of the Precambrian Shield. The Panel Mine lies in the middle distance.*

Proterozoic Rocks

Proterozoic sedimentary rocks, which make up a thick sequence called the Huronian Supergroup, underlie most of the Southern Province of the Canadian Shield between Sudbury and Sault Ste. Marie. This province is bounded on the north by the older rocks of the Superior Province, on the south by younger Paleozoic rocks, and on the east by rocks of the Grenville Province (map 1). The contact between the Grenville and other provinces is known as the Grenville Front, and this contact can be traced for over 1,200 miles northeastward from Lake Huron past Sudbury to the coast of Labrador. The highly deformed and metamorphosed rocks of the Grenville Province south of Sudbury are possibly also of Proterozoic age.

Post-Huronian granitic and gabbroic to diabasic intrusions, ranging in age from 2,160 million years to 1,100 million years, occur in all the geological provinces of the region. In the southern part of the guidebook area the Huronian rocks and some of the post-Huronian intrusive rocks have been strongly deformed and metamorphosed during late Proterozoic mountain building.

Photo 6. *Kennebec Falls on the Serpent River from Highway 17. (Courtesy Ont. Min. Industry and Tourism).*

HURONIAN SUPERGROUP

INTRODUCTION

Rocks of the Huronian Supergroup occupy a belt over 200 miles long and up to 40 miles wide along the north shore of Lake Huron: they attain a total thickness of up to 35,000 feet. They consist mainly of medium to coarse grained detrital sedimentary rocks derived from the Archean basement rocks to the north. The Huronian rocks were deposited in shallow water by south-flowing currents. They were probably deposited between 2,160 and 2,500 million years ago in troughs formed by faulting around and on top of blocks of the Archean rocks typical of the Superior Province (table 2).

The Huronian sedimentary rocks display several peculiar features which may be related to factors attendant on their early Proterozoic age. During that time it is thought that the earth's atmosphere evolved from one lacking free oxygen to one containing free oxygen as at present. There were periodic glacial conditions and a pattern of cyclic sedimentation developed in shallow to moderately deep water.

The Huronian Supergroup can be divided into four groups and twelve formations on the basis of rock types (table 3). Each group is separated by an unconforinity or disconformity (see glossary) and the entire sequence displays cyclic repetitions of coarse grained and fine grained sediments. A study of these features indicates repeated cycles of uplift, regional tilting, and erosion.

ELLIOT LAKE GROUP

The lowermost, oldest Huronian group consists of volcanic rocks (the Thessalon, Pater, Dollyberry Lake, Salmay Lake, Stobie, and Copper Cliff Formations), feldspathic sandstone and uranium bearing conglomerate (the Matinenda Formation), and argillaceous sedimentary rocks (the McKim Formation). Successions within the group differ from place to place. Near Elliot Lake, the Matinenda Formation forms the greater part of the group. Near Sudbury, the McKim forms the greater part of the group.

Matinenda Formation

The Matinenda Formation unconforinably overlies weathered Archean rocks and consists of greenish arkose (feldspar rich sandstone) with or without quartz pebble conglomerate beds, followed by conglomerate with quartz and greenstone pebbles in a greywacke matrix, and grey sandstone and argillaceous sandstone. This sandstone grades into the McKim Formation. The Matinenda Formation is up to 2,000 feet thick in this area.

Lenses of uranium bearing conglomerate in the Matinenda consist of well rounded quartz pebbles in an arkosic matrix rich in sericite and pyrite (photo 7). The average ore mined in the Elliot Lake camp gives about 2 lbs. of uranium oxide (U_3O_8) per ton of rock and the uranium occurs mainly in the minerals brannerite and uraninite, and to a lesser extent in monazite. The conglomerates were deposited in zones partially controlled by basement topography.

The Matinenda Formation is well bedded, and there are abundant features such as crossbedding and ripple marks to indicate that it was deposited in water.

> Sedimentary rocks, particularly sandstones, commonly have an arrangement of internal laminae transverse to the bedding planes which is referred to as crossbedding. There are three general types of crossbedding: simple crossbedding in which the major bedding surfaces are non-erosional, planar crossbedding in which the major bedding surfaces are erosional and the crossbeds are straight, and trough crossbedding in which the surfaces are erosional and curved.
>
> Crossbedding is formed by the passage of a current of water or air over granular sediment, causing the deposit to be extended downstream by the addition of laminations inclined to the major boundary surfaces of the sand body. The direction of slope of the crossbeds is an indication of the direction of flow of depositional currents. The shape and thickness of the crossbeds gives information on the nature of the depositional currents. Consequently, studies of crossbedding, in conjunction with studies of other current-formed structures such as ripple marks, provide information on the direction and nature of the depositional currents, on the direction of source areas, and on the shape and size of the depositional basin.

Matinenda sedimentary rocks were apparently derived from the basement rocks of the Superior Province lying to the north and were deposited near the regional shoreline partly in ancient stream channels and deltas. For a complete discussion of the features of the Matinenda (known formerly as the Lower Mississagi Formation) see Ontario Department of Mines Geological Circular No. 6, "The Sedimentary Petrology of the Mississagi Quartzite in the Blind River Area" by J. P. McDowell.

McKim Formation

The McKim Formation, a sequence of siltstone, greywacke, argillaceous sandstone, and argillite, lies on top of the Matinenda Formation in conformable contact with it. In the north and west the McKim Formation is thin or absent but thickens markedly to the south and east, so that in the Sudbury area it attains a thickness of several thousand feet. The poorly sorted nature of the rocks and the presence of sedimentary structures such as graded bedding, convolute bedding, load casts, ripple marks, and small scale current laminations indicate that the McKim sedimentary rocks were probably deposited in deeper water by turbidity currents.

> Turbidity currents are dense flows of sediment-laden water, which because of their high density are capable of flowing down underwater slopes at considerable speed. Turbidity currents commonly occur when large volumes of loose sediment resting on submarine slopes are suddenly thrown into suspension by earthquakes, landslides, or influxes of flood waters. The flow is turbulent and additional sediment is picked up from the bottom in transit. As the turbidity current slows down, the suspended sediment is deposited. Since the current velocity loss is gradual, the largest grains settle out first, followed by progressively finer grained material. Consequently the resulting deposits (turbidites) commonly display graded bedding with a gradual decrease in grain size from bottom to top of the beds and are typically poorly sorted greywacke. In the tranquil environment where such flows terminate, silts and muds are the normal deposits. Thus turbidites may be interbedded with shale: post-depositional structures because of the collapse of the heavier sands into the muds are common.

> The best documented recent example of a turbidity current occurred in 1929 when an earthquake shook the Grand Banks of Newfoundland. Submarine cables off the mouth of the Cabot Strait were broken by a turbidity current and from the timing of the breaks it is clear that the peak velocity was between 40 and 50 miles per hour. It is believed that the resulting turbidite covered some 100,000 square miles of ocean floor to a depth of 15 to 40 inches.

Many greywackes show graded bedding i.e, the coarser and heavier grains tend to be concentrated in the lower part of a bed and the finer grained clay-rich material towards the top of the bed. When highly altered or metamorphosed, the clay minerals tend to recrystallize into micas and minerals such as garnet and staurolite so that what was the fine grained part of the bed becomes the coarse grained part. This is termed reverse graded bedding (photo 100).

In a sequence such as occurred when the McKim Formation was laid down, where sands were deposited on underlying clays and silts, they tended to slump into the clays because the water trapped in the clays prevented the clays from becoming solid. Downward projecting pendants of the sand in the underlying clay, and their consolidated equivalents, are called load casts, or

Photo 7. *Uraniferous conglomerate, discovery locality, Pronto Mine.*

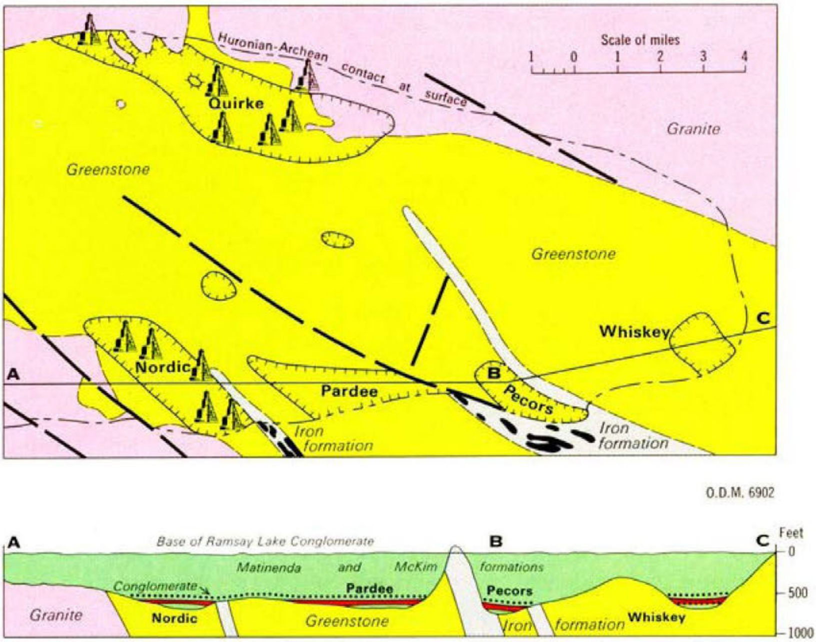


Figure 2. *Distribution of uranium deposits of the Quirke Syncline relative to the underlying Archean rocks. The section shows that the ore lies in depressions in the Archean surface which are named in bold face type on the map.*

where numerous cause convolute bedding. If the slumped material separates from the parent bed, slumpage balls or pillows are formed. Fluid material from the underlying bed may be forced upwards as flame structures or as sedimentary dikes. These features can be seen in the unmetamorphosed rocks of the McKim Formation together with small scale current lamination and ripple marks, but they have been largely destroyed in the metamorphosed rocks.

Volcanic Rocks

Volcanic rocks occur at several localities, notably around and northwest of Thessalon, Spragge (Pater Formation), and between Massey and Sudbury (Salmay Lake, Stobie and Copper Cliff Formations). Recently similar rocks have been found both at surface and in drill holes at Dollyberry Lake and Ten Mile Lake (Dollyberry Lake Formation), and other localities near Elliot Lake. They are mainly basaltic in composition, with minor amounts of rhyolite and some sedimentary rocks which were laid down between the intervals of volcanic activity. These are known as interflow sediments. The only acid volcanic unit of appreciable thickness is the Copper Cliff rhyolite in the Sudbury area. Where undeformed the volcanic rocks display amygdaloidal and porphyritic textures and pillows. Locally however they have been metamorphosed and deformed to basic schist and gneiss. Limited radiometric age data indicate the volcanic rocks are about 2,400 million years old.

HOUGH LAKE GROUP

The Hough Lake Group comprises: the Ramsay Lake Formation, a conglomeratic greywacke 5 to 600 feet thick; the Pecors Formation, up to 1,500 feet of interbedded siltstone, sandstone, and argillite; and the Mississagi Formation, 1,500 to 4,000 feet of sandstone.

Ramsay Lake Formation

Throughout most of the region, the Ramsay Lake Conglomerate overlies the McKim Formation of the Elliot Lake Group (figure 2). However, in the north and west, the Hough Lake Group oversteps the northern margin of the Elliot Lake Group, and here Ramsay Lake Conglomerate rests on the Matinenda Formation, on Huronian volcanic rocks, or on the Archean basement. Economically significant uranium deposits have only been found in rocks older than the Ramsay Lake Formation hence its use as a marker horizon. A marker horizon or bed is one which, because of readily identified charateristics and extent, can be used for tracing geological structures.

The Ramsay Lake Conglomerate (photo 8) consists of partially sorted, rounded to angular pebbles and boulders of granite, quartz, and greenstone, sparsely distributed in a greywacke or quartzite matrix. The presence of large grains (1/10 inch) of smoky quartz and of sulphides in the matrix is characteristic. In the transition zone between the Ramsay Lake and the overlying Pecors Formation there are pebbles and cobbles which apparently have been dropped into unconsolidated clay and silt (photo 113). These were probably dropped from melting icebergs or pack ice and it is possible that the Ramsay Lake and lower Pecors Formations were deposited by glacial processes.

Pecors Formation

The Pecors Formation lies above the Ramsay Lake Formation. In the Quirke Lake – Elliot Lake area the Pecors comprises a sequence of argillites. In the Blind River area siltstones predom-

Photo 8. *Ramsay Lake conglomerate, Hyman Township, near Nairn. Note the sparse distribution of the pebbles, some of which, being softer than the matrix, have weathered more rapidly, leaving a pitted surface.*

inate with minor quartzite and argillite, and in the vicinity of Spanish and eastwards it comprises interbedded siltstone, argillite and quartzite.

As noted above, the presence of scattered pebbles in the transition zone from the Ramsay Lake Conglomerate (photo 113) is of particular interest as indicating near-frigid conditions. Where lenses of siltstone and quartzite are present, crossbedding or lamination is characteristic. Many argillite bedding planes are ripple marked and a few at Quirke and Ten Mile Lakes are mud cracked. These features indicate deposition in very shallow water.

In the sequences containing siltstone and quartzite, slumpage structures are common. These are well seen at Tube Lake in Victoria Township and along the south bank of the Spanish River in Indian Reserve 5, southwest of Massey.

The Pecors Formation shows marked lateral thickening away from ancient shorelines and local basement highs (possibly islands at the time of deposition). Minor radioactivity may be recorded in argillite but this is not thought to be of economic importance.

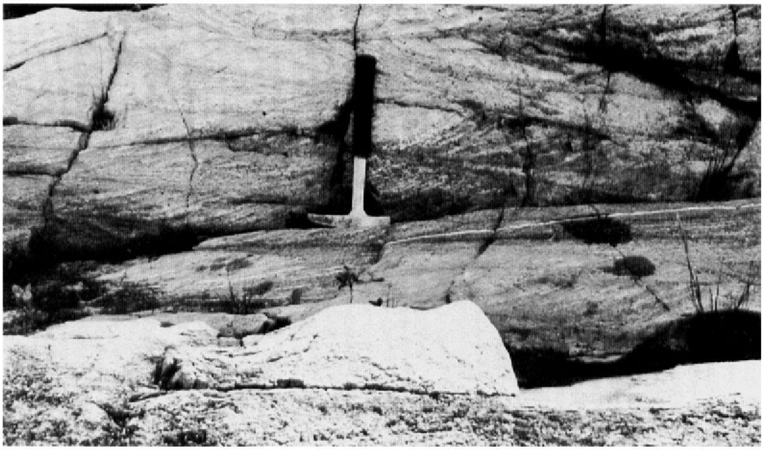


Photo 9. *Festoon crossbedded arkose of the Mississagi Formation. Turbulent conditions prevailed during deposition. Quirke Lake, Township 150.*

Mississagi Formation

The Mississagi Formation in the Endikai Lake – Ten Mile Lake – Quirke Lake area (photo 9), where it lies near the original shoreline, consists of green crossbedded arkose with thin radioactive quartz pebble bands. To the south the formation thickens, is less feldspathic, and the crossbedding is indicative of less turbulent conditions. Rocks of this latter type are exposed throughout the

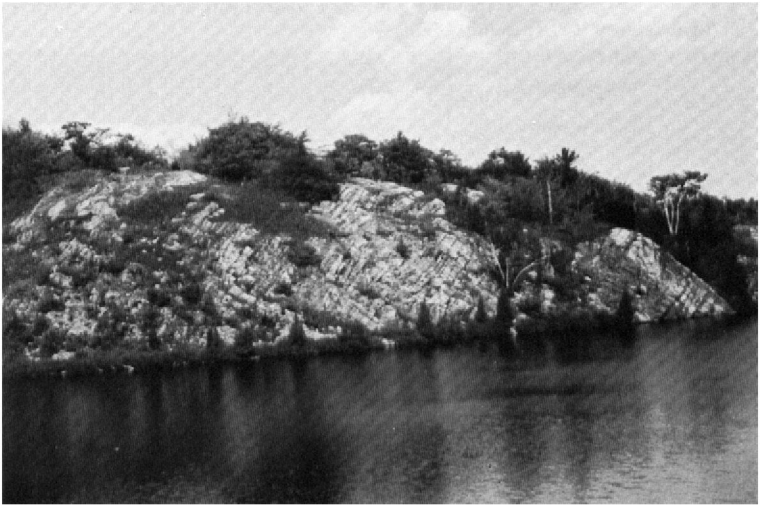
Photo 10. *Planar crossbedded quartzite of the Mississagi Formation, laid down under less turbulent conditions than those illustrated in photo 9 above. Highway 17, east of Bruce Mines.*

Elliot Lake - Blind River – Bruce Mines area (photo 10). East of Pronto Mine the Mississagi Formation lies on a basement high. It is more feldspathic; turbulent conditions prevailed during deposition. Towards Sudbury and in the Wahnapitae – Coniston area the Mississagi Formation comprises well bedded, crossbedded, impure quartzites and greywackes. These are well exposed on the bare hills adjacent to Highway 17 east of Sudbury.

The formation, like all quartzite, is resistant to erosion and here forms high rugged ground. An excellent example is the escarpment running east from Elliot Lake on which the Elliot Lake fire tower is located. The ridge running north of and parallel to Highway 17 between Massey and Mount Victoria, and the chain of islands to the south of the Whalesback Channel of Lake Huron, are other occurrences.

The geological formational names in the early literature have often been quite confused. In early reports and maps the term Mississagi Formation was used in a wider sense to include both the entire Hough Lake Group and the Elliot Lake Group but it is now used in the narrower sense described here. Only where the term is used in the earlier wider sense is it correct to link the Mississagi with commercial uranium deposits, and it is better that this usage should be dropped altogether to avoid continued confusion.

Photo 11. *Mississagi quartzite in Foster Township, east of Espanola*



QUIRKE LAKE GROUP

The Quirke Lake Group comprises the Bruce Formation (conglomerate), the Espanola Formation (largely carbonate and siltstone) and the Serpent Formation (feldspathic quartzite). The group is well exposed and is of particular interest to geologists because of the wealth of depositional and post-depositional structures displayed and because it contains both an ancient till (Bruce Formation) and some of the oldest known carbonate-bearing sedimentary rocks in the world.

Bruce Formation

The Mississagi Formation is overlain by the Bruce Formation, a conglomerate which consists of boulders, cobbles, and pebbles of granite, greenstone, and quartz, in a partly sorted siliceous greywacke matrix (photo 12). The matrix also normally carries minor amounts of pyrite and pyrrhotite. Rarely there may be lenses of quartzite. In the uppermost part of the formation a laminated greywacke may be found with scattered cobbles that were probably dropped from floating ice. The conglomerate is normally more densely packed in the north near the old shoreline and less densely packed away from the shoreline (photos 13, 12). The thickness of the conglomerate deposit normally decreases away from the northerly source area.

Like the similar Ramsay Lake Conglomerate, the Bruce

Photo 12. *Typical sparsely packed conglomerate of the Bruce Formation, consisting of granite (grey), quartz (white) and greenstone (black) fragments in a greywacke matrix. Highway 108, Township 149.*

Formation conglomerate is probably an ancient consolidated till (or what is called a tillite) laid down in and partially re-worked by water. Striated and faceted boulders similar to those found in Pleistocene tills have been obtained at a number of localities in the guidebook area.

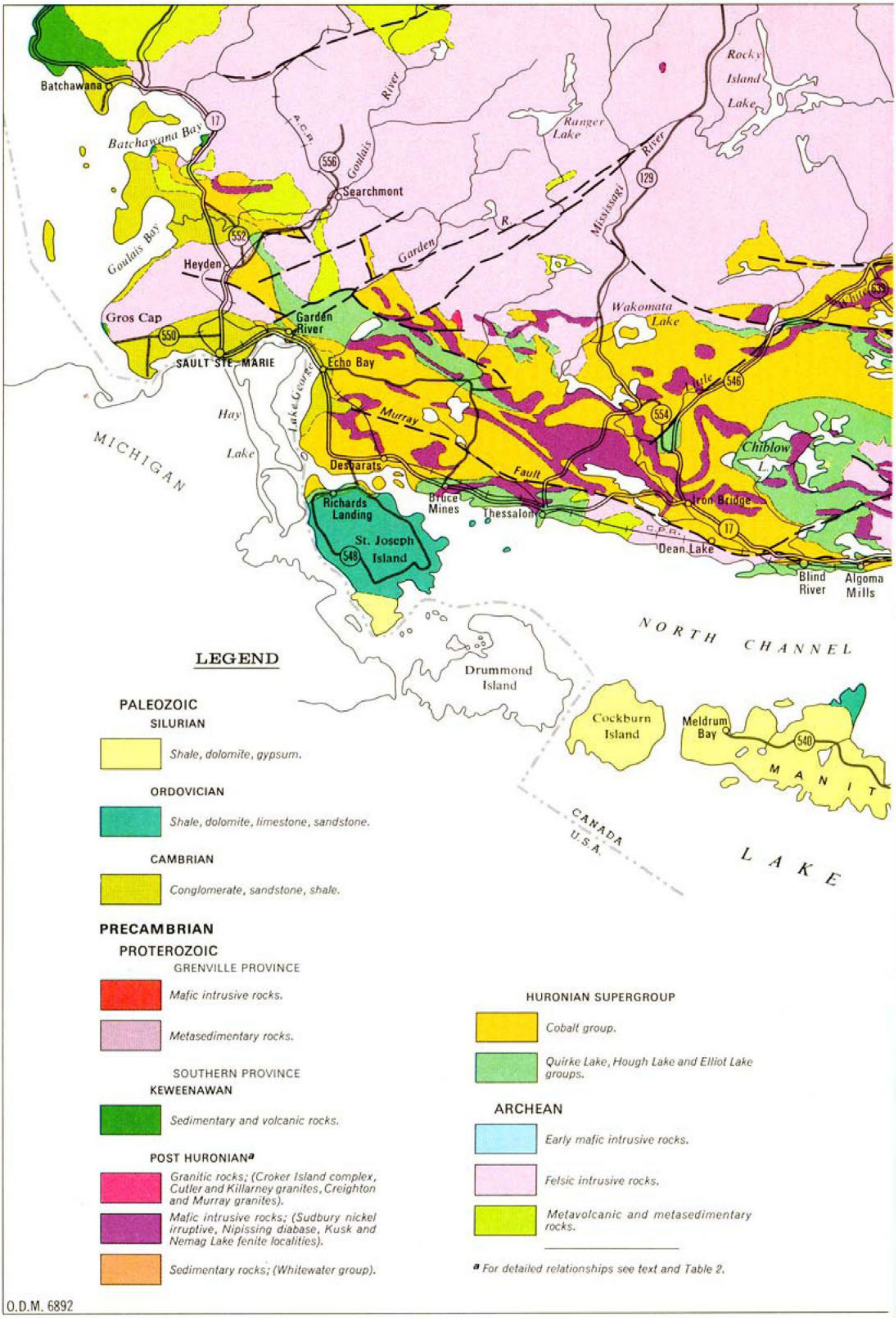
Espanola Formation

The Espanola Formation comprises a sequence of siltstone, sandstone, and limestone or dolomite, and was originally subdivided into three parts: a lower limestone-siltstone member; a middle siltstone-greywacke member; and an upper siltstone-greywacke-dolomite member. This subdivision is generally used in in the Elliot Lake – Bruce Mines area where the units are known as the Bruce Limestone, Espanola Greywacke, and Espanola Limestone respectively.

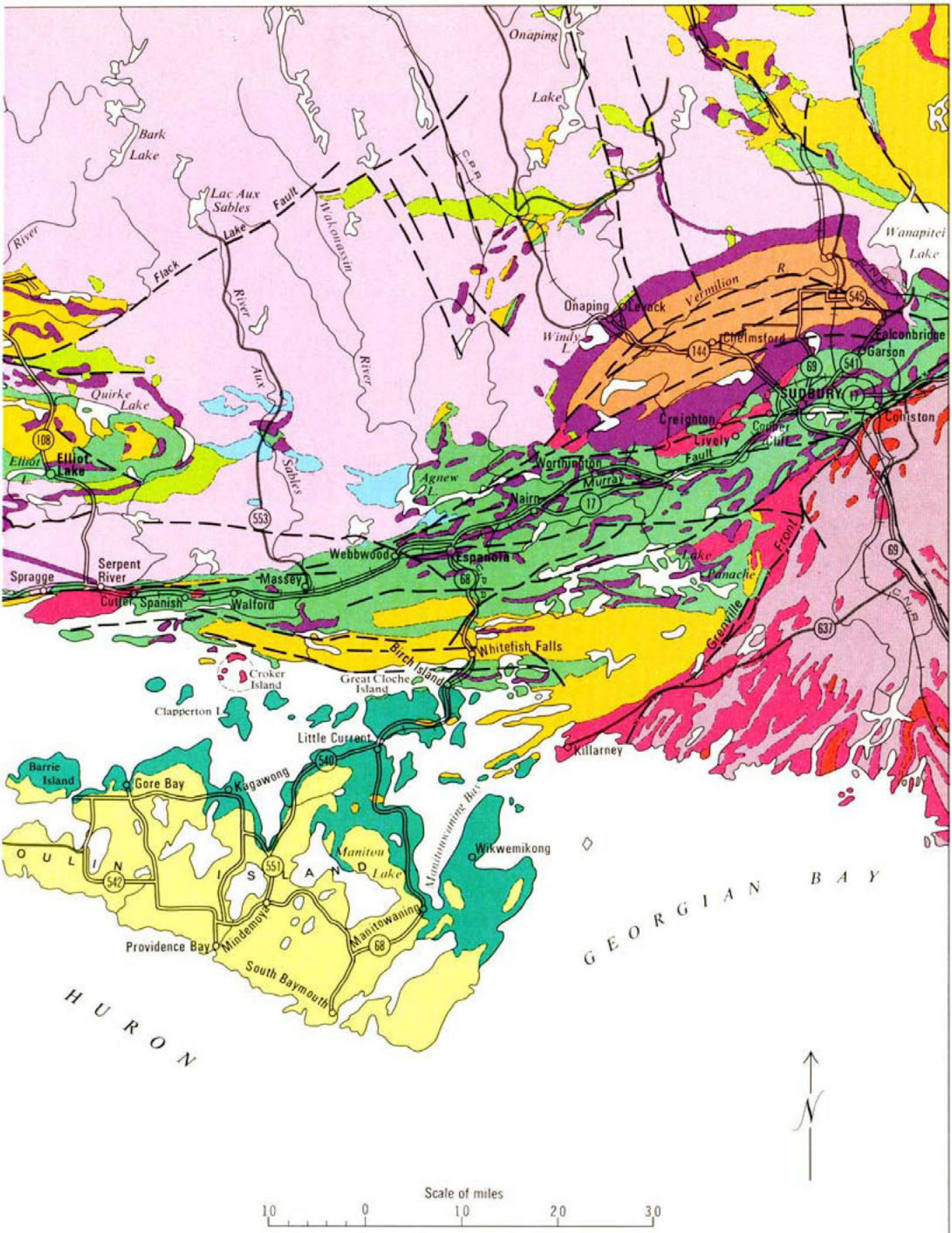
In the Massey – Whitefish Falls area the division is less distinct and there is in addition a thick sandstone calcareous siltstone unit in the upper part of the formation. Near and southwest of Elliot Lake, where the Espanola Formation is overlain unconformably by the Gowganda Formation, only the Bruce Limestone is present.

The lower member consists of thinly bedded cream coloured limestone and black siltstone. Differential erosion of the softer limestone layers and fold structures in the rock give it a spectac-

Photo 13. *Densely packed conglomerate of the Bruce Formation at Quarry Bay, Quirke Lake, Township 150. The size, variation in size and rock types, and packing, indicates proximity to the source.*



Map 2. *The generalized geology of the North Shore of Lake Huron Region.*



Note:
Roads shown in a double line
indicate guidebook routes.
Roads shown in grey indicate
other means of access.

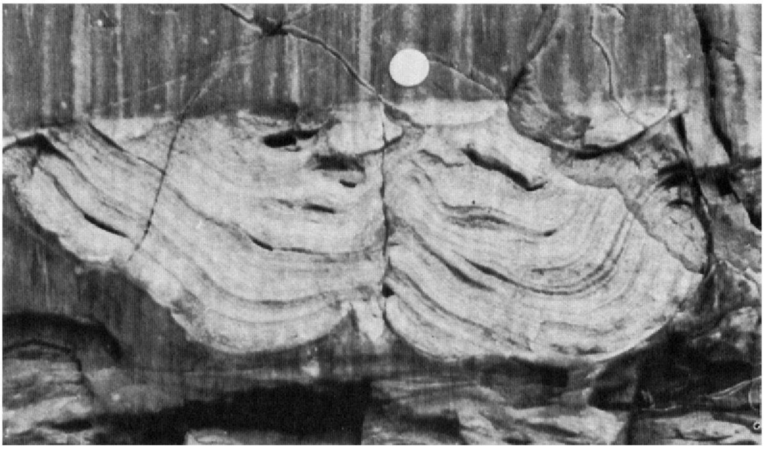


Photo 14. *Convolute bedding, due to slumpage of laminated sandstone into siltstone, Espanola Formation, near Aird Island, North Channel of Lake Huron. The striae on the siltstone beds (top and bottom of photo) are due to ice scour.*

ular appearance. The middle siltstone-greywacke member consists of thinly bedded calcareous and non-calcareous siltstone and greywacke. The sandstone member consists of medium bedded calcareous and non-calcareous quartzite and siltstone. Crossbedding is common in the quartzite. The upper member consists of thinly bedded dolomitic siltstone, greywacke, and dolomite.

Sedimentary structures such as ripple marks, mud cracks, dessication breccia, and crossbedding are abundant. Such structures are common in Huronian rocks and are illustrated by photos 116, 16, 111. Structures due to slumpage of the unconsolidated sediment such as load casts, flame structures, slumpage pillows and balls, convolute bedding (photo 14), and slumpage breccias are common. Clastic dikes and sills of siltstone, sandstone, and conglomerate are also found (photos 110, 67).

These features indicate accumulation in generally shallow water with frequent exposure to the atmosphere. There would be intervening periods of deposition during which the currents carrying or shifting the sediment continually changed speed, intensity and direction. Earthquakes, landslides, and slumpage periodically took place and triggered brecciation, sediment intrusion, and turbidity currents. The environment would be all-in-all an unstable one.

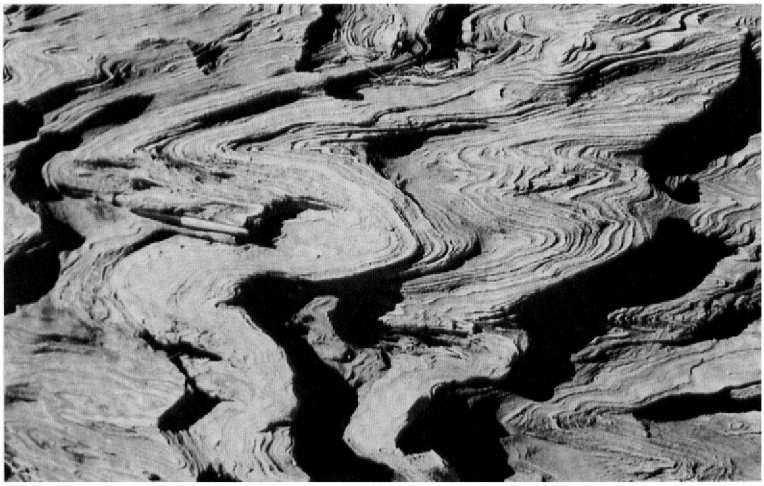
Metamorphism has resulted in the formation of minerals such as biotite, scapolite, amphiboles, diopside, grossular garnet, idocrase, wollastonite, and magnetite. Contact metamorphism, in particular of the Bruce Limestone by the Nipissing Diabase, has produced the rocks known as skarns (page 162). Regional metamorphism, particularly in the Massey – Whitefish Falls area, has produced rocks containing scapolite, amphibole, and epidote. Deformation has resulted in complex fold and fracture patterns (photos 15, 122).

Serpent Formation

The Serpent Formation rests on the Espanola Formation and is a white feldspathic quartzite best exposed at Quirke and Ten Mile Lakes but also found near Lake Panache, the North Channel of Lake Huron, Bruce Mines, and Aweres Township near Sault Ste. Marie.

It shows crossbedding and ripple marks and related shallow water structures. Mud cracks are fairly common, particularly in siltstone interbeds (photo 16). The feldspar in the formation in the Elliot Lake area is plagioclase and this is relatively fresh, suggesting deposition in cold water. Further south and east, the feldspars plagioclase and microcline are both present. The crossbedding directions indicate a northwesterly source (see page 14) in the Elliot Lake area and a northerly to northeasterly source in the Espanola – Lake Panache area. There is considerable variation in the thickness of the Serpent Formation. This is apparently due to folding after deposition, followed by erosion before the deposition of the Gowganda Formation of the Cobalt Group.

Photo 15. *Thinly bedded Espanola Formation. The carbonate beds are etched, the sandstone beds stand in relief. Note the complex fold pattern.*



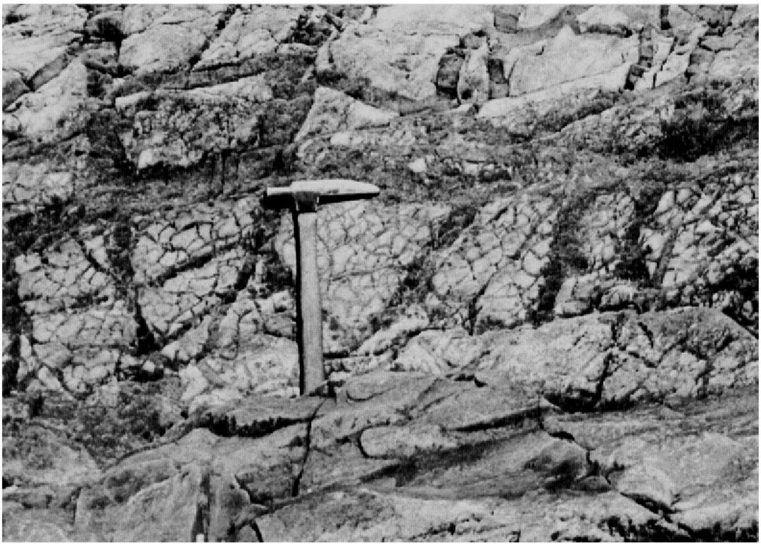


Photo 16. *Large and small mudcracks on a siltstone interbed. Serpent Formation, south shore of Aird Island.*

COBALT GROUP

The Quirke Lake Group was folded and eroded, and then the Cobalt Group was laid down. Locally, particularly in the north and west, the contact is sharp. It truncates the structures of the underlying rock. Rarely, fragments of the older Huronian rocks may be found in the lowermost beds of the Gowganda. Elsewhere the contact is gradational and apparently there was little or no break in the sedimentation process.

The Cobalt Group consists of the Gowganda Formation, the Lorrain Formation, the Gordon Lake Formation, and the Bar River Formation. Of these the most widely exposed is the Gowganda Formation: the other formations are exposed northwest of Elliot Lake; in the Bruce Mines – Echo Bay area; and in the country extending from the Spanish River Indian Reserve to south of Espanola and Lake Panache, thence to Killarney and the Grenville Front. The Gowganda Formation is of special interest because of convincing evidence of glaciation and change from reducing to oxidizing conditions. The Lorrain Formation probably accumulated under warm conditions and in the Lorrain and Bar River Formations there are possible indications of primitive life forms (photo 22).

Gowganda Formation

The Gowganda Formation lies unconformably on older rocks. It can be seen lying on the Archean basement in the Mount Lake and Rawhide Lake area; elsewhere it rests on those formations which are listed in the stratigraphic table between the Mississagi Formation and the Serpent Formation (table 3).

The Gowganda Formation is a heterogeneous assemblage up to 4,500 feet thick of conglomerate, greywacke, quartzite and argillite. These rock types are found throughout the sequence both vertically and laterally, although there is a concentration of boulder conglomerate both towards the base of the formation and northwards towards the source areas.

Dense boulder conglomerates (photo 18) were laid down in water but some may have been originally transported by ice. Sparse cobble conglomerates are probably tillites (photo 19). Argillites (photo 108) and hematitic feldspathic quartzite were water laid in tranquil conditions. Thinly bedded greywackes with scattered cobbles and with graded bedding showing a change from a coarse grained base to a finer grained top (photo 131) were water laid, but in an area subject to freezing and thawing. Each

Photo 17. *Near Iron Bridge on Highway 17. (Courtesy Ont. Min. Industry and Tourism).*

Photo 18. *Densely packed conglomerate (washed tillite) of the Gowganda Formation. Highway 108, Township 149.*

graded unit formed under such conditions is termed a varve.

As glaciers move they become charged with soil and rock debris from the areas over which they pass and on occasion are able to dislodge pieces of bedrock. This rock material is most concentrated at the base of the sheet which may be likened to a large sheet of sandpaper. The weight of the ice is such that the "sandpaper" scours, scratches, and polishes the bedrock over which it passes. The rock surface is then known as a glacial pavement. The direction of the striae (scratches) gives the direction of ice flow. Similarly, the material carried within the ice becomes scratched and polished and some boulders become flattened or faceted on one or more sides. Such striated and faceted stones are common in the material deposited in till or moraine by the glaciers of Pleistocene time.

Pre-Gowganda glacial pavement has been observed south of Lake Timiskaming and in northwestern Quebec, but not within the area covered by this guide. Striated boulders and cobbles have been found at many localities and can be readily obtained in road cuts on Highway 108. However in many cases, perhaps the majority, it can be shown that these striae are related to post-consolidation deformation of the rocks.

Photo 19. *A recent, striated, glacial pavement developed on sparse conglomerate (tillite) of the Gowganda Formation. Highway 17 near Iron Bridge.*

The hematitic feldspathic quartzites are best developed in the upper part of the formation and are well exposed on Highway 108 near the junction with the Stanrock access road. They are of interest in that the preservation of hematite suggests an oxidizing rather than the reducing environment characteristic of the older Huronian rocks. The greywackes, argillites and siltstones in the upper part of the Gowganda Formation carry detrital magnetite. The grade is not sufficient to be iron formation but is sufficient to cause magnetic anomalies and in some cases to attract a hand magnet.

The distribution of well bedded rocks and other features indicates that the ice sheets came from the north and that a continental environment persisted in the north and that a sea or large lake existed to the south.

Lorrain Formation

The Lorrain Formation overlies the Gowganda Formation conformably except in the northern fringes of the area where it may extend beyond the Gowganda Formation and lie on the Archean basement. The formation may be subdivided into several members. The formation as a whole and the individual members thicken to the southeast and the rocks become fine grained, although all were probably laid down in fairly shallow water.

In the west and northwest (the Bruce Mines – Mount Lake areas) the following sequence is found, totalling from 3,000 to 4,000 feet thick: pink ferruginous quartzite and siltstone; coarse grained green arkose; pink hematitic arkose with radioactivity (thorium:uranium 10:1); interbedded pink, buff, and greenish quartzite, with quartz-jasper-chert pebble bands particularly in the upper part; massive white quartzite with quartz-jasper-chert pebble bands in the lower portion (photo 20). The presence of clay minerals in non-feldspathic beds in the last two members suggest the onset of warm rather than frigid conditions. The hematitic beds and the presence of thorium rather than uranium suggests an oxidizing environment. The first two members are preserved in basin structures at Mace – Lillybet Lakes and Dunlop Lake. Basin structures are elliptical areas in which the sedimentary rocks dip (slope) inward. The youngest rocks are found in the centre of the structure and the oldest rocks on the margin. Crossbedding in these northwesterly localities indicates derivation from the northwest. The jasper pebble bands are one of Canada's best known ornamental stones. The best material for polishing is obtained from boulders in the glacial drift near Bruce Mines and St. Joseph Island. Parts of the Lorrain sequence show an abundance of crossbedding and occasional ripple marks, particularly near Desbarats on Highway 17 (photo 134). Possible fossils (worm-casts) have been found on bedding planes near Desbarats.

Photo 20. *Jasper conglomerate of the Lorrain Formation at Rydal Bank, north of Bruce Mines. Note the pebbles of jasper (red), quartz (white), and chert (black), in a buff quartzite matrix.*

Photo 21. *Lorrain quartzite at the Willisville Fire Tower in the La Cloche Mountains near Highway 68. Massive white quartzite forms the higher ground in this rugged terrain.*

The Lorrain Formation outcrops again in the belt of Huronian folded rocks from Massey eastward to the Grenville Front. The thickness is approximately 6,000 feet. Near-vertical quartzite beds form the prominent ridges of the La Cloche Hills (photo 21). The spectacular scenery at Killarney and near Whitefish Falls (photo 70) is due to these ridges.

In the southern area the following units have been recognized: interbedded pink and grey impure quartzite, coarse grained arkose, medium to coarse grained green arkose, ferruginous buff-weathering quartzite with thin quartz pebble bands, medium grained white kaolinitic quartzite, and fine grained cherty orthoquartzite. The rocks are tightly folded and locally intensely sheared. Slip surfaces are coated with hematite and striated quartz grains (slickensides). Grains and pebbles have been flattened or stretched parallel to the foliation (schistosity). The rocks have been recrystallized and the clay minerals have been replaced by kyanite and andalusite. Kyanitic quartzite and quartz segregations with kyanite can be seen at Dreamers Rock near Whitefish Falls.

The pure quartzite of the uppermost members is quarried at Willisville near Whitefish Falls for smelter flux at the International Nickel Co. of Canada Limited smelter in Sudbury. Other quarries have provided material for the manufacture of silicon carbide and the rock has potential use in making glass.

Cordon Lake Formation

In places the Lorrain Formation is overlain by the Gordon Lake Formation. In the Flack Lake and Echo Lake - Gordon Lake areas, it is a 1,000 foot thick sequence of shallow water siltstone, chert, and fine to medium grained sandstone. These rocks are best exposed on Highway 639 south of the Boland River and at Flack Falls (photo 121), both in Township 157.

The rocks are characterized by such shallow water features as ripple marks (photo 119); mud cracks and dessication cracks; and slumpage structures such as flame structure, slumpage balls and pillows, load casts, and convolute bedding. The Gordon Lake Formation also is exposed at La Cloche Lake and eastwards, in the troughs of synclinal folds. The rocks are sheared as a result of deformation and the bedding plane features are obscured. However the internal structures such as current lamination and slumpage structures are well preserved. In the southeastern area the siltstones contain detrital magnetite and the outcrop area shown on Geological Survey of Canada Map 21-1968 corresponds to a distinctive area of high magnetic intensity (an anomaly) on the regional magnetic maps published by the Ontario Department of Mines and Northern Affairs and the Geological Survey of Canada. The iron content is however too low to be of economic significance.

Bar River Formation

The Gordon Lake Formation in its turn is succeeded conformably by the Bar River Formation– a sequence of shallow water sandstones. These are best exposed on Highway 639 near Flack Lake in addition to the type area of Bar River. At Flack Lake 1,500 feet are exposed and near Killarney some 4,000 feet are exposed.

The formation is characterized by crossbedding and an abundance of ripple marks; mud cracks are also found. There are a number of localities, for example on Highway 639 at Jimchrist (Christman) Lake and Flack Lake, where structures are found on ripple marked bedding planes. These are ½" to 1½" long slender bodies, curved in plan view and rounded to polygonal in cross section. Some have ribbed (corrugated) surfaces and some have a shallow furrow running their length. These structures do not merge but lie across one another (photo 22). Many geologists

Photo 22. *Rhysonetron lahtii, Hofmann 1967. Upper surface view of corrugated spindles (possibly fossils, possibly mud crack fillings) concentrated in ripple troughs preserved in sandstone, Bar River Formation, Highway 639, Flack Creek. (Courtesy Geological Survey of Canada Photo 200090D).*

believe that they are casts of worm burrows. However the rocks in the same area show many dessication structures similar to those of the Gordon Lake Formation. Other geologists believe that the problematical structures are the sand fillings from dessication cracks which have been transported and redeposited when the silts were removed by later currents.

The Bar River Formation is also exposed near Killarney and on Manitoulin Island where it is nearly vertical, composed of pure quartzite, and forms high ground. Quarries are being developed in the Bar River Formation on Badgeley Island to provide silica for glass manufacture and other industrial uses.

Table 3.

SUMMARY OF HURONIAN STRATIGRAPHY

Group	Formation	Lithology	Thickness (Feet)	Depositional Mode Environment	Source	Mineralization
Cobalt	Bar River	Sandstone, siltstone.	1000-4000	Shallow marine	North (northwest to northeast)	Silica source
	Gordon Lake	Siltstone. sandstone, chert.	1000-3000	Shallow marine	Northwest	
	Lorrain	Sandstone	2000-6000	Shallow marine	North, northwest	Silica source Th-U
	Gowganda	Conglomerate, greywacke, sandstone.	500-4500	Glacial in north; marine glacial in south	North, northwest	
Quirke Lake	Serpent	Sandstone.	0-2400	Fluvial, fluvial-deltaic, shallow marine	Northwest, north	
	Espanola	Dolomite, limestone, sandstone, siltstone.	0-1500	Tidal mudflat, shallow marine	West, northwest, north	Copper tungsten near diabase
	Bruce	Conglomerate.	0-450	Glacial marine	North?	
Hough Lake	Mississagi	Sandstone.	0-4000	Fluvial, fluvial-deltaic	Northwest, west, north	Uranium near basement
	Pecors	Argillite, sandstone.	40-1500	Fluvial-deltaic	North, northwest	Minor uranium near basement
	Ramsay Lake	Conglomerate	5-600	Glacial marine	North, northwest?	Minor uranium
Elliot Lake	McKim	Argillite, siltstone, sandstone.	0-2500	Shallow water turbidite	Northwest, north	Minor uranium near basement
	Matinenda	Sandstone, conglomerate.	0-2000	Fluvial, fluvial-deltaic	Northwest, north	Uranium, thorium near basement
	Volcanic rocks	Basalt, andesite, rhyolite.	Local	Marine?		Copper in flows and intercalated sediments. Uranium in conglomerate interbeds.

HURONIAN STRATIGRAPHY

Table 3 is a summary of the Huronian stratigraphic sequence. As previously explained the sedimentary rocks were derived from the Archean basement rocks to the north, and were transported southward mainly by streams and glaciers and deposited in and along the margins of shallow seas which gradually transgressed northward across the Archean basement. The sedimentary rocks of the lower half of the Huronian Supergroup were deposited rapidly, apparently under rigorous weathering conditions with periodic glaciation. Possibly the atmosphere at this time lacked free oxygen, and consequently, easily oxidized and subsequently dissolved minerals such as uraninite, pyrite, and magnetite were preserved. Locally, basaltic or basaltic and rhyolitic lava flows were erupted, possibly from fault fissures. The sedimentary rocks of the upper half of the sequence have features indicative of more prolonged weathering and extensive sorting and reworking in the depositional environment. The presence of minerals such as hematite and kaolinite or their subsequent metamorphic equivalents possibly indicates a change to warmer oxidizing atmospheric conditions.

The frequent repetition of similar sequences of rock types within the Huronian Supergroup, namely coarse conglomeratic sedimentary rocks, overlain by fine grained argillaceous sedimentary rocks, which in turn are succeeded by medium grained sandstones, is probably the result of alternating uplift and downwarp in the area from which they came and the resulting changes in sea level.

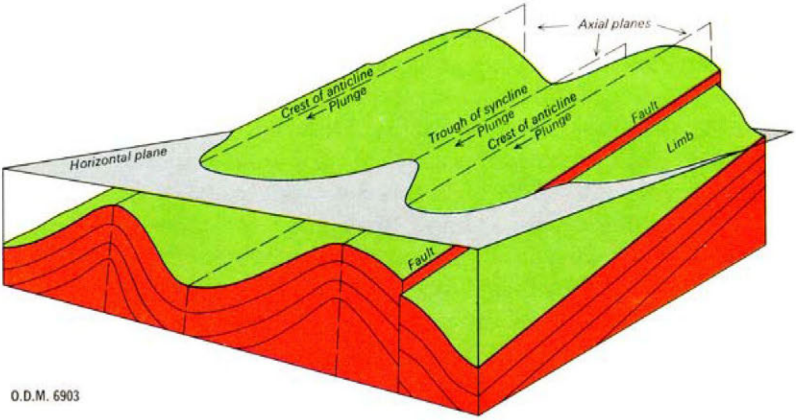


Figure 3. *Schematic diagram illustrating anticlines, synclines and faults.*

POST HURONIAN EVENTS

STRUCTURAL GEOLOGY

The major structural elements of the Sudbury – Sault Ste. Marie area consist of large synclines and anticlines which are approximately paralleled by major fault systems (see map 5). Synclines are folds, the rocks of which slope inward to form trough structures; anticlines are folds, the rocks of which slope outward to form arch structures; faults are fractures along which movement of the rock walls has occurred (figure 3). For more complete definitions please refer to the glossary.

Regional structures trend east to northeasterly near Sudbury; east-west in the Blind River – Elliot Lake area; and west to northwesterly in the Bruce Mines - Sault Ste. Marie area. The most important of the major fault systems are those of the Murray and Flack Lake Faults which parallel the synclines and anticlines. North of Sudbury the main folds trend approximately north. Northeast of Sudbury the major faults of the Lake Timiskaming system trend northwest.

The intensity of deformation of the rocks varies markedly from place to place, but in general it increases toward the south and east. For example, folds in the Elliot Lake – Sault Ste. Marie area are simple, open structures with gently dipping limbs, while in the Sudbury – Espanola area they are tight, complex structures with steeply dipping limbs (compare photos 23 and 24).

This structural pattern was produced by several superimposed mountain building events which occurred intermittently over a period of possibly 1,000 million years. Evidence for repeated deformation includes the presence of several generations of major and minor structures, some of which pre-date certain intrusive rocks while others post-date them. There is evidence for repeated movements at various times and in various directions on most of the major faults. The main Murray fault zone which extends from east of Sudbury to Blind River marks an important "hinge line" which influenced Huronian sedimentation. Possibly at an early stage in Proterozoic time the area south of the Murray Fault dropped down while the area to the north remained relatively high. Subsequently during early major folding, these faults were reactivated, but at that time the southern block was uplifted relative to the northern block. During later orogenic events, lateral movements occurred and the southern block moved west with regard to the northern block.

Photo 23. *A gentle anticline in the Bar River Formation, Highway 639, near Flack Lake.*

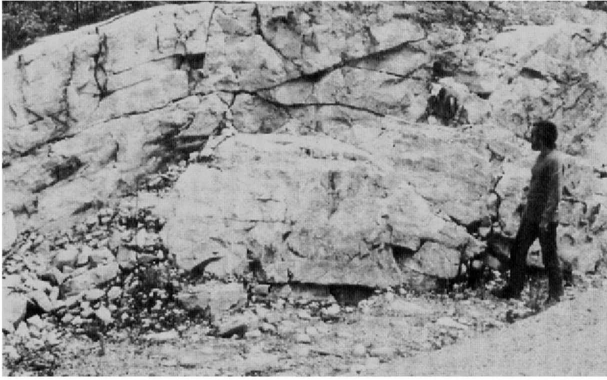


Photo 24. A *complex fold in interbedded schist and quartzite. Note later crenulation cleavage and slip folds. The axial plane is subparallel to the hammer. Sheddon Township.*

Photo 25. *Coarse grained dioritic diabase, Whiskey Lake, Township 138.*

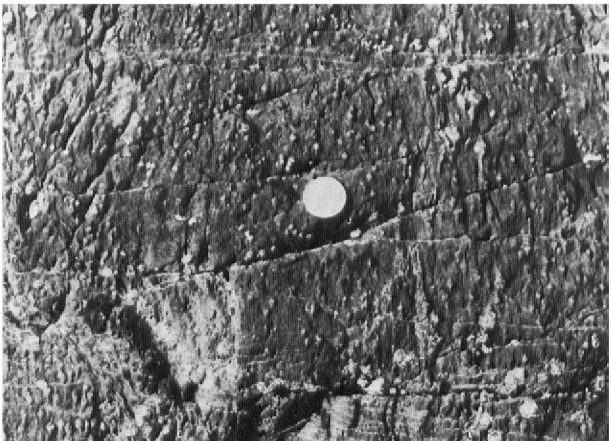


Photo 26. *Metamorphosed diabase. Massive amphibolite with garnet crystals. Cutler P.O. Highway 17, I.R.5*

THE PENOKEAN OROGENY

The presence of disconformities and angular unconformities within the Huronian sequence indicates that earth movements occurred during Huronian sedimentation. Huronian deposition was probably terminated approximately 2,200 million years ago by large scale uplift and mountain building known as the Penokean orogeny. At this time the rocks were folded, faulted, and mildly metamorphosed. In the Sudbury area the Creighton and Murray granites may have been emplaced at this time at relatively high levels in the earth's crust.

