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ONTARIO DEPARTMENT OF MINES
AND NORTHERN AFFAIRS

Geological Report 94

**Geology of the
North Bay Area
Districts of Nipissing and Parry Sound**

By

S. B. LUMBERS

1971



ONTARIO
DEPARTMENT OF MINES
AND NORTHERN AFFAIRS

HONOURABLE LEO BERNIER, *Minister*

D. P. DOUGLASS, *Deputy Minister*

J. E. THOMSON, *Director, Geological Branch*

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North Bay Area
Districts of Nipissing and Parry Sound

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Geological Map

(back pocket)

Map 2216 (coloured)—North Bay area, Nipissing and Parry Sound Districts. Scale 1 inch to 2 miles.

ABSTRACT

The North Bay area is in the northwestern part of the Grenville Province of the Canadian Precambrian Shield and covers about 1,700 square miles between Latitudes 46°00'N and 46°30'N, and Longitudes 79°00'W and 80°00'W. Reconnaissance mapping at a scale of 1 inch to 1 mile (final map at 1 inch to 2 miles) shows that the area is underlain mainly by a high-rank metamorphic complex of gneissic metasediments and plutonic rocks, although intrusive and sedimentary rocks younger than the metamorphic complex are also present.

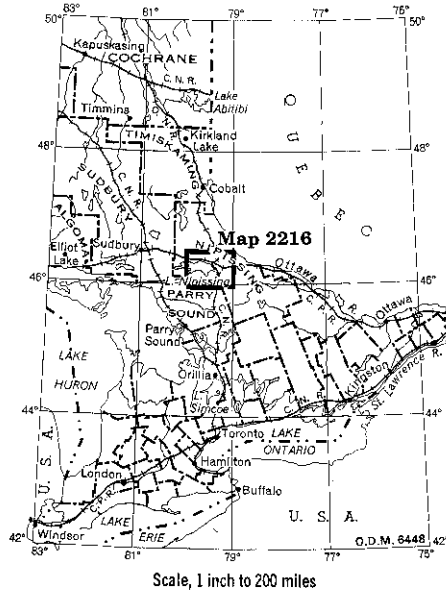


Figure 1—Key map showing location of the North Bay area.

Field relationships and geochronologic data indicate that the metamorphic complex underwent a complicated history of deformation, plutonism, and metamorphism during the Middle and Late Precambrian, and that following the major plutonism, the entire complex was subjected to a late high-rank regional metamorphism culminating between 1,400 and 1,200 million years ago. In general, complex foliation trends in the gneisses indicate isoclinal passive flow folds with northwest-trending axes refolded about axes trending north-northwest to east-west. Mineral assemblages of the gneisses are most typical of the kyanite-almandine-muscovite subfacies of the almandine-amphibolite facies, and migmatitic phases of the metasedimentary and felsic plutonic gneisses developed during the late high-rank regional metamorphism. Close to granite in composition, the migmatitic gneisses formed by partial anatexis controlled in part by the bulk chemistry of the rocks. Although mineral assemblages of the gneisses reflect only the late high-rank regional metamorphism, a lower grade regional metamorphism probably accompanied the emplacement of early, widespread, syntectonic or pre-tectonic granitic rocks about $1,700 \pm 150$ million years ago.

The oldest and most abundant rocks of the metamorphic complex are metasediments derived largely from siliceous sandstone and siltstone that probably accumulated to considerable thicknesses during Middle Precambrian time but whose base is not exposed. Two major sedimentary facies are represented: 1) biotite gneiss probably reflecting a eugeosynclinal facies of poorly sorted sand and silt deposited by turbidity currents in either relatively deep water, or below wave base; and 2) feldspathic gneiss and muscovitic and quartzose gneiss reflecting a miogeosynclinal facies of moderately to well sorted sand and silt deposited in a

near-shore environment under the influence of wave action. The eugeosynclinal facies greatly predominates over the miogeosynclinal facies, but both facies are intercalated and some miogeosynclinal deposits could represent eugeosynclinal deposits reworked in a near-shore environment. Traces of marble are present, but calc-silicate gneiss derived from calcareous sandstone and siltstone is widespread in the siliceous gneisses indicating that chemical carbonate sedimentation accompanied deposition of the clastic siliceous sediments. Major features of the metasedimentary sequence together with available geochronologic data suggest that the sequence could be eugeosynclinal facies of the miogeosynclinal Huronian Supergroup of the Southern Province deposited between 2,550 and 2,150 million years ago.

Most of the plutonic rocks are gneissic felsic varieties forming stocks, sheets, and a few batholiths and are subdivided into two major groups, granitic rocks and monzonitic rocks, on the basis of quartz and mafic mineral contents. The granitic rocks range in composition from potassic granite to granodiorite, but most are quartz monzonite. Monzonitic rocks, which have not been reported previously from this part of the Grenville Province, are similar chemically to charnockitic and pyroxene-bearing syenitic rocks of the anorthosite kindred but differ modally in that hornblende predominates over pyroxene. At least three ages of granitic rocks can be recognized by the relative intensity of deformation and of regional metamorphism. Geochronologic studies suggest that most of the granitic rocks are older than masses of monzonitic rocks, which also contain granitic phases, although at least one granitic batholith is younger than the monzonitic rocks. Metamorphosed mafic plutonic rocks of several ages, some of which may be older than the felsic plutonic rocks, form small, sheet-like bodies, stocks, and dikes in the felsic plutonic rocks and in the metasediments. Amphibolite dikes, probably metamorphosed gabbroic hypabyssal intrusions, are among the youngest rocks of the metamorphic complex. Small dikes of massive granite pegmatite concentrated near northeast-trending faults were emplaced within all rocks of the metamorphic complex during the waning stages of the late high-rank regional metamorphism.

During the Late Precambrian and at least the Early Paleozoic, following the high-rank regional metamorphism and plutonism, the region was subjected to faulting along two major systems, a west-northwest system and a northeast system; movement along faults of the northeast system appears to be slightly older than that along the west-northwest system. During this tectonism, gabbroic stocks and dikes of diabase intruded rocks of the metamorphic complex, and by the Cambrian, a westerly trending graben had formed across the central part of the area. Within this graben, which is a westerly extension of the Ottawa-Bonnechere graben system, Cambrian alkalic complexes and associated lamprophyre dikes were emplaced. Middle Ordovician sedimentary rocks, the youngest rocks exposed, were deposited within the graben and at one time may have covered most of the earlier rocks outside the graben.

The area was subjected to Pleistocene glaciation, and when the ice margin of the Wisconsin ice-sheet retreated north of the area, about 9,500 to 10,000 years ago, post-glacial lakes forming part of the prehistoric Great Lakes inundated parts of the area. As a result of post-glacial uplift of the land, these lakes drained leaving numerous smaller lakes in depressions and extensive deposits of varved clay and sand and gravel. Recent deposits consist of swamp accumulations and local fluvial and lacustrine deposits.

A variety of metallic and non-metallic mineral deposits are present, but the only mineral production is mainly clay and sand and gravel from Pleistocene sediments, minor stone from some of the gneisses and the Paleozoic rocks, and a few tons of mica and feldspar from late pegmatite dikes. Metallic mineralization consists mainly of iron, copper, nickel, magnesium, niobium, and uranium, but minor concentrations of pyrite and pyrrhotite and traces of gold, silver, and molybdenum are found. Much of the known iron mineralization is associated with faults of the west-northwest system and with the miogeosynclinal metasediments, but minor iron, and most of the known copper, nickel, niobium, and uranium mineralization are associated with the late mafic and Cambrian alkalic intrusions. Muscovitic and quartzose gneiss is particularly favourable for deposits of iron and uranium. Non-metallic mineralization consists mainly of feldspar, mica, kyanite, industrially useful rocks, clay, and sand and gravel. Extensive sand and gravel deposits in the eastern half of the area could prove to be a major resource for sand and gravel in central and southern Ontario.

Geology of the North Bay Area

Districts of Nipissing and Parry Sound

By

S. B. Lumbers¹

INTRODUCTION

Most of the northwestern part of the Grenville Province in Ontario has received little geologic mapping since early reconnaissance and exploration surveys carried out between the 1820s and 1920s, and as a result presently held geologic concepts are extremely tentative. From available data, this part of the Grenville Province appears to be a high-grade metamorphic complex of orthogneiss and paragneiss with local layers of marble and amphibolite, and age, origin, and stratigraphic succession are difficult to decipher. According to K-Ar radiometric ages shown by micas from the various gneisses, the metamorphic complex underwent regional metamorphism about 900 ± 100 million years ago (Stockwell 1964).

A major northeasterly trending tectonic zone, the Grenville Front, separates the metamorphic complex from less metamorphosed and more easily decipherable rocks of the Early Precambrian Superior Province and the Middle Precambrian Southern Province to the northwest. In a few places it has been shown (Johnston 1954; Grant *et al.* 1962; Grant 1964; Krogh and Hurley 1968; Henderson 1967) that rocks of the Superior and Southern Provinces extend across the Grenville Front into the immediately adjacent Grenville Province, and one might speculate that much of the northwestern part of the Grenville Province is underlain by high metamorphic rank equivalents of rocks of both the Superior and Southern Provinces. If so, then the Grenville Province may contain mineral deposits of a similar, although much more metamorphosed, nature to those in the Superior and Southern Provinces. In addition, the Grenville Front, one of the major tectonic features of the Canadian Shield, could also be an important locus of mineralization.

The mineral potential of this region is poorly known, and to date, only a few industrial mineral deposits and some Pleistocene sediments have been exploited commercially. In the North Bay area deposits of iron, copper, nickel, niobium, uranium, brucite, feldspar, kyanite, mica, industrially useful rocks, clay, and sand and gravel have been either explored or utilized, but present production is confined to clay products and to sand and gravel. If the mineral potential of this region is to be fully appreciated, a much better understanding of the regional geology is needed, and in particular, the possibilities men-

¹Geologist, Ontario Department of Mines and Northern Affairs, Toronto. Manuscript accepted for publication by the Chief Geologist, 4 May 1970.

North Bay Area

tioned above regarding mineralization must be carefully examined. Thus, in 1964 the author began a reconnaissance geological survey of the northwestern part of the Grenville Province north of Latitude $46^{\circ}00'N$ and west of Longitude $79^{\circ}00'W$. The author was fortunate in being able to co-ordinate his work with geochronological studies by T. E. Krogh of the Department of Terrestrial Magnetism, Carnegie Institution of Washington. This geochronologic work not only has enhanced the author's geologic concepts gained from reconnaissance mapping, but also has contributed greatly to understanding the complex relationships between the Grenville and the Southern and Superior Provinces.

The first of a series, the present report on the North Bay area covers about 1,700 square miles from Latitudes $46^{\circ}00'N$ to $46^{\circ}30'N$, and from Longitudes $79^{\circ}00'W$ to $80^{\circ}00'W$. The area is shown on the Powassan, North Bay, Sturgeon Falls, and Nipissing map sheets of the National Topographic Series and includes the eastern two-thirds of Lake Nipissing.

From the present work in the North Bay area, several features of the regional geology heretofore unrecognized became apparent. For example, about two-thirds of the region is underlain by metasediments whose gross primary characteristics are decipherable and which could be a eugeosynclinal facies of the Huronian Supergroup of the Middle Precambrian Southern Province. This sequence was subjected to Middle and Late Precambrian plutonic and regional metamorphic events, and no evidence of an Early Precambrian history was found. Moreover, felsic rocks of the anorthosite kindred, previously unreported from the northwestern part of the Ontario Grenville Province, are present and form two batholiths and several smaller intrusions. One lithologic unit in the metasediments is particularly favourable for deposits of iron and uranium.

PRESENT GEOLOGICAL SURVEY

Geologic mapping of the North Bay area was accomplished in seven months by the author and his assistants during parts of the 1964, 1965, and 1967 field seasons. A traverse interval of 1 mile was chosen because Aeromagnetic Maps published by the Geological Survey of Canada (GSC 1965a, b, c, and d) and controlled photo-mosaics of Operation Overthrust (Parkinson 1962) at a scale of 1 inch to 1 mile, cover the area and reveal that mapping at intervals larger than 1 mile would miss many magnetic and structural features. Before beginning the field work, a compilation was made of structural trends shown on 1 inch to 1 mile air photographs and photo-mosaics. These trends were plotted directly on a 1 inch to 1 mile base map printed on transparent plastic film and used as an overlay on the photo-mosaics. The base map was prepared by the Cartography Section of the Ontario Department of Mines and Northern Affairs from maps of the Forest Resources Inventory, Silviculture Section, Timber Branch, of the Ontario Department of Lands and Forests. During the field work any necessary topographic additions and corrections were made to the base map by the author.

In the field, the many roads and waterways in the area were mapped first, not only to verify the continuity of lithologic units suggested by structural trends, but also to determine the best grouping of the various rock types present for the scale of mapping used. By combining this field data with air photograph interpretation and aeromagnetic data, additional areas were selected for traversing in order to extend lithologic boundaries and major structural features. As a final step, the area was examined from a low-

flying aircraft to check inferred lithologic boundaries and to select areas for additional check traverses. It should be noted that the aircraft reconnaissance was done when the deciduous trees forming most of the forest cover were free of leaves, that rock exposure is good in most parts of the area, and that outcrops generally are not thickly coated with lichens and mosses.

All geologic data were plotted in the field on transparent plastic film fitted to 1 inch to 1 mile air photographs and then transferred to the base map by using the base map as an overlay on the photo-mosaics. After a geological interpretation was made from the data on the base map, the geology was generalized to produce a manuscript copy for the final map (Map 2216, back pocket) published on a scale of 1 inch to 2 miles. The field work was supplemented by petrographic and chemical examination of many rock specimens in the laboratory; this examination supplemented field observations and aided in preparing the classification of the rocks shown by symbols on Map 2216 (back pocket).

ACKNOWLEDGMENTS

The author was assisted in the field by I. M. Mason in 1964, by P. S. Ray and Glen Ramsay in 1965, and by T. Kataki, F. J. Dewis, and J. W. Ponikvar in 1967. P. S. Ray and T. Kataki carried out independent mapping, and Mr. Ray aided the author in some of the laboratory and compilation work. L. S. Jensen assisted the author for a few weeks in the fall of 1967.

Many residents and resort operators in the area, too numerous to name individually, were helpful in many ways, and the author would like to express his appreciation to them all. Carl Palangio of North Bay, S. A. Barton, Ontario Department of Lands and Forests, Powassan, and C. B. Swackhamer of Nipissing were particularly helpful in locating old workings in mineral deposits.

J. Satterly, Chief, Review and Resources Section, Ontario Department of Mines and Northern Affairs, provided field notes and other information concerning his work on mineral deposits within the map-area. Numerous discussions with T. E. Krogh were helpful in evolving the geologic interpretation of the area.

Unless stated otherwise, all chemical analyses in this report were done by the Laboratory and Research Branch, Ontario Department of Mines and Northern Affairs.

MEANS OF ACCESS

Except for the extreme northern, southeastern, and southwestern parts, the area is accessible by provincial highways and township roads. Highway 11 extends northward across the central part of the area, and Highway 17 extends westward across the central and northwestern parts; Highways 63 and 533 give access to the northeastern corner. Most parts of the area not accessible by motor roads can be reached either by water, or by logging roads. The southeastern corner lies within Algonquin Provincial Park, and travel here is regulated by the Ontario Department of Lands and Forests. The area also is crossed by main railway lines of the Canadian National Railways, Canadian Pacific Railway, and Ontario Northland Railway.

North Bay Area

PREVIOUS GEOLOGICAL WORK

Except for early exploration and reconnaissance surveys by Bigsby (1821), Logan (1847), Murray (1857), Barlow (1895; 1896; 1899; 1908) and Bell (1877; 1898), the area was unmapped geologically before the present study. A few mineral occurrences are described in the early reports, and Satterly (1942) described some general geological features and mineral occurrences in the southern part of the area south of Lake Nipissing. Harding (1944) mapped Orlig Township and the brucite occurrences near the eastern end of Lake Talon northeast of the village of Rutherglen. Friedman (1955) studied the Lake Memesagamesing mafic intrusion in the southwestern corner of the area. Some features of the alkalic complexes and associated rocks exposed in Lake Nipissing have been described by Goodwillie (1893), Knight (1949), Gill and Owens (1957), Rowe (1954; 1958, p. 45-62), and Currie (1969). Krogh (in Davis *et al.* 1967; Krogh *et al.* 1968; Krogh and Davis 1969b) has presented some results of his continuing geochronologic studies in the region. A preliminary geological map of the area has been issued (Lumbers 1968).

Colquhoun (1958) has studied the stratigraphy of the Paleozoic sedimentary rocks exposed near the village of Nipissing and on the Manitou Islands. The area contains numerous deposits and features pertaining to the prehistoric Great Lakes, and various studies of the Pleistocene geology have been made, most of which are summarized by Hough (1958; 1963). Recent regional studies of the Pleistocene in the vicinity of the map-area have been made by Terasmae and Hughes (1960), Boissonneau (1966), and Harrison (1969).

The area is covered by Geological Survey of Canada Aeromagnetic Maps published in 1965 (GSC 1965a, b, c, and d).

PHYSIOGRAPHY

The physiographic features of the map-area were formed by various geologic processes active over a long interval of time, probably in excess of 1,000 million years. High-grade metamorphic gneisses underlying most of the area were formed during the Middle and Late Precambrian, and although they were subjected to faulting and minor intrusive activity during the Late Precambrian and the Early Paleozoic, they were eroded to a peneplane by the Middle Ordovician, for marine sediments of this age were deposited on a previously formed peneplane in at least part of the area. The Precambrian peneplane was subsequently re-exposed by post-Ordovician erosion and by Pleistocene continental glaciation with attendant rise of the land surface following the retreat of the last ice-sheet, the Wisconsin, to form the present land surface. Although present drainage and topography are controlled to some extent by Precambrian structures in the metamorphic complex, the major control on drainage and topography are unconsolidated sediments deposited during the Pleistocene and Recent.

Relief

In general, relief in the area increases from west to east, and in the eastern part two water partings are present as shown in Figure 2. A northward-trending water parting separates the drainage basin of Lake Nipissing and the French River from that of the

Mattawa River, whereas a second water parting extending eastward from the first near the northern boundary of the area separates the Jocko River and Mattawa River drainage basins. Elevations along the water partings generally range from 1,000 to 1,400 feet with local elevations as low as 700 feet and as high as 1,600 feet. The highest point in the area, a little over 1,600 feet, is at the southern boundary of the map-area in the northwestern corner of Ballantyne Township, whereas Lake Nipissing, with an average elevation of 644 feet, is the lowest point. Maximum relief in the area as a whole is thus about 950 feet, but it may be greater because some waterways such as Trout Lake and the Mattawa River probably cover deep, pre-Pleistocene valleys in fault zones.

West of the northerly trending water parting the area is dominated by Lake Nipissing, which rarely exceeds 60 feet in depth and near which the local relief rarely exceeds 50 feet with elevations ranging from 650 to 800 feet. South of South Bay, Lake Nipissing, rocky uplands are found with elevations between 1,000 and 1,250 feet. North of Lake Nipissing prominent escarpments with elevations between 800 and 1,000 feet trend northwesterly parallel to the Canadian National Railway line and mark either zones of faulting, or strand lines related to the Nipissing and earlier stages of the Upper Great Lakes (Hough 1958; 1963).

East of the northerly trending water parting, the area is dominated by an eastward-trending, south-facing escarpment marking a fault zone and rising as much as 600 feet above the northern side of Trout Lake and the Mattawa River. North of this escarpment the grain of the topography conforms closely to layering and foliation in the underlying metamorphic gneisses, and prominent ridges striking northwestward rise 100 to nearly 400 feet above intervening valleys. South of the escarpment local relief is generally less than 50 feet, and elevations are less than 1,000 feet. South and east of Lake Nosbonsing and Wistiwasung Lake the land rises abruptly to rocky uplands with elevations between 1,000 and 1,600 feet, and local relief of as much as 400 feet.

Drainage

Drainage within the map-area is controlled by three drainage systems: the Mattawa River system, the Jocko River system, and the Lake Nipissing-French River system. The Mattawa River and Jocko River systems are part of the Ottawa River drainage basin whereas the Lake Nipissing-French River system is part of the Georgian Bay and Lake Huron drainage basin. Major tributaries of the Mattawa River system draining the area are Nosbonsing River, North River, and Antoine Creek; Amable du Fond River, another tributary of this system just east of the map-area, drains the southeastern corner of the area. Most of French Township and all but the southern part of Mulock Township are drained by the Jocko River system via the Little Jocko River, to the north of the map-area. Several major tributaries to the Lake Nipissing-French River system flow through parts of the area and include the Sturgeon, Tomiko, Smoke, Little Sturgeon, La Vase, Wistiwasung, Restoule, and Memesagamesing Rivers.

In recent years beaver have increased in numbers within the area and have dammed many of the small streams to create numerous ponds and swampy areas. Such flooding is particularly extensive south of Lake Nipissing where the relief is low.

North Bay Area

Rock Exposure

In general, bedrock is moderately to well exposed, but locally in the eastern and northwestern parts of the area Pleistocene and Recent deposits cover most of the bedrock. The most extensive of these covered areas are shown on Map 2216 (back pocket), and within these areas, outcrops are either scarce or lacking. Elsewhere, bedrock is covered by only a thin mantle of drift and 10 to 60 percent outcrop is present. The best rock exposure, about 60 percent, is near French River and the southern shore of Lake Nipissing in Bertram, Hardy, Patterson, and Nipissing Townships where wave action by waters of the prehistoric Great Lakes removed almost all the Pleistocene drift. Similar wave washed exposures are common in other parts of the area below elevations of 1,200 feet, and locally, outcrop density reaches nearly 50 percent. Above 1,200 feet, glacial deposits, mainly in the form of ground moraine, reduce rock exposures to 10 to 25 percent.

Lichen and moss overgrowths on outcrops are scarce to thin along shore lines and below elevations of about 800 feet. At elevations between 800 and about 1,100 feet this vegetal overgrowth thickens slightly but rarely obscures outcrops, but above 1,100 feet, thick lichen and moss overgrowths partly obscure some outcrops.

In general, calc-silicate gneisses and relatively late, unmetamorphosed, mafic and alkalic intrusive rocks within the area weather more rapidly than other rock types and form hollows and valleys; highest points in the area are underlain by granitic plutonic rocks. Metamorphosed mafic intrusive bodies commonly are characterized by rugged and irregular topography.

GENERAL GEOLOGY

For the most part, the North Bay area is underlain by a metamorphic complex of gneissic rocks regionally metamorphosed to the almandine-amphibolite facies, although intrusive and sedimentary rocks younger than the metamorphic complex are also present; the general succession of the rocks is summarized in Table 1.

The oldest and most abundant rocks of the metamorphic complex are metasediments derived largely from siliceous sandstone and siltstone that probably accumulated to considerable thicknesses during Middle Precambrian time but whose base is unknown. Calc-silicate gneiss and rare impure marble, the products of both clastic and chemical sedimentation, are interlayered locally with the clastic siliceous metasediments. Gneissic units of unequivocal volcanic origin have not been found, but one large amphibolite inclusion in plutonic rocks contains structures suggestive of a volcanic origin. The metasediments underwent partial anatexis during regional metamorphism with the result that many are now migmatitic containing numerous discontinuous veins and lenses of granitic material. The high-rank metamorphism and complex flow folding, to which the metasediments were subjected, destroyed primary structures indicative of tops of beds so that detailed structural studies would be needed to establish the stratigraphic succession, and at the present time these rocks are subdivided on a lithologic basis only.

A variety of plutonic rocks, probably ranging in age from Middle to Late Precambrian, were emplaced within the metasediments before the high-rank regional metamorphism and accompanying deformation ended and are themselves metamorphosed. Of the various plutonic rocks, gneissic felsic varieties forming stocks, sheets, and a few batholiths are the most abundant. As shown in Table 1, these rocks are subdivided into

two major groups, granitic rocks and monzonitic rocks, on the basis of quartz and mafic mineral contents, and at least three ages of granitic rocks can be recognized by the relative intensity of deformation and of regional metamorphism. Geochronologic studies suggest that most of these granitic rocks are older than the monzonitic masses (which also contain granitic phases) although at least one granitic mass is younger than the monzonitic rocks. The monzonitic rocks are similar chemically to felsic rocks of the anorthosite kindred. Metamorphosed mafic plutonic rocks of several ages, some of which may be older than the felsic plutonic rocks, form small, sheet-like bodies, stocks, and dikes in the felsic plutonic rocks and in the metasediments. Amphibolitic dikes, probably metamorphosed gabbroic hypabyssal intrusions, are among the youngest rocks of the metamorphic complex. Small dikes of massive pegmatite were emplaced within all the rocks of the metamorphic complex during the waning stages of regional metamorphism.

Following the high-rank regional metamorphism and plutonism, the region was subjected to faulting during the Late Precambrian, and at least the Early Paleozoic. During this tectonism gabbroic stocks and dikes of diabase intruded rocks of the metamorphic complex, and by the Cambrian, a westerly trending graben had formed across the central part of the map-area through Lake Nipissing. Within this graben, Cambrian alkalic complexes and associated lamprophyre dikes were emplaced. Middle Ordovician sedimentary rocks, the youngest rocks exposed, were deposited within the graben and at one time may have covered most of the earlier rocks outside the graben.

METAMORPHIC COMPLEX

Metasediments

Metasedimentary gneisses of the metamorphic complex are divided lithologically into two major groups: (1) clastic siliceous metasediments and (2) calcareous metasediments. Clastic siliceous metasediments form all but a small part of the metasedimentary gneisses and are derived from sandstones and siltstones probably ranging in original composition from orthoquartzite to greywacke. Megascopically, these gneisses can be distinguished from plutonic rocks of the metamorphic complex by their prominent compositional layering reflecting relic bedding and by their fine- to medium-grained granular texture reflecting their original clastic nature. On the basis of mineralogic and metamorphic features, the clastic siliceous metasediments are subdivided for mapping purposes into four units, each of which is named according to the most characteristic feature: 1) biotite gneiss; 2) migmatitic biotite gneiss; 3) feldspathic gneiss; and 4) muscovitic and quartzose gneiss. Geologic boundaries drawn in these metasedimentary gneisses are necessarily somewhat subjective because individual units commonly have gradational contacts and contain locally abundant interlayers of other units.

Calcareous metasediments consist mainly of hornblende-rich gneisses probably derived from calcareous sandstones and siltstones originally containing as much as 50 percent carbonate minerals. Most of the hornblende gneisses are calc-silicate rocks generally with 20 to 40 percent hornblende and a variety of other calc-silicate minerals. Rare marble units derived from impure limestone and dolostone are interlayered with hornblende gneiss, and locally within sequences of this gneiss, small lenticular units of amphibolite are found.

North Bay Area

Table 1

TABLE OF LITHOLOGIC UNITS FOR THE NORTH BAY AREA

CENOZOIC

RECENT

Swamp, lake, and stream deposits

PLEISTOCENE

Varved clay, sandy and silty boulder clay, sand, pebble gravel, boulder gravel

Unconformity

PALEOZOIC

UNCLASSIFIED

Sandstone (on Iron Island)

ORDOVICIAN

MIDDLE ORDOVICIAN

Limestone, dolostone, shale, sandstone, conglomerate

Unconformity

CAMBRIAN

ALKALIC AND MAFIC INTRUSIVE ROCKS

Carbonatite and barite veins, lamprophyre and felsite dikes, nepheline and alkalic syenites, fenite, mafic and ultramafic alkalic rocks, carbonatite, silicocarbonatite

Intrusive Contact

PRECAMBRIAN

LATE PRECAMBRIAN^a

MAFIC INTRUSIVE ROCKS

DIABASE DIKES

Diabase, quartz diabase

Intrusive Contact

MAFIC STOCKS

Norite, olivine gabbro, uralitized gabbro, metagabbro, uralitized and serpentinized pyroxenite and peridotite

Intrusive Contact

METAMORPHIC COMPLEX (PROBABLY MIDDLE TO LATE PRECAMBRIAN)

LATE PEGMATITE

Granite pegmatite dikes

High-Rank Regional Metamorphism

MAFIC PLUTONIC ROCKS^b

Metagabbro, metadiorite, metamorphosed ultramafic rocks, fine-grained and medium-grained amphibolite dikes, metadiabase dikes

FELSIC PLUTONIC ROCKS

MONZONITIC ROCKS

Pink, grey, and green, gneissic, garnet-hornblende monzonitic rocks with minor associated gneissic granitic rocks; gneissic tonalite and gneissic diorite

GRANITIC ROCKS^b

Migmatitic and gneissic biotite granite; non-migmatitic, gneissic biotite granite; migmatitic and gneissic garnet-biotite granite; migmatitic and gneissic hornblende-biotite granite

Intrusive and Metamorphic Contact

METASEDIMENTS

CALCAREOUS METASEDIMENTS

Carbonate metasediments, hornblende gneiss

CLASTIC SILICEOUS METASEDIMENTS

Quartzose and muscovitic gneiss, feldspathic gneiss, biotite gneiss; migmatitic varieties common

^a Some mafic intrusive rocks may be Early Paleozoic in age.

^b Multiple ages represented.

CLASTIC SILICEOUS METASEDIMENTS

Biotite Gneiss and Migmatitic Biotite Gneiss

Most of the metasediments underlying the North Bay area are fine- to medium-grained biotite-quartz-feldspar gneisses containing 10 to 35 percent biotite and minor hornblende. These gneisses exhibit prominent compositional layering reflecting, in part, original bedding and, in part, layering developed during metamorphism and deformation (Photos 1 and 2). Metamorphic layering is subparallel to the relic bedding and consists generally of 1) discontinuous, subparallel veins and lenses of medium-grained granitic material generally no more than a few inches thick and, rarely, 2) zones of agmatite, a breccia-like rock containing mafic-rich fragments, in a granitic matrix (Photo 2). Where 10 percent or more of the sequence contains granitic veins and lenses, the sequence is mapped as migmatitic biotite gneiss.

Petrographic evidence to be discussed below suggests that the migmatitic facies of the biotite gneiss formed by partial melting (anatexis) controlled at least in part by the bulk composition of the original rock. Because the bulk composition within the sequences is variable, the distribution shown for migmatitic and non-migmatitic biotite gneiss on the accompanying map (Map 2216, back pocket) is greatly generalized with some non-migmatitic biotite gneiss invariably intercalated with the migmatitic variety and, locally, forming as much as 50 percent of migmatitic sequences. Only those units relatively free of granitic veins and lenses, and sufficiently large to be shown at the scale of reproduction, are distinguished separately as biotite gneiss. Nevertheless, places where biotite gneiss is relatively abundant within the migmatitic biotite gneiss are indicated on the map by the appropriate symbol. Minor amounts of other metasedimentary lithologies, particularly hornblende gneiss and feldspathic gneiss, commonly are intercalated with the biotite gneisses, and in many places the biotite gneisses grade into feldspathic gneiss by a decrease in biotite content.

Megascopically, the biotite gneisses are light to dark grey, markedly well foliated rocks, and both the grain size and the biotite content vary from layer to layer. The original beds are relatively continuous but because of metamorphism and deformation,

North Bay Area



Photo 1—Relic bedding in biotite gneiss showing a thick bed of coarse metasandstone (dark grey) intercalated with thinly bedded metasandstone and metasilstone; southeast end of Chebagnet Lake, Field Township.



Photo 2—Typical migmatitic biotite gneiss showing subparallel veins and lenses of medium-grained granitic material and a zone of agmatite (left side of photo); Highway 17 near Highway 94.

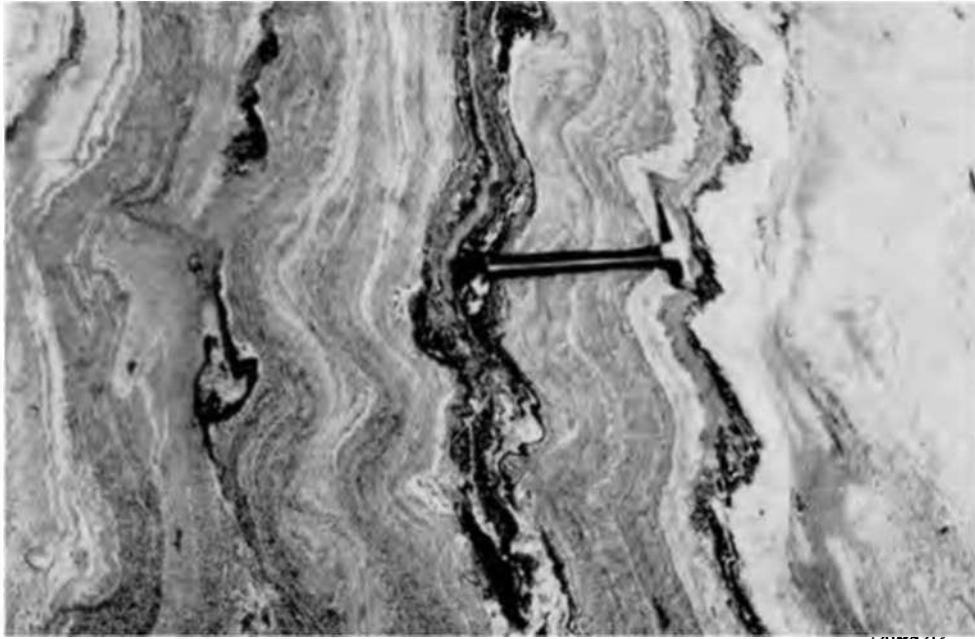


Photo 3—Typical thinly bedded biotite gneiss showing relic rhythmic bedding with thin, fine-grained, biotite-rich layers (dark gray) alternating with hornblende gneiss layers (black) and thicker fine-grained to medium-grained more quartzo-feldspathic layers; about ½ mile south of the east end of Hillside Lake, Widdifield Township.

they are disrupted and variable in thickness. Most commonly, the biotite gneisses are thinly bedded¹ with thin, fine-grained, schistose, biotite-rich layers alternating with thicker, fine- to medium-grained, gneissic, more quartzo-feldspathic layers (Photo 3). These relationships suggest that the original sediment was rhythmically bedded with either graded sand-silt couplets, or alternating sand and silt beds, or both. In many places originally thick-bedded to very thick-bedded, relatively coarser sandstones occur within the thinly bedded sandy and silty sequences (Photo 1) and are now coarser in grain size than the metasandstones in the originally thinly bedded sequences. Most of the hornblende gneiss found within the biotite gneiss is in the thinly bedded sequences.

Metamorphic recrystallization and deformation have destroyed primary sedimentary structures indicative of tops of beds, and locally in thinly bedded sequences deformation has resulted in fragmentation of the biotite-rich layers, forming tectonic breccia. In the thinly bedded sequences medium- to coarse-grained porphyroblasts of biotite, garnet, hornblende, feldspar, and, rarely, kyanite are found, but in the thick-bedded sequences only porphyroblasts of feldspar and quartz are common and this difference may reflect slightly different bulk compositions of the sequences. Where migmatitic, the biotite gneiss commonly contains numerous coarse-grained porphyroblasts and porphyroblastic aggregates of quartz and feldspar resembling pebbles, but no convincing evidence was found to indicate that conglomeratic or sedimentary breccia deposits were originally present.

¹Bedding is classified according to Dunbar and Rodgers (1957, p.97).

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Fifty specimens of the biotite gneisses were examined microscopically, and the major minerals present in order of decreasing abundance are quartz, plagioclase, potassic feldspar, and biotite. However, the gneisses can be subdivided into six petrographic varieties on the basis of relative abundance of the major minerals and presence of accessory minerals (Table 2). The six varieties are characterized by the following major mineral contents in order of increasing abundance:

1. K-feldspar + biotite + quartz + plagioclase
2. Biotite + K-feldspar + quartz + plagioclase
3. Biotite + plagioclase + K-feldspar + quartz
4. Hornblende + biotite + K-feldspar + quartz + plagioclase
5. Hornblende + quartz + plagioclase + biotite
6. Kyanite + biotite + plagioclase.

Table 2 RANGE IN MODAL COMPOSITION (VOLUME PERCENT) OF THE PETROGRAPHIC VARIETIES OF BIOTITE GNEISS AND MIGMATITIC BIOTITE GNEISS IN THE NORTH BAY AREA

| Petrographic Variety | (1) | (2) | (3) | (4) | (5) | (6) |
|-------------------------|---------|---------|---------|---------|-------|--------------|
| Number of Thin Sections | 21 | 15 | 4 | 5 | 3 | Average of 2 |
| Quartz | 15-40 | 25-40 | 30-40 | 25-35 | 5-20 | 1.3 |
| Plagioclase | 30-55 | 25-50 | 15-25 | 30-35 | 25-30 | 60.1 |
| percent An | 17-30 | 10-22 | 17-20 | 10-30 | 17-30 | 40 |
| K-feldspar | 6-17 | 15-25 | 25-35 | 15-25 | 0-5 | 0.6 |
| Biotite | 10-20 | 10-15 | 10-15 | 10-15 | 25-35 | 23.3 |
| Hornblende* | 0-9 | 0-1 | ... | 8-10 | 5-10 | 1.1 |
| Kyanite | 0-1 | ... | ... | ... | ... | 7.0 |
| Garnet | 0-5 | 0-3 | 0-1 | 0-2 | 0-1 | ... |
| Muscovite | 0-1 | 0-1 | 0-1 | ... | ... | 5.6 |
| Opaque minerals | 0-4 | 0-2 | 0.5-2 | 0-2 | 0-3 | 0.1 |
| Apatite | 0-1 | 0-1 | 0-0.5 | 0.5-1 | 1-2 | 0.4 |
| Sphene | 0-1 | 0-2 | 0-1 | 0.5-2 | 1-3 | 0.2 |
| Scapolite | ... | ... | ... | 0-1 | 0-2 | 0.1 |
| Others** | 1.0-2.5 | 0.5-2.0 | 0.5-1.0 | 0.5-1.0 | 1 | 0.2 |

* In variety 6 amphibole is cummingtonite-grunerite

**Zircon, carbonate, chlorite, epidote, allanite

As shown by the ranges in modal composition in Table 2, there is overlap in major mineral abundance among the first 4 varieties, but varieties (5) and (6) show distinct differences in major mineral abundances. Sandy biotite gneiss is characterized by varieties (1) to (3), and quartz and feldspar in these varieties are inequigranular with the average grain size between 1 and 2 mm. Silty biotite gneiss, on the other hand, is characterized by varieties (4) and (5), and these varieties are relatively equigranular with an average grain size generally less than 0.5 mm. Variety (4) is generally richer in hornblende and contains more calcic accessory minerals than the first three varieties. Variety (1) commonly contains less potassic feldspar, slightly more biotite, and more accessory hornblende and garnet than varieties (2) and (3). Variety (2) generally contains less potassic feldspar than variety (3), and variety (3) is most common near sequences of feldspathic gneiss. Variety (6) is rare and is found most commonly in units of non-migmatitic biotite gneiss.

