Ontario Geological Survey

Report 201

Geology of the

Bethune Lake Area

Districts of Kenora and Rainy River

By

G.R. Edwards

1983

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FOREWORD

BETHUNE LAKE AREA

This report is part of a series on the detailed mapping of the southwestern part of the Wabigoon Subprovince, east of Highway 71, the Kenora-Fort Frances road. The supracrustal rocks, mainly mafic metavolcanics are cut by a synvolcanic hypabyssal intrusion surrounded by coeval extrusive rocks, and later mafic and ultramafic intrusions. The area has substantial gold potential associated with carbonate-rich cherty exhalite units. The mafic-ultramafic intrusions have Cu-Ni potential.

E.G. Pye
Director
Ontario Geological Survey

CONTENTS

TABLE

FIGURE

PHOTOGRAPHS

Geological Map

(back pocket)

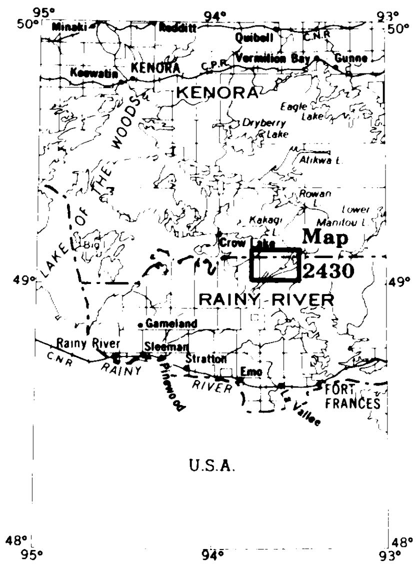

Figure 1–Key map showing location of the Bethune Lake area.
Scale 1:3 168 000 (1 inch to 50 miles).

ABSTRACT

The Bethune Lake map-area (Districts of Kenora and Rainy River) is an area of approximately 260 square km bounded by Latitudes 49°00'N and 49°07'30''N and Longitudes 93°30'W and 93°45'W. Nestor Falls, a small community on Highway 71 midway between Kenora and Fort Frances is located approximately 23 km west of Pipestone Lake.

With the exception of west-northwest-trending late diabase dikes, all bedrock in the area is of Early Precambrian (Archean) age. Variable thicknesses of Pleistocene till cover much of the bedrock.

Rocks west of Pipestone Lake (north of Dad Lake) are a homoclinal sequence of submarine mafic flows intruded by thick, usually composite gabbro sheets and folded in a broad anticline (the Nightjar Anticline) around, and intruded by, an eastward protruding trondhjemite border phase of the Sabaskong Batholith.

Between Helena Lake and the eastern boundary of the map-area, and separated from the homoclinal sequence by the north-northeast-trending Helena-Pipestone Lakes Fault, submarine mafic flows and rare intrusive ultramafic sheets with minor gabbro are folded in an accordion-like fashion with fold axial traces trending roughly northeastward. Gabbros similar to those in the homoclinal sequence are prevalent in the large peninsula west of Ross Island.

South of the south arm of Pipestone Lake, and paralleling the south shore is a 700 to 1000 m wide zone of strongly to weakly regionally metamorphosed mafic volcanic rocks which lie along the north contact of a predominantly syenodioritic intrusion, the Jackfish Lake Complex.

At Loonhaunt Lake the syenodiorite is bounded to the southeast by a leucocratic gneiss and migmatite dome, part of the Rainy Lake Batholith.

Subvolcanic felsic porphyry stocks intrude the homoclinal sequence in the vicinity of Dash and Phinney Lakes. These intrusions may be related to the trondhjemite border phases of the Sabaskong Batholith. Felsic and intermediate extrusive rocks, chert, minor carbonate-rich iron formation, and volcanic conglomerate resulting from the emplacement of the subvolcanic stocks occur north of Dash Lake. Minor felsic and intermediate metavolcanics occur in Line Bay (Pipestone Lake) and along the north shore of Weld Lake and the Manomin River.

Structurally the area is divided along the Helena-Pipestone Lakes Fault. In addition, both the south and north limbs of the Nightjar Anticline are folded, probably because of compression in the limbs.

Faults offset the contact between the Sabaskong Batholith and the bordering supracrustal rocks as well as the contact between the Jackfish Lake Complex and its bordering supracrustal rocks.

Except for amphibolites adjacent to the Jackfish Lake Complex, metamorphic grade of the supracrustal rocks is greenschist or lower.

Gold (0.04 oz/ton) and silver (0.14 oz/ton) (Geoscience Laboratories, Ontario Geological Survey, Toronto) were found to be present in a grab sample taken from an irregular, 5 to 10 cm wide quartz vein at the north tip of the largest island in the northern part of Gates Ajar Narrows (Pipestone Lake). Small amounts of copper were found by analyses of grab samples taken at two locations. A sheared ultramafic sill on Ross Island contains a narrow vein of slip-fibre asbestos. The submarine piercement and extrusive character of the felsic porphyry stock north of Dash Lake is of economic interest as a possible environment for base metal accumulation in an exhalitive environment. In situ gravity fractionation of the mafic and ultramafic sheets may have led to the local accumulation of ilmenite.