Nipissing Diabase

Approximately 2,160 million years ago, Nipissing Diabase intruded the Archean and folded Huronian rocks of the region. The emplacement was partly controlled by pre-existing structural features such as folds, bedding, jointing and faults. A sheet-like body of igneous rock intruded along bedding is called a sill, and a near vertical body is called a dike. In this area both were formed.

The Nipissing "diabases" are dominantly gabbro to diorite in composition (photo 25) and the fresh rocks consist mainly of pyroxenes, partly altered to hornblende, and plagioclase. Minor amounts of granophyre, composed of quartz and alkali feldspars, occur in the upper parts of some intrusions. Sulphide minerals, mainly pyrrhotite, chalcopyrite, and locally, gold-bearing arsenopyrite, occur in quartz-carbonate veins (photos 120, 128) and as disseminations in and around diabase intrusions. In the Cobalt area to the north, silver and cobalt mineralization is closely associated with the Nipissing Diabase. Local metamorphism at the contact between the carbonate rocks of the Espanola Formation and some larger diabase bodies resulted in the formation of minerals such as garnet, idocrase, diopside, wollastonite, epidote, tremolite, scapolite, scheelite and magnetite. Other rocks have become impregnated with albite or chlorite.

Late Penokean Orogenic Events

After the intrusion of the Nipissing Diabase, the region was subjected to a series of deformational and metamorphic events, the detailed sequence of which has not yet been fully worked out. Folding along east-west axes, approximately parallel to old pre-diabase folds, varied greatly in intensity from place to place and modified the earlier structures to varying degrees. Folding was

Photo 27. *Chloritoid crystals (dark) in metamorphosed greywacke of the McKim Formation at the junction of old Highway 17 and High Falls road, near Nairn.*

approximately coincident with regional metamorphism which also varied in intensity, and probably took place at different intervals of time from place to place. In general the grade of metamorphism, like the intensity of folding, increases from north to south. In the Elliot Lake – Sault Ste. Marie area, the Huronian rocks and Nipissing diabases have been only slightly altered or metamorphosed while in the Sudbury -Espanola area, they have been moderately to strongly metamorphosed. The more altered rocks occur in elliptical zones along several east-west trending belts in patterns reminiscent of strings of beads. Typical metamorphic minerals which have been developed in the argillaceous sedimentary rocks, include micas, chloritoid (photo 27), garnet, staurolite, (photo 60) and andalusite. Pyrophyllite, andalusite, and kyanite have developed in kaolin bearing Lorrain sandstones, and tremolite-actinolite, hornblende, diopside, scapolite, and idocrase in calcareous sedimentary rocks of the Espanola Formation. Amphiboles, epidote, and garnet occur in the Nipissing Diabase (photo 26).

Basic dikes which cut the Nipissing Diabase were intruded, probably at an early stage in the orogenic sequence, and were metamorphosed in the later stages.

Photo 28. *Geological relationships of the Cutler granite. Note inclusions of metasediments (mid-grey) showing reverse graded bedding, tops to the left, and inclusions of metadiabase (black), in granite (light grey). Inclusions are sub parallel, reflecting original orientation; one fragment has been rotated. The granite has been foliated, then intruded by pegmatite (light speckled) which cuts granite and inclusions.*

THE HUDSONIAN OROGENY

Highly deformed and metamorphosed Huronian sedimentary rocks and post-Huronian basic rocks were intruded during the Hudsonian orogeny by the Cutler granite (photo 28) near Cutler and by the Killarney granite along the Grenville Front zone between Killarney and Sudbury. These intrusions are at least 1,750 million years old as determined by radiometric age dating. The Sudbury Nickel Irruptive, dated as 1,730 million years, was emplaced at approximately the same time. The Whitewater Group sedimentary rocks, preserved only within the Sudbury Basin, was probably formed just prior to the intrusion of the Irruptive. The mountain building events which reach the peak of their intensity 1,750 million years ago are called the Hudsonian orogeny.

Cutler and Killarney Batholiths

A batholith is a very large mass of igneous rock formed deep in the earth's crust.

The Cutler granite occurs near Highway 17 along the north shore of Lake Huron between Cutler and Spanish. It was intruded into the core of the Spanish Anticline in the Huronian sedimentary rocks and is found to include numerous blocks of previously metamorphosed Huronian and Nipissing rocks (photo 28).

Killarney granites were emplaced along the northeast trending Grenville Front zone, apparently at relatively high levels in the earth's crust. They intrude previously deformed and metamorphosed Huronian sedimentary rocks on the north and probably are younger than several deformational -metamorphic events which affected the adjacent Grenville Province rocks.

Sudbury Nickel Irruptive

The Sudbury Nickel Irruptive is an intrusive body (map 3) which is exposed at the surface as an elliptical ring 37 miles long and 17 miles wide. The body comprises an outer ring of gabbroic rocks, a transition zone composed of rocks of variable composition ranging from gabbroic to granophyric, and an inner ring of granophyre. The outer contacts generally dip inward at angles of 30 to 90 degrees. There are dike-like offshoots from the main nickel irruptive termed "offsets" which extend out into the country rocks for several miles. The world's greatest known concentration of nickel-copper sulphide ores occurs around the outer edge of the Nickel Irruptive proper and in the "offsets".

The ores consist of mixtures of massive to disseminated sulphides, mainly pyrrhotite, pentlandite, and chalcopyrite with minor pyrite, nickel, cobalt, and platinum arsenides, and silicates, including blocks of ultrabasic igneous rocks. The ore bodies are associated with a complex assemblage of intrusions and intrusive breccias which form a "sub-layer" at the base of the nickel irruptive. This sub-layer probably represents an injection of magma which varied in composition from a silicate fluid to a sulphide fluid.

The Sudbury Nickel Irruptive is located at the contact between the Superior and Southern Provinces, a few miles north of the Grenville Front (map 3). To the north it intrudes Archean granitic gneisses of the Superior Province, while in the south, it intrudes highly deformed and metamorphosed lower Huronian volcanic and sedimentary rocks. Along its inner contact it intrudes rocks of the Whitewater Group. In terms of regional structure, the Irruptive is apparently perched on top of a major domal structure in the country rocks, approximately at the intersection of two major fault systems, the east to northeast trending Murray system, and the northwest trending Lake Timiskaming system. The rocks around the Nickel Irruptive are highly deformed by regional faulting, folding, and shearing, and are highly metamorphosed. Some of the deformational and metamorphic events have affected the Nickel Irruptive, especially its south part which has been uplifted by major faulting. In addition, the rocks outside the Irruptive have been extremely brecciated (photo 44) and contain shatter cones (conical fracture surfaces, photo 41) the origin of which is enigmatic but is undoubtedly related to extraordinary events connected with the origin of the Irruptive and the Whitewater Group rocks.

Photo 29. *Onaping Falls, Vermilion River, northwest of Sudbury. Here the river crosses the Onaping Formation, which because of its composition and texture is resistant to erosion.*

Origin of the Sudbury Nickel Irruptive

The origin of the Irruptive has long been debated. Early workers concluded that it was emplaced along an unconformity at the base of the Whitewater Group of rocks as a single flat-lying sheet of magma.

> Magma consists of molten or partially molten rock constituents formed at high temperature usually deep within the earth. As magma cools it starts to crystallize. Those minerals such as olivine, pyroxene and calcium-rich feldspar which have high solidification (or melting) points crystallize out and tend to settle at the base of the magma body. The liquid remaining thus has a different composition from the original magma. Later at lower temperature, amphiboles and biotite and less calcic feldspars crystallize out, and in extreme cases, if the earlier crystallizing material is unable to react with the remaining liquid, the liquid becomes enriched in the components of quartz and sodic and potassic feldspars. A rock in which these latter minerals are intimately inter-

> grown is termed a granophyre. Thus a magma of originally basic composition can give rise to rocks as varied as diabase, olivine gabbro, gabbro, diorite, and granophyre. The process whereby different rock types are formed from the same original magma is called magmatic differentiation. The Nipissing Diabase and the Sudbury Nickel Irruptive are accepted examples of differentiated magmas.

The early workers considered that the flat sheet of magma had differentiated into a lower basic portion termed "norite" and an upper granophyric portion termed "micropegmatite". Sulphides were thought to have settled out along the base of the sheet, and radial fractures were considered to have been filled with silicate minerals and sulphides to form the "offsets". Later subsidence and deformation brought the Irruptive to its present position. Other workers considered the Irruptive to be a composite ring-dike intrusion, first of "norite" (hypersthene gabbro) followed quickly by granophyre. They based their hypothesis mainly on the fact that the apparent volume of granophyre is much in excess of what would be expected from differentiation of a gabbroic magma. Another theory holds that the Irruptive is a funnel shaped body (lopolith) which consists of more basic material at depth and that the apparent volume relationships between "norite" and granophyre do not represent the true relationship. Inclusions of ultrabasic igneous rocks, presumably derived from deeper levels within the Irruptive, have recently been found, thus supporting this interpretation.

Recently it has been suggested that the Sudbury Basin was formed by meteorite impact. Evidence for this hypothesis includes the extraordinary Sudbury breccias, the shatter cones, and some unique structures and textures in the Onaping Formation, the lowermost formation of the Whitewater Group. Many of these features have only been found at known meteorite impact craters and at atomic blast sites.

WHITEWATER GROUP

The Whitewater Group, which occupies the Sudbury Basin inside the Nickel Irruptive, comprises three formations: the Onaping Formation at the base, the Onwatin Formation in the middle, and the Chelmsford Formation at the top. The Onaping rocks have been radiometrically dated at approximately 1,800 million years.

The Whitewater Group has been correlated with the Huronian rocks immediately outside the Nickel Irruptive. There are few, if any, similarities between the Huronian volcanic rocks and the Onaping Formation rocks, although the McKim and Chelmsford Formations resemble one another in the sense that they were both presumably deposited by turbidity currents. However, there is evidence that the Huronian rocks underwent deformation and intrusion by Nipissing Diabase prior to deposition of the Whitewater Group rocks. Radiometric dating indicates ages of about 2,300 million years for the Huronian rocks and 1,800 million years for the Whitewater rocks.

Onaping Formation

The Onaping Formation is intruded by the granophyre of the Nickel Irruptive and consists of fragmental, tuff-like rocks or breccias composed of rock, mineral, and devitrified glass fragments ranging in size from several feet to submicroscopic. These rocks are essentially unstratified and were apparently deposited very rapidly. Recently a zone of quartzite breccia has been discovered at the base of the Onaping containing rock fragments similar to the Huronian rocks outside the basin. The origin of the Onaping Formation is, like most features of Sudbury geology, a matter of conjecture. Some workers believe that these rocks represent the products of explosive volcanism and are ignimbrites or glowing avalanche deposits. According to the meteorite hypothesis, they represent "fall-back" of broken and melted rock blown out of the crater by the meteorite impact.

Onwatin Formation

The Onwatin Formation consists mainly of black, carbonaceous, pyritic slate. In the contact zone between the Onaping and Onwatin Formations there is an assemblage of thinly laminated limestones and cherts, which were probably formed by hot spring activity. Copper, lead, and zinc sulphide minerals occur in these rocks in the southwest part of the basin.

Chelmsford Formation

The Chelmsford Formation consists mainly of medium grained greywackes. These rocks have a poorly sorted texture, and structures such as thick graded beds, indicating they were deposited by turbidity currents. For discussion see page 15. Some horizons are marked by large spheroidal rusty-weathering patches sometimes called "footballs" (photo 30); as the original bedding continues through them, they are considered to be a type of replacement concretion.

LATE OROGENIC EVENTS

After formation of the Cutler and Killarney Granites, the Whitewater Group, and the Sudbury Nickel Irruptive, the region again became tectonically active. Cleavages trending east-west to northeast were formed and there was probably further folding and faulting. Cleavage is the direction in which a rock can be split easily, caused by the orientation of platy minerals under pressure. The easy splitting of slate is a good example. Possibly the broad open folds in the Whitewater Group rocks were formed at this time. Strain-slip cleavages were also imposed on the rocks. They trend northwest and northeast. Strain-slip or fracture cleavage is a closely spaced jointing which results in a direction of easy splitting. It does not depend on the orientation of minerals and the fractures are not evenly distributed throughout the rock.

There was probably also mountain building activity in the Grenville Province to the south and east at this time as there are intrusions and metamorphic events which have radiometric ages of approximately 1,800, 1,700, 1,500, 1,200, and 1,000 million years. These events in the Grenville Province have led to "overprinting" of radiometric ages in the rocks and minerals of this, the adjoining Southern Province, so that around Sudbury, single rock units can have radiometric "ages" ranging from more than 1,800 million years to less than 1,000 million years.

Small Igneous Intrusions

Several small igneous intrusions were emplaced in the Huronian rocks, apparently after the Hudsonian deformation and metamorphism had ceased.

Croker Island Complex

In Lake Huron some ten miles southwest of Massey there is a group of islands which outline a circular intrusion about 6 miles in diameter (photo 31, map 5). This intrusion is also outlined by a circular magnetic anomaly which may be seen on Map 2255G published by the Ontario Department of Mines and the Geological Survey of Canada. The body consists of a core of biotite syenite, diorite, and gabbro and an outer shell of quartz monzonite. It intrudes folded Huronian sedimentary rocks on the north, and is covered by water and Paleozoic strata on the south. It has been dated as 1,450 million years old. For a more detailed description see The Croker Island Complex by K.D. Card, Geological Circular No. 14, published by the Ontario Department of Mines.

Photo 30. *Concretions in the Chelmsford Formation near Dowling.*

Mongowin Pluton

The Mongowin Pluton is a small intrusive body which cuts Huronian rocks in Mongowin Township south of Espanola. It also gives a pronounced circular magnetic anomaly. See Map 1522G published by the Geological Survey of Canada. The intrusion is composed mainly of altered ultramafic rocks with minor intermediate (dioritic) and granophyric segregations. Copper-nickel sulphides and a vein of magnetite with unusual colloform and radiating structures are present in the ultramafic rocks (figure 4). This is one of three known occurrences of such magnetite in North America. A detailed account has been given by K.D. Card in The Mongowin Pluton published in 1968 as Miscellaneous Paper No. 14 of the Ontario Department of Mines.

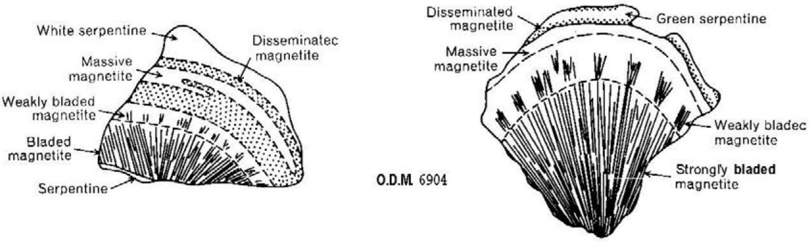


Figure 4. *Sketches of radiating magnetite nodules, Mongowin Township. About one third actual size.*

Photo 31. *The Croker Island complex. See Map 5. The La Cloche Syncline lies north of Lake Huron; its limbs are defined by the La Cloche Mountains formed over steeply dipping Lorrain quartzite (white). The North Channel is underlain by the McGregor Bay Anticline, approximately defined by the Mississagi Formation. The circular pattern of islands reflects the Croker Island complex. The island west of the complex is of Paleozoic limestone. A number of faults may be recognized as linear valleys. Scale about 1½ miles to the inch. Photos courtesy National Air Photo Library.*

Other Igneous Rocks

Small dikes of lamprophyre, a micaceous hornblendic rock, intrude the Huronian strata. They have been dated as approximately 1,400 million years.

Recently two small intrusions of aegerine-riebeckite-dolomite-breccia have been discovered near Lake Panache. These contain small rutile bearing pegmatite dikes. These breccias contain fragments of metamorphic rocks, presumably 1,750 million years old. They are cut by Sudbury swarm dikes of 1,100 million years and therefore lie between these two ages.

Certain circular bodies of intrusive carbonate rich igneous rocks (carbonatites) are of interest. They often carry minerals of niobium, apatite, and minor amounts of thorium. Several such bodies are found at Chapleau, north of the area. They lie in a northeast trending zone between Sault Ste. Marie and James Bay. This zone is characterized by a high gravity anomaly and represents a zone where the earth's crust was once relatively thin. The southernmost of these carbonatite intrusives lies at Seabrook Lake (5 miles west of Highway 129, 50 miles north of Thessalon).

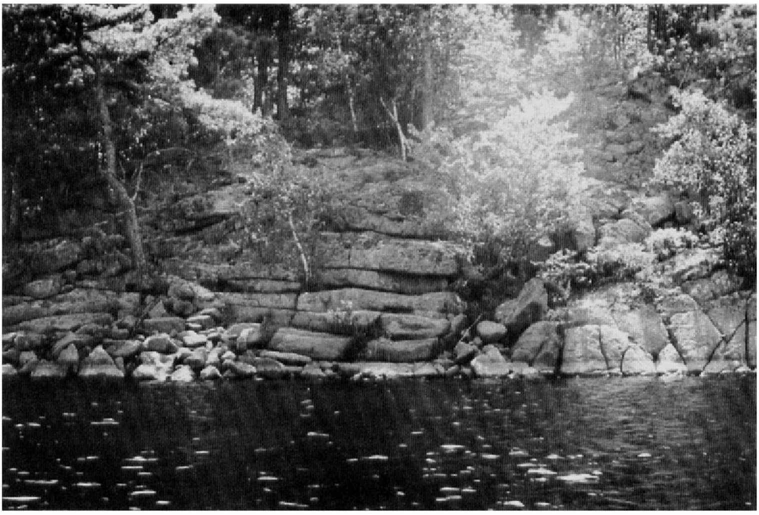
KEWEENAWAN ROCKS

The youngest Precambrian rocks found in the district are the Keweenawan igneous rocks.

Keweenawan Volcanic and Sedimentary Rocks

Keweenawan volcanic rocks, together with some interbanded conglomerate and sandstone, are found in several localities in the Lake Superior region. The area is described fully in Geological Guidebook No. 2 of this series. Keweenawan rocks are exposed on the large peninsula separating Black and Nipigon bays and on the islands between this peninsula and Schreiber; on Michipicoten Island; at intervals along the shoreline near Sault Ste. Marie and northward for 65 miles to Mica Bay; and in the states of Michigan and Minnesota in the United States. They can be examined most conveniently at the Mamainse mine. They are principally lava flows (photos 143, 144) of basic or basaltic composition, and many, perhaps most of them, are amygdaloidal. The vesicles or gas cavities in these lavas are filled with such minerals as agate, amethystine quartz, calcite, chlorite, datolite, epidote, prehnite, thornsite and zeolites. Native copper is also found in trace amounts at the old Mamainse mine and the Coppercorp Ltd. mine at Batchawana.

Photo 32. *A Keweenawan diabase dike, showing characteristic jointing pattern and weathering surface. I.R. 7, North Channel, Lake Huron.*



A contact of vesicular basalt against Archean granite can be seen at Chippewa Falls, the mid point of the Trans-Canada Highway (photo 40).

Keweenawan Basic Intrusive Rocks

The Keweenawan lava flows are cut by olivine diabase dikes north of the guidebook area in the Theano Point–Agawa Bay area. The contact zones of these dikes with the Archean rocks are characterized by vein deposits carrying pitchblende. Dikes of Keweenawan age dated at 1,130 million years are found cutting both the Huronian and Archean rocks of the Sault Ste. Marie – Sudbury area. These dikes are characterized by well developed lath shaped crystals of feldspar, a rusty red-brown weathering zone and blocky fracturing (photo 32). The weathering extends inward from the joints, reducing the rock to rounded masses in a feldspar sand; this is called spheroidal weathering. Porphyritic diabase (photo 61) is rarely found. The Keweenawan diabase dikes belong to two groups. One, best developed in the Sudbury area and having a northwest trend, consists of olivine diabase, and the other, best developed northeast of this guidebook area and having a northeast trend, consists of a variety of diabase rock types. These two groups are called the Sudbury dike swarm and the Abitibi dike swarm. The Sudbury dikes cut all other rocks of the Sudbury – Espanola – Elliot Lake area, but are themselves displaced by the latest movement on the Murray Fault system (pages 38, 47) which indicates that this fault was active as late as 1,100 million years ago.

It should be noted that there are two sets of northeast trending differentiated quartz diabase dikes; an earlier set cut by the northwest trending Onaping faults and the Sudbury dikes, and a later set which are not cut by the northwest faults and which cut the Sudbury dikes.

The later set is the Abitibi; the earlier, which includes dikes at Mount and Kirkpatrick Lakes (see map 7) is not dated with certainty and may be related to the Nipissing Diabase.

LIPALEAN INTERVAL

The Lipalean Interval, a long period of erosion, began approximately 1,000 million years ago after the intrusion of the Keweenawan diabase dikes and after the final uplift and stabilization in the Grenville Province. It was brought to a close approximately 600 million years ago during the early Paleozoic era when shallow

Photo 33. *The Lipalean surface. Thinly bedded Paleozoic limestone lying on an irregular weathered surface of white massive Lorrain quartzite. The time gap represented by this unconformity is known as the Lipalean Interval.*

seas advanced northward across the continent and deposited sandstone, limestone, and shale.

Thus the Lipalean Interval lasted for many millions of years, during which time the mountainous terrain of the Shield was reduced to a low peneplain, probably much as we see today. This ancient erosion surface can be seen at several localities along the north shore of Lake Huron where it has been preserved under the Paleozoic strata (photo 33).

Phanerozoic Rocks

GENERAL DESCRIPTION

The Paleozoic, Mesozoic and Cenozoic eras are described collectively as the Phanerozoic, a major period of geological time which can be translated as the eon of evident life. Unlike the Precambrian which preceded it, the Phanerozoic can be broken down by age and classification with relative ease; its formations are readily identified because of their undisturbed condition and the abundant traces of life which they contain.

The consolidated deposits of the Phanerozoic – all of them Paleozoic sedimentary rocks in this guidebook area – occur in the southern part of the area, mostly on the islands of Lake Huron. Mesozoic deposits are not found in the southern half of Ontario but Cenozoic deposits are fairly widely distributed as an unconsolidated mantle of sands, gravels, silts and tills lying on the Precambrian or Paleozoic bedrock.

Paleozoic Rocks

Paleozoic sedimentary rocks which cover much of North America overlap the margin of the Precambrian Shield along the north shore of Lake Huron. The Paleozoic strata dip gently southwest, and as some formations are resistant to erosion, several northeast facing escarpments are present (photo 34). The most important of these, the Niagara Escarpment, continues south through southern Ontario and is responsible for Niagara Falls. The Escarpment is described in detail in Industrial Mineral Circular No. 35, published by the Ontario Department of Mines and Northern Affairs. During the early Paleozoic, invertebrate animals (without backbones) were the dominant animal life. These animals lived in the shallow Paleozoic seas and many had the ability to take calcium carbonate from seawater to build their shells. Such hard parts tend to be preserved in the rocks, leaving an excellent record of early Paleozoic marine life. Fossil remains are very abundant in some of the Paleozoic strata and include various types of corals, trilobites, ostracods, bryozoa, pelecypods, gastropods, and graptolites (plates A to D).

MANITOULIN ISLAND REGION
ORDOVICIAN AND SILURIAN FOSSILS

by

Thomas E. Bolton and M. J. Copeland
Geological Survey of Canada, Ottawa.

PLATE A

MIDDLE ORDOVICIAN FOSSILS

Ostracods

1. *Tetradella ulrichi* Kay. Right valve, X15. Gull River Formation, road-cut on Highway 68, 0.4 miles south of Roosevelt Memorial. Hypotype, G.S.C. No. 27657.

2. *Euprimitia labiosa* (Ulrich). Right valve, ×15. Gull River Formation, same locality as figure 1. Hypotype, G.S.C. No. 27658.

3. *Cryptophyllus oboloides* (Ulrich and Bassler). Right valve, ×15. Bobcaygeon Formation, 12 feet above base, north side of road-cut on Highway 68, 1 mile west of McGregor Bay railroad-highway crossing. Hypotype, G.S.C. No. 27659.

4. "*Bythocypris*" *granti* Ulrich. Right valve, ×15. Bobcaygeon Formation, 16 to 19 feet above base, same locality as figure 3. Hypotype, G.S.C. No. 27660.

5. *Krausella* sp. cf. *K. arcuata* Ulrich. Right valve, ×15. Bobcaygeon Formation, same locality as figure 4. Hypotype, G.S.C. No. 27661.

13, 19, 20. *Eoleperditia fabulites* (Conrad). Right, ventral, and left views, X4. Lindsay Formation, west end of railway-cut on Goat Island near Highway 68. Hypotypes, G.S.C. Nos 27662-27664.

Cephalopods

6. *Gonioceras anceps* Hall. Natural section of part of a phragmocone exposing wide siphuncle, X1. Bobcaygeon Formation, north side of old Highway 68 east of west end of lake on Great Cloche Island. Hypotype, G.S.C. No. 27665.

11. *Cyrtorizoceras* sp. Lateral (venter left) view, ×1. Lindsay Formation, road-cut at south end of highway-railroad bridge, Little Current. Fig. spec., G.S.C. No. 27666.

Trilobites

7. *Amphilichas*(?) sp. Immature specimen allied to *Hemiarges* sp., ×2. Gull River Formation, small quarry on west side of railroad immediately west of McGregor Bay railroad-highway crossing. Fig. spec., G.S.C. No. 27667.

8, 16. *Hemiarges paulianus* (Clarke). Two incomplete cranidia, ×2. Lindsay Formation, same locality as figure 11, and Verulam Formation, road-cut north end of Goat Island. Hypotypes, G.S.C. Nos. 27668, 27669.

Gastropod

9. *Liospira* sp. Abapertural view, ×1. Bobcaygeon Formation, same locality as figure 6. Fig. spec., G.S.C. No. 27670.

Echinoderms

10. *Cyclocystoides* sp. cf. *C. halli* Billings. Oral view, ×2. Verulam Formation, same locality as figure 16. Hypotype, G.S.C. No. 21099.

14, 21. *Carabocrinus huronensis* Foerste. Three specimens and an isolated plate, ×1. Verulam Formation, same locality as figure 16. Hypotypes, G.S.C. Nos. 27671, a, b, 27672.

22. *Cupulocrinus jewetti* (Billings). Posterior view of crown, ×2. Verulam Formation, same locality as figure 16. Hypotype, G.S.C. No. 21100.

Brachiopod

12. *Rhynchotrema* sp. Brachial view, ×2. Lindsay Formation, same locality as figure 11. Fig. spec., G.S.C. No. 27673.

Bryozoan

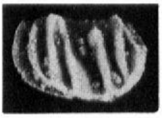
15. *Stictopora* sp. Bifoliate form, X2. Verulam Formation, same locality as figure 16. Fig. spec., G.S.C. No. 27674.

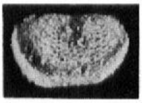
Coral

17. *Tetradium fibratum* Safford. Transverse thin-section of part of corallum with lacunae, X4. Lindsay Formation, same locality as figure 11. Hypotype, G.S.C. No. 27675.

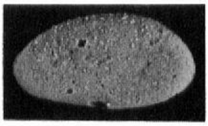
Stromatoporoid

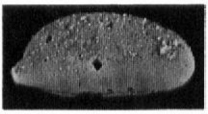
18. *Cystostroma minimum* (Parks). Vertical thin-section of massive colony with regular mamelons, X10. Verulam Formation, same locality as figure 16, top of section. Hypotype, G.S.C. No. 27676.

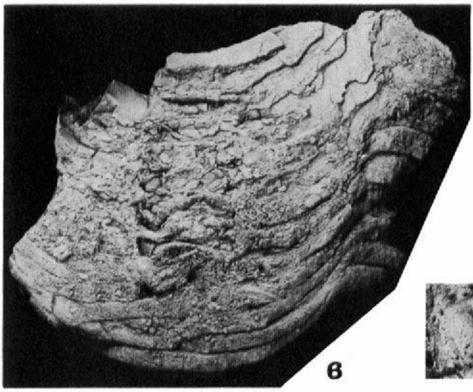

1

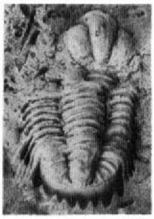

2

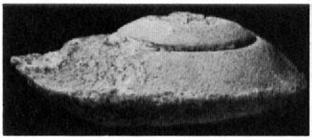

3


4

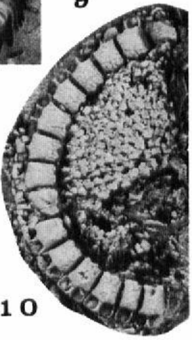

5


6

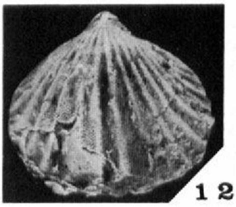

7

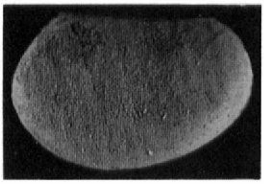

9

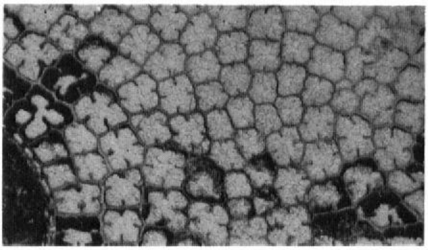

8


10

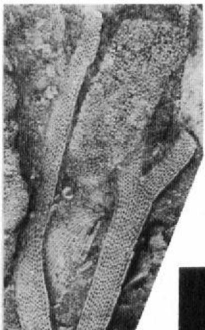

11


12

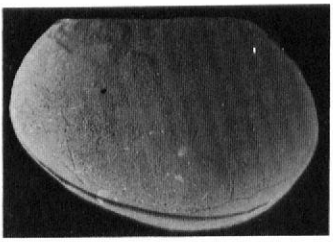

13

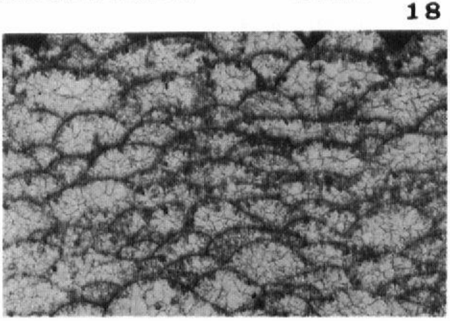

17

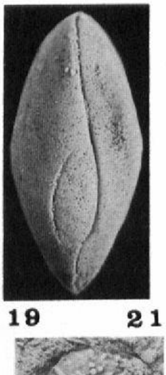

14


15


16


20


18


19


21

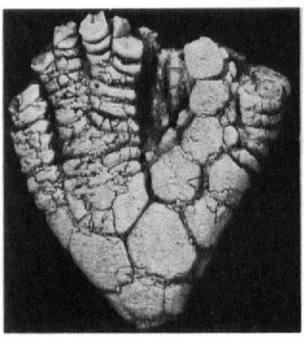

22

PLATE B

UPPER ORDOVICIAN FOSSILS

Cephalopod

1. *Spyroceras hammelli* (Foerste). Phragmocone, ×1. Georgian Bay Formation (Meaford beds), Cape Smyth. Hypotype, G.S.C. No. 18663.

Brachiopods

2, 13, 14. *Zygospira modesta* (Hall). Side, brachial and pedicle views, X2. Georgian Bay Formation (Kagawong beds), Highway 68 corner in Ten Mile Point area, lots 20-21, con. XII-XIII, Sheguiandah Tp. Hypotypes, G.S.C. Nos. 27677-27679.

6, 10. *Glyptorthis insculpta* var. *manitoulinensis* Foerste. Brachial views, ×1 and ×2. Georgian Bay Formation (Meaford and Kagawong beds), Clay Cliffs, 3 miles north of Wekwemikongsing, and road exposure along boundary Howland and Bidwell Tp., approx. 3½ miles west of Shrguiandah. Hypotypes, G.S.C. Nos. 6784, 27680.

7, 8. *Lepidocyclus perlamellosus* (Whitfield). Pedicle and brachial views, ×1. Georgian Bay Formation (Kagawong beds), same locality as figure 10. Hypotypes, G.S.C. Nos. 27681, 27682.

12. *Strophomena* sp. aff. *S. vetusta* (James). Brachial exterior, ×1. Georgian Bay Formation (Kagawong beds), same locality as figure 10. Hypotype, G.S.C. No. 27683.

18. *Strophomena huronensis* Foerste. Pedicle interiors, X1. Georgian Bay Formation (Meaford beds), same locality as figure 1. Hypotype, G.S.C. No. 18664.

Gastropods

3. *Liospira helena* (Billings). Apertural view, ×1. Georgian Bay Formation (Meaford beds), same locality as figure 6. Hypotype, G.S.C. No. 18671.

4. *Lophospira manitoulinensis* Foerste. Abapertural view, ×1. Georgian Bay Formation (Meaford beds), same locality as figure 6. Syntype, G.S.C. No. 8501c.

17. *Archinacella kagawongensis* Foerste. Dorsal view, X2. Georgian Bay Formation (Kagawong beds), same locality as figure 2. Hypotype, G.S.C. No. 27684.

Stromatoporoid

5. *Beatricea undulata* Billings. Exterior, ×½. Georgian Bay Formation (Meaford beds), Rabbit Island, Georgian Bay. Hypotype, G.S.C. No. 18673.

Corals

9, 11. *Grewingkia rustica* (Billings). Side and polished vertical section, X1. Georgian Bay Formation (Kagawong beds), same locality as figure 10 and Drummond Island, Michigan, U.S.A. Hypotypes, G.S.C. Nos. 27685, 1983b.

Echinoderm

15. *Iocrinus subcrassus* (Meek and Worthen). Crown, X4. Georgian Bay Formation (Wekwemikongsing beds), lot 11, con. XI, Howland Tp. on Highway 68 approximately 3 miles south of Little Current. Hypotype, G.S.C. No. 27686.

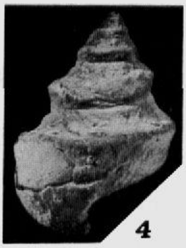
Pelecypod

16. *Ortonella stewarti* Foerste. Interior right valve, X2. Georgian Bay Formation (Kagawong beds), same locality as figure 2. Hypotype, G.S.C. No. 27687.


1


2

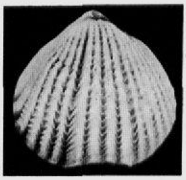

3


4

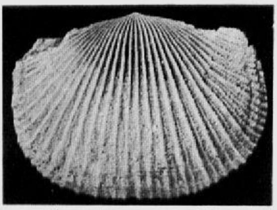

5


6

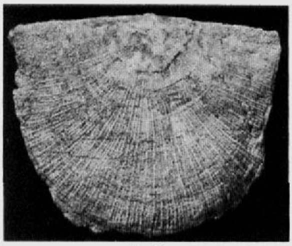

7


8


9

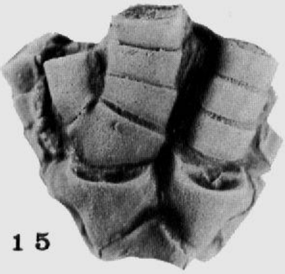

10

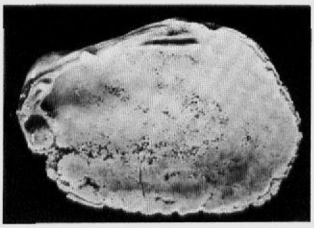
11


12


13


14


15


16


17


18

PLATE C

LOWER AND MIDDLE SILURIAN FOSSILS

Specimen

Brachiopods

1, 2. *Mendacella* sp. Brachial and posterior views, X2. Manitoulin Formation, East-West secondary road, ¾ mile east of Rockville road, Bidwell Tp. Fig. specs., G.S.C. Nos. 27688, 27689.

3, 14. *Resserella eugeniensis* (Williams). Brachial interior and brachial views, X1 and X2. Cabot Head Formation, Eugenia Falls, and Manitoulin Formation, same locality as figure 1. Hypotypes, G.S.C. Nos. 17956, 23572.

4. "*Orthorhynchula*" *bidwellensis* Bolton. Brachial view, X2. Manitoulin Formation, same locality as figure 1. Hypotype, G.S.C. No. 27690.

5, 10. *Dolerorthis flabellites* (Foerste). Brachial view, X1, and brachial and pedicle interiors, X2. Manitoulin Formation, same locality as figure 1. Hypotypes, G.S.C. Nos. 27691, 27692,a.

6. *Zygospiraella planoconvexa* (Hall). Pedicle view, X2. Manitoulin Formation, main highway % mile east of Ice Lake. Hypotype, G.S.C. No. 27693.

16. *Fardenia plicata* Bolton. Brachial view, X1. Manitoulin Formation, north end of road exposure ½ mile southwest of Y-junction near east shore of South Bay, Indian Reserve No. 26. Hypotype, G.S.C. No. 20474.

20, 22. '*Platystrophia biforata*' (Schlotheirn). Brachial views (small valve with Palaeophyllum *umbellicrescens* Chadwick), X1. Manitoulin Formation, Bidwell road ¼ mile northwest of Bidwell Tp. line, northwest of Manitowaning and same locality as figure 6. Hypotypes, G.S.C. Nos. 27694, a, 27695.

21. *Spirigerina* (*Eospirigerina*) *parksi* (Williams). Pedicle view, X2. Manitoulin Formation, north end of lot 19, con. XII, Billings Tp. Hypotype, G.S.C. No. 27696.

Corals

7. Palaeophyllum *umbellicrescens* Chadwick. Transverse thin-section, X4 (see figure 20). Manitoulin Formation, "Devils Needle". Hypotype, G.S.C. No. 27697.

11. *Paleofavosites asper* (D'Orbigny). Inclined view of corallum, X1. Manitoulin Formation, south of Kemble. Hypotype, G.S.C. No. 17961.

18. *Streptelasma* sp. Natural transverse section, X2. Manitoulin Formation, same locality as figure 16. Fig. spec., G.S.C. No. 27698.

Echinoderms

8, 19. *Brockocystis tecumseth* (Billings). Typical stem segment and right view of theca, X1. Manitoulin Formation, ¾ mile east of entrance to town of Gore Bay and same locality as figure 6. Hypotype, G.S.C. No. 29468; neotype, G.S.C. No. 8447.

Ostracods

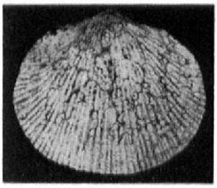
9. *Aparchites*(?) sp. Lateral view of a left valve, X2. Wingfield Formation, east shore MacRae Cove, south end of Meldrum Bay. Fig. spec., G.S.C. No. 27699.

12, 13. *Zygocosta williamsi* (Ulrich and Bassler). Female left and male right valves, X16. Dyer Bay Formation, Jacksons Cove, Bruce Peninsula. Hypotypes, G.S.C. Nos. 20502, a.

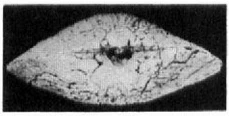
15. *Herrmannina* sp. Lateral view of a right valve, X2. Wingfield Formation, same locality as figure 9. Fig. spec., G.S.C. No. 27700.

Graptolite

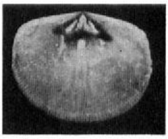
17. *Dictyonema scalariforme* var. *creditensis* Foerste. Fragment of rhabdosome, X2. Manitoulin Formation, 2 miles southeast of Honora village. Hypotype, G.S.C. No. 27701.



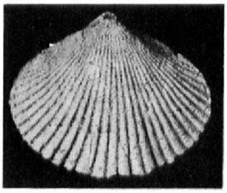
1



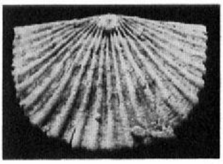
2



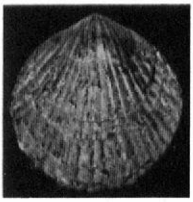
3



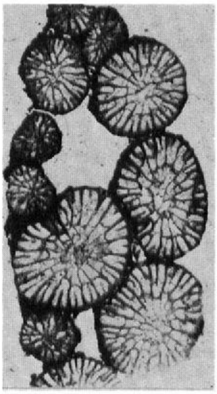
4



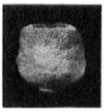
5



6

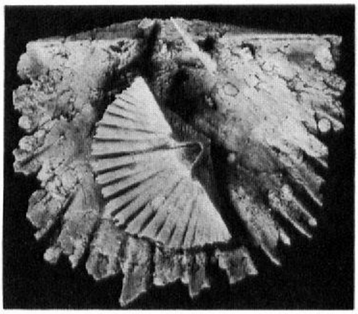


7

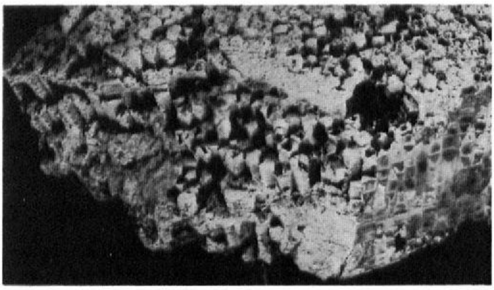


8

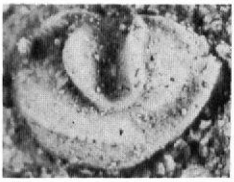
9



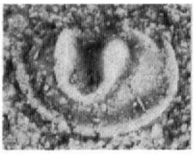
10



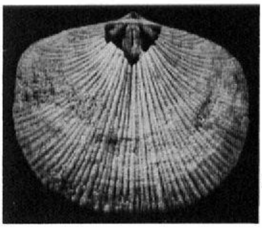
11



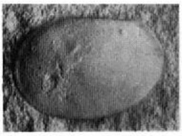
12



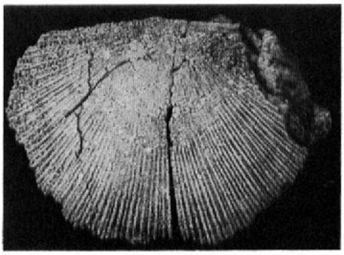
13



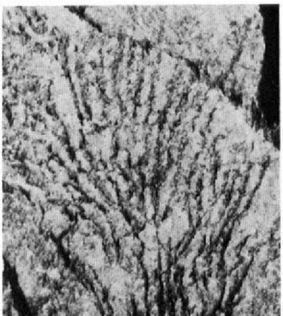
14



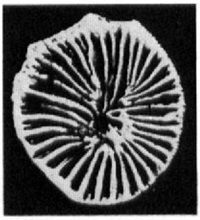
15



16



17



18

19

20

21

22

PLATE D

MIDDLE SILURIAN FOSSILS
(Fossil Hill Formation)

Specimen

Stromatoporoid

1. *Clathrodictyon drummondense* Parks. Vertical thin-section, X10. Uppermost beds in shore section, Martin Lake. Hypotype, G.S.C. No. 27702.

Corals

2. *Halysites labyrinthicus* (Goldfuss). View of distal surface of a small colony, X1. Road exposures ¾ mile east of Snowville, northwest of Tehkummah. Hypotype, G.S.C. No. 27703.

4. *Catenipora huronensis* (Teichert). Surface view of small colony, X1. On road from Manitou Lake near cabin on east shore of Otter Lake. Hypotype, G.S.C. No. 27704.

5. "*Vermipora niagarensis* Rominger". Branching corallum, X1. 0.3 miles south of Manitowaning-South Baymouth highway, lot 9, con. I, Assiginack Tp. Hypotype, G.S.C. No. 27705.

7, 8. *Heliolites* sp. aff. *H. distans* Foerste. Tangential and oblique vertical thin-sections, X4. Top of section at end of Sandfield-Tehkummah Tps. boundary road, lots 3-4, con. I, Sandfield Tp. Hypotype, G.S.C. No. 27706.

11. *Porpites michiganensis* (Bassler). Calyx and lower views of two coralla, X2. Junction of Manitowaning-South Baymouth and The Slash roads, lot 4, con. II, Assiginack Tp. Hypotype, G.S.C. Nos. 23589, a.

12. *Romingerella major* (Rominger). Surface view of part of a corallum, X4. Corner of Windfall Lake and Big Lake roads, northwest of Sandfield. Hypotype, G.S.C. No. 20537.

13. *Kionelasma spongaxis* (Rominger). X2. East-central Otter Lake, south of West Bay village. Hypotype, G.S.C. No. 20516.

15. Common phaceloid coral with syringoporoid habit and dissepiments formerly assigned to "*Diphyphyllum multicaule* (Hall)". Inclined view, X1. Fossil Hill. Fig. spec., G.S.C. No. 3917.

18. *Fauosites favosus* (Goldfuss). Inclined view, X1. Corner on road boundary con. XIV-XV, lot 9, Assiginack Tp. Hypotype, G.S.C. No. 20542.

Brachiopods

3. *Plicostricklandia manitouensis* (Williams). Brachial view, X1. Same locality as figure 11. Hypotype, G.S.C. No. 23597.

6. *Eospirifer radiatus* (Sowerby). Brachial view, X1. Same locality as figure 11. Hypotype, G.S.C. No. 27707.

10. *Dolerorthis flabellites* (Foerste). Pedicle valve, X1. East-west portion of main highway at southwest end of Lake Manitou, ¾ mile east of Carnarvon-Sandfield Tps. boundary. Hypotype, G.S.C. No. 27708.

14. *Pentameroides* sp. Brachial view, X1. Same locality as figure 7, middle of section. Fig. spec., G.S.C. No. 27709.

16. Common small atrypid, brachial view, X2. Along road into shore of Kagawong Lake, 2 miles east of Long Bay. Fig. spec., G.S.C. No. 27710.

17. *Whitfieldella nitida* (Hall). Brachial view, X2. Ridge section corner of lot 15, con. VIII-IX boundary, Carnarvon Tp., south of Lake Mindemoya. Hypotype, G.S.C. No. 27711.

Gastropod

9. *Euomphalopterus* (*Euomphalopterus*) sp. Basal view, X1. Same locality as figure 2. Fig. spec., G.S.C. No. 27712.

Additional forms common to the region are illustrated in the following:

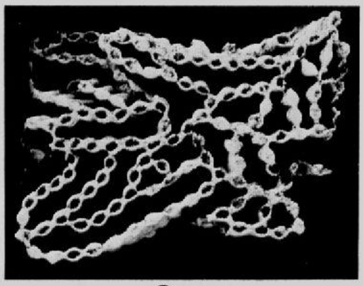
O.D.M. Geological Guide Book No. 3, 1969 (Middle Ordovician fossils).

American Association of Petroleum Geologists Guidebook "Geology of Central Ontario", 1964 (Middle-Upper Ordovician and Silurian fossils).

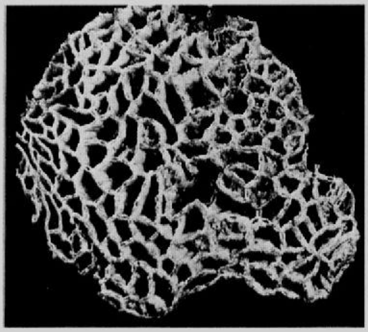
Michigan Basin Geological Society Guidebook "The Geology of Manitoulin Island", 1968 (Silurian fossils).

Geol. Surv. Can., Paper 66-5, 1966 (Silurian fossils).

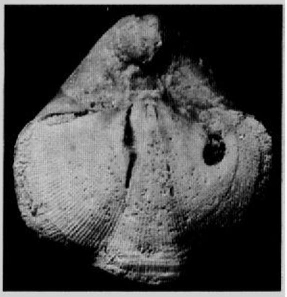

1

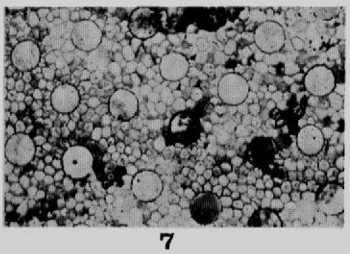

2

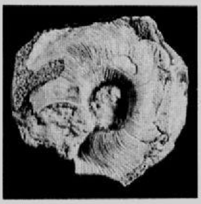

3

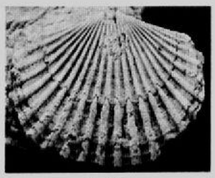

4

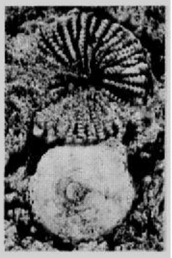

5


6

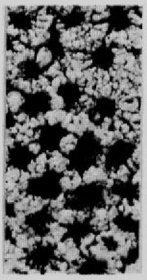

7

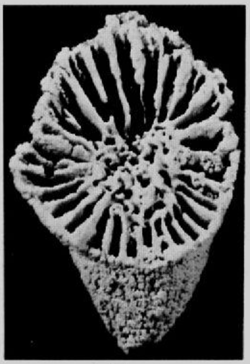

9


10


11


8


12


13


14


15


16


17


18

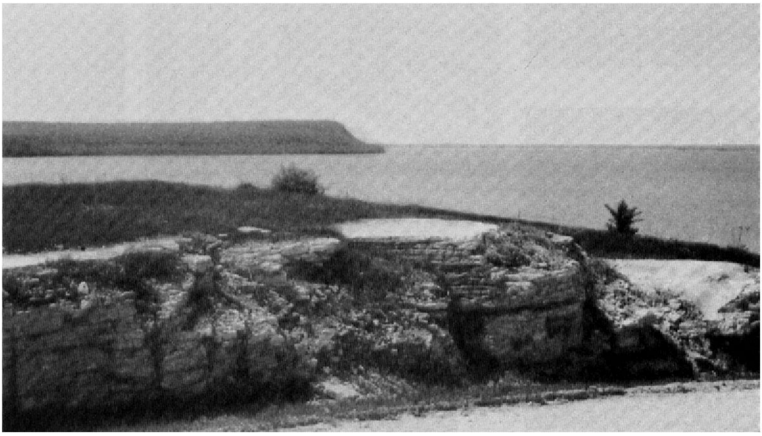


Photo 34. *Escarpment overlooking Campbell Bay. Note the Fossil Hill Formation in the foreground.*

CAMBRIAN ROCKS

The Lake Superior or Jacobsville Sandstone

Flat lying shallow water sandstone with local basal conglomerate lies on Archean granitic rocks and younger Proterozoic strata around Sault Ste. Marie. This formation, the Lake Superior or Jacobsville Sandstone, is probably of Cambrian age, the earliest Paleozoic period.

ORDOVICIAN AND SILURIAN ROCKS

Manitoulin Island, St. Joseph Island, and smaller islands along the North Channel of Lake Huron are underlain by gently dipping fossiliferous strata of Ordovician and Silurian age. The Paleozoic section is approximately 1,700 fect thick. It consists mainly of limestone, dolomite, and shale, and has been divided into the formations shown in table 4. Typical fossils from these formations are fully described on pages 54 to 61.