Opaque minerals in the six varieties are mainly iron-titanium oxides, minor pyrrhotite, and rare pyrite. Trace amounts of carbonate as a secondary alteration product are found in hornblende-bearing varieties, and in some varieties biotite is partly altered to chlorite. In variety (6) the amphibole is a member of the cummingtonite-grunerite

series, but in all other varieties the amphibole is a dark green hornblende. Plagioclase is slightly antiperthitic with a few coarse blebs and spindles of potassic feldspar, but potassic feldspar grains are only rarely perthitic and show grid twinning indicative of microcline. Zircons are generally rounded and corroded suggesting a detrital origin, but in a few specimens metamorphic overgrowths on zircon grains are present. Foliation in the biotite gneisses is caused by alignment of matrix micas, quartz, and feldspar, and porphyroblasts are generally elongated subparallel to this foliation.

Rocks exhibiting varieties (2) and (3) are generally migmatitic, and from Table 2, these rocks contain a moderate amount of quartz and appear to be more alkalic and distinctly less calcic than rocks of varieties (4) to (6), which are only rarely migmatitic. Although generally non-migmatitic, rocks of variety (1) are slightly migmatitic where the plagioclase is more sodic than An_{20} , where the potassic feldspar content is greater than about 15 percent, and where the quartz content is less than 35 percent. Thus there is a compositional control on the development of migmatitic biotite gneiss. Only those gneisses close to granite in composition are migmatitic.

Present data are insufficient to determine the original rocks from which the biotite gneisses were derived, but the present field and petrographic data suggests that these rocks could represent feldspathic sandstones relatively rich in clay minerals and close to greywacke in composition. Although the relatively large variation in grain size of quartz and feldspar in the sandy parts of beds could be largely metamorphic, this variation also may reflect original poor sorting in the sandstones. Abundant evidence of primary rhythmic bedding within the biotite gneisses suggests the possibility that deposition was accomplished at least in part by turbidity currents. The apparent lack of coarse clastic debris in the gneisses suggests either a distal source area, or perhaps, a source area of low relief.

Feldspathic Gneiss

Fine- to medium-grained, pink to light grey, foliated feldspathic gneiss containing as much as 50 percent quartz and less than 10 percent biotite is the second most abundant metasediment of the metamorphic complex. It is intercalated with both biotite gneiss and muscovitic and quartzose gneiss, and although it is abundant in units of muscovitic and quartzose gneiss, mappable units were found only within the biotite gneisses, such as in Commanda, Beaucage, Pedley, Grant, and Patterson Townships. Most of these mappable units contain intercalated biotite gneisses. Although much of the feldspathic gneiss is granitic in modal composition, its derivation from sedimentary deposits is shown by the presence of relic bedding (Photo 4), by megascopic vestiges of a clastic texture, and by gradations into biotite gneiss in some places, and into muscovitic and quartzose gneiss in other places. In addition, accessory zircons in the gneiss invariably are detrital in appearance with rounded, corroded outlines and rare metamorphic overgrowths.

Relic bedding in the feldspathic gneiss is defined most commonly by 1) variations in grain size and in biotite content, 2) thin layers and seams of biotite (Photo 4), and 3) layers of hornblende gneiss. The relic bedding is relatively continuous but is disrupted and complexly deformed, and like the biotite gneiss, the feldspathic gneiss was apparently originally thinly bedded to very thick bedded with most of the intercalated hornblende gneiss occurring within thinly bedded sequences. In a few places within units of muscovitic and quartzose gneiss, such as west of Timber Lake on

North Bay Area



Photo 4—Relic bedding in feldspathic gneiss defined by variations in grain size and by thin layers and seams of biotite; Ferris Point, Cache Bay, Lake Nipissing.

Highway 533 in the northeastern corner of the area, the feldspathic gneiss contains flattened fragments, less than 3 inches long, of fine-grained feldspathic gneiss and of muscovitic and quartzose gneiss. The fragmental rock forms discontinuous layers, less than 2 feet thick, and could be intraformational conglomerate. The feldspathic gneiss is locally migmatitic with 10 to 40 percent discontinuous veins and lenses, largely sub-parallel to the foliation, of medium-grained to rarely coarse-grained granitic material. The most migmatitic feldspathic gneiss generally does not contain as much granitic material as the most migmatitic biotite gneiss. Porphyroblasts are rare in the non-migmatitic gneiss and are mainly garnet and iron-titanium oxide minerals, but where the gneiss is migmatitic, porphyroblasts of feldspar are common. One variety of the gneiss that contains nearly 50 percent quartz also contains foliated coarse-grained kyanite porphyroblasts. Locally in some units of the gneiss porphyroblasts of iron-titanium oxides constitute nearly 15 percent of the rock and produce slight positive aeromagnetic anomalies. The gneisses rich in kyanite and iron-titanium oxides are discussed further in the "Economic Geology" section.

Microscopic examination of 24 specimens of feldspathic gneiss reveals that it is essentially a quartz-feldspar rock, but on the basis of relative abundance of the major minerals and presence of accessory minerals, the gneiss can be subdivided into five petrographic varieties (Table 3). These varieties are characterized by the following major mineral contents in order of increasing abundance:

1. Plagioclase + K-feldspar + quartz
2. K-feldspar + plagioclase + quartz
3. K-feldspar + quartz + plagioclase
4. Kyanite + K-feldspar + plagioclase + quartz
5. Plagioclase + quartz.

Table 3

RANGE IN MODAL COMPOSITION (VOLUME PERCENT) OF THE PETROGRAPHIC VARIETIES OF FELDSPATHIC GNEISS IN THE NORTH BAY AREA

| Petrographic Variety | (1) | (2) | (3) | (4) | (5) |
|-------------------------|-------|-------|--------------|--------------|------|
| Number of Thin Sections | 13 | 6 | Average of 2 | Average of 2 | 1 |
| Quartz | 30-45 | 35-45 | 31.2 | 48.7 | 46.0 |
| Plagioclase | 15-25 | 25-33 | 37.0 | 14.8 | 44.9 |
| percent An | 5-20 | 15-25 | 15 | 32 | 23 |
| K-feldspar | 25-35 | 20-30 | 23.0 | 12.7 | 1.6 |
| Biotite | 3-7 | 2-4 | 5.4 | 5.4 | 5.6 |
| Muscovite | 0-1 | 0.2-3 | 0.1 | 2.8 | ... |
| Kyanite | 0-1.5 | ... | ... | 12.0 | ... |
| Garnet | 0-0.5 | 0-1.5 | ... | ... | ... |
| Hornblende | 0-8 | 0-1 | ... | ... | ... |
| Opaque minerals | 0.5-4 | 2-8 | 1.8 | 3.4 | 1.0 |
| Sphene | 0.1-2 | 0-2 | 0.6 | 0.2 | 0.2 |
| Others* | 0.3-1 | 0.5-1 | 0.6 | trace | 0.7 |

*Apatite, zircon, epidote, chlorite, allanite

Opaque minerals are mainly iron-titanium oxides and only rarely pyrrhorite. Epidote is an accessory mineral in all varieties except the fourth, and zircons are generally rounded and corroded suggesting a detrital origin. In most assemblages biotite is partly altered to chlorite, and plagioclase is partly sericitized and slightly antiperthitic. Potassic feldspar is rarely perthitic and displays grid twinning indicative of microcline. The average grain size of the gneiss is variable, but the rock is distinctly more equigranular than the biotite gneisses. Those varieties richest in quartz and plagioclase are coarser grained (up to 1.5 mm) than those containing approximately equal proportions of quartz, plagioclase, and potassic feldspar, and the finest grained rocks (about 0.3 mm) are confined to variety (1). Most of the feldspathic gneiss is richer in quartz than the biotite gneiss. Migmatitic facies of the gneiss are generally present only in varieties (1) and (3), although variety (2) is migmatitic locally. In general, migmatitic feldspathic gneiss is characterized by abundant potassic feldspar and sodic plagioclase, and by less than 40 percent quartz.

From the present data, the feldspathic gneiss appears to represent original arkosic sandstone and siltstone. Variations in grain size of the gneiss could reflect original sandy and silty material, and the local abundance of iron-titanium oxides may indicate that the original sandstone and siltstone were locally ferruginous. Like the biotite gneiss, the feldspathic gneiss generally contains more plagioclase than potassic feldspar, and most of the feldspathic gneiss is associated with biotite gneiss. The tendency for quartz and feldspar in the feldspathic gneiss to be more equigranular than in the biotite gneiss could indicate that the feldspathic gneiss was originally a better sorted sandstone. These relationships may indicate that the feldspathic gneiss represents in part reworking of the poorly sorted sands and silts that gave rise to the biotite gneiss. Some feldspathic gneiss could represent original felsic flows and pyroclastic material, but no evidence indicative of such an origin was found and independent evidence indicating widespread volcanism within the sedimentary accumulation is lacking. However, the feldspathic gneiss could represent material eroded from a volcanic terrain.

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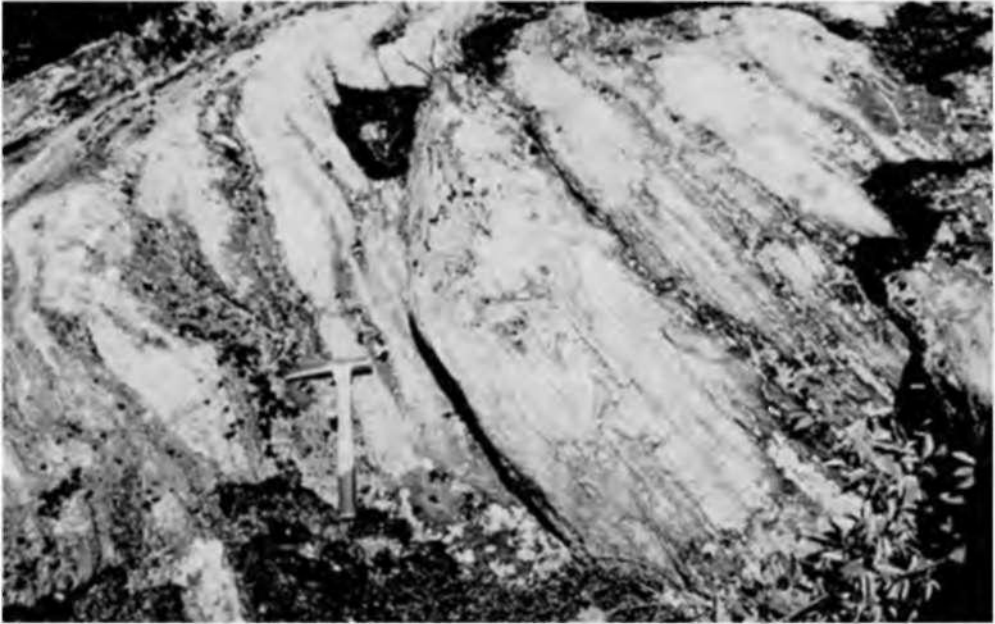


Photo 5—Deformed relic bedding in muscovitic and quartzose gneiss marked by muscovite-rich layers; ½ mile east of Highway 63 and ¼ mile south of north boundary of Phelps Township.

Muscovitic and Quartzose Gneiss

Sequences of predominately white to pale pink, foliated, medium-grained muscovitic and quartzose gneiss with intercalated, coarsely recrystallized orthoquartzite form an extensive unit underlying much of the northeastern corner of the North Bay area and are sufficiently abundant near the western shore of South Bay, Lake Nipissing, to be distinguished separately on the map (Map 2216, back pocket). Elsewhere in the area, this gneiss forms only thin units, no more than a few tens of feet thick, in some feldspathic gneiss sequences and, rarely, in the biotite gneisses, particularly near French River in Bertram Township.

Sequences of this gneiss consist mainly of muscovite-feldspar-quartz rocks and muscovite-quartz rocks and typically contain widespread, thin units of hornblende gneiss and locally abundant, thin units of feldspathic gneiss and biotite gneiss. Unlike the biotite gneiss and feldspathic gneiss, the muscovitic and quartzose gneiss is only slightly migmatitic, and subparallel veins and lenses of granitic material, which are generally coarse-grained to pegmatitic, form less than 25 percent of migmatitic facies of the gneiss. Complexly deformed, relic bedding is present in the gneiss (Photo 5) and is marked by layers of orthoquartzite and other sedimentary lithologies, by layers, less than 3 inches thick, rich in muscovite, and by discontinuous layers, only a fraction of an inch thick, rich in specular hematite; in general, sequences of the gneiss are thinly bedded. The muscovite varies in colour from greenish to reddish, and this colour variation defines a gneissosity subparallel to relic bedding. Individual colour units range in thickness from a fraction of an inch to tens of feet. The reddish units contain specular hematite as the only iron oxide whereas the greenish units contain

both hematite and magnetite suggesting that the greenish units are enriched in ferrous oxide relative to the reddish units. For the most part, the muscovitic and quartzose gneiss is more equigranular and is coarser in grain than either the biotite gneiss or the feldspathic gneiss. Porphyroblasts are rare and are generally garnet and muscovite.

Microscopically, the muscovitic and quartzose gneiss consists of five petrographic varieties in addition to orthoquartzite. These varieties are characterized by the following major mineral contents in order of increasing abundance:

1. Plagioclase + muscovite + K-feldspar + quartz
2. Muscovite + quartz
3. K-feldspar + muscovite + quartz
4. Muscovite + K-feldspar + plagioclase + quartz
5. Muscovite + plagioclase + K-feldspar + quartz.

The orthoquartzite consists mainly of interlocking quartz grains with 10 percent or less muscovite and minor accessory feldspar, opaque minerals, sphene, and zircon.

Table 4 RANGE IN MODAL COMPOSITION (VOLUME PERCENT) OF THE PETROGRAPHIC VARIETIES OF MUSCOVITIC AND QUARTZOSE GNEISS IN THE NORTH BAY AREA

| Petrographic Variety | (1) | (2) | (3) | (4) | (5) |
|-------------------------|-------|---------|-----------------|-----------------|-------|
| Number of Thin Sections | 6 | 3 | Average of 2 | Average of 2 | 1 |
| Quartz | 40-50 | 65-70 | 48.3 | 36.1 | 42.3 |
| Plagioclase | 12-16 | 3-9 | 8.0 | 35.6 | 12.1 |
| percent An | 15-25 | 20-25 | 18 | 17 | 10 |
| K-feldspar | 20-25 | 2-11 | 11.8 | 14.5 | 28.9 |
| Muscovite | 14-18 | 12-14 | 27.5 | 12.6 | 11.4 |
| Biotite | 0-6 | 0.2-0.7 | ... | 0.9 | 1.2 |
| Opaque minerals | 0.5-3 | 1-2 | 3.4 | 0.3 | 3.3 |
| Garnet | 0-2 | 0.1-0.3 | 0.3 | ... | 0.8 |
| Others* | 0-0.5 | 0.5-1 | 0.7 | trace | trace |

*Apatite, zircon, epidote, kyanite

Modal data for the five petrographic varieties together with plagioclase compositions are given in Table 4. Apatite and zircon are minor accessory constituents in all varieties, and zircon grains are rounded and corroded, rarely with metamorphic overgrowths. Epidote is a minor accessory mineral in varieties (2), and (3), and kyanite is a minor accessory mineral in variety (2). Allanite, a common accessory mineral in the other metasedimentary gneisses, is rare in the muscovitic and quartzose gneiss. In all varieties plagioclase is slightly antiperthitic, and potassic feldspar is relatively coarsely perthitic and shows grid twinning indicative of microcline. The first two varieties form most of the gneiss, and only variety (4) is commonly migmatitic. Varieties (1) and (5) are slightly migmatitic, but variety (1) is non-migmatitic if the plagioclase is more calcic than about An₂₀ and if quartz is more abundant than about 40 percent. Again, as in the other metasedimentary gneisses described above, the development of migmatite appears to be dependent at least in part on bulk composition.

A comparison of Tables 2, 3, and 4 shows that the muscovitic and quartzose gneiss is not only richer in quartz, but also has lower plagioclase to potassic feldspar ratios and is probably more potassic than the biotite gneiss and the feldspathic gneiss. Muscovitic and quartzose gneiss appears to represent relatively mature, well sorted sands that originally contained 1) abundant intercalated calcareous sands and silts, now represented by the widespread intercalated hornblende gneiss, and, probably, 2) thin beds of

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clay-rich material now represented by the muscovite-rich layers. Such deposits can be derived from source areas eroded to near base level and deposited under near-shore conditions where the sands undergo repeated washing and winnowing. The facts that much of the gneiss contains feldspar and is not mainly orthoquartzite and that biotite gneiss and feldspathic gneiss intercalations are locally present suggest that the original quartzose deposits were first-cycle sands rather than sands that had gone through more than one cycle of sedimentation. The common presence of thin discontinuous specular hematite layers suggests that the original sandstones were ferruginous and possibly contained a secondary iron cement. Some of the orthoquartzite may be metamorphosed chemically deposited silica.

CALCAREOUS METASEDIMENTS

Hornblende Gneiss

Fine- to medium-grained, dark green to black, foliated rocks, having hornblende as an essential constituent and containing discontinuous, alternating, mafic and felsic layers, generally less than 1 inch thick, are intercalated with the clastic siliceous metasediments throughout the area and are grouped together for mapping purposes as hornblende gneiss. This gneiss consists of two major lithologies: calc-silicate gneiss and amphibolite, with calc-silicate gneiss greatly predominating over amphibolite. The two rock types most commonly occur as thin layers and discontinuous masses generally less than 6 feet thick within other metasediments. Thicker mappable units composed mainly of calc-silicate gneiss occur in muscovitic and quartzose gneiss underlying the northeastern corner of the area, and the calc-silicate gneiss here commonly contains pods and lenticular masses up to a few feet long of coarse-grained, white to salmon pink calcite. Migmatitic biotite gneiss underlying the region south of Trout Lake and the Mattawa River between the eastern end of Lake Nipissing and the Bonfield batholith also contains many thin layers of calc-silicate gneiss, which in places is the dominant lithology over a wide enough area to form mappable units. One such unit exposed on the southern shore of Trout Lake near its junction with the Mattawa River contains thin, dismembered layers of marble (Photo 6). Units of predominantly non-migmatitic biotite gneiss generally contain more thin layers and lenticular patches of calc-silicate gneiss than units of predominantly migmatitic biotite gneiss, although because of the thinness of the layers this doesn't show on Map 2216 (back pocket), and, locally, the biotite gneiss grades into calc-silicate gneiss by a gradual increase in hornblende. Metamorphic reaction zones, generally less than a few centimetres wide, are present at some of the contacts between feldspathic clastic siliceous metasediments and hornblende gneiss; biotite is concentrated at the borders of hornblende gneiss layers whereas potassic feldspar is depleted, and plagioclase is enriched in the adjacent clastic siliceous metasediments.

The calc-silicate gneiss shows large variations in mineralogy, and from microscopic examination of 15 specimens of the most common varieties, seven major mineral assemblages are present as follows:

1. Quartz-hornblende-plagioclase \pm biotite, K-feldspar, epidote, garnet, scapolite
2. Biotite-hornblende-plagioclase \pm sphene, quartz, K-feldspar, diopside, garnet, epidote

Photo 6—Thin, dismembered layers of marble (light grey) in hornblende gneiss; south shore of Trout Lake near junction with the Mattawa River, East Ferris Township.



3. Garnet-epidote-plagioclase-hornblende \pm quartz, scapolite, biotite, K-feldspar
4. Quartz-diopside-hornblende-epidote \pm plagioclase
5. Garnet-plagioclase-hornblende \pm quartz, biotite, epidote
6. Quartz-hornblende \pm epidote
7. Diopside-scapolite-quartz \pm plagioclase, biotite, K-feldspar, garnet

Opaque minerals commonly form as much as 8 percent of the assemblages and consist mainly of iron-titanium oxides with minor pyrrhotite and rare pyrite. Apatite, allanite, sphene, and calcite are minor accessory constituents in most assemblages, and assemblages (1) and (2) contain rare grains of zircon with rounded, corroded outlines. Plagioclase ranges in composition from An_{20} to An_{45} and is most calcic in assemblages rich in epidote, diopside, and scapolite. Assemblages (1) and (2) are more abundant

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than the others, and all gradations are found between the first two assemblages and hornblende-bearing assemblages of the biotite gneiss. Individual units of calc-silicate gneiss can contain either one main assemblage or several assemblages interlayered, and all assemblages are found in each of the clastic siliceous metasedimentary lithologies, although assemblages (4) and (5) are most abundant in muscovitic and quartzose gneiss. Epidote is generally the iron-rich variety pistacite, but clinozoisite is also present in the plagioclase-rich assemblages. Coarse-grained potassic feldspar aggregates, some with intergrown quartz, are found locally in many calc-silicate gneiss layers composed of assemblages (1) and (2), but the calc-silicate gneiss is non-migmatitic.

The mineralogy, the complex and intricate interlayering of the calc-silicate gneiss with clastic siliceous metasediments, and the rare presence of marble and pods of coarse-grained calcite show that the calc-silicate gneiss is probably derived from calcareous sandstones and siltstones. A sedimentary origin is suggested also by the facts that 1) calc-silicate gneiss grades into biotite gneiss containing only minor hornblende, 2) most of the calc-silicate gneiss in the biotite gneiss and feldspathic gneiss occurs in thinly bedded sequences of these gneisses, and 3) some calc-silicate gneiss contains rounded, corroded zircons similar to those in the clastic siliceous metasediments and most likely detrital in origin.

Metasedimentary amphibolite, a rock similar in appearance to the calc-silicate gneiss, but composed chiefly of equal amounts of plagioclase and hornblende, is found mainly as locally developed lenticular masses in calc-silicate gneiss units; garnetiferous and biotitic varieties are locally present. Other amphibolite units, locally of mappable dimensions, appear to represent metamorphosed mafic igneous rocks, mainly metagabbro and metadiorite (see section on "Mafic Stocks"). Amphibolite associated with the calc-silicate gneiss, on the other hand, may have developed during regional metamorphism by metamorphic differentiation of calc-silicate gneiss. Inclusions of massive to foliated and contorted amphibolite are found in many of the plutonic rocks of the area, particularly south of Lake Nipissing and in the Powassan and Bonfield batholiths. One large amphibolite inclusion within the Powassan batholith on the northern side of the South River, west of the reservoir in South Himsworth Township, contains elliptical-shaped, epidotized masses up to 1 foot in size that resemble bombs in a mafic agglomerate. This is the only amphibolite, seen in the area by the author, containing structures suggestive of a volcanic origin.

Carbonate Metasediments

Carbonate metasediments are rare in the area and occur mainly as irregularly-shaped inclusions in felsic plutonic rocks of the Bonfield batholith east of Lake Talon in Orlig Township. As mentioned in the previous section, minor marble is also intercalated with calc-silicate gneiss at the eastern end of Trout Lake, and pods of calcite, possibly indicative of originally carbonate-rich sediments, are associated locally with calc-silicate gneiss intercalated with muscovitic and quartzose gneiss.

Marble east of Lake Talon, which, as suggested by Harding (1944), could represent roof pendants in the felsic plutonic rocks, is locally rich in brucite and contains some graphite, serpentine, diopside, tremolite, and phlogopite. Concentrations of magnetite and botryoidal hematite occur near the margins of the marble inclusions, and hematite veinlets are particularly common along contacts with the host plutonic rocks. Brucite-bearing marble represents metamorphosed dolostone, but much of the marble is derived from dolomitic and calcitic limestone containing less than 50 percent clastic impurities. Calc-silicate gneiss is intercalated locally with the marbles.

METASEDIMENTARY INCLUSIONS IN PLUTONIC ROCKS

Metasedimentary inclusions are relatively common in plutonic rocks emplaced within the metasedimentary gneisses. In general, these inclusions are less severely deformed and contain better preserved primary features than the metasedimentary gneisses, and thus detailed work on these inclusions could reveal features of the parent sedimentary deposits not preserved in the metasedimentary gneiss. However during the course of the present study, only the general characteristics of these inclusions could be recorded.

Most of the inclusions are similar in mineral composition to either biotite gneiss or calc-silicate gneiss; inclusions mineralogically similar to feldspathic gneiss and to quartzose and muscovitic gneiss are present but are not abundant. Metasedimentary inclusions in the plutonic rocks are not migmatitic although they do show various degrees of assimilation by the host plutonic rock; large roof pendants of metasediments present in some plutons, however, are migmatitic.

Inclusions are commonly hornfelsed, but those mineralogically similar to biotite gneiss show relic rhythmic bedding with sandy layers either grading into, or alternating with silty layers. Inclusions similar in mineralogy to feldspathic gneiss and to quartzose and muscovitic gneiss also retain relic sandy and silty habits and provide further confirmation that these gneisses also represent original sandstones and siltstones. No feldspathic inclusions were found containing primary volcanic textures or structures.

SUMMARY OF THE METASEDIMENTARY SEQUENCE

The metasedimentary sequence is a relatively thick accumulation of siliceous sandstone and siltstone virtually free of coarse clastic detritus. Although the base of the sequence is not exposed, the thickness is probably on the order of magnitude found in geosynclinal tracts. Two major sedimentary facies appear to be represented: 1) the biotite gneisses probably reflect a eugeosynclinal facies of poorly sorted sand and silt deposited by turbidity currents in either relatively deep water, or below wave base; and 2) the feldspathic gneiss and quartzose and muscovitic gneiss reflect a miogeosynclinal facies of moderately to well sorted sand and silt deposited in a near-shore environment under the influence of wave action. The eugeosynclinal facies greatly predominates over the miogeosynclinal facies, but both facies are intercalated and some miogeosynclinal deposits could represent eugeosynclinal deposits reworked in a near-shore environment. Calc-silicate gneiss, derived from calcareous sandstone and siltstone, is widespread in the siliceous gneisses and indicates that chemical carbonate sedimentation accompanied deposition of the clastic siliceous sediments.

Several divergent views exist concerning geosynclinal sedimentation, but those expressed by Dietz (1963; 1966) and based upon recent marine geologic studies appear to be particularly adaptable in understanding the major features of the present geosynclinal metasedimentary sequence. Dietz envisages geosynclinal sedimentation to be initiated along a tectonically-at-rest continental margin. A prism of turbidity current deposits of continental detritus gradually accumulates, at the base of the continental slope, building a continental rise. This prism is a eugeosyncline, and as it grows, the prism slowly subsides isostatically, causing a down warping of the adjacent sialic continental margin. Prograding coastal plain and near-shore sediments build up a monoclinial wedge of continental platform or miogeosynclinal deposits on this marginal flexure. As sedimentation causes the subsidence, this entire geosynclinal development is

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gravitationally induced. Eventually the continental-rise beds lap up to the top of the continental slope and the continental margin grows seaward. Thus near the continental margin eugeosynclinal and miogeosynclinal facies can interfinger, and eugeosynclinal deposits could be reworked in near-shore environments.

Lithologically, the metasedimentary sequence reflects an older cratonic source area, and the presence of both miogeosynclinal and eugeosynclinal facies could indicate deposition along a continental margin such as envisaged by Dietz (1963; 1966). Because eugeosynclinal facies sediments dominate the sequence, and because coarse clastic detritus is scarce, the sequence could be part of an ancient continental rise deposited in relatively deep water. The intercalated miogeosynclinal facies sediments may indicate fluctuations in sea level possibly caused by isostatic adjustments during the growth of the continental rise to the top of the continental slope. On the other hand, the metasedimentary sequence is complexly deformed and some units of miogeosynclinal sediments may have been telescoped with the eugeosynclinal rocks during deformation.

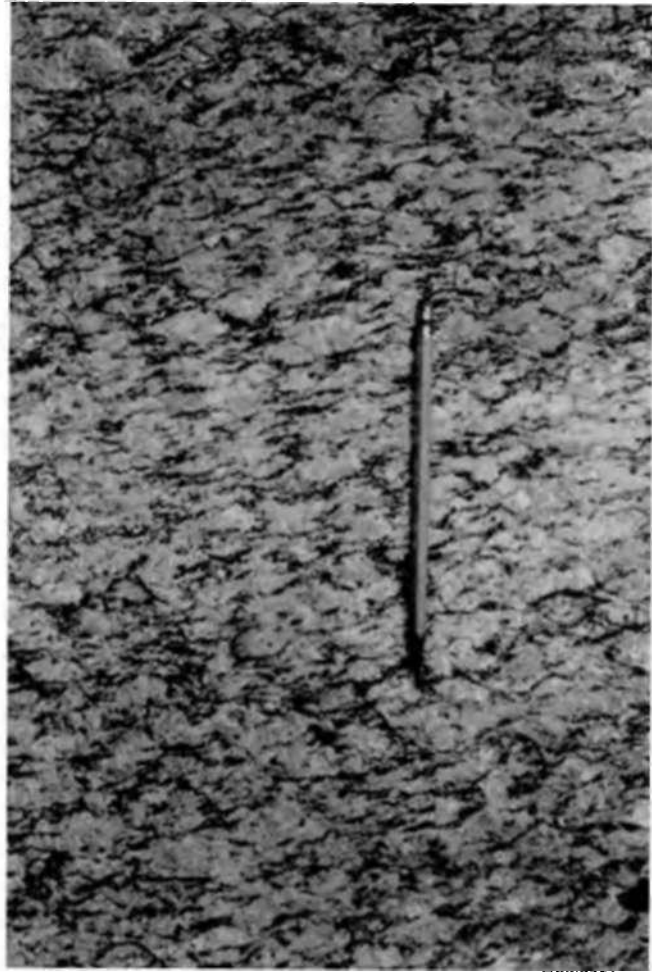
This possible continental rise is probably Middle Precambrian in age, and as Dietz and Holden (1966) have suggested, the complementary monoclinical wedge of miogeosynclinal deposits could be the Middle Precambrian Huronian Supergroup of the Southern Province to the west. The Early Precambrian Superior Province was the cratonic mass supplying detritus for this Middle Precambrian geosyncline, and the Grenville Front possibly marks the continental slope of the Early Precambrian continent. Geochronologic studies indicate that the oldest felsic plutonic rocks emplaced in the metasedimentary sequence are about 1,700 million years old (Krogh and Davis 1969), and this age is therefore a minimum age for the sequence in the map-area. The Huronian Supergroup probably was deposited between 2,550 and 2,150 million years ago and also contains intrusions about 1,700 million years old (Fairbairn *et al.* 1969). Rocks of the Huronian Supergroup were derived from the older Superior Province and are characterized by submature, fluvial sediments and other continental and shallow-water marine sediments deposited upon an irregular, unstable platform adjacent to a rising highland source area (Roscoe 1969). This miogeosynclinal accumulation thickens towards the southeast where it abuts against the Grenville Province south of Sudbury (Quirke and Collins 1930; Roscoe 1969).

Thus, the major features of the metasedimentary sequence in the North Bay area are consistent with the suggestion of Dietz and Holden (1966) that the metasediments of the northwestern part of the Grenville Province are a eugeosynclinal facies of the Huronian Supergroup and are remnants of a former continental rise prism.

Felsic Plutonic Rocks

About a third of the metamorphic complex in the North Bay area consists of gneissic, felsic plutonic rocks that are divisible into two major lithologic groups on the basis of quartz and mafic mineral contents: 1) pinkish granitic rocks characterized by biotite, biotite and hornblende, or less commonly by biotite and garnet as the major mafic constituents and by abundant visible quartz; and 2) pink, grey, and green monzonitic rocks characterized by garnet, hornblende, and biotite, and, locally, pyroxene as the major mafic constituents and by only minor or no visible quartz. Both lithologic groups are regionally metamorphosed and have many textural and other features in common so that these can be described before dealing with the groups separately.

Photo 7—Typical augen structure shown by the gneissic felsic plutonic rocks; hornblende-biotite granite near Bingham Chute; 1.5 miles west of Powassan, South Hiramworth Township.



Texturally, the felsic plutonic rocks differ markedly from the metasediments and are mainly medium- to coarse-grained and gneissic with a pronounced augen structure: medium-grained constituents are concentrated in thin, discontinuous layers that deflect around lenticular augen, up to 1 inch long, composed of medium- to coarse-grained aggregates of either quartz, or feldspar, or both (Photo 7). Locally, the felsic plutonic rocks are massive and display relic, primary igneous textures with numerous, coarse-grained, euhedral phenocrysts of partly recrystallized feldspar in a fine- to medium-grained, recrystallized granular groundmass of quartz, feldspar, and mafic minerals (Photo 8). This porphyritic variety commonly grades into augen gneiss, and augen of granular feldspar probably represent original feldspar phenocrysts. Equigranular, metamorphosed aplitic phases of the granitic rocks are present, but they generally form dikes and irregularly shaped masses in augen gneiss (Photo 9). Many of the monzonitic rocks contain medium- to coarse-grained hornblende and garnet porphyroblasts and porphyroblastic aggregates in a medium-grained, equigranular, feldspatic matrix (Photo 10). Most plutons of the granitic and monzonitic rocks contain narrow dikelets of

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Photo 8—Massive, porphyritic, monzonitic rock containing numerous coarse-grained, euhedral phenocrysts of partly recrystallized perthitic potassic feldspar in a fine- to medium-grained, recrystallized groundmass of quartz, feldspar, hornblende, garnet, and biotite; northeast corner of South Bay, Lake Nipissing, Nipissing Township.

recrystallized, gneissic, granitic pegmatite presumably formed during the latter stages of emplacement of the plutonic masses. Younger, massive granitic pegmatites, which postdate regional deformation and the culmination of the regional metamorphism, are also common, not only in the plutonic rocks, but in the metasediments, and are discussed below in a separate section; these pegmatites are not shown on Map 2216 (back pocket).

That the felsic plutonic rocks underwent regional metamorphism and deformation is shown not only by their megastructures and megatextures, but also by their mineralogy, microtextures, and by the presence of amphibolitized mafic dikes in all bodies of these rocks. In thin sections of massive, porphyritic, felsic plutonic rocks, coarse-grained feldspar phenocrysts and coarse quartz grains commonly show serrated boundaries, quartz is recrystallized and strained, some feldspar phenocrysts are partly granulated, and matrix quartz and feldspar form polygonal aggregates. In thin sections of augen gneiss phases, coarse quartz and feldspar augen are surrounded by elongate to granular aggregates of fine-grained quartz, feldspar, and mafic minerals; original feldspar phenocrysts forming augen are granulated, quartz augen are recrystallized and strained, and serrated boundaries on groundmass quartz and feldspar grains are common. In garnetiferous granitic rocks, groundmass quartz and feldspar are commonly elongated defining a foliation that is deflected around garnet porphyroblasts. In general, foliation is defined by aligned quartz, feldspar, and mica, although garnet and hornblende porphyroblasts are locally aligned parallel to the foliation in some rocks but are random in others. Garnet and hornblende porphyroblasts are sieved with inclusions mainly of quartz and feldspar. Pyroxene in the

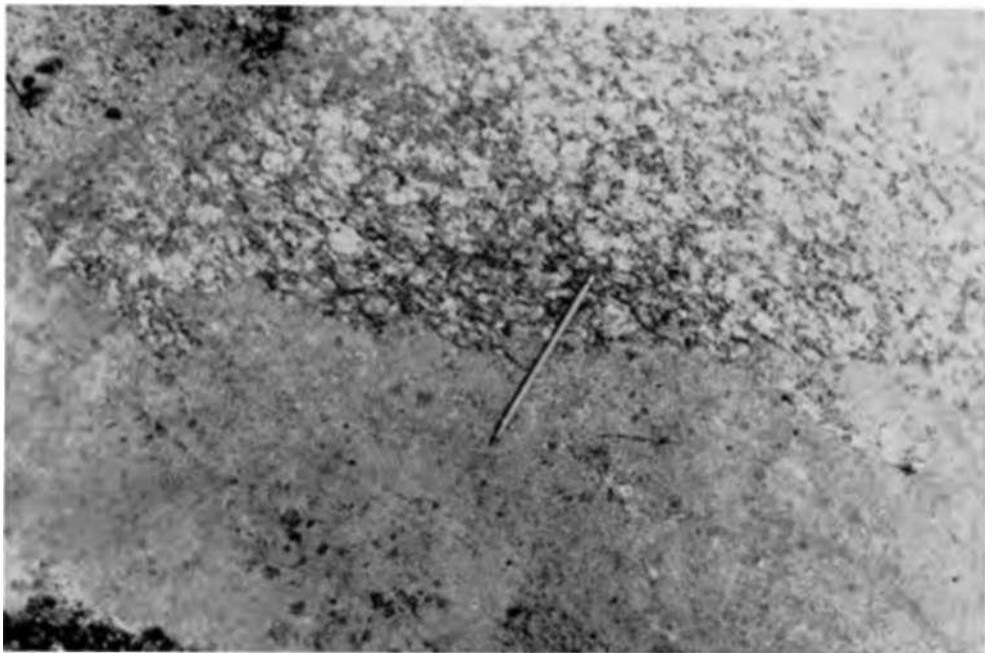


Photo 9—Dike of gneissic aplite cutting across gneissic biotite granite with coarse feldspar eugen; Mulock batholith about 2 miles west of Highway 11, Merrick Township.

monzonitic rocks generally forms fine-grained, granular grains and aggregates commonly with minor intergrown hornblende and garnet.

Like the metasediments, some of the granitic rocks are also migmatitic with lenticular, discontinuous veins of massive to slightly foliated, coarse-grained granitic material developed subparallel to the foliation (Photo 11). Migmatitic facies are common in intensely deformed biotite and garnetiferous granitic rocks, rare in hornblende-bearing granitic rocks, and virtually absent in the monzonitic rocks. Generally, the granitic veins form less than 5 percent of the rock, but zones of intense deformation in many outcrops of migmatitic granitic rocks contain a higher proportion of granitic veins that are complexly contorted (Photo 12). Such zones of intense deformation are also found in non-migmatitic granitic and monzonitic rocks but contain only a few deformed granitic and quartzose veinlets.

As shown below, the monzonitic rocks are more calcic and less siliceous than the granitic rocks, and the most migmatitic granitic rocks are leucocratic quartz-alkalic feldspar rocks with biotite as the chief ferromagnesian mineral. Migmatitic facies probably developed in response to the high-rank regional metamorphism, by partial melting controlled in part by the original composition of the rocks involved. These leucocratic granitic rocks are commonly migmatitic except for the Mulock batholith, which is massive to only slightly gneissic and only rarely migmatitic. These relationships suggest that the batholith was emplaced during the waning stages of regional metamorphism. This conclusion is supported by geochronologic studies (see section on "Age of Felsic Plutonic Rocks"), which indicate that this pluton is one of the youngest felsic plutonic masses in the area.

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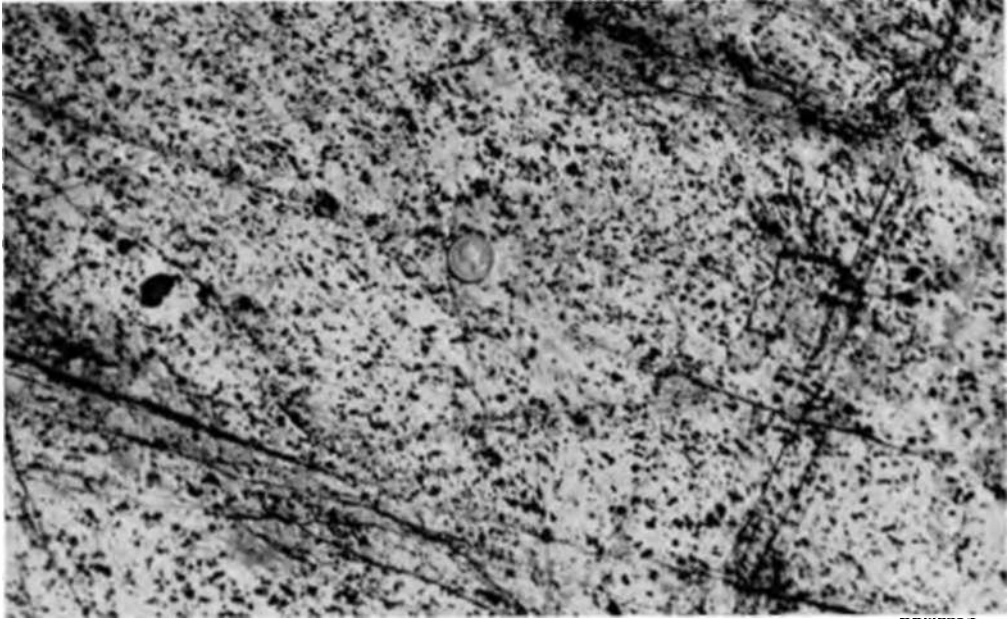
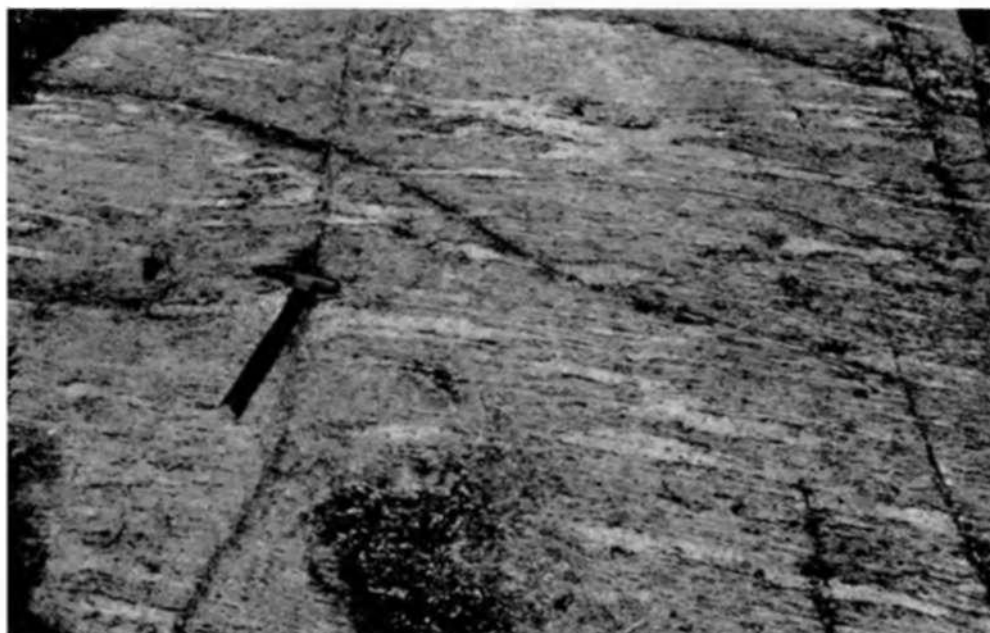


Photo 10—Slightly foliated monzonitic rock containing medium- to coarse-grained porphyroblastic aggregates of hornblende and garnet in a medium-grained, equigranular, feldspathic groundmass. The narrow fractures and breccia zones are related to a nearby late fault. Scale is a 50-cent piece. Highway 11, South Hinsworth Township, about 1.25 miles north of the south boundary of the map-area.

Despite deformation and regional metamorphism, abundant evidence is preserved to show that the felsic plutonic rocks were emplaced as magmatic intrusions rather than formed in place by granitization. Such evidence is best preserved in massive to slightly foliated rocks containing relic feldspar phenocrysts and consists of: 1) angular, rotated inclusions of both country rocks and early intrusive phases in the massive plutonic rocks (Photos 13 and 14); 2) near inclusions, feldspar phenocrysts in the massive plutonic rocks are oriented with their long axes defining a flow pattern; 3) the plutonic rocks show sharp contacts with the country rocks; 4) dikes and sills of the plutonic rocks are present in the country rocks adjacent to plutons; and 5) metasedimentary gneiss next to the plutonic bodies is more migmatitic than elsewhere, regardless of lithology, and is partly granitized suggesting original contact metamorphic effects. Inclusions in the gneissic plutonic rocks are deformed and are now elliptical in outline with their long axes aligned parallel or subparallel to the foliation in the host plutonic rock. Relatively small metasedimentary inclusions in the plutonic rocks are commonly hornfelsed and show various stages of assimilation by the host plutonic rocks. No inclusions of migmatitic metasedimentary gneiss were found in the felsic plutonic rocks suggesting that the metasediments and the felsic plutonic rocks underwent regional migmatization after the emplacement of the felsic plutonic rocks.

Evidence of an igneous history for the felsic plutonic rocks is also reflected by their accessory zircon grains. In the metasedimentary gneisses, which would be the parent rock if the granitic rocks formed by granitization, zircons invariably are clouded and have rounded, corroded outlines, with some having unzoned overgrowths. In the felsic plutonic



ODM8525

Photo 11—Typical migmatitic, gneissic biotite granite containing lenticular, discontinuous veins of massive to slightly foliated, coarse-grained leucogranite developed subparallel to the foliation; island just west of Callander Bay, Lake Nipissing.



ODM8526

Photo 12—Zone of intense deformation containing abundant, complexly contorted, granitic veins in migmatitic gneissic biotite granite; island on east side of South Bay, Lake Nipissing.

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Photo 13--Metasedimentary inclusions in gneissic hornblende-biotite granite in which the foliation is parallel to the hammer handle. Some inclusions are partly assimilated by the hornblende-biotite granite but none are migmatitic; east end of Sandy Island, Lake Nipissing.

rocks, on the other hand, zircons show simple, subhedral to euhedral forms with sharp dipyrnidal terminations and are either clear or much less intensely clouded than in the metasediments. Colour zoning and elongate inclusions are present in some zircons, and others rarely have complexly zoned, igneous overgrowths. The zircons also reflect the regional metamorphic history of the felsic plutonic rocks, for where these rocks are poorly foliated, corroded zircons are rare, but where these rocks are gneissic corroded zircons are common. Further work on zircons from the felsic plutonic rocks is planned by the author and others and will be reported elsewhere. Rubidium-strontium data assembled from felsic plutonic rocks of the area by Krogh (in Davis *et al.* 1967; Krogh *et al.* 1968; Krogh and Davis 1969b) and Krogh and Davis (1969a) also reflect an igneous history prior to regional metamorphism.

GRANITIC ROCKS

Modal and Chemical Data

Three varieties of the gneissic granitic rocks can be mapped: biotite granite, hornblende-biotite granite, and garnet-biotite granite, and in addition, migmatitic varieties of these granites are common, although hornblende-biotite granite is only slightly migmatitic. Most of the granitic bodies in the area are mixtures of biotite granite and hornblende-biotite granite, and only one mass, the Burnt Island pluton near the mouth of the French River, is mainly garnet-biotite granite. Modally, the gneissic

Photo 14—Massive, coarse-grained, porphyritic, recrystallized monzonitic rock containing an inclusion of an older, equigranular, recrystallized monzonitic phase which in turn contains a metasedimentary inclusion; northeast corner of South Bay, Lake Nipissing, Nipissing Township.



ODM#528

granites range in composition from potassic granite to granodiorite with most showing mineral assemblages typical of quartz monzonite. In naming these rocks, the term granite is used only in a general way to simplify nomenclature.

Average modes based on typical specimens of the three types of granite are given in Table 5 together with estimated ranges of each constituent in the biotite and hornblende-biotite granite. Compared to the other two granites, garnet-biotite granite shows a much smaller range in modal composition. Potassic feldspar in all of the granitic rocks shows grid twinning indicative of microcline and is slightly perthitic, except in some hornblende-biotite granites where it is mesoperthite with about 50 percent exsolved sodic plagioclase. Plagioclase is unzoned and is rarely antiperthitic containing tiny spindles of potassic feldspar; most of the antiperthitic plagioclase is found in hornblende-biotite granite associated with the Powassan monzonitic mass (see section on "Powassan Batholith"). Coarse-grained, relic feldspar phenocrysts in the granitic rocks are generally perthitic potassic feldspar, but some, particularly in hornblende-biotite granite, are plagioclase. Opaque minerals are mainly iron-titanium oxides, commonly partly sur-

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Table 5 | AVERAGE MODES (VOLUME PERCENT) OF THE GRANITIC ROCKS IN THE NORTH BAY AREA

| Rock Type | Biotite Granite | | Hornblende-Biotite Granite | | Garnet-Biotite Granite |
|-----------------|--------------------|-----------------|----------------------------|-----------------|------------------------|
| | Average of 7 modes | Estimated range | Average of 7 modes | Estimated range | Average of 2 modes |
| Quartz | 30.7 | 28-33 | 29.0 | 23-37 | 27.3 |
| Plagioclase | 32.1 | 27-38 | 33.0 | 24-38 | 30.7 |
| percent An | 10 | 5-20 | 12 | 10-20 | 20 |
| K-feldspar | 30.0 | 24-34 | 24.8 | 18-31 | 23.4 |
| Biotite | 5.1 | 2-11 | 6.0 | 1-13 | 13.8 |
| Hornblende | ... | ... | 4.4 | 1-8 | ... |
| Garnet | ... | ... | 0.5 | 0-3 | 2.7 |
| Sphene | 0.1 | 0-1 | 0.9 | 0-3 | 0.9 |
| Opaque minerals | 1.0 | trace-2 | 0.6 | trace-2 | 0.3 |
| Apatite | 0.3 | trace-1 | 0.4 | trace-1 | 0.7 |
| Zircon | 0.5 | trace-2 | 0.3 | trace-2 | 0.2 |
| Muscovite | 0.2 | ... | ... | ... | ... |
| Allanite | ... | ... | 0.1 | ... | trace |
| Totals | 100.0 | ----- | 100.0 | ----- | 100.0 |

rounded by sphene. Pinkish hues typical of the granitic rocks are due mainly to hematite coatings on quartz and feldspar grains and along fractures.

The biotite granites are the most abundant of the granitic rocks and are generally more migmatitic than the other varieties; three specimens spanning the complete compositional range of the biotite granites were analysed chemically with the results shown in Table 6. The first specimen is albite granite, which is found only among the biotite granites, the second is one of the richest in potassic feldspar of all the granitic rocks examined microscopically, whereas the third specimen is close to the average mode of the biotite granites given in Table 5. The modal and chemical data show that the biotite granite is composed essentially of quartz, potassic feldspar, and albite in proportions comparable to minimum melting compositions in the experimental granite system of Tuttle and Bowen (1958). Thus the biotite granites may not only have formed by crystallization from a melt, but are also of such composition that they would readily undergo anatexis during high-rank regional metamorphism. As pointed out by Winkler (1967), the higher the anorthite content of plagioclase in a gneiss, the higher the temperature at which anatexis begins. The modal data in Table 5 show that the biotite granites are less calcic and their plagioclase has a lower anorthite content than either the hornblende-biotite granites or the garnet-biotite granites, and thus, if the migmatitic granitic rocks formed by anatexis, the biotite granites should be the most migmatitic. That this is so is strong evidence supporting the hypothesis of anatectic formation of the migmatitic granitic rocks. Thus it is believed both the metasedimentary and granitic migmatites formed by anatexis.

Distribution

Granitic rocks are more widespread throughout the area than the monzonitic rocks and form large batholiths near Sturgeon Falls in the northwestern part of the area and near Mulock on the Ontario Northland railway in the northern part of the area. They

Table 6

MODAL AND CHEMICAL ANALYSES AND NORMS OF THE BIOTITE
GRANITES IN THE NORTH BAY AREA

| Specimen No. | 64-L-5 | 64-L-14 | 64-L-61 |
|------------------------------------|--------|---------|---------|
| Chemical Analyses (weight percent) | | | |
| SiO ₂ | 74.5 | 75.9 | 74.4 |
| Al ₂ O ₃ | 15.4 | 14.0 | 16.3 |
| Fe ₂ O ₃ | 0.92 | 0.62 | 0.23 |
| FeO | 0.97 | 0.52 | 0.42 |
| MgO | 0.3 | 0.2 | 0.2 |
| CaO | 0.70 | 0.50 | 0.49 |
| Na ₂ O | 4.12 | 4.04 | 3.45 |
| K ₂ O | 3.68 | 5.37 | 5.25 |
| H ₂ O + | 0.22 | 0.02 | 0.06 |
| H ₂ O - | 0.24 | 0.20 | 0.20 |
| CO ₂ | 0.10 | 0.15 | 0.25 |
| TiO ₂ | 0.24 | 0.08 | 0.05 |
| P ₂ O ₅ | 0.03 | 0.05 | 0.01 |
| S | 0.01 | 0.02 | 0.01 |
| MnO | 0.03 | 0.01 | 0.01 |
| Totals | 101.5 | 101.7 | 101.3 |
| C.I.P.W. Norms | | | |
| Quartz | 34.1 | 30.5 | 32.9 |
| Orthoclase | 21.4 | 30.8 | 30.4 |
| Albite | 34.1 | 33.7 | 28.6 |
| Anorthite | 3.6 | 2.5 | 2.5 |
| Corundum | 3.3 | 0.7 | 4.2 |
| Hypersthene | 1.2 | 0.8 | 1.1 |
| Magnetite | 1.4 | 0.9 | 0.2 |
| Ilmenite | 0.7 | 0.1 | ... |
| H ₂ O | 0.2 | ... | 0.1 |
| Totals | 100.0 | 100.0 | 100.0 |
| Modes (volume percent) | | | |
| Quartz | 31.2 | 31.7 | 30.8 |
| Plagioclase | 37.7 | 30.7 | 33.7 |
| percent An | 8 | 10 | 10 |
| K-Feldspar | 24.4 | 32.2 | 30.8 |
| Biotite | 4.7 | 3.0 | 3.7 |
| Sphene | ... | 0.4 | ... |
| Opaque minerals | 1.1 | 1.4 | 0.8 |
| Apatite | 0.2 | ... | ... |
| Zircon | 0.7 | 0.5 | 0.2 |
| Muscovite | ... | 0.1 | ... |
| Totals | 100.0 | 100.0 | 100.0 |

also form small sheets and a few stocks within the metasedimentary gneisses and are associated with some of the monzonitic masses south and east of Lake Nipissing, especially where metasedimentary inclusions are abundant. Granitic rocks along the western margin of the area in Hardy and Bertram Townships between the Restoule River and the French River are the easternmost extensions of a large granitic batholith underlying much of the east-central Burwash area adjoining the North Bay area to the west (Lumbers, in preparation). Only the largest of the minor granitic bodies can be shown separately on the map (Map 2216, back pocket), but other bodies are indicated by appropriate symbols. Because of the reconnaissance nature of the mapping, some minor bodies of granitic rocks may have been missed, and boundaries of those bodies

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shown are necessarily generalized. Moreover, the detailed distribution of the various lithologies within a given body could not be determined. Migmatitic phases are common in all bodies except the Mulock batholith and are best developed in narrow sheets and near the borders of larger bodies. Brief descriptions of some of the larger bodies are given below; the Powassan mass contains abundant monzonitic rocks as well as granitic rocks and is described under the monzonitic rocks.

MULOCK BATHOLITH

The Mulock batholith is an elongate mass extending northwestwards from north-eastern Widdifield Township through eastern Mulock Township and most of Merrick Township to at least Notman Township in the Tomiko area to the north (Lumbers 1967b). In the North Bay area, this body is composed mainly of gneissic biotite granite with minor, fine- to medium-grained, equigranular, gneissic hornblende-biotite granite that commonly contains minor visible epidote. Locally near the margins of the mass and in the relatively narrow southern end west of Redbridge, where metasedimentary inclusions are abundant, the biotite granite is partly migmatitic. Elsewhere the biotite granite is either an augen gneiss or, less commonly, poorly foliated to massive with abundant, coarse-grained phenocrysts of feldspar. Sharp contacts with the surrounding metasediments and local crosscutting relationships are common, and dikes and sills of the biotite granite are locally abundant in the metasediments up to a quarter mile from the main mass. Relatively fine- to medium-grained aplitic phases of the biotite granite containing inclusions of the porphyritic or augen gneiss phase are common in places, and a few small inclusions of metasediments and narrow dikes of recrystallized granite are found throughout the mass.

This batholith is unique among the granitic masses of the area in that migmatitic phases are scarce, and on a large scale, deformation is less than in the other granitic masses. These features suggest that the Mulock body was emplaced when regional metamorphism was on the wane.

BEAUCAGE GRANITE SHEETS

In Beaucage Township and southwestern Commanda Township, several concordant sheets of biotite granite, composed predominantly of migmatitic augen gneiss, are folded with the host metasediments, and some contain long, tabular inclusions of the metasediments. Minor hornblende-biotite granite is associated with the biotite granite in some of the sheets. The biotite granite body near Beaucage Point on the north shore of Lake Nipissing is separated from the granitic sheets to the north by a major fault zone and contains numerous zones of shearing, brecciation, and intense hematization, commonly with quartz vein networks. These granitic sheets appear to be either syntectonic or pre-tectonic intrusions.

STURGEON FALLS BATHOLITH

Granitic rocks in Springer, Pedley, and Field Townships and in the Nipissing Indian Reserve (No. 10) between Dukis Point and Jocko Point on Lake Nipissing appear to form a

complexly deformed, syntectonic or pre-tectonic batholith containing numerous concordant layers of metasediments. Biotite granite along the north shore of Lake Nipissing, north of Beaucage Point and south of the major northwesterly trending fault, as well as granitic rocks forming most of the islands in Lake Nipissing could be part of this batholith. Biotite granite, mainly migmatitic augen gneiss, and hornblende-biotite granite, also a slightly migmatitic augen gneiss, predominate in the mass, which is referred to herein as the Sturgeon Falls batholith.

The southern part of the batholith is obscured by extensive deposits of varved clay, but from the available exposures, hornblende-biotite granite appears to be more abundant here than in the northern part that contains many more metasedimentary layers and is mainly biotite granite. Structural trends within the batholith and the surrounding metasediments are conformable and suggest that these rocks were folded after emplacement of the batholith to form a dome, centred north of the village of Crystal Falls in Field Township. The western contact of the batholith extends into the neighbouring Burwash area (Lumbers 1967a).

BURNT ISLAND PLUTON

Along the southern shore of Lake Nipissing, south of Sandy Island, a concordant, tabular or sheet-like mass of garnet-biotite granite extends eastward from Wabiscaunk Point through Burnt Island to Blueberry Island where it is off-set southward by a northeasterly trending fault and is again exposed south of Frank Bay in northern Patterson Township. Numerous northeasterly trending faults cut across the pluton causing minor displacements of its southern contact; the northern contact is poorly exposed.

The garnet-biotite granite is pink to grey, slightly migmatitic augen gneiss, notably richer in biotite than either the biotite granite or the hornblende-biotite granite forming the other plutons. Locally near the borders of the pluton, the granite is a mylonite gneiss and is somewhat similar in appearance to biotite gneiss of the clastic siliceous metasedimentary group. Massive, relatively undeformed phases of the pluton appear to be absent, and that part of the pluton south of Frank Bay contains some migmatitic biotite granite. Narrow layers of metadiorite and amphibolite up to $\frac{1}{4}$ mile long are found in places along the northern side of the pluton on Burnt Island. A few small, metasedimentary inclusions are present and are deformed into ellipsoidal bodies with their long axes parallel to the foliation.

CROSS POINT PLUTON

A sheet-like mass composed predominantly of hornblende-biotite granite is exposed near Cross Point at the northwestern corner of South Bay, Lake Nipissing and is lithologically similar to the southern part of the Sturgeon Falls batholith. At Cross Point and in adjacent headlands, a dike of metagabbro-metadiorite intruded the pluton and was subsequently deformed.

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EAST FERRIS STOCK

South of the eastern end of Trout Lake in northeastern East Ferris Township, a granitic stock composed mainly of migmatitic and gneissic biotite granite, with some gneissic hornblende-biotite granite, is separated from granitic rocks of the Bonfield monzonitic batholith to the south by a narrow screen of metasediments. The stock is cut by a late northeasterly trending fault. In the central part of the northern lobe the rocks are less intensely foliated and less migmatitic than elsewhere, but south of the fault, the rocks of the southwestern part are intensely deformed and migmatitic suggesting that perhaps some of the intense deformation was caused by emplacement of the nearby Bonfield monzonitic batholith. If so, then the Bonfield batholith would postdate the East Ferris stock.

MONZONITIC ROCKS

Modal and Chemical Data

The monzonitic rocks are characterized by only minor visible quartz and by abundant hornblende, garnet, and less commonly, by clinopyroxene and biotite, and are similar chemically to charnockitic and pyroxene-bearing syenitic rocks of the anorthosite kindred (Buddington 1939; Buddington and Leonard 1962; Hødal 1945; Philpotts 1966) so common in the Grenville Province of Quebec and New York State. Modally, however, the monzonitic rocks differ from the charnockitic and syenitic rocks because in the monzonitic rocks hornblende predominates over pyroxene whereas in charnockitic rocks the reverse is true. Previous to the present study, monzonitic and charnockitic rocks had been reported only rarely from the Grenville Province of Ontario (see for example Hewitt 1967, p.19), but in the author's experience, monzonitic rocks are found throughout the Ontario Grenville Province between the Bancroft-Madoc area (Lumbers 1967c) and the French River-Lake Nipissing region. The fact that this part of the Ontario Grenville Province is largely unmapped probably accounts for the scarcity of references to these rocks. At least some monzonitic rocks in the Ontario Grenville Province are associated with anorthosite masses (Lumbers, in preparation), but the monzonitic rocks of the map-area are associated with granitic rocks rather than anorthosite and are found mainly in two closely spaced batholiths in the southeastern part of the area.

In Table 7 modes are given of seven monzonitic rocks, illustrating the common range in mineral composition, together with an average of 12 modal analyses. Without exception, rocks containing 1 percent or more pyroxene are light green to dark green on unweathered surfaces and grey to rusty on weathered surfaces. The green colour is due to greenish micaceous films on quartz and feldspar grains. Rocks essentially free of pyroxene lack the greenish micaceous films and are grey to pink on unweathered surfaces and pink on weathered surfaces. Like the granitic rocks, the pinkish hues of the monzonitic rocks are caused by hematite coatings on quartz and feldspar grains and along fractures. Thus pyroxene-bearing facies of the monzonitic rocks can be mapped easily in the field by colour and weathering characteristics.

Although only minor quartz is visible in hand specimen, the monzonitic rocks generally contain 10 to 15 percent quartz mostly as fine-grained recrystallized granules in the groundmass. Plagioclase is antiperthitic, rarely zoned, and is partly replaced by potassic feldspar. In most rocks, potassic feldspar only rarely shows grid twinning and is perthitic containing as much as 50 percent plagioclase as films, strings, and patches.

Table 7

MODAL ANALYSES (VOLUME PERCENT) OF MONZONITE ROCKS IN THE NORTH BAY AREA

| Specimen No. | 64-L-9 | 64-L-17 | 64-L-20 | 64-L-21 | 64-L-31 | 65-L-25 | 67-L-130 | Average of 12 modes |
|-----------------|--------|---------|---------|---------|---------|---------|----------|---------------------|
| Quartz | 14.5 | 13.2 | 8.9 | 17.7 | 16.1 | 6.6 | 19.7 | 15.0 |
| Plagioclase | 39.5 | 35.9 | 47.9 | 37.5 | 37.5 | 33.9 | 37.3 | 38.9 |
| percent An | 12 | 17 | 28 | 12-18 | 12 | 8 | 11 | 14 |
| K-feldspar | 31.7 | 20.6 | 23.2 | 18.3 | 33.9 | 30.4 | 24.1 | 27.2 |
| Biotite | 3.9 | 17.7 | 2.8 | 3.6 | 0.3 | 0.4 | 9.6 | 4.6 |
| Hornblende | 6.4 | 8.5 | 2.4 | 6.8 | 8.7 | ... | 2.0 | 5.6 |
| Garnet | 2.4 | 1.1 | 4.9 | 7.4 | 2.3 | 5.5 | 4.6 | 3.5 |
| Clinopyroxene | ... | ... | 6.8 | 4.6 | ... | 17.2 | ... | 2.8 |
| Orthopyroxene | ... | ... | 0.3 | 1.0 | ... | 3.9 | ... | 0.5 |
| Opaque minerals | 0.4 | 0.2 | 2.2 | 2.0 | 0.5 | 2.1 | 0.5 | 1.0 |
| Apatite | 0.3 | 1.4 | 0.6 | 0.8 | 0.1 | trace | 0.3 | 0.4 |
| Zircon | 0.7 | 1.4 | trace | 0.3 | 0.4 | trace | trace | 0.2 |
| Others* | 0.2 | trace | trace | trace | 0.2 | trace | 1.9 | 0.3 |
| Totals | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |

*Sphene, carbonate, allanite, epidote.

Table 8

CHEMICAL ANALYSES AND NORMS OF THE MONZONITIC ROCKS IN THE NORTH BAY AREA

| Specimen No. | 64-L-9 | 64-L-17 | 64-L-20 | 64-L-21 | 64-L-31 | 67-L-130 |
|------------------------------------|--------|---------|---------|---------|---------|----------|
| Chemical Analyses (Weight percent) | | | | | | |
| SiO ₂ | 63.9 | 61.9 | 61.5 | 64.3 | 68.4 | 66.7 |
| Al ₂ O ₃ | 18.8 | 15.2 | 16.6 | 15.0 | 16.1 | 14.4 |
| Fe ₂ O ₃ | 0.89 | 2.04 | 1.17 | 1.81 | 0.30 | 0.73 |
| FeO | 3.25 | 6.41 | 6.54 | 5.94 | 2.70 | 3.78 |
| MgO | 0.52 | 1.70 | 0.44 | 1.15 | 0.30 | 0.45 |
| CaO | 2.10 | 2.40 | 3.53 | 3.30 | 1.65 | 2.82 |
| Na ₂ O | 4.17 | 3.27 | 4.14 | 3.45 | 4.04 | 3.65 |
| K ₂ O | 5.07 | 4.27 | 4.17 | 3.73 | 5.76 | 4.59 |
| H ₂ O+ | 0.29 | 0.91 | 0.31 | 0.19 | 0.32 | 0.40 |
| H ₂ O- | 0.26 | 0.36 | 0.26 | 0.31 | 0.18 | 0.22 |
| CO ₂ | 0.08 | 0.10 | 0.15 | 0.30 | 0.26 | 1.06 |
| TiO ₂ | 0.49 | 0.94 | 0.83 | 1.09 | 0.42 | 0.58 |
| P ₂ O ₅ | 0.11 | 0.34 | 0.27 | 0.35 | 0.08 | 0.18 |
| S | 0.01 | 0.04 | 0.05 | 0.01 | 0.02 | 0.02 |
| MnO | 0.08 | 0.16 | 0.16 | 0.17 | 0.05 | 0.11 |
| Totals | 100.0 | 100.0 | 100.1 | 101.1 | 100.6 | 99.7 |
| C.I.P.W. Norms | | | | | | |
| Quartz | 12.6 | 15.2 | 9.8 | 18.7 | 17.3 | 21.6 |
| Orthoclase | 30.1 | 25.7 | 25.1 | 21.6 | 34.3 | 27.4 |
| Albite | 35.6 | 27.9 | 34.6 | 28.7 | 34.0 | 31.0 |
| Anorthite | 10.6 | 10.4 | 14.5 | 14.0 | 6.5 | 7.3 |
| Corundum | 2.4 | 1.3 | ... | ... | 0.5 | 0.7 |
| Hypersthene | 5.8 | 13.2 | 10.4 | 10.9 | 4.8 | 6.7 |
| Diopside | ... | ... | 1.2 | ... | ... | ... |
| Magnetite | 1.4 | 3.0 | 1.9 | 2.5 | 0.5 | 0.9 |
| Ilmenite | 0.9 | 1.7 | 1.5 | 2.0 | 0.8 | 1.2 |
| Apatite | 0.3 | 0.7 | 0.7 | 0.7 | 0.3 | 0.4 |
| Calcite | ... | ... | ... | 0.7 | 0.7 | 2.4 |
| H ₂ O | 0.3 | 0.9 | 0.3 | 0.2 | 0.3 | 0.4 |
| Totals | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |

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Relic, coarse-grained phenocrysts of feldspar are most commonly perthitic potassic feldspar, but plagioclase also forms phenocrysts in some rocks. Both the clinopyroxene and orthopyroxene apparently formed by metamorphic recrystallization and are free of exsolved lamellae of pyroxene. From optical determinations, the clinopyroxene appears to be a member of the diopside-hedenbergite series, and the orthopyroxene appears to be relatively iron-rich. Hornblende shows dark greenish brown to dark green pleochroism and in some rocks is partly altered to carbonate and chlorite. Opaque minerals are mainly iron-titanium oxides, but pyrrhotite is found rarely. Allanite, which is present in some of the more calcic granitic rocks, is rare in the monzonitic rocks, and the minor constituents grouped in Table 7 are mainly sphene and carbonate; epidote is found rarely.

Although the modes in Table 7 indicate the common range in mineral composition of the monzonitic rocks, varieties rich in clinopyroxene, such as specimen 65-L-25, and others equally rich in hornblende are not abundant and are found as poorly defined layers and streaks in more felsic monzonitic rocks; some of this layering could be a primary magmatic feature. In such layered sequences potassic feldspar-poor rocks close to diorite and quartz diorite in modal composition are rarely found and contain garnet, biotite, and hornblende as the chief mafic minerals. Similar dioritic rocks also form small stocks on the south side of Patterson Lake in Patterson Township.

Chemical analyses and norms of all but the pyroxene-rich monzonitic rock (sample 65-L-25) listed in Table 7 are given in Table 8. These analyses indicate the range in chemical composition of the most common monzonitic rocks found in the area, and in general, ferrous to ferric iron ratios and ferrous iron to magnesia ratios are relatively high. Compared to the predominantly migmatitic biotite granites (Table 6), the non-migmatitic monzonitic rocks are: richer in iron, lime, and magnesia; similar in alkalis; and poorer in silica. These chemical differences are also reflected in the norms of the monzonitic rocks that are much richer in anorthite and hypersthene and much poorer in quartz than the norms of the biotite granites.

In Table 9, the mean of the six chemical analyses of the monzonitic rocks is compared to average chemical analyses of charnockitic and pyroxene-bearing syenitic rocks associated with anorthosites of the Adirondack region in New York and of the Morin Series rocks in Quebec. Nockolds' (1954) average chemical composition of monzonite, alkalic syenite, granodiorite, and tonalite are also included. From this comparison the monzonitic rocks of the map-area are chemically similar to the charnockitic and syenitic rocks associated with anorthosites, and all of these rocks differ significantly from average alkalic syenite only in their lower sodium and total alkali contents. The monzonitic rocks in the map-area differ markedly from average granitic rocks with similar silica and alumina contents and from the average monzonite. Nevertheless, most of the monzonitic rocks are modally similar to monzonite in their quartz and feldspar contents so that in the absence of rigid definitions for the more siliceous and alkalic members of the anorthosite suite, these rocks in the map-area are best referred to as monzonitic.

Krank (1961) believed that within the Grenville Province, the anorthosite suite, including the charnockitic and pyroxene-bearing syenitic rocks, is confined to a belt occupying the southeastern half of the province, which Osborne and Morin (1962) have referred to as the Grenville A Sub-province. Osborne and Morin further considered this sub-province to have been metamorphosed to a higher grade than the Grenville B Sub-province, which forms the northwestern part of the Grenville Province. The North Bay area contains features most akin to the Grenville B Sub-province, and thus it is important to note that this area contains rocks chemically similar to, but modally different from the charnockitic and syenitic rocks of the Grenville A Sub-province. Perhaps the modal differences shown by the monzonitic rocks of the map-area, chiefly the

Table 9

AVERAGE CHEMICAL ANALYSIS OF THE MONZONITIC ROCKS OF THE NORTH BAY AREA COMPARED TO CHEMICAL ANALYSES OF CHARNOCKITIC AND SYENITIC ROCKS OF THE ANORTHOSITE KINDRED AND TO NOCKOLDS' (1954) AVERAGE CHEMICAL COMPOSITION OF MONZONITE, ALKALIC SYENITE, GRANODIORITE, AND TONALITE.

| Rock Type | Monzonitic Rocks ¹ | Quartz Mangerite ² | Charnockitic Rock ³ | Quartz Syenite ⁴ | Monzonite ⁶ | Alkalic Syenite ⁶ | Granodiorite ⁵ | Tonalite ⁵ |
|--------------------------------|-------------------------------|-------------------------------|--------------------------------|-----------------------------|------------------------|------------------------------|---------------------------|-----------------------|
| SiO ₂ | 64.4 | 62.98 | 62.29 | 63 | 55.36 | 61.86 | 66.88 | 66.15 |
| Al ₂ O ₃ | 16.0 | 14.24 | 14.59 | 16 | 16.58 | 16.91 | 15.66 | 15.56 |
| Fe ₂ O ₃ | 1.16 | 2.78 | 2.19 | 2.7 | 2.57 | 2.32 | 1.33 | 1.36 |
| FeO | 4.77 | 3.34 | 6.31 | 3.1 | 4.58 | 2.63 | 2.59 | 3.42 |
| MgO | 0.76 | 1.04 | 0.92 | 1.0 | 3.67 | 0.96 | 1.57 | 1.94 |
| CaO | 2.63 | 3.28 | 3.66 | 3.3 | 6.76 | 2.54 | 3.56 | 4.65 |
| Na ₂ O | 3.79 | 3.33 | 3.56 | 4.5 | 3.51 | 5.46 | 3.84 | 3.90 |
| K ₂ O | 4.60 | 5.27 | 4.52 | 5.0 | 4.68 | 5.91 | 3.07 | 1.42 |
| H ₂ O + | 0.40 | 0.40 | ... | ... | 0.60 | 0.53 | 0.65 | 0.69 |
| H ₂ O - | 0.26 | 0.06 | ... | ... | ... | ... | ... | ... |
| CO ₂ | 0.32 | ... | ... | ... | ... | ... | ... | ... |
| TiO ₂ | 0.73 | 1.03 | 1.05 | 0.8 | 1.12 | 0.58 | 0.57 | 0.62 |
| P ₂ O ₅ | 0.22 | 0.35 | 0.39 | 0.4 | 0.44 | 0.19 | 0.21 | 0.21 |
| MnO | 0.12 | 0.09 | ... | 0.1 | 0.13 | 0.11 | 0.07 | 0.08 |

¹Average of 6 chemical analyses (from Table 8)

²Average of 5 chemical analyses of quartz mangerite from the Morin Series (Philpotts 1966)

³Average of 11 chemical analyses of charnockitic rocks of the Tupper Complex (Buddington and Leonard 1962, p.38)

⁴Estimated chemical composition of Diana Complex based on weighted average of chemical analyses (Buddington 1939, p.103)

⁵Nockolds 1954

relative scarcity of orthopyroxene, could be due to the lower grade of regional metamorphism or to an initially higher water content in the monzonitic magma, or to both factors. Moreover, anorthosite bodies, some with associated monzonitic rocks, are present in the Burwash area adjoining the North Bay area to the west (Lumbers, in preparation), so that in assessing the distribution, economic potential, and origin of rocks of the anorthosite suite, these important occurrences in Ontario must be considered.