THE POST SILURIAN INTERVAL

Following the deposition of the Silurian rocks and the withdrawal of the Paleozoic seas, the area has probably remained land until the present day and has been subject to only minor up and down movements. The region was once again exposed to erosion and the land surface originally formed during the Lipalean Interval was further eroded. Faulting has occurred at various times. In adjacent areas, there is evidence of minor igneous activity during this period.

Cenozoic Rocks

PLEISTOCENE AND RECENT

The Cenozoic deposits are the unconsolidated materials deposited during the Pleistocene ice age and the subsequent Recent epoch.

About one million years ago, at the start of the Pleistocene period, the climate over much of the earth became colder and continental glaciers were formed. Gigantic glaciers, probably thousands of feet thick, spread across much of the northern half of North America. As this ice sheet advanced southward, it stripped off the mantle of soil and weathered rocks which had been accumulating since Precambrian time, and scratched, grooved, and polished the hard bedrock (photo 35). During this time, there were several retreats and readvances of the ice sheet. Toward the end of Pleistocene time, the climate became warmer and the ice sheet, wasted away by melting, gradually retreated northward. During the northward retreat, the glacial meltwaters were ponded in the Great Lakes basin and formed a succession of lakes known as Algonquin, Stanley, Nipissing, Algoma, and Huron.

Photo 35. *A glacial groove in Lorrain sandstone, McGregor Bay area.*

These lakes were drained at different times by rivers which flowed through the valley of the present St. Croix River in Minnesota and Wisconsin, and via North Bay and the Ottawa River valley. During most of these lake stages, the waters were deeper and more extensive than the present Great Lakes, although at one stage (Lake Stanley) the waters drained to an extremely low level through the glacially depressed North Bay outlet. With lowering lake levels and with isostatic rebound of the earth's crust following the removal of the tremendous weight of glacier ice, a series of shorelines formed. This succession of abandoned beaches and wave cut terraces is well developed on Manitoulin Island. Table 5 shows a summary of these events.

Inland from the Great Lakes basin, the retreating glaciers periodically halted, and even re-advanced. The successive ice-front positions are marked by sand and gravel deposits called moraines. Locally, the meltwaters were ponded to form lakes, in which varved clays and silts were deposited. Glacial meltwaters also flowed south into the Great Lakes basin, depositing sediments as eskers and valley train deposits, and carving broad valleys, many of which are partly occupied by modern streams. Isostatic rebound of the earth's crust after withdrawal of the glaciers led to great disruption in the drainage pattern. Since there has not been sufficient time for a new pattern to established itself, the present day drainage is very poor and the myriad lakes of the Canadian Shield are our glacial legacy.

EARLY MAN

Early man probably came to North America during the Pleistocene. At Sheguiandah on Manitoulin Island, there are residual hills of Precambrian rocks exposed through the Paleozoic cover. Much of this is a pure, chert-like, metamorphosed sandstone suitable for tool making and it was so utilized by early man. The site has been excavated by archeologists from the National Museum of Canada and the University of Toronto who have unearthed a great variety of artifacts (photo 83). One of the most startling finds was that of artifacts incorporated in glacial till, indicating the presence of man in pre-glacial or interglacial time, possibly as much as 30,000 years ago. If the evidence has been correctly interpreted, this discovery is one of the earliest indications of man in North America.

PART 2

Points of Interest

Sudbury and Area

The first four sections of Part 2 deal with the city of Sudbury, its neighbouring municipalities, the Sudbury Basin, and the general area surrounding the city. Various trips are suggested to give the visitor the opportunity of enjoying some of the scenery of the area, to inspect the mining activity and to see the principal geological features and formations of the area. There is good accommodation in this multi-lingual, multi-cultural city of nearly one hundred thousand people which rightfully can call itself the nickel capital of the world.

Nickel ores look very much like copper ores when mined. Early German miners, smelting what they took to be copper ore, encountered a hard metal which they could not recognize nor treat by the methods of the day. Believing that the devil had cast a spell over their mine, they called it "Old Nick's Copper" or "Kupfer-nickel" in their language; hence the word nickel of the present day. There was very little use for the metal and such requirements as there were were mostly supplied from mines in Norway and the South Seas.

During the construction of the Canadian Pacific Railway, and while blasting was taking place along it, a large deposit of copper was discovered not far from Sudbury Station. There was an immediate staking rush to the area. However, the disappointing news that the copper was heavily contaminated with nickel nearly caused the abandonment of the mines.

In Scotland, the discovery had already been made that nickel added to steel toughened the steel but the cost of refining the nickel made the process uneconomic. Efforts were concentrated on the development of a cheaper method with great success and gradually nickel took its place as a major metal of industry, in great demand for its many alloys and applications. In addition to nickel and copper, the Sudbury ores also yield many products including

Photo 36. View across Ramsey Lake towards the City of Sudbury. Laurentian University campus lies in the foreground. (Courtesy Ont. Min. Industry and Tourism).

gold, silver, platinum, cobalt, iron and sulphur, and such lesser known metals as iridium, rhodium, ruthenium, selenium, and tellurium.

Two large Canadian companies operate the copper-nickel mines of the area, the International Nickel Company of Canada Limited and Falconbridge Nickel Mines Limited, and of necessity their names appear frequently in this guidebook. The Mines Division, Ministry of Natural Resources normally gives the full title whenever a company is mentioned in its publications, out of courtesy to the companies and to avoid confusion of similar names. However, because of the awkwardness of repeating long names, in this guidebook frequent use is made of the popular abbreviations by which these great companies are known around the world —Inco and Falconbridge.

Sudbury

The city of Sudbury is the administrative centre of the Sudbury District, the home of Laurentian University, and the focal point for twenty-two producing mines and the smelters and related plants which they feed.

Original Settlement

The original settlement began with the fur trade, the Wahnapitae Post being established by the Hudson Bay Company in 1822. The original industry of the area was lumbering, centred around immense stands of virgin pine; for four decades the lumber companies furnished the major economic base upon which a struggling mining camp operated until the problems of inadequate technology and uncertain markets had been overcome.

Early Mineral Discoveries

Mining came to Sudbury in 1883 although there are two earlier records of mineralization in the area. The first was a report by the Geological Survey of Canada twenty-five years previously which covered an area west of the city later occupied by the Creighton Mine. This is described fully on page 98. The second report came from a search party looking for a lost stipendiary magistrate, whom they found sitting on a small hill about two miles northeast of the present city centre. Dr. Howey, a physician with the Canadian Pacific Railway construction team and perhaps Sudbury's first permanent resident, picked up mineral samples from the knoll while waiting with the magistrate, but in the opinion of Federal Government experts they were of little value.

Shortly afterwards, the Canadian Pacific Railway reached Sudbury and a blacksmith, Tom Flanagan, working on the line on the same small hill noticed a patch of gossan. Digging down, he found copper sulphide. When the railway grade reached the spot, the

Photo 37. *Summer in a Sudbury park.*

Photo 38. *Centennial Numismatic Park. The Big Nickel at sunset. (Courtesy Ont. Min. Industry and Tourism).*

Photo 39. *Rivers of fire. Incandescent molten slag attracts the cameras of tourists at Copper Cliff. (Courtesy Ont. Dept. Industry and Tourism).*

Photo 40. *Sailing on Ramsey Lake. (Courtesy Ont. Min. Industry and Tourism).*

presence of further mineralization was established. In February, 1884, lot 11, concession 5, McKim Township was purchased from the Ontario Government by Thomas and Henry Murray, Henry Abbott and John Laughrin. This became Sudbury's first mine, the Murray. The property was purchased by H. H. Vivian, a Welsh company which worked it until 1894. It was re-activated during the First World War by the British American Nickel Corporation. After the Second World War it was again reactivated by Inco and was in steady production until 1971 when a closing was announced.

Meanwhile a great deal of prospecting had gone on during the years following the find, and many of the major ore deposits had been discovered. Many companies became interested in the area. A notable failure was the famous inventor, Thomas Edison, who was looking for nickel for his new storage battery. Edison in 1901 used early geophysical methods to detect what eventually became the Falconbridge Mine but had difficulty with a diamond drill in heavy overburden and pulled out a few feet from his goal.

Growth of Mineral Industry

By the early years of this century, three major corporations had evolved; the British American Nickel Corporation, the Canadian Copper Company and the Mond Nickel Company. Of these, the big producer was Canadian Copper, which had a somewhat unusual origin. Samuel Ritchie and associates of Ohio had built a railway in southeastern Ontario to develop iron deposits but the iron was found to be unsuitable for smelting in the United States. Looking for freight for his line, Ritchie bought out the interests of five Sudbury prospectors in 1886 under the impression that he would have copper ore as freight, but found that it was nickel-copper. An extremely energetic man, he put on a campaign to promote the uses of nickel and pointed out to various maritime nations, at a time when the great international naval armaments race was beginning, that nickel alloyed with steel gave a much tougher product than steel plate alone. In this he was greatly assisted by the Federal Government which was anxious to find a market for the metal, at that time a virtual monopoly of the French colonies. His efforts did nothing for his railway which lay 150 miles to the southeast, but it put Ontario nickel on world markets.

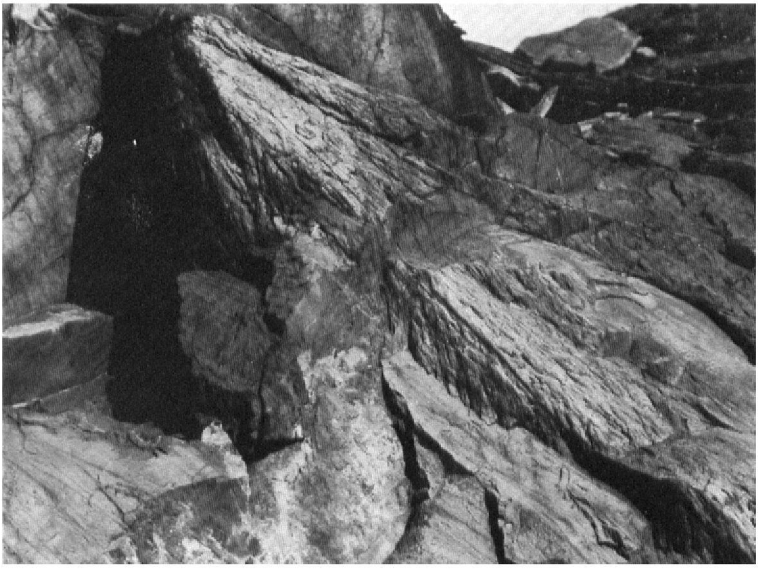
Improved refining techniques were developed, and less warlike uses were found for the metal. By 1928, the three corporations had been merged into the International Nickel Company of Canada Limited, with ownership of such famous mines as the original Murray, the mines at Copper Cliff, the Creighton, the Frood, the Stobie, the Garson and many others.

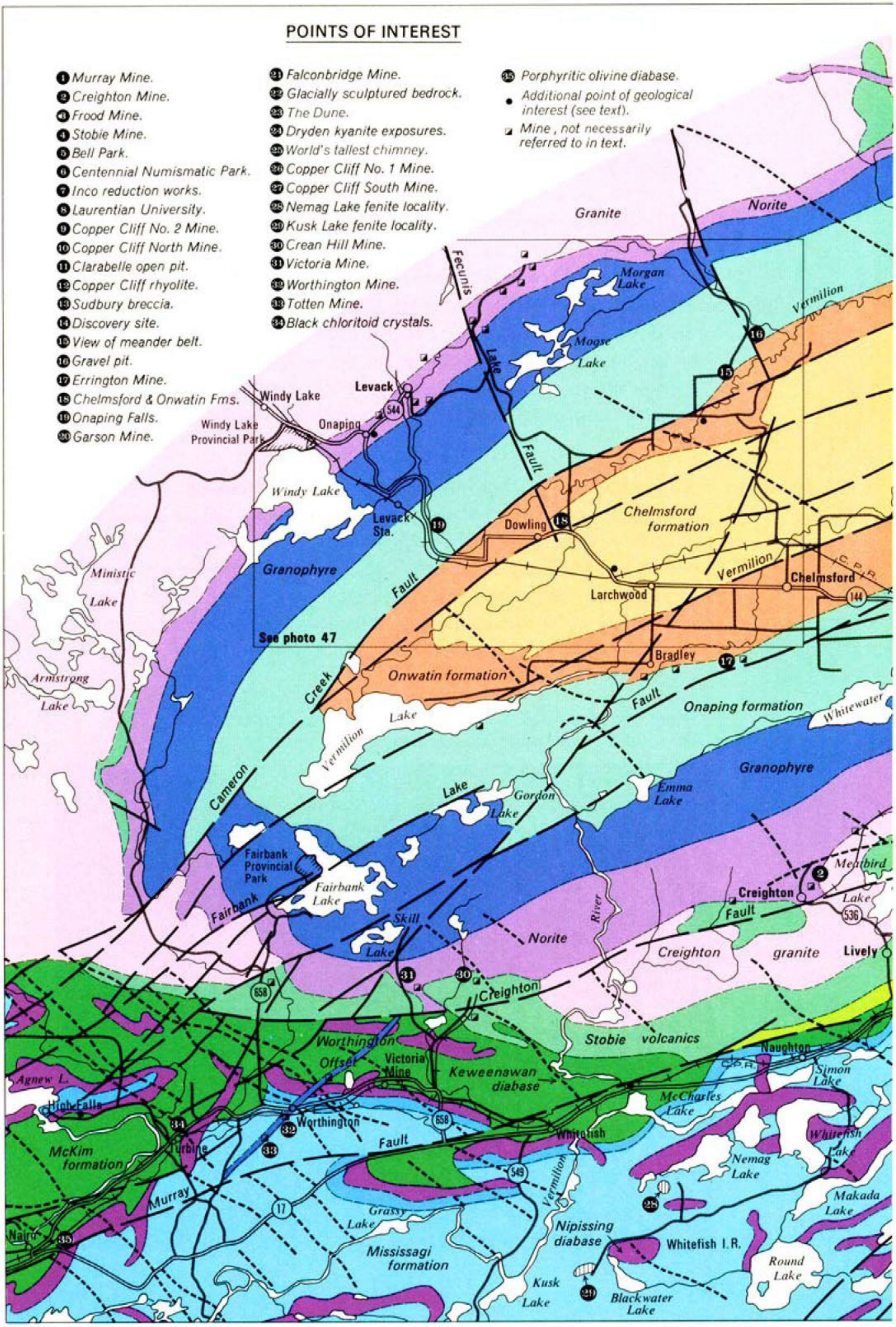
While this merger was taking place, Thayer Lindsley, a well known mine developer, bought the original Edison property from a Minneapolis corporation and formed Falconbridge Nickel Mines Limited in 1928 to set up an independent operation east of the city, described in more detail on page 86. Thus it was that the nickel capital of the world acquired its two independent companies whose operations encompass the entire globe. Both companies have prospered and mining activities have steadily increased.

Sudbury Ores

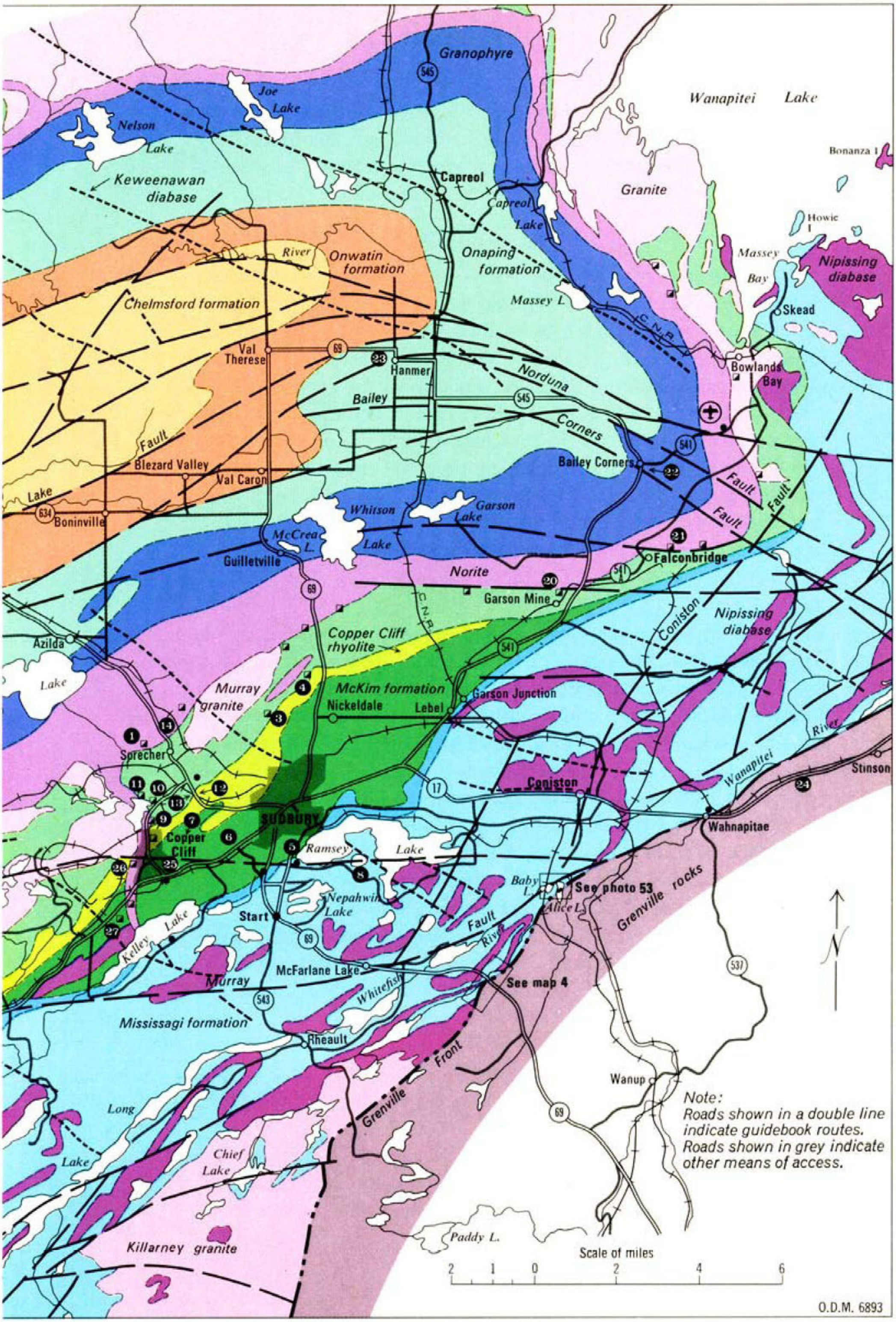
At Sudbury the nickel minerals are found with other sulphides in massive or disseminated sulphide replacement bodies associated with basic intrusive rocks such as norite. The nickel commonly occurs as the nickel iron sulphide, pentlandite, which is usually intergrown with the iron sulphide, pyrrhotite. Other nickel minerals are the nickel arsenide, niccolite; the nickel antimonide, breithauptite; the nickel sulphide, millerite; and gersdorffite.

Photo 41. *Shatter cones in the Mississagi Formation, Waters Township: evidence of shock, possibly the result of meteor impact.*





Map 3. *The Sudbury Area.*



Note:
Roads shown in a double line indicate guidebook routes.
Roads shown in grey indicate other means of access.

O.D.M. 6893

Production of nickel and copper at Sudbury to the end of 1970 exceeded 12,310 million and 11,832 million pounds respectively, which with the other metals and products recovered was worth more than 10,907 million dollars to the Canadian economy.

Pollution Control

As is well known today, the forty years of logging operations coupled with the primitive smelting techniques of the early years denuded the area of much of its lush growth, while the sulphur fumes released at ground level interfered with the normal ecological cycle, the existence of which was unsuspected in those early years. Today's mining companies have been called upon, and with very considerable success, to find means both of combatting the day-to-day pollution and recovering from the effects of primitive smelting and early lumbering techniques. The evidence of their success is increasingly apparent in the replanting that has taken place in the area and in the parks and gardens of Sudbury.

Points to Visit

In the metropolitan area itself, one of the points worth visiting is Bell Park, five minutes from downtown Sudbury, which, in addition to its auditorium for public entertainment, displays a 20,000 lb. specimen of ore, a map of the Sudbury Basin and the first geological site marker set up in Ontario. The Centennial Numismatic Park, west on Highway 17 at the city limits, with its giant coins (photo 38) and miniature mine where visitors can go underground is a commercial attraction of merit.

Visitors aged 16 and over are very welcome at the Inco reduction works at Copper Cliff between May 15th and Sept. 15th at 10 a.m. and 1.30 p.m. except public holidays; on Saturday there is one tour at 9.30 a.m. The dumping of Inco slag is an impressive and photogenic sight at night and a great attraction with tourists (photo 39). Falconbridge mine tours, out of town, are dealt with on page 86.

Laurentian University, south of Ramsey Lake, also welcomes visitors in summer at 10 a.m. and 3.00 p.m. It has an excellent rock and mineral collection. A young university, it is the pride of this northern community.

The mines of the area are indicated on map 3. There is a one-way street system in the centre of the city and tourists are advised to follow highway route signs rather than read maps when commencing the excursions which follow.

Sudbury Basin northwest of Sudbury

The Sudbury Basin was first recognized as a distinct basin of oval shape by Robert Bell of the Geological Survey of Canada in 1890. Its long axis lies southwest-northeast and is some thirty-six miles long. The short axis is about sixteen miles long. It is completely surrounded by the Sudbury Nickel Irruptive, described on page 43. This trip starts at the southern limits of the city of Sudbury and is arranged to visit the principal geological units exposed and other points of interest in a tour which crosses the basin along its shorter northwest-southeast axis.

SUDBURY AND COPPER CLIFF

Mississagi Formation

Start at the junction of Highway 69S and Paris Street, about three miles south of the centre of Sudbury and proceed northeast on Paris Street for 1.3 miles to Ramsey Lake Road. This is the access road to Laurentian University. Metamorphosed sandstone of the Mississagi Formation is exposed in the first road cut on Ramsey Lake Road. Bedding, crossbedding, and shatter cones may be seen. The shatter cones appear as curved joint-like surfaces, commonly stained reddish. These structures were apparently formed by a "hammer-blow" type of stress, and are part of the evidence for meteorite impact discussed on page 45 (photo 41).

Ramsay Lake Formation

Turn back (south) about half a mile on Paris Street as far as Walford Road. Go west on Walford Road to Highway 69, then north three-tenths of a mile to some apartment buildings on the east side of the highway. Immediately south of Ramsey View Court, massive unstratified conglomeratic sandstone of the Ramsay Lake Formation is exposed in the rock cuts. Note the variations in size, rounding and composition of the included rock fragments. This rock possibly represents an ancient marine glacial deposit. The difference in spelling between the formation and the lake is not an error but arose because the formation name was formalized many years ago at a time when the recorded spelling of the lake was Ramsay.

McKim Formation

Continue north on Highway 69 following route signs to Highway 17 West. On Highway 17 west, go west to Balsam Street leading into Copper Cliff. Immediately south of Highway 17 at the Balsam Street junction there are exposures of thinly bedded sedimentary rocks of the McKim Formation, origirally rich in clay minerals. These rocks display original sedimentary features, including thin rhythmic bedding, graded bedding, ripples, and small scale crossbedding. Small porphyroblasts of staurolite are abundant in some beds. Shatter cones can also be recognized. This highway is busy and caution should be used when crossing it.

Copper Cliff offset and Copper Cliff No. 2 Mine

Go north on Balsam Street and Clarabelle Road for about a mile. This road is private property though the public generally has access to it. The former mine workings at the east side of the road are the Copper Cliff No. 2 Mine.

Here a dike of quartz diorite known as the Copper Cliff Offset (see page 43) extends southward from the main body of the Sudbury Nickel Irruptive and cuts across the older rocks. At this locality, the Copper Cliff offset intrudes a type of granitic rock called quartz monzonite which is part of the Creighton intrusion. Note the presence of sulphide minerals in the quartz diorite dike and the abundant evidence of past mining activities.

Copper Cliff North Mine, Clarabelle Mine

To the north, Inco's Copper Cliff North Mine and Clarabelle open pit are visible.

Huronian Supergroup

Proceed north and east on Clarabelle Road past the new Clarabelle mill to the junction of Highway 144. Metamorphosed sedimentary and volcanic rocks, probably part of the Huronian Supergroup, are exposed in this area. On the east side of Highway 144

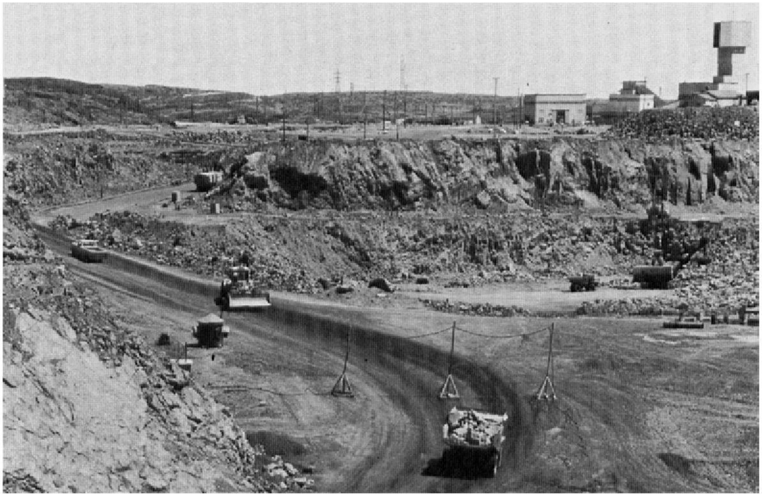


Photo 42. *Part of the International Nickel Clarabelle open pit. The buildings, top right, include the headframe and service buildings of the Copper Cliff North Mine and the Clarabelle crushing plant. (Courtesy International Nickel).*

across from Clarabelle Road there is metamorphosed mudstone with abundant crystals or porphyroblasts of altered staurolite.

Copper Cliff rhyolite and Sudbury breccia

These rock units are described here for those not returning to Sudbury but, because of traffic and parking conditions, they are more conveniently visited at the end of the trip on the return journey.

Turn southeast towards Sudbury on Highway 144 for about half a mile. Use caution in parking on this heavily travelled road. Copper Cliff rhyolite, a pink fine grained volcanic rock, is exposed immediately north of the highway and forms the surrounding hills. Flow layering (photo 43), a segregation of rock constituents into thin irregular layers brought about by the mechanism of flow in a highly viscous lava, is prevalent. Also there are small crystals of garnet, indicating that the rock was metamorphosed after formation.

On the south side of the road, Sudbury breccia is exposed. This rock consists of rounded to angular fragments of rocks from nearby formations, here from Copper Cliff rhyolite and McKim greywacke, in a fine grained comminuted matrix consisting of rock flour and fine rock fragments. It was probably formed by an explosive shock mechanism, possibly by meteorite impact (compare with photo 44).

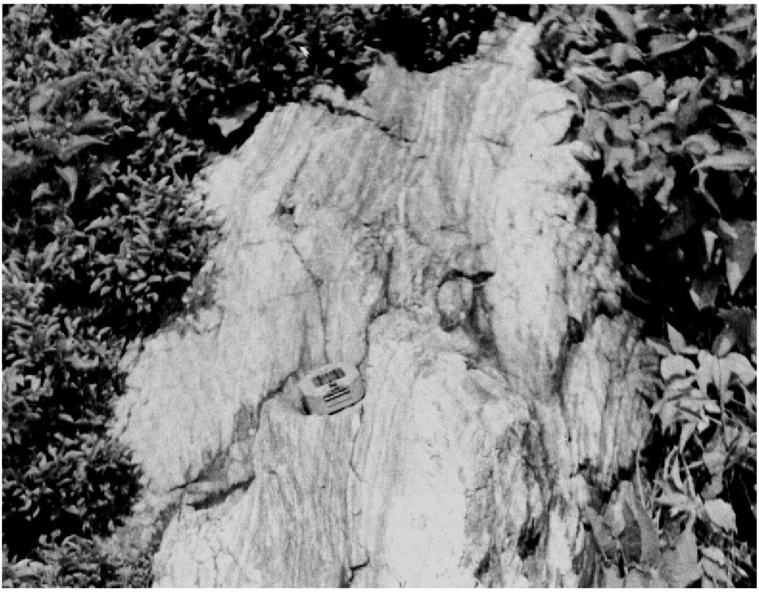


Photo 43. *Flow banding* in *Copper Cliff rhyolite.*

DISCOVERY SITE

Base of Sudbury Nickel Irruptive

On the east shoulder of Highway 144, about one and a half miles beyond Clarabelle Road, there is a plaque commemorating the discovery of the Sudbury ores.

Breccia type sulphide ore is exposed in the outcrop of "blue quartz norite", another phase of the Irruptive. To the south there are outcrops of "Sudburite": metamorphosed or altered basic volcanic rocks along and close to the contact of the Irruptive (see page 43 for discussion on the nature of the Irruptive).

The breccia ore consists of boulder-like inclusions of rock in a sulphide matrix consisting mainly of pyrrhotite, pentlandite, and chalcopyrite. This outcrop is of considerable historic interest and a noted site for geological study. Sample collecting is not permitted in order to preserve the site intact.

CENTRAL PLAIN

Pleistocene deposits

Highway 144 continues in a northwesterly direction across the Sudbury Basin via Azilda. The basin is a topographic as well as a geological structure, the higher rugged outer rim being made up

Photo 44. *Sudbury-type breccia, probably caused by explosive shock.*

of Precambrian rocks and the lower central plain a thick deposit of sands, gravels and clays with a few outcrops of bedrock. In the concluding stages of Pleistocene time, an icecap, which had covered the entire area, retreated to the north, yielding great quantities of glacial meltwater. While locally the land became ice free, the natural drainage of the Lake Huron area was obstructed by ice which still remained further east and great glacial lakes were ponded behind the ice dams, their levels well above present day Lake Huron. The Sudbury Basin was occupied by such a lake which probably drained about ten thousand years ago. The flat land in the centre of the basin formed as the bottom of this lake.

River meanders

Just south of Azilda, Highway 144 drops down from the Precambrian rocks on to the former lake bottom. In crossing this flat terrain the Vermilion River has formed a wide meander belt of river meanders, oxbow lakes and meander scars, features which show up on topographic maps and air photos (photo 47).

The meander belt is best seen about seven miles from the highway by following Errington Avenue north through Chelmsford, which is four miles beyond Azilda. Turn west on Main Street, then

Photo 45. *The original discovery locality. During construction of the Canadian Pacific Railway in 1883, the discovery of gossan and sulphides on this outcrop eventually lead to the development of Sudbury's mining industry.*

north at the first main road to a railway crossing and north on a gravel township road about three and a half miles to the Morgan-Balfour township line (see map 3). Keep right where the road forks near a power line. Outcrops along these roads are of the Chelmsford sandstone; concretionary structures are well displayed. Before entering cultivated land near the Vermilion River there

Photo 46. *A close-up view of a concretion, Chelmsford sandstone, near Dowling.*

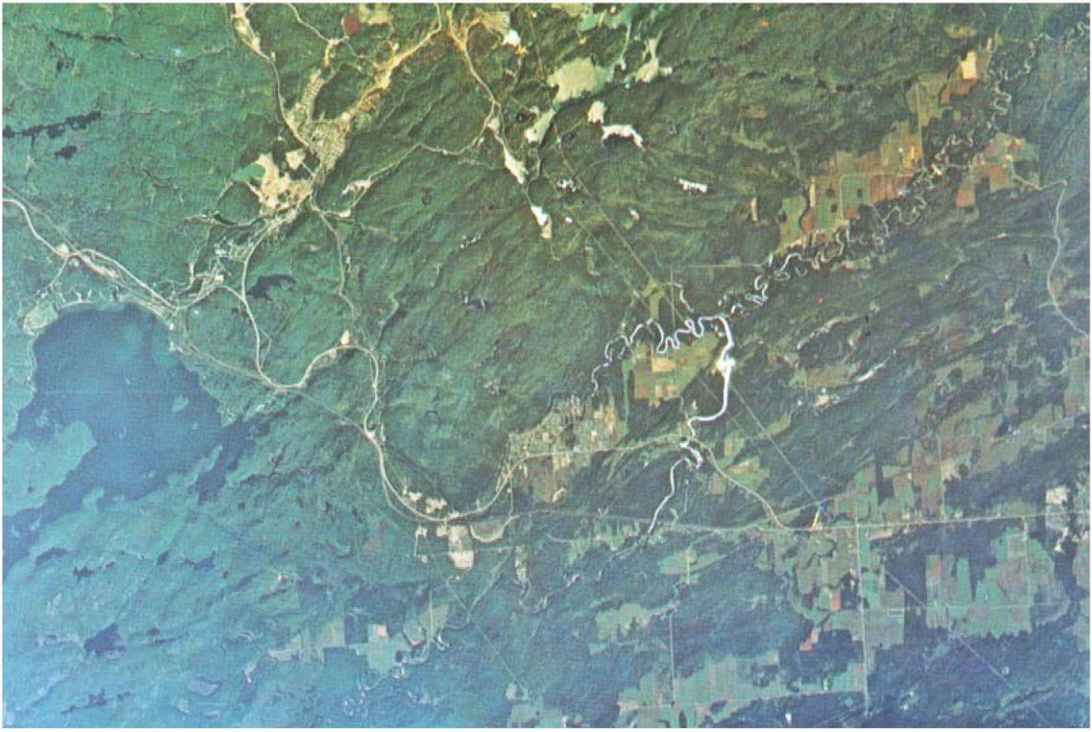


Photo 47. *Part of the North Range, Sudbury Basin showing: bottom right, Chelmsford; bottom centre, Dowling; bottom left, Windy Lake; top centre, Levack and adjacent mines. For geology compare with map 3. Note the meander belt of the Vermilion River over Onwatin slate; the fold pattern in Chelmsford sandstone; the rough topography of the Onaping Formation, the Nickel Irruptive and the Archean granite. The Fecunis Lake Fault shows as a linear, displacing topographic features. Photo scale about 2 miles to the inch. (Courtesy National Air Photo Library).*

are a few small outcrops of Onwatin slate. About a mile west along the township line the road crosses the Vermilion River. Just south of the bridge, a point bar deposit, which will eventually isolate the adjacent meander creating an oxbow lake, is being formed in the river bed.

When a river flows through flat land composed of soft materials of even texture, the river will curve from side to side in wide loops known as meanders. The action of the water tends to accentuate the curves because the current on the outside of the curve, accelerating around the bend, scours the outer bank, whereas the flow on the inside curve, decelerating, provides more sheltered water favourable for sediment deposition. Finally the curve will form almost a complete circle, until the river cuts through the narrow neck of land, leaving the abandoned meander as dead water, to be cut off by new deposition and form an oxbow lake. Ultimately it will silt up, leaving a meander scar. The meanders of a river swing from side to side of the alluvial plain due to this action, forming a meander belt.

> Under some conditions point bars will develop on the inside curve of a meander. As a point bar extends into a meander curve, a series of ridges and sloughs may form and where the sloughs become sealed off, lakes or swamps form which gradually silt up with fine material in time of flood. The different grades of material in the ridges and sloughs and the vegetation they attract show up well on air photographs; hence, these features can be traced long after the river has abandoned them.

Continue a quarter of a mile beyond the river and turn north on to Nickel Offset Road. After a mile the road turns east for a mile and then north. About a quarter of a mile past this corner the overgrown meander belt of the river may be seen from an overlook where it will be noted that a meander scar reaches right up to the road. About a mile further on, the road passes a gravel pit in a spectacular gravel terrace which is 85 feet high. The return to Chelmsford is by the same route. Alternatively, return to the junction of Nickel Offset Road and continue on the township road to rejoin Highway 144 at Dowling just west of the Vermilion River (see map 3).

Errington Mine

About three and a half miles beyond the Chelmsford crossroads and two and a half miles east of the Vermilion River at Dowling, Vermilion Lake Road turns south from Highway 144. The Errington Mine of Giant Yellowknife Mines Limited lies off this side road.

Onwatin and Chelmsford Formations

Continue west on Highway 144 for 3.4 miles beyond Vermilion Lake Road to the brow of a slight hill descending into Dowling. Here the outcrops are of the Chelmsford Formation, a thick bedded, poorly sorted greywacke with excellent graded bedding. It was probably deposited by turbidity currents (see page 15). Note the abundance of "cannon-balls" (photo 46), which are concretions formed as the result of the spontaneous migration of a minor rock constituent (carbonate) toward some nucleus such as might be provided by a pebble or a grain of sand, and a precipitation and accumulation of this constituent near and around it.

A small outcrop of Onwatin slate occurs on the south side of Highway 144 part way down the hill descending into Dowling, a third of a mile east of the Dowling shopping centre and just under a mile west of the river. This is a thinly bedded black carbon-bearing slate with pyrite crystals. A steeply dipping secondary cleavage is also present. The carbon in this rock is probably of organic origin and, if so, is evidence that life existed here at least 1,800 million years ago.

About a mile and three quarters west of the Dowling shopping centre, there are two sand and gravel pits. The active pit on the north side of the road shows good exposures of deltaic sands and

Photo 48. *Sedimentary structures in Pleistocene glaciofluvial deposits.*

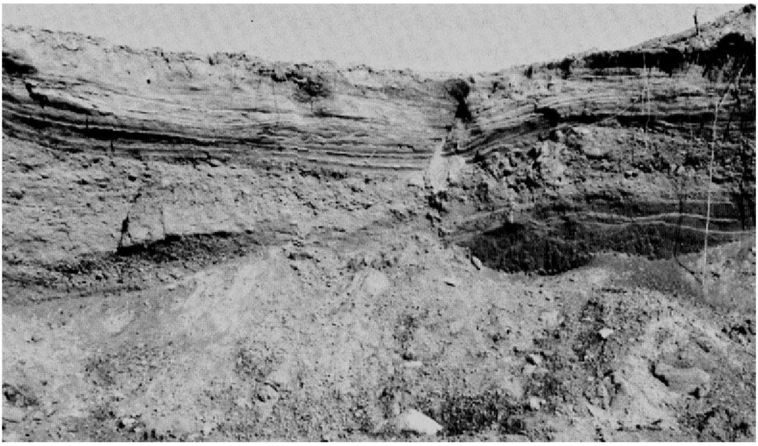
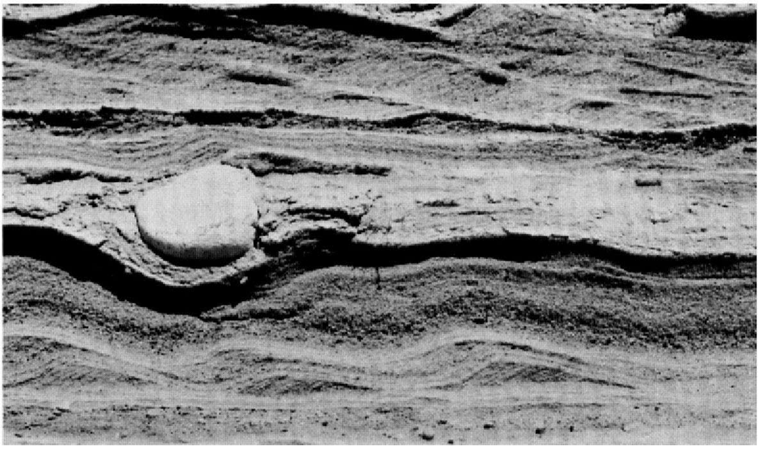


Photo 49. *Cobble dropped from floating ice into crossbedded sand and gravel. Compare this and photo 48 with photos 113 and 131 which show similar features in consolidated Proterozoic rocks.*



gravels. The deposits were laid down in the lake occupying the Sudbury Basin during the late Pleistocene by a river which followed the course of the present Onaping River valley.

THE NORTH RIM

Onaping Formation

Continue north on Highway 144 for one and a half miles to the Onaping Falls (see photo 29). There is safe parking at a picnic spot with a good view of the falls. This is the type locality for the Onaping Formation at the base of the Whitewater Group. The term type locality is discussed on page 168. Note the massive character of the rock, the abundance of rock and crystal fragments, some of which show evidence of marginal melting, and the presence of sulphide minerals. This rock probably comprises the broken and partly melted materials expelled from a crater, formed by the impact of a large meteorite. This debris fell back into the crater and was preserved.

Nickel Irruptive Granophyre, Transition Zone, Norite

Highway 144 winds northwesterly to Onaping, located at the junction with Highway 544, the road to Levack. From the Levack railway station to the junction of Highways 144 and 544 there are outcrops of typical granophyre, which is a pink medium grained rock composed of feldspars, quartz, and hornblende. To the north along the Levack Road there are outcrops of rocks of the transition zone and of the norite. In this section there appears to be a gradual transition from light coloured acid rocks of the granophyre to dark coloured basic rocks of the norite. The rocks of the intervening transition zone are of intermediate composition and colour.

WINDY LAKE PROVINCIAL PARK

About two miles west of this junction on Highway 144, the Ontario Ministry of Natural Resources maintains a small provincial park on the north shore of Windy Lake. One of a series of recreational parks throughout Ontario, Windy Lake Park boasts one of the biggest and best swimming beaches in the Sudbury Area. There are nearly eighty camp and trailer sites, a boat launching ramp, a small store and trailer dumping facilities. The camping area occupies the end of an esker complex which can be traced in a northeasterly direction as far as the town of Levack.

Return to Sudbury via Highway 144.

Sudbury Basin northeast of Sudbury

This trip permits visitors to visit the Falconbridge plant and inspect the Pleistocene deposits of the northeast part of the Sudbury Basin. Drive east from Sudbury on Highway 17 and turn northeast on Highway 541, about 3 miles from downtown Sudbury. A modified deltaic esker complex can be traced from Garson Junction as far as Bowlands Bay on Lake Wanapitei, some twelve miles to the northeast in the general line of Highway 541. The sand and gravel deposits are generally finer and better sorted away from the major source area, which lay to the north and east, and the many pits along the highway give evidence of the economic importance of these deposits.

Photo 50. *A kettle lake near Sudbury Airport along Highway 541.*

Garson Mine

Continue along Highway 541 past Inco's Garson Mine. Originally prospected by John Cryderman in 1891, the property came into operation in 1908 as the Garson Mine of Mond Nickel and, when that company merged to form Inco in 1929, continued under Inco management (see page 70). It has remained in continuous production as one of the mainstays of the great International Nickel operation and currently produces 5,000 tons of ore per day. The No. 2 shaft reaches to 4,242 feet below surface and the 5,000 foot level is currently being developed via an internal shaft (1971).

Falconbridge Mine

Continue on to Highway 541A to the Falconbridge Mine. Visitors are taken on tours of the surface workings and the mine plant from mid June to mid September at 10 a.m. and 1.30 p.m. Appointments are not necessary but women are recommended to wear low heeled shoes and slacks for personal comfort.

The inventor, Thomas Edison, carried out exploration here in 1901 but Falconbridge Nickel Mines were the first to bring a mine into production at this site, commencing underground exploration in 1928. The mine started to ship ore in 1930 and was the forerunner of seven other Falconbridge mines in the Sudbury Basin and the foundation on which the company built a complex of mines, mills, smelters, refineries and laboratories employing 4,500 people in the Sudbury area and 15,000 throughout the world (see page 71).

Bailey Corners

Return to the main highway and turn north about three and a half miles towards Bailey Corners. At Bailey Corners, the junction of Highways 541 and 545, continue to the right on Highway 541 towards the airport. Immediately at this corner on the south side of the road there is an area of glacially sculptured bedrock exhibiting glacial striae with glacial grooves up to one and a half feet deep showing that the ice advanced in a southwesterly direction. Note that the side from which the ice advanced is steep but smooth and polished whereas the downflow side is ice quarried where frost action and ice movement combined to pluck sections from the bedrock (figure 5).

Sudbury Airport

The airfield area lies on an overridden delta which was laid down in the glacial lake that occupied the Sudbury Basin in late Pleistocene times (see page 78). The delta was deposited by a glacial river flowing from the northeast and subsequently leveled by an ice readvance from the same direction. Note that the delta itself lies above the level of the general lake bottom and its edge can be seen on the west side of the airport, the slumped deltaic sediments having a high angle of repose.

About half a mile past the airport entrance, the highway crosses a steep valley running northeast to southwest containing more than twenty five lakes. During a late glacial readvance, ice covered the delta and an esker complex occupied the valley area where very large blocks of ice became grounded. They were covered and insulated by the sands and gravels surrounding them so that the ice remained after the main glacial period was over. When the ice eventually melted, it left large holes known as kettles, which are now occupied by lakes. Sandy, gravelly till is preserved in the geologic section of this complex. The conditions prevailing then may be likened to those in Arctic Canada on Baffin Island today. The airport obtains its water supply from this source.

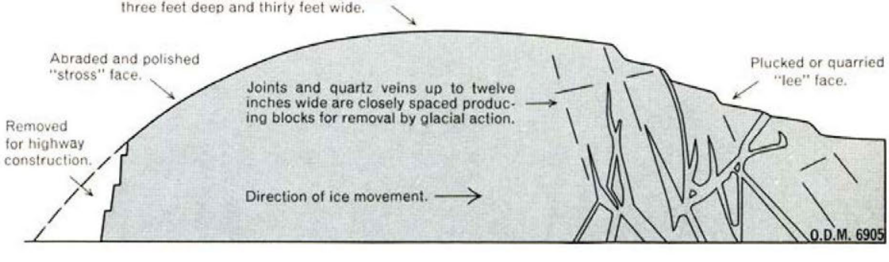


Figure 5. *Schematic diagram illustrating ice scoured bedrock at Bailey Corners.*

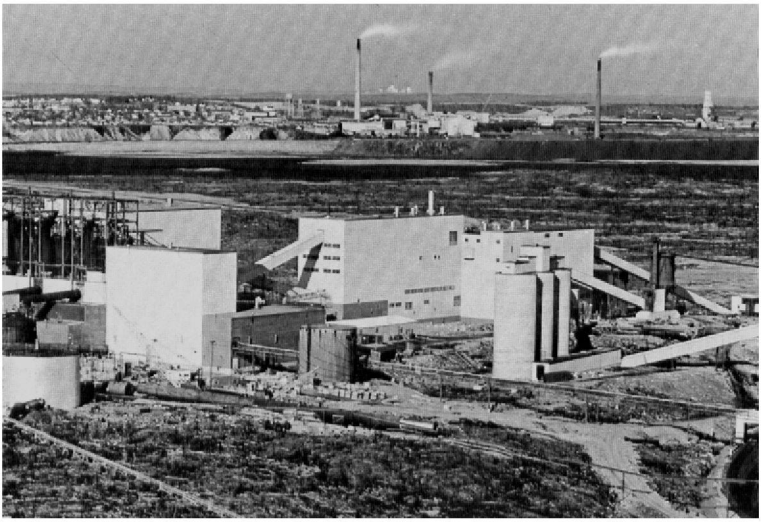


Photo 51. *The nickel-iron refinery of Falconbridge Nickel Mines. The Falconbridge smelter complex lies in the distance (centre) with the mine shaft of the original mine to its right. The plant will treat 500,000 tons of pyrrhotite annually and produce about 300,000 tons of iron-nickel pellets. Advanced sulphur recovery techniques will represent major progress in the control and abatement of air pollution. (Courtesy Falconbridge Nickel Mines).*

Hanmer Plain

Return to Bailey Corners and continue north then west along Highway 545 for about six miles. Note that the plain has acquired a character quite unlike Shield country and is reminiscent of the plains of Manitoba, having been deposited under similar conditions. The highway turns north towards Hanmer and Highway 69. About a quarter mile beyond the turn, the highway crosses a former river channel which is level with the surrounding countryside but easily distinguished from it because of its wet, boggy nature and the vegetation it favours. Turn west on Highway 69, and continue through Hanmer. A quarter of a mile past the town and south of the road, there is a feature known locally as The Dune. This, the only major topographic relief on the plain, is a bedrock high covered by lake deposits of very fine sand which were reworked by wind action probably blowing from the ice cap to the north and east.

The trip returns to Sudbury westward along Highway 69 via Val Therese and south through Val Caron, climbing back out of the basin at McCrea Lake.

Grenville Front south and east of Sudbury

The contact between the Southern and Grenville geological provinces lies to the south of Sudbury (see page 4, maps 2 and 3). It follows a generally northeast–southwest direction and at its nearest point is about six miles from the city. The zone of contact is known as the Grenville Front and has been the subject of considerable study for many years.

The Grenville Front, a northeast trending zone about 15 miles wide, separates highly deformed and metamorphosed rocks of the Grenville Province from the relatively little deformed and little

Photo 52. *View from the Canadian Pacific Railway looking northeastward along the boundary between the Southern (left) and Grenville (right) provinces, with the stacks of the Coniston smelter on the skyline. (Courtesy S. Lumbers).*

metamorphosed rocks of the Southern Province. The Grenville Front zone has had a long complex history of repeated deformation and igneous intrusion and probably represents a major zone of thrusting of the relatively mobile Grenville block against the more rigid Southern and Superior blocks. Geological and radiometric age investigations indicate that the Grenville Front is a relatively late superimposed feature, and that the eastern Southern and western Grenville provinces had a lengthy common depositional and tectonic history.

To the east of Sudbury, south of Coniston and in the Wahnapitae area (Wahnapitae has several spellings; the local signpost spelling is used here for the community), the rocks of the Southern and Grenville provinces are in contact approximately along the Murray Fault. Further west the front swings southward away from the fault until, in the vicinity of Highway 69, there is a wide zone over which the grade of metamorphism and intensity of deformation increase southward. The front, marked by a valley along a fault, is crossed by the highway at the Wanapitei River, but for those requiring a more detailed study with better rock exposures a certain amount of walking over fairly rough terrain is necessary and visitors are recommended to wear stout rubber soled boots on the field trip south of Coniston. Kyanite and sillimanite may also be seen near the front, particularly east of Wahnapitae.

GRENVILLE FRONT NEAR CONISTON

Commencing the journey in Sudbury, drive east to Coniston along Highway 17, about eight miles. For those wishing to inspect the front thoroughly, a four mile walk over rock ridges is involved. The Coniston stacks can be used as landmarks along most of the route. Turn south into Coniston on Second Street, drive west on Government Road and south on Edward Street to the Coniston refuse dump. Park.

Walk south about two-thirds of a mile to the northwest corner of Alice Lake (photo 53). Feldspar-rich crossbedded Mississagi sandstone forms extensive outcrops in the area. Immediately north of the small creek joining Alice Lake and Baby Lake, a metamorphosed Nipissing Diabase body intrudes the sandstones. The creek approximately marks the location of the Murray Fault. Immediately south of it there are crushed or mylonitized rocks which probably represent both highly deformed granites and metamorphosed sedimentary rocks.

Photo 53. *Air photo showing the topography of the Grenville Front south of Coniston, Neelon Township. (Forest Resources Inventory photo. Scale 1 inch to ¼ mile.)*

Cross the creek and go south a quarter of a mile to the Grenville Front proper. The front is marked by the growth of garnet porphyroblasts or crystals and by the appearance of migmatite, a mixture of older rocks and granite. There is also a change here in style of deformation from brittle, mylonitic deformation to ductile deformation characterized by numerous small folds indicating the rocks have flowed under conditions of high temperature and pressure. The rocks south of the front consist of gneisses, formed by metamorphism of sedimentary rocks; amphibolite, a dark basic rock representing metamorphosed basic intrusions; and minor granitic intrusions.

Turn southwest to the railway, about half a mile (photo 53). Follow the railway north to Baby Lake, about half a mile. The rail line is heavily used and visitors are cautioned to stay off the right of way. The Grenville Front and the "transition zone" are again crossed. Here there are bodies of fairly homogeneous gneissic granite with quartzite inclusions. These probably represent the northeastward extension of a group of granitic intrusions, the "Killarney granites", which have been intruded along the Grenville Front zone.