Distribution

Monzonitic rocks are found mainly in two batholiths in the southeastern part of the area; the Powassan batholith extending southward for an unknown distance beyond the map-area from the southeastern end of Lake Nipissing, and the Bonfield batholith extending eastward beyond the map-area for an unknown distance and underlying the region from Lake Talon to Lake Nosbonsing and part of Chisholm and Boulter Townships and northwestern Ballantyne Township. The northern part of another large monzonitic mass of unknown extent is exposed in the southeastern corner of the area in Wilkes Township and adjacent northeastern Ballantyne Township. A small stock of monzonitic rocks with some hornblende-biotite granite is found near the western end of Trout Lake, and a narrow sheet of monzonitic rocks is just west of the Powassan batholith near the eastern boundary of Patterson Township about 2 miles west of the mouth of the South River. All of these monzonitic bodies are closely related spatially and display similar deformation, so that they could have been emplaced during a single plutonic episode. Small stocks of dioritic and tonalitic rocks on the south side of Patterson Lake in Patterson Township could also be related to the monzonitic rocks.

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Contacts of the monzonitic rocks shown on the map (Map 2216, back pocket) are generalized, particularly where extensive Pleistocene and Recent deposits considerably reduce outcrop density. Green, pyroxene-bearing phases of the monzonitic rocks are confined to the large masses and are less abundant than the pyroxene-free pink and grey phases. Further work is needed to determine the genesis of the green pyroxene-bearing monzonitic rocks, but they could represent separate intrusive phases differing slightly in chemistry from the pinkish monzonitic rocks. Tables 7 and 8 show that the pyroxene-bearing varieties are distinctly more calcic and possibly slightly less oxidized than the pyroxene-free varieties. Moreover, in some road cuts exposing unweathered monzonitic rocks, irregularly shaped zones of pinkish monzonitic rocks cut across the green pyroxene-bearing variety, whereas in other road cuts, the pyroxene-bearing variety forms dikes in the pinkish variety. Towards the weathered surface in such exposures, the greenish monzonitic rocks gradually become grey to slightly pink, and where weathered these rocks still contain pyroxene but lack the greenish micaceous films around quartz and feldspar grains.

POWASSAN BATHOLITH

The Powassan batholith is separated from the Bonfield batholith by a relatively narrow screen of metasediments containing numerous small bodies of monzonitic and granitic rocks. Foliation within the Powassan batholith generally dips eastward and steepens from west to east and is nearly vertical near the metasedimentary screen. Within the screen, foliation trends suggest a complex synform plunging southward and overturned slightly towards the east. Foliation near the western margin of the adjacent Bonfield batholith dips steeply westward so that, at depth, both batholiths could be connected to form a single plutonic complex.

Within the map-area granitic and monzonitic rocks are about equally abundant, but south of the map-area, a rapid reconnaissance of part of the batholith suggests that monzonitic rocks are most abundant. Granitic rocks are particularly abundant near the margins of the batholith and in Nipissing Township and western North Himsworth Township where large masses of metasediments, mainly migmatitic biotite gneiss, are surrounded by the plutonic rocks and are probably roof pendants. The spatial association of granitic rocks with metasediments suggests that at least some of the more siliceous granitic rocks were formed by contamination of the monzonitic magma by these metasediments. On the other hand, the granitic rocks could be in part siliceous concentrations in the upper part of the batholith. Relative age relationships of the granitic and monzonitic rocks are poorly known, but all gradations can be found in the field between the monzonitic rocks and hornblende-biotite granite, and in a few places the granitic rocks appear to cut across the monzonitic rocks. Biotite granite predominates over hornblende-biotite granite near the roof pendants in the eastern part of the batholith and near the margins of the batholith but elsewhere hornblende-biotite granite predominates. Regardless of their composition, the granitic rocks are generally most migmatitic near the margins of the batholith and near the roof pendants; elsewhere these rocks are commonly gneissic to slightly foliated. The monzonitic rocks are mainly gneissic, but massive to slightly foliated phases are common in the interior of the batholith and between Johnston Point and Brills Island at the northeastern tip of South Bay, Lake Nipissing. Between Callander and North Bay, a northern extension of the batholith is much more intensely deformed than elsewhere and near Callander was intruded by a Cambrian alkalic complex, which brecciated and metamorphosed the adjacent plutonic rocks.

Compared to the granitic plutons, the Powassan batholith shows structural characteristics intermediate between the syntectonic (or pre-tectonic) Sturgeon Falls batholith and the late tectonic Mulock batholith. The Powassan batholith is less deformed and more discordant than all of the granitic intrusions except the Mulock batholith. Some of the apparent discordance along the western contact of the Powassan batholith may be partly structural because the foliation in both the plutonic rocks and the metasediments outlines complex fold patterns with low dips. The Powassan batholith is possibly intermediate in age between the intensely deformed granitic rocks and the weakly deformed Mulock batholith.

BONFIELD BATHOLITH

The Bonfield batholith extends eastward beyond the map-area at least as far as the Amable du Fond River in Lauder Township where it is exposed along Highway 630 north of Kiosk. The northeastern contact of the batholith crosses Highway 17 at Pimisi Lake about 1 mile east of the map-area, and here, slightly gneissic monzonitic rocks are separated from an intensely deformed sheet of biotite granite by a narrow zone or screen of migmatitic biotite gneiss. Because of its more intense deformation, the granitic sheet could be older than the Bonfield batholith just as the intensely deformed East Ferris granitic stock described previously.

In its structure and degree of deformation, the Bonfield batholith is similar to the Powassan batholith, but granitic rocks are much less abundant and are found locally as border phases separating the monzonitic rocks from the metasediments. Moreover, except for the marble east of Lake Talon, large roof pendants are absent and metasedimentary inclusions are less common. Thus, just as in the Powassan batholith, the granitic rocks in the Bonfield batholith could represent contaminated phases of the monzonitic magma, and the Bonfield batholith could be a more deeply exposed section of a single plutonic complex consisting of the Bonfield and Powassan batholiths. Monzonitic rocks in the central part of the batholith are generally slightly foliated, and massive varieties are common, but near the margins of the batholith, the monzonitic rocks become increasingly gneissic and granitic rocks are mainly migmatitic.

WILKES PLUTON

The monzonitic Wilkes pluton extending westward from Wilkes Lake to Fassett Lake in the southeastern corner of the area is poorly exposed, but appears to consist mainly of gneissic to slightly foliated monzonitic rocks. The contact of the pluton is exposed in places along the southeastern shore of Fassett Lake, and near the contact the monzonitic rocks contain inclusions of biotitic and feldspathic metasediments. Northwest of the pluton, a few narrow sills and dikes of monzonitic rocks are present in the metasediments.

AGE OF THE FELSIC PLUTONIC ROCKS

Differences in the relative intensity of deformation and metamorphism suggest that the felsic plutonic rocks could represent three major plutonic events: 1) early granitic intrusion represented by the intensely deformed, syntectonic (or pre-tectonic) sheet-like

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granitic masses such as the Sturgeon Falls and Beaucage masses; 2) monzonitic intrusions; and 3) late granitic intrusion represented by the Mulock batholith, which was emplaced when regional metamorphism was on the wane.

These apparent age relationships are being investigated isotopically by Krogh (see Davis *et al.* 1967; Krogh *et al.* 1968; Krogh and Davis 1969b) and Krogh and Davis (1969a) using the rubidium-strontium whole-rock isochron technique. Results obtained to date confirm the three plutonic events and suggest that the earliest granitic intrusions (now represented by syntectonic or pre-tectonic bodies) are $1,700 \pm 150$ million years old. A whole-rock isochron obtained from the Powassan and Bonfield monzonitic batholiths shows that this plutonic complex is $1,330 \pm 70$ million years old. Incomplete results from the Mulock batholith suggest a maximum whole-rock age of about 1,200 million years. Thus, the felsic plutonic rocks probably range in age from Middle to Late Precambrian, and the fact that all of these rocks show evidence of regional metamorphism and deformation indicates a complex, multiple, metamorphic and tectonic history for the area.

Mafic Plutonic Rocks

Mafic plutonic rocks form only a minor part of the metamorphic complex and occur either as small, rounded to elongate stocks, or as dikes and sills. Most of the stocks are found within and near the Powassan and Bonfield batholiths and in Patterson Township; some of these mafic bodies are intrusive into the monzonitic rocks, but others are older, so that multiple ages are represented. A few of the mafic stocks contain minor granitic phases. Mafic dikes and sills are widespread throughout the metamorphic complex and many are intrusive into the felsic plutonic rocks and are thus younger than these rocks.

MAFIC STOCKS

The mafic stocks consist of medium- to coarse-grained, dark green to black metagabbro, metadiorite, and minor metamorphosed ultramafic rocks. In all bodies, the metagabbro and metadiorite are generally foliated and gneissic with alternating mafic-rich and plagioclase-rich layers but primary igneous textures are locally preserved. Metagabbro and metadiorite consist of about equal proportions of hornblende and plagioclase with minor garnet and biotite and accessory quartz, apatite, sphene, epidote, and iron-titanium oxide minerals; quartz and biotite are more abundant in the metadiorite than in the metagabbro. Metagabbro, with relic primary texture, locally contains relic orthopyroxene and clinopyroxene grains and fine-grained granular aggregates that are commonly surrounded by a corona of fine-grained, granular garnet; in some rocks granular aggregates of orthopyroxene are surrounded by an inner zone of fine-grained granular hornblende and an outer zone of fine-grained garnet. The ultramafic rocks consist mainly of a medium- to coarse-grained aggregate of hornblende, commonly with abundant accessory apatite and less than 10 percent plagioclase. In all the mafic rocks, plagioclase ranges in composition from oligoclase to andesine except in metagabbro with relic primary textures where tabular grains of primary labradorite as calcic as An_{65} are locally present. The labradorite is marginally granulated with a partial envelope of fine-grained, more sodic plagioclase. Hornblende, which is commonly sieved with plagioclase and minor quartz, is dark green to brown parallel to the slow vibration direction.

The northern end of the elongate metagabbro body intruding granitic rocks of the Powassan batholith, east of Beatty and Ruth Lakes in Nipissing Township, contains metamorphosed ultramafic phases that have local concentrations of iron-titanium oxide minerals. Ultramafic phases are rare in most of the other stocks, although they are locally present in the Patterson Township mafic stocks; these ultramafic phases are too small to show on Map 2216 (back pocket).

Two mafic stocks contain granitic border phases, one in Patterson Township 1½ miles southwest of Durrell Point on Lake Nipissing, and the other near the eastern end of Turtle Lake on the Mattawa River. Granitic rocks associated with the Turtle Lake stock are mainly gneissic garnet-biotite granite, whereas hornblende-biotite granite and migmatitic biotite granite are found in the Patterson stock.

MAFIC DIKES AND SILLS

Fine- to medium-grained amphibolite dikes and sills are common in the felsic plutonic rocks and in the metasediments and are similar in mineralogy to metagabbro and metadiorite stocks. A few of these dikes and sills, particularly in felsic plutonic rocks, locally have primary textures but most are foliated and gneissic, and a few dikes in the felsic plutonic rocks have relic marginal chilled zones.

Just east of Lake Nipissing south of North Bay in West Ferris Township, a prominent southeast-trending metadiabase dike intruded folded metasediments and is itself deformed, gneissic, and locally dismembered. Nevertheless, in many places this dike is massive with a well preserved primary ophitic texture and primary labradorite and clinopyroxene. Fine-grained garnet is disseminated in the metadiabase, and both the plagioclase and clinopyroxene are partly recrystallized about their margins with some clinopyroxene rimmed by fine-grained hornblende and garnet. Other pyroxene grains are completely recrystallized to fine-grained aggregates of clinopyroxene with intergrown biotite. Iron-titanium oxide grains are also surrounded by reddish brown biotite, and less commonly, by sphene.

The metamorphosed mafic dikes and sills probably represent hypabyssal intrusions emplaced at relatively shallow crustal levels. Most of the mafic dikes and sills found are indicated on the map (Map 2216, back pocket), but because they are widespread, more detailed work probably would reveal many others. Some of the dikes shown are less deformed than their host rocks whereas others have the same degree of deformation, which suggests more than one generation of these mafic intrusions. The mafic dikes in the felsic plutonic rocks may indicate that the plutonic rocks were deformed and uplifted prior to the onset of the high-rank regional metamorphism and deformation that affected the entire metamorphic complex. The relic chilled margins of some of these dikes show that the felsic plutonic rocks were relatively cool and able to fracture at the time of mafic dike emplacement, and the general features of the felsic plutons suggest that they were emplaced at lower levels than the mafic dikes.

Granite Pegmatite Dikes

Late dikes of massive granite pegmatite are found in all rocks of the metamorphic complex and were emplaced after the culmination of the high-rank regional metamorphism and accompanying deformation. The dikes have sharp contacts and either

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00M6529

Photo 15—Late granite pegmatite dike cutting across the foliation (marked by hammer handle) in gneissic hornblende-biotite granite; island south of Dukis Point, Lake Nipissing.

cut across the foliation in the host gneisses (Photo 15), or are subparallel to the foliation. They pinch and swell and range in dip from subvertical to nearly horizontal. Most of the dikes are lenticular, and the length to width ratio varies considerably. The largest dikes rarely exceed a few hundred feet in length and most are no more than a few feet wide, but a few are as much as 100 feet across. The migmatitic rocks are richer in these dikes than the non-migmatitic rocks, but the largest and most persistent dikes are found in the non-migmatitic plutonic rocks and calc-silicate gneiss because these rocks were apparently structurally more competent during emplacement of the pegmatite. Because these dikes are small, widespread, and numerous, they cannot be shown on the accompanying map (Map 2216, back pocket).

All the dikes examined by the author are low in radioactivity and are simple pegmatites consisting mainly of quartz, alkalic feldspars, and minor micas. Zoning of the major constituents is rare, but in a few of the larger bodies, pods of quartz are found near the centre. Biotite is the most common mica, but some dikes contain either muscovite or both muscovite and biotite. Dikes cutting across intercalated sequences of calc-silicate gneiss and clastic siliceous metasediments commonly show a variation in mineralogy related to the host rock. Hornblende, biotite, and magnetite are the minor constituents of the dikes in calc-silicate gneiss whereas micas and garnet are the minor constituents of the dikes in clastic siliceous metasediments. Pegmatite dikes in hornblende-biotite granite and in monzonitic rocks commonly contain hornblende, and in some quartzose and muscovitic metasediments some pegmatite dikes are composed mainly of quartz with only minor alkalic feldspar. Other minerals found sparingly in the dikes are zircon, apatite, allanite, molybdenite, specularite, and pyrite. Graphic intergrowths of

quartz and alkalic feldspar are common, and some dikes contain coarse crystals of feldspar and mica up to 3 feet across and have been quarried for mica and feldspar; these are discussed further in the "Economic Geology" section.

Although much more work is needed to determine the genesis of the pegmatite dikes, their field and petrologic relationships allow some preliminary speculation on their origin. The pegmatitic solutions most likely were generated during the advanced stages of the high-rank regional metamorphism, possibly at levels deeper within the metamorphic complex than that at which they now occur. The dikes were emplaced at their present level when the metamorphic complex was cooling and able to fracture and when regional deformation was on the wane.

Metamorphism of the Metamorphic Complex

In this section the main metamorphic features revealed by the present mapping of the metamorphic complex are summarized, and some tentative conclusions are given regarding the metamorphism of the northwestern Grenville Province.

Field relationships and geochronologic data indicate that the metamorphic complex underwent a complicated history of deformation and plutonism, and that following the major plutonism, the entire complex was subjected to a late high-rank regional metamorphism during the waning stages of which granite pegmatite dikes were emplaced. Most likely, the complex was subjected to more than one period of regional metamorphism because the oldest plutonic rocks are syntectonic (or pretectonic), intensely deformed bodies that are widespread throughout the complex. Almost certainly, regional metamorphism accompanied this early plutonism, but mineral assemblages in rocks of the metamorphic complex seem to reflect only the late high-rank regional metamorphism. Some evidence of contact metamorphism and local granitization older than the late regional metamorphism is preserved in metasediments next to felsic plutons, but metasedimentary inclusions in the felsic plutons indicate that the metasediments were non-migmatitic when the plutons were emplaced. Thus the early regional metamorphism was apparently less intense than the late metamorphism.

Mineral associations in rocks of the metamorphic complex indicate that the pressure and temperature conditions during the late high-rank regional metamorphism were uniform. Mineral assemblages are most typical of the kyanite-almandine-muscovite subfacies of the almandine-amphibolite facies described by Turner and Verhoogen (1960) and Winkler (1967). This subfacies is considered by Winkler (1967) and others to be typical of the Barrovian-type of metamorphism where the geothermal gradient is relatively low, and thus temperatures necessary for the metamorphic reactions were attained only at great depth under high pressure. Migmatitic phases of the metasediments and felsic plutonic rocks are common in the metamorphic complex, and evidence obtained from modal and chemical analyses of these rocks shows that the migmatitic phases formed by partial anatexis controlled in part by the bulk chemistry of the rocks. Mineralogically, the migmatitic rocks are characterized by: 1) biotite as the chief mafic component; 2) sodic plagioclase; 3) less than 40 percent quartz; and 4) abundant potassic feldspar. They are thus close to granite in composition whereas non-migmatitic phases are distinctly richer in calcic and ferromagnesian minerals and in quartz. Under the temperature and pressure conditions attained in the kyanite-almandine-muscovite subfacies, quartz- and biotite-bearing gneisses containing relatively sodic plagioclase will undergo melting in the presence of water (Winkler 1967), but melting of the more calcic rocks requires higher temperatures.

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The late high-rank regional metamorphism apparently culminated after the emplacement of the monzonitic rocks, but before the emplacement of the Mulock batholith. Available geochronologic data suggest that this metamorphic culmination occurred in the Late Precambrian between about 1,400 and 1,200 million years ago. This is slightly older than the culmination of high-rank regional metamorphism in the southern part of the Grenville Province of Ontario (Lumbers 1967c). This culmination has been previously placed at about 950 million years on the basis of potassium-argon age determinations on micas (Stockwell 1964), but the potassium-argon data give only minimum ages and the actual culmination is much older (Silver and Lumbers 1966). Furthermore, this late regional metamorphism varied in intensity and probably did not culminate throughout the entire Grenville Province at the same time; judging from metamorphic histories in younger orogenic belts, differences of as much as a few hundred million years can be expected in the time of this culmination from place to place in the Grenville Province.

The regional metamorphism that probably accompanied the emplacement of the earliest granitic rocks, which are about $1,700 \pm 150$ million years old, is similar in age to a regional metamorphism affecting the Huronian Supergroup in the Middle Precambrian Southern Province (Fairbairn *et al.* 1969). Quirke and Collins (1930) among others suggested that rocks of the Huronian Supergroup extend into the Grenville Province. Although no direct correlation of the metasediments in the map-area can be made with the Huronian Supergroup, both accumulations may have been affected by the same regional metamorphic event, and this suggests that they are part of a single geosynclinal accumulation. James (1955) and Card (1964) have shown that the 1,700 million year old metamorphism varies in intensity within the Huronian Supergroup, and perhaps further work in the northwestern Grenville Province will reveal evidence of at least local high-rank regional metamorphism during the Middle Precambrian.

LATE PRECAMBRIAN(?)

Mafic Intrusive Rocks

Following the Late Precambrian high-rank regional metamorphism, two mafic stocks were emplaced within rocks of the metamorphic complex in the western part of the area, and numerous diabase dikes were intruded throughout the area along regional fractures trending west to west-northwest. Although only one of the stocks is cut by the diabase dikes, both are probably older than the dikes, and are most likely Late Precambrian in age. Some of the diabase dikes are in faults that underwent post-dike movement. Conceivably some dikes could be latest Precambrian or earliest Paleozoic in age.

MAFIC STOCKS

The two mafic stocks intrusive into rocks of the metamorphic complex are the Chebogomog Lake ultramafic stock near the boundary of Field and Grant Townships north of Crystal Falls, and the Memesagamasing Lake norite stock in the southwestern corner of the area. Both stocks contain disseminated sulphide mineralization, which is described in the "Economic Geology" section.

Chebogomog Lake Stock

The Chebogomog Lake stock is poorly exposed on islands and along the shore of an elongate bay of Chebogomog Lake. Elliptical in plan, the body is about 1 mile long and as much as 1,800 feet across. Major geologic features of the mass are shown in Figure 4.

Country rocks surrounding the stock are biotite gneiss with some intercalated calc-silicate gneiss, but actual contacts are exposed only at the southwestern end of the stock; the intercalated calc-silicate gneiss occurs in very thin units and is widespread but is not shown on Map 2216 (back pocket). Next to the stock, hornblende gneiss is noticeably recrystallized, locally with a granoblastic texture, and is mainly a garnet-epidote-hornblende rock; biotite gneiss, on the other hand, is only slightly recrystallized and is rarely granoblastic. The intrusive rocks are in sharp contact with the gneisses, but are much more intensely altered and foliated near the gneisses than elsewhere within the stock.

As exposed, most of the stock consists of massive, altered, medium-grained, dark green to black, pyroxenite and minor peridotite. Pyroxenite contains almost completely unaltered clinopyroxene and orthopyroxene and minor iron-titanium oxide minerals, whereas peridotite is similar but contains more than 10 percent serpentinized olivine and numerous patches and veinlets of carbonate. Altered mafic gabbro with some pyroxenite and peridotite predominates in the northwestern and southwestern tips of the stock. The gabbro is a medium-grained, massive to foliated, dark green rock with up to 75 percent unaltered pyroxene and less than 50 percent altered plagioclase. Disseminated sulphide mineralization appears to be associated only with the ultramafic phases.

Memesagamesing Lake Stock

The Memesagamesing Lake stock, exposed along the shores of Memesagamesing Lake in Hardy Township, is crudely elliptical in plan with its long axis trending northwest. The northwestern part of the stock extends into the adjacent Burwash area (Lumbers, in preparation), but all of the stock is described here. Over half of the stock is covered by the lake, but available exposures suggest that the stock is about 3.25 miles long and up to 1.25 miles across. Friedman (1955) mapped the stock and studied the petrology of the intrusive phases, and much of the data following are taken from his work. Except for a northern extension of the stock not mapped by Friedman on the northern shore of the lake in the Dokis Indian Reserve (No. 9), the author's mapping is in essential agreement with that of Friedman. This northern extension of the stock is just to the west of the map-area and is shown in Figure 3 along with the main geologic features of the stock.

The stock intruded migmatitic metasediments containing gneissic biotite granite sheets, but contacts are poorly exposed. Dikes and small apophyses of norite are present in the immediately adjacent gneisses, and locally, the gneisses are brecciated and recrystallized with a granoblastic texture. Inclusions of the gneisses are found within the stock near its margins, and some inclusions are separated from the surrounding intrusive rocks by narrow reaction zones rich in garnet. A diabase dike intrudes the stock at the mouth of Rainy Creek, and at least three major fault zones, one of which contains the diabase dike, cut across the stock without appreciable lateral displacement.

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Rocks found in the stock are norite, minor olivine gabbro exposed on small islands in the lake (Figure 3), and granite pegmatite dikes. Norite is a medium-grained, light grey, brown-weathering rock composed essentially of labradorite, hypersthene, and augite. Hypersthene predominates over augite, and microscopically the norite shows evidence of cataclastic deformation with granulation of the primary minerals and development of mortar structure. Pyroxene grains are partly altered to amphibole, biotite, garnet, quartz, epidote, and iron-titanium oxides. Plagioclase, which shows oscillatory zoning and ranges in composition from An_{48} to An_{60} , is clouded in some rocks due to minute opaque inclusions and is rarely altered to scapolite. Coronas of garnet and quartz separate plagioclase and pyroxene grains with the quartz generally concentrated next to the pyroxene. Much of the norite is anorthositic with plagioclase ranging in abundance from about 50 to 65 percent near the margin and from 65 to 80 percent near the core. The margin of the stock also has more calcic plagioclase and more magnesian hypersthene than the core.

Olivine gabbro consists of labradorite, clinopyroxene, orthopyroxene, and olivine with minor pyrrhotite, iron-titanium oxide minerals, and greenish spinel. Biotite, amphibole, serpentine, and garnet are secondary minerals. Some olivine is armoured by zones of other minerals, commonly orthopyroxene, spinel, and clinopyroxene with orthopyroxene next to olivine, and some orthopyroxene is armoured by clinopyroxene. Other olivine and pyroxene is separated from plagioclase by garnet reaction zones.

During the cooling of the stock after the mafic phases had largely crystallized, granitic pegmatite dikes were emplaced in late fractures. Norite adjacent to these dikes is recrystallized and altered to amphibolite. The granite pegmatite dikes are as much as 30 feet wide and are zoned with a quartz core and an outer zone of potassic feldspar, oligoclase, quartz, and muscovite. Biotite, garnet, and, rarely, tourmaline are minor accessory constituents in the outer zone.

DIABASE DIKES

Diabase dikes are found along some west- to west-northwest-trending regional faults in the area and the largest and most persistent dikes are marked by linear, weak to mild, positive aeromagnetic anomalies (GSC 1965b and c). More detailed work than was possible during the present survey could reveal the presence of other diabase dikes not shown on Map 2216 (back pocket). A few faults containing diabase were traced in detail through areas of abundant outcrop, and in one of these faults, diabase, instead of persisting continuously along the fault as in most dikes, is present only here and there along the fault.

Where exposed, contacts of the diabase dikes are sharp with narrow microcrystalline chilled margins. Dikes range in width from less than 1 foot to about 150 feet, and some pinch and swell along strike. Locally, country rocks are brecciated and intensely hematitized adjacent to the dikes, and a few small fragments of country rocks were included in the margins of wide dikes. Narrow subsidiary dikes, generally only a few inches wide, are found near, and parallel to the margins of some wide dikes.

Diabase is grey to black on fresh surfaces, brown-weathering, and massive with prominent tabular plagioclase. Except for the microcrystalline chilled zones, the rock is medium-grained with rare coarse-grained to pegmatitic patches in the widest dikes. Texturally, most of the dikes are subophitic to isogranular; ophitic texture is rare. Most of the dikes consist of oscillatory zoned andesine-labradorite, calcic clinopyroxene and

pigeonite, minor iron-titanium oxides and apatite, and rare interstitial quartz in granophyric intergrowth with plagioclase. Some dikes contain a few olivine grains armoured by clinopyroxene. Pyroxene and olivine are slightly altered; the chief secondary minerals are amphibole, serpentine, biotite, and carbonate.

A few dikes are sheared and slightly brecciated by post-dike faulting and contain disseminated sulphide mineralization as described in the "Economic Geology" section. At least some post-dike fault movement could be post-Middle Ordovician in age because one major east-trending fault, in which no diabase was found, displaces Middle Ordovician sedimentary rocks near Nipissing south of South Bay, Lake Nipissing. The dikes are probably Late Precambrian in age, although some diabase could have been intruded during the earliest part of the Paleozoic; no radiometric ages are available to prove this latter possibility.

PALEOZOIC

Cambrian

ALKALIC AND RELATED MAFIC INTRUSIVE ROCKS

Four alkalic complexes containing carbonatitic phases and partly exposed on islands in the central part of Lake Nipissing and at Callander Bay near Callander are within a western extension of the St. Lawrence rift system (Kumarapeli and Saul 1966) along the Mattawa Valley and Lake Nipissing. These Lake Nipissing alkalic complexes constitute one of four centres of Cambrian alkalic intrusive activity present along a 1,200-mile segment of the rift system (Doig and Barton 1968) and are about 565 million years old (Gittins *et al.* 1967). A fifth alkalic complex may be present in a low swampy area west of Highway 64 near Brule Creek in northern Springer Township where a local concentration of carbonate dikes is accompanied by metasomatic alteration of the wall-rock gneisses. Gneisses of the metamorphic complex within the rift system are markedly hematitized and jointed, particularly near the alkalic complexes; joint symbols are not shown on Map 2216 (back pocket). Lamprophyre and rare basaltic and phonolitic intrusions form complex dike systems around the four alkalic complexes and appear to be genetically related to the complexes. In addition, lamprophyre dikes and rare felsite dikes and carbonate veinlets are developed regionally in late fault zones possibly related to the rift system. The regional lamprophyre and associated dikes have not been dated isotopically but are probably similar in age to the alkalic complexes.

These regionally developed dikes and the dike systems around the alkalic complexes are described in separate sections following the description of the alkalic complexes.

Alkalic Complexes

The four Lake Nipissing alkalic complexes, herein referred to as the Iron Island, Burritt Island, Manitou Islands, and Callander Complexes, are mainly covered by water so that details of their geology are necessarily limited. As described in the "Economic Geology" section, all four complexes contain niobium mineralization and all but the Burritt Island Complex have received some subsurface exploration by the mining industry. The Manitou Islands Complex is a relatively high-level exposure of an elliptical

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Photo 16—Typical aegirine-potassic feldspar fenite containing numerous fractures, lenticular patches and radial aggregates of aegirine, and dikes and nests of potassic feldspar; Little Manitou Island, Lake Nipissing.

ring structure of partly altered fenites, alkalic rocks, and carbonatite, but the internal structure and lithology of the other complexes are poorly known.

The four complexes were emplaced discordantly within granitic or monzonitic rocks of the metamorphic complex, and most of the rocks exposed are fenites produced metasomatically by reaction of the host granitoid rocks with alkali-rich solutions or fluids generated by the magmas of the complexes. The fenites, which are among the oldest rocks present in each complex, appear to form zones of variable width and petrologic complexity around the margins of the complexes and are characterized by numerous, irregularly oriented macrofractures and microfractures containing concentrations of sodic mafic minerals (Photo 16). These fractures indicate that fenitization was either preceded or accompanied by shattering of the granitoid host rocks possibly due to explosive activity that probably initiated the development of the complexes. In detail the intensity of fenitization varies greatly, but in general, the intensity increases from the borders inward.

Where least fenitized, the granitoid rocks retain most of their textural features but are shattered with numerous hematite veinlets, minor carbonate veinlets, and a few mafic veinlets of: 1) aegirine or sodic amphibole, or both; 2) carbonate accompanied by one or more of aegirine, sodic amphibole, apatite, fluorite, biotite, pyrite, and hematite. Quartz is strained and shows undulatory extinction, and potassic feldspar is partly clouded



Photo 17—Foliated carbonatite containing streaks and lenses of aegirine, and minor apatite, magnetite and mica; Calder Island, Lake Nipissing.

by finely dispersed hematite. These least fenitized rocks grade inward into quartz fenite in which: 1) relict textures of the original gneisses are poorly preserved; 2) hematite veinlets are subordinate to mafic veinlets; 3) carbonate veinlets are present; 4) aegirine partly replaces quartz in the body of the rock; and 5) potassic feldspar is partly recrystallized into larger perthitic potassic feldspar grains clouded by finely dispersed hematite. With a decrease in quartz and hematite and an increase in grain size, quartz fenite grades inward into medium- to coarse-grained aegirine-perthitic potassic feldspar fenite (Photo 16) containing lenticular patches and radial aggregates of aegirine and fine-grained tabular albite that replaces and veins clouded perthite and forms aggregates with aegirine. Locally, nepheline partly altered to a fine-grained aggregate of zeolites and white mica is a minor constituent. Abrupt textural changes and variations in the mafic mineral content are common in the aegirine-potassic feldspar fenite; nests and dikes of coarse-grained to pegmatitic aegirine, carbonate, and potassic feldspar are common, and patches and veinlets of fluorite are present locally. Some potassic feldspar and aegirine show comb-structure and appear to have crystallized in late fractures. This fenite also contains fillings and veinlets similar to those in the quartz fenite.

Dikes and lenticular masses of fine- to coarse-grained, partly foliated carbonatite (Photo 17) containing variable amounts of aegirine, sodic amphibole, magnetite, apatite, phlogopite, biotite, pyrite, fluorite, and, locally, pyrochlore, are present in places in the fenites. Most of the carbonatite is calcitic, but in the Iron Island Complex, dolomitic carbonatite is abundant. Brecciation of the fenites accompanied the intrusion of at least

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a few carbonatite intrusions containing partly carbonatized fenite fragments. A large lithologic variety of fine-grained, generally porphyritic, mafic and syenitic dikes also were emplaced within the fenite, and nepheline-bearing syenitic dikes are present locally in aegirine-potassic feldspar fenite.

IRON ISLAND COMPLEX

The Iron Island Complex is mainly covered by Lake Nipissing, but from available exposures on Iron Island and on nearby islands to the south, together with available aeromagnetic and assessment work data (see section on "Niobium and Uranium, Iron Island Complex"), the major geological features appear to be as shown in Figure 5. Part of the southern contact of the complex is exposed for a few hundred feet on the north side of a small island south of Iron Island (Figure 5), but elsewhere the contact is not exposed and cannot be defined precisely with the available data. From the present interpretation of the contact, the complex is crudely elliptical in plan and is about 1.5 miles long and up to 1 mile across. Paleozoic sandstone (see section on "Unclassified Paleozoic Sedimentary Rocks") locally overlies rocks of the complex along the southwestern shore of Iron Island.

The outer part of the complex probably consists of a fenitic zone of variable width; the zone is only a few hundred feet wide where defined along the southern part of the complex and appears to widen along the eastern part and is perhaps as much as a few thousand feet wide along the northern part. On Iron Island, shattered and locally brecciated quartz fenite predominates along the northern and northeastern shores, but aegirine-potassic feldspar fenite is present locally and increases in abundance towards the central part of the complex and predominates elsewhere on the island. On the other islands, fenitic rocks are mainly shattered, slightly fenitized granitic rocks and minor quartz fenite. All the fenites contain numerous carbonate veins, hematite-rich stringers, and lamprophyre dikes, and fenites on Iron Island contain a few dikes of aegirine-bearing syenite composed mainly of perthitic potassic feldspar.

The point near the southeastern end of Iron Island is underlain by hybrid silicate-carbonate rocks or silicocarbonatite containing a few dikes of coarse-grained to pegmatitic, leucocratic nepheline syenite with coarse-grained biotite phenocrysts, but the contact between these rocks and the fenites to the northeast is not exposed. The silicocarbonatite consists mainly of carbonate, biotite, and phlogopite, and variable amounts of apatite, iron-titanium oxide minerals, altered pyroxene and amphibole, zeolites (possibly in part altered nepheline), andraditic garnet, and locally, melilite and pyrite. Diamond drill logs and examination of a few drill core samples indicate that the silicocarbonatite extends south of Iron Island as shown in Figure 5 and surrounds a small mass of partly carbonatized ijolitic rocks rich in biotite, altered nepheline and pyroxene, and contains abundant carbonate stringers and local concentrations of iron-titanium oxide minerals and pyrite. Drill logs indicate that a moderately intense, positive aeromagnetic anomaly in the southern part of the complex is underlain by ultramafic- and mafic-rich rocks, probably alkalic pyroxenite and altered ijolitic rocks. Apatite, iron-titanium oxide minerals, sphene, and carbonate are common accessory minerals in the pyroxenite, and from drill logs, the pyroxenite appears to be partly altered and carbonatized and contains several magnetite-rich zones and local zones rich in pyrite and pyrrhotite; sparse chalcopyrite and minor tin mineralization are also reported but are too small to be shown on Map 2216 (back pocket). Dolomitic carbonatite in the central and northwestern parts of the

complex contains abundant massive veinlets and disseminated grains of iron-titanium oxide minerals, chiefly hematite and magnetite. Most of the rock is vuggy, and two drill core specimens examined contain numerous pyrite crystals partly coated with hematite and one of the specimens contains a massive pyrite vein with intergrown quartz. Minor syenitic rocks and silicocarbonatite occur with the dolomitic carbonatite. A local, positive gravity anomaly is centred over the dolomitic carbonatite in the northwestern part of the complex, and a more extensive positive gravity anomaly occupies the central and southern parts of the complex.

Calcite veins, barite veins, fluorite-barite-calcite veins, hematite-rich veins, and lamprophyre and "trap" dikes are reported in drill logs to cut across all the major rock types. A few lamprophyre dikes exposed on Iron Island are cut by carbonate and barite veins, and all of these veins could be among the youngest phases of the complex. Except for the fenitic rocks, which are probably the oldest phase of the complex, relative age relationships between the other phases are poorly known but could be approximately as shown in Figure 5.

BURRITT ISLAND COMPLEX

The Burritt Island Complex is exposed only on Burritt Island in Lake Nipissing, due south of the Little Sturgeon River. Most of the island is underlain by shattered, slightly fenitized granitic rocks, but towards the southern end these rocks grade through quartz fenite into aegirine-potassic feldspar fenite, which dominates the southern 400 feet of the island. On the eastern side of the island, the aegirine-potassic feldspar fenite contains mafic dikes, rich in aegirine, with some carbonate and altered nepheline, and a carbonatite intrusion that can be traced for about 200 feet along the shore and up to 50 feet inland. The carbonatite contains abundant fine- to coarse-grained aegirine crystals and crystal aggregates concentrated in crude layers, minor amounts of hematite, magnetite, apatite, and sodic amphibole, and traces of pyrite and pyrochlore crystals. Lamprophyre dikes are present in the fenites on the northern part of the island.

MANITOU ISLANDS COMPLEX

The Manitou Islands Complex is an elliptical ring structure about 2 miles long and up to 1.7 miles across. Most of the complex lies beneath Lake Nipissing and only fenitic rocks of the outer part of the complex, containing a few carbonatite intrusions, are exposed on the five islands of the Manitou group. Ordovician sedimentary rocks overlie rocks of the complex on all five islands (see the section on "Ordovician Sedimentary Rocks") as shown in Figure 6 depicting the general geology of the complex; on Newman Island the Ordovician rocks are covered by a mine dump. Concentrations of pyrochlore present in the fenitic rocks and carbonatite were explored extensively by diamond drilling and underground workings in the 1950s (see section on "Niobium and Uranium, Manitou Islands Complex"); the following summary of the complex is taken largely from Rowe (1954; 1958, p.45-62) who made a detailed study of the complex during this period of exploration.

Two concentric fenitic zones comprise the outer part of the complex: 1) an outer zone of quartz fenite as much as 400 feet wide; and 2) an inner zone of aegirine-potassic feldspar fenite as much as 1,500 feet wide. Quartz fenite is foliated due to crudely

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aligned, lenticular concentrations of aegirine and to elongate feldspar grains, but the aegirine-potassic feldspar fenite is mainly massive with only locally aligned aegirine-rich streaks. Generally conformable lenticular intrusions of carbonatite are present locally in the aegirine-potassic feldspar fenite, and near these intrusions, the fenite is brecciated and carbonatized, and xenoliths of carbonatized fenite are present in the adjacent carbonatite. The carbonatite is essentially a fine- to coarse-grained calcite rock and is massive to slightly foliated with streaks rich in aegirine and variable amounts of sodic amphibole, biotite, magnetite, apatite, and, locally, pyrochlore and pyrite.

The composition and structure of the inner part of the complex is poorly known, but diamond drilling indicates that the inner western margin of the fenite aureole is bounded by altered, massive, coarse-grained to pegmatitic pyroxene-rich rocks younger than the fenites and ranging in composition from alkalic pyroxenite to alkalic mafic syenite. Perthitic potassic feldspar and aegirine (partly altered to fine-grained carbonate), white mica, and chlorite are the major minerals in these rocks, but altered nepheline is present in some syenitic varieties together with interstitial plagioclase. Other minerals present in variable amounts are calcite, biotite, sodic amphibole, apatite, and iron-titanium oxide minerals; accessory minerals are pyrite, monazite, fluorite, and pyrochlore (largely altered to a fine-grained aggregate of carbonate), hematite, and chlorite. North of Newman Island, altered feldspathic rocks form the innermost phase of the complex (Figure 6).

Abundant lamprophyre dikes, minor altered basaltic dikes, and a few phonolitic dikes cut across the fenitic rocks in the outer part of the complex.

CALLANDER COMPLEX

The Callander Complex occupies much of Callander Bay, an almost circular depression about 2.25 miles in diameter at the eastern end of Lake Nipissing. Most of the complex is covered by water, and its precise extent is unknown, but from geophysical and other data (see section on "Niobium and Uranium, Callander Complex") and the available exposures, all but the southern and extreme western parts of the bay are probably underlain by the complex, as shown in Figure 7.

Quartz fenite and aegirine-potassic feldspar fenite underlie most of Darling and McPherson Islands in the western part of the bay (Figure 7), and the eastern outer part of the complex consists of a fenitic zone as much as ½ mile wide, which is well exposed in road cuts along Highway 11 and in Callander. Granitic and monzonitic rocks along the southern shore of the bay between Wasi Falls and Smith Island are not fenitized except within a few inches of several lamprophyre dikes present along the shore. Shattered, slightly fenitized granitoid rocks, at the outer edge of the eastern fenitic zone, grade inward towards the central part of the complex through quartz fenite to aegirine-potassic feldspar fenite, which is intruded by nepheline syenite along the eastern edge of the bay. Exploration work (see section on "Niobium and Uranium, Callander Complex") shows that the nepheline syenite extends beneath the bay for over ½ mile west of the dock at Callander. A narrow nepheline syenite cone sheet, ranging in width from 1 foot to 10 feet, intrudes fenite at the lookout on Highway 11 (Figure 7), and a second more extensive nepheline syenite cone sheet, up to 20 feet wide, intrudes fenites south and east of the lookout. A few nepheline syenite boulders found in a small area of no outcrop on the eastern side of Highway 11, about 2 miles south of the southeastern margin of the complex (see Map 2216, back pocket), could mark a third cone sheet off the southeastern flank of the complex.

The fenites contain numerous carbonate veins and are locally intensely brecciated and hematitized, especially near small carbonatite intrusions present in a few places on Darling and McPherson Islands and in the inner part of the eastern fenitic zone. The carbonatites are similar in mineralogy to those on Calder Island in the Manitou Islands Complex, but pyrochlore is relatively rare. Syenitic dikes containing altered nepheline are locally present in aegirine-potassic feldspar fenite.

Nepheline syenite, in both the cone sheets and along the eastern shore of the bay, is massive and medium to coarse grained and ranges in composition from foyaitite to pulaskite. Foyaitite predominates and consists of about 30 to 40 percent euhedral to subhedral nepheline in part poikilitically intergrown with perthitic potassic feldspar, forming 30 to 45 percent of the rock; other minerals are 10 to 25 percent aegirine-augite and accessory biotite, sphene, apatite, zircon, iron-titanium oxide minerals, and minor pyrite. Pyroxene is partly altered to carbonate and fine-grained chloritic material, and nepheline is partly altered to a fine-grained aggregate of zeolites and white mica with finely dispersed hematite. Pulaskite is similar in appearance to foyaitite but is richer in perthitic potassic feldspar and contains less nepheline and aegirine-augite. In a few outcrops on Burford Point and locally in the cone sheets, veinlets of sodalite cut across the nepheline syenite. Drill cores show that nepheline syenite underlying the bay is intensely hematitized and carbonatized with up to 10 percent disseminated pyrite and traces of fluorite; lamprophyre dikes and mafic dikelets rich in altered pyroxene are abundant. These features suggest that carbonate-rich rocks and possibly alkalic mafic rocks are present in the central part of the complex.

Lamprophyre, and basaltic and phonolitic dikes cut across all the rocks of the fenitic zone, and these dikes are in turn cut by late calcite and barite veins, especially in road cuts along Highway 11 south of the lookout. Some of the late calcite veins contain microscopic quartz lenses and the barite veins contain disseminated crystals of specular hematite.

FENITIC ROCKS IN SPRINGER TOWNSHIP

Near Brule Creek, about $\frac{1}{2}$ mile west of Highway 64, a few small outcrops of granitic rocks are locally shattered and show incipient fenitization. A 706-foot diamond drill hole, put down in the vicinity of these outcrops, revealed a wide zone of altered and shattered fenitic rocks containing carbonate veins (see section on "Niobium and Uranium, Fenitic Rocks in Springer Township"). A beaver pond covers the area in which the veins occur, but perhaps a small alkalic complex is present, or alternatively, the veins and fenitization could be only one of several localized zones of shattering and fenitization within the regional rift system. Such localized zones have been reported from other rift systems in the vicinity of alkalic complexes (Heinrich 1966).

MAFIC DIKE SYSTEMS ASSOCIATED WITH THE ALKALIC COMPLEXES

Complex mafic dike systems associated with the alkalic complexes extend outward to just beyond the edge of the fenitic zones. The dikes are deuterically altered making their petrographic classification difficult, but in approximate order of decreasing abundance, the major lithologic varieties present are: 1) feldspar-free lamprophyric dikes; 2) basaltic dikes; and 3) phonolitic dikes. Lamprophyric dikes are present in all the complexes whereas basaltic dikes are most abundant in the Callander and Manitou Islands

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Complexes and are absent on Burritt Island; phonolitic dikes are exposed only in the Callander and Manitou Islands Complexes. All the dikes are typically sinuous and all but some of the lamprophyres are relatively short and lenticular radial dikes; some lamprophyres appear to form cone sheets. The dikes postdate all the exposed phases of the complexes, except late carbonate and barite veins, and are probably genetically related to the complexes.

Lamprophyric dikes appear to be mainly monchiquite containing medium- to coarse-grained phenocrysts of partly altered titanite, biotite, and amphibole in an altered fine-grained groundmass consisting mainly of zeolites, scapolite, carbonate, iron-titanium oxide minerals, chloritic material, apatite, and traces of melilite. Fenitic rocks of the Callander Complex exposed in road cuts along Highway 11 contain a few brecciated alnöitic dikes containing phenocrysts of reddish biotite, apatite, and altered olivine. Basaltic dikes consist mainly of fine-grained labradorite (about An_{65}) ophitically intergrown with fine-grained altered clinopyroxene, and accessory minerals are iron-titanium oxide minerals and apatite. Phonolitic dikes consist of medium- to coarse-grained phenocrysts of altered nepheline and rare alkalic feldspar in a fine-grained, trachytic groundmass of alkalic feldspar with subordinate altered mafic minerals and accessory iron-titanium oxide minerals.

Regionally Developed Lamprophyre and Associated Dikes

Monchiquite dikes similar to those associated with the alkalic complexes are also developed regionally and are generally either within, or near, major faults or lineaments. The dikes are poorly exposed and, in general, can be readily identified only in unweathered outcrops free of vegetal growth along lake shores, in stream valleys, or in cuts along roads and railways. The dikes are no more than a few feet wide and their host rocks are generally intensely hematitized and fenitized up to a few inches from the dike margins. Most of the dikes found are near Lake Nipissing, or along Highway 11 south of Callander, or between Callander and Lake Nobsong. A few monchiquite dikes are present in the northern part of the area on Highway 533 west of Timber Lake, on Highway 63 near the northern boundary of Phelps Township, and on the Ontario Northland railway. Those dikes on the railway, on Highway 63, and locally on Highway 11 have associated calcite veinlets. Two dikes, one at Meadow Bay on the western side of South Bay, Lake Nipissing, and the other exposed at a rapids on the Tomiko River near the power line crossing in Field Township, are intensely hematitized and altered, fine-grained syenitic rocks containing altered nepheline, alkalic feldspar, and minor altered mafic minerals.

A more detailed search than was possible during the present study could reveal many more dikes. Local concentrations of these dikes, in conjunction with carbonate veins and abundant fenitization, could be indicative of a nearby central alkalic complex.

Ordovician Sedimentary Rocks

Ordovician sedimentary rocks, either flat-lying or dipping at low angles, unconformably overlie Precambrian and Cambrian metamorphic and igneous rocks in the Manitou Islands and just south of the South River, west of Nipissing. A few large

boulders of similar strata are found on the southern shore of Phantom Lake in Patterson Township near the granitic unit that crosses the western end of the lake. Ordovician outcrops and boulders south of Lake Nipissing are on the northern side of major fault zones along which these rocks were probably downthrown and thus preserved. Ordovician strata in the Manitou Islands are probably preserved in structures related to the underlying alkalic complex, but in places the sedimentary rocks are displaced by low angle reverse faults. Fossiliferous limestone and dolostone predominate in the Ordovician exposures, and Colquhoun (1958) showed that these rocks are Middle Ordovician in age. A few outliers of similar Early Paleozoic strata are known east of the map-area near Kiosk and Brent on the Canadian National railway to Pembroke and Ottawa. Although Ordovician outliers are scattered and small, it is possible that much of the Precambrian terrane between the Ottawa River and Georgian Bay was once mantled by Early Paleozoic strata.

Middle Ordovician strata are found in all five islands of the Manitou group, but exposures on the southwest shore of Newman Island are now covered by mine dump material. The thickest and most complete section exposed, about 28 feet, is on the western shore of Little Manitou Island. Here, a basal zone with a maximum thickness of about 6 feet consists of conglomerate with interbedded sandstone and shale; the conglomerate contains gneissic granitic boulders up to 2 feet in diameter. Seven feet of calcareous sandstone overlies, and interfinger with, the basal beds, and this sandy unit grades upward into about four feet of massive dolostone through a four-foot section of sandy dolostone. A 4-inch shale unit overlies the dolostone and, in turn, is overlain by massive to thinly bedded limestone forming the remaining 7 feet of the section. In other islands of the Manitou group, strata are similar to the lower part of the Little Manitou section, although a small patch of limestone is exposed on the southern shore of the eastern part of Great Manitou Island.

West of Nipissing, about 20 feet of Middle Ordovician strata, largely dolostone, are exposed. The lower 6 feet of the section are exposed only in test pits south of the road in lot 16, concession XI and in lot 218, concession A, Nipissing Township. The upper 14 feet are exposed in a 20-foot cliff about 900 feet south of the road, but when the author examined this section in 1965, the test pits were largely filled by debris; Satterly (1942, p.16) examined the section when it was better exposed and reported as follows:

As observed in the test-pits in lot 16, concession XI, the dolomite is somewhat irregularly bedded, the beds being 4 to 6 inches and occasionally as much as 1 foot in thickness. The bedding in these exposures is practically horizontal. Six chains south of the road, in the eastern part of lot 218, concession A, the strike of the bedding is N. 65°-70° E., and the dip 10°-15° S. At about 14 chains south of the road, a 20-foot cliff is formed of dolomite and pre-Cambrian granite gneiss separated by a gully 15 to 20 feet in width. The face of the granite gneiss in the gully strikes N. 75°W., and dips 70°N. The bedding of the dolomite is from 2 to 4 inches thick; the strike is N. 20°W., and the dip 12°E. Small lenses and irregular stringers of white-weathering chert occur along the bedding in the upper part of the dolomite. This exposure suggests a fault between the dolomite and the granite gneiss, but it may also be interpreted as the old shore line in the Ordovician sea.

The gully referred to by Satterly is partly filled with rubble of the metamorphic complex and probably represents a fault along which the Ordovician strata were downthrown.

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Unclassified Paleozoic Sedimentary Rocks

Two small patches of essentially flat-lying, non-fossiliferous sandstone unconformably overlies rocks of the Iron Island alkalic complex between the two prominent points on the southwestern side of the island. Several boulders of the sandstone are scattered along the shore of the island, particularly between the two points. Because the sandstone is non-fossiliferous its age is unknown, but it is probably Paleozoic and is possibly only slightly younger than the underlying Cambrian alkalic rocks, for reasons discussed below.

As much as 12 feet thick, the sandstone shows a striking colour variation with light grey, red, and, rarely, green phases intermingled as layers and irregularly distributed lenticular patches. Crossbedding is present in a few places, and for the most part, the sandstone is thickly bedded. Microscopically, the rock consists of subrounded to rounded and rarely angular quartz and minor chert grains with an average grain size of about 1.5 mm in a barite cement that forms about 35 percent of the rock; the clastic grains are corroded and partly embayed by the barite cement. The sandstone shows fair sorting. Reddish phases appear to be due to red ferric oxide stain in the barite cement, whereas greenish phases appear to be due to green ferrous oxide(?) discoloration in the cement.

Sandstones containing a barite cement are uncommon (Petrijohn 1957, p.652), and the fact that late barite dikes are associated with the underlying alkalic complex could indicate that the barite cement was derived from this complex either by circulating ground waters, or, possibly, at a late stage during the cooling of the complex. Conceivably, the sandstone could be only slightly younger than the complex.

CENOZOIC

Pleistocene

During the Pleistocene, the Great Lakes region was subjected to four glaciations, but evidence of only the last glaciation, the Wisconsin, is found within the map-area. This ice-sheet retreated from the North Bay area about 9,500 to 10,000 years ago (Terasmae and Hughes 1960; Lowdon and Blake 1968, p. 215), but as the ice margin receded northward across the area, glacial melt waters were dammed against the wasting ice front and inundated much of the area below elevations of about 1,300 feet. When the ice margin retreated north of the area, post-glacial lakes continued to inundate parts of the area, but eventually many of these lakes drained, as the result of post-glacial uplift of the land, leaving numerous, smaller lakes in depressions. Lake Nipissing is the largest remnant in the area of these glacial and post-glacial lakes that once extended far to the west and south to form part of the glacial and post-glacial Great Lakes described in detail by Hough (1958; 1963). Most of the Cenozoic sediments shown on Map 2216 (back pocket) were deposited in these glacial and post-glacial lakes, although some represent drift partly modified by lake waters. Major features of the Pleistocene geology are summarized in Figure 2.

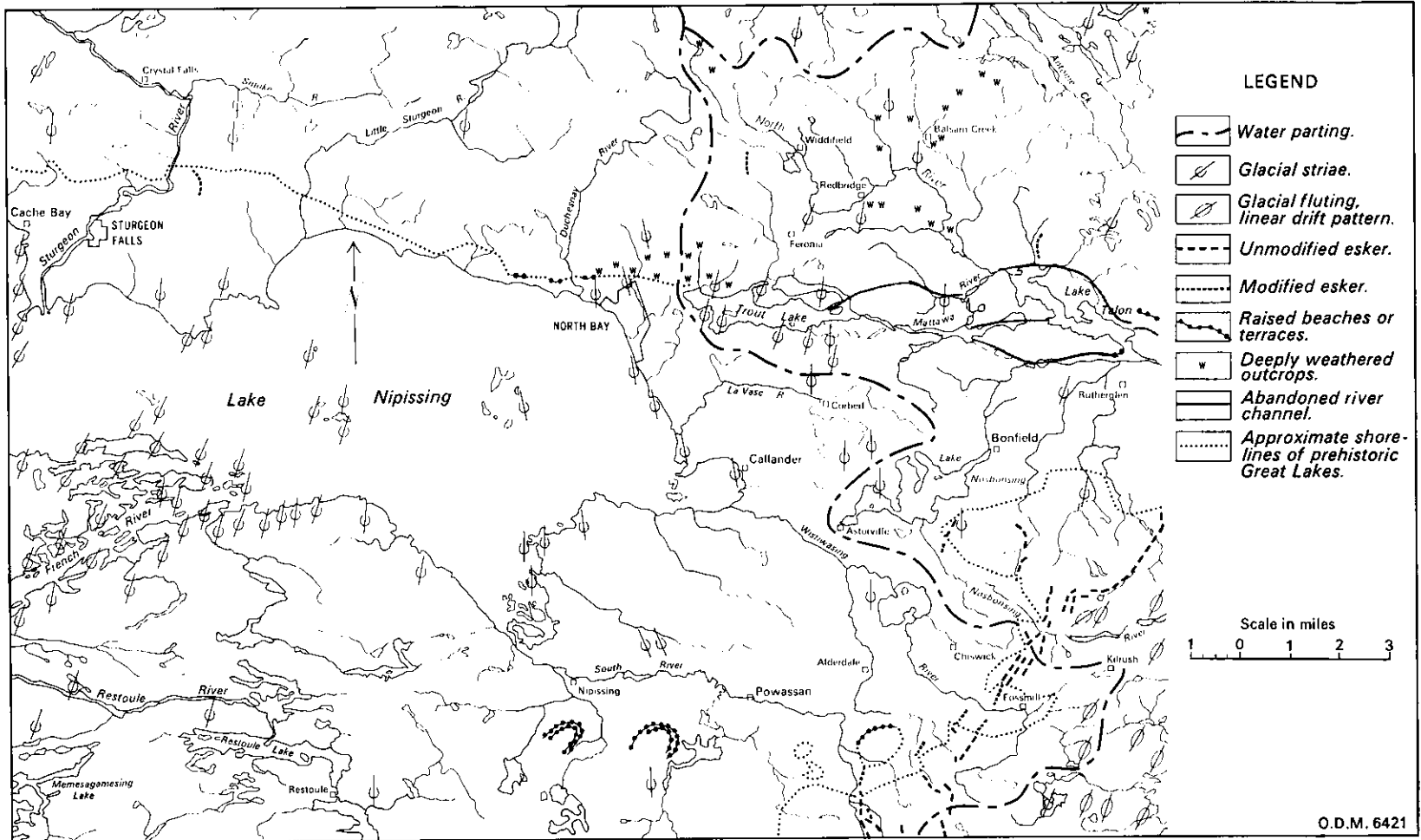


Figure 2—Some major features of the Pleistocene geology of the North Bay area.

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DIRECTION OF ICE MOVEMENT

The direction of ice movement within the North Bay area as recorded by glacial striae ranges from S20E to S30W; south to southwest-trending striae predominate and probably represent the movement direction of the last major ice advance. Striations measured within the area are plotted in Figure 2, and in general, they show a progressive change in trend from south to slightly west of south in the eastern part, to southwest in the western part. Southeasterly trending striations were found only near the eastern end of Lake Nipissing where they are parallel to the eastern shore of the lake and to the foliation in the rocks of the metamorphic complex. Probably these southeasterly trending striations represent a local change in the ice flow direction rather than a separate ice lobe or glaciation. Nevertheless, a local readvance of the retreating ice sheet is suggested by fluting and linear patterns, trending S20W to S50W, in drift in the southeastern corner of the area (Figure 2).

DRIFT

Glacial drift in the form of eskers, ground and recessional moraines, delta plains, and kames is thickest in the eastern half of the area and is largely absent in the southwestern quarter and near Lake Nipissing where it was removed by wave action of the prehistoric Great Lakes. Unmodified drift features are found only in the southeastern corner of the area above the shoreline indicated in Figure 2, and in upland areas over about 1,300 feet in elevation in the northwestern quarter. Elsewhere in the area drift was modified by lake waters.

Extensive sand and gravel deposits in the eastern part of the area, extending northward from Boulter Township to southeastern French Township (Map 2216, back pocket), appear to be part of a complex moraine system formed during the retreat of the ice front. Prominent esker systems, with associated kames and kettles, extend southwestward from the moraine system into Chisholm and South Himsworth Townships, and in southwestern Chisholm Township esker systems appear to converge on a delta plain. Near Fossmill on the Canadian National railway in southeastern Chisholm Township and below the prehistoric shoreline, the drift was reworked by lake waters, and sandy deposits derived from the drift interfinger with, and are overlain by, lacustrine varved clay. North of Chisholm and Boulter Townships moraine material was also reworked by lake waters and is interstratified with varved clay. Other reworked moraine material is represented by extensive sand and gravel deposits in western Widdifield and adjacent Commanda and Blyth Townships.

As suggested by Harrison (1969, p.200) among others, the western part of the ice front in the North Bay area could have retreated more rapidly than the eastern part during deglaciation. Fluting and linear patterns, in drift in the southeastern corner of the area, indicate that a local readvance of the ice sheet may have taken place here.

Pebbles, cobbles, and boulders found in the drift are largely of local derivation. Some coarse detritus derived from rocks of the Huronian Supergroup to the north and west of the Grenville Province is common in the drift, but coarse detritus derived from the Early Precambrian Superior Province is relatively rare.

PREHISTORIC GREAT LAKES AND RELATED DEPOSITS

Raised beaches and sand terraces now at elevations ranging from slightly less than 700 feet to about 1,250 feet above sea level are found in various parts of the North Bay area and were formed during various stages in the complex history of the prehistoric Great Lakes. Beaches below about 800 feet in elevation were developed during the Nipissing post-glacial stage of the Great Lakes about 4,200 years ago (Hough 1963). The Nipissing stage shoreline is best preserved in the northwestern quarter of the area where it can be traced from west of Sturgeon Falls to North Bay (Figure 2). Beaches and sand terraces, now over about 800 feet in elevation, are related to earlier glacial lake stages when the ice margin blocked the Mattawa Valley. These glacial lakes are responsible for the varved clays found near Redbridge and Balsam Creek on Highway 63 (Map 2216, back pocket) and for the shoreline and raised beaches in the southeastern part of the area (Figure 2). Details of the history of these glacial lakes within the map-area are poorly known, but at least some of these lakes drained eastward to the Ottawa Valley through a channel at Fossmill (Chapman 1954; Hough 1963).

By Nipissing time, the ice-front had retreated north of the map-area, and post-glacial Lake Nipissing drained along the Mattawa Valley to the Ottawa Valley. Within the Mattawa Valley, in the map-area, several abandoned river channels can be recognized, and the major ones are indicated in Figure 2. In addition, a series of terraces, first recognized by Lang (1943), are on the northern side of the Mattawa Valley east of Shields Bay, Lake Talon; many of the terraces are east of the map-area. With post-glacial uplift of the land the Mattawa Valley outlet of the Upper Great Lakes ceased to function, and the entire discharge shifted southward through the Lake St. Clair outlet. Downcutting of this outlet caused water levels to drop to the approximate level of the present Great Lakes about 2,500 years ago (Hough 1963).

Shorelines of the prehistoric Great Lakes, shown in Figure 2, are marked mainly by sand and gravel terraces with rare superimposed beach ridges. North of Trout Lake and the Mattawa River, shorelines cannot be defined, partly because they were obscured by discharge waters along the Mattawa Valley outlet, and partly because the rugged topography produced irregular shorelines that effectively reduced the effect of wave action and the concomitant formation of terraces and beaches.

Below the ancient shorelines, shown in Figure 2, deposits of varved clay with interstratified sand and silt predominate over drift, particularly in the southeastern part of the area and near Sturgeon Falls. Low bedrock hills and ridges flanked by sand and gravel aprons stand above the relatively flat to gently rolling clay plains (Photo 18) and were islands during the later stages of the prehistoric Great Lakes. The sand and gravel aprons interfinger laterally with the clay, and some of the lowest hills are partly overlapped by clay. In reworked moraine and associated drift deposits, in western Widdifield Township, extensive deposits of fine sand and silt are found locally and may represent in part wind-blown sands formed after retreat of the glacial lake waters.

WEATHERING OF THE BEDROCK

In the northeastern part of the area bedrock outcrops, above the ancient Nipissing shoreline but below the highest glacial lake beaches and terraces, are deeply weathered in many places (Figure 2), and such weathering is particularly common along the upper

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Photo 18—View looking southeast over a gently rolling clay plain toward Highway 11 from a rocky ridge 1 mile west of Highway 11 near the south boundary of the area in South Himsworth Township. The rocky ridge in the foreground and rocky hills in the distance are flanked by sand and gravel aprons that interfinger with varved clay of the clay plain.

part of the escarpment north of North Bay. In roadcuts exposing weathered outcrops, the degree of weathering is variable with some zones more deeply weathered than others (Photo 19).

This weathering has not been reported previously, and its origin presents a problem. The weathering is probably older than the Nipissing post-glacial stage because no weathered outcrops were found below the Nipissing beaches and shoreline. The weathered outcrops are in a zone of poorly developed beaches where waters may have retreated rapidly and wave action was slight. Many of the weathered outcrops are in low drift covered hills and are found on both north- and south-facing slopes. These outcrops could represent pre-glacial weathering that was not eroded by glaciers because the weathered rocks were mantled by thick drift. On the other hand, lack of weathered outcrops at elevations above the glacial lake deposits suggests that the weathering was accomplished, possibly by circulating ground waters, after these early lakes retreated, but prior to development of the Nipissing stage. This explanation seems unlikely, however, because it would allow only a few thousand years for development in a cold, rigorous climate where chemical weathering is a restricted phenomenon.



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Photo 19—Deeply weathered biotite gneiss showing typical variations in the degree of weathering found in outcrops of deeply weathered bedrock; roadcut, Highway 123 just north of North Bay, Widdifield Township.

Recent

Recent sediments comprise swamp accumulations, beach deposits along Lake Nipissing, and clay, silt, sand, and gravel deposited in streams and lakes. The largest swamp accumulations are found in the western half of the area where the relief is lowest; particularly large swamps are in northern Commanda Township and adjacent Blyth Township. Recent and Pleistocene fluvial sand and gravel are essentially indistinguishable. In many places streams have eroded Pleistocene sediments to form deep V-shaped valleys, and some of the most deeply entrenched valleys are in the extensive Pleistocene sediments in Boulter Township and southern Bonfield Township.

The level of Sobie Lake, drained by the Nosbonsing River north of Kilrush on the Canadian National railway in Boulter Township, was lowered by a severe storm in the 1950s. Prior to this storm, the lake extended about 1 mile farther west than at present and its outlet was restricted by a Pleistocene sand and gravel ridge $\frac{1}{2}$ mile east of the road across Boulter Township, north of the lake. During the storm this ridge was removed by flood waters thus allowing the lake to drain to its present level, and the sand and gravel was washed to form an alluvial plain.

STRUCTURAL GEOLOGY

Structural data obtained during the present study of the North Bay area are summarized in Map 2216 (back pocket). Foliation attitudes measured in the gneisses of the metamorphic complex are generalized and shown as trend lines that outline complex fold systems, and only the major fold axes are shown. Other structural elements shown are lineations measured in the gneisses and major faults.

DEFORMATION OF THE METAMORPHIC COMPLEX

As discussed in the "General Geology" section, the metamorphic complex reflects a complicated history of deformation, plutonism, and metamorphism culminating in a Late Precambrian high-rank regional metamorphism with accompanying intense deformation. A deformational history earlier than the high-rank regional metamorphism is suggested by the plutonic history and by the complex fold patterns in the gneisses, but most of the structural features appear to be related to intense deformation accompanying the late regional metamorphism. More data are needed to interpret the deformational history, but some of the major features apparent from Map 2216 (back pocket) are discussed in this section. Because no top determinations are available in the metasediments, the terms anticline and syncline used in discussing folds indicate only folds closing either in the direction of plunge (anticline), or in the opposite direction (syncline).

Foliation and Folding of the Metasedimentary Gneisses

The deformation of the metasedimentary gneisses is interpreted largely from the orientation of foliation planes in these rocks. The only important set of foliation planes present is parallel with compositional layering reflecting original bedding accentuated by metamorphic and granitic segregations; the foliation is therefore stratiform. Spacing of foliation planes is irregular and dependent largely on the original stratification of the gneisses (see Photos 1 to 3) and is no indication of the intensity of deformation. Between foliation planes, platy and prismatic minerals such as biotite and hornblende are moderately well aligned in laminated micaceous gneisses derived from siltstone but are poorly aligned in gneisses derived from sandstone. Locally, however, narrow shear zones are present in the metasediments in which the constituent minerals show a high degree of alignment, and such zones are probably relatively late structures.

Stratigraphic marker units suitable for tracing major structures in the metasediments are uncommon, but in places, sufficiently thick and extensive feldspathic gneiss units intercalated with biotite gneisses show the complexity of the folds. In general, the folds are isoclinal passive flow folds with northwesterly trending axes refolded about axes trending north-northwest to east-west. In the limbs of the isoclinal folds, foliation is indistinguishable from axial-plane foliation, but in the apices of the folds, foliation traces out the structure; locally in the apices of some folds a schistosity parallel to the axial-plane is present. Axial-planes of minor folds, within larger structures, are commonly

parallel with the locally prevailing foliation so that the minor folds cannot be used in determining the shape of the major folds. On the noses of upright to moderately overturned major folds, where foliation is transverse to the direction of the major axial-plane, minor fold axial-planes are recumbent. Good examples of such recumbent minor folds can be seen in migmatitic biotite gneiss exposed along some of the bays leading north from the French River in Bertram Township.

Thickening and thinning of different lithologic units around folds and the local presence of boudins show that the ductility (the ability of a rock to fold without fracture or faulting) of the various metasediments was not uniform during deformation. In general, migmatitic biotite gneiss, micaceous, originally silty metasediments, and hornblende gneiss show evidence of greater ductility during deformation than other varieties of the metasediments. During the high-rank regional metamorphism, migmatitic biotite gneiss was rendered more ductile than non-migmatitic biotite gneiss by partial melting (see Photo 2), and inspection of Map 2216 (back pocket) shows that sequences dominated by this rock are more complexly folded than those dominated by non-migmatitic biotite gneiss. The ductility of a particular lithologic unit is not everywhere the same, but varies relative to the ductility of the surrounding lithologic sequence. Boudins are confined mainly to micaceous, originally silty layers in biotite gneiss (Photo 3), to hornblende gneiss layers intercalated with clastic siliceous metasediments, and to metamorphosed mafic dikes and sills in the metasediments.

Several areas within the metasediments appear to be characterized by distinctive styles of folding. Biotite gneiss and muscovitic and quartzose gneiss together with minor intercalated migmatitic biotite gneiss, north of the Mattawa River Fault and east of Beaucage and Commanda Townships, are deformed into northwest-trending isoclinal folds overturned, 20 to 50 degrees, towards the southwest. The folds appear to plunge at low angles to the southwest and, locally, to the northwest. In the vicinity of Trout Lake and the French River and in the northwestern part of the area, metasediments, mainly migmatitic biotite gneiss, show complex dome and basin structures with northwest-trending fold axes refolded about north- to east-trending axes. Some dome and basin structures contain small intrusions in their cores that could have influenced the development of the surrounding structures. Moreover, many of the mafic stocks of the metamorphic complex are in basin structures, and well developed basin structures associated with the Chebogomog and Memesagamesing late mafic stocks were apparently formed by the forceful emplacement of these stocks. Metasediments forming the screen separating the Bonfield and Powassan batholiths are deformed into a series of closed, dominantly upright folds plunging southeastward. In the southeastern corner of the area, between the Bonfield batholith and the Wilkes pluton, metasediments show foliation trends conforming closely with the contacts of these intrusions, and fold axes are overturned toward the Bonfield batholith. In the southeastern quarter of the area west of the Powassan batholith, the gross structural trends suggest a regional synclinorium plunging southwards beyond the map-area. Down the plunge of this structure, south of the map-area in Lount Township bordering Pringle Township on the south, Satterly (1955) reported a metasedimentary sequence dominated by amphibolite and marble. Some of the amphibolite could represent mafic metavolcanics, and if so, the sequence is lithologically similar to the Late Precambrian metavolcanic-marble-rich metasedimentary sequence of the Bancroft-Madoc area (Lumbers 1967c) and could be a northern extension of this Late Precambrian sequence overlying the Middle Precambrian metasedimentary sequence of the map-area.

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Structural Relations of the Felsic Plutons

Foliation in the early, syntectonic (or pre-tectonic) granitic sheets is generally concordant and continuous with foliation in the surrounding metasediments, which suggests that both the sheets and the metasediments underwent a similar tectonic history. The largest of these granitic sheets, the Sturgeon Falls batholith, appears to be on the southwestern margin of a northeasterly elongated domical complex in metasediments centred on the southern end of Tomiko Lake just north of the map-area in Grant Township. The batholithic sheet appears to be complexly folded about northwest-trending axes that were refolded causing the sheet to conform with structural trends in the southwestern margin of the domical complex. In contrast to the early granitic sheets, the younger monzonitic Powassan and Bonfield batholiths appear to be anticlinorial bodies, and isoclinal folds in the immediately surrounding metasediments are complexly contorted and generally overturned towards the batholiths. During the Late Precambrian high-rank regional metamorphism, the metasediments were apparently deformed against the batholiths, which acted as relatively rigid elements in relation to the surrounding metasediments. A similar relationship between anticlinal rigid structures and mobile zones of overturned isoclines is described by Buddington and Leonard (1962) from the Adirondack area. Foliation attitudes along the flanks of the Mulock batholith, the youngest of the felsic plutons, are generally concordant with those of the surrounding metasediments, but towards the interior of the batholith in Merrick and Mulock Townships the foliation steepens, and discordant relationships are evident near the southern end of the batholith in Widdifield Township. Both the batholith and the surrounding metasediments show a prominent eastward-plunging lineation (see below) that suggests that regional deformation continued after the emplacement of the batholith.

Lineation

The most common lineation recorded in the map-area is a rodding structure consisting of a series of parallel columns on foliation planes, about 0.5 inch to 3 inches in diameter and up to several feet long; macroscopic mineral elongation along the trend of the columns is rare. In the felsic plutonic rocks, lineation is marked in many places by stretched augen of recrystallized quartz and feldspar and segregations of mafic minerals in foliation planes, but minerals of the augen and the segregations are generally not elongated. In migmatitic facies of the metasediments and felsic plutonic rocks, lineation is also produced by parallel irregular ellipses and columns of medium- to coarse-grained granitic material.

Most of the lineations plunge 10 to 50 degrees southeastward with an average plunge value of about 25 degrees and appear to be subparallel to northwest-trending fold axes. In areas of dome and basin structure, however, lineation attitudes vary greatly, but in general, the lineations plunge outward from cores of domes and inward toward cores of basins. North of the Mattawa River Fault, in the region of northwest-trending isoclinal folds markedly overturned to the southwest, all the gneisses show prominent lineations consistently plunging eastward at an average angle of about 15 degrees. The lineations are at a relatively high angle to the northwest-trending fold axes and could indicate intense westward flowage in this series of overturned folds.

FAULTING

The Late Precambrian high-rank regional metamorphism obscured evidence of early faulting in rocks of the metamorphic complex, but following the culmination of this metamorphism the area was subjected to extensive late faulting during the Late Precambrian and at least the Early Paleozoic. During this tectonism the Memesagamesing and Chebogomog mafic stocks, diabase dikes, and the Cambrian alkalic complexes and related lamprophyre dikes intruded rocks of the metamorphic complex. These igneous rocks, particularly the alkalic intrusions, and much of the faulting appear to be related to a westerly extension of the Ottawa- Bonnechere graben, which forms part of the St. Lawrence rift system of Kumarapeli and Saull (1966).

Most of the faults are marked by prominent lineaments readily apparent on air photographs and are so numerous that only the major ones can be shown on Map 2216 (back pocket). A few of the most persistent faults are named for reference purposes.

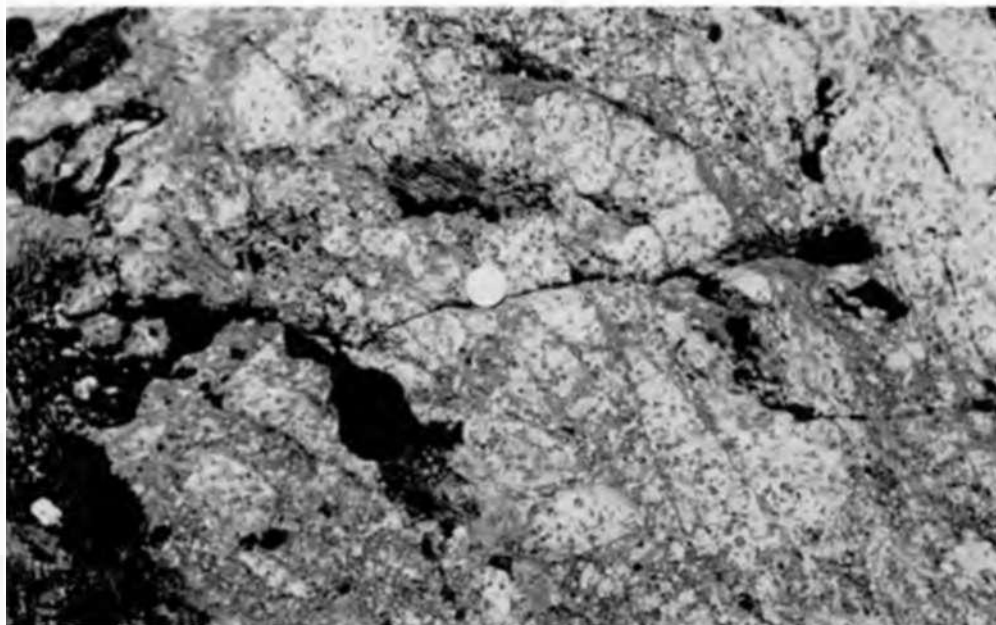
Evidence of Faulting

That the numerous prominent lineaments coincide with faults is shown by several structural features in rocks exposed either within or nearby the lineaments such as: 1) displacement of geological contacts; 2) major discordancies in foliation trends; 3) prominent scarps; 4) zones of mylonitization, brecciation, and shearing; 5) locally intense hematitization; 6) quartz vein networks; and 7) diabase and lamprophyre dikes and carbonate veins. Inspection of Map 2216 (back pocket) shows that displacement of geological contacts and discordancies in foliation trends are common to nearly all the faults. Narrow zones of mylonitization, brecciation, and shearing are common near many of the faults (see Photo 10), but westerly trending faults that cut across felsic plutonic rocks south of Lake Nipissing locally contain spectacular breccia zones (Photo 20) up to a few feet across in which angular felsic plutonic rock fragments are in a hematite-rich, silicified matrix containing fine-grained disseminated quartz. Intensely hematitized fracture surfaces are common along many of the faults, particularly those trending west to northwest, and in southern Boulter and Chisholm Townships; such intensely hematitized fault zones coincide with mild negative aeromagnetic anomalies (compare Map 2216, back pocket, and Map 1477G, GSC 1965a). Diabase and lamprophyre dikes and carbonate veins were found only along west- to northwest-trending faults.