Continue north then northeast around the northwest corner of the lake back to the Coniston dump, about a mile and a quarter, and return to the car. Drive back to Highway 17 and continue east.

GRENVILLE FRONT NEAR WAHNAPITAE

A little over three miles east of the junction of Highway 17 and Second Street, the Wanapitei River marks the location of the Murray (Wanapitei) Fault, which here constitutes the Grenville Front. It will be readily seen from the highway that on the northwest side of the river there are steeply inclined sedimentary rocks, whereas on the southeast side the rocks are gneissic in character.

Dryden Kyanite Exposures

Continue 2.6 miles east of the river crossing. There are several pits on the south side of the highway exposing gneiss with crystals of biotite, kyanite, and garnet. Sillimanite is developed locally in fractures and quartz veins.

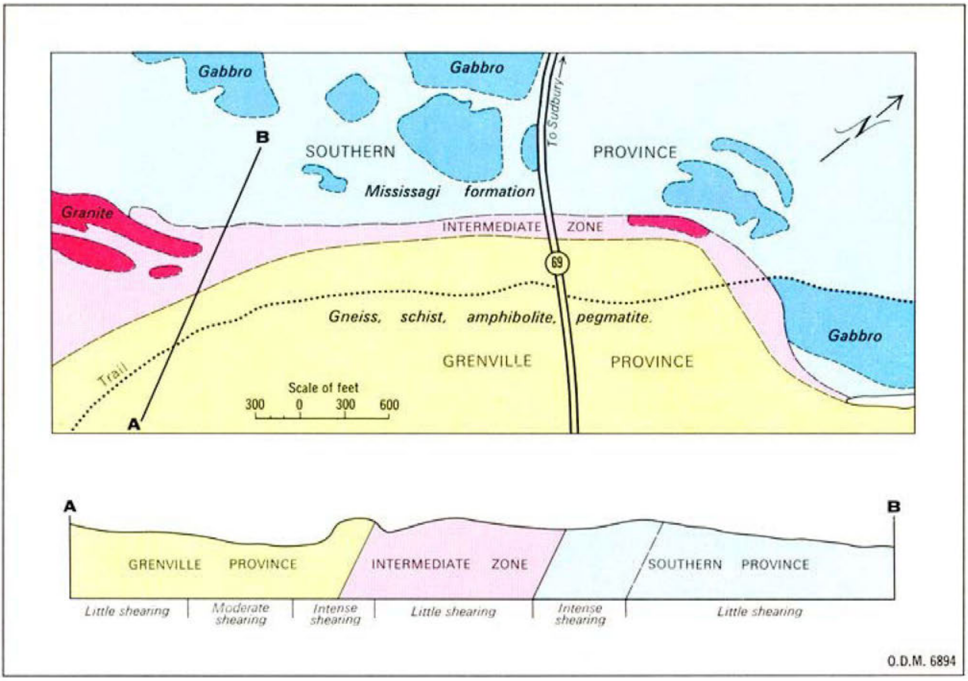
Return to Sudbury via Highway 17 west.

Photo 54. *View from the Canadian Pacific Railway just north of the Grenville Province looking southwest towards Daisy Lake, showing steeply folded rocks of the Mississagi Formation in fault contact with cataclastic granite rocks of the Killarney batholith in the left background. (Courtesy* S. *Lumbers).*

GRENVILLE FRONT NEAR HIGHWAY 69 SOUTH

Setting out from Sudbury in a southeasterly direction along Highway 69, note the mileage at the Paris Street traffic light. The highway passes through the community of McFarland Lake, and crosses the Whitefish River a mile further on. The highway rises over a hill through rock cuts and dips to a small swampy stream 5.9 miles from the Paris Street traffic light. The Grenville Front crosses Highway 69 at this point, although the contact is obscured by swamp.

The rocks of the Southern Province north of the front consist of metamorphosed Mississagi sandstone, Nipissing Diabase, and olivine diabase. The Grenville rocks south of the front consist of gneiss rich in quartz and feldspar, biotite rich schist, amphibolite, and pegmatite. In the zone between the two terrains there are coarse grained deformed granitic rocks, metamorphosed sandstones, and basic rocks which have been interpreted as meta-



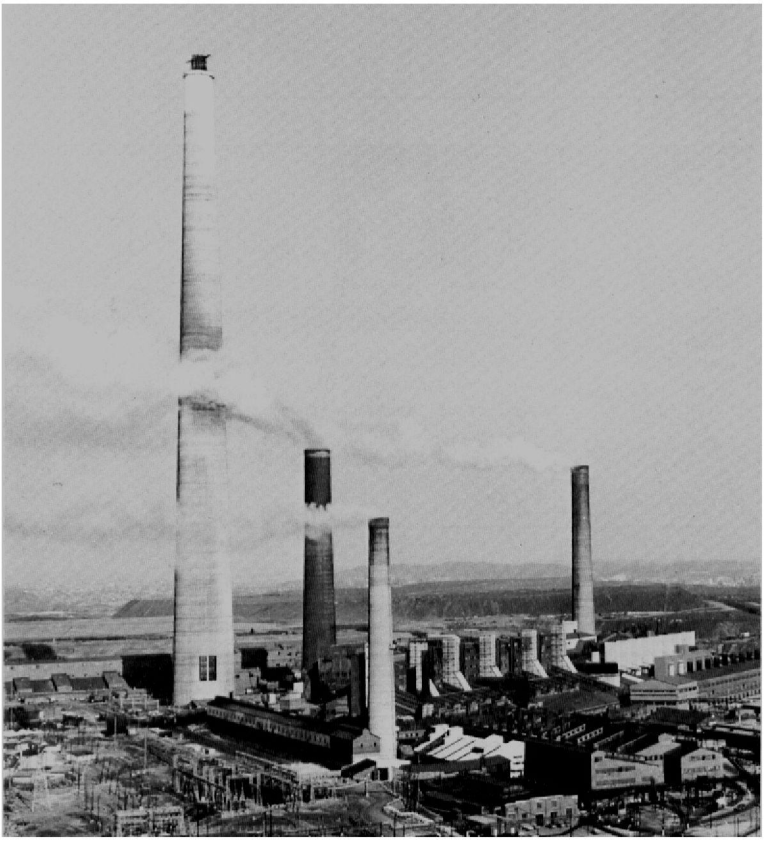
Map 4. *The Grenville Front southeast of Sudbury along Highway 69. The cross-section is at a larger scale than the map. (Modified after. T. Kwak).*

morphosed gabbro and diabase. The Southern Province rocks north of the front have not been as highly metamorphosed or deformed as those of the Grenville Province to the south, where most of the original features of the rocks have been destroyed.

Walk southwest on a trail for approximately half a mile. A section across the Grenville Front zone here (represented by section A-B on map 4) shows the extreme deformation of the rocks. Deformation apparently occurred both before and after the formation of the granite.

Return on Highway 69 north to Sudbury.

Photo 55. *The world's tallest chimney, International Nickel's giant 1,250 foot stack at Copper Cliff is a distinctive landmark of the Sudbury area. Designed to diffuse smelter gas, from which much sulphur and almost all dust has been removed, it represents a very significant advance in pollution control. (Courtesy International Nickel).*

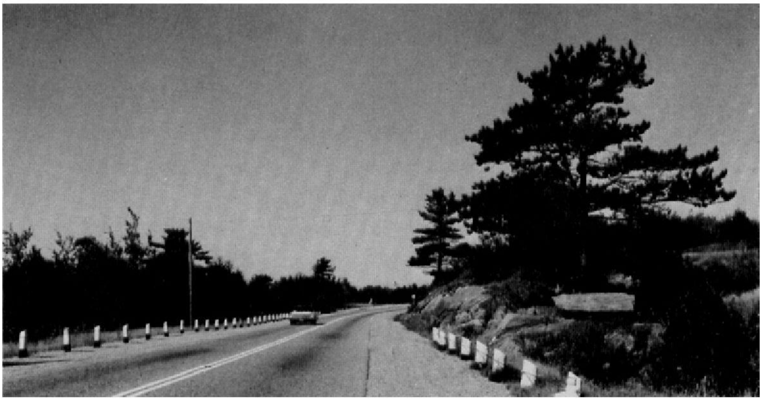


Highway 17

Highway 17 is one of the major highways of the Province and part of the Trans-Canada highway system, crossing Ontario from the Quebec border near Montreal to the Manitoba border near Winnipeg, a distance of some 1,350 miles. The geology and scenery along the section northwest of Thunder Bay is described in Guidebook No. 1. Guidebook No. 2 describes the highway where it follows the north shore of Lake Superior.

The 250 mile long section dealt with in this guidebook runs from Wahnapitae east of Sudbury to Batchawana north of Sault Ste. Marie and generally follows the North Channel of Lake Huron, but for the most part lies a few miles inland from the Huron shore. Many scenic side trips away from Highway 17 are described in the following sections; these include a tour of Manitoulin Island and a tour of the Elliot Lake uranium area. Visitors are strongly recommended to take as many of these side trips as possible because much of the best scenery and most interesting geology lies along them.

Photo 56. *Highway 17, west of Walford. (Courtesy Ont. Min. Transportation and Communications).*



Sudbury to Espanola

INCO SMELTER AND PLANT

Drive west on Highway 17 past Copper Cliff. At the Balsam Street entrance to Copper Cliff, three and a half miles from Sudbury, there is an excellent view of the International Nickel Company of Canada Limited smelter, dominated by the recently constructed chimney stack twelve hundred and fifty feet high.

World's Tallest Chimney

This super-stack is the tallest chimney in the world. It replaced the three shorter stacks which are now capped and which themselves for decades were the tallest in the British Commonwealth. The base of the concrete outer shell is 116 feet 5¼ inches in diameter with 3½ foot thick walls; the top is 51 feet 9½ inches with 10¾ inch walls, and the concrete to build this giant weighed 43,000 tons when poured. Within the shell an insulated stainless nickel steel liner extends from the base to five feet above the outer shell; this alone weighs 2,000 tons. Elevators and ladders between the shell and liner give access to eight service platforms from which aircraft warning lights are maintained. The chimney was built by pouring the concrete between two huge sliding steel collars, hydraulically raised and adjusted to the correct wall spacing every ten inches. Special measures had to be taken to overcome the tendency of the unit to turn due to the earth's rotation. The smelter gases from the plant are passed through an extensive system of cleansing and dust precipitation before being dispersed in the atmosphere via this chimney at an altitude of some twenty-two hundred feet above sea level (photo 55).

Inco Offices

The new company offices lie south of the highway about half a mile beyond the junction. Looking southwest from the offices there are three building complexes; from east to west these are the Inco refinery, the Inco pyrrhotite and CIL acid plant, and the Copper Cliff South Mine. At the pyrrhotite plant, Inco manufactures iron ore pellets from the Sudbury ores and at the adjacent plant Canadian Industries Limited utilizes the sulphur gases to make sulphuric acid.

Copper Cliff South Mine

A mile and a quarter beyond the Balsam Street junction, just west of the Canadian Pacific rail overpass, the Copper Cliff South mine is located on the Copper Cliff offset. This mine occupies the site of the long dormant Evans Mine, an important producer in the early days of the Sudbury camp, which started production in 1886 and had two open pits, a shaft and other workings to a depth of 250 feet. Now, as the Copper Cliff South Mine, it has two large shafts reaching to a depth of 3,000 feet and a ramp to the lower extremities of the Evans pit on which load-haul-dump diesel equipment is used. The re-activated mine produces nearly 5,000 tons a day.

Photo 57. *The former Whitefish Bay Post of the Hudson's Bay Company, established in 1824.*

Highway 17 west of Sudbury

Four miles along Highway 17 from the rail overpass, Highway 536 leads north to the dormitory town of Lively and the Creighton Mine. From this point Highway 17 follows the valley of the Murray Fault southwesterly for a number of miles and crosses several Huronian formations which are exposed in the numerous rock cuts. The Murray Fault occupies a narrow linear valley for most of its length; see page 38 for a discussion of the major fault systems in the area.

NAUGHTON HISTORIC SITES

Creighton Mine Discovery

At the east end of Naughton a historic sites marker commemorates the early surveyor Salter and the discovery of the well-known Creighton Mine. In 1856 Albert Salter, engaged in establishing a meridian line running north from Whitefish Lake, observed unusual compass deflections some three miles north of Naughton. Alexander Murray, one of the pioneer geologists of what became the Geological Survey of Canada, attributed the disturbance to an immense mass of magnetic trap. Analysis showed significant nickel, copper, and iron. No further interest in the locality was shown until 1886 when a prospector, Henry Ranger, rediscovered the locality. The Canadian Copper Company, one of the companies which later merged to form the International Nickel Company of Canada Limited, started operations at the Creighton Mine in 1900 and it has been in steady production with short interruptions since 1901. For many years it was the major producer of the area and certainly, because of its record of continuity, it is among Canada's best known mines.

Whitefish Lake Post

The former Whitefish Lake Post of the Hudson's Bay Company has been preserved (photo 57) at Naughton and a historic sites marker beside the post summarizes its history. The post was established in 1824 at Whitefish Lake, two miles southeast of Naughton, to prevent independent fur traders gaining influence in the country north of the French River. It was moved to Naughton in 1887 following construction of the railway and remained in operation until 1906, by which time lumbering had become a major industry to the detriment of fur trapping. The building is in good repair but has been slightly modified to permit habitation.

WHITEFISH INDIAN RESERVE

Fenite Localities

Rocks found adjacent to carbonatites, syenites, and similar igneous rocks commonly have reacted chemically with fluids rich in soda, potash, ferrous iron and magnesium. Such rocks are called fenites after Fen in Sweden where they were first described. The process whereby the country rock is altered chemically by interaction with fluids derived from an adjacent igneous body is termed metasomatism. Two such fenite localities are shown on Map 3 at Nemag Lake and Kusk Lake. They occur on the Whitefish Indian Reserve No. 6 some seven miles southwest of Naughton and are accessible only over Reserve roads and trails. Both localities comprise irregular bodies of brecciated Mississagi quartzite up to one quarter mile in diameter, the individual blocks showing various stages in the development of fenite. The Nemag Lake locality is the better of the two.

The first visible indication of alteration is the development of veinlets of blue-green sodic amphibole (riebeckite) in fractured Mississagi quartzite. With increasing intensity of brecciation and of alteration, sodic pyroxene (aegerine) forms veins cutting and replacing the quartzite and the riebeckite veins. The typical breccia (photo 58) comprises fragments and blocks of quartzite, most of which show prominent green outer veins up to one inch thick, reflecting the replacement by riebeckite and aegerine. The matrix surrounding the blocks is largely dark green aegerine and coarse pink albite, with minor amounts of niobium-bearing rutile. At the Kusk locality, carbonate and sphalerite have also been identified.

Alkalic Intrusions

The Whitefish Indian Reserve fenite breccias may represent alteration zones above alkalic-carbonatite intrusions at depth. The fenites lie close to the intersection of east – west and northeast trending fault systems. Alkalic-carbonatite intrusions and associated fenites occur to the east of the guidebook area near North Bay. However, the intrusions near North Bay are 560 million years old, while those near Naughton are at least 1,100 and possibly as much as 1,750 million years old (see page 49).

HIGHWAY 17 WEST OF NAUGHTON

Highway 17 continues westward passing north of Simon and McCharles Lakes (photo 59), and crossing the Vermilion River about five miles beyond Naughton. The Canadian Pacific Railway crosses the river just north of the road near a low waterfall and the

Photo 58. *Reaction rim around breccia fragments in fenite, near Nemag Lake, Whitefish Indian Reserve No. 6. (Courtesy K. Siemiatkowska).*

Photo 59. *The Vermilion River from Highway 17 near McCharles Lake. The Murray Fault runs through the depression below the falls.*

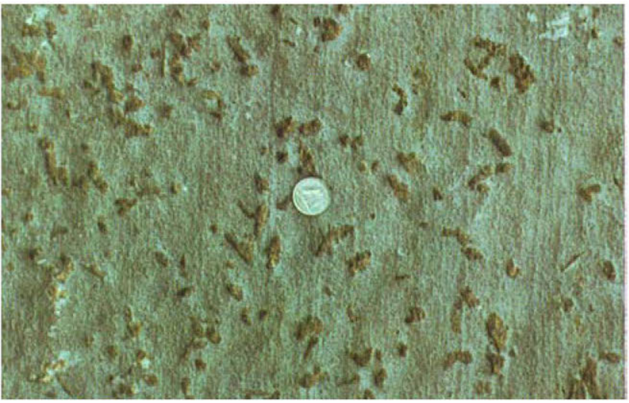


Photo 60. *Staurolite crystals (brown) in thinly bedded greywacke near High Falls, north of Nairn.*

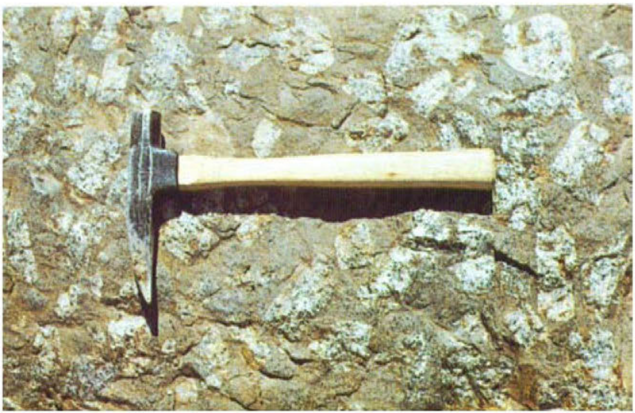


Photo 61. *Porphyritic olivine diabase dike, Highway 17, one mile east of Nairn.*

Murray Fault is expressed as the change of relief south of the railway bridge, the shattered rocks in the fault having been more readily eroded than the undisturbed rocks on either side.

OLD HIGHWAY 17 SIDE TRIP

West of Whitefish the tourist has the choice of continuing on Highway 17 or taking a side trip through mining country along old Highway 17 via Highway 658. The two routes rejoin at Nairn Centre. The Provincial Park at Fairbank Lake, one of Ontario's provincial recreationalparks operated by the Ministry of Natural Resources may be reached by Highway 658.

Crean Hill, Victoria, Worthington and Totten Mines

The community of Whitefish lies two miles west of the Vermilion River. Beyond it, Highway 17 sweeps south to bypass several mining communities lying on the former highway which still exists as a gravel road. Two and a half miles west of Whitefish, Highway 658 turns north, then west, following old Highway 17. Just beyond the turn a road leads north to two working mines, the Crean Hill and the Victoria and to many old prospects. The Crean Hill Mine was discovered by J. Crean in 1885 but was not worked until 1905 and has been operated by the International Nickel Company of Canada Limited and its predecessors at various intervals since that time. The Victoria Mine, discovered in 1886 by the same Henry Ranger who found the Creighton and the Vermilion mines, was brought into production in 1900.

The old Worthington and new Totten Mines on the Worthington Offset (see page 43) are located some five and a half miles from Highway 17 along Highway 658. The original Worthington Mine, now marked by a small pond, lay northeast of the Totten Mine buildings which can be seen from the road.

The Worthington orebody was found in 1884, only a few months after the original Murray discovery, when the Canadian Pacific Railway again cut through mineralized rock and laid its track on an orebody.

The mine was operated by Inco and its predecessors until 1927, when a massive cave-in occured.

Fairbank Provincial Park

Supplies may be purchased at Worthington for those visiting Fairbank Provincial Park on Fairbank Lake. This beautiful park has nearly one hundred and fifty tenting and trailer sites, a group camping ground, twelve acres of picnic area and a sheltered bathing beach. It is situated in a pocket of deciduous trees, unusual for so far north. The park is reached by following Highway 658 which turns north again, leaving the alignment of the former Highway 17.

High Falls Road

The geological side trip continues west from Worthington along the old highway. Two and two-tenths miles west from Highway 658 there is an outcrop north of the road containing abundant black chloritoid crystals up to one-half inch in cross-section (photo 27). Crystals are scattered through the thinly bedded metamorphosed sedimentary rock and are locally concentrated in narrow "veins". Small brown staurolite crystals are also present. A dike of metamorphosed Nipissing Diabase outcrops immediately adjacent to the road. A quarter of a mile further on, a road leads north to High Falls, the old highway swinging south across the railway track. The outcrop at the junction contains staurolite, chloritoid and andalusite. A bluff away from the road and a quarter of a mile northeast of the junction exhibits good chloritoid crystals.

Turn northwest on the High Falls road past the Agnew Lake Mine road. At the Agnew Lake Mine, uranium bearing conglomerate in Huronian quartzite lies adjacent to the Archean basement. The mine has been developed but no mill has been constructed pending a greater demand for uranium. One and a half miles beyond the mine road a small quarry lies a few hundred feet north of the road. The metamorphosed sedimentary rocks carry fresh brown staurolite crystals (photo 60). The community of High Falls lies just beyond this point. Agnew Lake was created by the power dam at High Falls, an Inco development on the Spanish River. Turn here, rejoin old Highway 17 and continue west to Nairn Centre and the new Highway 17.

HIGHWAY 17 EAST OF NAIRN

One mile east of Nairn Centre, a northwest striking olivine diabase dike crosses the road. This dike has large crystals of feldspar. The best exposures on the north side of the highway have been partially destroyed by blasting (photo 61).

HIGHWAY 17 WEST OF NAIRN

Continue west on Highway 17 to McKerrow and Highway 68. Five miles beyond Nairn the highway reaches the Spanish River bridge and in a further four miles the village of McKerrow is reached, the road and rail junction for Espanola and Manitoulin Island.

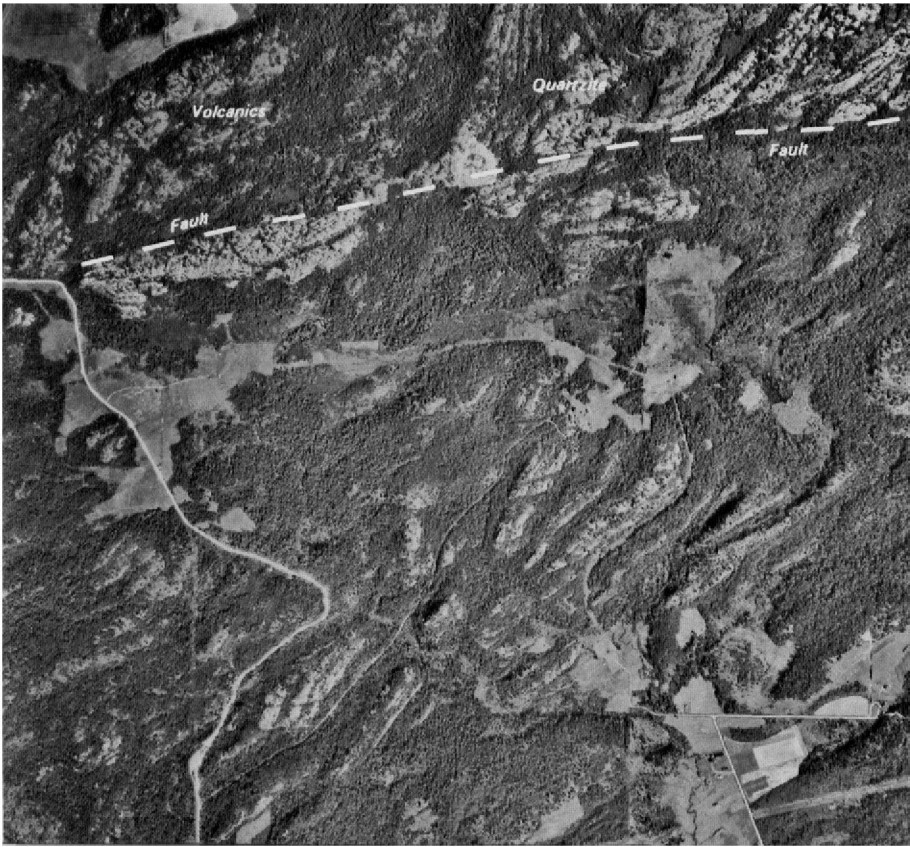
McKERROW

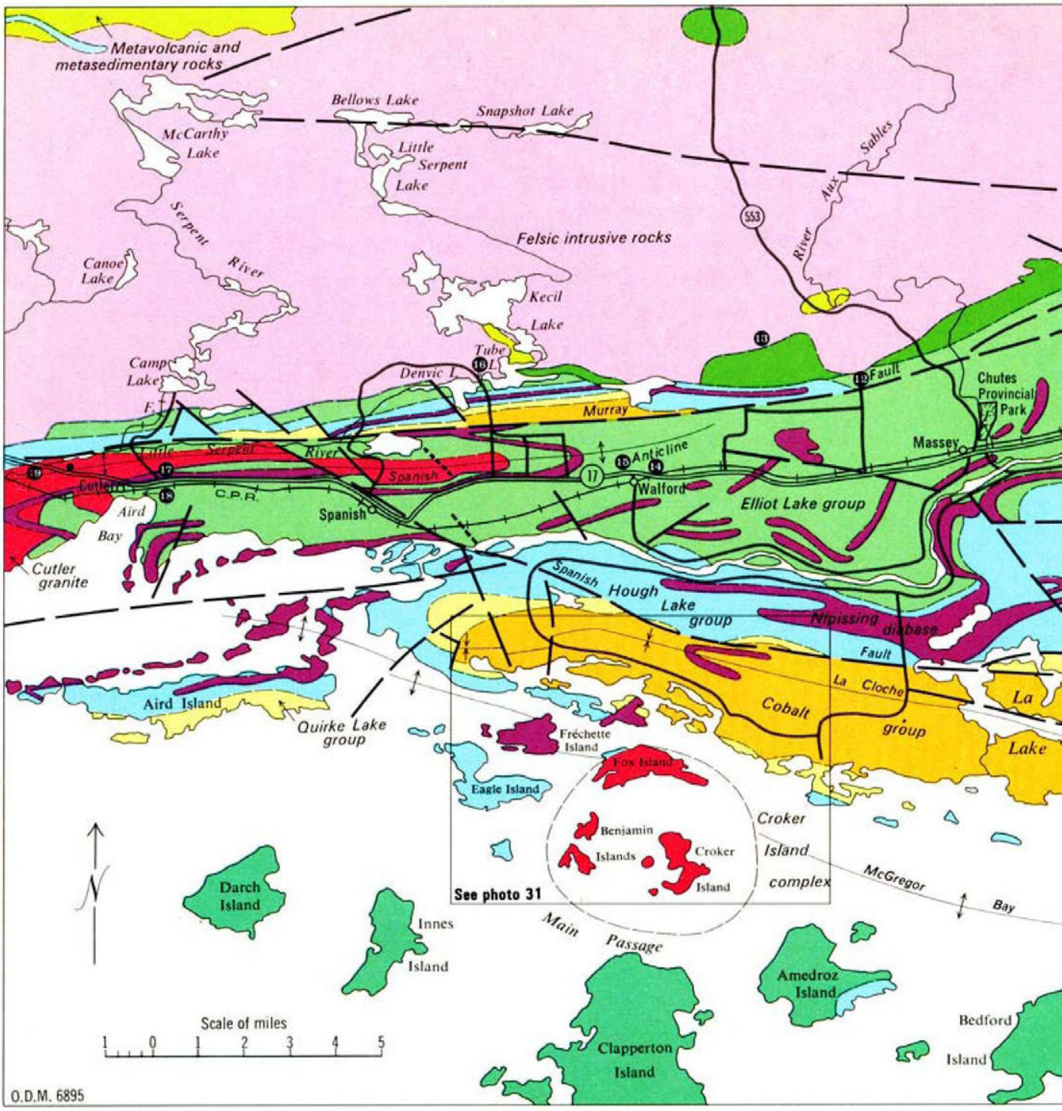
Murray Fault

At McKerrow, a concession road leads north from Highway 17 to Agnew Lake, a tourist attraction in the summer months. This road crosses the main Murray Fault zone about three miles north of the highway. The aerial photograph (photo 62) seen below clearly shows this main regional fault. In places it forms a narrow valley between the quartzite ridges; at other points it is revealed by a fault scarp. Note that, where it is bounded by quartzite (light coloured rock) and lava (dark coloured), its exact location can be seen very clearly on the photograph. Faults subsidiary to the main structure are often marked by lines of trees or shrubs growing out of crevices in the otherwise bare quartzite ridges.

Espanola, a mile south of McKerrow, is described in the next section. The description of Highway 77 continues on page 743.

Photo 62. *Air photo showing the Murray Fault three miles north of McKerrow. The light coloured outcrops are white quartzite; the dark coloured outcrops are basic volcanics and basic intrusives. The bedding of the quartzite, the quartzite-volcanic contact, the fault and the drag of the beds at the fault are clearly shown. Scale about 2000 feet to the inch. Forest Resources Inventory photo. (After J. E. Thomson).*

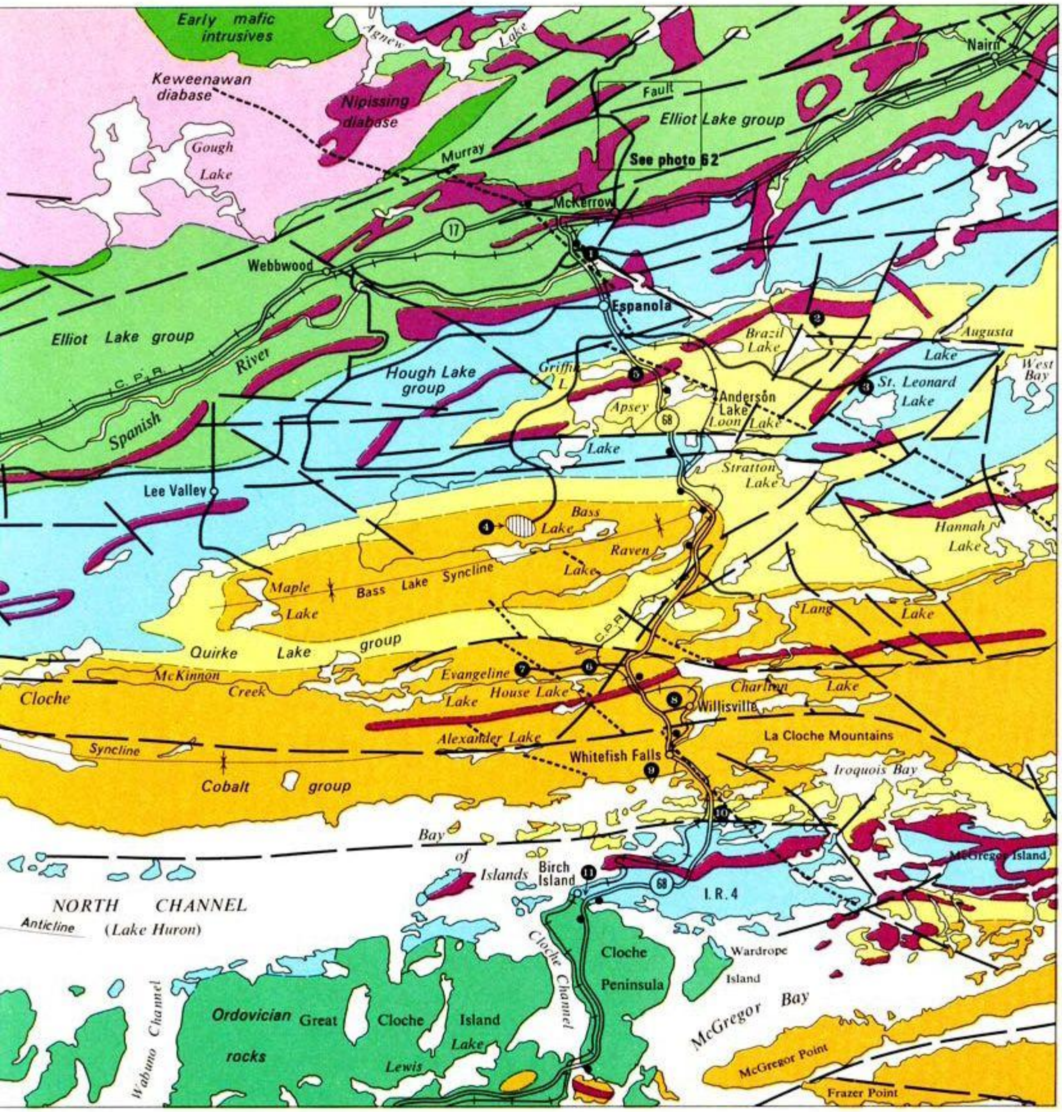




POINTS OF INTEREST

❶ *Deposit of Pleistocene varved clay.*
❷ *Brazil Lake cobaltite occurrence.*
❸ *St. Leonard scheelite locality.*
❹ *Mongowin Pluton.*
❺ *Espanola Municipal Centennial Park.*
❻ *Majestic Mine.*
❼ *McMillan Mine.*
❽ *Willisville fire tower.*
❾ *Wallace Mine.*
❿ *Parking area.*
⓫ *Roosevelt Monument.*
⓬ *Massey Mine.*
⓭ *Hermina Mine.*
⓮ *Walford bridge.*
⓯ *Walford church.*
⓰ *Waterfalls resort.*
⓱ *Outcrop of staurolite bearing foliated rock.*
⓲ *Former Cutler acid plant.*
⓳ *Kennebec falls and picnic area.*
● *Additional point of geological interest (see text).*

Map 5. *The Nairn–Espanola–Cutler Area*



Note: Roads shown in a double line indicate guidebook routes. Roads shown in grey indicate other means of access.

Espanola, Whitefish Falls and Manitoulin Island

The long side trip described in the next two sections starts at and returns to Espanola via Highway 68. It varies, with several alternative routes and side visits to mineral localities, but may be as long as 300 miles, round trip. Note that the ferry route shown on many maps from the west end of Manitoulin Island to Blind River is not in use at the time of writing, the only route for the motorists to and from the north shore of Lake Huron being via Highway 68. A ferry runs to Tobermory and southern Ontario from the south tip of the island during the summer months.

This journey goes through some of Ontario's most delightful lakeshore scenery and passes from the Precambrian rocks of the mainland to the Paleozoic rocks and Pleistocene and Recent deposits of Manitoulin and the other islands. The trip is of considerable historical interest because of the area's close association with North American history and pre-history. Highway 68 passes the site of one of North America's earliest human settlements. It traverses lands where Indian folklore and legend still flourish; where rock paintings and engravings testify to the Indian culture that existed before the arrival of Europeans. The highway crosses the main canoe route used by traders and explorers in opening up central Canada during the seventeenth and eighteenth centuries. It penetrates into rural Ontario communities whose buildings and fence lines are unchanged since the days of the earliest European settlement.

The area caters to tourists. Accommodation is plentiful and the various trips and side trips cover most of Manitoulin Island except for its westermost extremity.

Photo 63. *Summers Creek near Dunlop Lake.*

Espanola to Whitefish Falls and Birch Island Road

HIGHWAY 68

Just west of McKerrow, Highway 68 leads south to Espanola, a distance of about a mile. Half a mile south of the junction of Highways 17 and 68, an olivine diabase dike of the Sudbury swarm outcrops on the east side of the road. Note the typical rusty brown weathering and the rounded surface of the weathered rock. This is known as spheroidal weathering. Half a mile further south on Highway 68 and just north of the Spanish River, rocks of the McKim Formation are exposed in a large rock cut. Note the thin bedding of the metamorphosed sedimentary rocks, ripple marks and small scale crossbedding. Sudbury type breccia is spectacularly developed on top of the exposure on the east side.

Here the contact between the folded McKim rocks and the crosscutting breccia zone can be seen on the east wall of the cut. On the west side, cleavages (parallel planes along which the rock splits, which reflect a preferred orientation of mineral grains formed during deformation and metamorphism) and lineations (linear elements in deformed rocks, which also reflect a preferred orientation of mineral grains) are exposed. Chlorite aggregates, which probably represent altered chloritoid crystals, are also present.

ESPANOLA

Approximately one-quarter mile east of Highway 68 on the north bank of the Spanish River opposite the pulp and paper mill, there is a deposit of Pleistocene varved clay. The clays are thinly laminated and various laminae are coloured in shades of grey and pink. Claystone nodules, which are concretionary structures formed by accumulation of minerals about central nuclei, occur in the varved clay.

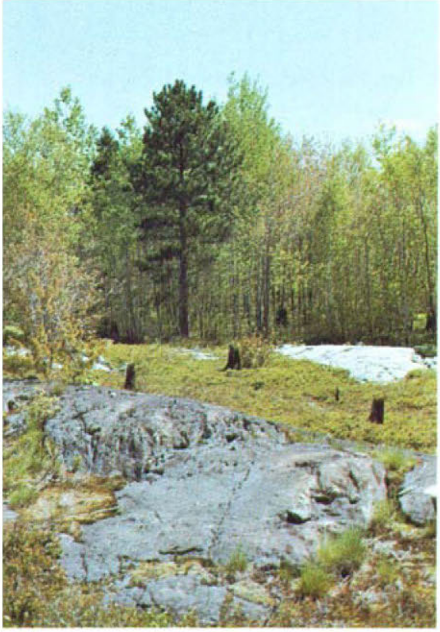


Photo 64. *Large quartz vein in diabase near Brazil Lake.*

Photo 65. *St. Leonard Lake.*

Photo 66. *Clear Lake, south of Espanola from Highway 68.*

Photo 67. *Conglomerate dike in well-bedded Espanola siltstone, Clear Lake, Highway 68.*

To the south of the Spanish River lies the town of Espanola, a pulp and paper manufacturing town, tourist centre and supply centre for the surrounding countryside. Some of the original mill buildings and houses were built of a red brick, fired at the turn of the century from deposits of the local clay, which in this vicinity was fired directly as excavated without further preparation because certain selected beds contained a suitable proportion of clay and sand.

MINERAL LOCALITIES NEAR ESPANOLA

The following two side trips away from Highway 68 involve driving over old roads and some walking in bush country. They are not recommended during or after wet weather for private cars. Visitors are advised to wear heavy footwear. The description of Highway 68 continues on the next page.

BRAZIL LAKE — ST. LEONARD LAKE SIDETRIP

Continue on Highway 68 through Espanola immediately south of the town to the West Bay Penage road. Penage Lake is the local spelling of a lake, shown on most maps as Panache Lake. Turn off Highway 68 and go east on this road approximately five miles, passing two lakes. One-tenth of a mile beyond the second (Brazil) lake, turn left on an old road, continue one and a quarter miles to a cabin by a beaver pond on Brazil Creek and park. Continue north on foot one and a quarter miles on a bush road to an old adit and dump.

Brazil Lake Cobaltite Occurrence

A Nipissing Diabase dike intrudes rocks of the Espanola Formation. Pits have been dug for surface exploration of a vein carrying quartz, carbonate, pyrrhotite, actinolite, cobaltite and minor chalcopyrite. A horizontal opening or adit has been used for subsurface exploration. Cobaltite crystals up to one inch across and actinolite crystals are to be seen in the dump. The top of the bluff adjacent to the adit affords a good view of Brazil Lake. There is a massive but barren quartz vein at this point (photo 64). Return to the West Bay Penage road.

St. Leonard Scheelite Locality

Continue east on the Penage road for about one and a half miles, cross a small creek and pass a pond on the north side of the road to a spot where the road curves past a diabase outcrop on the north shoulder. There is a slight clearing on the south side of the road and, a few yards to the southeast, there is a trench. In this trench and in a series of pits and trenches on the south side of the hill about a quarter mile south of the road, the following minerals occur in metamorphosed rocks of the Espanola Formation: idocrase (vesuvianite), garnet, scheelite (fluorescent), powellite (fluorescent), molybdenite, sphalerite, and chalcopyrite. Scheelite and sulphides have also been found in Mississagi quartzite exposed between the above locality and St. Leonard Lake (photo 65).

Return to Highway 68.

MONGOWIN PLUTON SIDETRIP

Bass Lake Magnetite Occurrence

Turn west off Highway 68 at the West Bay Penage road intersection. Proceed half a mile and turn south on the Apsey Lake road. After a further three and three-quarter miles take the left fork south and after a mile and a quarter take the right fork south. Three-quarters of a mile further on, park, turn right onto a rough road and continue for three-quarters of a mile. In a clearing on the north side of Bass Lake, there are several old buildings, partially collapsed. Walk west about fifty yards to an old pit and dump.

The pit is one of several used to explore the Mongowin Pluton for nickel and copper. The basic rocks of the pluton can be examined in these pits and outcrops adjacent to the access road. In the pit, a vein cutting basic rocks contains masses of magnetite with a colloform, radiating structure and coatings of dense cream coloured serpentine (figure 4).

Return to the junction of Highway 68 and the West Bay Penage road and resume the journey south on Highway 68.

HIGHWAY 68 SOUTH OF ESPANOLA

Espanola Municipal Centennial Park

Drive south on Highway 68 a mile and a quarter south of the West Bay Penage road to a small point which projects out into Clear Lake, shown on most maps as Griffin Lake (photo 66). This area has picnic grounds and a public bathing beach. Here, thinly bedded metamorphosed calcareous siltstones and impure limestones of the Espanola Formation are intruded by several tabular dike-like bodies of conglomerate (photo 67). These have presumably formed as a result of injection of water-soaked sediments into partly consolidated Espanola sediments. The dike rock resembles the rocks of the underlying Bruce Formation. This locality is considered classic and has been illustrated in text books, reports and professional papers. To preserve the outcrop, sampling is not

Photo *68. Large scale crossbedding in the Espanola Formation, Highway 68 at Anderson Lake side road.*

permitted. Sedimentary structures present in the Espanola rocks include bedding, ripple marks and ball-and-pillow structures. Small white crystals of scapolite, a metamorphic mineral, are also present.

Outcrops along Highway 68

Seven-tenths of a mile south of Clear Lake, large scale crossbedding is exposed in calcareous sandstone of the Espanola Formation. This small outcrop is to be found on the east side of the road a few yards north of the Anderson Lake side road. In a further seven-tenths of a mile, there is crossbedded sandstone of the Serpent Formation.

Two and a half miles south of Clear Lake, a rock cut exposes a fault zone in the Mississagi Formation west of the road. Vein quartz and crushed or mylonitized sandstone fragments constitute the zone, whilst on the south fringe of the outcrop a few hundred feet west of the present road there are exposures of Bruce type conglomerate with stretched pebbles.

Continuing south on Highway 68, roads leading to Loon Lake and Raven Lake are passed to the east. Three-tenths of a mile beyond the Raven Lake road, an outcrop on the west side of the highway shows large scale crossbedding in sandstones of the

Serpent Formation; the thickness of the individual crossbeds is of the order of feet.

A mile south of the Raven Lake road, outcrops of Gowganda Formation argillite, conglomerate, and quartzite occupy the nose of the Bass Lake Syncline. Many outcrops are intensely brecciated and contain blocks derived from the underlying formations. Here a mass of Sudbury breccia has been forced into the nose of the fold.

Just over a mile further south, an outcrop on the west side of the railway track contains large, angular to rounded blocks of quartzite in breccia considered by some to be of Sudbury type. This outcrop can be seen from the Lang Lake road sign post. The Lang Lake road leads off to the east a few hundred yards past this point.

HOUSE LAKE GOLD PROSPECTS

This short side trip visits old gold prospects. Part of the route is accessible in good weather by private cars.

Two and a half miles beyond the Lang Lake road, the former Highway 68 forks off to the west. Leave Highway 68 and follow this road round a right angled corner to a track leading west. This track follows the north shore of House Lake, a long narrow lake eroded along a fault. East striking quartz-carbonate-pyrite-arseno-

Photo 69. *Interbedded red and green sandstones of the Lorrain Formation on the north* limb *of the La Cloche Syncline, Highway 68.*

pyrite veins outcrop in Gowganda sandstone just north of the lake. These have been explored for the minor gold content of the sulphides at the east end of the lake, at the Majestic Mine south of the trail immediately west of the railway track, and at the McMillan Mine near the west end of the lake at the west end of the trail. The track is drivable in good weather to the railway, but there is currently no graded crossing and the road beyond is not suitable for private cars.

McMillan Mine

The McMillan Mine was the only property to achieve production as the result of this prospecting activity and, in the period 1934 to 1937, gold and silver valued at $97,357 were recovered. Specimens of gold-bearing arsenopyrite and pyrite are to be seen on the dumps at both the McMillan and Majestic mines.

Return and continue the journey south on Highway 68.

NORTH RANGE LA CLOCHE MOUNTAINS

Just beyond the old Highway 68 road junction there is a road cut in interbedded pink and grey sandstones of the Lorrain Formation (photo 69). Three-tenths of a mile beyond the junction, there are occurrences of feldspar-rich, crossbedded, greenish weathering sandstone of the Lorrain Formation.

The highway then crosses the Canadian Pacific Railway and rises over the north range of the La Cloche Mountains. A section through the upper part of the Lorrain Formation is exposed in the rock cuts. There are several members of the Lorrain present, including green pebbly sandstone, pink hematitic sandstone, and white sandstone.

Willisville Lookout

The Willisville road turns off east along the south face of the ridge of sandstone below the Willisville fire tower. Just east of the road junction there is a suitable parking area. Excellent views looking south towards Manitoulin Island can be obtained here. The valley in the foreground marks the outcrop of the easily eroded Gordon Lake Formation in the trough of the La Cloche Syncline (photo 70). The next ridge to the south marks the outcrop of the Lorrain Formation on the south limb of the syncline. Ridges in the distance mark the outcrop of resistant Lorrain and Bar River Formations surrounded by flat lying Paleozoic limestone and shales.

Continuing south on Highway 68, "cherty" sandstone occurs four-tenths of a mile south of the Willisville turn off at the top of the Lorrain Formation. This rock is quarried at the nearby Lawson Quarry of the International Nickel Company of Canada Limited and is shipped to the company's smelters at Sudbury where it is used as flux. On top of the outcrop to the west of the road, glacially polished surfaces are exposed. To the south, white Lorrain sandstone containing microscopic grains of kyanite, andalusite, and pyrophyllite is exposed.

WHITEFISH FALLS AREA

Village of Whitefish Falls

Highway 68 crosses the Whitefish River above Whitefish Falls (photo 71), and the former highway forms an access road to the village of Whitefish Falls, a residential and resort community on the edge of Indian Reserve No. 4 of the Ojibway Whitefish River Indian Band. There are government docks along the Whitefish River and it is the starting point for cruises into the scenic Bay of Islands. It is a favourite location for motion picture and television crews producing stories of the outdoors and of the present day Indian way of life. Ancient Indian glyphs, trail markers made with some unknown dye more than a century ago, can be reached by boat from Willisville. They lie to the east along the rocky walls of Charlton Lake at Alligator Mountain.

From the access road, a fine view is obtained of the falls and of the bridges carrying the highway and railway over the Whitefish River. Immediately west of the road bridge on the north side of the river, a diabase dike (dark) cuts the Lorrain sandstone (light) (photo 72). The dike does not continue on the south side, evidence that the gorge is eroded along a fault. The falls occur where a harder band of the Lorrain quartzite interrupts the flow of the river.

Wallace Mine

The old Wallace Mine lies about three-quarters of a mile west of Whitefish Falls on the north shore of the Bay of Islands. This is the site of the first discovery of nickel in Ontario, made and developed in 1847. Chalcopyrite, nickel, ferrous pyrrhotite and pyrite form the mineralization. There was no production from this site.

Continuing south on Highway 68, at a parking area on the east side of the highway a mile and three-quarters from the Whitefish Falls turn-off, there is interbedded conglomerate and laminated argillite of the Gowganda Formation cut by at least

Photo 70. *Frood Lake from the Willisville side road. The valley marks the outcrop of the easily eroded Gordon Lake shales and siltstones in the trough of the La Cloche Syncline. The highground is Lorrain quartzite.*

one and possibly two sets of diabase dikes. Interesting features include the variety of pebbles in the conglomerate, the rhythmic bedding in the argillite and the cleavages, minor folds (photo 73), and breccias. Two-tenths of a mile further on, the contact between the Gowganda Formation and the underlying Serpent Formation is exposed on the east side of the road.

BIRCH ISLAND ROAD

The Birch Island road joins the highway from the west just over four miles south of the parking area. Three-tenths of a mile before this road is reached, mica rich sandstone of the Mississagi Formation may be seen showing well developed cleavage. Material from several pits south of the highway was used for tile in the Montreal Metro subway. One-tenth of a mile before the Birch Island road on the north side of the highway, Paleozoic conglomerate unconformably overlies rocks of the Mississagi Formation. The conglomerate consists of angular fragments of the older Huronian rocks in an impure limestone matrix.

Roosevelt Monument

At the road junction, a monument commemorates a fishing trip taken by Franklin Delano Roosevelt in 1943 prior to the Quebec conference where Roosevelt and Churchill laid the plans for the invasion of Normandy and for the conduct of the war in south-east Asia (photo 75).

Photo 71. *Whitefish Falls and the road bridge carrying Highway 68.*

Photo 72. *A diabase dike cutting the Lorrain quartzite, seen from the highway bridge at Whitefish falls.*

Photo 73. *Gowganda Formation near Whitefish Falls. Note the thin rhythmic bedding of the argillite, fold structures, and cleavage (parallel to the hammer handle).*

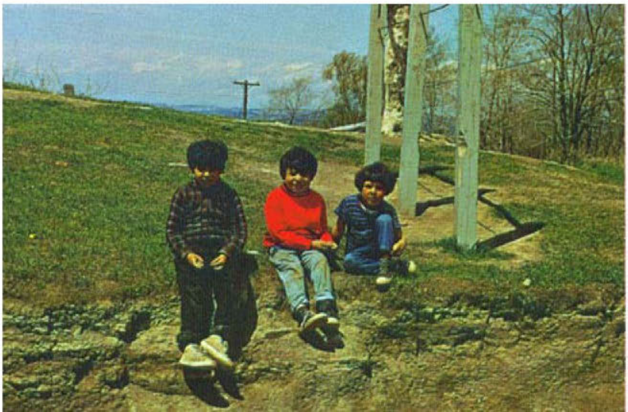


Photo 74. *Young members of the Whitefish Falls Indian community at Birch Island, sitting on Paleozoic shales at the junction of Birch Island Road and Highway 68.*

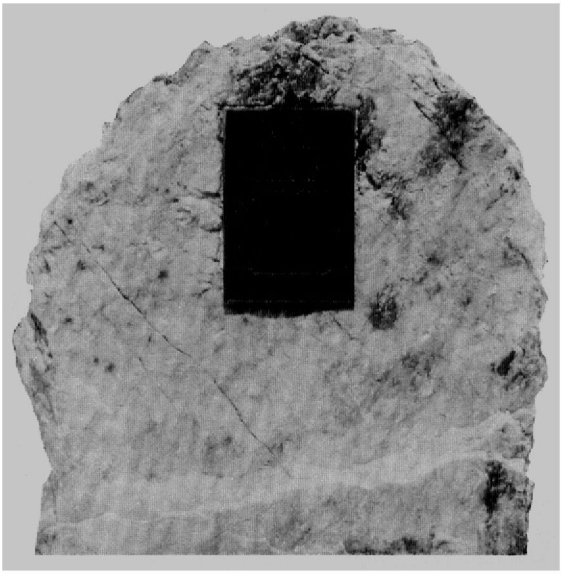
Other points of interest are the stone church at the road junction and an outcrop of Paleozoic shales weathering green and red (photo 76). Excellent views of the Bay of Islands and the La Cloche Mountains can be obtained from the road or from the dock in the village of Birch Island (photo 77). On the shore west of the railway station, pyrite rich sandstone lies at the base of the Paleozoic rocks.

Southern Limit of the Precambrian Shield

The Birch Island road junction marks the southern limit of continuous outcrop of the ancient rocks of the Precambrian Shield and the northern limit of the relatively young Paleozoic rocks forming Cloche Peninsula, Great Cloche Island, Goat Island and Manitoulin Island.