Character and Age of the Faults

The character of the faults is poorly known because fault surfaces are rarely exposed, but two major systems of faulting are present: a northeast system in which strike orientations range from north-northeast to east-northeast; and a west-northwest system in which strike orientations range from west to northwest. The west-northwest system is the dominant direction of faulting, but faults of both systems cut across the bedrock without regard to lithology or foliation trends, and many extend for several miles. Zones of mylonitization, shearing, and brecciation generally dip subvertically, although locally, the zones dip at angles as low as 60 degrees. These features suggest that the faults are

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Photo 20—Breccia zone in a late fault in monzonitic rocks. Angular fragments of monzonitic rocks are in a hematite-rich silicified matrix. Scale is a 50-cent piece; Highway 11, South Himsworth Township, about 1.25 miles north of the south boundary of the area.

high-angle gravity faults reflecting block faulting. Little data is available to estimate movement along the faults, but along many, the movement apparently had both vertical and horizontal components. Middle Ordovician rocks locally preserved on the north side of the Nipissing Fault indicate that the downthrow of this fault is to the north, and the south-facing escarpment along the Mattawa River Fault suggests that the downthrow is to the south.

The age of the faults is also poorly known, but they were probably active from the Late Precambrian, following the culmination of the high-rank regional metamorphism, to at least the Early Paleozoic, and some faults could follow fracture systems predating the high-rank regional metamorphism. Of the two fault systems, the west-northwest system shows most evidence of a long and complicated movement history. Late Precambrian to possibly Early Paleozoic diabase dikes and mafic stocks, and the Cambrian alkalic complexes and related dikes, are spatially associated with this system, and repeated movement along faults of this system, from the Late Precambrian to post-Middle Ordovician time, is suggested by the local presence of shearing in diabase dikes occupying some of the faults and by the post-Middle Ordovician movement on the Nipissing Fault.

Faults of the northeast system appear to be concentrated in a broad zone trending northeast across the area and roughly delimited on the northwest and southeast by the late mafic stocks and the Cambrian alkalic complexes. This distribution pattern suggests that either the faults were formed by stresses related to the emplacement of the mafic and alkalic stocks, or the intersection of these faults with the west-northwest system was a major control in localizing the intrusion of the stocks. This second alternative is pre-

ferred because some evidence indicates that the northeast system formed either earlier than the west-northwest system or at an early stage in the development of this system. Faults of the northeast system are not as intensely hematitized as those of the west-northwest system, and they appear to lack associated mafic dikes. These relationships combined with the fact that most of the northeast faults are displaced by faults of the west-northwest system suggest that the northeast system is either older, or represents cross-faults that formed early in the history of the west-northwest system. South of the Iron Island Complex in Bertram Township and near the Memesagamesing Lake stock in Hardy Township, a few northeast-trending faults appear to displace faults of the west-northwest system, but this displacement could be due to reactivation of these faults by local stresses accompanying the emplacement of the intrusions. Local concentrations of late pegmatite dikes, many of which trend northeastwards, are present near the faults of the northeast system, particularly in the vicinity of the French River and south of Lake Nipissing, but appear to be absent near faults of the west-northwest system. This suggests that faults of the northeast system developed during the waning stages of the high-rank regional metamorphism when the pegmatites were emplaced.

Ottawa-Bonnechere Graben

Paleozoic outliers in Lake Nipissing and near the village of Nipissing are down-faulted in the Ottawa-Bonnechere graben, a major structural feature of the area containing the Cambrian alkalic complexes and formed by faults of the west-northwest system. Originally described by Kay (1942) in the vicinity of Pembroke and Arnprior on the Ottawa River, this graben is now known to extend west-northwest from the St. Lawrence Valley along the Ottawa and Mattawa Valleys through Lake Nipissing, and at the junction of the Ottawa and Mattawa Valleys a poorly defined branch may extend northwest parallel to the Ottawa River and Lake Timiskaming to include the Paleozoic outlier north of Lake Timiskaming. Recently, Kumarapeli and Saull (1966) postulated that the graben could be part of a much more extensive rift system, the St. Lawrence rift system, that includes the St. Lawrence, Saguenay, and Champlain Valleys and the St. Lawrence or Cabot trough.

In the map-area, the Mattawa River and Crystal Falls Faults probably mark the northern margin of the graben because the Mattawa River Fault has a south-facing scarp suggesting downthrow to the south and can be traced as a prominent lineament eastwards to the Ottawa River where it is continuous with the Coulonge Fault west of Mattawa that marks the northern margin of the graben as originally defined by Kay (1942). The southern margin of the graben is poorly defined in the map-area, but in the southern part, the prominent zone of *en echelon* faults that includes the Bass Lake, Restoule River, and Nipissing Faults is probably on the southern side of the graben, but only the Nipissing Fault is known to be downthrown to the north. This zone can be traced east-southeast through the northern part of Algonquin Park in the vicinity of Cedar Lake to the Ottawa Valley where it merges with faults downthrown to the north on the southern side of the graben.

Kay (1942) showed that the throw on the Coulonge Fault, on strike with the Mattawa River Fault, diminishes to the east and west of Allumette Island where the minimum throw is about 1,000 feet. The escarpment along the Mattawa River Fault decreases in elevation westward, which could indicate that the throw also decreases westward. West of the map-area along the trend of the graben, Paleozoic outliers and

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scarps with high relief appear to be absent, and it is possible that the graben loses its identity. The Crystal Falls Fault can be traced as a lineament northwest of the map-area to within a few miles of the Grenville Front and is on strike with the Onaping lineament described by Wilson (1949). The prominent zone of faulting on the south side of the graben in the southern part of the area can be traced westward along the French River and across the Grenville Front (Lumbers, in preparation) where it appears to merge with westerly-striking faults along the North Shore of Lake Huron.

Kay (1942) postulated that the graben is Tertiary in age but evidence presented here together with other recent work on the graben and elsewhere on the St. Lawrence rift system (Kumarapeli and Saull 1966; Doig and Barron 1968) show that the entire structure has had a long and complicated history, probably dating back to at least the Late Precambrian, and some segments are seismically active today.

ECONOMIC GEOLOGY

The North Bay area contains a variety of metallic and non-metallic mineral deposits, but the only mineral production recorded is mainly clay and sand and gravel from Pleistocene sediments, minor stone from some of the gneisses of the metamorphic complex and from the Paleozoic rocks, and a few tons of mica and feldspar from late pegmatite dikes. In 1967, mineral production was confined to clay used locally in the manufacture of brick and drainage tile and to sand and gravel used locally for road construction and in the manufacture of concrete products.

Metallic mineralization consists mainly of iron, copper, nickel, magnesium, niobium, and uranium, but minor concentrations of pyrite and pyrrhotite and traces of gold, silver, molybdenum, and tin are found. Much of the known iron mineralization is associated with faults of the west-northwest system and with feldspathic gneiss and muscovitic and quartzose gneiss, but minor iron, and most of the known copper, nickel, niobium, and uranium mineralization are associated with the late mafic and Cambrian alkalic intrusions. Magnesium mineralization in the form of brucite is confined to the marble inclusions in the Bonfield batholith east of Lake Talon. Non-metallic mineralization consists mainly of feldspar, mica, kyanite, industrially useful rocks, clay, sand and gravel, minor apatite, barite, and fluorite, and a trace of graphite. The only mica and feldspar of possible commercial interest are associated with late pegmatite dikes, and kyanite is locally abundant in some of the metasedimentary gneisses in the northeastern quarter of the area. Apatite, barite, and fluorite are found mainly in the Cambrian alkalic complexes but the known concentrations are generally too small to be shown on Map 2216 (back pocket).

Although only minor mineral production has been reported from the bedrock of the area, muscovitic and quartzose gneiss is particularly favourable for deposits of iron and uranium, and this gneiss together with some other gneisses of the metamorphic complex are potential sources of building stone. Further exploration of the Cambrian alkalic complexes could reveal additional copper, niobium, and uranium mineralization.

PROSPECTING AND MINING ACTIVITY

Recorded data concerning mineralization in the area date back to the 1800s and the initial exploratory surveys of Bigsby (1821), Logan (1847), Murrav (1857), Bell (1877), and Barlow (1899; 1908), but active prospecting was not initiated until the

late 1800s and early 1900s following the discovery of copper near Parry Sound (Coleman 1889; 1900, p.164-172). During this period, copper mineralization was discovered in the Memesagamesing Lake stock, a few workings were opened elsewhere in the area in a vain search for copper, and a few mica and feldspar deposits in late pegmatite dikes were explored. Some minor mineral production occurred between the late 1800s and the First World War; limestone was quarried on Little Manitou Island for use in the construction of the Canadian Pacific railway west of North Bay (Barlow 1899, p.46), and small brick and tile works were established at Sturgeon Falls, North Bay, and Powassan (Baker 1906; Montgomery 1930). The North Bay and Powassan works have operated periodically to recent times, but in 1967 only the Powassan works was operating.

Prospecting activity declined between the two World Wars, but during the Second World War increased demands for raw materials caused renewed interest in the area and deposits of iron, brucite, mica, and feldspar were discovered, but only a few tons of mica and feldspar were produced. In 1952 and 1955, copper and nickel deposits in the Memesagamesing Lake stock were re-tested by geophysical surveys and diamond drilling conducted mainly by Sudbury Midzone Mines Limited.

The area was extensively prospected for uranium during the rush of the 1950s, and niobium and uranium mineralization were discovered in the Iron Island, Manitou Islands, and Callander alkalic complexes. The Iron Island Complex was initially explored for iron between 1948 and 1953, but geophysical surveys and extensive drilling failed to disclose economic quantities of iron. Nevertheless, minor sulphide mineralization was discovered, and after the drilling was completed niobium and uranium mineralization was found in the drill core; no further work has been carried out. Niobium and uranium mineralization discovered in the Manitou Islands Complex in 1952 was explored by drilling that outlined a relatively large deposit of uranian pyrochlore near the eastern end of Newman Island. This deposit was further explored by underground development from a shaft sunk to 442 feet, and a pilot plant was constructed on the north shore of Lake Nipissing due north of the Manitou Islands (see section on "Niobium and Uranium, Manitou Islands Complex"). By 1960 operations had ceased and the pilot plant was closed.

Recent interest in the area has focussed upon copper-nickel mineralization in the Memesagamesing Lake and Chebogomog Lake stocks and upon exploration of the Callander Complex. In 1967 and early 1968, the Memesagamesing Lake stock was again re-examined by geophysical surveys and diamond drilling conducted by North Rankin Nickel Mines Limited, and early in 1968 Geosearch Consultants Limited carried out a ground magnetometer and electromagnetic survey of the Chebogomog Lake stock for Kennco Explorations (Canada) Limited. In 1966 and 1967, Min-Ore Mines Limited conducted ground magnetometer and electromagnetic surveys of the Callander Complex and sank a few, short diamond drill holes.

METALLIC MINERALIZATION

Copper and Nickel

Copper and nickel mineralization are mainly confined to the Memesagamesing Lake and Chebogomog Lake stocks, but minor disseminated chalcopyrite is present in shear zones developed locally in the diabase dike in Nipissing Township and northern Gurd Township and in some phases of the Iron Island Complex (see section on "Niobium and

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Uranium, Iron Island Complex"). Traces of chalcopyrite were noted by the author in many of the metagabbro intrusions of the metamorphic complex and rarely in hornblende gneiss. From the available data, the late mafic stocks and possibly the Cambrian alkalic complexes would appear to offer the best targets in the area for concentrations of copper and nickel. The greatest concentrations known are in the Memesagamesing Lake stock, but exploration work completed in this stock to the end of 1967 has failed to outline mineralization in economic amounts.

DESCRIPTION OF DEPOSITS

Memesagamesing Lake Stock, Hardy Township

Six zones of disseminated pyrite, pyrrhotite, and chalcopyrite mineralization are exposed within the Memesagamesing Lake stock in Hardy Township as shown in Figure 3. Originally discovered in the late 1890s, the mineralization has been explored periodically for about 70 years, and in 1967 and 1968, North Rankin Nickel Mines Limited held six optioned claims in the southeastern part of the stock.

Exploration work was initiated in the late 1890s by the Parry Sound Mining Company, and a 30-foot shaft was sunk on the eastern shore of the lake (Figure 3) from the floor of an open-cut, 15 by 40 feet and 10 feet deep. A pit, 10 feet square and about 10 feet deep, was sunk just northwest of the open-cut, and a few other pits were sunk in some of the mineralized zones indicated in Figure 3. The shaft and the pit, just to the northwest, are on patented land consisting of the north half of lots 23 and 24, concession VIII, Hardy Township, and these workings are known locally as the Kelcey claim. Data on file with the Resident Geologist, Ontario Department of Mines and Northern Affairs, Toronto, indicate that in 1952 Peter Hermiston of North Bay put down two x-ray diamond drill holes south of the shaft (holes not shown on Figure 3), and in 1955, Geo-Technical Development Company Limited carried out ground magnetic and electromagnetic surveys over the southeastern part of the stock for Sudbury Midzone Mines Limited (now Midrim Mining Company Limited). Sudbury Midzone also explored this part of the stock by four drill holes totalling 1,739 feet (holes not shown on Figure 3). In 1967, M.E.M. Consultants Limited conducted ground magnetic and electromagnetic surveys for North Rankin Nickel Mines Limited in the southeastern part of the stock south of the Kelcey claim. In the winter of 1968, North Rankin put down four drill holes (Nos. 68-1 to 68-4, Figure 3) totalling 1,587 feet; hole 68-4 was to be continued.

The petrology of the stock is discussed in the "General Geology" section and the main geologic features are shown in Figure 3. The mineralized zones are poorly exposed, but the mineralization appears to be in shear zones in the norite and consists mainly of disseminated pyrrhotite, pyrite, magnetite, and chalcopyrite in approximate order of decreasing abundance. At the mineralized locations shown in Figure 3, the disseminated sulphide minerals do not exceed about 15 percent of the rock, and commonly form less than 10 percent. A few broken pieces of massive sulphide rock are present on a dump near the shaft, but no massive sulphide mineralization was seen by the author in place. At the time of the author's examination of the mineralization in 1965, the open-cut, shaft, and pit at location (1), Figure 3, were poorly exposed, but Satterly (1942, p.34) describes this location as follows:

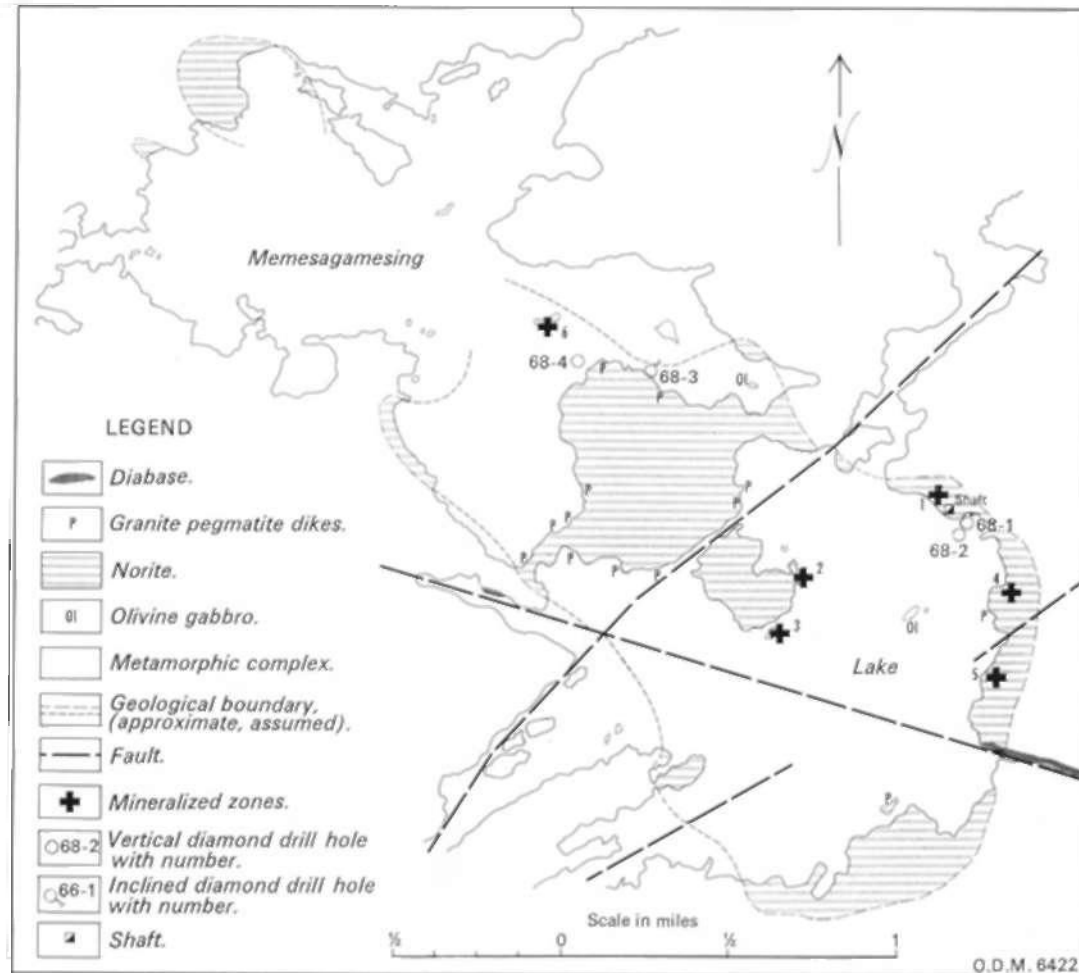


Figure 3: Sketch map showing the geology and mineralized zones of the Memesagamesing Lake stock.

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The open cut exposes rusty-weathering norite with a well-developed jointing striking N. 85°W. and dipping 85°S. This jointing is intersected by a flat jointing, which produces a blocky structure. There is a little disseminated sulphide at the east end of the open cut. In the pit just northwest a 3-pound grab sample of disseminated chalcopyrite and pyrrhotite in norite taken by the writer assayed 0.17 per cent. copper and 0.22 per cent. nickel. A 5-pound grab sample of norite containing disseminated sulphides from the dump assayed 0.05 per cent. copper and no nickel; and a 12-pound grab sample of the solid sulphides from the dump taken by the writer assayed 0.68 per cent. copper and 0.71 per cent. nickel. It is presumed that the solid sulphides are of small extent, as none can be seen in place in the present workings.

At location (2) an irregularly shaped gossan zone up to 50 feet across is exposed about 20 feet in from the shore, and a pit, 10 feet square and 6 feet deep, has been sunk in the zone. Magnetite, pyrite, pyrrhotite, and traces of chalcopyrite are sparsely disseminated in the zone, and a grab sample taken by Satterly (1942, p.35) from the pit showed no copper or nickel upon assay. At locations (3), (4), and (6) the mineralization is in the form of sparsely disseminated sulphide minerals forming small, irregularly shaped gossan zones in altered norite, but at location (5), a shear zone in norite, up to 15 feet across and dipping subvertically, is intensely altered in the central part with up to 12 percent disseminated sulphide minerals.

Electromagnetic surveys carried out in the southeastern part of the stock revealed a few zones of poor conductivity near the margin of the stock. The magnetic surveys revealed only two moderately intense positive anomalies; one is centred over the diabase dike that cuts across the stock (Figure 3), and the other is centred over the area between locations (2) and (3). The best assays from the Sudbury Midzone drill core are 0.65 percent copper and 0.38 percent nickel over 6 feet, and 0.59 percent copper and 0.40 percent nickel over 5 feet.¹ The core producing these copper and nickel concentrations was obtained from drill holes put down in the vicinity of the Kelcey claim.

Chebogomog Lake Stock, Grant Township

Three small areas of sparsely disseminated sulphide mineralization were observed by the author in uralitized pyroxenite and peridotite that forms most of the Chebogomog Lake stock, at the northern boundary of the area in Grant Township. Local residents informed the author that prospectors have examined outcrops of the stock, but no record of this work could be found. During the winter of 1968, Geosearch Consultants Limited carried out ground magnetic and electromagnetic surveys of the stock for Kennco Explorations (Canada) Limited. This work, which is on file with the Resident Geologist, Ontario Department of Mines and Northern Affairs, Sudbury, showed no bedrock electromagnetic conductors or magnetic anomalies.

Figure 4 shows the general geology of the stock discussed in the "General Geology" section and the observed sulphide mineralization. At each of the three mineralized areas the sparsely disseminated sulphide minerals are pyrrhotite, pyrite, and chalcopyrite in approximate order of decreasing abundance. The sulphide minerals appear to be most abundant in the southern mineralized area where they form as much as 10 percent of the rock; a grab sample collected by the author from this area containing about 9 percent disseminated pyrrhotite, chalcopyrite, and minor pyrite gave upon analysis, by the Laboratory and Research Branch of the Ontario Department of Mines and Northern Affairs, 0.33 percent copper and 0.08 percent nickel.

¹Assessment work files, Resident Geologist's office, Ontario Department of Mines and Northern Affairs, Toronto.

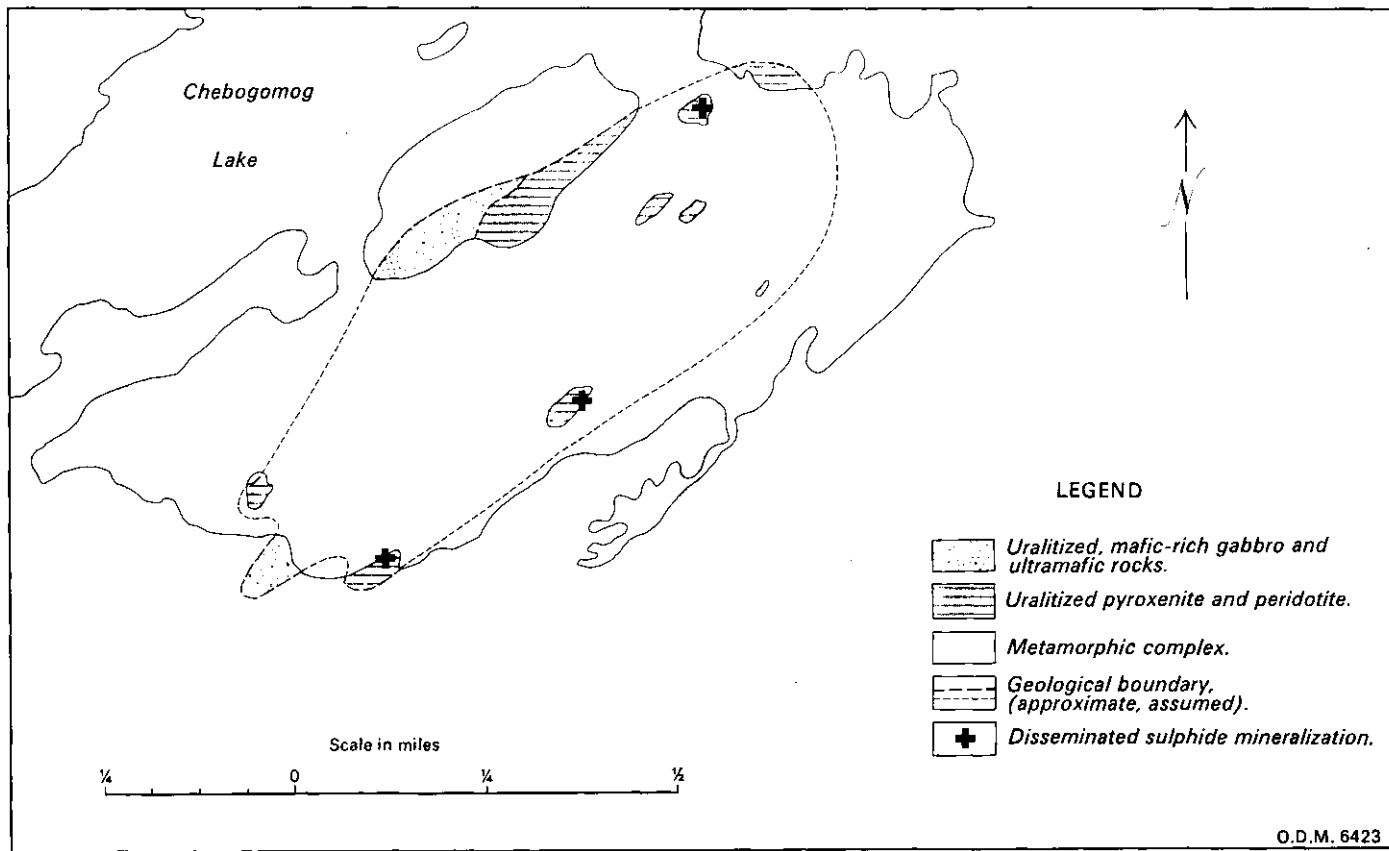


Figure 4-Sketch map showing the geology and mineralized zones of the Chebogomog Lake stock.

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Lots 28 and 29, Concession X, Nipissing Township

W. T. King, Jr., has explored sparsely disseminated sulphide mineralization in a sheared and fractured diabase dike along Reserve Creek in lots 28 and 29, concession X, Nipissing Township. Several pits and trenches have been put down in the diabase and adjacent country rocks, but the main workings, which were initially opened in 1935, are about 1,600 feet upstream from Duncan Lake. In 1967, the author visited the workings with Mr. King, but most of the pits and trenches were partly filled with forest litter and a trench and pit at the main workings were partly filled with water. Near the main workings, the diabase dike is about 200 feet wide, and in the main workings, the dike contains quartz vein networks and numerous narrow shear zones. On a dump near the main workings, some sparsely disseminated chalcopyrite and pyrite are present in broken pieces of sheared and fractured diabase, and fine-grained quartz crystals, filling some of the fractures, rarely contain coatings of pyrite and chalcopyrite. According to Mr. King, most of the mineralization is in the pit and near the north end of the trench.

Satterly (1942, p.38-39) visited the deposit in 1941 and reported as follows:

At 24 chains upstream from Duncan lake on lot 28 a trench 1 chain south of the creek, trends S.10°W. and cuts into the side of a hill for a length of 45 feet. The trench is from 6 to 10 feet wide and has a maximum depth of 9 feet. All but the southern 6 feet is in a much fractured, spheroidally weathered diabase. The last 6 feet is in a red and white, brecciated pegmatite containing varying amounts of white carbonate. The contact between the pegmatite and the diabase is brecciated and filled with a green and red clay gouge. A similar fractured zone with gouge occurs across a width of from 3 to 6 inches at the face of the trench. These contacts trend N.55°W. and dip 70°S. A little chalcopyrite occurs with the carbonate in the pegmatite. No gold was found on an assay of a grab sample taken by the writer.

An exposure of diabase in the creek indicates a width of at least 150 feet for the diabase dike.

Just northwest of the mouth of the trench a pit 10 by 10 feet and 10 feet deep exposes fractured diabase. Rarely a little chalcopyrite coats minute quartz crystals filling joints. A grab sample taken by the writer failed to show any gold when assayed. The owner reports gold values as much as 0.10 ounces per ton.

On lot 29 on Reserve creek trenching and a pit 10 by 10 feet and 10 feet deep exposes shattered diabase with numerous closely spaced fractures parallel to the contact of the diabase dike. The dike contact trends N. 55° W. and dips vertically; a pink augen granite gneiss containing streaks of pegmatite lies to the south. It is reported by the owner that silver occurred in a seam in the diabase and that traces of gold were obtained on assay.

The trench at the main workings was extended northwards about 5 feet since Satterly's visit.

Widdifield Township

According to Hoffman (1906, p.14), niccolite, cobaltite, and native silver were found in the vicinity of North Bay in Widdifield Township in the early 1900s. The author was unable to obtain information concerning this mineralization, but Hoffman reported as follows:

Among some of the more recently received mineral specimens sent for identification, was one consisting of a compact, massive, niccolite, through which is distributed a little cobaltite, which was found by Mr. J. Boyer on lot No. 287, on McIntyre Street, North Bay, Widdifield township, Nipissing district, Ontario, and another, consisting of niccolite, with some cobaltite and a little native silver, in a gangue composed of a ferruginous dolomite, which had been found on lot 22, concession A, Widdifield township, or about 2 miles and a half north-northwest of the first mentioned occurrence.

Iron

Minor concentrations of iron-titanium oxide and iron oxide minerals are common within the map-area and are found in three major types of deposits: 1) metasedimentary deposits in which thin, discontinuous layers and disseminated grains of iron-titanium oxide minerals were probably derived from originally ferruginous sedimentary rocks; 2) magmatic deposits associated with the alkalic complexes; and 3) hematitic vein and replacement deposits. Titanium is concentrated mainly with iron in the magmatic deposits, and only these deposits and a few of the hematitic vein and replacement deposits have been explored.

Metasedimentary deposits are confined mainly to feldspathic gneiss and muscovitic and quartzose gneiss. In the feldspathic gneiss, iron mineralization generally consists of disseminated, medium- to coarse-grained magnetite and minor hematite porphyroblasts, generally forming less than 10 percent of the rock. Nevertheless, a feldspathic gneiss unit intercalated with muscovitic and quartzose gneiss near the French-Butler township boundary contains up to 15 percent disseminated magnetite porphyroblasts and a few massive lenses of magnetite, up to 6 inches long and 0.5 inch across. This mineralization produces a mild positive aeromagnetic anomaly trending northwest, just west of Antoine Creek, through southwestern Butler Township and east-central French Township (GSC 1965b), and the most abundant mineralization seen is just south of a small lake straddling the French-Butler township boundary, about 1 mile south of the northern boundary of the map-area. In the muscovitic and quartzose gneiss, iron mineralization consists of discontinuous layers, only a fraction of an inch thick, of specular hematite and minor magnetite parallel with the stratiform foliation, and a few veinlets of coarse-grained quartz and minor specular hematite that cut across the stratiform foliation. Although this mineralization is common in the gneiss, the richest concentrations of hematite and magnetite seen are about 20 percent and are in the muscovitic and quartzose gneiss unit about 1 mile south of Valin Lake in Mulock Township. Near the southeast shore of Olmstead Lake in Odrig Township, hematite and magnetite locally form as much as 20 percent of the gneiss.

As mentioned previously in the "General Geology" section, iron-titanium oxide minerals form as much as 8 percent of the hornblende gneiss, and magnetite is sufficiently abundant in some units to produce mild positive aeromagnetic anomalies. Good examples of anomalies caused by this gneiss are: the one just north of Lake Nosbonsing in East Ferris and Bonfield Townships (GSC 1965a); and the one west of Lake Talon in Phelps Township (GSC 1965b).

In the alkalic complexes, local segregations of iron-titanium oxide minerals are common in carbonatite phases, but in the Iron Island Complex, diamond drilling indicated that alkalic pyroxenite contains minor massive units of iron-titanium oxide minerals, and that dolomitic carbonatite contains veinlets and disseminated grains of hematite and magnetite locally forming as much as 60 percent of the rock (see section on "Niobium and Uranium, Iron Island Complex"). On Iron Island, boulders of almost pure hematite, up to half a ton in weight and presumably derived from the alkalic complex, were reported by Murray (1857), but during the 1800s most of the boulders were hauled from the island in barges (Barlow 1899), and in 1965, only a few small hematite boulders were seen on the island by the author.

Hematite veins, generally no more than a few inches across, are common at the contacts of the marble inclusions in the Bonfield batholith, east of Lake Talon in Odrig Township. The hematite is botryoidal and was apparently deposited following the

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culmination of the high-rank regional metamorphism. As described in the "Structural Geology" section, concentrations of hematite are associated with faults of the west-north-west system, and some of these faults, particularly near Nipissing, contain hematite-enriched, silicified breccias, some of which have been explored for iron as described below.

In addition to these three major types of deposits, minor concentrations of magnetite are found in some of the late pegmatite dikes, particularly where they cut across hornblende gneiss units, and disseminated grains of magnetite and hematite locally form up to 8 percent of some of the gneissic granitic rocks. Some of the metagabbro stocks also contain local concentrations of iron-titanium oxide minerals.

Although the known iron mineralization in the map-area does not appear to be of economic value, muscovitic and quartzose gneiss contains widespread, minor hematite mineralization and should be carefully examined for possible large concentrations of hematite. In the Tomiko area to the north of the map-area, muscovitic and quartzose gneiss in Parkman Township is separated from underlying biotite gneiss by a basal facies of bedded chert-magnetite iron formation with intercalated marble and calc-silicate gneiss (Lumbers 1969); further work could disclose iron formation in association with muscovitic and quartzose gneiss in the map-area, but aeromagnetic data suggest that large units of magnetite-bearing iron formation are absent.

DESCRIPTION OF DEPOSITS

Lot 218, Concession A, Nipissing Township

In lot 218, concession A, Nipissing Township, hematite-enriched, silicified, brecciated granitic rocks of the Powassan batholith, exposed in the Nipissing Fault at the base of a talus slope on the south side of the Paleozoic outlier about 1.7 miles west of Nipissing, have been explored for iron. The main showing is about 800 feet south of the road leading west from Nipissing and was explored in 1941 by a 300-foot diamond drill hole put down by W. Holder, and in 1951 and 1952, by gravimetric and geological surveys completed for J. H. Dumouchel (assessment work files, Resident Geologist, Ontario Department of Mines and Northern Affairs, Toronto). This work failed to disclose economic concentrations of iron. The deposit was poorly exposed at the time of the author's visit in July, 1965, but Satterly (1942, p.47) described the deposit as follows:

The hematite deposit is at the base of a talus slope 12 chains from the road. Between the deposit and the road, Paleozoic dolomite is exposed from 1 to 6 chains south of the road. The talus cliff is 50 feet high, and the talus consists of fragments of granite gneiss stained with a red film of hematite. Examination of the cliff face shows a granite gneiss breccia with a cement of reddish-brown hematite. This cliff peters out westward. As no outcrops east or west of the exposures mentioned were found, it is not known how big an area is underlain by the dolomite.

At the time of the writer's visit on July 26, 1941, no new work had been done on the deposit, and nothing could be seen in a partially caved-in timbered pit at the base of the talus. The only hematite seen was on the dump. This material is a hard, fine-grained, grey and brown hematite containing disseminated glassy quartz.

A grab sample collected by Satterly (1942, p.41) from the dump near the old pit gave upon assay 55.65 percent Fe, 18.73 percent SiO₂, and 0.10 percent S. The diamond drill hole intersected 1- and 3-foot sections that gave upon assay 41.26 and 34.62 percent

iron respectively (assessment work files, Resident Geologist's office, Ontario Department of Mines and Northern Affairs, Toronto).

Lots 22 to 25, Concession XV, Nipissing Township

Hematite-enriched, silicified, brecciated granitic rocks of the Powassan batholith, marking a fault of the west-northwest system, have been explored for iron on the west side of South Bay, Lake Nipissing, just north of the South River in lots 22 to 25, concession XV, Nipissing Township. The hematite-enriched fault breccia is exposed in places along the bush road leading west from South Bay to Fright Lake and is locally as much as 100 feet wide. Two small pits have been sunk in the fault zone just south of the road; one in lot 23, and the other in lot 24. In 1952 and 1953, J. H. Dumouchel had gravimetric and geological surveys completed in the vicinity of the hematite mineralization (assessment work files, Resident Geologist's office, Ontario Department of Mines and Northern Affairs, Toronto), but no further work has been performed to the writer's knowledge.

Magnesium

Brucite, a hydrated oxide of magnesium, occurs as small granules disseminated throughout dolomitic marble beds forming part of the marble-rich inclusions within the Bonfield batholith in Orlig Township east of Lake Talon (see section on "Calcareous Metasediments, Carbonate Metasediments"). M. F. Goudge discovered the brucite in 1937, and this was the first brucite discovery in Canada (Harding 1944, p.25). In 1942 and 1943, the Aluminum Company of Canada Limited carried out a diamond drilling program to determine the size and grade of the principal brucite-bearing bodies, and five claim groups were acquired, two of which, the McDonough and Green Lake groups, are within the map-area.

The brucite deposits are described in detail by Harding (1944) and Goudge (1939, p.8-9). In general, the brucite-bearing bodies contain 11 to 23 percent brucite, but locally, as much as 30 percent is present. The bodies do not extend to depths greater than 200 feet, and the tonnages available in the scattered individual bodies range from a few thousand to more than a million tons.

Harding (1944, p.44) describes the McDonough group as follows:

The McDonough group comprises 9 claims, S. 33,918 to 33,924, 34,312, and 34,360, all of which were staked in 1939 for the McDonough Mining Syndicate, Limited. In addition, two claims, S. 36,998 and 36,990, adjacent to the McDonough claims and held by the Aluminum Company of Canada, are for purposes of this report included with the McDonough group. These claims are in lots 8 and 9, concession A, Orlig township, and the southwestern part of the group forms the shore of Lake Talon. Several masses of brucite-bearing limestone, ranging in length from a few feet to several hundred feet, occur on these claims and are surrounded by pink granite gneiss, which strikes in a northwesterly direction. Stripping, trenching, and the sinking of shallow pits were carried on by the McDonough Syndicate from 1939 to 1941, and during 1941 two of the largest brucite-bearing limestone bodies, situated on claims S. 33,920 and 33,919, were explored by diamond-drilling. Altogether about 1,200 feet of drilling was completed by means of 12 short holes. Most of the holes penetrated the brucite-bearing limestone bodies and encountered the granite below. The deepest hole, which was drilled to a depth of 176 feet, was still in limestone when drilling was suspended. The drilling was undertaken as assessment work, and the information obtained was not exhaustive. The results suggest, however, that the brucite lenses extend down to the bottom of the limestone bodies, but that the latter are shallow.

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During the summer of 1943, the Aluminum Company carried out diamond-drilling on three of the main brucite-bearing limestone bodies exposed on the surface.

Concerning the Green Lake group, Harding (1944, p.45) stated:

The Green Lake group of 4 claims, S. 32,214, 37,049, 37,093, and 37,096, is situated southeast of Green Lake in lots 7 and 8, concession A, Orlig township. Brucite-bearing limestone bodies occur in the vicinity of the southeast corner of claim S. 32,214 near the centre of the group. Diamond-drilling was carried out by the Aluminum Company of Canada in this locality in 1943.

Molybdenum

Traces of molybdenite are present in veins and lenses of granitic material in migmatitic biotite gneiss in many parts of the area, and in late pegmatite dikes west of Duncan Lake in lots 28 and 29, concession X, Nipissing Township. None of these occurrences appear to be of economic interest and are not shown on Map 2216 (back pocket). Hoffman (1890, p.44) reported minor molybdenite mineralization on Great Manitou Island in association with pyrite in a quartz-feldspar rock. No molybdenite was found on the island by the author, but traces of graphite are locally present in the fenitic rocks and this mineral may have been mistaken for molybdenite. In this regard, molybdenite reported by Barlow (1899) in marble at Talon Chute on the Mattawa River in Orlig Township, at the eastern boundary of the map-area, was later identified as graphite (Rogers 1916, p. 21).

Niobium and Uranium

Niobium and uranium mineralization in the form of uranian pyrochlore are associated with the Cambrian alkalic complexes in Lake Nipissing, and traces of uranium mineralization have been reported from late pegmatite dikes in Calvin, Chisholm, and Hardy Townships (Lang 1952). In 1953, East Bay Gold Mines Limited explored parts of the Sturgeon Falls batholith in lot 7, concession C, Springer Township, and in lots 4 and 5, concession V, and lot 4, concession IV, Pedley Township, in search for uranium (assessment work files, Ontario Department of Mines and Northern Affairs, Toronto). Ground magnetic and geiger counter surveys were carried out, but no uranium mineralization was found.

Northeast of the map-area at Hunters Point in the Kipawa region of Quebec, muscovitic and quartzose gneiss, similar to that in the map-area, contains concentrations of uraninite and gold (Roscoe 1969, p.117-118), and uranium mineralization has been discovered recently in the same gneiss south of Hunters Point near Grindstone Lake about 22 miles east of Temiscaming, Quebec. As discussed in the "General Geology" section, the muscovitic and quartzose gneiss represents deposits of well-sorted sands, and such deposits can contain concentrations of economically useful heavy minerals such as gold and uranium-bearing minerals and should be carefully examined for such minerals. Moreover, to the east of the map-area in southeastern Orlig Township, southwestern Mattawan Township, and northern Calvin Township, some late pegmatite dikes that cut across units of muscovitic and quartzose gneiss contain minor uranium mineralization (Lang 1952).

DESCRIPTION OF DEPOSITS

Iron Island Complex

The Iron Island Complex, in the western part of Lake Nipissing south of Sturgeon Falls, contains a variety of economically useful minerals, the most abundant of which are iron-titanium oxide minerals, sulphide minerals, uranian pyrochlore, and apatite. Minor amounts of barite and fluorite are present in addition to tin mineralization; these occurrences are too small to be shown on Map 2216 (back pocket).

Exploration work has centred mainly on the iron mineralization that was first noted by Murray (1857) and subsequently by Barlow (1899) and Knight (1949). In 1948, Dominion Gulf Company carried out an aeromagnetic survey of the area and outlined an anomaly of 2,000 gammas near the southern contact of the complex, and another anomaly of 400 gammas over Iron Island. During the winters of 1951-1952 and 1952-1953, Nipiron Mines Limited explored the complex by ground gravimetric and magnetic surveys on the ice, and between January 1952 and September 1953, 26 diamond drill holes, totalling 16,318 feet, were completed. In 1953, Nipiron Mines acquired two leases in Lake Nipissing covering 23,668 acres and most of the complex except that part on Iron Island.

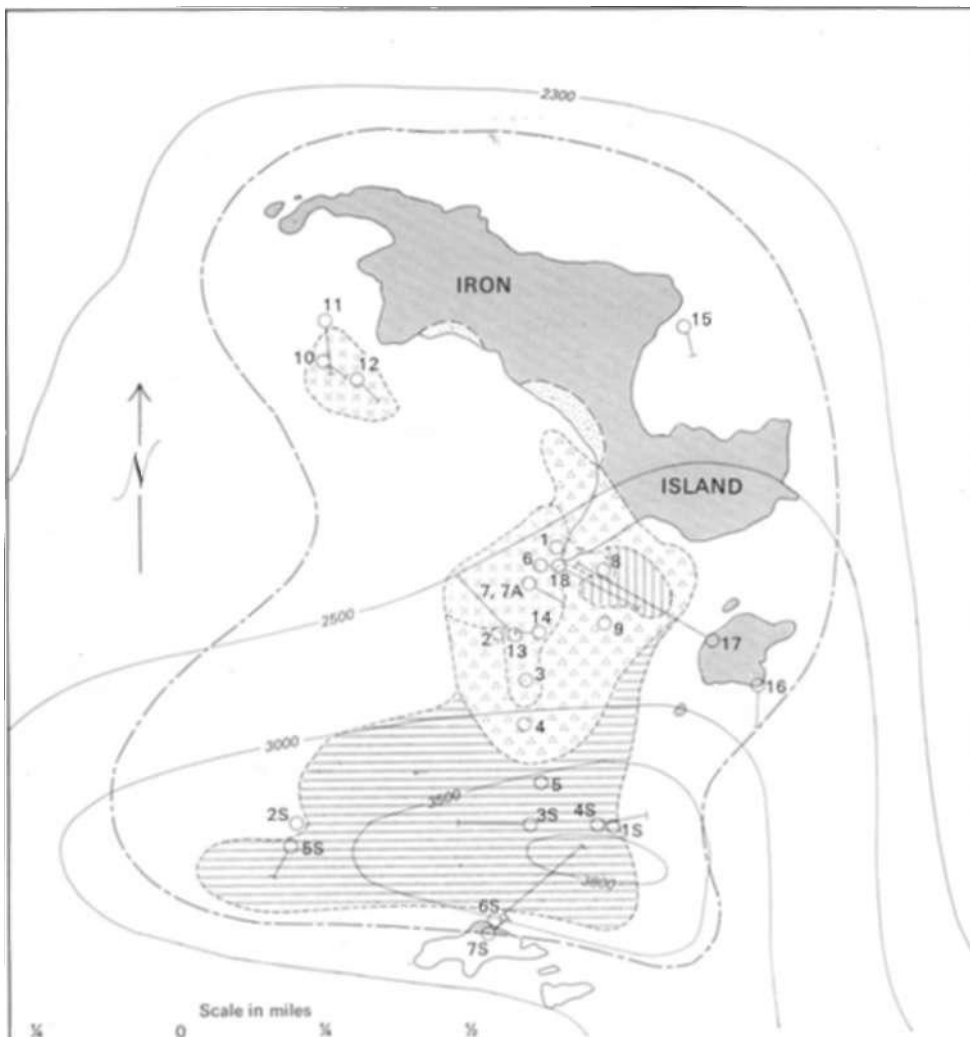
The general geology of the complex, isomagnetic lines from published aeromagnetic data (GSC 1965d), and the location of the 26 diamond drill holes completed by Nipiron Mines are shown in Figure 5; drill hole locations were obtained from assessment work data on file with the Resident Geologist, Ontario Department of Mines and Northern Affairs, Toronto. The petrology of the complex is discussed in the "General Geology" section, and only the mineralization is described here.

Iron-titanium oxide minerals are present in all the phases of the complex, but the greatest concentrations are in dolomitic carbonatite, which, from the drill logs, contains up to 60 percent disseminated grains and massive stringers of hematite and magnetite. Alkalic pyroxenite commonly contains 5 to 10 percent disseminated iron-titanium oxide minerals, and in drill holes No. 5 and 3-S a few sections up to 5 feet wide contain abundant disseminated to massive magnetite.












Disseminated sulphide minerals, mainly pyrite, minor pyrrhotite, and traces of chalcopyrite, are reported in the drill logs from all the intrusive phases of the complex, and traces of disseminated chalcopyrite are present in 6 to 12 drill core specimens examined by the author from various parts of the complex. Disseminated pyrite and pyrrhotite generally do not exceed about 10 percent and appear to be most abundant in the alkalic pyroxenite and dolomitic carbonatite. In drill hole No. 13, consisting mainly of dolomitic carbonatite and minor silicocarbonatite, nickel mineralization was detected in two 5-foot sections that gave upon analysis, 0.08 and 0.05 percent nickel.¹ This nickel mineralization together with the presence of minor amounts of pyrrhotite and traces of chalcopyrite in the intrusive phases suggest that possibly economic concentrations of both copper and nickel could be present in the complex.

Niobium and uranium mineralization, in the form of uranian pyrochlore, are present in silicocarbonatite and ijolitic rocks in drill holes No. 11, 13, and 17. Chemical analyses by x-ray fluorescent methods indicate that the greatest concentrations of niobium and uranium in the three drill holes are: hole No. 11, 0.30 percent Nb_2O_5 over 10 feet and 0.14 percent U_3O_8 over another 10-foot section; hole No. 13, 0.30 percent Nb_2O_5

¹Assessment work files, Resident Geologist's office, Ontario Department of Mines and Northern Affairs, Toronto.



LEGEND

| | | | |
|---|--|---|--|
|  | <i>Paleozoic sandstone.</i> |  | <i>3500 Isomagnetic lines.</i> |
|  | <i>Dolomitic carbonatite.</i> |  | <i>16 Vertical diamond drill hole with number.</i> |
|  | <i>Silicocarbonatite.</i> |  | <i>15 Inclined diamond drill hole with number.</i> |
|  | <i>Alkalic pyroxenite, magnetite-rich pyroxenite, ijolitic rocks.</i> |  | <i>Geological boundary.(approximate, assumed)</i> |
|  | <i>Ijolitic rocks.</i> |  | <i>Possible boundary of the complex.</i> |
|  | <i>Fenite containing numerous carbonate veins and lamprophyre dikes.</i> | | |

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Figure 5-Sketch map showing the major geological features of the Iron Island Complex.

and 0.10 percent U_3O_8 over 5 feet, 0.30 percent Nb_2O_5 and 0.07 percent U_3O_8 over 9 feet, and 0.30 percent Nb_2O_5 and 0.03 percent U_3O_8 over 20 feet; and hole No. 17, 0.366 percent Nb_2O_5 over 60 feet, and 0.17 percent Nb_2O_5 over 72 feet.¹

Apatite locally forms as much as 20 percent of the silicocarbonatite exposed on Iron Island and is locally abundant in association with iron-titanium oxide mineral concentrations in the pyroxenitic rocks. An assay of 0.15 percent tin over 9.4 feet is reported in the log for drill hole No. 1-S¹. Fluorite and barite are mainly confined to late veins that cut across the major phases of the complex; a 3-foot wide vein of fluorite-barite-carbonate is present in drill hole No. 13.

Burritt Island Complex

In the description of the Burritt Island Complex in the "General Geology" section, mention was made of a few fine- to medium-grained pyrochlore crystals disseminated in a small carbonatite intrusion on the eastern side of the island. The crystals are slightly radioactive when tested with a geiger counter, but the occurrence appears to be too small to be of economic interest. Nevertheless, additional mineralization could be present in the vicinity of the island beneath Lake Nipissing.

Manitou Islands Complex

The Manitou Islands Complex contains five uranian pyrochlore deposits, the largest of which is just to the east of Newman Island (Figure 6). These were the first large pyrochlore deposits to be discovered in North America, and the history of their development and description of the general geology and the mineralization are given by Rowe (1954; 1958, p.45-62) and Gill and Owens (1957). Figure 6, showing the general geological features of the complex, is modified after Rowe (1958, Figure 14), and the isomagnetic lines are from published aeromagnetic data (GSC 1965d). The history of development and the mineralization are summarized only briefly here, but detailed information can be obtained from the references cited above.

Radioactivity was first discovered in the Manitou Islands Complex in 1952 by James Strohl of Tunkhannock, Pennsylvania. Shortly after this discovery, two North Bay residents, Martin Van Clieaf and J. J. Kenmey, obtained mineral exploration holdings in the vicinity of the discovery and collected a sample of the radioactive rock that was found upon analysis to contain 0.11 percent U_3O_8 . J. E. Thomson of the Ontario Department of Mines examined radioactive outcrops on the islands and eight samples collected gave upon analysis 0.01 to 0.12 percent U_3O_8 (Rowe 1958, p.45-62). The major radioactive mineral was later identified as uranian pyrochlore.

Early in 1953, Beaucage Mines Limited was formed to acquire the holdings of Van Clieaf and Kenmey. During 1953, Beaucage Mines explored the complex by ground magnetic and aeromagnetic surveys and by more than 80 diamond drills holes. In 1954,

¹Assessment work files, Resident Geologist's office, Ontario Department of Mines and Northern Affairs, Toronto.



Figure 6—Sketch map showing the major geological features and mineral deposits of the Manitou Islands Complex (modified after Rowe 1958, Figure 14).

a vertical shaft was sunk to 442 feet on Newman Island, and 2,500 feet of drifts and crosscuts were driven to examine extensive pyrochlore mineralization outlined by the drilling just east of the island (Figure 6). In 1956, The Consolidated Mining and Smelting Company of Canada Limited acquired control of Beaucage Mines and managed the exploration and development work. A pilot treatment plant was constructed on the north shore of Lake Nipissing due north of the Manitou Islands, and in 1958, the company name was changed to Nova Beaucage Mines Limited. In 1960, Consolidated Mining and Smelting relinquished control of Nova Beaucage Mines, and all operations were closed.

The five uranian pyrochlore deposits are confined to the aegirine-potassic feldspar fenite zone (Figure 6), and the host rocks are either altered syenitic and pyroxenitic rocks, or carbonatite. The uranian pyrochlore forms brownish crystals ranging in size from about 0.01 mm to 3.5 mm characterized by colour zoning caused by various degrees of metamictization.

At the Newman deposit the rocks are mineralogically and structurally complex, but the uranian pyrochlore is concentrated in two main rock types: 1) potassic feldspar-sodic pyroxene rock characterized by reddish feldspar; and 2) sodic pyroxene rock composed mainly of sodic pyroxene, biotite, calcite, and apatite. Fragments of potassic feldspar-sodic pyroxene rock partly replaced by biotite and sodic pyroxene are common in the sodic pyroxene rock, and both rock types are partly replaced by carbonate and contain a few percent magnetite, pyrite, and pyrrhotite. Zones rich in uranian pyrochlore cut across the two rock types, and the contact between the two types dips steeply outwards from the centre of the complex. The deposit has been traced along its easterly strike for 1,100 feet and has a maximum width of about 400 feet. Its eastward extent is unknown, but calcite-biotite-apatite-uranian pyrochlore rock becomes abundant near the eastern extremity of the explored part. In March 1958, Nova Beaucage Mines reported 1,893,000 tons of mineralized rock averaging 0.049 percent U_3O_8 and 0.86 percent Nb_2O_5 , and 2,962,000 tons of mineralized rock averaging 0.041 percent U_3O_8 and 0.69 percent Nb_2O_5 all 200 feet below the lake bottom.

At the Great Manitou deposit the mineralized rock consists of 20 to 60 percent apatite, 20 to 60 percent aegirine, 0 to 20 percent biotite, magnetite, pyrite, and pyrochlore, and a trace of uraninite. Pyrochlore is partly replaced by hematite and magnetite, and the proportion of niobium to uranium is lower than in pyrochlore from the Newman deposit. About 27,000 tons of mineralized rock averaging 0.38 percent Nb_2O_5 , 0.10 percent U_3O_8 , and 10 percent P_2O_5 have been outlined by 20 short, vertical diamond drill holes (Owens 1953, p.19).

At the Calder deposits pyrochlore is associated with concentrations of apatite in small carbonatite intrusions containing about 40 percent combined apatite, magnetite, biotite, and aegirine. Nineteen drill holes that intersected mineralization failed to show a continuous high-grade mineralized zone, but local concentrations of niobium and uranium as high as 0.11 percent U_3O_8 over 5 feet and 0.48 percent Nb_2O_5 over 10 feet were obtained in the drill core (Owens 1953, p.20).

Callander Complex

The Callander Complex at the eastern end of Lake Nipissing contains minor concentrations of niobium in carbonatite and hematitized and carbonatized nepheline syenite. Major geological features of the complex described in the "General Geology" section are

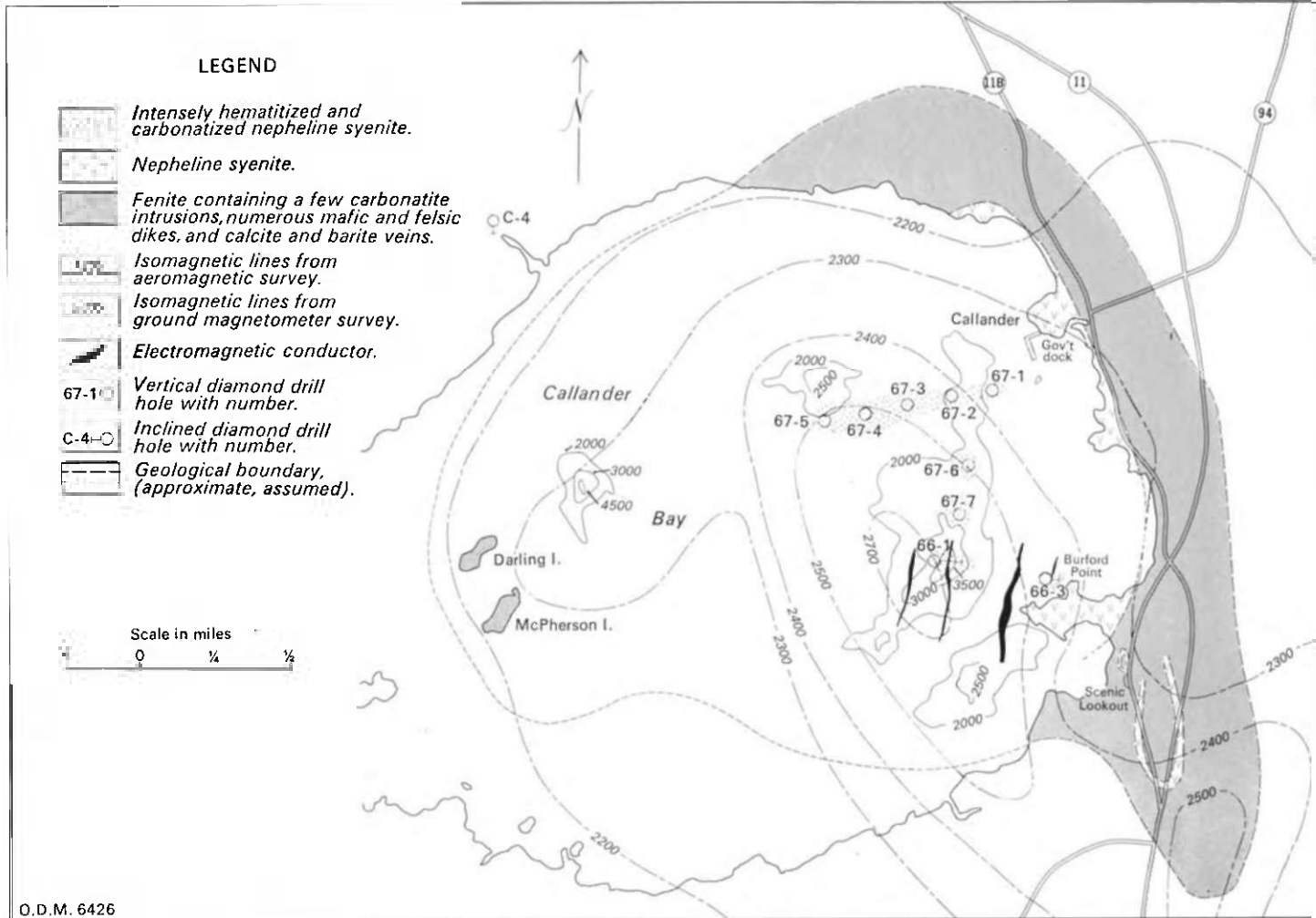


Figure 7—Sketch map showing the major geological features of the Callander Complex.

shown in Figure 7, which was compiled from data of the author, published aeromagnetic data (GSC 1965a), and assessment work data (Resident Geologist files, Ontario Department of Mines and Northern Affairs, Toronto).

Niobium mineralization was first reported from the complex by O. E. Owens¹ in 1956 who examined parts of the complex for Beaucaige Mines Limited. Up to 0.05 percent Nb₂O₅ was obtained in samples of carbonatite from McPherson Island containing fenite fragments¹, and in January 1958, a 166-foot diamond drill hole was put down near the northwestern margin of the complex (drill hole No. C-4, Figure 7), which intersected unmineralized gneissic biotite granite of the Powassan batholith containing a few lamprophyre dikes. Minor concentrations of magnetite are present in the carbonatite intrusions on Darling and McPherson Islands, and locally, these intrusions are slightly radioactive.

During the winters of 1966 and 1967, Min-Ore Mines Limited carried out geophysical and diamond drilling exploration in Callander Bay on an area covered by an exploratory license held by Carl Palangio of North Bay. Ground magnetic and electromagnetic surveys, taken on the ice, outlined four magnetically anomalous areas and four electromagnetic conducting zones, as shown in Figure 7. One of the magnetic anomalies coincides with an electromagnetic conductor, and drill hole No. 66-1 was put down 554 feet to explore this feature. The drill hole intersected hematitized and carbonatized nepheline syenite containing a few lamprophyre dikes and up to 10 percent disseminated pyrite and pyrrhotite, minor disseminated magnetite, and traces of chalcopyrite. Sampled sections of the core ranging in length from 1 foot to 6 feet gave upon analysis 0.01 to 0.05 percent Nb₂O₅, less than 0.01 percent U₃O₈, and traces of gold¹. Drill hole No. 66-3 (Figure 7) was put down to 200 feet to explore another electromagnetic conductor and intersected partly altered nepheline syenite. A semiquantitative spectrographic analysis of core taken at 198 feet gave 0.5 percent copper and 0.5 ounces silver per ton¹. Seven short drill holes (No. 67-1 to 67-7, Figure 7), put down north of the electromagnetic conducting zones, penetrated bedrock for lengths ranging from 1 foot to 30 feet, and the holes intersected hematitized and carbonatized nepheline syenite containing a trace to 0.03 percent Nb₂O₅¹.

Fenitic Rocks in Springer Township

In the "General Geology" section mention was made of carbonate veins in shattered fenitic rocks near Brule Creek in lot 5, concession VI, Springer Township. In 1969, Geophysical Engineering and Surveys Limited put down a 706-foot diamond drill hole to explore the fenitic rocks (assessment work files, Ontario Department of Mines and Northern Affairs, Toronto) and a prominent zone of carbonate veins in shattered fenite was intersected. A variety of minerals, some of which were unidentified, are reported in the veins including iron-titanium oxide minerals, pyrite, fluorite, and possible xenotime. Bastnaesite, a fluo-carbonate of the cerium group of rare earth elements, is present in places. Although no niobium or uranium mineralization have been reported, the geological and mineralogical features of the occurrence suggest that these elements could be present.

¹Assessment work files, Resident Geologist's office, Ontario Department of Mines and Northern Affairs, Toronto.

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Lot 27, Concession VIII, East Ferris Township

In May 1955, O'Leary Malartic Mines Limited drilled six short diamond drill holes totalling 196 feet in migmatitic biotite gneiss east of the Callander Complex in the north half of lot 27, concession VIII, East Ferris Township (Resident Geologist files, Ontario Department of Mines and Northern Affairs, Toronto) in search of uranium. No uranium mineralization was found.

Precious Metal Mineralization

As described above, traces of gold and silver are present in some of the Cambrian alkalic complexes and have been reported from the diabase dike along Reserve Creek in Nipissing Township. In the late 1890s and early 1900s, a few quartz veins, a diabase dike, and pegmatite dikes containing traces of pyrite and pyrrhotite were explored in vain for gold in Nipissing and Gurd Townships. From the descriptions of these old workings given below, the only mineralization appears to be minor pyrite and pyrrhotite and some workings appear to be lacking in mineralization. On Map 2216 (back pocket) therefore, these workings are shown as sulphide occurrences.

DESCRIPTION OF DEPOSITS

Lot 24, Concession XVIII, Nipissing Township

Near the western shore of South Bay, Lake Nipissing, in lot 24, concession XVIII, Nipissing Township, a shaft 9 feet square and 25 feet deep in a thin unit of ortho-quartzite with some intercalated muscovitic and quartzose gneiss was opened about 1896. Locally known as the Cummins Mine, the shaft exposes a network of vuggy quartz fissure veins containing angular fragments of the surrounding gneisses and numerous quartz crystals. Minor hematite and muscovite are the only other minerals visible in the veins.

Lot 10, Concession XIX, Gurd Township

Satterly (1942, p.36) describes old workings in a diabase dike in northern Gurd Township as follows:

On lot 10, concession XIX, Gurd township, a pit, 9 by 7 feet and 5 feet deep, has been sunk in pink biotite granite gneiss cut by a 1-foot green altered basalt dike trending N. 77° W. and dipping 88° N. The south contact of the dike forms the south wall of the pit. Some disseminated pyrite in small cubes in the basalt is the only mineralization. A grab sample taken by the writer gave a trace of gold on assay.

Ruth Lake, Nipissing Township

Old workings in the vicinity of Ruth Lake, Nipissing Township, are described by Satterly (1942, p.38) as follows:

On lot 20, concession I, Nipissing township, two pits have been put down in the south-east bay of Ruth Lake, one 10 feet in diameter at the shore, and the other 3 by 3 feet and 1 foot deep 2 chains from the shore. The rock exposed is a biotite granite gneiss cut by a number of irregular white pegmatite dikes from 1 to 10 feet in width. A few grains of pyrrhotite were found in the pegmatite.

The pit of the old Hewitt mine on lot 25, concession I, Nipissing township, extends 15 feet into the face of a cliff 20 feet high. This work was carried out about 1900. Stringers of pyrite or finely disseminated pyrite occur in biotite or garnet-biotite gneiss. A grab sample taken by the writer gave a trace of gold on assay.

Lot 6, Concession XV, Nipissing Township

The following is taken from Satterly (1942, p.39):

In a pit, 5 by 5 feet and 3 feet deep, 3½ chains from the road in lot 6, concession XV, Nipissing township, pink granite gneiss contains a band of biotite schist 5 feet wide with an exposed length of 25 feet. Pegmatite stringers in the biotite schist show a few specks of pyrite.

Another pit, 11 by 4 feet and 4 feet deep, 12 chains west of the road, exposes a band of coarse, black biotite schist in pink biotite granite gneiss with *lit par lit* pegmatite. No sulphide mineralization was found.

Lot 22, Concession XV, Nipissing Township

The following is taken from Satterly (1942, p.39):

A pit, 20 chains west of South bay, Lake Nipissing, in lot 22, concession XV, Nipissing township, has been put down on a 3-foot pegmatite dike cutting pink biotite granite gneiss. The dike strikes N. 70° W. and dips 45° S.W. No mineralization was found.

Minor Sulphide Mineralization

Hornblende gneiss in lot 14, concession III, Orlig Township, has been explored by diamond drilling, but no record of this work was found. Minor disseminated pyrite and pyrrhotite are present in broken pieces of drill core scattered on the ground near an old drill hole. The metagabbro and metapyroxenite intrusion in the Powassan batholith in Nipissing Township locally contains disseminated pyrite and pyrrhotite in the vicinity of lot 8, concessions IV and V. Old picket lines cross the intrusion at this locality, but no other evidence of exploration work was found. A metagabbro body intruded by rocks of the Powassan batholith in lots 4 and 5, concession III, South Himsworth Township, contains a few massive pyrite veinlets less than 1 inch across and minor disseminated pyrite in quartz veins near the contact with the batholith. Minor disseminated pyrite and pyrrhotite are present in the metagabbro.

NON-METALLIC MINERALIZATION

Apatite

Apatite is locally abundant in the Manitou Islands and Iron Island alkalic complexes; the Iron Island occurrences are too small to show on Map 2216 (back pocker). In the

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Manitou Islands Complex apatite forms up to 60 percent of the mineralized rock at the Great Manitou deposit, and in the Iron Island Complex it forms as much as 20 percent of silicocarbonatite exposed on Iron Island. Elsewhere in the area apatite occurs only as a minor accessory mineral and is most common in the late pegmatite dikes and in gabbroic and ultramafic intrusions.

Barite and Fluorite

Minor barite and fluorite occur together in late carbonate veins in the Iron Island and Callander Complexes, a few hematite-barite veins are present in the Callander Complex, and traces of fluorite are present in fenitic rocks in all the alkalic complexes. Fluorite is also present in carbonate veins in the fenitic rocks in Springer Township.

Feldspar and Mica

Small quantities of feldspar and muscovite have been quarried from a few of the late pegmatite dikes, and one dike in Patterson Township contains amazonite, a green variety of microcline used as a semi-precious stone. Muscovite in the pegmatites is generally light green to greenish brown, the books are small and are generally less than 2 feet in size, and the quality is poor.

The pegmatite dikes explored for feldspar and mica are among the largest and most persistent found in the area, most strike northeasterly and are near major faults of the northeast system, and their host rocks are either metagabbro, or gneissic granite and monzonitic rocks. As pointed out in the "Structural Geology" and "General Geology" sections, late pegmatite dikes are commonly concentrated near faults of the northeast system, and all the largest and most persistent dikes are in nonmigmatitic plutonic rocks and hornblende gneiss because these rocks were apparently structurally more competent than other rock types during emplacement of the pegmatite. These relationships suggest that the search for additional pegmatites of commercial interest should be concentrated near the non-migmatitic plutonic rocks and calc-silicate gneiss, particularly where these rocks are traversed by faults of the northeast system.

DESCRIPTION OF DEPOSITS

Lot 7, Concession II, Grant Township

In lot 7, concession II, in southwestern Grant Township just north of the concession road leading east from Crystal Falls, an irregularly shaped late pegmatite dike, up to 30 feet across, in an elongate metagabbro intrusion has been quarried for feldspar. Where exposed in an open-cut driven into the side of a hill a few hundred feet north of the road, the dike appears to strike northeast and dip subvertically, and consists mainly of pink, perthitic microcline containing minor intergrown quartz and accessory biotite and muscovite. No information could be obtained concerning the workings, but from the size of the open-cut and the amount of material on a nearby dump, some feldspar appears to

have been taken from the deposit. The dike was tested, by the author, with a geiger counter for radioactivity, with negative results.

Lot 47, Concession XV, Patterson Township

In lot 47, concession XV, Patterson Township, about 1.5 miles southwest of Durrell Point on the west shore of South Bay, Lake Nipissing, an irregularly shaped pegmatite dike up to 50 feet across and striking N75E has been quarried for muscovite. According to C. B. Swackhamer, who operates a tourist camp near Durrell Point, 4,500 tons of muscovite concentrate were shipped from the deposit in the early 1940s to the North Bay Mica Company Limited.

The dike intrudes a small metagabbro stock, and the workings consist of an open-cut, 20 feet wide and 10 feet long with a 10-foot face, driven into the north side of a hill. A few shallow pits were blasted in the dike in the hill above the cut. The dike is locally sheared and dips subvertically, and consists mainly of quartz, perthitic microcline, and light green muscovite, which forms crystals up to 18 inches across. Most of the muscovite is concentrated in a 20-foot wide zone trending across the dike near the face of the cut, and accessory hematite is present locally throughout the dike. The dike was tested, by the author, with a geiger counter for radioactivity, with negative results.

Lot 48, Concession XII, Patterson Township

About 1,000 feet north of a small, circular beaver pond about ½ mile west of the east boundary of Patterson Township, in lot 48, concession XII, a pegmatite dike cutting across a narrow sheet of pink to grey monzonitic rocks has been explored for muscovite and amazonite. The dike is exposed mainly in a trench, 90 feet long, 5 to 10 feet wide, and up to 5 feet deep. Sharp contacts of the dike with the monzonitic host rocks exposed near one end and along one side of the trench indicate that the dike is about 50 feet wide and strikes N75E, but no exposures of the dike are present along strike beyond the trench. An outcrop of monzonitic rocks exposed by stripping, a few hundred feet north of the trench, contains a few late pegmatite dikes less than 3 feet wide. In September 1967, trimmed sheets of muscovite were piled near an old dump on the north side of the trench, and a few small, broken pieces of amazonite were piled in places along the trench. The muscovite was apparently quarried several years ago, but a few hundred pounds of amazonite have been quarried recently for the Nipissing Lapidary and Mineral Club of North Bay.

The dike is composed mainly of 1) pink microcline and minor amazonite forming crystals up to 3 feet across, 2) quartz commonly concentrated in irregularly shaped masses and rarely in graphic intergrowth with microcline, and 3) minor muscovite forming crystals, up to 1 foot across, irregularly distributed throughout the dike. Minor accessory minerals are hematite, zircon, garnet crystals up to 2 inches across, and traces of pyrite. The only amazonite exposed in 1967 was near the central part and eastern end of the trench, and irregular pinkish streaks and fractures coated by earthy hematite are common in the amazonite. Several broken pieces of uniformly green amazonite free of hematite and the pinkish streaks were on the floor of the trench. The dike was tested, by the author, with a geiger counter for radioactivity, with negative results.

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Lot 30, Concession X, Nipissing Township

Near the southwestern end of Duncan Lake in lot 30, concession X, Nipissing Township, a late pegmatite dike in gneissic biotite granite was explored for feldspar. The deposit was originally staked in 1941 (Satterly 1942, p.60) and according to W. T. King, Jr., who owns a farm adjoining the deposit to the east, two cars of feldspar were taken from the dike in 1944.

Workings consist of an irregularly shaped open-cut quarried for about 100 feet along the side of a hill overlooking Duncan Lake, and several strippings near the top of the hill. Within the cut, the dike strikes N50E and dips 20NW, and ranges in width from a few feet to about 20 feet. Pink microcline, forming crystals up to 1 foot across, and quartz are the main minerals present. Much of the quartz is in graphic intergrowth with the microcline rendering the deposit low-grade for feldspar. Accessory minerals are hematite and biotite. The dike was tested, by the author, with a geiger counter for radioactivity, with negative results.

Lot 24, Concession III, Chisholm Township

A late pegmatite dike on lot 24, concession III, Chisholm Township, referred to by Hoadley (1960, p.86) as the Campbell showing, has been stripped in places in the search for muscovite. The dike is poorly exposed in a swampy area and consists mainly of microcline and quartz with disseminated crystals of smoky muscovite up to 6 inches across. The dike was tested with a geiger counter by the author for radioactivity with negative results.

Lots 7 and 8, Concessions D and E, Olrig Township

Harding (1944, p.28) described mica showings in late pegmatite dikes in lots 7 and 8, concessions D and E, Olrig Township as follows:

In 1940, Albert MacDonald, of Toronto, staked a group of 4 claims, S. 35,358 to 35,361, about a mile south of Perron lake in concessions D and E, Olrig township. Since that time assessment work has been carried out by Albert MacDonald and Huntley McDonald, who are partners in this enterprise.

Bill Greer, of Haileybury, an early prospector, is reported to have recovered several hundred pounds of mica sometime during the period 1908-10 from a muscovite-bearing dike in the vicinity of these claims.

Since 1940, some prospecting has been carried out on this group and surface work has been done on pegmatite showings near the boundary between claims S. 35,358 and 35,359. No mica has been produced.

The deposits were not visited by the author.

Graphite

Traces of graphite are present locally in fractures in fenitic rocks of the Iron Island, Manitou Islands, and Callander alkalic complexes. Graphite is also a common accessory mineral in the marble inclusions within the Bonfield batholith east of Lake Talon. None of these occurrences, however, appear to be of economic interest.

Kyanite

In the northeastern part of the area, kyanite is locally abundant in feldspathic gneiss and in some biotite-rich silty facies of the biotite gneiss, and near Timber Lake in Butler Township, narrow units of kyanite-garnet-muscovite-biotite-quartz-feldspar gneiss are intercalated with muscovitic and quartzose gneiss and hornblende gneiss. Localities where kyanite appears to exceed 10 percent of the host gneiss are indicated on Map 2216 (back pocket), and of the six localities shown, only the two near Timber Lake have been reported previously (Hewitt 1952, p.3-4; Pearson 1959), and none have received exploration work.

DESCRIPTION OF DEPOSITS

Widdifield Township

Near Highway 11 north of North Bay in concessions A and B, Widdifield Township, units of kyanite-biotite-plagioclase gneiss generally only a few inches thick are locally intercalated with biotite gneiss. Kyanite occurs as disseminated, fine-grained, light green crystals resembling apatite in hand specimen and forms up to 15 percent of the rock. The kyanite is free of inclusions, but the occurrences appear to be too small and widely spaced to be of economic interest.