The highway continues across the Cloche Peninsula over Paleozoic rocks southwards through the Indian Reserve to Swift Current, at which point it leaves the mainland and crosses a causeway to Great Cloche Island and Manitoulin. For convenience this last part of the mainland is described on page 127 in the next section which deals with the Paleozoic rocks of Manitoulin and the islands.

Photo 75. *Roosevelt Memorial at Birch Island.*

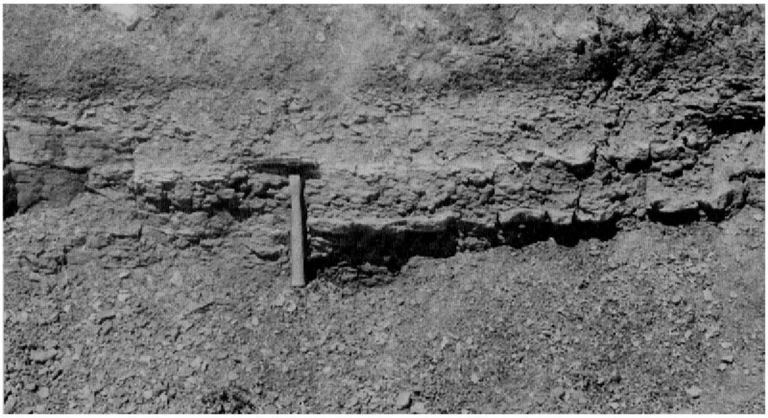


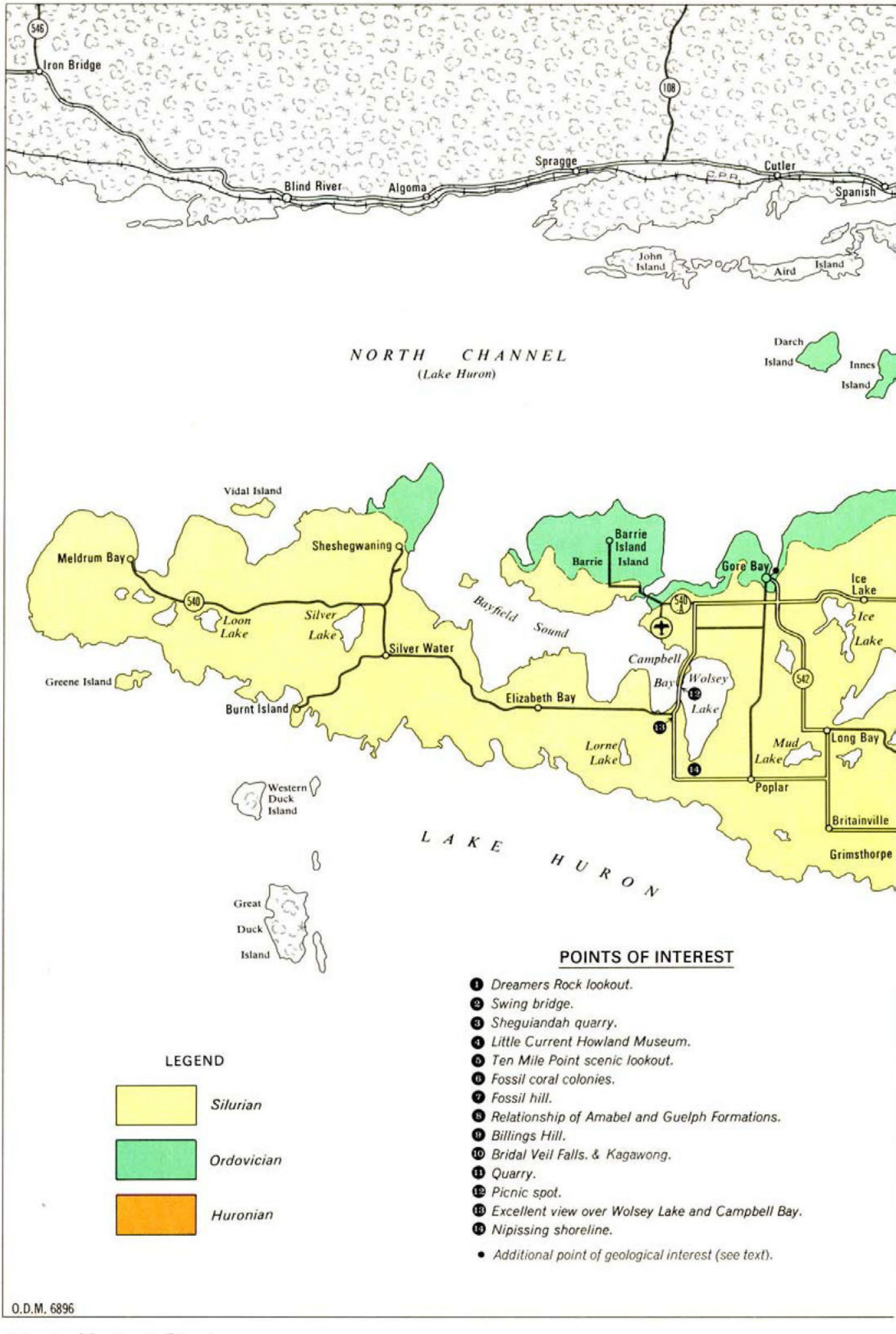
Manitoulin and the Islands of the North Channel

PALEOZOIC TOPOGRAPHY

The Paleozoic rocks of the area consist of well bedded limestones, dolomites and shales, which are generally moderately to richly fossiliferous. Some typical fossils are shown in plates A-D. The individual formations, their thicknesses, their dominant rock type and some characteristic fossils are listed in table 4. The rocks strike east-west and slope gently south. Thus, the northern part of the islands of the Manitoulin District is characterized by a dip and scarp or cuesta topography with northward facing scarps developed over the harder or more massive limestone and dolomite beds, while shelf or dip slopes mark the less resistant shales or thinly bedded sequences (photo 34). Streams flowing over these

Photo76. *Close up of the variegated shales weathering green and red shown* in *Photo74.*





LEGEND

🟨 *Silurian*

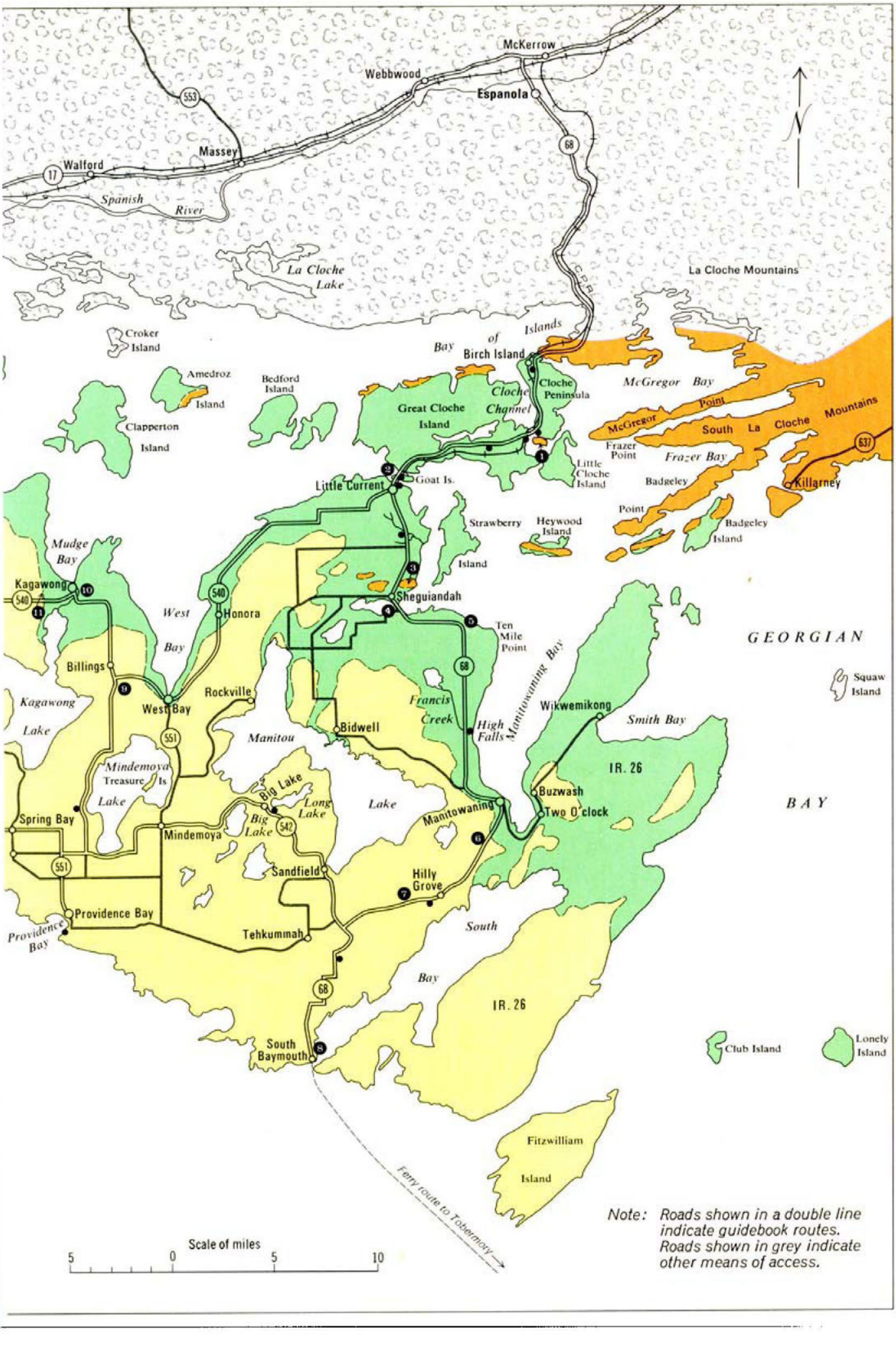
🟩 *Ordovician*

🟧 *Huronian*

POINTS OF INTEREST

❶ *Dreamers Rock lookout.*
❷ *Swing bridge.*
❸ *Sheguiandah quarry.*
❹ *Little Current Howland Museum.*
❺ *Ten Mile Point scenic lookout.*
❻ *Fossil coral colonies.*
❼ *Fossil hill.*
❽ *Relationship of Amabel and Guelph Formations.*
❾ *Billings Hill.*
❿ *Bridal Veil Falls. & Kagawong.*
⓫ *Quarry.*
⓬ *Picnic spot.*
⓭ *Excellent view over Wolsey Lake and Campbell Bay.*
⓮ *Nipissing shoreline.*
- *Additional point of geological interest (see text).*

Map 6. *Manitoulin Island.*



Note: *Roads shown in a double line indicate guidebook routes. Roads shown in grey indicate other means of access.*

Table 4.

PALEOZOIC STRATIGRAPHY OF MANITOULIN ISLAND
(after B. A. Liberty)

Formation	Lithology	Fossils	Thickness Feet
Silurian			
Guelph	Dolomite	Stromatoporoids, Favosites, Eospirifer	0-30
Amabel	Dolomite	Corals, pentamerids	50-180
Fossil Hill	Dolomite	Pentamerids, corals	50-135
Mindemoya	Dolomite	Stromatoporoids, ostracods, corals	60-100
Cabot Head	Shale, dolomite, gypsum	Ostracods, corals, brachiopods.	110
Manitoulin	Dolomite	Parmorthis eugeniensis Coelospira planoconvexa Brockocystites sp. Paleofavosites sp.	70
Ordovician			
Georgian Bay	Limestone, shale	Brachiopods, bryozoa pelecypods, gastropods, corals	300-480
Whitby	Shale, limestone	Graptolites, brachiopods, ostracods, trilobites	25
Lindsay	Limestone, dolomite	Tetradium fibraturn Isotelus maximum Pseudogygites	40-85
Verulam	Limestone, shale	Brachiopods, bryozoa	60
Bobcaygeon	Limestone, dolomite	Brachiopods, bryozoa crinoids, corals	80-135
Gull River	Limestone, dolomite	Tetradium, columnaria ostracods, bryozoa	80-235
Basal Beds	Shale, sandstone, conglomerate		0-80

Table 5.

LATE GLACIAL AND POST-GLACIAL LAKE PHASES IN THE HURON BASIN

Phase commenced years ago	Lake Phase	Original Lake Elevation	Present Raised Shoreline Elevation
2,000	Huron	580	580
4,000	Algoma	596	625
6,000	Nipissing	605	650
9,000	(Uplift began due to glacial unloading)		
10,000	Stanley	200?	600-550
	Kosak	390?	695
	Sheguiandah	435?	765
	Payette	465?	800
	Cedar Point	495?	850
	Penetang	510?	875
1,000	(Ice retreat)		
	Main Algonquin	605	1015
12,000	Early Algonquin	605	
13,000	Saginaw	695	

All elevations in feet above mean sea level.

escarpments have picturesque waterfalls, as for example High Falls south of Ten Mile Point (photo 84) or Bridal Veil Falls at Kagawong (photo 87).

PLEISTOCENE AND RECENT DEPOSITS

Beach and Strand Lines

As noted and summarized in table 5, the islands document much of the Pleistocene and Recent history of what is now Lake Huron. Precise levelling studies of old beach lines traced around the Great Lakes and carbon dating of organic remains trapped in or below beach deposits have permitted the compilation of the data shown in the table.

The dip and scarp topography of Manitoulin Island has been further modified by the beach and strand lines of the different stages of the development of the Great Lakes; those related to the Nipissing stage (650 feet) are particularly conspicuous. These features are either the result of erosion – wave cut terraces in unconsolidated materials, and platforms and scour surfaces on bedrock (photo 78) now partially covered by soil and residual deposits of boulders and cobbles; or of deposition - sands and silts deposited as sheets, bars (photo 91), or dunes (photo 93).

MANITOULIN ISLAND

Manitoulin Island is the largest fresh water island in the world, 110 miles long and up to 50 miles wide. Deep bays indent the shoreline and there are many inland lakes, the largest of which are Manitou, Kagawong and Mindemoya. The total land area is approximately one million acres, of which roughly a quarter is occupied by farms, with two fifths in pasture, two fifths in woodlot and a fifth devoted to crops.

Communications and Facilities

The approach to the island is by Highway 68 previously described or through the Bruce Peninsula to Tobermory and then by ferry to South Baymouth. An airstrip is maintained at Gore Bay. The branch of the Canadian Pacific Railway to the island only handles freight from the docks on Goat Island opposite Little Current. Bus service is maintained to Espanola and the Trans-Canada Highway.

The island, with its pleasant rural scenery, good access, good fishing and hunting, and facilities for cruising and sailing in the waters of the North Channel, Bay of Islands, McGregor Bay, Frazer Bay, and Georgian Bay, is popular with tourists and cottagers.

Resources

Of the population of 12,000, some 3,000 are Indians. The main occupation is farming, largely the raising of beef and dairy cattle, sheep, and turkeys for which Manitoulin Island is famous. Lumbering, boat building, and the tourist industry provide additional income.

The rocks of the island have attracted attention as possible reservoirs for oil and gas. Exploration was begun in 1863 after an oil seep was found near Wikwemikong. Over one hundred holes have been drilled and, prior to 1961, there was some minor oil production.

MANITOULIN HISTORY

Route of the Voyageurs

Although known to prehistoric man and the Indians, it was not until 1615 that Champlain first made mention of the island after a journey over what became the first part of the route of the voyageurs– the overland and canoe route used by explorers, missionaries and fur traders. This route led from Montreal by the Ottawa River to Mattawa, thence to Lake Nipissing, the French River and Georgian Bay. It continued through the North Channel of Lake Huron, skirting the north shore of Lake Huron past the eventual trading posts of La Cloche and the mouth of the Mississagi River, and carried on to the St. Marys River, Sault Ste. Marie and Lake Superior.

Its success as a route for the French fur traders in the 1660s caused the English to set up a competitive trading route through Hudson Bay, which led to the formation of the Hudson's Bay Company in 1670. In 1779, at the height of the fur trade, Montreal traders formed the North West Company using the voyageurs' route to control the rich fur trade along and northwest of the Great Lakes, through their La Cloche, Mississagi and Green Lake posts, until in 1821 they merged with the Hudson's Bay Company. The route was used by many of the notables of central Canada's early history: Allouez, Brûlé, Dulhut, des Groseilliers, Henry, McGillivray, Nicolet, Radisson, Simpson, Thompson, Verendrye, among others. It is of interest that in 1669 Father Allouez was sent to investigate Indian stories of copper in the Huron – Superior region.

Jolliet, Marquette and La Salle also explored Lake Huron in the 18th century. La Salle's ship The Griffon, the first to be built on the Great Lakes, was wrecked near Manitoulin. The

Photo 77. *Shore scene, Birch Island.*

Photo 78. *A terrace cut by wave action on unconsolidated material during the Nipissing stage of the Great Lakes development. Large scale glacial fluting has been preserved on the bedrock platform.*

Photo 79. *A rural scene on Manitoulin Island. Note the split rail fence crossing a wave cut terrace.*

THE MANITOWANING
INDIAN TREATIES

In accordance with Sir John Colborne's plan to gather on reserves the hunting tribes of the Lakes Huron and Superior region, a treaty was signed at Manitowaning on August 9, 1836, by his successor, Lieutenant-Governor Sir Francis Bond Head, and chiefs of the Chippewa (Ojibwa) and Ottawa Indians. By its terms the resident tribes relinquished their claims to this island, which became a reserve for all Indians wishing to settle there. However, few mainland Indians came, and by a second treaty signed here October 6, 1862, the Manitoulin Indians living west of Manitowaning Bay and South Bay gave up their land. Subsequently, save for six small reserves, this was sold to white settlers.

Erected by the Ontario Archaeological and Historic Sites Board.

Photo 80. *A historic sites market at Manitowaning.*

actual site has never been identified although claims have been made for wrecks found near Tobermory and Mississagi.

Manitoulin's Indians

Ottawa Indians inhabited the island until 1652 when they were driven out by the Iroquois. No mention is made of the island between 1700 and 1815, but it is believed that sickness struck the island and that to purify the land and rid it of evil spirits the Indians burned the vegetation.

Following the war of 1812, Indians fleeing the Americans took refuge on the island. In 1832, a mission was set up at Smith Bay, founding the community of Wikwemikong; the mission continues as a major project of the Jesuits to the present day.

In 1836 a treaty set aside the island for the Indians living there, and such others as wished to relocate. Few availed themselves of this option and a second treaty in 1862 surrendered to the Government all but the eastern end of the island, now the Manitoulin Indian Reserve. Subsequently a number of other Indian reservations were created.

Early Settlement

Ample evidence of the early settlers who followed can be found in their farms, with fields bounded by split rail fences and boulders laboriously cleared into large heaps. On many farms, the older buildings still stand near the larger and better homes, which were built in later years when farms and families became established.

The weathered timber, the varied style of the buildings, the crossroad churches, one room schools, and community halls, largely disused, testify to a way of life which has passed. Historic site markers at Swift Current, Ten Mile Point and Manitowaning commemorate this early history of the island.

Photo 81. *Flat lying Gull River limestone beside the Voyageur marker, Cloche Peninsula.*

Highway 68
Birch Island Road to Little Current

CLOCHE PENINSULA AND ISLAND

The journey continues south on Highway 68 from the junction of the Birch Island road. A road cut on the west side of the road, four-tenths of a mile beyond the Birch Island road, shows the Bobcaygeon Formation overlying the Gull River Formation, the contact being placed at the base of a ten foot shale unit. Three and a half miles further south and east, the highway approaches a causeway linking Cloche Peninsula and Great Cloche Island. At this point the road runs due west. The channel here is variously known as Cloche Channel or Swift Current. A historic sites plaque commemorates the route of the voyageurs.

The Gull River Formation is exposed in low outcrops adjacent to the road and around the shore. This comprises well bedded limestone with some red beds. Hills of the Lorrain Formation, which were islands in Ordovician seas at the time of the deposition of the Ordovician formations, stick up through the limestone.

DREAMERS ROCK LOOKOUT

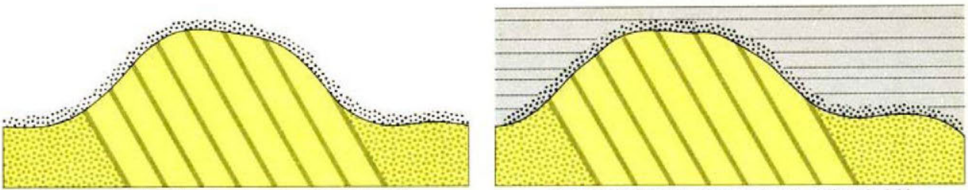
The view from this lookout is one of the finest in Ontario and is well worth the short diversion from the main highway. Turn in at the Birch Lake Lodge side road, about one hundred yards east of the voyageurs plaque, and drive in for three-quarters of a mile past a gravel road forking south. Park at a dirt road leading south. Walk down this dirt road and across the bar separating two bays. Note the well bedded Paleozoic sediments underlying the bar, and contrast them with the ridge to the north and the hill to the south, which comprise Precambrian Lorrain quartzite. From the south end of the bar, a well marked trail climbs the prominent hill, the summit of which is known as Dreamers Rock.

The view from the top is spectacular. To the north and west lie the North Channel, the Bay of Islands, and the La Cloche Mountains (photo 82); to the east there is McGregor Bay and Frazer Bay with the white hills of McGregor Point, Frazer Point, and Badgeley Point; and to the south Manitoulin Island spreads out in the vicinity of Little Current and Manitowaning Bay.

According to local Indian legend, youths from local tribes came here for their period of fasting before entering manhood. Several "bird-track" carvings are deeply incised in the hard rocks at the summit of this hill. A. J. Casson of the "Group of Seven" Canadian artists painted here and on the islands.

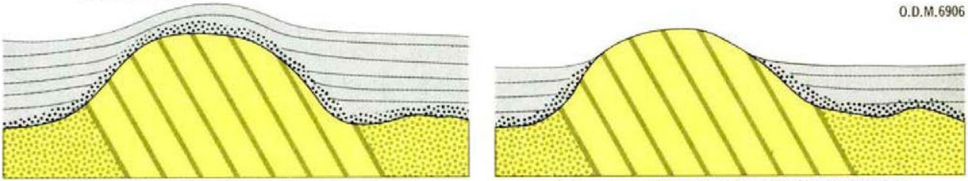
Return to Highway 68 and cross the causeway.

Photo 82. *View northwest from Dreamers Rock.*



1- Land surface developed over rocks; hard rock forms hills, soft rock forms low ground, boulders and soil at surface.

2- Land surface is submerged, wet sediments laid down, boulders and soil material incorporated in sediments close to contact.



3- Consolidation of sediments into rock, reduction of volume largely due to expelled water, of approximately one third.

4- Renewed uplift and erosion. Hill of hard rock sticks up in core of apparent anticline.

Figure 6. *Schematic diagram illustrating the development of drape folds.*

GREAT CLOCHE ISLAND AND GOAT ISLAND

The Great and Little Cloche Islands are named from the French word "cloche", meaning bell, after a group of rocks which when struck give a clear bell-like tone. Indian legend has it that they were tocsin rocks, struck and sounded on the approach of the enemy. The rocks are located at the eastern tip of the Great Cloche Island and are reached by a trail on the high plateau.

On the west shore of the channel north of the causeway, residues of weathered Lorrain sandstone are exposed immediately below the Paleozoic rocks. These represent weathered surfaces developed during the Lipalean Interval which have been preserved by the Paleozoic cover and are just now being re-exposed. To preserve the occurrences, sampling is not permitted.

Beyond the causeway near the railway crossing, bedrock comprising limestone and minor shale of the Bobcaygeon and Gull River Formations may be seen. These rocks are generally flat lying except in the vicinity of knobs and hillocks of the underlying Lorrain Formation, such as may be seen from Highway 68 between one mile and two miles south of the railway. Fold structures in the limestone, caused by compaction of the sediments during induration, reflect the structure of the contacts; thus, anticlines and domes in the sediments can be used to predict the shape of the contacts. Such folds are called drape folds or compaction folds (figure 6). These relationships are well exposed along Highway 68 on Great Cloche Island.

Continue over the bridge to Goat Island, on which the railway yards and the Little Current docking facilities are located. Immediately across the bridge there is a prominent road cut developed in limestone of the Verulam Formation.

Highway 68 on Manitoulin Island
Little Current to South Baymouth

A single-lane swing bridge leads from Goat Island to Little Current over the North Channel at the narrows leading to Georgian Bay. The bridge affords a view of the docking facilities on Goat Island. All shipping using Goat Island or passing between Georgian Bay and the North Channel passes this locality.

LITTLE CURRENT

Little Current is the largest community in the District of Manitoulin, for which it is also the administrative centre. It serves as a supply centre for the residents and the numerous tourists. Docking facilities for float planes, cruisers and yachts are available. Prominent road and railway cuts at the south end of the bridge expose the Lindsay Formation, which is moderately fossiliferous.

LITTLE CURRENT TO SHEGUIANDAH

Highway 68 meets Highway 540 in Little Current. Leave Little Current southbound on Highway 68. Three and a tenth miles from the junction, the road crosses a meandering creek. Shales of the Sheguiandah beds, the uppermost members of the Whitby Formation, are exposed in the banks of the creek. Graptolites, brachiopods, gastropods, cephalopods and crinoid stems are found in these shales. Approximately two-tenths of a mile further south, the next sequence above the Whitby Formation, namely the Wikwemikongsing beds of shale and limestone of the Georgian Bay Formation, are exposed on the west side of the road.

Half a mile beyond this point, there is a good view to the east over the eastern section of the North Channel and the entrance to Manitowaning Bay.

Sheguiandah Quarry

At a point five miles from Little Current, the old Sheguiandah quarry lies to the southeast of the road. The quarry was developed in a ridge of Bar River Formation penetrating the Paleozoic cover rocks. The hard quartzite of this formation provided prehistoric man with the source material for his spear and arrow heads and crude implements.

EARLY ARTIFACTS AT SHEGUIANDAH

Quartzite Tools

The village of Sheguiandah lies a mile and a quarter beyond the quarry. At this locality in 1951, scientists performing archeological

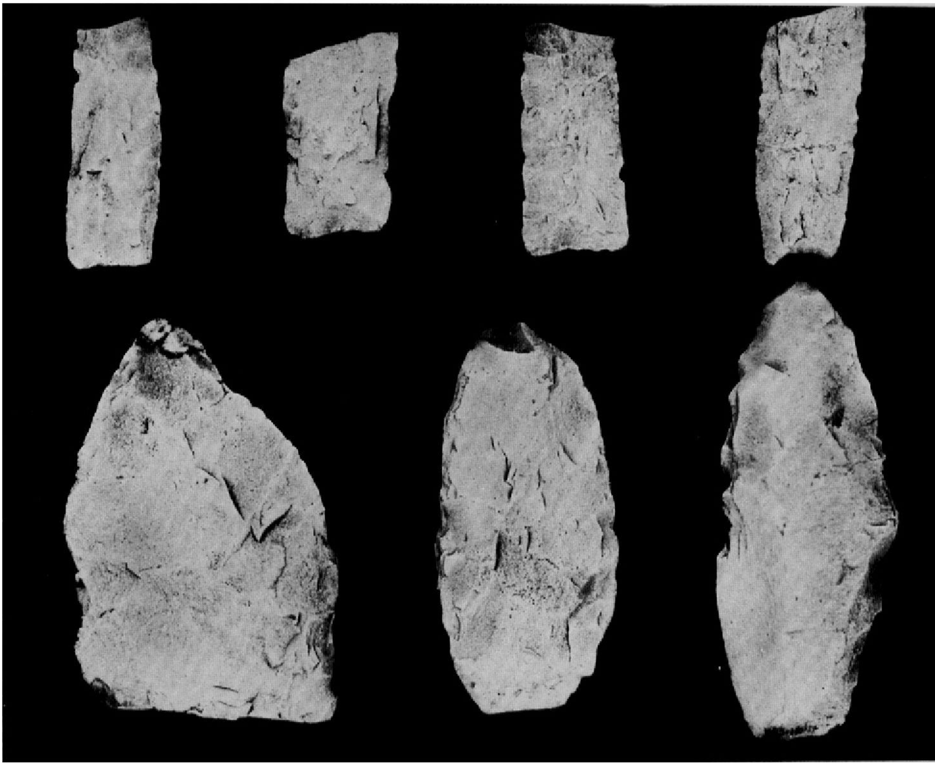


Photo 83. *Quartzite artifacts from Sheguiandah, Highway 68. Sheguiandah was a prehistoric quarry site found to contain artifacts in various stages of manufacture. The broken projectile points (upper row) are lance or spearheads probably made by late Paleo-Indian (Plano) peoples between 7000-8000 BC or possibly somewhat earlier. The large cutting and chopping tools (lower row) are also a type probably made by these early hunters as well as by later peoples (Shield Archaic) who also visited the site. The site was excavated by Thomas E. Lee of the National Museum of Man (Ottawa) in the early 1950s. (Photo courtesy Peter Storck, Royal Ontario Museum. Scale half actual size.)*

surveys for the National Museum of Canada found nearly a thousand quartzite artifacts at the surface of a hilltop site near several quartzite ridges. Excavating, the archeologists uncovered a massed layer of artifacts and quartzite chips but strangely no spear or arrow heads; lower still in a thin yellow soil layer, they found projectile points of an unusual type resembling those used by prehistoric western Indians. Further down in unsorted materials containing fairly large boulders, they uncovered fragments of quartzite tools quite different from those of the uppermost layer; deeper yet, another type of quartzite tool was found. At still lower levels, artifacts were encountered in meltwater deposits.

An Early Quarry

Meanwhile, beneath a nearby peat bog, they uncovered a rock surface identified as one quarried by human hands, together with more artifacts. This early quarry lay beneath a layer of peat which they found by radioactive age dating to be 9,000 years old.

Artifacts in Glacial Till

Obviously the artifacts found in the relatively undisturbed soil layers indicate a history of occupancy by man after the last ice had left the area. However, geologists identified the unsorted materials in which the lower artifacts were found at the first site as glacial till, leading to the conclusion that the site was occupied during the ice age. It is suggested that men occupied campsites along a glacial front in the area. As minor ice advances and retreats took place, the glacial till was reworked and the artifacts which had become incorporated in the deposits were moved short distances, then dropped.

The Area's Earliest Habitation

Various interpretations have been made from the evidence available. Certainly the site must have been worked more than 9,000 years ago and is the oldest indication of human habitation dated with certainty in the area. Some scientists, relating the glacial tills to specific interstadial times (halts with minor oscillations in the advance or retreat of ice sheets), have published opinions that they may be 30,000 years old or even older, but this is not universally accepted. The interest caused by the problems of age-dating the locality may have drawn attention from the fact that this locality has an astonishingly long history of quarrying and of persistent attraction for human habitation, for the Sheguiandah quarries were worked until quite recently and the site overlaps into the present day village. The local museum, with its exhibits on Indians and early settlers, is well worth visiting.

HIGHWAY 68 SOUTH OF SHEGUIANDAH

Just south of the Sheguiandah crossroads and adjacent to the Little Current Howland Museum, road cuts show Lindsay and Whitby Formations lying on an irregular surface of the Precambrian Bar River quartzite. Large blocks, boulders, cobbles and fragments of quartzite are abundant in the Ordovician sediments, particularly in the Lindsay Formation. The Ordovician sediments show drape folding over the knobs of quartzite. These features provide clear evidence of the unconformity.

Ten Mile Point Scenic Lookout

Continuing southward on Highway 68, the crest of the main escarpment occurs three miles south of Sheguiandah. At the Ten Mile Point scenic lookout, there is an excellent view eastwards over Manitowaning Bay and northeasterly over Heywood Island

and beyond to Badgeley Point and Frazer Bay. A historic sites marker commemorates the early Jesuit missions and particularly the mission established in 1648-1650.

High Falls

Five and a half miles further south, immediately east of the highway at High Falls, Francis Creek flows over a caprock comprising six feet of Ordovician limestone above 23 feet of thinly bedded shales and limestone (photo 84). Fossil coral is found at the base of the sequence.

HIGHWAY 68 SOUTH OF MANITOWANING

Manitowaning Area

The Manitowaning sideroad leads from Manitowaning to Wikwemikong and the Manitoulin Island Indian Reserve No. 26. In Manitowaning, the Pioneer Museum preserves early buildings and other relics of the settlers. Beside the museum, a historic

Photo 84. *High Falls, Manitoulin Island. Here Francis Creek flows over a caprock of massive Ordovician limestone overlying thinly bedded shales and limestones.*

sites marker commemorates the Indian treaties and the events leading to the colonization of Manitoulin Island (photo 80).

One and three-quarter miles south of Manitowaning on Highway 68, road cuts show massive tan and grey carbonate rocks that weather brown. These are the Silurian Manitoulin Formation. Fossil coral colonies are to be observed here.

One and a quarter miles past the Black Rock road on the east side of Highway 68, a tree-covered hillock is a drumlin into which a shoreline was cut during the Nipissing Stage of Great Lakes development.

Fossil Hill

Two and a quarter miles south of the Black Rock road, the Fossil Hill Formation is exposed to the west of the highway and along former Highway 68. This is the type section (see page 168). However, better fossil collecting is to be had on the western end of Manitoulin Island. Parking is best on the Eagles Nest road at the top of the hill.

HIGHWAY 68 SOUTH OF HIGHWAY 542

The junction of Highway 542 occurs about three and a quarter miles further south. A side trip along this road is described

Photo 85. *A limestone outcrop of the Amabel and Guelph Formations, illustrating facies change (see opposite page).*

below. Continuing south, the Amabel Formation is exposed in a road cut, two and a quarter miles beyond the Highway 542 junction.

At the South Bay road, an outcrop on the east side of the highway between the South Bay road and the outskirts of South Baymouth shows the relationships of the Amabel and Guelph Formations. At the south end of the outcrop, a massive bed of bluish crystalline limestone represents a former reef core. At the north end of the outcrop, thin bedded grey and pinkish carbonate rocks are draped against the core and constitute the flanking deposits. Within the flank deposits, a two foot tongue of tan dolomitic limestone of the Guelph Formation can be traced eastwards into the Amabel sequence. Such a lateral change from one sequence to another, by change in bedding and lithology, is referred to as facies change (photo 85).

SOUTH BAYMOUTH

Highway 68 ends at South Baymouth Dock, seventy-six miles from Espanola. From this point, ferry service is maintained during the summer months to Tobermory near the head of the Bruce Peninsula in southern Ontario. This is a popular access route from southwestern Ontario and adjacent parts of the United States. The rock exposures along the shore at this point show the Amabel Formation. Carious weathering (solution pits) and solution widening of the joints are characteristic.

Visitors may return to Little Current direct or continue on trips exploring the island to the west on roads, some of which are gravel. Return to Little Current may be made conveniently from several points along the side trips, notably Mindemoya and West Bay.

Highways 542 and 551

South Baymouth to Providence Bay

HIGHWAY 542

Return north to the junction of Highway 542 and turn west on Highway 542. Four miles from the junction, Highway 542 passes through the village of Sandfield, lying at the outlet from Manitou Lake, the largest of the inland lakes of Manitoulin. Just past the Silver Bay road, which is five and a half miles beyond Sandfield, there is a road cut in well bedded moderately fossiliferous limestone of the Fossil Hill Formation.

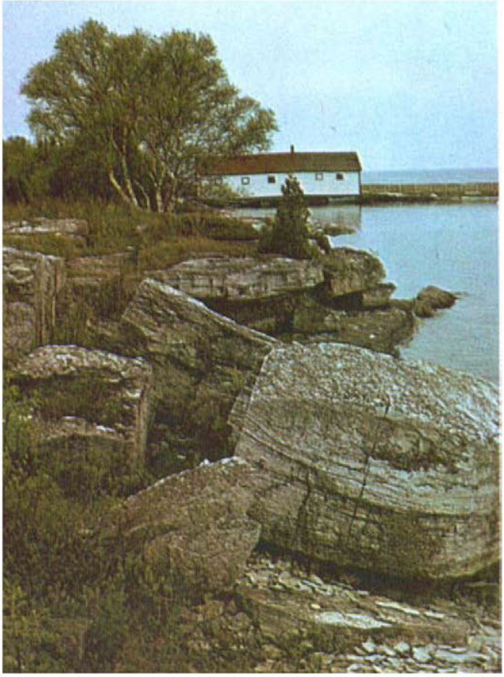


Photo 86. *Blocky limestone along the shore of Providence Bay.*

HIGHWAY 542 AND 551

Mindemoya

Highway 542 skirts Big Lake and reaches the village of Mindemoya. *For those breaking off the side trip at this point, Highway 551 leads north past Mindemoya Lake, with an excellent view of Treasure Island, to West Bay on the north shore of the island and easy access to Little Current.*

Continue west seven miles on joint Highways 542 and 551 past the southern tip of Mindemoya Lake. Turn south to Providence Bay on Highway 551.

PROVIDENCE BAY

At Providence Bay, follow the pavement through the village and along the east side of the bay to a junction with a gravel road leading east. The rocks exposed along the shore southwards past the Providence Bay dock to the lighthouse are of the lower Amabel Formation and the upper Fossil Hill Formation. The rocks are moderately to very fossiliferous, yielding mainly corals but also crinoids, brachiopods, and gastropods (photo 86).

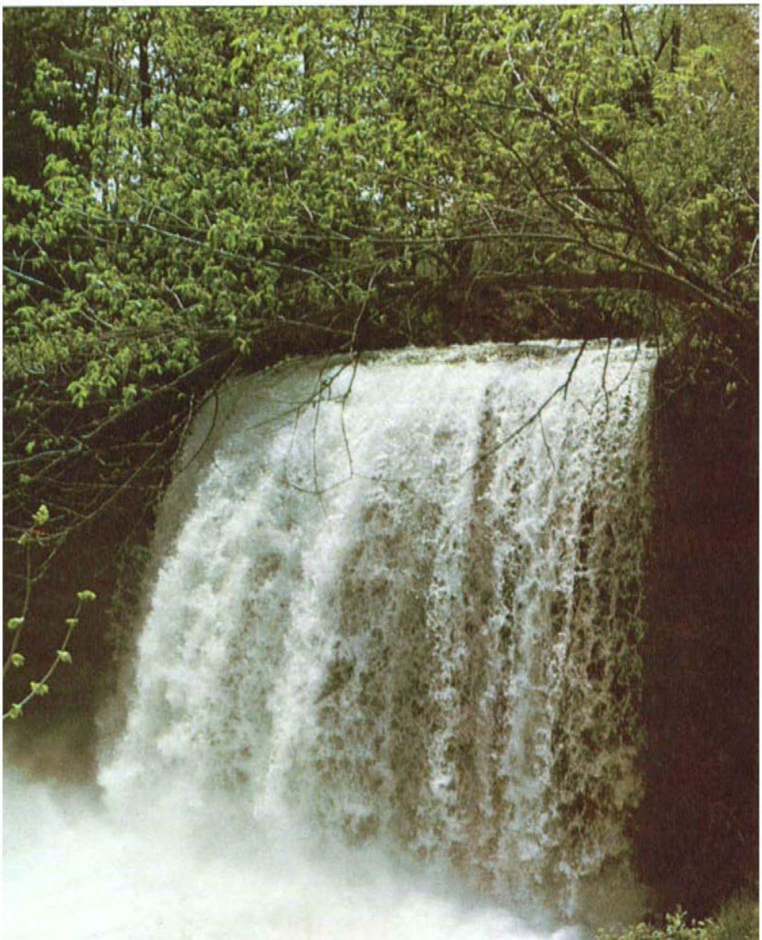
Providence Bay to Billings via sideroads

It is advisable to note mileages carefully on this short trip. Return north to the junction of Highways 551 and 542, and turn east on the joint Highways 551 and 542 towards Mindemoya. Go east 1.3 miles, then turn north on a gravel road. This road passes along the west side of Mindemoya Lake. At 2.4 miles north of Highway 542 on the brow of a hill, the Fossil Hill Formation (here very fossiliferous) overlies the Mindemoya Formation.

BILLINGS HILL

At 5.9 miles north of Highway 542, turn left at a road junction and at 7.2 miles fork left. The top of Billings Hill lies at 9.2 miles from Highway 542. Park at the top of the hill. This is the top of the escarpment. In the cuts descending the hill, the Fossil Hill and upper part of the Mindemoya Formation can be examined.

Photo 87. *Bridal Veil Falls, Kagawong.*



The Fossil Hill Formation is moderately to richly fossiliferous. The junction with Highway 540 is met at 9.6 miles. To the west, ditches on the south side of the road expose variegated shales of the Cabot Head Formation.

Those wishing to return to Little Current may turn east on Highway 540 (21 miles) via West Bay. For those going west on Highway 540, see the next trip.

Highway 540
Little Current to Campbell Bay

HIGHWAY 540 TO KAGAWONG

Drive west on Highway 540 from Little Current. Five and a half miles along the highway there is a beautiful view north over the North Channel of Lake Huron to the La Cloche Mountains. The prominent mountain at the west end is Mount McBean.

High Hill and West Bay

Twelve miles out of Little Current, the view ahead is of High Hill and the Silurian Escarpment. At the community of West Bay,

Photo 88. *Village of Kagawong from the dock.*

Photo 89. *The Ordovician-Silurian contact in a limestone quarry, one and a half miles west of Kagawong. The contact lies at the base of the narrow weathered band.*

Highway 551 leads south to Mindemoya and Providence Bay (see page 137). The Manitoulin District High School is located on the west side of West Bay.

Billings Hill

Three miles beyond West Bay at Billings, the junction is reached with the gravel road leading south to Mindemoya Lake described on page 137. The Billings Hill fossil locality lies on this road four-tenths of a mile south of the junction.

BRIDAL VEIL FALLS, KAGAWONG

The Bridal Veil Falls (photo 87) lie just east of the highway at the entrance to Kagawong. A limestone bed forms the caprock over a series of shales and limestone beds. A public footpath follows the creek to Mudge Bay. Highway 540 swings west here, but visitors are advised to follow the old road into the village of Kagawong (photo 88). Outcrops here are of the upper member of the Georgian Bay Formation (limestone forming the scarp) over the lower member of the Georgian Bay Formation (interbedded shales and limestones). Turn at the dock and return to Highway 540.

Photo 90. *A former Nipissing lake bar, represented by a gravel hill behind the dock, Gore Bay.*

Photo 91. *Campbell Bay and the Wolsey causeway.*

Photo 92. *Fossils in the Fossil Hill Formation, in a rock cut above Campbell Bay.*

Photo 93. *Sand dunes over a Nipissing platform near Poplar.*

Photo *94. The Manitoulin-Niagara escarpment across Campbell Bay from the Wolsey causeway.*

HIGHWAY 540 TO GORE BAY AND CAMPBELL BAY

Ordovician — Silurian Contact

The highway crosses a slight escarpment a mile and three-quarters west of Bridal Veil Falls. A quarry on the north side of the road shows 18 feet of massive dolomitic limestone overlying half a foot of thick bedded eroded dolomitic limestone. These constitute the basal part of the Manitoulin Formation of the Silurian System. They overlie 9.5 feet of thick bedded dolomitic limestone of the Georgian Bay Formation, which is the uppermost formation of the Ordovician System. Fossils are to be seen particularly in the uppermost unit (photo 89).

GORE BAY

The community of Ice Lake is passed after four miles; half a mile further on, Ice Lake itself lies to the south of the road. At the junction of Highways 540 and 542, Highway 540B leads north into the village of Gore Bay. The government dock is located two miles north of Highway 540 and provides an excellent view of the town of Gore Bay and of the escarpment on the east side of the bay. North of the dock, glacial and ice contact deposits have been modified by the Nipissing Lake Stage of the Great Lakes. The hill adjacent to the dock probably formed a bar in the earlier lake. To the north, a former beach line can be seen (photo 90).

Returning to the junction of Highways 540 and 542, continue west on Highway 540. The highway passes over a wave-washed bedrock plain on which remain lag deposits of abundant boulders, where these have not been cleared by the early settlers.

CAMPBELL BAY AREA

Highway 540A gives access to the Gore Bay air strip, and 540 swings south across a causeway separating Wolsey Lake from Campbell Bay. There is a picnic spot on the causeway just south of the bridge over the outlet from Wolsey Lake. This locality affords an excellent view of the Niagara Escarpment on the west side of Campbell Bay. Note the dip and scarp form or cuesta (photo 94).

Three-quarters of a mile beyond the picnic spot, take a gravel road which forks left and park at the top of the hill. The scarp is developed in the Fossil Hill Formation over the Mindemoya Formation. The Fossil Hill Formation is moderately fossiliferous (photo 92). A major attraction of this locality is the excellent view over Wolsey Lake and Campbell Bay (photos 91, 74).

The visitor may return to Little Current by Highway 540 or may continue west on Highway 540 to Meldrum Bay, the westernmost community on Manitoulin Island and the former docking point for a ferry service to Blind River. It is important to note that the ferry no longer operates.

RETURN VIA POPLAR AND MINDEMOYA

A slightly different return route may be followed by continuing along the gravel road south and east through Poplar to Highway 542, rejoining Highway 540 at Gore Bay or continuing east to Mindemoya.

Four and a quarter miles along this road from the Wolsey Lake south roadcut, and two and three-quarter miles before reaching Poplar, the Nipissing shoreline is well exposed. On the north side of the road, a wave cut bluff is cut into Pleistocene till (photo 78). The nearshore flat is marked by bedrock showing prominent southwest trending glacial fluting. To the east and south of the road the base of the Nipissing bluff and the wave cut platform are obscured by sand dunes (photo 93).

This concludes the description of Manitoulin Island. Visitors should now return to Espanola and Highway 17.

Espanola to Serpent River

HIGHWAY 17 TO MASSEY

Drive west on Highway 17, which follows the Spanish River for some sixteen miles beyond McKerrow, keeping south of the Murray Fault. Half a mile west of Highway 68, on the north side of the road, a northwest striking Keweenawan olivine diabase dike cuts both an east striking metamorphosed sill of Nipissing Diabase and metamorphosed sedimentary rocks. The ridges which occur in this vicinity and as far west as Webbwood and Massey are composed of quartzite (white) or metamorphosed Nipissing Diabase (black). The low lying farmland is generally on clay and sand deposited at the bottom of lakes which formed in Recent time after the retreat of the Pleistocene ice sheet.

RIVER AUX SABLES, CHUTES PROVINCIAL PARK

Massey lies at the junction of the Aux Sables and Spanish rivers, and is a community of some 1,200 people serving an agricultural area and an Indian Reservation. Highway 553, a gravel road, runs north from Highway 17 and serves the Chutes Provincial Park and tourist camps in the vicinity of Whiskey Lake, Madawanson Lake, and Lac aux Sables. The Ontario Ministry of Natural Resources operates the Chutes Provincial Park on the northern outskirts of Massey beside a waterfall on the River Aux Sables. Note that some local signs use the spelling Aux Sable.

From Highway 17 to north of the Chutes Park, the River Aux Sables moves through a series of gorges eroded in schists interbedded with quartzite. The gorge to the north of the present highway bridge is well worth a visit. The park's name was derived from the log chute used to by-pass the falls as the logs were driven to the mill. The falls, which may be viewed from the picnic area, result from differential erosion, the harder rock units resisting the effects of water and abrasive rock fragments and the softer units being carried away. The park has nearly a hundred tent and trailer sites, a central water system, trailer dumping facilities and a picnic area. There is a small swimming beach.

MASSEY

The Massey Centennial Museum houses a collection of relics, photographs and records of the pioneer life of the area, and particularly of Fort La Cloche, the Hudson's Bay Company trading post formerly located at the mouth of the creek connecting La Cloche Lake to Lake Huron. La Cloche Lake is controlled by faults in the Lorrain quartzite, which forms the ridges or hills known as the La Cloche Mountains.

MASSEY AND HERMINA MINES

Mining and prospecting have long been part of the life of Massey. Copper was first discovered in 1900 just north of Massey at the site of what was to become the Massey Mine. Shortly afterwards and further to the west, the ore zone that became the Hermina Mine was discovered. These two properties have been owned and explored by various companies at intervals to the present day. The Massey had produced 633,264 pounds of copper by 1916 and the Hermina over a million pounds by 1909. The Hermina shipped only high grade ore, dumping the rest. Exploration continued intermittently, with various new mineralized zones being located. In 1965, Hermina Copper Limited commenced recovery of metal from the dumps and later mining was undertaken in the area of an old adit. Exploration continues.

The gravel road leading north from Highway 17 to these properties is two miles west of Massey and is well signed. The property owners will arrange tours on an informal basis and visitors are advised to enquire locally in Massey. Chalcopyrite, chalcopyrite-bornite, minor copper carbonate weathering products, pyrite and quartz are found on the properties.

Whiskey Lake Copper Showings

A number of copper showings are known in the Whiskey Lake area (reached by Highway 553), and there is one copper-lead showing and one gold showing, but these localities can only be reached by boat.

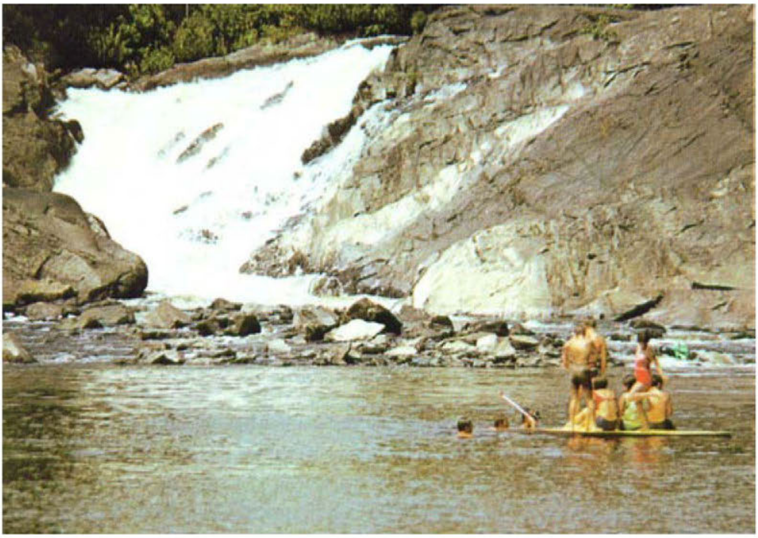


Photo 95. *The falls and swimming area, Chutes Provincial Park. (Courtesy Ont. Min. Industry and Tourism).*

WALFORD

Highway 17 continues westward, where possible following low lying ground over clay, sand, and gravel deposited in post glacial lakes or rivers. The ridges are of metamorphosed diabase or quartzite interbedded with minor schist.

Walford Bridge

Outcrops adjacent to the bridge over the Canadian Pacific Railway at Walford show interbedded quartzite and schist. The first outcrop east of the bridge on the south side of the road is the most conveniently examined. The rocks comprise well bedded, light grey, schistose quartzite passing upwards to dark grey, mica schist representing the original muddy material at the top of graded greywacke. The individual beds range in thickness from 6 inches to 18 inches. They strike at 80° east of north and dip 70° south. The schistosity is parallel to the bedding. In the more micaceous tops of the beds and in micaceous interbeds, the schistosity is cut by a later set of fractures, movement on which has caused crenulation of the micas. This younger or second foliation is called a fracture cleavage or crenulation cleavage (photo 24). In the quartzitic portions of the beds, there is a series of quartz veins striking at 60° east of north. These veins are called gash veins and fill a series of tension fractures which formed during differential shearing of the beds.

Looking southeasterly from the bridge, the high ridge of the La Cloche Mountains can be seen. To the north of Walford, another prominent ridge marks the outcrop of the Mississagi Formation on the north side of the Murray Fault.

Walford Church

At the Walford road junction, gravel pits have been developed in remnants of post glacial sands and gravels. An interesting outcrop lies along the north side of Highway 17 from Walford Church to the west end of the Walford by-pass. The dominant rock type is quartzite schist grading into mica-garnet-staurolite schist. The latter materials were originally the fine grained muddy material at the top of graded greywacke beds. The rocks strike parallel to the road (N 80° E) and dip 40° south towards the road. The schistosity, defined by the mica plates, is parallel to the bedding. The schistosity is cut by and bent parallel to a series of near vertical fractures, also roughly parallel to the road. These fractures are a second foliation or fracture cleavage, indicating deformation later than the metamorphism and first foliation or schistosity.

A sill of Nipissing Diabase is exposed at the west end of the outcrop opposite the west entrance to Walford. The basic min-

Photo 96. *Argillite and fine grained quartzite of the McKim Formation, Tube Lake, Victoria Township. Note some beds are laminated, some are cross laminated.*

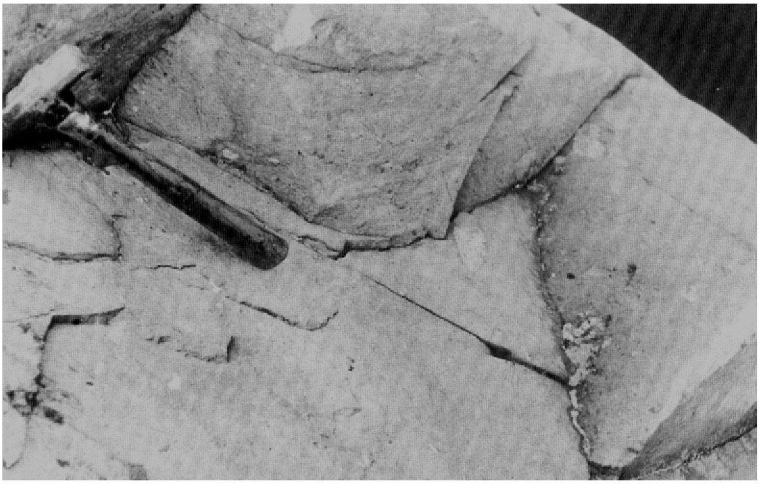
erals have been converted to hornblende and the hornblende crystals are aligned 80° east of north and are near horizontal. Both the metamorphosed diabase and the schists are cut by several northwest trending dikes of olivine diabase. These dikes cut across all the metamorphic textures and are therefore younger.

WATERFALLS ROAD SIDETRIP

This road, which is 3.4 miles west of Walford and the second of two roads signposted to Waterfalls resort, leads north to Denvic and Tube Lakes about three miles north of Highway 17.

A Bell relay tower is located on a ridge between the highway and a hydro line just under a mile north of Highway 17. The ridge follows the crest of a complex upfold or anticline of metamorphic rocks intruded by Cutler granite. Keep left at the junction with a concession road and continue north to a ridge of Nipissing Diabase 2.4 miles from the highway. The Murray Fault can be detected at 2.6 miles as a slight gully on the north side of the ridge. The next outcrop is in the Gowganda Formation. The waterfalls between Tube and Denvic Lakes are on the far side of the Waterfalls resort. Archean granite and the Matinenda, McKim (photo 96), Ramsay Lake (photo 97), Pecors, Mississagi, and Bruce Formations are well exposed along the shores of Denvic and Tube Lakes (map 5), and adjacent to the Waterfalls road between the Murray Fault and Tube Lake.

Photo 97. *Scattered granite pebbles in sparse conglomerate of the Ramsay Lake Formation, Denvic Lake, Victoria Township.*



HIGHWAY 17 TO SPANISH

Returning to Highway 17, a prominent ridge on the north side of the highway, which can be traced westward through Spanish to Cutler, is a metamorphosed Nipissing Diabase sill. Some bodies of quartz in this sill carry ilmenite. Altered staurolite crystals can be found in the schists of the schist complex between the Waterfalls road and the Elliot Lake road junction.

SPANISH

Spanish lies at the mouth of the Spanish River and has marina facilities for those wishing to operate boats in the North Channel of Lake Huron. The Spanish upfold or anticline is defined by a metamorphosed diabase sill and the core is intruded by Cutler granite. The anticline is broken by the Spanish Fault, and is cut off to the north by the Murray Fault. The geological relationships at Spanish are indicated on map 5. West of Spanish, Highway 17 enters rocky country but continues to follow the Nipissing Diabase sill.

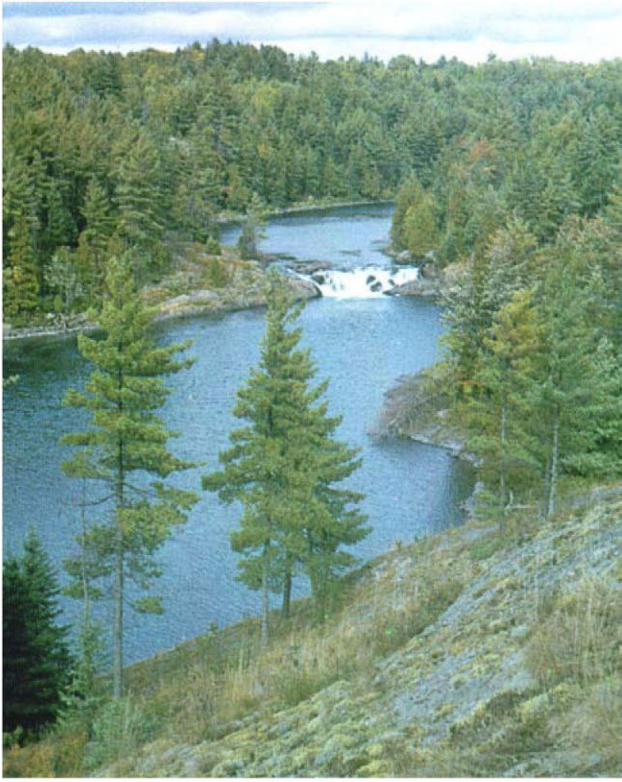
SERPENT RIVER ROAD (PIERCE'S ROAD)

This road turns north from Highway 17 just east of Cutler. At the northeast corner of the road junction, there is an outcrop of staurolite-bearing foliated rock or schist, cut by granite and pegmatite. The Serpent River road climbs generally northwards over the core of the Spanish Anticline and then drops sharply into the valley of the Little Serpent River, which follows the Murray Fault. Just west of this road is the Serpent River, the course of which is broken by several waterfalls marking the outcrop of the harder beds in the McKim-Pecors units (photo 98). These harder beds have resisted erosion by water and the sand and rock fragments carried along by the river, whereas the soft beds have gradually eroded.

CUTLER AREA

Westward along Highway 17 about half a mile west of the Serpent River road lies the site of the former Cutler Acid plant, where sulphuric acid was produced for use in the uranium mills of Elliot Lake. At the plant site and to the southeast are exposures of schists and quartzites showing minor folds and foliations formed at various geological time intervals. To the north of the highway lies the metamorphosed Nipissing Diabase sill, here represented by a hornblende schist. To the north of the sill lies a complex of metamorphosed sedimentary rocks with granite and pegmatite.

Photo 98. *The Serpent River north of Highway 17. The falls occur at the harder beds in the McKim-Pecors units.*



The hornblende schist is cut by a rectangular pattern of pegmatite dikes but not by granite. The hornblende crystals of the hornblende schist are elongate and sub-parallel to parallel with a near horizontal attitude. Such a rock is said to show mineral lineation, the lineation being due to the pressures which acted in the rock during the formation of the Spanish Anticline, at which time the hornblende was formed.

Aird Bay

At Cutler, the road looks out over Aird Bay to the islands in the North Channel of Lake Huron. Islands in the middle distance consist of Huronian quartzite and, on the horizon on a clear day, the limestone escarpment of Manitoulin Island can be seen.

Cutler Post Office

Near Cutler Post Office, outcrops of metamorphosed or altered sedimentary rocks and metamorphosed diabase (photo 26) show both an early foliation schistosity and a later foliation or fracture cleavage (crenulation cleavage), and are cut by Cutler granite and pegmatite. The granite and pegmatite were intruded along bedding and foliation planes and other fractures in the older rocks. Garnet and hornblende can be seen in the marginal phases of the metamorphosed diabase.

HIGHWAY 17 WEST OF CUTLER

Spanish Anticline

A mile west of Cutler, Highway 17 enters a series of road cuts. Detailed examination shows that to the north of the road the rocks slope north and to the south they slope south: the road is running along the axis of the Spanish upfold or anticline. The outcrops clearly show several easterly trending near-vertical foliations in the metamorphosed sedimentary rocks, and tabular shaped bodies (sills and dikes) of granite and later pegmatite following the bedding and foliation planes. Quartz, feldspar, muscovite, and small garnets are found in the pegmatite.

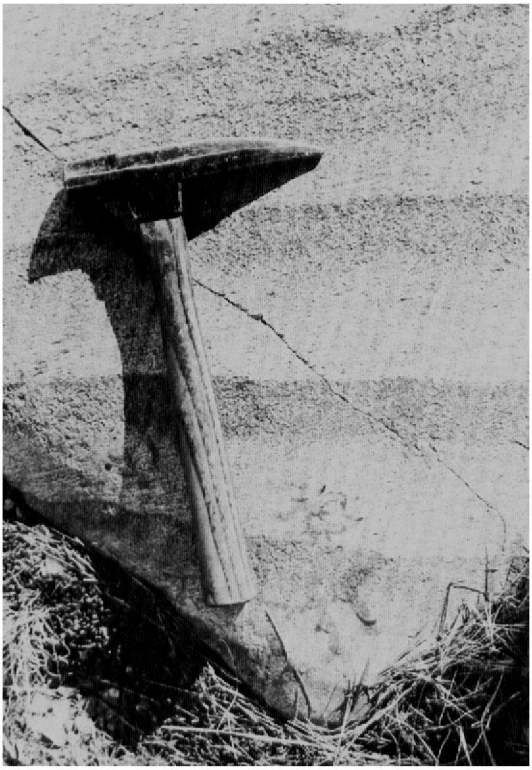
An interesting aspect of these rocks is that the pegmatites at this locality give age dates of 1,750 million years, which is interpreted as the minimum age of their intrusion, but the granites which are cut by them, and which therefore must be older, in fact give younger age dates of 1,350 million years. The explanation is that a second thermal event took place at 1,350 million years and the coarse grained pegmatite minerals were only marginally affected by it, whereas the older, fine grained granitic minerals were completely affected. 1,750 million years is thus the true minimum age of the Cutler granite.

SERPENT RIVER AND KENNEBEC FALLS

A parking and picnic area is located west of the bridge. In the vicinity of the bridge and falls, quartzites and schists and minor

Photo 99. *Aird Bay. The high ground in the middle distance comprises Nipissing Diabase. The islands on the horizon consist of Huronian quartzite. (Courtesy Ont. Min. Industry and Tourism).*

Photo 100. *Metamorphosed greywacke of the McKim Formation showing reverse-graded bedding. The hammer head is parallel to the schistosity (post-recrystallization foliation). The tops of the beds lie towards the top of the photo.*



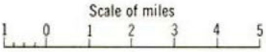
metamorphosed or altered diabase are exposed. Several foliations are visible, including at least two generations of easterly trending near vertical foliation and a late northerly trending vertical foliation, represented by the axial planes of sharp folds (or kink bands). Westwards from the community of Serpent River, the road runs parallel to high ridges of metamorphosed or altered diabase separated by valleys eroded in schists and quartzites.

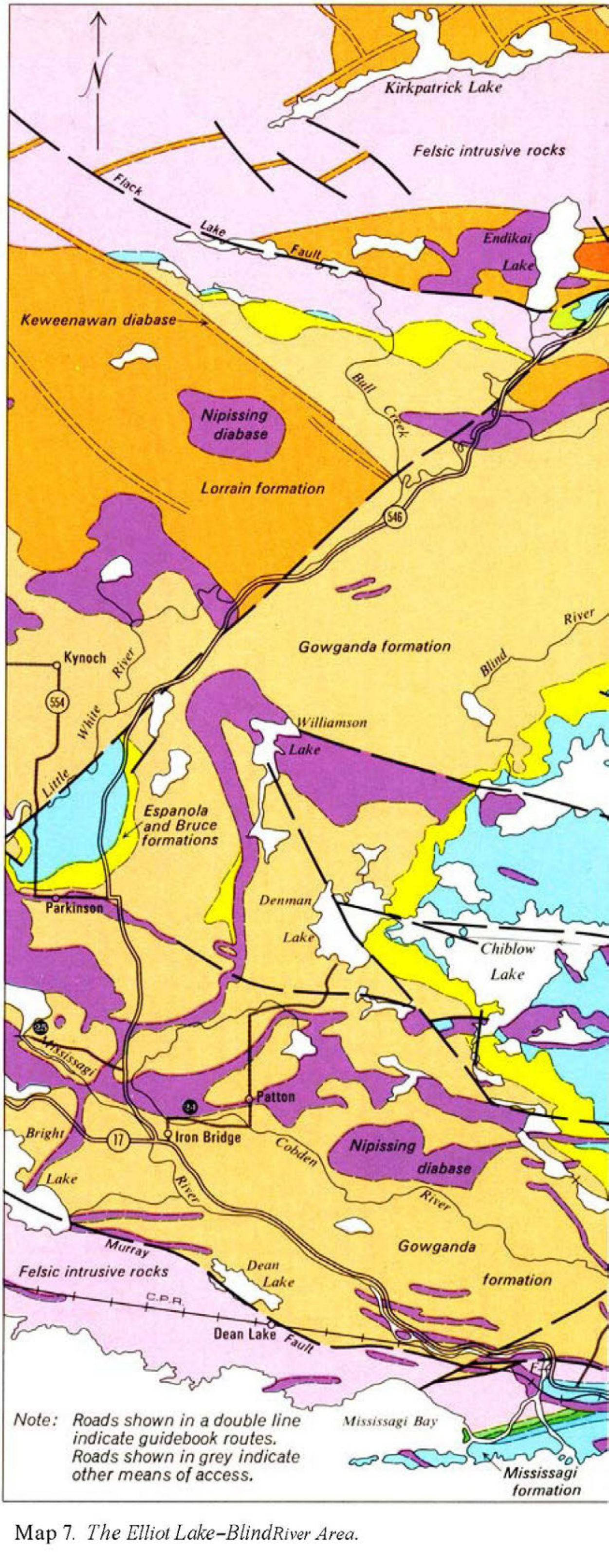
JUNCTION WITH HIGHWAY 108

Half a mile west of Serpent River, Highway 108 leads north to Elliot Lake. The outcrops immediately east of the south service station show McKim greywacke converted to staurolite mica schists (photo 100). The schists represent graded beds, in which coarse materials which originally graded upward into finer ones have been converted into medium grained quartz-feldspar-mica schists grading upward into coarse grained mica-staurolite schists.

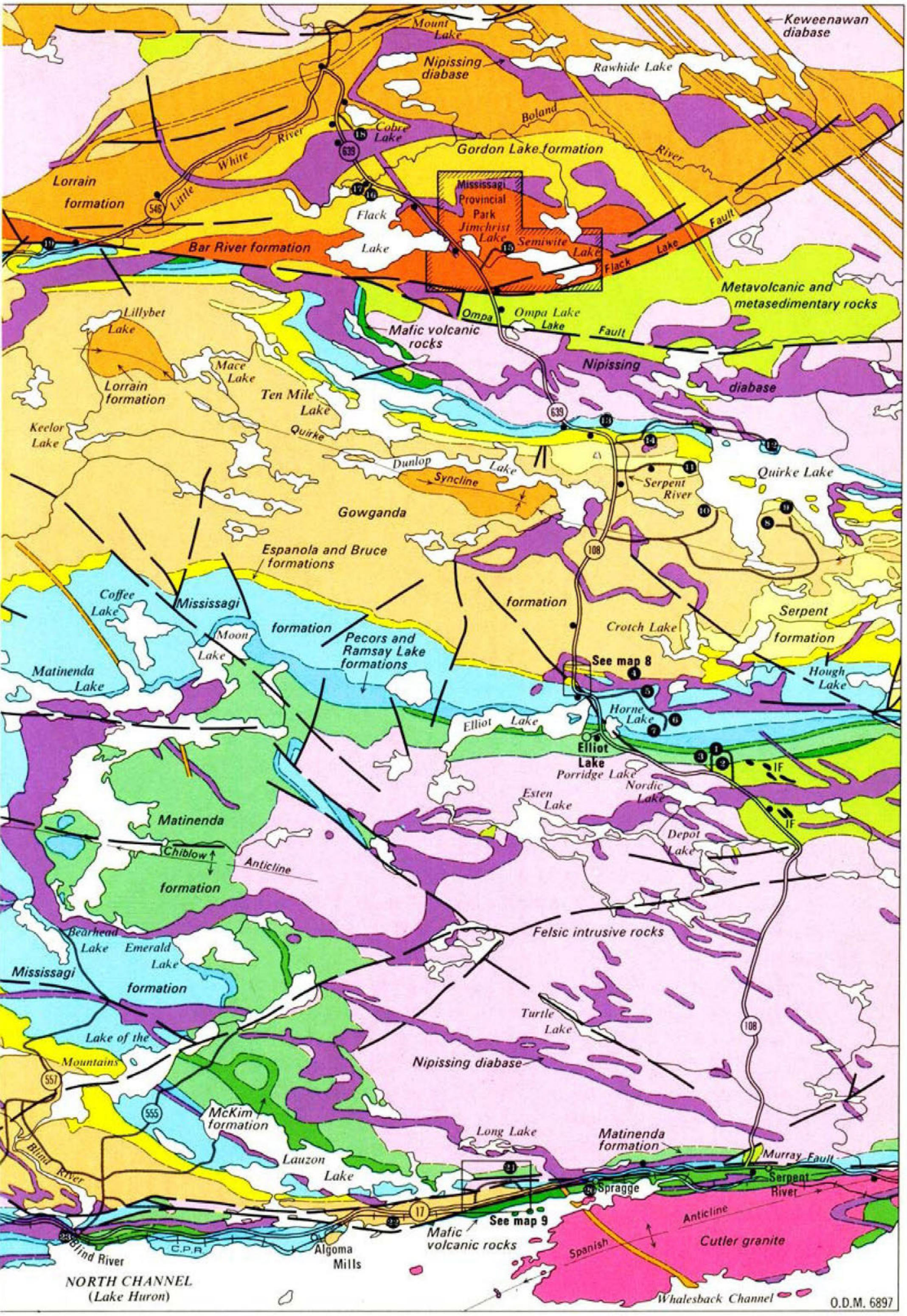
POINTS OF INTEREST

- ① *Nordic Mine.*
- ② *Elliot Lake Mines Research Station.*
- ③ *Buckles Mine.*
- ④ *Stanleigh Mine.*
- ⑤ *Milliken Mine.*
- ⑥ *Lacnor Mine.*
- ⑦ *Elliot Lake fire tower.*
- ⑧ *Stanrock Uranium Mine & Rooster Rock.*
- ⑨ *Can-Met Mine.*
- ⑩ *Spanish American Mine.*
- ⑪ *Denison Mine*
- ⑫ *Panel Mine.*
- ⑬ *Quirke No. I Mine.*
- ⑭ *Quirke No. 2 Mine & siltstone dikes.*
- ⑮ *Semiwite Campground.*
- ⑯ *Laurentian Lodge.*
- ⑰ *Flack Falls.*
- ⑱ *Bi-Ore Mine*
- ⑲ *Scarbo Bridge.*
- ⑳ *Pater Mine.*
- ㉑ *Pronto Mine.*
- ㉒ *Highway lookout.*
- ㉓ *J. J. McFadden Mill.*
- ㉔ *Glagoma Mine.*
- ㉕ *Red Rock Falls dam and generating station.*
- • *Additional point of geological interest (see text).*





Map 7. *The Elliot Lake–BlindRiver Area.*


Mount Lake
Keweenawan diabase
Nipissing diabase
Rawhide Lake
Boland River
Cobre Lake
18
639
Gordon Lake formation
Lorrain formation
546
Little White River
17
16
Mississagi Provincial Park
Jimchrist Lake
Semiwite Lake
15
Flack Lake
Flack Lake Fault
19
Bar River formation
Metavolcanic and metasedimentary rocks
Ompa Lake
Ompa Lake Fault
Mafic volcanic rocks
Lillybet Lake
Lorrain formation
Mace Lake
Ten Mile Lake
Nipissing diabase
Keelor Lake
Quirke
639
13
14
12
Dunlop Lake
Syncline
11
Serpent River
Quirke Lake
10
9
8
Gowganda formation
108
Espanola and Bruce formations
Coffee Lake
Mississagi formation
Moon Lake
Pecors and Ramsay Lake formations
Crotch Lake
Serpent formation
See map 8
4
Matinenda Lake
5
Hough Lake
Horne Lake
6
7
Elliot Lake
Elliot Lake
3
1
2
IF
Porridge Lake
Nordic Lake
Esten Lake
IF
Matinenda
Depot Lake
Chiblow Anticline
formation
Felsic intrusive rocks
Bearhead Lake
Emerald Lake
Mississagi formation
Turtle Lake
108
Lake of the Mountains
Nipissing diabase
557
McKim formation
555
Long Lake
Matinenda formation
Murray Fault
Blind River
Lauzon Lake
21
Spragge
20
Serpent River
17
22
See map 9
Anticline
23
Blind River
C.P.R.
Algoma Mills
Mafic volcanic rocks
Spanish
Cutler granite
NORTH CHANNEL (Lake Huron)
Whalesback Channel
O.D.M. 6897

The Elliot Lake Area

The long side trip described in the next section gives the opportunity of visiting the Elliot Lake uranium mining area and the hunting, fishing and touring country to the north. For those who do not wish to return via the same route, a connection can be made with Highway 17 about thirty five miles further west at Iron Bridge. The possibility also exists of working across on country roads to the Chapleau route of the Trans-Canada Highway, rejoining Highway 17 at Thessalon.

A number of side visits away from the highway are also described. If they are included, the return trip could exceed 150 miles. There is accommodation in Elliot Lake, at the tourist resorts and at the Semiwite Provincial campground.

Highways 108, 639, 546 and the adjacent roads give access to Elliot Lake, the nearby mines and the hunting, fishing and tourist country in the vicinity of Elliot Lake, also to Dunlop Lake, the Mississagi Provincial Park, Flack Lake and the upper reaches of the Little White River. Prior to the discovery of uranium, the only industries were lumbering and the tourist trade, and the only access was by plane or by gravel road from Iron Bridge along the Little White River. With the discovery of uranium and the rapid development of the area, the town of Elliot Lake was founded. The history of the discovery and development of the Blind River-Elliot Lake camp is described in a later section (on page 177).

Photo *101. A beaver dam near the junction of Highways 108 and 17, Spragge Township. Note the man in the foreground.*

Photo 102. *Elliot Lake, the uranium capital of Canada.*

Photo 103. *Milliken Mine, Elliot Lake. The hill behind the mine building is a sill of Nipissing Diabase. (Courtesy Ont. Min. Industry and Tourism).*

Highways 108, 639 and 546

HIGHWAY 108 TO THE NORDIC MINE

Turn north on Highway 108. The first outcrop north of the junction shows chlorite schist developed along and marking the position of the Murray Fault. About a quarter mile beyond this point, Archean basement rocks and rocks of the Mississagi Formation lying above them have been tilted into a vertical position adjacent to the Murray Fault. They are best seen along the power line east of Highway 108.

For the next ten miles to Depot Lake, the road passes over the Archean granitic complex, with zones of gneiss representing ancient sediments and amphibolite representing ancient basic igneous rocks. The complex is cut by numerous diabase dikes. The terrain is hummocky and the lower areas are swampy. Beaver dams and huts may be seen from or near the highway (photo 101). One mile north of Highway 17, amphibolite breccia is cut by granite. An amphibolite is a rock consisting mainly of amphibole (a silicate mineral) and formed by the recrystallization of basic igneous or volcanic rocks; a breccia is a rock consisting of angular rock fragments surrounded by fine grained material, in this case amphibolite and granite. There is a similar occurrence a mile and three-quarters beyond this point.

Depot Lake Area

Highway 108 bears northwest at Depot Lake where there are public picnic grounds. From Depot Lake to the vicinity of the Nordic Mine access road, the highway runs over Keewatin rocks cut by Nipissing Diabase. Roadside rock exposures are of greywacke, lean iron formation, chloritic slate, and basic volcanic rocks. The greywackes are thinly bedded and weather in shades of grey. The bases of the beds are light grey and are medium to coarse grained. The tops of the beds are darker grey, muddier in composition, and are medium to fine grained. Beds of this type are said to be graded. Grading is caused by the larger and heavier grains settling rapidly through water and the finer material settling more slowly, or by deposition from currents flowing rapidly initially but slackening as deposition proceeds.

Half a mile past the road to the Elliot Lake airport there are large gravel pits. The prominent ridge north of the gravel pits is a Nipissing diabase-diorite intrusive. It is unmetamorphosed and should be contrasted with the metamorphosed rocks along Highway 17. Iron formation may be seen by walking along the old highway southeasterly from the southwest corner of the pit on the east side of the highway, as far as a beaver pond. Immediately south of the beaver pond there are good exposures of iron formation (photo 104). Iron formation is a sedimentary rock containing more than fifteen percent iron. In this case the rock is finely banded quartz and quartz-magnetite.

Photo 104. *Thin bedded Keewatin iron formation.*

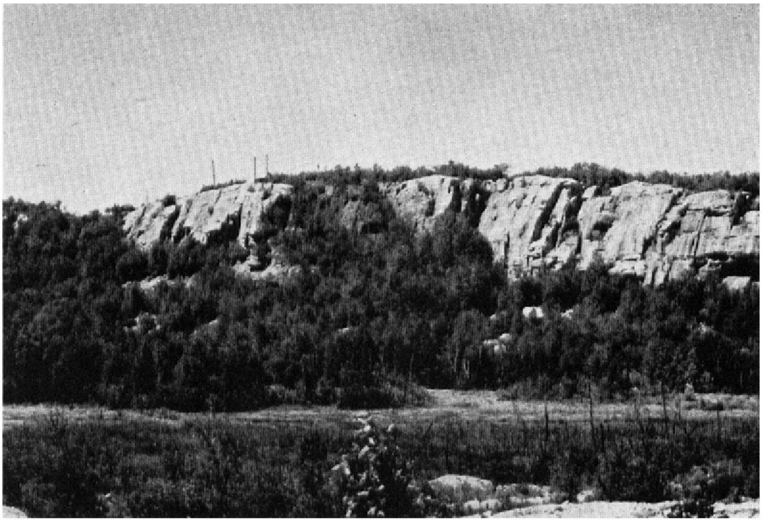
BUCKLES AND NORDIC MINE AREA

Returning to Highway 108, a mile and one quarter further north on the east side of the highway, an access road leads to the Nordic Mine, the Elliot Lake Golf Course and the Elliot Lake Mines Research Station. Half a mile beyond the Nordic Mine road, the site of the former Buckles Mine lies north of Highway 108. The cliff between the Buckles and Nordic Mines is the scarp of the Matinenda Formation (photo 105). Several thin diabase dikes cut the arkose but run parallel to the cliff. The low outcrop in the valley is feldspar-rich quartzite of the Matinenda Formation overlying the ore zone. Pebble bands are radioactive but the arkose is only weakly radioactive.

RADIOACTIVITY IN ROCKS

A radioactive element is one which breaks down spontaneously to form another element whilst giving off minute particles and energy waves. The best known examples are uranium, thorium and potassium. Almost all commercial uses of radioactivity are based on uranium. The energy created is used in weapons, in power stations, and to make other substances radioactive. Geologically, radioactive elements are important because age relation-

Photo 105. *The escarpment of the Matinenda Formation near the Nordic Mine. A near-vertical diabase dike can be seen cutting the quartzite.*



ships can be determined from them. By measuring the rate of decay and the proportion of the parent isotope to the product isotope present, it is possible to calculate the time in the past at which no product isotope was present. This can be related to geologic events such as the crystallization of an igneous rock or a period of major metamorphism.

Radioactivity can be detected and measured with a number of instruments, in particular the geiger counter, the scintillometer, and the gamma ray spectrometer. Both the scintillometer and the gamma ray spectrometer can be used in low flying aircraft but they only record the radiation from rocks at the surface.

ELLIOT LAKE AREA

About two miles beyond the Buckles Mine near Porridge Lake, Highway 108 runs along a fault. The Matinenda Formation outcrops on the east side of the road, but Archean granitic rocks outcrop on the west side. The Matinenda Formation outcrops on the west side of the road at the southern outskirts of Elliot Lake townsite and in the commercial area of Elliot Lake (photo 106).

THE TOWN OF ELLIOT LAKE

Highway 108 by-passes the town of Elliot Lake, which is a modern community boasting a wonderful setting, summer and winter sports, a school for continuing education, an art school, a nuclear museum featuring exhibits of the nuclear industry and local natural history, a community centre, a hospital, a regional high school and a technical school. The town has waxed and waned with the uranium industry but currently its population is about 12,000. As uranium comes into its own as the fuel of the latter part of the 20th century, continued growth and prosperity seems certain. The municipal offices and the Elliot Lake nuclear museum are located (1971) in the former Elliot Lake Hotel, a quarter mile north of the southern entrance to Elliot Lake.

Horne Lake lies across Highway 108 from the Elliot Lake townsite. To the east of Horne Lake, there is an escarpment in which the Mississagi Formation (light grey, thick bedded) is seen to rest on the Pecors Formation (dark grey, thin bedded). Outcrops along the highway and in the vicinity of the Elliot Lake shopping area are of the Matinenda Formation. These outcrops show bedding and crossbedding. One outcrop on Balsam Place shows

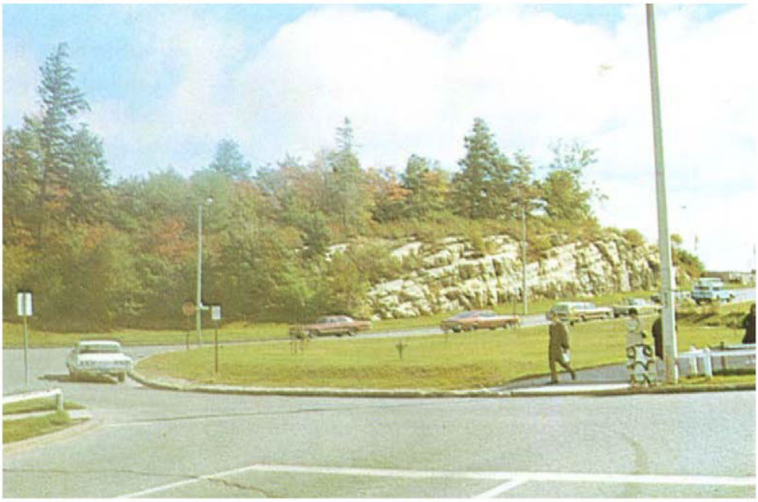


Photo 106. *An outcrop of the Matinenda Formation, near the Post Office, Elliot Lake.*

the McKim Formation cut by a diabase dike. The McKim Formation is here unmetamorphosed and should be contrasted with the schists and foliated or schistose quartzites on Highway 17 between Sudbury and the junction with Highway 108. The sequence here is of argillite and impure quartzites. These rocks have fractured under stress but the attitude or slope of the fractures varies with the rock type.

STANLEIGH, MILLIKEN AND LACNOR MINE ROAD

A short side trip along the sideroad to the former Stanleigh, Milliken and Lacnor Mines leads east from Highway 708 and gives access to the Elliot Lake fire tower, which provides a good view over the area.

On leaving the town of Elliot Lake, the lake itself lies to the west of the highway. There is access to the lake near the trailer park for visitors. The access road runs east from the highway along low ground, to the south of which lies a ridge marking the outcrop of the Mississagi Formation. To the north, the high ground marks the outcrop of a Nipissing Diabase sill. Half a mile east of Highway 108 there is an outcrop showing excellent cross-bedding in the Mississagi Formation (grey feldspar-rich or feldspathic quartzite). The Stanleigh and Milliken Mines lie to the north side of the road (photo 103).

Elliot Lake Lookout

Half a mile southeast of Milliken Mine, a gravel road runs south up the dip slope of the Mississagi escarpment to the Elliot Lake fire tower and lookout. An excellent view of the countryside can be obtained from this point, even from the ground level (photo 107). On a clear day, Manitoulin Island and the La Cloche Mountains stand out in the distance and, in the foreground, the Elliot Lake townsite and the mine sites of the Nordic orebody can be seen.

Geological structures control topography. Hard rocks tend to form ridges or escarpments and softer rocks are eroded as valleys. Where the rocks dip or slope, the steep side of the ridge is known as the escarpment and the gentle side, more or less parallel to the slope or dip of the rock, is called the dip slope.

The gate to the Lacnor Mine lies a quarter mile east of the fire tower access road. An outcrop just west of the gate shows shattered Mississagi flaggy quartzite. A flaggy sedimentary rock is one which is thinly bedded and splits along the bedding, giving sheets of rock similar to those used for flagstone or crazy paving. Some bedding planes show ripple marks, others show slickensides. When rocks have fractured and moved against each other in response to earth forces, the surfaces of the fractures become

Photo 107. *The view looking southeast from the Elliot Lake Lookout towards the La Cloche Mountains. The Nordic Mine may be seen in the middle distance.*

scratched or striated. Frequently these surfaces are coated with minerals such as calcite or chlorite which are also striated. The sense of movement can usually be determined from these scratched surfaces, which are called slickensides. Crossbedding is characteristic of these quartzites.

Return to Highway 108 by the same road and continue north.

HIGHWAY 108 NORTH OF ELLIOT LAKE

An interesting section of highway occurs just north of Elliot Lake (see map 8) and special note should be made of the mileage from the Stanleigh road junction. At 0.8 miles from the junction, an outcrop on the west side of the highway shows excellent crossbedding in the Mississagi Formation. The Nipissing Diabase sill, referred to previously as forming the Lacnor – Milliken – Stanleigh ridge, will be seen at road level at 1.0 miles. Over the next few hundred feet, the following units may be observed: 1, the Nipissing Diabase previously mentioned; 2, the Mississagi Formation showing albite (pink) and chlorite (green) introduced from the diabase; 3, the contact with the Bruce Formation; 4, a second part of the diabase intrusion; 5, the Bruce Formation; 6, a transition zone to the Bruce Limestone member of the Espanola Formation; 7, the Bruce Limestone.

The Bruce Limestone has been recrystallized by the heat given up by the diabase body: a recrystallized carbonate rock of this type is called a skarn. Grossular (garnet), idocrase, diopside, and minor wollastonite are found; these do not show their crystal form. Drag folding caused by differential movement of differing layers during the formation of the Quirke Syncline, soft sediment slump folds, etched weathering, and a thin diabase sill exposed on the west side of the highway are other points of interest. The Bruce Limestone outcrop is bounded on the north by a gully at 1.3 miles north of the road junction, north of which the Gowganda Formation is exposed: the actual contact of the Bruce Limestone and the Gowganda Formation is not exposed.

Over the next mile, Highway 108 climbs through a series of road cuts which show Gowganda conglomerate of tillite type (compare with photo 19). Some people use this as an ornamental stone. At the top of the hill there is a spectacular road cut in bedded boulder conglomerate (photo 18) with conglomeratic quartzite interbeds. This conglomerate also makes a good ornamental stone. The relay tower for the Elliot Lake television satellite station is located on this ridge.

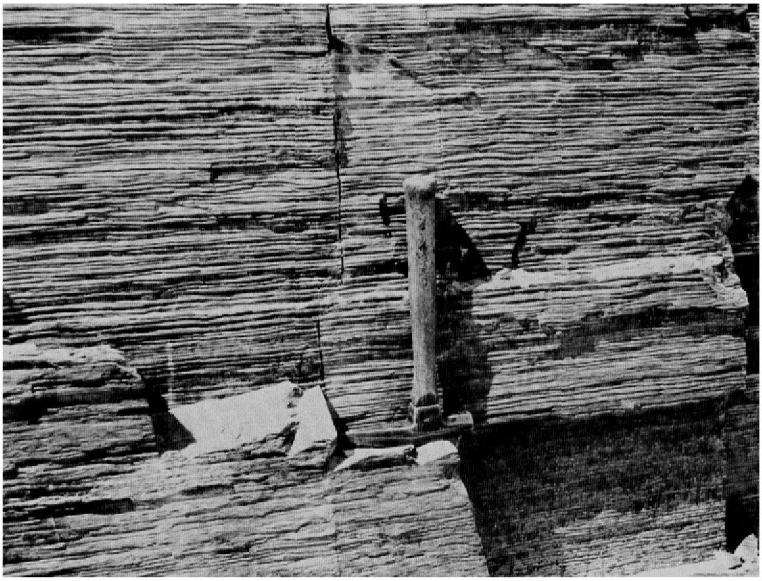


Photo 108. *Pebble free argillite of the Gowganda Formation along the Stanrock Mine road.*

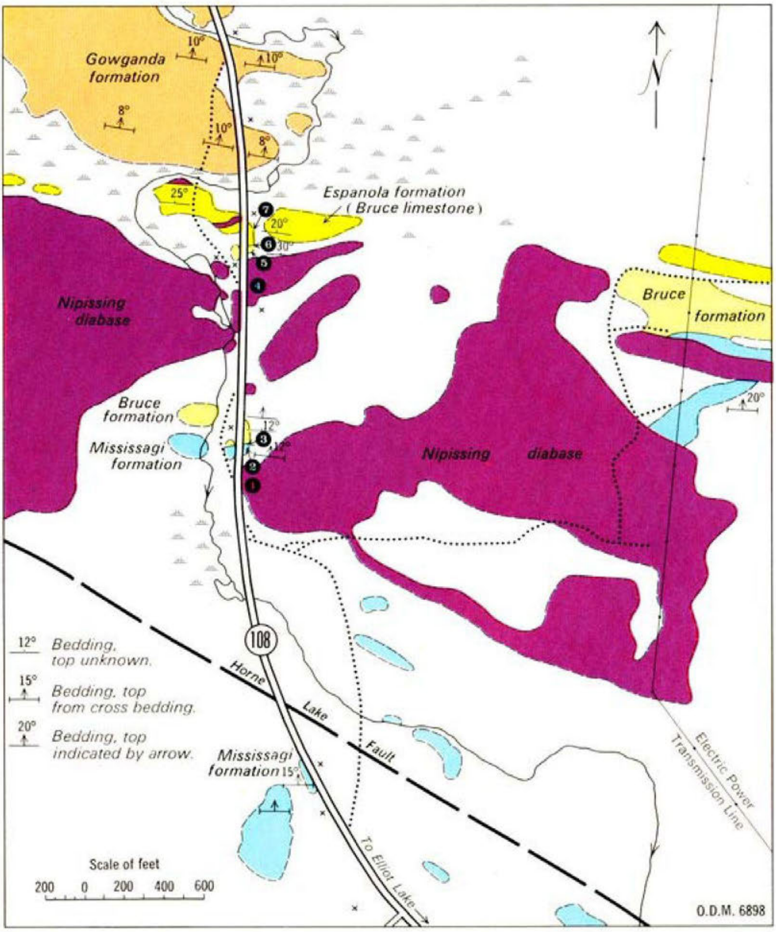
STANROCK, CAN-MET AND SPANISH AMERICAN MINE ROAD

The access road to the Stanrock, Can-Met and Spanish American Mines leads to the east about four and a half miles north of Elliot Lake. Just over a mile on the access road there is an outcrop of pebble-free argillite (photo 108). Highway 108 then continues north through interbedded sparse pebble conglomerate (tillite), pink feldspathic quartzite, and greywacke of the Gowganda Formation.

SERPENT RIVER, DENISON MINE ROAD

The Serpent River west of the highway gives access to Dunlop Lake, from which Ten Mile Lake can be reached by a portage near the west end of Dunlop Lake. At the east end of Dunlop Lake, there is a sinuous ridge of sand and gravel which follows Highway 108 northwards past the access road to Denison Mine. This ridge marks the site of a former stream which flowed in a crevasse or tunnel within the Pleistocene ice sheet; the sand and gravel was left by it. It is called an esker.

The access road to the Denison Mine leads east from Highway 108 a mile north of the Serpent River. Denison Mine is the free



Map 8. *Highway 108 just north of Elliot Lake. The bottom of the map lies 0.5 miles northwest of the junction of the Stanliegh mine road and Highway 108.*

world's largest single uranium production facility (photo 109). Between Highway 108 and the Denison Mine gate there are exposures of Gowganda Formation lying unconformably on the Serpent Formation. An unconformity is an ancient erosion surface preserved in the rock. Generally the rock above is a different type from the rock below and the bedding of the rock above truncates that of the rock below.

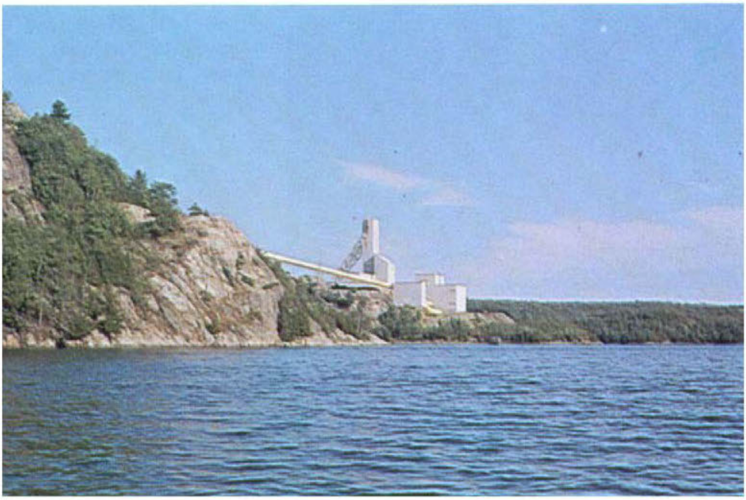
SIDE TRIP ALONG THE PANEL AND QUIRKE MINES ACCESS ROAD

The access road to the Panel Mine and the Quirke No. 2 Mine makes an interesting longer side trip of some 70 miles. It turns east about a quarter of a mile from the end of Highway 108 and the start of Highway 639.

Most of the rock outcrops which occur on the final quarter mile of Highway 108 and along the Panel road as far as the end of pavement at Quirke No. 2 Mine are in the Espanola limestone member of the Espanola Formation. The access road over much of this distance is close to a fault and near-vertical dips can be seen in several of the outcrops adjacent to the road.

The first outcrop east of the side road to Quirke No. 2 Mine shows most features of the Espanola Limestone, an interbedded brown weathering dolomitic siltstone and siltstone. They include such sedimentary features as ripple marks, small scale cross-bedding and dessication breccias. Slumpage structures, such as slumpage pillows, convolute bedding, flame casts, and siltstone dikes (photo 110), can also be seen. The formation is also well exposed on the shore of Quirke Lake at Denison Mine (photo 111), and on islands in Quirke Lake. These localities are only accessible by water.

Photo 109. *Denison Mine, No. 2 Shaft. The Denison Mine is the free world's largest single uranium mine. The contact between the Gowganda Formation (dark grey) and the Serpent Formation (pink-white) follows the tree belt in the cliff to the left of the mine.*



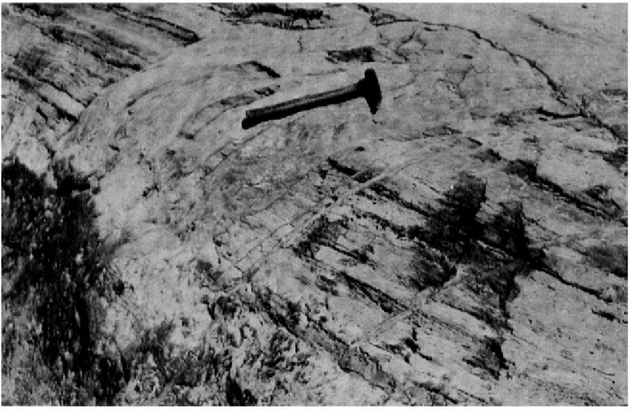


Photo 110. *A siltstone dike in the Espanola Formation at the entrance to Quirke No. 2 Mine, Township 150.*

Photo 111. *Dessication breccia in the Espanola Formation, Quirke Lake, Township 150.*

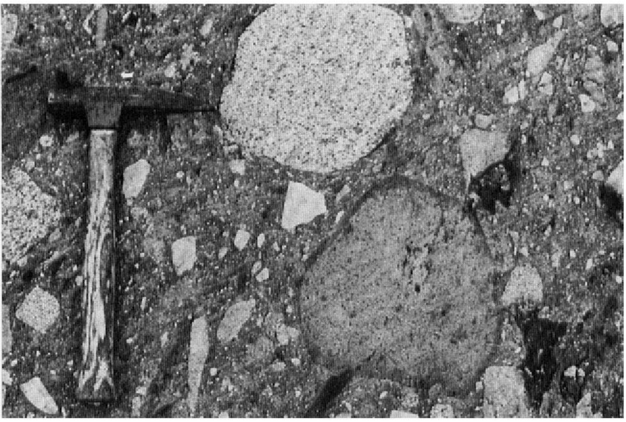


Photo 112. *Dense near-source conglomerate of the Ramsay Lake Formation, Panel road, northwest end of Quirke Lake.*

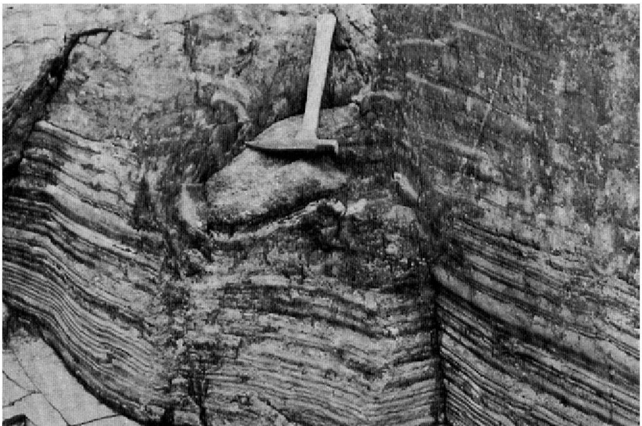


Photo 113. *Argillite with an ice rafted boulder of granite in the Pecors Formation, Panel road, northwest end of Quirke Lake.*

The Panel road swings north over the fully automatic railway which transports ore from the Quirke No. 2 shaft to the Quirke mill. A roadside cut shows the thin bedded white Bruce Limestone overlain by Espanola Greywacke. The next outcrop on the road shows Bruce Conglomerate. This is more densely packed than that already seen on Highway 108, indicating greater proximity to the source area (compare photos 12, 13).

Serpent River Valley

The road then turns eastward along the valley of the Serpent River. Outcrops on the south side of the road show green feldspathic sandstone of the Mississagi Formation. Pebbly horizons are moderately radioactive. Rocks of the same formation exposed on the Milliken access road and at the Elliot Lake fire tower are of quartzite and feldspathic quartzite without pebbles. The coarse grained feldspathic rocks were deposited by strong currents near the shoreline or source, and the fine grained rocks were deposited by relatively weak currents away from the shore or source. The Serpent River valley is eroded over the soft argillite of the Pecors Formation. The high ground to the north of the valley consists of red Archean granite.

Quirke Lake

Crossing from east of the Serpent River to the Panel Mine gate, the road runs just north of Quirke Lake along the contact between rocks of Archean and Proterozoic age.

Outcrops at the northwest corner of Quirke Lake show the boulder conglomerate of the Ramsay Lake conglomerate (photo 112) resting against weathered basement rocks. An outcrop just north of the road shows banded rhyolite, but most outcrops are of red granite. The boulder conglomerate is overlain by grey wacke showing graded bedding transitional to argillite. This sequence shows a number of pebbles and cobbles dropped from floating ice (photo 113, see also page 18). Outcrops in the Serpent River bed at the entrance to Quirke Lake show shattered argillite with numerous quartz stringers. Mud cracks and ripple marks may be observed in the argillite-conglomerate transitional rocks at a number of localities on the Panel road and at Quirke Lake. The mud cracks indicate that the rocks were exposed to the atmosphere and dried before the next layer was formed, and the presence of ripple marks indicates that the sediments were affected by wave action.

Islands in Quirke Lake

From the access road along the north shore of Quirke Lake, there are excellent views of the lake, the regional geology, and the uranium mines. Particularly impressive is Rooster Rock, a high cliff of Gowganda Formation on which is located the Stanrock Mill (photo 114). Two chains of islands cross Quirke Lake. The more northerly marks the outcrop of the arkosic Mississagi Formation; the southerly marks the outcrop of the Espanola greywacke member of the Espanola Formation.

Reference Sections

The west shore of Quirke Lake from the mouth of the Serpent River to the vicinity of the Spanish American Mine forms the Principal Reference Section for much of the Huronian Sequence. The area from which a formation, group, or supergroup has been described is called the type area. The locality within that area at which the sequence was measured is called the type section. On occasion, because no type section was measured when the unit was first described, a section is measured at a much later date. Such a section is termed the Principal Reference Section. Other measured sections which geologists may require for special purposes are then called reference sections. Markers indicate the formation boundaries in the field and specimens and descriptions are on file at the Mines Division, Ontario Department of Natural Resources in Toronto.

Return to Highway 108 by the same route and continue north to meet Highway 639.

HIGHWAY 639 TO SEMIWITE CAMPGROUND

The Quirke No. 1 Mine and the Quirke mill lie north of the junction of Highways 108 and 639. Half a mile beyond the junction, exposures on the south side of Highway 639 are of Bruce conglomerate similar to that on the Panel road. The cuts on the hill are in green-brownish arkosic Mississagi Formation and pebble bands show weak radioactivity.

Huronian Volcanics

The road then crosses the valley eroded over the Pecors Formation and the Ramsay Lake Formation. Outcrops at the roadside north of the valley 1.4 miles from the start of Highway 639 are of red Algoman quartz monzonite. On the south fringe of the outcrop west of the road, massive to amygdaloidal and/or porphyritic basic volcanic rocks can be seen resting on a regolith, formed on a granitic basement. A regolith is an ancient soil,

Photo 114. *Stanrock Mill and Rooster Rock, Quirke Lake, looking north. The Panel Mine access road follows the distant shore.*

the incoherent rock material which once formed a land surface above the granitic bedrock. Locally, quartz pebble conglomerate can be seen between the volcanic rocks and the Archean rocks, and elsewhere granite inclusions can be seen in flow rocks or granite cobbles in interflow sedimentary rocks.

During the initial mapping of this area, the presence of Huronian volcanic rocks was not suspected and the rocks were mapped as older Archean volcanics. However, further mapping in adjacent areas and recent exploration drilling clearly established Huronian volcanicity, which led to a re-examination of the locality and recognition of the relationships described above.

Ompa Lake Fault

Brick red granitic rocks cut by diabase dikes are exposed to Ompa Lake. The road is crossed by a fault, the Ompa Lake Fault, just over four miles along Highway 639; in a further half mile, road cuts and shoulders expose volcanic and sedimentary rocks of Keewatin type with good exposures of pillow lavas (photo 115). Pillow lavas are lava flows in which the lava tends to form globular masses several inches to several feet across. These probably formed under water.