Phelps and Orlig Townships

Along the power line in eastern Phelps and Orlig Townships, kyanite-bearing feldspathic gneiss units containing less than 10 percent biotite, muscovite, garnet, and iron-titanium oxide minerals, and generally no more than a few feet thick, are intercalated locally with muscovitic and quartzose gneiss, kyanite-free feldspathic gneiss, and hornblende gneiss. Within the kyanite-bearing gneiss, kyanite occurs as coarse-grained, flat-bladed crystals, up to 3 inches long and 0.5 inch across, concentrated in irregularly spaced layers, less than 1 inch thick, parallel to the stratiform foliation in the gneiss. In the plane of foliation, the long axes of the crystals are oriented parallel to the plunge of a regional south-southeast-trending lineation developed in the various surrounding gneisses. The crystals are mainly light green, but some contain light blue zones in their central parts. The quantity of kyanite exposed is difficult to estimate because of the mode of occurrence, but in general, it probably averages about 10 percent of the kyanite-bearing gneiss units. Kyanite appears to be most abundant near the boundary between Phelps Township and Orlig Township, where a road along the power line turns south. Here, kyanite exposed in an outcrop blasted for pole foundations forms up to 20 percent of the gneiss. Fine-grained inclusions of muscovite, quartz, feldspar, and iron-titanium oxide minerals are commonly sparsely disseminated in the kyanite crystals.

Butler Township

Near Timber Lake in Butler Township, kyanite-garnet-muscovite-biotite-quartz-feldspar gneiss units are exposed over widths up to 600 feet, but the units dip at low

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angles and they probably have a true thickness of less than 300 feet. About 10 to 12 percent kyanite is disseminated throughout the gneiss and consists of flat-bladed, grey to blue crystals, up to 2 inches long and 0.25 inch across, randomly oriented in the plane of foliation. Fine-grained inclusions appear to be more abundant in this kyanite than in kyanite in Phelps and Orlig Townships.

Industrially Useful Rocks

Near the boundary between Pedley and Beaucage Townships about 1.75 miles north of Highway 17, biotite gneiss has been quarried at two localities (see Map 2216, back pocket) for crushed stone used in making asphalt for nearby sections of the highway. Middle Ordovician limestone on Great Manitou Island was quarried for making lime used in the construction of the Canadian Pacific railway (Barlow 1899, p.46), and ruins of an old lime kiln can be seen on the south shore of the island. Middle Ordovician dolostone near Nipissing was also quarried for making lime used in the construction of the Canadian Pacific railway, and was explored by pits and trenches in the 1930s for possible use as concrete aggregate (Goudge 1938, p.144-145). From chemical analyses of the dolostone, Satterly (1942, p.72) concluded that the deposit has only limited economic possibilities.

Because of the geographical position of the area with its major rail and highway routes giving direct access to the main North American markets, some rocks of the metamorphic complex should be considered as possible sources of building stone. Some of the muscovitic and quartzose gneiss in the northwestern part of the area is similar to that quarried for building stone near Reynolds Lake in McAuslan Township to the north in the Tomiko area (Lumbers 1969). Massive, even-grained to porphyritic, pink to grey monzonitic rocks in the Powassan and Bonfield batholiths take a good polish and could prove to be excellent sources of building stone, but greenish varieties are less desirable because they stain when weathered. Other rocks possibly suitable for building stone are migmatitic biotite gneiss, biotite-rich silty facies of the biotite gneiss, and fenitic rocks, characterized by complex textures and structures, associated with the Cambrian alkalic complexes.

Clay

Pleistocene varved clay deposited during the Nipissing and other post-glacial stages of the Great Lakes (see section on "Cenozoic, Prehistoric Great Lakes and Related Deposits") has been utilized for the manufacture of brick and tile at Sturgeon Falls, North Bay, and Powassan. In the late 1800s the Sturgeon Falls Power Company built a brick plant to produce brick for construction of power houses, factories, and offices required by the company at Sturgeon Falls (Baker 1906, p.84), and many of these buildings are now part of the present operations of the Abitibi Power and Paper Company. Although the clay used gave considerable trouble (Baker 1906, p.84), the plant continued production for the local market until the early 1900s and produced brick for many of the buildings in Sturgeon Falls. Descriptions of brick-making and the clay deposits used are given by Baker (1906, p.84-85), but the plant and clay pit were disposed of many years ago (Montgomery 1930, p.140). Brick plants were also established at North

Bay and Powassan in the late 1800s (Baker 1906, p.83,88) and have produced brick and tile periodically to the present. A plant at North Bay in lot 16, concession C, Widdifield Township, built and operated for several years by R. Wallace and Son, was operated from 1961 to 1965 by Gravell Brick Company Limited, and at Powassan in lot 15, concession XI, South Himsworth Township, a plant built by Gomoll Brick and Tile is still operated by this company (see property 3 on Map 2216, back pocket). Early descriptions of brick-making at North Bay are given by Baker (1906, p.83), Keele (1924, p.120), and Montgomery (1930, p.140), and at Powassan, by Baker (1906, p.88) and Satterly (1942, p.17-18). Recent operations on these sites, including descriptions and results of chemical, mineralogical, and ceramic tests of clay used, are given by Guillet (1967, p.154-156).

Sand and Gravel

As described in the section on the "Pleistocene", sand and gravel deposits in the form of eskers, kames, raised beaches and terraces, delta planes, and reworked moraine material are widespread and abundant, particularly in the eastern half of the area. These deposits are used extensively for local construction purposes, and the major pits present in the area in 1967 are shown on Map 2216 (back pocket). Most of these pits are small and are used mainly for maintaining gravel-surfaced township roads and in the construction of logging and forest access roads. However, five companies operate large pits near Powassan, in South Himsworth Township, and near North Bay, north of the Mattawa River Fault in Widdifield Township, and produce large quantities of sand and gravel using crushing and screening plants for concrete aggregate and crusher-run road gravel.

Near Powassan, a pit (property 6 on Map 2216, back pocket) operated by Gilbert Young Construction Limited, is in a thick sand and gravel terrace deposit, whereas pits operated near North Bay by City Sand and Gravel Limited (property 1), Delorme Construction (property 2), North Bay Construction Products Limited (property 4), and J. M. Wright Limited (property 5), are in a complex moraine system formed during the retreat of the ice-front and modified by lake waters. City Sand and Gravel works well-sorted sand deposits, possibly representing in part wind blown sands formed after the retreat of the glacial lake waters, and interbedded coarse sand and gravel, which are treated in a crushing and screening plant. Delorme Construction works several pits in the sand and gravel deposits west of Highway 11 in Widdifield Township. In 1967 and 1968, gravel pits, about 2 miles north of Highway 17 in Pedley Township near the boundary with Beaucage Township, were worked extensively by Peel Construction Company Limited using a portable crushing and screening plant to obtain crusher-run road gravel for resurfacing nearby sections of Highway 17 (these pits are not given property numbers on Map 2216, back pocket).

Although the extensive sand and gravel deposits in the eastern half of the area are utilized on a relatively small scale, they constitute a major resource for sand and gravel in central and southern Ontario. In the future, they could supply not only an expanded local market, but also part of the rapidly growing markets in densely populated areas of southern Ontario, because the deposits are particularly well situated with respect to major transportation routes.

North Bay Area

SUGGESTIONS FOR FUTURE EXPLORATIONS

In the above sections describing the various metallic and non-metallic deposits found in the area, tentative conclusions are given regarding the economic potential of each commodity based on available data, and only the most important of these conclusions are summarized here.

Of the metallic mineralization present in the area, only copper, nickel, niobium, uranium, and iron appear to be concentrated in sufficient quantities for economic interest. Copper and nickel are concentrated mainly in the late mafic stocks that postdate the metamorphic complex, but traces of copper and nickel mineralization found in some of the Cambrian alkalic complexes, particularly in mafic phases of the Iron Island Complex, should be explored further. Copper and nickel mineralization are virtually unknown in rocks of the metamorphic complex, and taking into account the lithology of these rocks, about the only group that could be expected to contain copper and nickel concentrations are the mafic intrusions.

Known concentrations of niobium and uranium are confined to the Cambrian alkalic complexes, but only the Manitou Islands Complex has been extensively explored for these elements. Although no uranium mineralization has been found in units of muscovitic and quartzose gneiss within the map-area, this rock type is favourable for uranium mineralization and is known to contain uranium and gold mineralization northeast of the map-area in the Kipawa region of Quebec (Roscoe 1969). Traces of uranium mineralization have been reported in a few late pegmatite dikes, but most of the dikes are low in radioactivity and do not appear to be favourable for uranium. Further search for pegmatites of commercial interest should be concentrated near non-migmatitic plutonic rocks and hornblende gneiss of the metamorphic complex, particularly where these rocks are traversed by faults of the northeast system.

Minor concentrations of iron are found in many of the rock types in the area, but the muscovitic and quartzose gneiss containing widespread hematite mineralization appears to be the most favourable rock type for possible large concentrations of iron.

Extensive sand and gravel deposits in the eastern half of the area are the chief non-metallic mineral resource, but because the area is well situated with respect to major transportation routes, some gneisses of the metamorphic complex, particularly the muscovitic and quartzose gneiss and pink and grey facies of the monzonitic rocks, are potential sources of building stone. Detailed examination of the kyanite occurrences along the power line in Phelps and Orlig Townships should be undertaken to determine their economic potential.

Amethyst has been found just east of Indian Lake and is of interest to mineral collectors. This occurrence was not examined by the author.

The Cambrian alkalic complexes and late mafic stocks were emplaced in an area where faults of the west-northwest system intersect a prominent zone of faults of the northeast system, and this apparent structural control on the emplacement of these intrusions could prove useful in locating other late mafic and alkalic intrusions elsewhere in the northwestern part of the Grenville Province of Ontario. Another consideration not mentioned previously concerning the graben system in the central part of the area is the possible presence of diamond-bearing kimberlite intrusions in association with this structure and the carbonatite-bearing alkalic complexes. Diamond-bearing kimberlite intrusions are associated with carbonatite-bearing alkalic complexes near rift valleys in many places throughout the world (Heinrich 1966; Kumarapeli and Saull 1966), and although only monchiquite dikes are known to be regionally associated with the graben system in the map-area, kimberlite intrusions could also be present.

REFERENCES CITED

- Baker, M. B.
1906: Clay and the clay industry of Ontario; Ont. Bur. Mines, Vol. 15, pt. 2, 127p.
- Barlow, A. E.
1895: Summary report on the operations of the Geological Survey for the year 1892; Geol. Surv. Canada, Ann. Rept., Vol. 6, pt. A, p.34-35.
1896: Summary report on the operations of the Geological Survey for the year 1894; Geol. Surv. Canada, Vol. 7, pt. A, p.56-57.
1899: Report on the geology and natural resources of the area included by the Nipissing and Temiscaming map-sheets; Geol. Surv. Canada, Ann. Rept., Vol. 10, pt. I, 302p. Accompanied by 1 map, scale 1 inch to 4 miles.
1908: Second edition of the report on the geology and natural resources of the area included by the Nipissing and Temiscaming map-sheets; Geol. Surv. Canada, Pub. No. 962, 303p.
- Bell, Robert
1877: Sketch of the geology of the route of the intercolonial railway; Canadian J. Nat. Sci., Vol. 15, p.381-387.
1898: Report on the geology of the French River sheet; Geol. Surv. Canada, Ann. Rept., Vol. 9, pt. I, 29p. Accompanied by Map 570, scale 1 inch to 4 miles.
- Bigsby, J. J.
1821: Geological and mineral observations on the northwest portion of Lake Huron; American J. Sci., First Ser., Vol. 3, p.254-272.
- Boissonneau, A. N.
1966: Surficial geology of Algoma, Sudbury, Timiskaming, and Nipissing; Ontario Dept. Lands and Forests, Map No. S465, scale 1 inch to 8 miles.
- Buddington, A. F.
1939: Adirondack igneous rocks and their metamorphism; Geol. Soc. America, Mem. 7, 354p. Accompanied by 1 map.
- Buddington, A. F., and Leonard, B. F.
1962: Regional geology of the St. Lawrence County magnetite district northwest Adirondacks, New York; United States Geol. Surv. Prof. Paper 376, 145p. Accompanied by 1 map, scale 1 inch to 1 mile.
- Card, K. D.
1964: Metamorphism in the Agnew Lake area, Sudbury District, Ontario, Canada; Geol. Soc. America Bull., Vol. 75, No. 10, p.1011-1030.
- Chapman, L. J.
1954: An outlet of Lake Algonquin at Fossmill, Ontario; Geol. Assoc. Canada Proc., Vol. 6, pt. 2, p.61-68.
- Coleman, A. P.
1899: Copper in Parry Sound district; Ontario Bur. Mines, Vol. 8, pt. 2, p.259-262.
1900: Copper and iron regions of Ontario; Ontario Bur. Mines, Vol. 9, p.143-191.
- Colquhoun, D. J.
1958: Stratigraphy and palaeontology of the Nipissing-Deux Rivieres outliers; Geol. Assoc. Canada Proc., Vol. 10, p.83-93.
- Currie, K. L.
1969: Alkaline rocks, Callander Bay and Brent, Ontario; p.136-137 in Report of Activities, Part A: April to October, 1968, Geol. Surv. Canada, Paper 69-1, 263p.
- Davis, G. L., Hart, S. R., and Aldrich, L. T., with Krogh, T. E., and Munizaga, Fernando
1967: Geochronology: geochronology of the Grenville Province of Ontario; Carnegie Inst. Wash., Year Book, Vol. 65, p.379-387.
- Dietz, Robert S.
1963: Collapsing continental rises: An actualistic concept of geosynclines and mountain building; J. Geol., Vol. 71, p.314-333.
1966: Passive continents, spreading sea floors, and collapsing continental rises; American J. Sci., Vol. 264, March, p.177-193.
- Deitz, Robert S., and Holden, John C.
1966: Miogeoclines (miogeosynclines) in space and time; J. Geol., Vol. 74, p.556-583.
- Doig, Ronald, and Barton, Jackson M., Jr.
1968: Ages of carbonatites and other alkaline rocks in Quebec; Canadian J. Earth Sci., Vol. 5, No. 6, p.1401-1407.

North Bay Area

- Dunbar, Carl O., and Rodgers, John
1957: Principles of stratigraphy; John Wiley and Sons, Inc., New York.
- Fairbairn, H. W., Hurley, P.M., Card, K. D., and Knight, C. J.
1969: Correlation of radiometric ages of Nipissing Diabase and Huronian metasediments with Proterozoic orogenic events in Ontario; Canadian J. Earth Sci., Vol. 6, No. 3, p.489-497.
- Friedman, Gerald M.
1955: Petrology of the Memesagamesing Lake norite mass, Ontario, Canada; American J. Sci., Vol. 253, p.590-608.
- GSC
1965a: Powassan sheet, Ontario; Geol. Surv. Canada, Geophysical Paper 1477, Aeromagnetic Map 1477G, scale 1 inch to 1 mile. Survey flown June 1959 to October 1960.
1965b: North Bay sheet, Ontario; Geol. Surv. Canada, Geophysical Paper 1478, Aeromagnetic Map 1478G, scale 1 inch to 1 mile. Survey flown June 1959 to October 1960.
1965c: Nipissing sheet, Ontario; Geol. Surv. Canada, Geophysical Paper 1487, Aeromagnetic Map 1487G, scale 1 inch to 1 mile. Survey flown June 1959 to October 1960.
1965d: Sturgeon Falls sheet, Ontario; Geol. Surv. Canada, Geophysical Paper 1488, Aeromagnetic Map 1488G, scale 1 inch to 1 mile. Survey flown June 1959 to October 1960.
- Gill, J. E., and Owens, O. E.
1957: Columbium-uranium deposits at North Bay, Ontario; Canadian Inst. Min. and Met. Trans., Vol. 60, p.244-250.
- Gittins, J., Macintyre, R. M., and York, D.
1967: The ages of carbonatite complexes in Eastern Canada; Canadian J. Earth Sci., Vol. 4, No. 4, p.651-655.
- Goodwillie, J. M.
1893: A geological sketch, with notes, on the geology of the Manitou Islands of Lake Nipissing, Ontario; Science, Vol. 22, p.101-104.
- Goudge, M. F.
1938: Limestones of Canada, their occurrence and characteristics, part IV, Ontario; Canada Dept. Mines and Resources, Bur. Mines, No. 781, 362p. Accompanied by 2 maps.
1939: A preliminary report on the brucite deposits in Ontario and Quebec and their commercial possibilities; Canada Dept. Mines and Resources, Memorandum Ser. No. 75, 57p.
- Grant, James A.
1964: Rubidium-strontium isochron study of the Grenville Front near Lake Timagami, Ontario; Science, Vol. 146, p.1049-1053.
- Grant, J. A., Pearson, W. J., Phemister, T. C., and Thomson, Jas. E.
1962: Geology of Broder, Dill, Neelon, and Dryden Townships, District of Sudbury; Ontario Dept. Mines, GR9, p.1-24. Accompanied by Map 2017, scale 1 inch to 1/2 mile.
- Guillet, G. R.
1967: The clay products industry of Ontario; Ontario Dept. Mines, IMR22, 206p. Accompanied by Maps 2130 and 2131, scale 1 inch to 16 miles.
- Harding, W. D.
1944: Geology of the Mattawan-Olrig area; Ontario Dept. Mines, Vol. 53, pt. 6, p.1-47, (published 1946). Accompanied by Map 53d, scale 1 inch to 1 mile.
- Harrison, J. E.
1969: North Bay-Mattawa region, Ontario; p.200 in Report of Activities, Part A: April to October 1968, Geol. Surv. Canada, Paper 69-1, 263p.
- Heinrich, E. W.
1966: The geology of carbonatites; Rand McNally and Co., Chicago, 555p.
- Henderson, J. R.
1967: Structural and petrologic relations across the Grenville Province-Southern Province boundary, Sudbury District, Ontario; Ph.D. thesis, McMaster University, Hamilton, Ontario.

- Hewitt, D. F.
 1952: Kyanite and sillimanite in Ontario; Ontario Dept. Mines, IMC4, 9p.
 1967: Geology and mineral deposits of the Parry Sound-Huntsville area; Ontario Dept. Mines, GR52, 65p. Accompanied by Map 2118, scale 1 inch to 2 miles.
- Hoadley, J. W.
 1960: Mica deposits of Canada; Geol. Surv. Canada, Econ. Geol. Ser. No. 19, 141p.
- Hødal, Johanne.
 1945: Rocks of the anorthosite kindred in Vossestrand, (Norway); Norsk. geol. Tidsskrift, Vol. 24, p.129-243.
- Hoffmann, G. Christian
 1890: Chemical contributions to the geology of Canada; Geol. Surv. Canada, Ann. Rept., Vol. 4, Sec. R, 68p.
 1906: Section of chemistry and mineralogy; Geol. Surv. Canada, Pub. 958, p.14.
- Hough, Jack L.
 1958: Geology of the Great Lakes; University of Illinois Press, Urbana, Illinois, 313p.
 1963: The prehistoric Great Lakes of North America; American Scientist, Vol. 51, p.84-109.
- James, Harold L.
 1955: Zones of regional metamorphism in the Precambrian of northern Michigan; Geol. Soc. America Bull., Vol. 66, No. 12, pt. 1, p.1455-1487.
- Johnston, W. G. Q.
 1954: Geology of the Temiskaming-Grenville contact southeast of Lake Temagami, northern Ontario, Canada; Geol. Soc. America Bull., Vol. 65, No. 11, p.1047-1073.
- Jones, R. J.
 1957: Columbium (niobium) and tantalum; Canada, Dept. Mines and Technical Surveys, Mines Branch, Memorandum Ser. No. 135, 56p.
- Kay, G. Marshall
 1942: Ottawa-Bonnechere graben and Lake Ontario homocline; Geol. Soc. America Bull., Vol. 53, No. 4, p.585-646.
- Keele, J.
 1924: Preliminary report on the clay and shale deposits of Ontario; Geol. Surv. Canada, Mem. 142, 176p.
- Knight, Cyril W.
 1949: Hematite boulders on Iron Island, Lake Nipissing (abstract); Geol. Assoc. Canada, Vol. 1, p.925? (last unnumbered page in Vol.).
- Krank, E. H.
 1961: The tectonic position of the anorthosites of eastern Canada; Bull. Comm. geol. Finlande, Vol. 196, p.299-320.
- Krogh, T. E., and Davis, G. L.
 1969a: Old isotopic ages in the northwestern Grenville Province, Ontario; p.189-192 in Age relations in high-grade metamorphic terrains, edited by H. R. Wynne-Edwards, Geol. Assoc. Canada, Sp. Paper No. 5, 228p.
 1969b: Geochronology of the Grenville Province; Carnegie Inst. Wash., Year Book, Vol. 67, p.224-230.
- Krogh, T. E., Davis, G. L., Aldrich, L. T., Hart, S. R., and Stueber, A.
 1968: Geochronology: Geological history of the Grenville Province; Carnegie Inst. Wash., Year Book, Vol. 66 for 1966-1967, p.528-536.
- Krogh, T. E., and Hurley, P. M.
 1968: Strontium isotope variation and whole-rock isochron studies, Grenville Province of Ontario; J. Geophys. Res., No. 22, Vol. 73, p.7107-7125.
- Kumarapeli, P. S., and Saull, V. A.
 1966: The St. Lawrence valley system: a North American equivalent of the East African rift valley system; Canadian J. Earth Sci., Vol. 3, No. 5, p.639-658.
- Lang, A. H.
 1943: Terraces near North Bay, Ontario; Roy. Soc. Canada Trans., Vol. 37, Sec. 4, p.49-52.
 1952: Canadian deposits of uranium and thorium (interim account); Geol. Surv. Canada, Econ. Geol. Ser., No. 16, 173p.
- Logan, W. E.
 1847: On the topography and geology of the Ottawa River and some of its tributaries with notes on economic minerals; Geol. Surv. Canada, Rept. of Progress 1845-1846; p.40-51.

North Bay Area

- Lowdon, J. A., and Blake, W., Jr.
1968: Geological Survey of Canada radiocarbon dates VII; Geol. Surv. Canada, Paper 68-2, pt. B, p.207-245.
- Lumbers, S. B.
1967a: Burwash sheet, Districts of Nipissing, Sudbury, and Parry Sound; Ontario Dept. Mines, Geol. Compilation Series, Prelim. Geol. Map P.415, scale 1 inch to 2 miles. Geological compilation 1966.
1967b: Tomiko sheet, District of Nipissing; Ontario Dept. Mines, Geol. Compilation Series, Prelim. Geol. Map P.394, scale 1 inch to 2 miles. Geological compilation 1966.
1967c: Stratigraphy, plutonism, and metamorphism in the Ottawa River remnant in the Bancroft-Madoc area of the Grenville Province of southeastern Ontario, Canada; Ph.D. thesis, Princeton University, Princeton, New Jersey.
1968: North Bay sheet, Districts of Nipissing and Parry Sound; Ontario Dept. Mines, Geol. Compilation Series, Prelim. Geol. Map P.381, scale 1 inch to 2 miles (issued 1967, re-issued with additions and revisions 1968). Geology 1964, 1965, 1967.
1969: Tomiko area, District of Nipissing; p.61-64 in Summary of Field Work, 1969 by the Geological Branch, Edited by E. G. Pye, Ontario Dept. Mines, MP32, 70p.
In preparation:
Geology of the Burwash area; Ontario Dept. Mines and Northern Affairs, GR.
- Montgomery, Robert J.
1930: The ceramic industry of Ontario; Ontario Dept. Mines, Vol. 39, pt. 4, 196p.
- Murray, A.
1857: Report for the year 1854; Geol. Surv. Canada, Report of Progress 1853-1856, p.101-125.
- Nockolds, S. R.
1954: Average chemical compositions of some igneous rocks; Geol. Soc. America Bull., Vol. 65, p.1007-1032.
- Osborne, F. Fitz, and Morin, Marcel
1962: Tectonics of part of the Grenville Subprovince in Quebec; p.118-143 in The tectonics of the Canadian Shield; Roy. Soc. Canada, Special Publ. No. 4, 180p.
- Owens, O. E.
1953: Unpublished geological report on Beaucage Mines Ltd.; Assessment work files, Resident Geologist's office, Ontario Dept. Mines and Northern Affairs, Toronto.
- Parkinson, R. N.
1962: Operation Overthrust; p.90-101 in The tectonics of the Canadian Shield, Roy. Soc. Canada, Special Publ. No. 4, 180p.
- Pearson, W. J.
1959: Origin of kyanite occurrences in the Wanapitei and Crocan Lakes areas of Ontario; unpub. Ph.D. thesis, Queen's University, Kingston, Ontario.
- Pettijohn, F. J.
1957: Sedimentary rocks; Harper and Brothers, New York, second edition, 718p.
- Philpotts, A. R.
1966: Origin of the anorthosite-mangerite rocks in southern Quebec; J. Petrology, Vol. 7, p.1-64.
- Quirke, T. T., and Collins, W. H.
1930: The disappearance of the Huronian; Geol. Surv. Canada, Mem. 160, 129p. Accompanied by 2 maps.
- Rogers, W. R.
1916: Statistical review of the mineral industry of Ontario for 1915; Ontario Bur. Mines, Vol. 25, pt. 1, 51p.
- Roscoe, S. M.
1969: Huronian rocks and uraniferous conglomerates in the Canadian Shield; Geol. Surv. Canada, Paper 68-40, 205p.
- Rowe, Robert B.
1954: Notes on geology and mineralogy of the Newman columbium-uranium deposit, Lake Nipissing, Ontario; Geol. Surv. Canada, Paper 54-5, 25p.
1958: Niobium (columbium) deposits of Canada; Geol. Surv. Canada, Econ. Geol. Ser. No. 18, 108p.

- Satterly, J.
 1942: Mineral occurrences in Parry Sound District; Ontario Dept. Mines, Vol. 51, pt. 2, 86p. (published 1943). Accompanied by Map 51a, scale 1 inch to 2 miles.
 1955: Geology of Lount Township; Ontario Dept. Mines, Vol. 64, pt. 6, 46p. (published 1956). Accompanied by Map 1955-4, scale 1 inch to ½ mile.
- Silver, Leon T., and Lumbers, S. B.
 1966: Geochronologic studies in the Bancroft-Madoc area of the Grenville Province, Ontario, Canada (abstract); p.156 in Geol. Soc. America, Spec. Publ. No. 87, 366p.
- Stockwell, C. H.
 1964: Fourth report on structural provinces, orogenies, and time-classification of rocks of the Canadian Precambrian Shield; p.1-21 in Age determinations and geological studies, Geol. Surv. Canada, Paper 64-17, pt.2, 29p.
- Terasmae, J., and Hughes, Owen L.
 1960: Glacial retreat in the North Bay area, Ontario; Science, Vol. 131, May 13, p.1444-1446.
- Turner, Francis J., and Verhoogen, Jean
 1960: Igneous and metamorphic petrology; McGraw-Hill Book Co., Inc., New York, 694p.
- Tuttle, O. F., and Bowen, N. L.
 1958: Origin of granite in the light of experimental studies in the system NaAlSi₃O₈-KAlSi₃O₈-SiO₂-H₂O; Geol. Soc. America, Memoir 74, 153p.
- Wilson, J. Tuzo
 1949: Some major structures of the Canadian Shield; Canadian Inst. Min. and Met. Trans., Vol. 52, p.231-242.
- Winkler, H. G. F.
 1967: Petrogenesis of metamorphic rocks; Springer-Verlag, New York, second edition, 237p.

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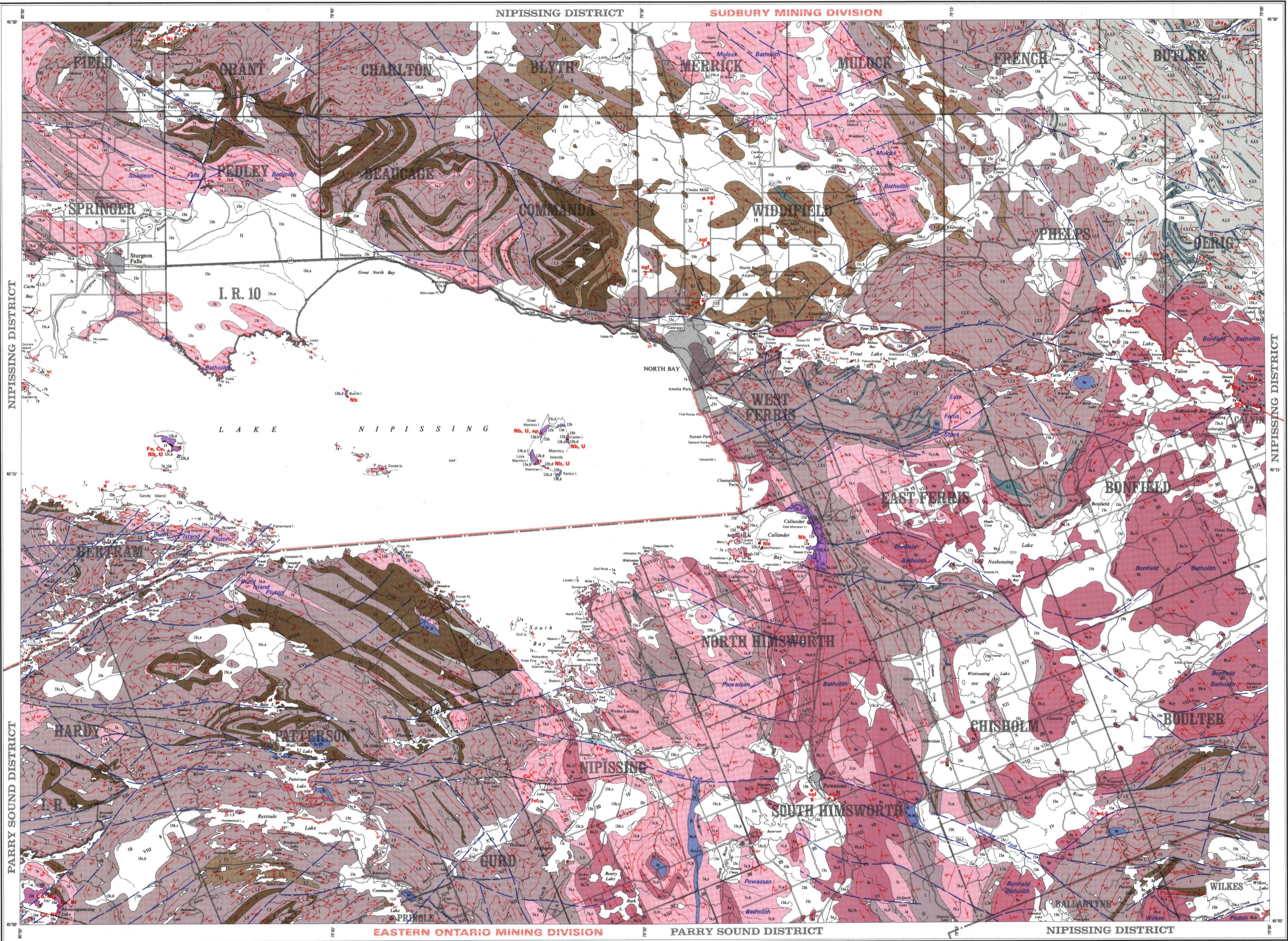
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- LEGEND**
- CENOZOIC***
PLEISTOCENE AND RECENT
15 Swamp accumulations.
15a Boulder gravel, gravel, sand, silt.
15c Boulder clay, varve clay, minor gravel, sand, and silt.
- PALEOZOIC**
UNCLASSIFIED
14 Red, green, and grey mottled quartz sandstone on Iron Island.
- ORDOVICIAN**
Middle Ordovician
13a Limestone, dolostone.
13b Conglomerate, sandstone, shale.
- CAMBRIAN**
UNCLASSIFIED
Alkaline and Related Mafic Intrusive Rocks
12a Nepheline syenite.
12b Felsite, minor alkalic syenite and carbonates; numerous late lamprophyre dikes and carbonate veins.
12c Mafic and ultramafic alkalic rocks; silicofonolite.
12d Lamprophyre dikes.
12e Felsite dikes.
- INTRUSIVE CONTACT**
- PRECAMBRIAN**
LATE PRECAMBRIAN^b
MAFIC INTRUSIVE ROCKS
Diabase Dikes
11 Diabase, quartz diabase.
- INTRUSIVE CONTACT**
- Mafic Stocks
10a Norite and rare olivine gabbro.
10b Unutilized gabbro and melagabbro.
10c Utilized and serpentinized pyroxenite and peridotite.
- INTRUSIVE CONTACT**
- METAMORPHIC COMPLEX** (probably Middle to Late Precambrian)
LATE PEGMATITE^c
Granite pegmatite dikes.
- HIGH RANK REGIONAL METAMORPHISM**
MAFIC PLUTONIC ROCKS^d
10a Melagabbro and melafelsite.
10b Metamorphosed ultramafic rocks.
10c Fine-grained and medium-grained amphibolite dikes; metabasite dikes.
- FELSIC PLUTONIC ROCKS***
Monzonitic Rocks
8a Pink and grey, gneissic, garnet-hornblende monzonitic rocks with minor gneissic granitic rocks.
8b Green, gneissic, pyroxene-bearing, garnet-hornblende monzonitic rocks.
8c Grey, gneissic, quartz diorite and gneissic diorite.
- Granitic Rocks***
7a Migmatitic and gneissic biotite granite and minor hornblende-biotite granite.
7b Migmatitic and gneissic hornblende-biotite granite and minor hornblende-biotite granite.
7c Biotite, granitic and minor biotite granite.
7d Migmatitic, gneissic biotite granite and minor gneissic hornblende-biotite granite.
7e Migmatitic and gneissic garnet-biotite granite.
- INTRUSIVE AND METAMORPHIC CONTACT**
CALCAREOUS METASEDIMENTS*
Carbonate Metasediments
6 Mainly marble with interlayered calc-silicate gneiss.
- Hornblende Gneiss**
5 Calc-silicate gneiss generally with hornblende, quartz, and plagioclase as major constituents and containing variable amounts of biotite, epidote, diopside, garnet, scapolite, and sphene; minor associated amphibolite, garnet amphibolite, and biotite-garnet amphibolite.
- CLASTIC SILICEOUS METASEDIMENTS***
Muscovitic and Quartzose Gneiss
4 Muscovite-feldspar-quartz gneiss and muscovite-quartz gneiss with interlayers of orthoquartzite and hornblende gneiss; interlayers of biotite gneiss and felspathic gneiss present locally; felspathic varieties commonly migmatitic with veins and lenses of granitic material.
- Felspathic Gneiss**
3 Quartz-feldspar gneiss with interlayers of biotite gneiss and migmatitic biotite gneiss; locally kyanite-bearing; some varieties migmatitic with veins and lenses of granitic material.
- Biotite Gneiss**
2 Biotite-quartz-feldspar gneiss and hornblende-biotite-quartz-feldspar gneiss with interlayers of felspathic gneiss, fine-grained hornblende, quartz-feldspar-biotite gneiss, and hornblende gneiss; interlayers of kyanite-biotite-plagioclase gneiss present rarely.
- Migmatitic Biotite Gneiss**
1 Similar to unit (2) but richer in alkalic feldspar and less calcic; veined by ten percent or more granitic material.
- 8 Sulphide mineralization.

- SYMBOLS**
- Gneissosity, (horizontal, inclined, vertical).
 - Lineation with plunge.
 - Geological boundary, position interpreted.
 - Lineament or fault.
 - Anticline, syncline, with plunge.
 - Motor road, provincial highway number encircled where applicable.
 - Other road.
 - Kilnash.
 - Railway, with station, siding, or similar facility.
 - Aircraft landing facilities.
 - District boundary, approximate position only.
 - Township boundary, base or meridian line, approximate position only.
 - Suburb.
 - Mining division boundary, approximate position only.
 - Altitude in feet above mean sea level.
 - Mineral occurrence.
 - Producer.

- PRODUCERS**
- 1 City Sand and Gravel Ltd. Sand and Gravel
 - 2 DeLorme Construction. Sand and Gravel
 - 3 Gonnell Brick and Tile. Clay
 - 4 North Bay Construction Products Ltd. Sand and Gravel
 - 5 Wright, J. M., Ltd. Sand and Gravel
 - 6 Young, Gilbert. Sand and Gravel

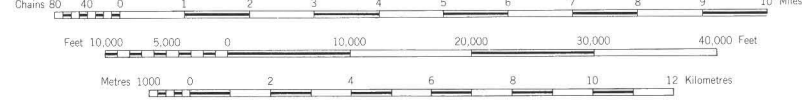
- METAL AND MINERAL REFERENCE**
- As. Arsenic
 - Cl. Clay
 - Cu. Copper
 - F. Feldspar
 - Fe. Iron
 - Ky. Kyanite
 - Mg. Magnesium
 - Mi. Mica
 - Ni. Nickel
 - Nb. Niobium
 - St. Stone
 - U. Uranium
 - S. Sand and Gravel

SOURCES OF INFORMATION

Geology by S. B. Lumbers, 1964, 1965, 1967.
Map No. 606, Nipissing Area, Geological Survey of Canada, 1957.
Map No. 531, Ontario Department of Mines, 1944.
Map No. 516, Ontario Department of Mines, 1942.
Geological Survey of Canada Aeromagnetic Maps 1477G, 1478G, 1487G, 1488G.
Preliminary Map P. 381, North Bay Area, scale 1 inch to 2 miles, re-issued with additions and revisions 1968.
Cartography by C. A. Harris and B. L. Perkins, Ontario Department of Mines and Northern Affairs, 1970.
Base map derived from maps of the Forest Resources Inventory, Ontario Department of Lands and Forests, air photographs, and additional information by S. B. Lumbers.
Magnetic declination in the area varied from 9°W in the western part to 10°W in the eastern part in 1965.

Map 2216
NORTH BAY AREA
NIPISSING AND PARRY SOUND DISTRICTS

Scale 1:126,720 or 1 Inch to 2 Miles



* Only the thickest and most extensive Cenozoic deposits in which bedrock outcrops are absent or scarce, are shown.
* Some mafic intrusive rocks may be Early Paleozoic in age.
* Not shown.
* Multiple ages represented.
* Recrystallized and metamorphosed granite pegmatite dikes are common in these rocks, and migmatitic varieties contain lensoid bodies and discontinuous layers of massive leuco-granite.
* Rocks of these groups are subdivided lithologically and the order does not imply age relationships either within or between groups.