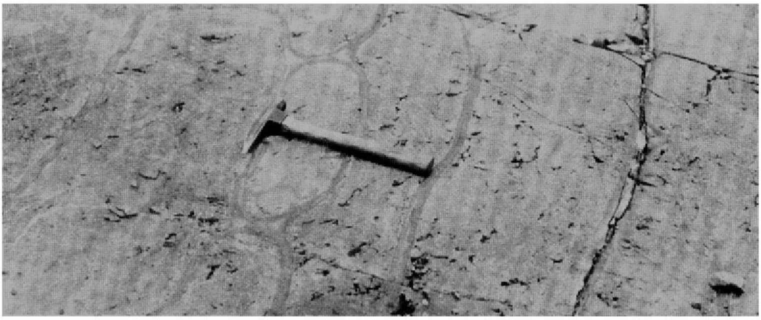


Photo 115. *Keewatin pillow lava one mile north of Ompa Lake, Highway 639. The hammer handle points towards the top of the sequence.*

Flack Lake Fault

At the north end of this series of outcrops, there are exposures of schists developed from graded-bedded greywackes: going northward they are strongly fractured and intruded by quartz veins. Highway 639 drops sharply into a valley, at the bottom of which is an outcrop of shattered quartzite of the Bar River Formation. The Flack Lake Fault lies between this outcrop and the schists previously described and is located right at the marker indicating the south boundary of the Mississagi Provincial Park. The Bar River Formation is exposed over the next few miles. It is essentially well bedded, cream coloured quartzite (photo 23) showing crossbedding, ripple marks (photo 116), mud cracks (photo 117),and other dessication features characteristic of deposition in intermittent shallow water. Some horizons are iron stained. Folding (photo 23) decreases in intensity away from the Flack Lake Fault.

Photo 116. *A ripple marked bedding plane in the Bar River Formation, Highway 639 near Semiwite Lake, Mississagi Provincial Park. (Courtesy N. Woodward).*

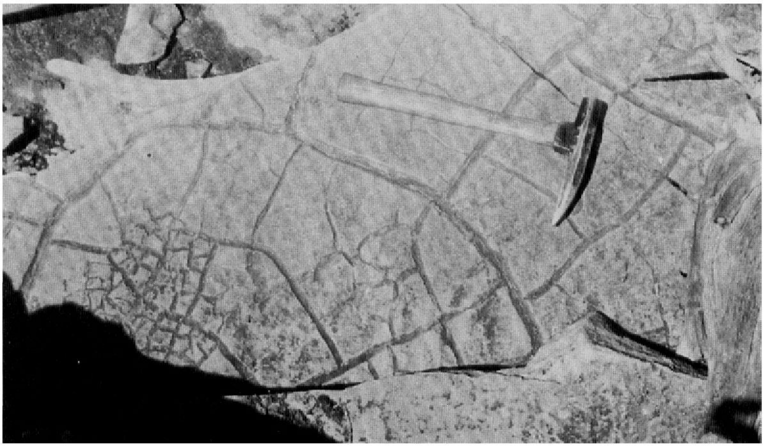


Photo 117. *A bedding plane showing mudcracks, Bar River Formation, Flack Lake, Township 157.*

SEMIWITE PROVINCIAL CAMPGROUND

Just under a mile beyond the Flack Lake Fault, an access road leads east to the Semiwite Campground of the Ontario Ministry of Natural Resources. This campground is located in the Mississagi Provincial Park, one of Ontario's natural environment parks. In addition to facilities for canoe trips and bush trail hiking, there are about a hundred and twenty family campsites, as well as picnic sites, swimming beaches, docks and boat ramps. Campers are advised to obtain supplies at Elliot Lake.

HIGHWAY 639 TO BOLAND RIVER

Flack Lake

Highway 639 continues north past Jimchrist Lake, shown on most maps as Christman Lake, and crosses Flack Creek joining Jimchrist and Flack Lakes. Ripple marked flaggy quartzites and iron bearing quartzites are exposed on the highway and along the creek. A pleasant short walk westward along an old portage leads to Flack Lake. A few hundred feet further north on Highway 17, the Flack Lake access road of the Ontario Ministry of Natural Resources also leads down to the lake. The hills on the west side of Flack Lake are folded white quartzites of the Bar River Formation. Both on the highway a mile north of the Semiwite road and along the shores of Flack Lake, ripple marked bedding planes have sinuous structures which some geologists believe to be fossils, possibly worm casts (photo 22; see page 34 for explanatory text).

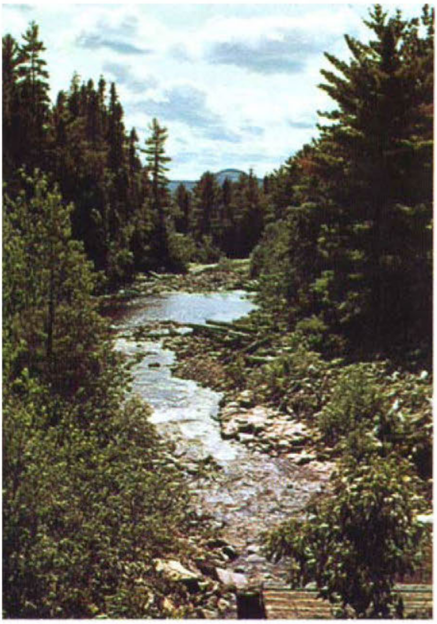


Photo 118. *Flack Creek from Highway 639. Old Baldy, a prominent quartzite ridge is seen on the horizon.*

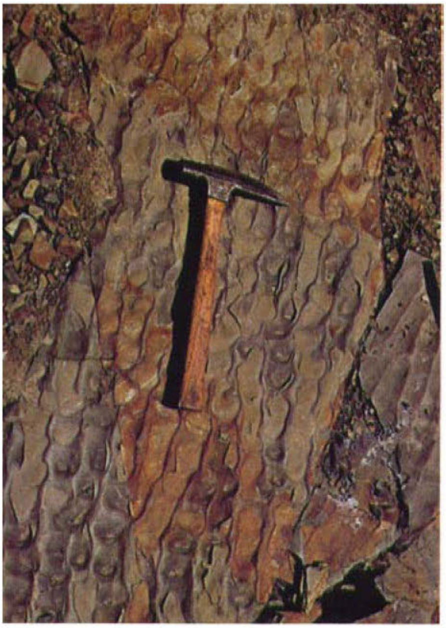
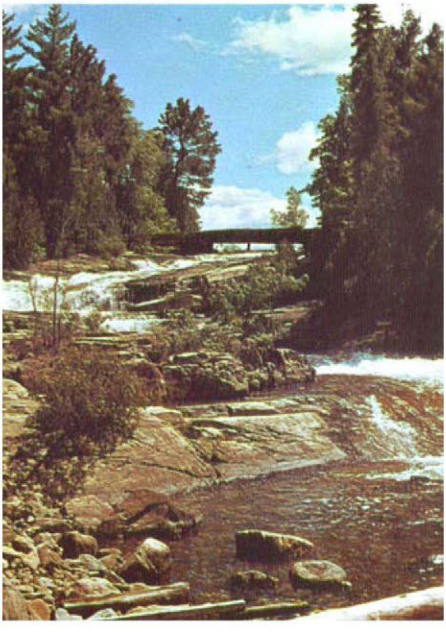


Photo 119. *Ripple marks in the Gordon Lake Formation. Highway 639 at the entrance to Laurentian Lodge.*

Photo 120. *The east trench wall, Bi-Ore Mine, Cobre Lake. The vein comprises massive chalcopyrite (brassy) in quartz (grey) and carbonate (white). Weathering has developed malachite (green) and limonite (brown).*

Photo 121. *Flack Falls at Laurentian Lodge. Flack Creek cascades over hard bands in the Gordon Lake Formation.*



Half a mile beyond Flack Creek, a small scale anticline in the Bar River quartzite (photo 23) may best be seen on the east side of the highway. The Bar River Formation continues for a mile and three-quarters north of Flack Creek, until bedded, fine grained, pinkish quartzite marks the transition zone between the Bar River and Gordon Lake Formations.

Immediately north of this point there, is an outcrop of diabase showing columnar jointing. When basic igneous rocks cool, they develop fractures or joints. These fractures sometimes form a hexagonal pattern dividing the rocks into columns, the long axis of which is at right angles to the cooling surface. The fractures thus formed are called columnar joints, the best known example of which is the Giant's Causeway on the north coast of Ireland.

BOLAND RIVER

The road descends to the Boland River, crossing through intermittent exposures of interbedded siltstones, cherts, and fine grained sandstones of the Gordon Lake Formation. The best outcrop lies a quarter of a mile south of the Boland River at the entrance to Laurentian Lodge. Here ripple marks, mud cracks, crossbedding, convolute bedding, flame structure and a late cleavage are well displayed. An access road leads westward to Laurentian Lodge and Flack Falls (photo 121). The falls result from differential erosion of the middle member of the Gordon Lake Formation. At the latter locality and on the shore of Flack Lake, there are further good exposures of the Gordon Lake Formation.

The prominent ridge north of the Boland River, which affords an excellent view of the Boland valley and Flack Lake, is formed by a large body of Nipissing Diabase. Road cuts show that the body of the rock is differentiated, varying from diabase (black) through diorite (grey-green) to granophyre (pink) with needle-like hornblende crystals. Epidote veins are associated with the granophyre. The variation is caused by crystallization of certain minerals (pyroxene and feldspar) at an early stage in the cooling, thus enriching the remaining fluid in quartz and potash feldspar. The process whereby rocks of differing composition are formed from the same original magma is called differentiation. Beyond the diabase, an outcrop on the west side of the road a mile and three-quarters beyond the Boland River shows baked quartzites of the Gordon Lake Formation with spots of chlorite and biotite.

The rocks were metamorphosed when the Nipissing Diabase magma was intruded into them.

To the north and northwest lies the valley of the Little White River. The hills to the west are of Lorrain Formation and to the northwest of Archean granite.

BI-ORE MINE

Two miles beyond the Boland River, a gravel road leads southeast about a mile to Cobre Lake where there is an old copper mine, the Bi-Ore Mine. Ore storage bins and trestles remain standing. The workings comprise two adits and an extensive trench. Specimens of banded chert, chalcopyrite, pyrite, specular hematite, quartz, and carbonate minerals including malachite and azurite are to be seen in the loose materials where the buildings were formerly located, and in the trench on the easterly vein (photo 120).

About a quarter mile northwest of the junction of the Cobre Lake road and Highway 639, there are several small outcrops of white Lorrain quartzite with crossbedding developed.

Highway 639 continues north over Pleistocene sands and gravels filling the Little White River valley and joins Highway 546. River-cut terraces may be seen at this junction.

HIGHWAY 546 AND THE LITTLE WHITE RIVER

Highway 546 northeast of the junction serves former lumbering and present tourist camp areas, and southwest of the junction it follows the valley of the Little White River for 33 miles to Parkinson, then continues south for five miles to Iron Bridge on Highway 77. At Parkinson, Highway 554 goes northwards across country to join Highway 729 and the Chapleau Route of the Trans-Canada system (see page 786).

HIGHWAY 546 TO SCARBO BRIDGE

Turning southwest on Highway 546, between five and nine miles from its junction with Highway 639, the high ground west of the road gives good exposures of Lorrain Formation. Quartz-jasper pebble bands are locally developed. A prominent ridge five and a half miles from the junction is a dike of Nipissing Diabase and three-tenths of a mile beyond it, there is a spectacular view of a cliff of Lorrain quartzite with bedding sloping to the southeast.

About nine miles from the junction, the road crosses the Flack Lake Fault. A cliff beyond the fault on the west side of the road is of near vertical Bruce Limestone (photo 122). It is interesting to note that the limestone has flowed under stress, whereas the silt-

Photo 122. *Espanola Formation (Bruce Limestone) along Highway 546 near Scarbo Bridge showing interbanded limestone and siltstone adjacent to Flack Lake Fault. Note the limestone has flowed under pressure but the siltstone has fractured.*

stone beds have fractured. Different rocks with different compositions, textures, and structure, when subjected to stress, behave differently. A brittle rock will fracture readily, whereas another rock with a laminated structure may develop a foliation such as a schistosity. A fracture cleavage may develop in a rock of one type trapped between layers of another rock type. A rock type which fractures at one intensity of stress may at a higher intensity become plastic and flow like toothpaste. Also, under a given set of conditions of stress, one rock type may fracture and another may flow. At this locality, the siltstone beds have fractured, giving rhomb shaped blocks, whereas the carbonate beds have flowed and are continuous.

From the Flack Lake Fault to the Little White River crossing at Scarbo Bridge, which is eleven miles from Highway 639, outcrops along the road show radioactive greenish Mississagi Arkose and highly contorted Bruce Limestone. The latter occurs in the last three-tenths of a mile.

The traveller may retrace his route through Elliot Lake, or continue southwesterly through Parkinson, rejoining Highway 17 at Iron Bridge, or from Parkinson continue to Highway 129 via Highway 554.

Serpent River to Thessalon

HIGHWAY 17 TO SPRAGGE

Highway 17 more or less follows the Murray Fault from the junction with Highway 108 as far as Spragge, a former lumbering town. Outcrops north of the fault are of near vertical unmetamorphosed Huronian rocks, but outcrops to the south are of quartzite, schist and metamorphosed diabase, the latter forming high ridges. To the south of the Serpent River estuary, high ground has formed over the erosion resistant Cutler granite. The only readily accessible outcrop of the Murray Fault zone occurs about two and three-quarter miles west of the junction, where it is marked by a chlorite schist zone. The outcrop lies at the north shoulder of the road under a power line. A deep cavity in the schists marks the site of a sub-glacial pot hole.

SPRAGGE, PATER MINE

Continuing west on Highway 17, volcanic rocks are found south of the Murray Fault some six miles westward from Spragge to Mitchell Island.

In the 1950s, exploration of ground near the Pronto uranium discovery led to the rediscovery of old pits on a quartz-rich shear zone carrying sulphide mineralization cutting the volcanic rocks, a quarter mile east of Spragge station. Diamond drilling established a copper deposit of potentially mineable grade and dimensions. An exploratory shaft was sunk and in 1961, following the closure of the nearby Pronto uranium mine, the Pater copper mine was brought into production. The ore was trucked to the Pronto plant for milling and the concentrate was shipped by rail. To the end of 1970, Pater Mine produced 78,694,117 pounds of copper, with minor amounts of silver and gold to a total value of $32,189,146. The mine closed in April 1970. Chalcopyrite and pyrrhotite are to be seen on the dumps.

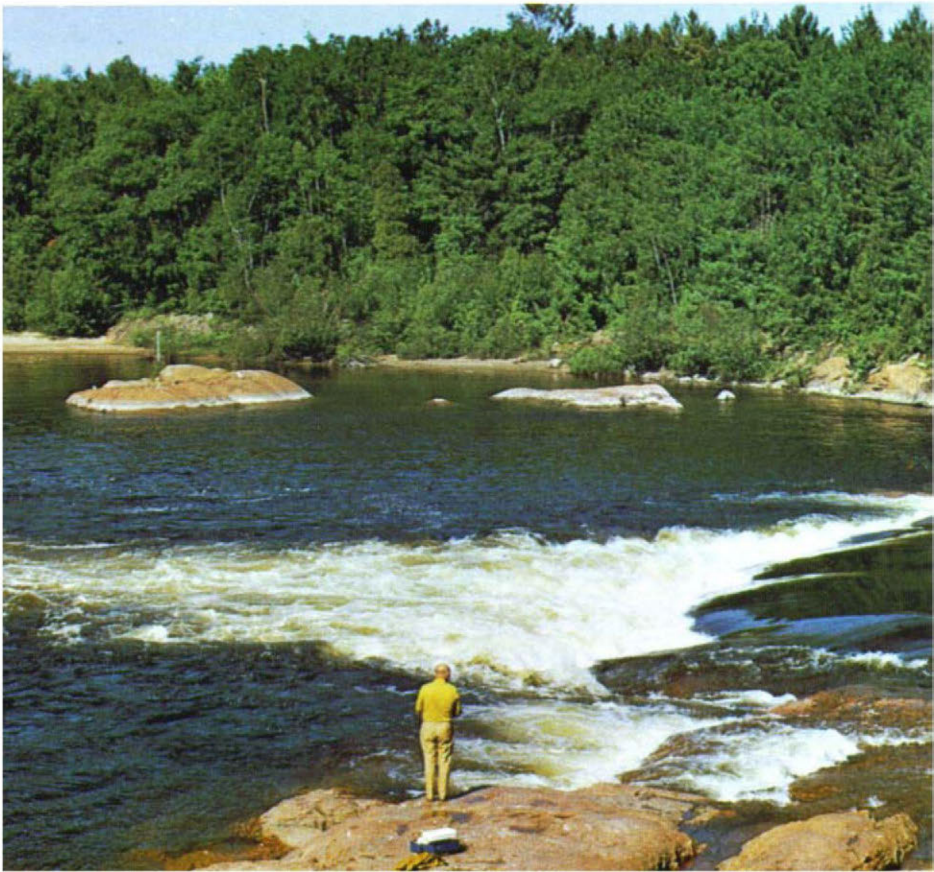
URANIUM MINING IN THE BLIND RIVER-ELLIOT LAKE AREA

Three miles west of Spragge, an access road turns north from Highway 17 to the Pronto Mine. The prospecting that led to the discovery of this mine also led to the discovery of the entire Blind River-Elliot Lake uranium mining camp — a fascinating story of good fortune, expert geological deduction, secret staking and international finance, which can only be dealt with briefly here. The mine itself and some nearby interesting geological localities are described following the history of the camp.

Search for Uranium in Ontario

Uranium was first discovered on the shores of Lake Superior in 1847 in the vicinity of Theano Point, some 80 miles north of Sault Ste. Marie. After World War II, prospecting was first concentrated in the Theano Point-Montreal River area and a number of pitchblende deposits were found. This area is des-

Photo 123. *Falls on the Mississagi River, west of Blind River. The rock is red granite of Algoman age.*



cribed in detail in Guidebook No. 2. In 1948, Karl Gunterman, a prospector associated with Aimé Breton of Sault Ste. Marie, ran a geiger counter over rock and mineral samples in the office of the Ontario Department of Mines mining recorder in Sault Ste. Marie. A piece of pyrite-bearing conglomerate labelled "Long" was sufficiently radioactive to arouse Gunterman's curiosity. The sample was traced to the east end of Lauzon Lake in Long Township west of Spragge, where a series of test pits had been dug in a bed of pyritic conglomerate (photo 7) by a prospector looking for gold or copper. Following the discovery, one of the geologists who became interested in the occurrence was Franc Joubin. Joubin's persistence lead in 1953 to a drilling programme supervised by Franc Joubin and financed by J. Hirshhorn, which confirmed the presence of economic quantities of uranium. Pronto Uranium Mines Limited was formed and brought the property into production.

Staking Rush

A secret staking bee was organized and, using a map published nearly thirty years previously by the Geological Survey of Canada (W. H. Collins' 1925 Blind River map) as a guide, the Huronian-Archean contact was followed in the vicinity of Elliot and Quirke Lakes. Large blocks of additional ground were staked, several of which later became mines. After these claims were recorded and the news broke, a major staking rush took place and major uranium reserves were established in the Elliot Lake-Quirke Lake area.

The new mining camp of Elliot Lake

The town of Elliot Lake grew up posthaste but as a properly planned community, avoiding the blight of so many earlier mining rushes. A large block of ground adjacent to the Quirke discovery became the Denison Mine. Through complex company transactions, the Hirshhorn-Joubin interests were obtained by the Rio Tinto Mining Company of England and Rio Algom Mines Limited was eventually formed. This company controlled or managed all but three of the mines developed. Two mines, Denison and Can-Met, are owned by Denison Mines Ltd. and the Stanrock Mine by Stanrock Uranium Corporation.

Slump and Recovery

By 1960, the free world's supply of uranium had outstripped its requirements and the majority of the mines had closed. Pronto Mine closed and the mill was converted to produce copper concentrate from the Pater Mine. For a number of years, only three mines (Denison, Nordic, and Stanrock) were in operation and the future of the area was in doubt. The Stanrock operation was particularly interesting in that traditional mining methods were terminated and bacterially charged fluids were circulated through the workings. The bacteria aided in the oxidation of the pyrite in the ores, which in turn acidified the mine waters, permitting them to dissolve uranium from the rocks. Stanrock closed in 1970.

In the late 1960s, interest in uranium revived as the utilities industry made plans for nuclear power stations. Exploration was renewed and much additional drilling was carried out in the Blind River-Elliot Lake area. Some holes were drilled deeper than 6,000 feet. Rio Algom transferred their operations from the Nordic Mine to Quirke No. 1 Mine, which was reopened and the mill rehabilitated; Quirke No. 2 was developed to provide ore for the Quirke mill when the mining operation at Quirke No. 1 would be completed. Nordic Mine was placed on a care and maintenance basis pending future development at greater depth,

Denison Mine increased its output and preparations were made to mine large areas under Quirke Lake. A number of new contracts were signed with companies in Japan, Germany, and Great Britain, as well as with the Ontario Hydro, and further negotiations were undertaken with these and other potential purchasers. Elliot Lake ceased to be regarded as a dying community. The population stabilized and started to increase. To the end of 1970, the uranium mines of the Elliot Lake-Blind River camp had produced 151,645,035 pounds of uranium oxide valued at $1,368,218,815, together with thorium and yttrium valued at $6,814,985.

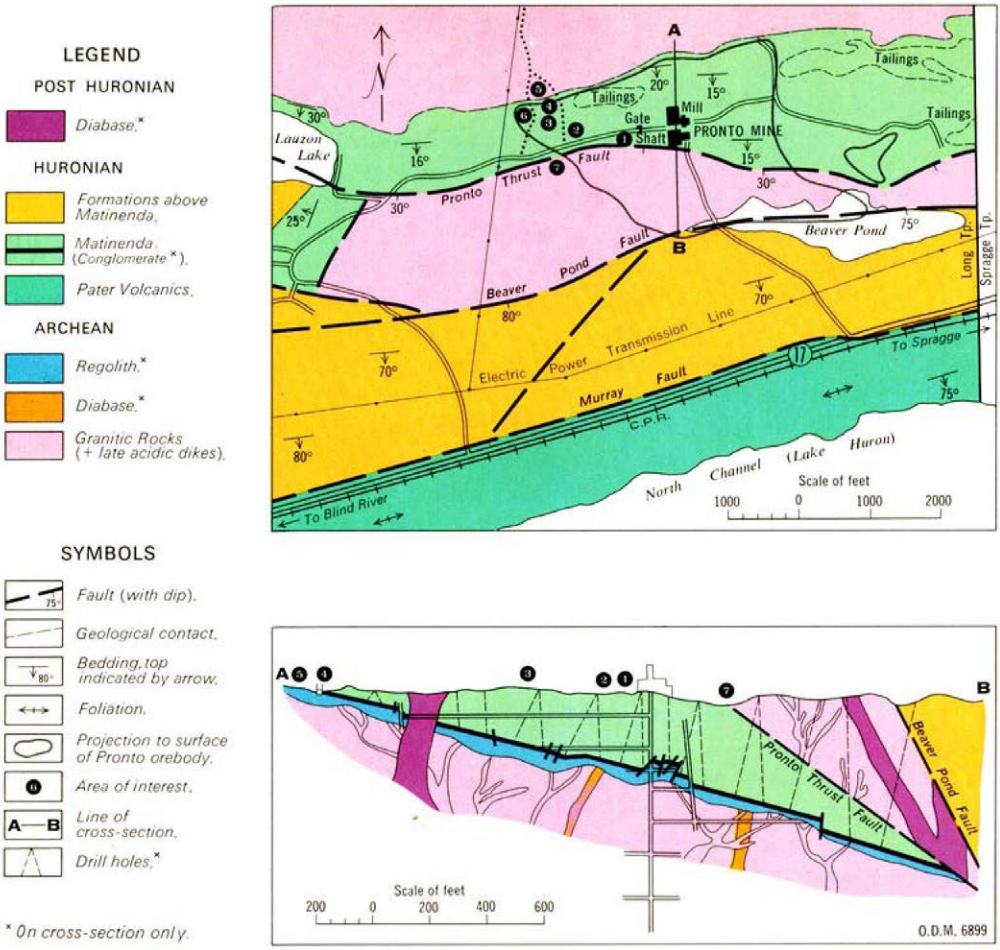
PRONTO MINE AREA

The following interesting localities are indicated by number on map 9 and the accompanying cross section of this historic mine area.

(1) Trough crossbedding which occurs in the Matinenda Formation shows weak radioactivity. South of the road, a gully marks the outcrop of the Pronto thrust fault, beyond which there is a ridge of Archean granitic rocks.

(2) Arkose of the Matinenda Formation is here cut by albitic veins.

(3) Note that the arkose here becomes coarser and more



Map 9. *Map and cross section of the Pronto Mine area.*

radioactive on going north. Thin pebble bands show moderate radioactivity.

(4) At this locality, there are glory holes or open pits from which ore has been extracted. On no account must visitors attempt to enter passages leading underground, which are extremely dangerous. The rocks described can be seen clearly without doing so. At the old mine workings, the ore conglomerate is exposed on Archean granite. The hangingwall (a mining term for the wall or side above an orebody) shows pebble bands and crossbedding. The arkose is weakly to moderately radioactive, the pebble bands are moderately radioactive and the ore bed is strongly so.

(5) At this point, the fossil soil developed on the Archean surface is well exposed, overlain by scattered patches of

Photo 124. *Robertsons Beach near the Pronto Mine, with an excellent view over the North Channel of Lake Huron.*

Photo 125. *Cataract Falls, Blind River, off Highway 557 north of the town of Blind River. The rock is Bruce conglomerate.*

Photo 126. *Tourist centre and antique fire engine, Blind River.*

Photo 127. *The pool below the falls, Mississagi River west of Blind River.*

pebble conglomerate. The front slope is essentially the pre-Huronian surface. The Archean rocks are cut by diabase dikes.

(6) The discovery locality. The discovery was made in a number of shallow pits and trenches, some of which post date the discovery. The original radioactive sample came from one of these pits. Note gossan (oxide stained rock) caused by the weathering of pyrite.

(7) The Pronto thrust fault repeats the Archean basement to the south.

A quarter of a mile west of the Pronto access road lies the Pronto east subdivision. A path leads to a beach on Lake Huron, where an excellent view of the North Channel can be enjoyed (photo 124).

HIGHWAY 17 TO BLIND RIVER

Three miles further west, there is a highway lookout over the North Channel of Lake Huron, the offshore islands and Manitoulin Island. The highway passes the south arm of Lauzon Lake, where there is a public swimming area and picnic tables, and continues through the village of Algoma Mills to the town of Blind River.

BLIND RIVER

The town lies at the mouth of the Blind River, so called because the mouth is hidden from the lake (photo 125). The west arm of the river lies in a hollow defining the Murray Fault. The town became the centre of the white pine lumbering industry on the north shore of Lake Huron, and the J. J. McFadden Mill was for many years the largest white pine mill east of the Rocky Mountains. In recent years, cutting operations were centred in the headwaters of the Little White River and the logs were floated down the Little White and the Mississagi rivers. Costs became too great and the mill was shut down in 1969. A small museum in Blind River commemorates the lumbering industry (photo 126). The town is now a service centre with a population of 3,000 catering to the surrounding population and to summer residents. Rural roads give access to many lakes and tourist camps.

MISSISSAGI RIVER

Highway 17 follows the Mississagi River to Iron Bridge. Occasional outcrops of Gowganda Formation are found along the road. The Mississagi was at one time an important access route for the fur traders and a Hudson's Bay Company post was located at the mouth of the river, which was also a staging point on the main route of the voyageurs. The river provided a route to the Bark Lake post and, for a period, to Biscotasing.

IRON BRIDGE

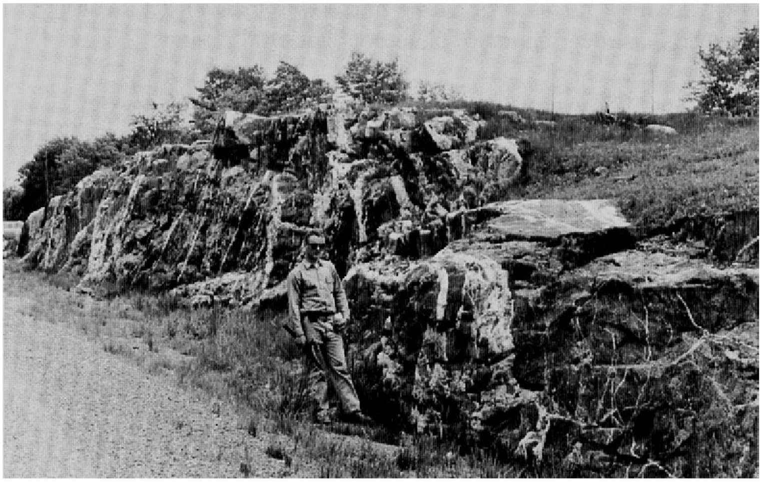
Glagoma Mine

The village of Iron Bridge is at the southern end of Highway 546 (see page 174). A short side trip may be taken by following a road leading north and east from the town in the direction of Denman and Chiblow Lakes. A number of copper showings are found a mile north of Iron Bridge near this road. The most accessible is the Glagoma Mine, located beside a power line just west of its crossing point with the road. Quartz, carbonate, pyrite, chalcopyrite, and specularite are to be seen in the mine dumps. The Red Rock Falls dam and generating station which lies some four miles northwest of Iron Bridge may also be reached by following Highway 546 north then turning west on a road about two miles north of Iron Bridge.

HIGHWAY 17 WEST OF IRON BRIDGE

Four and a half miles west of Iron Bridge, Highway 17 passes through a road cut in the Gowganda Formation that shows the development of quartz vein breccia (photo 128). A breccia is

Photo 128. *Quartz-carbonate veins bearing chalcopyrite, cutting brecciated Gowganda Formation, four and three-quarter miles west of Iron Bridge, Gladstone Township.*



a rock which consists of angular rock fragments enclosed in finer material of similar or different composition. In this case, the rock has fractured under stress. Silica, bearing some carbonate, sulphide and iron oxide, has entered the fractures and has crystallized. Such a breccia is called a quartz vein breccia. Quartz, carbonate (calcite and ankerite), and minor pyrite, chalcopyrite, and specularite can be found.

Sowerby and Basswood Lake

Continue west to Sowerby. Another short side trip to inspect mineralization may be made by following a short road leading north to Basswood Lake, shown on some maps as Big Basswood and some as Wakwekobi Lake. Half a mile north of Sowerby, a ridge shows a Nipissing Diabase intrusion cutting the Gowganda Formation. Scattered along the ridge, especially in contact areas with brecciated Gowganda Formation, there are traces of secondary copper, nickel, and cobalt minerals, sulphides, and pitchblende. A small pit on the west side of the road, three-quarters of a mile north of Highway 17, shows joint surfaces coated with films of pitchblende; radioactive samples may be detected.

Hagans Hill

Returning to Highway 17 westbound, the road crosses a ridge of gravel and sand (Hagans Hill) about two and a half miles west of Sowerby. This ridge is an esker (see page 163). Note the steep lateral slope of the sediments in the pits.

The country between Sowerby and Thessalon has long supported small farms. The early barns (photo 129) are of interest and some show departure from conventional design.

Photo 129. *A twelve sided barn just west of Hagans Hill near Sowerby.*

The Chapleau Highway

The Chapleau Highway, described overleaf, leads from Thessalon one hundred and forty miles north to Chapleau where it joins Highway 101, some eighty-five miles east of Wawa and one hundred and thirty miles west of Timmins. It gives access to some of the least developed areas of Ontario, four provincial parks and several picnic sites. It also connects via Highway 544 with Highway 546 described previously in the Elliot Lake excursion. Motorists are cautioned to watch out for moose on this road, especially in spring. Only the first thirty miles of highway are described here, providing a fairly short side trip to two copper mines.

Photo 130. *The adit at the Gould Copper Mine, near Highway 129.*

Chapeau Route of the Trans-Canada Highway

HIGHWAY 129

Turn north on Highway 129 at Thessalon. The outcrops near the town are of Thessalon volcanics (see page 17). The highway passes over good farming lands on old lake deposits and climbs up over various Huronian formations north of Basswood Lake. Sixteen miles from Thessalon, a road on the west side of the highway near the Mississagi River gives access to the Rayner and Wells dams and generating stations of Ontario Hydro.

TUNNEL LAKE

The general area has been known for its copper deposits for many years, and a mine called the Cheney or Grand Portage Mine on the Mississagi River, now flooded under Tunnel Lake northwest of the Mississagi River bridge, was operating as far back as 1864. There were also placer gold mining activities at the turn of the century along the river south of the bridge and there are many records of copper showings in the vicinity.

On the west side of Highway 129 two miles beyond the bridge, a high cliff of Gowganda Formation graded greywacke shows scattered pebbles and cobbles believed dropped from floating ice (photo 131). Highway 554 joins Highway 129 from the east just at this point, and Tunnel Lake is passed two and a half miles further north.

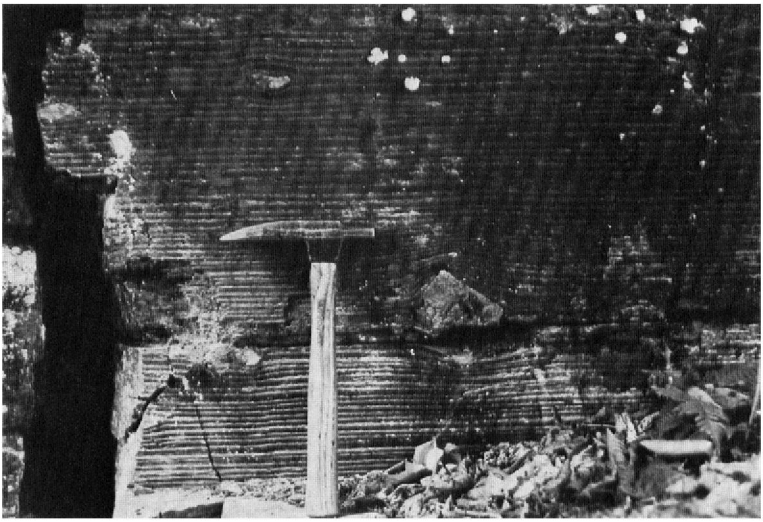


Photo 131. *Thinly bedded graded greywacke, with scattered granite cobbles, probably dropped from floating ice during early Proterozoic time. Junction of Highways 129 and 554, Wells Township.*

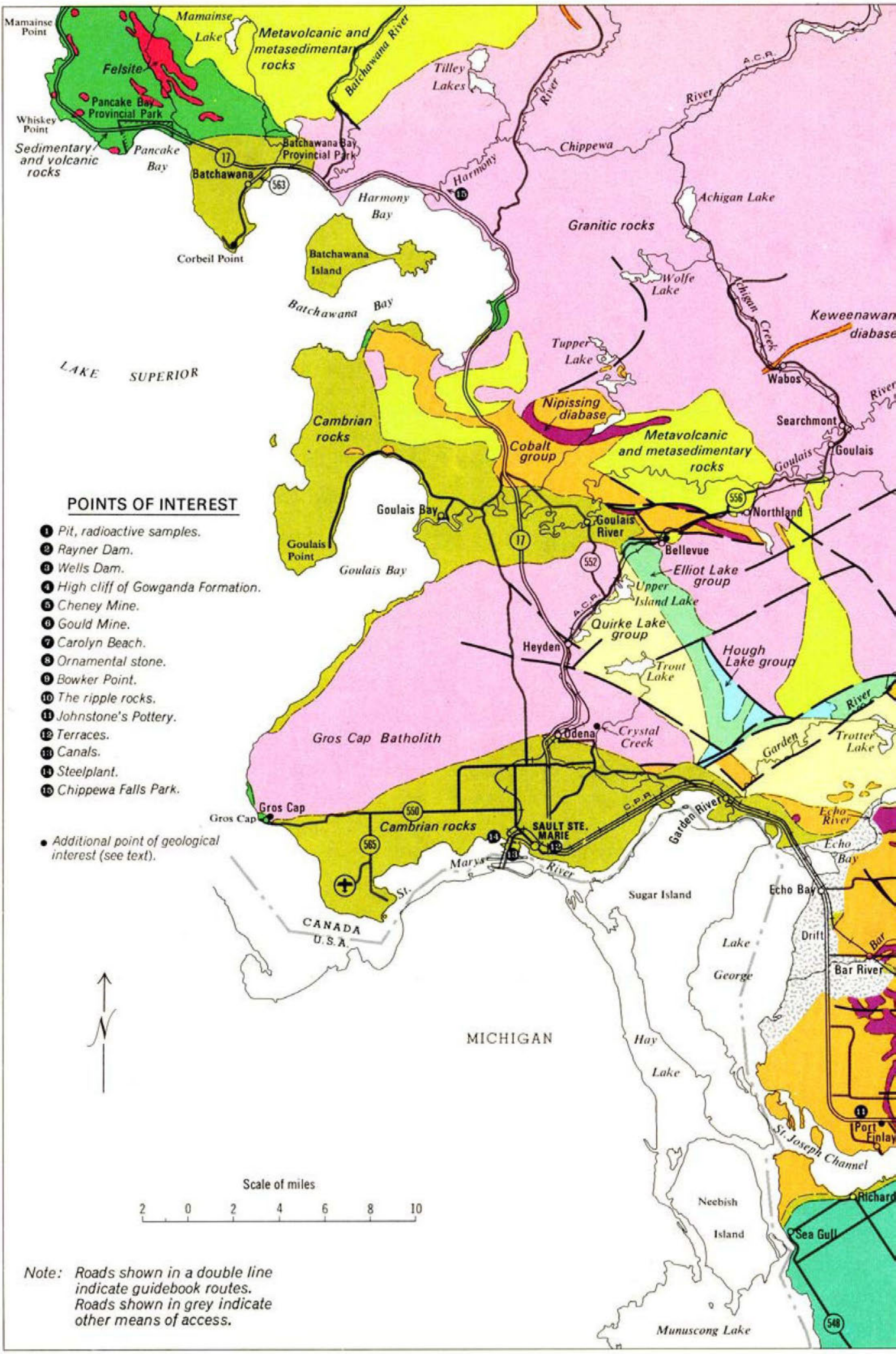
CHENEY MINE

Continue on Highway 129. Another Cheney Mine, but apparently completely unrelated to the one first mentioned, lies west of Highway 129 three-quarters of a mile south of Chub Lake and five miles north of Tunnel Lake, just south of a Bell relay tower. The occurrence has been known and explored intermittently for nearly a hundred years, but the present headframe dates from recent exploration. Quartz, carbonate, pyrite, chalcopyrite and epidote are to be seen on the dump. A trench a few yards west of the shaft shows chalcopyrite-quartz veins cutting brecciated Gowganda Formation. Malachite (copper carbonate) and limonite stain the rocks.

GOULD MINE

Two miles north of Chub Lake, the Gould Copper Mine access road turns west from Highway 129. One and a half miles westerly along this mine road, a cliff face shows a chalcocite vein. Specimens of chalcocite and specularite are to be seen on the mine dump. An adit has been driven a short distance on the vein (photo 130).

Return to Highway 17 by the same route and continue westward.



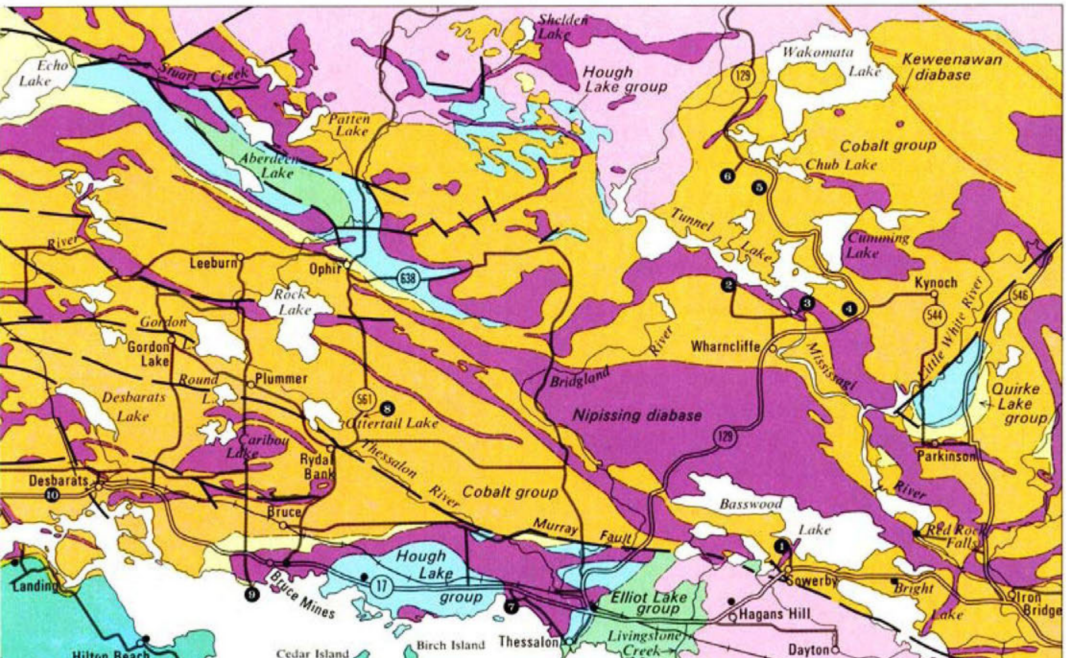
Map 10. *The Iron Bridge–Sault Ste. Marie–Batchawana Area.*

Most of the geology and scenery described in this guidebook may be seen from public roads. When stopping, visitors are asked to park safely off the road and use proper care when walking nearby. The Official Road Map of the Ontario Department of Transportation and Communications lists police headquarters, travel information centres and first aid posts, should they be required.

Much of the country away from the roads is not public property. Visitors must respect the rights of property owners and permission should be obtained from them before entering private property.

In respect of unpatented or unleased mining claims, permission should be obtained from the recorded holder of the claims. Without such permission, the visitor could be charged with trespassing.

Please do not smoke or light fires in the bush because of the hazard of forest fire.



Thessalon to Sault Ste. Marie

HIGHWAY 17 TO BRUCE MINES

Highway 17 by-passes Thessalon to the north. It continues westward towards Bruce Mines, Desbarats and the road to St. Joseph Island, then swings north round Lake George to Sault Ste. Marie. There is a good view over the North Channel from Carolyn Beach, about a mile west of the junction of the Thessalon by-pass and Highway 129; seven and a half miles further west, there are low rock cuts on the north side of the highway which show crossbedding in the Mississagi Formation (photo 10).

BRUCE MINES AREA

Copper was discovered at Bruce Mines in 1846, and the town became the first commercially successful copper mining area in Canada. The miners were largely Cornish. Local names to this day retain the Cornish and Dutch influence from the pioneer miners and farmers of the area. A plaque, erected by the Ontario Archeological and Historic Sites Board, and a local museum honour these pioneers.

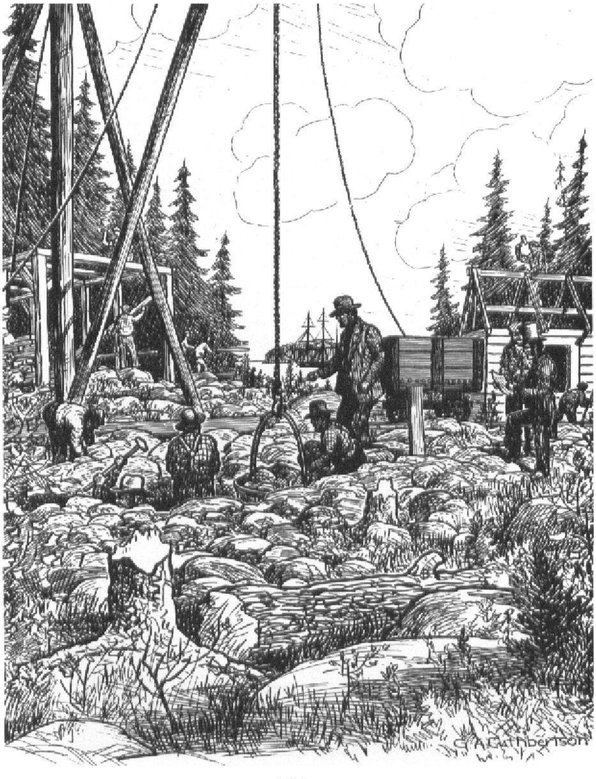
Ontario's First Copper Mine

The Montreal Mining Company acquired the property in 1847, shortly after it was discovered. The early workings were located on two parallel quartz-carbonate veins with chalcopyrite and minor bornite and barite, which cut a body of Nipissing Diabase. A depth of seventy fathoms was reached (over 400 feet) but mining was carried out under great difficulties. There were problems in obtaining staff, cholera broke out and the company lost its steamer laden with equipment and supplies, among other misfortunes. It is estimated that two fifths of the copper was lost in the hand dressing process.

The dressed ore and concentrates were sent to England and later to the United States, but an import tax imposed at the outbreak of the American Civil War closed that market. The West Canada Company took over the property from 1865 until 1876, when a big cave-in took place at the junction of the two ore bodies. Various companies worked the mine after that, the last recorded mining operation being in the year 1908, although the tailings were used as flux by the Mond Nickel Company in its smelter after that period.

The early mineral development led to detailed geological studies and the area was investigated by Sir William Logan and Alexander Murray, noted early geologists in pre-Confederation Canada. Their work and that of those who followed has made the Bruce Mines – Blind River area one of the classical areas for studying middle Precambrian rocks.

Photo 132. *An artist's impression of the first shaft being sunk at Bruce Mines. (Courtesy Canadian Mining Journal).*



Rydal Bank

For those interested in ornamental stone, eight miles north of Bruce Mines on Highway 561 and just north of Rydal Bank, a prominent ridge marks the outcrop of the Lorrain Formation. One member of this is characterized by the quartz-jasper pebble conglomerate or "pudding stone" (photo 20; see page 32). This is one of eastern Canada's best known ornamental stones but the best material is usually obtained from boulders, found in glacial drift or on beaches along Lake Huron.

At Bowker Point southwest of Bruce Mines, reached via the Bruce Bay road half a mile west of Highway 561 on Highway 17, there are excellent exposures of the Espanola Formation (photo 133).

DESBARATS

The Ripple Rocks

One and a half miles west of the village of Desbarats along Highway 17 and about two and three-quarter miles east of the road

Photo 133. *Espanola Formation at Bowker Point, one mile southwest of Bruce Mines. Note the thin bedding, etching and pitting of the carbonate bands, the folding and fracturing of the quartzite bed, the flowage of the carbonate-siltstone.*

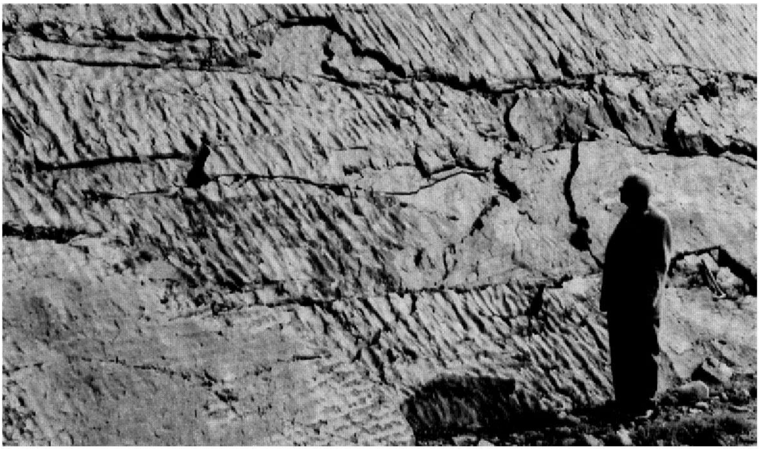


Photo 134. *Ripple marks caused by wave action, in Huronian quartzite, near Desbarats, east of Sault Ste. Marie. (Courtesy E. G. Pye).*

leading to St. Joseph Island, there is a large rock cut through an outcrop of thin bedded quartzite. There is parking available just west of this noted geological site, which is mentioned in standard North American geological texts. Sample collecting is not permitted, in order to preserve the site intact. The rock was laid down in late Huronian times as part of the Lorrain Formation. It strikes west-northwest and dips or slopes at about 60 degrees to the south. It was originally laid down in a horizontal or near horizontal position in a standing body of water, and obviously has been tilted to its present attitude as the result of folding due to compression in the earth's crust. Aside from the fact that the sandstone slopes at a steep angle, its principal characteristic is the presence of ripple marks. Where the rock has broken along its bedding planes, the ripple marks are very prominently displayed (photo 134).

The ripple marks lie from three to six inches apart, and they occur as symmetrical ridges that rise as much as an inch above the troughs between them. There is little doubt that the ripple marks were formed by the action of waves close to an old shoreline. In this regard, it is of great interest that in some beds the ripple marks are oriented almost at right angles to those in other beds. Therefore, one must conclude that, as the sand that gave rise to the ripple marked rock was being deposited, there were abrupt changes in the direction of either the depositional currents or the long-shore currents.

ST. JOSEPH ISLAND

Highway 548 leads south from Highway 17 to St. Joseph Island. There is a free ferry which is to be replaced by a bridge scheduled to be opened during 1972.

The Niagara – Manitoulin Escarpment continues on St. Joseph Island. The island is, however, largely drift covered and supports an agricultural community. It is a popular area with summer residents, pleasure craft operators, tourists and cottagers. The war memorial at Richards Landing on St. Joseph Island includes a tiered base, the bottom portion of which is composed of Lorrain quartz-jasper pebble conglomerate and the upper of Gowganda dense boulder conglomerate. An excellent museum contains relics of pioneer days. Other points of interest are a bird sanctuary and the remains of a fort at the extreme south of the island, used during the war of 1812 —Old Fort St. Joseph. A road cut on Highway 548 just south of the channel crossing and outcrops on the shore near Hilton Beach show fossiliferous limestone. The cut on Highway 548 (photo 135) yields several brachiopods, bryozoa, crinoid stems, cephalopods and corals (compare photographs on pages 54-60).

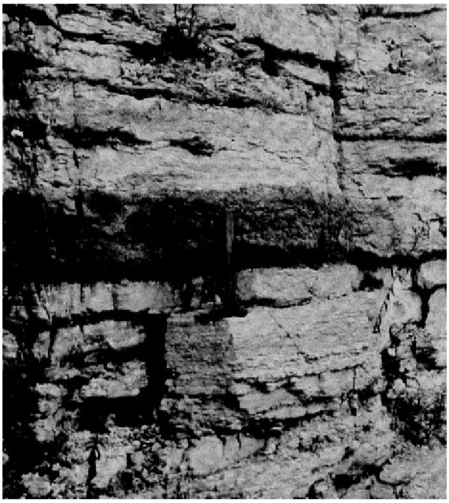


Photo 135. *Well bedded fossiliferous Ordovician limestone along Highway 548, St. Joseph Island.*

HIGHWAY 17 TO SAULT STE. MARIE

Bar River Lowlands

Back on the mainland on the south side of Highway 17, 0.3 miles west of the junction with Highway 548, there is an outcrop of Lorrain quartzite with quartz-jasper conglomerate; a mile and three-quarters further west, pottery is made at Johnstone's Pottery from local clay deposits, which were laid down in the expanded glacial Lake Huron. The highway swings into the Bar River lowlands and passes the communities of Echo Bay and Garden River before entering Sault Ste. Marie.

Echo Bay to Sault Ste. Marie

Continuing west from Echo Bay to Sault Ste. Marie, the road passes over lake deposits deposited on flat lying Jacobsville Sandstone. The high ground to the north of the highway marks the outcrop of Archean granite. Former lake terraces are well displayed to the north of Highway 17 and in the downtown business section of Sault Ste. Marie. The lake levels preserved are at 50 feet, 100 feet and 420 feet above the present level of Lake Superior.

SAULT STE. MARIE

Sault Ste. Marie, with a population of 75,000, is the administrative centre for the District of Algoma. There are government offices, the Ontario Provincial Air Service base, hospitals, religious and educational centres, including the Sault Ste. Marie campus of Cambrian College. It is the home of the Algoma Steel Corporation, Canada's third largest steel company. It is also the headquarters of the Algoma Central Railway, which brings iron ore south from Wawa and is the carrier for logs for the Abitibi Pulp and Paper Mill.

Sault Ste. Marie is an important border crossing area and, with road and rail links to the United States of America, the area handles large quantities of through traffic. The Lake Superior Route of the Trans-Canada Highway also brings large numbers of visitors to the city.

The canals permitting navigation between Lake Superior and Lake Huron and the St. Marys River are on one of the busiest shipping routes in the world. During the shipping season, more tonnage passes through these locks than in one year's operation of the Suez (when operating), Panama, and Kiel canals together. Boat cruises through the locks are a worthwhile experience; the restored Canoe Lock was originally completed by the North West Company in 1799.

GROS CAP BATHOLITH

Highway 550 runs west from Sault Ste. Marie, giving access to the airport. To the north of the road there are high granitic hills of the Archean Gros Cap batholith, the most prominent geolo-

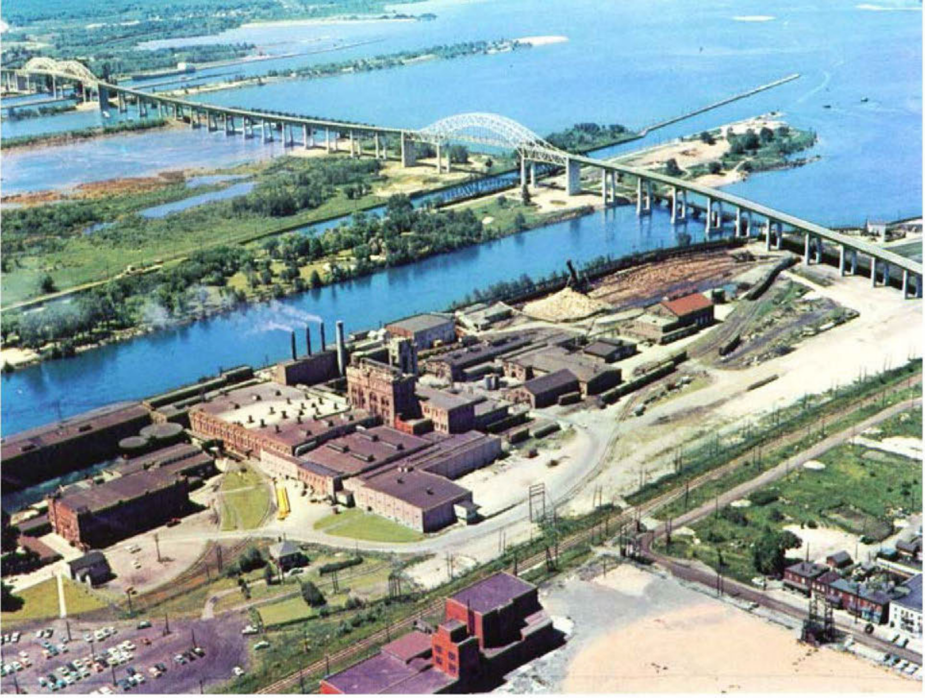


Photo 136. *Locks on the St. Marys River, Sault Ste. Marie, looking towards Lake Superior.*

gical feature in the vicinity of Sault Ste. Marie. A rugged highland, with elevations of 400 to 600 feet above Lake Superior, the batholith separates the St. Marys River and Goulais River lowlands. Its southern boundary is a prominent and somewhat irregular escarpment that stretches from Gros Cap, on the shore of Lake Superior, eastward to the Garden River Indian Reserve, a distance of about 20 miles. The highland is several miles wide, and is crossed by Highway 17, from 8 to about 15 miles north of downtown Sault Ste. Marie. It is the topographic expression of a large mass of Algoman granite.

As pointed out previously, a batholith is formed deep within the earth and is exposed to view only after a prolonged period of erosion. In this regard, it is of considerable interest that most batholiths are associated with intensely folded volcanic and sedimentary rocks in mountain ranges; thus, it is tempting to speculate that in Precambrian time the Gros Cap batholith was one of many such masses formed in a mountainous region, perhaps not unlike that found today along the western margin of the North American continent.

At Gros Cap itself, there are outcrops of Keweenawan lava flows (see page 199, Chippewa Falls Park, for the geology of such flows).

North of Sault Ste. Marie

Highway 17 turns north at Sault Ste. Marie and commences a four hundred and fifty mile swing around the north shore of Lake Superior. The final section of Part 2 describes the first fifty miles of this journey. The country between Sault Ste. Marie and Wawa is full of magnificent scenery and places of geological interest, and is worth a day's journey north from Sault Ste. Marie even for those not travelling to Thunder Bay.

Another excellent day excursion from Sault Ste. Marie is the return trip via the Algoma Central Railway north to Canyon, a lonely station in the Agawa River Canyon a few miles east of Agawa Bay. The railway runs through spectacular scenery which cannot be reached by road, some of the highlights being the crossing of Bellevue Creek, the trestle over the Montreal River and the run along the Agawa Canyon. This trip is particularly attractive in the fall.

Photo 137. *Black Bear Falls, Agawa River Canyon.*

Sault Ste. Marie to Batchawana

Follow Highway 17 north out of Sault Ste. Marie. For the first eight miles the highway passes over Cambrian rocks covered by lake deposits to the vicinity of Odena where it climbs up onto the Gros Cap batholith.

BELLEVUE AND HIGHWAYS 556 AND 552

At Heyden, 9 miles north of Sault Ste. Marie, Highway 556 runs east from Highway 17 towards Searchmont and a short diversion from the main Trans-Canada Highway is well worth taking as far as Bellevue for the spectacular view to be obtained there. For those taking the side trip, Highway 17 may be rejoined north of the Goulais River by following Highway 552 north instead of returning to Heyden.

GOULAIS RIVER

The Goulais River valley bears traces of lake terraces similar to those of the St. Marys River and Sault Ste. Marie area, but they are less conspicuous. Clay and sand flats of lake origin occur towards the eastern end of the valley but over most of the area they have been partially or wholly removed by the meandering Goulais River (see page 81 for a discussion of river action).

BATCHAWANA BAY

Four miles north of the junction of Highways 552 and 17, the first good view of Batchawana Bay of Lake Superior is obtained and the highway starts to follow the shore for some miles. Around Batchawana Bay, remnants of former Lake Superior shorelines can be seen as terraces on the hill sides.

Photo *138. View from above Canyon Station, Algoma Central Railway, looking south along the Agawa River. (Courtesy Ont. Min. Industry and Tourism).*

CHIPPEWA FALLS PARK

Chippewa Falls Park is located on the Harmony River, known locally as the Chippewa, about six miles east of Batchawana. There are two scenic waterfalls, about 150 feet apart, facing the southwest. They have been found to be attractive to tourists, and a park with facilities for picnicking has been established at the site by the Ontario Provincial Government. The mid-point marker of the Trans Canada Highway is also located here.

The Upper and Lower Falls

The upper falls can be reached conveniently by following a good trail from the park for about 800 feet along the southeast bank of the river. It occurs where the principal rock formation, a well jointed but otherwise massive pink granite, is cut by a dike of diabase. The dike is a vertical, or nearly vertical, tabular-shaped body about 65 feet thick. It trends northwest and stands up as a highly resistant wall, over which the river tumbles 20 to 25 feet in its descent toward Lake Superior. Standing on the dike and looking northwesterly along it, one will see that it terminates abruptly; this is because it has been faulted. It has been displaced to the right and is found on the opposite side of the river about 30 feet farther upstream (northeast) than would normally be anticipated.

The lower falls also drop 20 to 25 feet (photo 139). Here, however, there is no resistant dike to provide an escarpment. On the contrary, the falls occur where the granite is capped by a thin erosional remnant of a Keweenawan lava flow.

Volcanic Rocks

The Keweenawan volcanic rocks (photos 143, 144, 145), together with some interbanded conglomerate and sandstone, are found in several localities in the Lake Superior region. They are exposed at many places on the islands and north shore of Lake Superior, at intervals along the shoreline near Sault Ste. Marie and northward for 65 miles to Mica Bay, and in the states of Michigan and Minnesota in the United States. Their geology is discussed in detail on page 50. They are principally lava flows, of basic or basaltic composition. The volcanic rocks and their associated sedimentary rocks, exposed on Lake Superior islands, have been estimated to have an aggregate thickness of 6,000 to 10,000 feet; those at Mamainse Point north of Batchawana about 12,000 feet; those in Michigan, about 20,000 feet; and those in Minnesota, between Duluth and Tofte, about 25,000 feet.

Origin of Lake Superior Basin

The immense volume of lava represented by these deposits generally has been assumed to have originated at great depth beneath the area now occupied by Lake Superior. In this regard, it is significant that the volcanic rocks, almost without exception, slope or dip from the shore inward under the lake. They thus form a large structural basin or trough, and the suggestion has been advanced that the development of this basin was the result of foundering, upon the withdrawal of the magma that poured out at the surface as basic lava flows.

Volcanic Rock at Chippewa Falls

The remnant of volcanic rock at Chippewa Falls lies athwart the river bed. It slopes or dips about 30 degrees to the southwest near the upper part of the falls, but flattens so that, at the base of the falls, it slopes at angles of ten degrees or less. Like the diabase dike at the upper falls, this remnant of lava, too, has been faulted

Photo 139. *The lower Chippewa Falls on the Harmony River. Granitic rocks (red) are overlain by Keweenawan lavas (black) sloping gently towards Lake Superior.*

Photo 140. *A basic lava flow resting on granite and sloping southwest. Note the alteration of the granite and the thin tongue of lava extending along a fracture under the lens cap.*

Photo 141. *A pothole in basic lava, Chippewa Falls Park. (Courtesy E. G. Pye).*

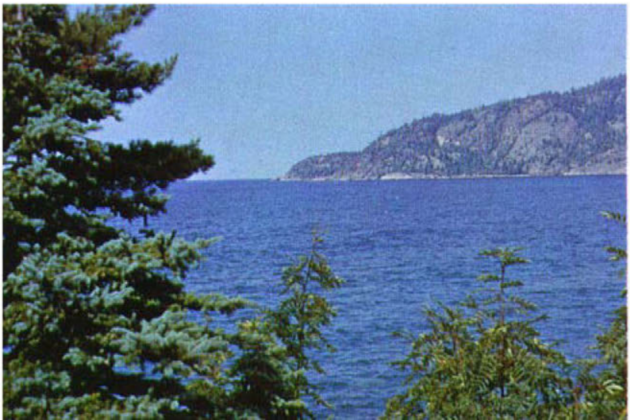


Photo 142. *Theano Point from across Alona Bay. Theano Point is the site of what was probably Canada's first uranium discovery in 1847, rediscovered a century later. (Courtesy E. G. Pye).*

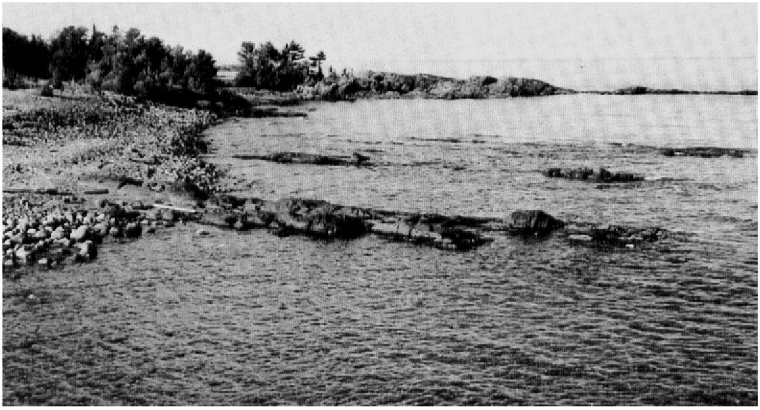


Photo 143. *Fingerlike headlands, Mamainse area. The headlands are parallel to the strike of the rocks (lava flows). They have gentle dip slopes facing the lake and have steep slopes or escarpments inland.*

and, as a result, its exposures along the northwest bank of the river lie farther upstream than those in the river bed and along the southeast bank.

The patch of lava is most 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. The lava flow is dark in colour and is basic or basaltic in composition. It crystallized from a liquid magma, which, before erup-

Photo 144. *Amygdaloidal lava, showing vesicles or gas cavities filled by late-formed minerals.*

tion, contained abundant water vapour and other gases. When this magma poured out over the surface, these gases escaped rapidly and, in doing so, left the lava riddled with rounded bubble holes or vesicles. Subsequently, those vesicles became filled with secondary minerals, such as dark green chlorite and pale green epidote, and the resulting rock became crudely spotted in appearance, and amygdaloidal. In addition, it is very closely jointed and its surface is exceedingly rough and jagged in appearance. It is also broken by irregular but persistent fractures. Along some of these, 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 are filled with white calcite. Where the basic lava is in contact with, and rests upon, the granite, it is very fine grained, no doubt because here the lava was rapidly chilled. In a general way, the boundary between the two rocks is fairly even. In detail, however, the contact is highly irregular; thin tongues of lava project downward and outward from the flow for several inches, extending along fractures, and in places completely enclosing small blocks of the older granite (photo 140).

Potholes

Where the water in a rapidly flowing river is given a rotary motion by eddying currents, as might be the case below a waterfall, it tends to grind out round depressions in the bedrock. Such round depressions, or potholes as they are called, are found in the basic lava and, to a lesser extent, in exposures of the granite near the base of the lower escarpment (photo 141). They are numerous and attain large sizes, with diameters as much as five feet and depths as great as three feet. They are outstanding examples of this geological phenomenon. Because of these large, well developed potholes, the geological conditions controlling the sites of the two waterfalls, the structures displayed by the bedrock formations, and the scenic attractiveness, there is little doubt that Chippewa Falls Park is one of the most interesting locations along the highway.

PROVINCIAL PARKS

Provincial Parks with camping facilities have been established on sandy beaches just off the highway near Batchawana and six miles further west at Pancake Bay. Pancake Bay was a stopping point on the route of the voyageurs. The name is said to derive from the flapjacks made by the voyageurs when they camped for the night. Here is one of the longest and widest sand beaches found along the entire Canadian shore of Lake Superior.

BATCHAWANA AND MAMAINSE POINT

Highway 563 leads south to Batchawana village just beyond Batchawana campground, and a gravel road continues to Corbeil Point whence there is an excellent view across Batchawana Bay. To the north of Batchawana lies the Mamainse Point area, with Keweenawan lava flows and interbedded conglomerates. Copper and chalcopyrite deposits are found in the lavas.

HIGHWAY 17 TO MONTREAL RIVER HARBOUR

Mica Bay and Pointe aux Mines, still further north, were the sites of early prospecting for copper, while uranium was first discovered in Canada near Theano Point in 1847, as previously described. A century, later the occurrence was rediscovered when pitchblende veins were found associated with Keweenawan diabase contacts. There was no production from these showings but one, the Ranwick Mine on Highway 17, is operated as a tourist attraction. Pitchblende and the fluorescent mineral schronkingerite can be obtained there. A rock shop is located at the mine. Continuing north, the road crosses the gorge of the Montreal River and passes the attractive village of Montreal River Harbour, north of which lies Agawa Bay and the Lake Superior Provincial Park.

THE ROAD TO THE CANADIAN LAKEHEAD

Highway 17 then wends its long route north and west around the north shore of Lake Superior, through Wawa, noted for its iron mines; White River, which claims to be Canada's coldest winter community; Nipigon, with its diabase mesas and cliffs; the Canadian lakehead; Kakabeka Falls, known as the Niagara of the North; Kenora; and on to the Manitoba border. Highway 61 leads south from Highway 17 at Thunder Bay, linking it with Pigeon River and the U.S.A. for those driving the circular route around the Great Lakes.

Travellers continuing on should consult Guidebooks 1 and 2 of this series for a description of the geology and scenery of one of the most scenic stretches of highway in central Canada.

PART 3

Rock Collecting, Glossary, References

LOCALITIES FOR COLLECTORS

A large variety of minerals and rocks, some of them suitable for cutting and polishing and some for ornamental stone, are obtainable in the Lake Huron area. Some examples are listed below.

Amygdaloidal Lava

Amygdaloidal lava occurs near Harmony River (please do not take samples at Chippewa Falls).

Ankerite

Ankerite is found in most chalcopyrite–quartz veins, for example in the vicinity of Iron Bridge at the Bi-Ore Mine, Cobre Lake, Township 1A; and at the Errington Mine, Creighton Township, near Chelmsford.

Anthraxolite

Anthraxolite may be found on Lot 10, Concession I, Balfour Township and in the old mine dumps, Errington Mine, Creighton Township, near Chelmsford.

Apatite

There are rare occurrences of apatite in some pegmatites at Aird Bay.

Argillite

Argillite may be found along the shores of Denvic and Tube Lakes, Victoria Township.

Arkose

Arkose (feldspar-rich sandstone or quartzite) occurs at the Pronto Mine, Long Township, and along Highway 639 west of the Quirke Mine, Township 150.

Arsenopyrite

Arsenopyrite is to be found at the McMillan Mine, Lot 7, Concession III, Mongowin Township and at the Long Lake Mine, Eden Township.

Azurite

Azurite (see Malachite).

Basalt

Basalt occurs at Thessalon, also along Highway 639 near Ompa Lake, and near the Harmony River.

Bornite

The Massey Mine, Number 3 Zone, Salter Township is a source of bornite.

Breccia

Breccia occurs in the Sudbury area, also at the Tribag Mine, and in copper showings in Thomson Township, near Iron Bridge.

Calcite

Calcite is found in most quartz-chalcopyrite veins; fluorescent calcite is obtainable in Lot 8, Concession III, Foster Township.

Chalcocite

Chalcocite occurs at and in the vicinity of the Gould Copper Mine, Gould Township.

Chalcopyrite

Chalcopyrite is found in the Sudbury area, also at the following mines: the Pater Mine near Spragge, the Massey Mine in Salter Township, the Bi-Ore Mine in Township 1A, the Glagoma Mine in the Iron Bridge area, and the Cheney Mine off Highway 129.

Chert

Chert may be found at the Bi-Ore Mine, Township 1A; also in conglomerates near Bruce Mines.

Chloritoid

Chloritoid crystals occur in outcrops northeast of Nairn Centre, Lot 7, Concession I, Drury Township.

Cobaltite

Cobaltite may be seen on Lot 10, Concession V, Foster Township.

Concretions

Concretions occur in the vicinity of Chelmsford, and as claystone in drift along the Spanish River at Espanola.

Conglomerate

Conglomerate occurs along Highway 108 in Townships 149 and 150 in the Bruce and Gowganda Formations. Uranium-bearing conglomerate is found at the Pronto Mine in Long Township. Lorrain quartz-chert-jasper conglomerate is found north of Rydal Bank, in drift near Bruce Mines and on St. Joseph Island, along the Little White River road in Township 163, and in the Mount Lake area, Township 1A.

Diopside

Diopside is found along Highway 108 north of Elliot Lake, disseminated in metamorphosed limestone.

Dolomite

Dolomite rock is found at Quirke Lake in Township 150.

Photo 145. *An aerial photograph of the Mamainse area, showing the fingerlike headlands projecting into the lake. The top of the photograph is slightly west of north. The deep gorge running across the headland is probably a fault which was eroded by wave action when the lake stood higher. (Courtesy Ont. Min. Industry and Tourism.)*

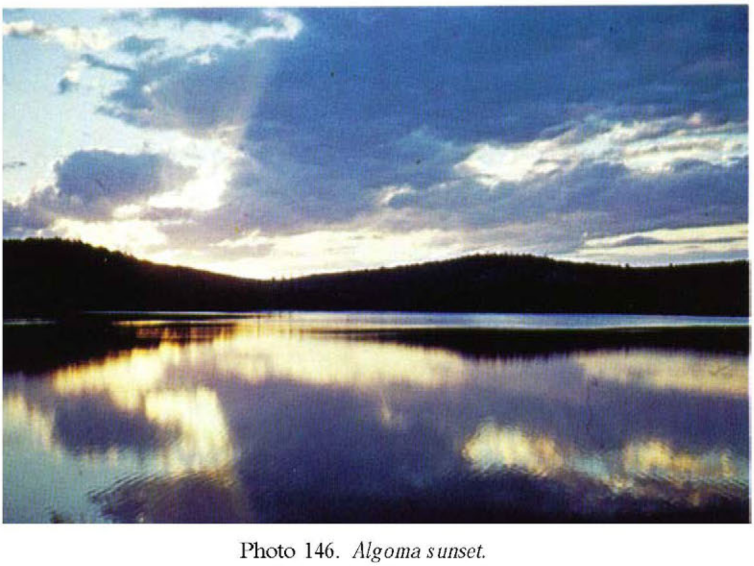


Photo 146. *Algoma sunset.*

Epidote

Epidote veins are associated with granophyre along Highway 639, north of the Boland River crossing.

Erythrite

Cobalt bloom (erythrite) may be seen in the northwest corner of Township 163 and along the Wakwekobi road, Sowerby.

Feldspars

Feldspars, microcline and plagioclase, may be found in pegmatites in the Grenville Province along Highway 17 east of Sudbury, and along Highway 69, south of Sudbury; also associated with the Cutler Batholith along Highway 17, in the vicinity of Cutler and at Aird Bay.

Fossils

Precambrian fossils are to be seen near Jimchrist and Flack Lakes, Township 157, but these are doubtful organic remains (see page 34). Paleozoic fossils occur on Manitoulin Island and St. Joseph Island.

Gabbro

Gabbro is found at East Bull Lake and at Sudbury.

Galena

There are occurrences of galena on Campbell Island in Whiskey Lake, Township 137 and at the White River Lead Mine.

Garnet

Garnet is to be found at the following localities: at Wahnapitae; along Highway 69 south of Sudbury; in metadiabase and pegmatite near Cutler. Small garnets occur in metasediments between Spanish and Spragge, and there is poor garnet in skarn along Highway 108 in Township 149.

Gneiss

Gneiss is to be found along Highway 17 east of Wahnapitae and along Highway 69 south of Sudbury.

Granite

Granite occurs north of Copper Cliff; in the Cutler area; along the Panel access road at Quirke Lake; along Highway 108 south of Elliot Lake; along Highway 639 between Quirke Mine and Ompa Lake; along Highway 129 north of the guidebook area; and along Highway 17 north of Sault Ste. Marie.

Granophyre

Granophyre is found in the Sudbury area, for example near Levack; also at Iron Bridge.

Greywacke

Greywacke may be seen along Highway 108 in Township 157, and in the Chelmsford Formation of the Sudbury Basin.

Grossularite Garnet

This occurs in Lot 8, Concession III, Foster Township, and there is massive grossularite garnet in skarn in the Bruce Limestone, Township 157.

Hematite

Hematite is to be found in most chalcopyrite-quartz veins, for example as specularite at the Bi-Ore Mine, Township 1A.

Idocrase

There is massive idocrase in skarn in the Bruce Limestone exposed on Highway 108, Township 149. Idocrase also is found on Lot 8, Concession III, Foster Township.

Ilmenite

Ilmenite occurs in quartz segregations in metadiabase on a ridge adjacent to Highway 17, one to two miles east of Spanish.

Iron Formation

There is low grade iron formation along Highway 108, north of Depot Lake, Proctor Township; and better grade on the former Highway 612 east of the present highway. There is also iron formation at the Lowphos Mine in Hutton Township, just north of this guidebook area.

Jasper

Jasper occurs in jasper pebble conglomerate north of Rydal Bank and in erratics near Bruce Mines and St. Joseph Island. There are minor amounts in conglomerate along the Little White River road in Township 163, and near Mount Lake in Township 1A.

Kyanite

Kyanite is to be found at Dreamers Rock near Whitefish Falls, also along Highway 17, 1 mile east of Wahnapitae.

Limestone

Precambrian (Bruce) limestone occurs along Highway 108 in Township 157, at Cataract Falls north of Blind River, at Quirke Lake and along Highway 546 in Township 163.

Paleozoic limestone is distributed throughout Manitoulin, Cloche, and St. Joseph Islands.

Magnetite

Magnetite is found in Mongowin Township. See also Iron Formation.

Malachite

Samples of malachite (plus minor azurite) are to be found in the rock stains at copper showings. Malachite is found in the Bi-Ore Mine east vein at Cobre Lake in Township 1A, and at the Cheney Mine, Highway 129.

Mica

Mica books are to be found in the pegmatites in Grenville rocks. Mica is found in the pegmatites associated with the Cutler Batholith and from Sudbury to Spragge as flakes in metasediments exposed along Highway 17.

Microcline

See Feldspar.

Molybdenite

Minor amounts of molybdenite occur in fractures in the granite along Highway 533, 18 miles north of Massey.

Olivine

Olivine is to be found in diabase dikes one mile east of Nairn Centre; also one mile west of the junction of Highways 68 and 17.

Pegmatite

Pegmatite occurs in Grenville rocks along Highway 17 east of Wahnapitae and along Highway 69 south of Sudbury. It also occurs in the Cutler Batholith at Cutler and Aird Bay.

Pentlandite

Pentlandite is found in the Sudbury area.

Plagioclase

See Feldspar.

Pillow lava

Pillow lava may be seen along Highway 639 north of Ompa Lake in Township 157, and near the Pater Mine at Spragge.

Pitchblende

There are occurrences of pitchblende at Wakwekobi Lake near Sowerby, and at the Theano Point-Montreal River area north of Sault Ste. Marie.

Pyrite

Pyrite occurs at the Tribag Mine; and in the Errington Mine area, Creighton and Balfour Townships.

Pyrrhotite

There is pyrrhotite in the Sudbury area and at the Pater Mine, Spragge. The former is nickeliferous, the latter is barren.

Quartz

There is quartz in most copper showings and it can be found at the Tribag Mine and on Passage Island at the mouth of the Spanish River.

Quartzite

This is a common rock type, particularly in the Lorrain Formation at Willisville–Whitefish Falls, La Cloche, and Rydal Bank. It also is present in the Mississagi Formation in the Elliot Lake and Sudbury areas.

Rhyolite

There is rhyolite north of the Panel access road at the northwest end of Quirke Lake; south of Thessalon Station; and in the Copper Cliff rhyolite of McKim Township.

Sandstone

Sandstone is found in the Sault Ste. Marie area.

Scapolite

This is found in metamorphosed limestone in Indian Reserve No. 5; also on Lot 6, Concession IV, Merritt Township, north of Espanola.

Scheelite

Fluorescent scheelite occurs on Lot 8, Concession III, Foster Township.

Schists

Schists are to be seen along Highway 17 between Sudbury and Spragge.

Shatter Cones

Shatter cones are found in the Sudbury area west to Nairn and south to Lake Panache. One location is on Lot 1, Concession V, Waters Township.

Siderite – Ankerite

Chalcopyrite-quartz veins furnish samples of siderite-ankerite, some examples being at the Bi-Ore Mine in Township IA, the Glagoma Mine near Iron Bridge, and along Highway 17, 4 miles west of Iron Bridge.

Siltstone

Siltstone occurs near Tube and Denvic Lakes, Victoria Township, and near the Boland River and at Flack Falls, Highway 639, Township 157.

Skarn

Skarn may be found along Highway 108 in Township 149, and on Lot 8, Concession III, Foster Township.

Slate

Slate occurs near Dowling in the Sudbury basin.

Staurolite

Staurolite may be found in the Sudbury–Copper Cliff area; on Lot 12, Concession I, Drury Township; and in the Spanish-Spragge area.

Syenite

Syenite occurs along Highway 533 north of Massey.

Tillite

Tillite is found in the Ramsay Lake Formation along Highway 69 in Sudbury; and in the Bruce and Gowganda Formations, for example along Highway 108 in Township 149.

Tremolite

Tremolite occurs in metamorphosed limestone in Indian Reserve No. 5; also in metamorphosed Espanola limestone of the Whitefish area.

Wollastonite

Wollastonite is found in skarn (rare) along Highway 108 in Township 149, and on Lot 8, Concession III, Foster Township.

GLOSSARY

Acid rock. An igneous rock containing 66 percent or more silica.

Agate. Banded silica found as nodules and amygdule fillings in basic lava flows.

Agglomerate. Coarse fragmental debris resulting from explosive volcanic activity.

Alluvial. Relating to alluvium, which is unconsolidated rock material deposited by water in geologically recent time.

Amphibole. Rock-forming minerals of complex composition. Hydrous silicates, usually with aluminum, calcium, iron and magnesium.

Amygdaloidal lava. A lava with numerous tiny gas cavities (vesicles) filled with late-formed minerals.

Andalusite. A rock-forming mineral found in some metamorphic rocks–aluminum silicate.

Andesite. An intermediate volcanic rock comprising an intermediate plagioclase and mafic minerals.

Angular unconformity. An erosion surface preserved in rocks, such that the bedding or structure in the underlying rock is truncated by the bedding of the overlying rock.

Anorthosite. An igneous rock made up largely of calcium plagioclase feldspar.

Anthraxolite. A form of carbon.

Anticline. A fold structure, or arch, in which the rocks slope in opposite directions away from a common ridge.

Apatite. A mineral consisting of calcium phosphate.

Argillaceous. Term applied to all rocks rich in clay.

Argillite. A moderately metamorphosed shale.

Arkose. A sandstone containing at least twenty-five percent feldspar.

Basal conglomerate. A coarse conglomerate usually found above an unconformity: the first material deposited after an erosional gap.

Basalt. A lava made up mainly of the minerals pyroxene or amphibole and feldspar, with or without olivine, of basic composition and dark colour.

Basic rock. An igneous rock with a low silica content, generally less than 55 percent.

Basin. A fold structure in which the rocks slope inwards. A depressed region, generally the site of prolonged sedimentation.

Batholith. A mass of igneous rock (such as granite) formed deep within the earth and occupying an area greater than 40 square miles.

Bedding. A primary layered structure in sedimentary rocks.

Bedding planes. The near-planar surfaces of beds.

Biotite. Black- brown mica.

Bornite. An ore mineral of copper (peacock ore) Cu_5FeS_4.

Boulder. A rock fragment, usually rounded, in a sedimentary rock having a diameter of over 256 mm (approx. 10 inches).

Brannerite. An ore mineral of uranium (UTi_2O_6), usually with traces of thorium, yttrium, rare earths. Occurs at Elliot Lake.

Breccia. A fragmental material, the pieces being of angular shape, for example volcanic breccia, sedimentary breccia, fault breccia.

Calcite. A vein mineral and rock-forming mineral having the composition calcium carbonate ($CaCO_3$).

Chalcocite. An ore mineral of copper (Cu_2S).

Chalcopyrite. An ore-mineral of copper ($CuFeS_2$)

Chert. An extremely fine-grained form of silica.

Chlorite. A rock-forming mineral, usually greenish in colour and platy (like mica). A hydrous silicate of aluminum, iron, and magnesium.

Chloritoid. A dark green iron-aluminum silicate mineral found in some metamorphosed sedimentary rocks.

Cleavage. A direction of easy splitting in a mineral. A foliation in a metamorphic rock characteried by easy splitting.

Cobble. A rock fragment, usually rounded, having a diameter of 64-625 mm (approx. 2½-10 inches).

Colloform Structure. Rounded masses of mineral characterized by concentric banding and generally by radiate structure, caused by crystallization from colloids.

Concretion. A rounded or nodular mass of seemingly foreign material in a sedimentary rock resulting from the concentration of one or more rock constituents about a central nucleus.

Conformable. A sequence of sedimentary rocks in which the bedding is consistently parallel is said to be conformable.

Conglomerate (puddingstone). A sedimentary rock comprising pebbles and boulders in a matrix of compacted sand, silt, or clay.

Convolute bedding. Distorted bedding caused by irregular slumpage of laminated sands into underlying muds or silts.

Cross bedding. A cross lamination within beds – the result of strong currents at the time the bed was formed.

Delta. A triangular shaped deposit of unconsolidated sedimentary material at the mouth of a river.

Desiccation breccia. A breccia in which the fragmental material was formed by the shrinkage and fracturing of argillaceous rock material during drying out and consolidation.

Diabase. A basic (mafic) igneous rock having the composition of gabbro and usually characterized by the presence of lath-shaped feldspar crystals.

Dike. A tabular mass of igneous rock cutting across older rocks, commonly near vertical.

Differentiation. The process whereby igneous rocks of differing composition and mineralogy are derived from the same original magma.

Diopside. A calcium-magnesium pyroxene found in metamorphosed limestone.

Diorite. An igneous rock composed of hornblende and plagioclase.

Disconformity. A surface of erosion within a sequence of rocks, such that bedding or flow structures in the rocks above and below are essentially parallel.

Dolomite. A vein mineral and rock-forming mineral having the composition of calcium-magnesium carbonate. Also, a sedimentary rock made up largely of the mineral dolomite.

Dome. A fold structure in which the rocks slope outwards.

Epidote. A green rock mineral. A hydrous silicate of aluminum, calcium, and iron.

Epoch. A subdivision of a period of geological time.

Era. A division of geological time of the highest order.

Esker. A sinuous ridge of sand and gravel marking the former site of a stream within an ice sheet.

Erythrite (cobalt bloom). A pink mineral formed by the weathering of rocks and minerals containing cobalt.

Faceted boulder. A boulder, one side of which has been ground flat and striated or polished by transportation in ice.

Fault. A fracture or zone of fractures along which a movement of the wall rocks has occurred. A normal fault is one where those rocks lying above a sloping fracture have apparently dropped downwards. A thrust fault is one where the rocks above a moderately sloping fracture have moved upwards. A wrench or tear fault is one where the rocks have moved laterally.

Feldspar. Common rock-forming minerals such as orthoclase, microcline, plagioclase (see standard mineralogy text for details). Aluminum silicates of one or more of calcium, sodium, potassium.

Feldspathic sandstone. A sandstone containing from five to twenty-five percent feldspar.

Fissile rock. A rock that is easily split along closely spaced parallel or near-parallel planes.

Flame structures. Projection of silt or clay into the base of an overlying sandstone bed.

Fluvial. Relating to rivers or streams.

Foliated rock. A metamorphic rock in which minerals have separated into crudely parallel layers. If fissile = schist.

Formation. An assemblage of sedimentary or volcanic rocks which is easily recognized and mapped over a wide area.

Fossil. Remains or traces of prehistoric life.

Front. A boundary of an area of intense metamorphism and/or structural deformation. A front usually separates geological provinces.

Gabbro. A coarse textured igneous rock having the same composition as basalt but intrusive, commonly as dikes or sills.

Galena. An ore-mineral of lead. PbS.

Garnet. A metamorphic rock-forming mineral found in metasediments and metamorphosed basic (mafic) igneous rocks. A complex calcium-iron-magnesium-aluminum silicate.

Glacial pavement. A bedrock surface scoured, polished and striated by the passage of an ice sheet.

Glowing avalanche. A body of highly gaseous lava errupted from the side of a volcano and which flows downhill under the influence of gravity.

Glowing avalanche deposits. (welded tuffs or ignimbrites) are formed by cooling of a glowing avalanche.

Gneiss. A rock containing bands rich in granular minerals alternating with bands rich in platy or micaceous minerals.

Gossan. A deposit made up of hydrous iron oxide formed at the surface by the weathering of iron-bearing sulphides in a rock.

Graded bedding. A bed in which the coarser and heavier material is at the base of the bed and the finer and lighter material is at the top. Common in greywacke. When metamorphosed, coarser grained new minerals develop at the top of the bed and reverse graded bedding is formed.

Granite. A coarse textured igneous rock made up of quartz, one or more feldspars and one or more micas and/or hornblende; usually found in batholiths. It is an acid rock, with a high silica content.

Granodiorite. A coarse textured igneous rock similar to granite but with two-thirds of the feldspar comprising intermediate plagioclase.

Granophyre. A fine grained igneous rock of granite composition but with quartz-feldspar intergrowths. Generally the end product of differentiation of basic magma.

Greenstone. An altered or metamorphosed basic igneous rock, usually basalt, rich in greenish minerals such as chlorite and some amphiboles.

Greywacke. A variety of sandstone with fragments of rock and rock minerals resulting from rapid erosion and deposition.

Grossular. A calcium-aluminum garnet found in metamorphosed limestones.

Group. An assemblage of geological formations.

Hematite. An ore mineral of iron. An iron oxide containing 70 percent iron.

Hornblende. A variety of amphibole, dark green or black in colour.

Hypersthene. A pyroxene mineral.

Idocrase (Vesuvianite). Complex hydrated calcium-magnesium-aluminum silicate found in metamorphosed limestones.

Igneous rock. A rock formed by the crystallization of molten or partially molten matter (magma).

Ignimbrite. A massive welded tuff formed by cooling of a glowing avalanche.

Ilmenite. An iron-titanium oxide mineral ($FeTiO_3$).

Intrusion. A body of igneous rock that has invaded older rocks.

Iron formation. A sedimentary rock having an unusually high iron content.

Irruptive. Intrusive generally used as a noun to mean a body of intrusive rock.

Isoclinal fold. A fold in which the limbs have the same slope.

Isostasy. The principle that masses of light rock of the earth's crust are underlain by bodies of relatively light rock projecting into the mantle, providing a gravitational balance.

Isostatic rebound. During the ice age, the weight of the ice depressed the base of the crust into the mantle; when the ice melted, the continents rose again.

Jasper. A variety of chert usually coloured red due to the presence of hematite.

Joint. A fracture that interrupts the physical continuity of a rock.

Kyanite. An aluminum silicate mineral, found in metamorphic rocks.

Lamination. Layering or bedding less than 1 cm thick.

Limestone. A sedimentary rock made up largely of the carbonate mineral calcite.

Limonite. A brown hydrated iron oxide formed by the weathering of iron minerals, particularly sulphides.

Lineation. Parallel or subparallel orientation of linear features, such as axes of small scale folds, intersection of bedding and foliation, or elongate minerals such as hornblende.

Load casts. Irregularities at the base of a sandstone bed project into an underlying silty or clay bed; caused by differential compaction and slumpage.

Lopolith. A large body of intrusive rock depressed in the centre like a spoon.

Magma. A hot mass of molten, or partially molten, rock constituents formed at high temperature within the earth.

Magnetite. An ore mineral of iron (Fe_3O_4). A magnetic oxide containing 72 percent iron by weight.

Malachite. Hydrated copper carbonate; forms a green stain in weathering of copper ores.

Marker horizon or bed. A bed that, because of readily identified characteristics and extent, can be used for tracing geological structure.

Member. A subdivision of a geological formation.

Metamorphic rock. A rock that has formed from a pre-existing rock as a result of changes in temperature or pressure or both.

Mica. Family of rock-forming minerals comprising potassium-iron-magnesium-aluminum silicates that readily split into flat sheets.

Microcline. A variety of feldspar. An aluminum silicate containing potassium.

Migmatite. A rock made up of gneiss interbanded with granite.

Millerite. Nickel sulphide (NiS).

Molybdenite. An ore mineral of molybdenum (MoS_2).

Monazite. A rare earth phosphate; occurs in placer deposits. Usually contains uranium and thorium. Occurs at Elliot Lake.

Muscovite. Transparent white mica.

Olivine. A rock-forming mineral. A silicate of one or both of magnesium and iron.

Orogeny. The cycle of events during which a mountain chain is formed.

Pebble. A rock fragment, usually rounded, having a diameter of 2 to 64 mm (up to 2½ inches).

Pegmatite. A coarse grained intrusive rock of granite composition.

Pelite. Mudstone.

Pelitic. Argillaceous.

Peneplane. A land surface approximating to a plain, the result of prolonged erosion.

Pentlandite. An ore mineral of nickel, $(FeNi)_9S_8$

Period. A fundamental unit of geological time, smaller than an era.

Pillow lava. A lava made up of rounded masses resembling pillows.

Phenocryst. A relatively large crystal in finer grained rock. Normally phenocrysts crystallized early, and changes in conditions caused rapid crystallization of the remaining magma.

Pitchblende. An ore mineral of uranium,(UO_2). Occurs at Theano Pt.

Plagioclase. A variety of feldspar. An aluminum silicate containing one or both of sodium and calcium.

Porphyroblast. Large, often well-formed crystals found in metamorphic rocks.

Porphyry. An igneous rock characterized by an abundance of phenocrysts, for example feldspar porphyry, quartz porphyry.

Pothole. A deep round hole worn into bedrock, often at falls or rapids, by sand and gravel spun around by water currents.

Province. A large area having a unified structural history.

Pyrite. A sulphide of iron, (FeS_2). "Fool's gold".

Pyroxenes. Rock-forming minerals. Complex silicates, usually with aluminum, calcium, iron and magnesium. Augite and hypersthene are examples.

Pyroxenite. An igneous rock consisting mainly of pyroxene.

Pyrrhotite. A weakly magnetic sulphide of iron $(Fe_{1-x})S$. Frequently contains nickel.

Quartz. A vein mineral and rock-forming mineral composed of silica.

Quartzite. An indurated silica-rich sandstone which breaks across rather than around the grains.

Quartz monzonite. An igneous rock similar to granite, containing approximately equal amounts of quartz, potash feldspar, and plagioclase feldspar, and some 5-10 percent ferromagnesian minerals.

Regional metamorphism. Large scale metamorphism, usually unrelated to individual bodies of igneous rocks representing areas subjected to orogenic activity.

Rhyolite. A lava having a composition similar to that of granite; usually light coloured.

Ring dike. A sheet of intrusive igneous rock, ring shaped in plan and vertical or near vertical in extension.

Ripple marks. Corrugations on bedding planes caused by wave motion or current action on unconsolidated material.

Sandstone. A compacted sand made up largely of quartz grains.

Scapolite. A complex calcium-sodium-aluminum silicate found in some metamorphosed limestones.

Schist. A foliated rock characterized by platy minerals with parallel orientation.

Segregation. A body of mineral or rock surrounded by other rock. Segregations may form by fluids passing through a rock, dissolving materials and transferring them to the deposition site, or they may form as the result of differentiation, where end-stage fluids fill gaps in the earlier crystallized rock.

Shale. A laminated sedimentary rock composed of compacted or cemented mud.

Shatter cones. Conical fracture surfaces found in clusters in rock subjected to very sudden hammer-blowtype stresses; believed caused by meteorite impact.

Siderite. An iron-bearing carbonate.

Silicates. Those minerals, generally of complex chemistry, in which the framework is made up of SiO_2.

Sill. A tabular mass of igneous rock occuring within and parallel to the structure of older rocks.

Siltstone. A sedimentary rock, not a shale, made up of very fine grained mineral particles.

Skarn. Metamorphosed limestone normally adjacent to an igneous rock.

Slate. A metamorphosed shale having a fissility, not necessarily parallel to the original bedding (= slaty cleavage).

Slickensides. Polished and striated slip surfaces, coated with minerals, that result from friction along a fault plane.

Slumpage (slump bedding). Disturbance of regular bedding in which sandstone bodies sink into underlying mudstones. Where the sandstone bodies separate from the sandstone bed they are called slumpage balls if round and slumpage pillows if ovoid.

Sperrylite. A rare platinum mineral ($PtAs_2$)

Sphalerite. An ore mineral of zinc (ZnS).

Staurolite. A metamorphic rock-forming mineral. A complex hydrated iron-aluminum silicate; often forms cross-shaped crystals.

Striae. Scratches on a rock surface caused either by movement of ice, enclosing rock materials, over the upper surface of the rock or by differential movement of rock along a fracture.

Supergroup. An assemblage of similar geological groups.

Syenite. An igneous rock that, except for the absence of quartz, is similar to granite in both appearance and composition.

Syncline. A fold, the rocks of which slope inward in opposite directions to form a trough-like structure.

Swarm. A large number of dikes with a sub-parallel trend.

Till. Rock debris carried and deposited from a glacier.

Tillite. Consolidated till.

Tremolite. An amphibole found in metamorphosed carbonate-bearing rocks.

Tuff. A rock made up of dust and fine rock fragments from explosive volcanic activity.

Turbidity current. A turbid current flowing under the influence of gravity along the bottom of a body of water. These currents become charged with sediment and rock fragments and eventually deposit layered rocks of greywacke composition characterized by graded bedding and other structure (turbidites).

Type area. The geographic area in which a geological phenomenon, for example formation, group, fossil, or mineral, was first described.

Unconformity. A surface of erosion separating younger sedimentary rocks from older rocks.

Uraninite. Crystalline uranium oxide (UO_2). Occurs in Elliot Lake ores.

Valley-train deposits. The material deposited by a stream flowing from a glacier.

Varve. Laminated sediment consisting of a coarser light layer grading into a fine dark layer; believed related to seasonal deposition in sub-temperate to arctic conditions.

Vesicle. A small cavity in a lava caused by the segregation of gas upon extrusion at the surface. When filled with later minerals, a vesicle is termed an amygdule.

Wollastonite. Calcium silicate found in metamorphosed limestones.

Zeolites. A family of minerals consisting of hydrous aluminum silicate of sodium, calcium, and potassium. These are commonly found in amygdules of basic flow rocks.

Zircon. Zirconium silicate ($ZrSiO_4$) occurs in minor amounts in Elliot Lake ores.

REFERENCES

In the preparation of the guidebook, considerable use was made of the extensive literature available on the geology of the region. For those who wish to pursue their studies beyond the scope of this compilation, the reports considered to be most comprehensive and pertinent are included in the following list of references. Many of these reports contain coloured maps.

Please note that the Ministry of Natural Resources, Division of Mines, assumed most of the functions of the former Ontario Department of Mines during a Govermnent of Ontario reorganization in 1972, and the Ontario Department of Mines went out of existence at that time. The publications of the Ontario Department of Mines now are available through the Publications Office of the Ministry of Natural Resources, Whitney Block, Parliament Buildings, Queen's Park, Toronto.

Publications of the Geological Survey of Canada are available through the Office of the Queen's Printer, Ottawa, Ontario.

Brown, L. Carson. 1967: Elliot Lake, The World's Uranium Capital; Canadian Geographical Journal, October 1967, reprints available from Ministry of Natural Resources, Ontario.

Card, K. D. 1964: Metamorphism in the Agnew Lake Area, Sudbury District, Ontario, Canada; Geological Society of America Bulletin Vol. 75, pp. 1011-1030.

1965: Hyman and Drury Townships; Ontario Department of Mines, Geological Report 34.

1965: The Croker Island Complex; Ontario Department of Mines, Geological Circular 14.

1968: Geology of Denison – Waters Area; Ontario Department of Mines, Geological Report 60.

1968: The Mongowin Pluton; Ontario Department of Mines, Miscellaneous Paper 14.

1969: Sudbury Mining Area; Ontario Department of Mines, Coloured geological map, Map 2 170, 1 inch to 1 mile.

1971: Panache Lake area (West part) Districts of Sudbury and Manitoulin; Ontario Department of Mines, Preliminary map P. 668, 1 inch to 1 mile.

1971: Panache Lake area (East part) Districts of Sudbury and Manitoulin; Ontario Department of Mines, Preliminary map P. 669, 1 inch to 1 mile.

Collins, W. H. 1925: The North Shore of Lake Huron; Geological Survey of Canada, Memoir 143 (reprinted 1956).

Dietz, R. S. 1964: Sudbury Structure as an astrobleme; Journal of Geology, Vol. 72, pp. 412-434.

Frarey, M. J. 1959: Echo Lake, District of Algoma; Geological Survey of Canada, Map No. 23-1959, 1 inch to 1 mile.

1961: Dean Lake, District of Algoma; Geological Survey of Canada, Map No. 5-1961, 1 inch to 1 mile.

1961: Wakwekobi Lake, District of Algoma; Geological Survey of Canada, Map, No. 6-1961, 1 inch to 1 mile.

1962: Bruce Mines, Ontario; Geological Survey of Canada, Map No. 32-1962, 1 inch to 1 mile.

1962: Lake George, District of Algoma; Geological Survey of Canada, Map No. 33-1962, 1 inch to 1 mile.

Frarey, M. J. and Cannon, R.T. 1969: Notes to accompany a map of the geology of the Proterozoic rocks of Lake Panache – Collins Inlet map areas, Ontario; (report and map) Geological Survey of Canada, Paper 68-63.

Giblin, P. E. and Leahy, E. J. 1967: Sault Ste. Marie – Elliot Lake Area; Ontario Department of Mines, Coloured geological map, Map 2108, 1 inch to 4 miles.

Ginn, R. M. 1965: Geology of Nairn and Lorne Townships; Ontario Department of Mines, Geological Report 35.

Hawley, J. E. 1962: The Sudbury Ores: their mineralogy and origin; Canadian Mineralogist, Vol. 7, pp. 1-207.

Hornick, G. L. (Editor) The Call of Copper: A History of Bruce Mines and Area; published by North Shore Printing, Bruce Mines, 1969.

LeBourdais, D. M. 1953: Sudbury Basin; Ryerson Press, Toronto.

McDowell, J. P. 1957: The sedimentary petrology of the Mississagi quartzite in the Blind River area; Ontario Department of Mines-Geological Survey of Canada, Ontario Department of Mines, Geological Circular 6.

Robertson, J. A. 1963: Geology of the Iron Bridge Area, Ontario; Ontario Department of Mines, Geological Report 17, Coloured geological map, 1 inch to ½ mile.

1968: Geology of Townships 149 and 150; Ontario Department of Mines, Geological Report 57, Coloured geological maps, 1 inch to ¼ mile.

1969: Geology and Uranium Deposits of the Blind River Area, Ontario; Canadian Institute of Mining and Metallurgy Bulletin, Vol. 62, June 1969, pp. 619-634.

1969: Township 163; Ontario Department of Mines, Preliminary map, P. 560, 1 inch to ¼ mile.

1969: Township 157; Ontario Department of Mines, Preliminary map, P. 561, 1 inch to ¼ mile.

1970: Geology of the Spragge Area, Ontario Department of Mines,

Geological Report 76, Coloured geological map, 1 inch to ½ mile.
1970: Township 1A; Ontario Department of Mines, Preliminary map, P. 609, 1 inch to ¼ mile.
1970: Township 1B; Ontario Department of Mines, Preliminary map, P. 610, 1 inch to ¼ mile.
1971: Blind River-Elliot Lake Sheet, District of Algoma and Sudbury; Ontario Department of Mines, Preliminary map P. 304, (1971 revision), 1 inch to 2 miles.
1971: A review of recently acquired geological data, Blind River-Elliot Lake area; Ontario Department of Mines, Misc. Paper 45.

Roscoe, S. M. 1969: Huronian Rocks and Uraniferous Conglomerates in the Canadian Shield; Geological Survey of Canada, Paper 68-40.

Van Schmus, W. R. 1965: The Geochronology of the Blind River — Bruce Mines Area, Ontario, Canada; Journal of Geology, Vol. 73, pp. 775-780.

Young, G. M. and Church, W. R. 1966: The Huronian System in the Sudbury District and adjoining Areas of Ontario; A review: Geological Association of Canada Proceedings, Vol. 17, pp. 65-82.

GUIDEBOOKS OF THIS SERIES

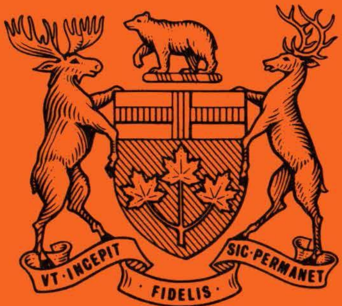
Geological Guidebook No. 1. Geology and Scenery: Rainy Lake and east to Lake Superior.

Geological Guidebook No. 2. Geology and Scenery: North Shore of Lake Superior.

Geological Guidebook No. 3. Geology and Scenery: Peterborough, Bancroft and Madoc Area.

Geological Guidebook No. 4. Geology and Scenery: North Shore of Lake Huron Region.

Other guidebooks are planned. The Publications Office, Ministry of Natural Resources, Queen's Park, Toronto, will be pleased to put you on their notification list.


VT · INCEPIT
· FIDELIS ·
SIC · PERMANET