Geology of the Bethune Lake Area, Districts of Kenora and Rainy River, by G.R. Edwards, Ontario Geological Survey Report 201, 59p. Published 1983. ISBN 0-7743-5041-5

CONVERSION FACTORS FOR MEASUREMENTS IN ONTARIO GEOLOGICAL SURVEY PUBLICATIONS

If the reader wishes to convert imperial units to SI (metric) units or SI units to imperial units the following multipliers should be used:

CONVERSION FROM SI TO IMPERIAL			**CONVERSION FROM IMPERIAL TO SI**		
SI Unit	*Multiplied by*	*Gives*	*Imperial Unit*	*Multiplied by*	*Gives*
			LENGTH		
1 mm	0.039 37	inches	1 inch	**25.4**	mm
1 cm	0.393 70	inches	1 inch	**2.54**	cm
1 m	3.280 84	feet	1 foot	**0.304 8**	m
1 m	0.049 709 7	chains	1 chain	20.116 8	m
1 km	0.621 371	miles (statute)	1 mile (statute)	**1.609 344**	km
			AREA		
1 cm^2	0.155 0	square inches	1 square inch	**6.451 6**	cm^2
1 m^2	10.763 9	square feet	1 square foot	**0.092 903 04**	m^2
1 km^2	0.386 10	square miles	1 square mile	2.589 988	km^2
1 ha	2.471 054	acres	1 acre	0.404 685 6	ha
			VOLUME		
1 cm^3	0.061 02	cubic inches	1 cubic inch	**16.387 064**	cm^3
1 m^3	35.314 7	cubic feet	1 cubic foot	0.028 316 85	m^3
1 m^3	1.308 0	cubic yards	1 cubic yard	0.764 555	m^3
			CAPACITY		
1 L	1.759 755	pints	1 pint	0.568 261	L
1 L	0.879 877	quarts	1 quart	1.136 522	L
1 L	0.219 969	gallons	1 gallon	**4.546 090**	L
			MASS		
1 g	0.035 273 96	ounces (avdp)	1 ounce (avdp)	28.349 523	g
1 g	0.032 150 75	ounces (troy)	1 ounce (troy)	**31.103 476 8**	g
1 kg	2.204 62	pounds (avdp)	1 pound (avdp)	**0.453 592 37**	kg
1 kg	0.001 102 3	tons (short)	1 ton (short)	**907.184 74**	kg
1 t	1.102 311	tons (short)	1 ton (short)	**0.907 184 74**	t
1 kg	0.000 984 21	tons (long)	1 ton (long)	**1016.046 908 8**	kg
1 t	0.984 206 5	tons (long)	1 ton (long)	**1.016 046 908 8**	t
			CONCENTRATION		
1 g/t	0.029 166 6	ounce (troy)/ ton (short)	1 ounce (troy)/ ton (short)	34.285 714 2	g/t
1 g/t	0.583 333 33	pennyweights/ ton (short)	1 pennyweight/ ton (short)	1.714 285 7	g/t

OTHER USEFUL CONVERSION FACTORS

1 ounce (troy)/ton (short)	20.0	pennyweights/ton (short)
1 pennyweight/ton (short)	0.05	ounce (troy)/ton (short)

NOTE–Conversion factors which are in bold type are exact. The conversion factors have been taken from or have been derived from factors given in the Metric Practice Guide for the Canadian Mining and Metallurgical Industries published by The Mining Association of Canada in co-operation with the Coal Association of Canada.

Geology of the

Bethune Lake Area

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by

G.R. Edwards[1]

INTRODUCTION

The Bethune Lake map-area, Districts of Kenora and Rainy River is an area of approximately 260 square km bounded by Latitudes 49°00'N and 49°07'30''N and Longitudes 93°30'W and 93°45'W. Nestor Falls, a small community on Highway 71 midway between Kenora and Fort Frances, is located approximately 23 km west of Pipestone Lake.

Exploration Activity

Surface exploration for gold appears to have been extensive during the minor gold "rush" of the early 1930s leading to the discovery of gold occurrences between Bethune and Knauf Lakes (the Bethune claims; Thomson 1936) and north of Line Bay (Pipestone Lake) just east of the present map-area. In 1960, Lun-Echo Gold Mines Limited (4)[2] diamond drilled two holes on a claim west of Helena Lake after gold values were reported from surface work grab samples (Assessment Files Research Office, Ontario Geological Survey, Toronto).

Records of the Assessment Files Research Office, Ontario Geological Survey, Toronto suggest that the Bethune Lake area has not been extensively explored for base metals although much work not submitted for assessment appears to have been performed.

In 1967 and 1969, the Canadian Nickel Company Limited (2) diamond drilled at three locations south of Pipestone Lake for a total footage of 464 feet (Assessment Files Research Office, Ontario Geological Survey, Toronto). The holes were spaced 2 miles apart along strike of magnetic cherty sulphide iron formation (pyrite, pyrrhotite) which parallels Pipestone Lake within migma-

[1]Geologist, Precambrian Section, Ontario Geological Survey, Toronto.
Manuscript accepted for publication by the Chief Geologist, May 31, 1978.
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[2]Numbers in parentheses refer to property number on Map 2430 (back pocket).

tite and banded amphibolite located approximately 152 m north of the batholith-metavolcanic contact.

In 1971 and 1972, following a large-scale airborne E.M. survey, Freeport Canadian Exploration Company (3) diamond drilled five holes on two claims for a total footage of 1,354 feet on two electromagnetic anomalies in two areas, each near a lake in the northern part of the map-area (Assessment Files Research Office, Ontario Geological Survey, Toronto).

Noranda Mines Limited (5) conducted a ground electromagnetic and magnetic survey on six claims over the southern part of Weld Lake in 1968 (Assessment Files Research Office, Ontario Geological Survey, Toronto).

As of December 31, 1975, two groups of claims were in good standing. These are: 1) six claims belonging to Freeport Canadian Exploration Company (3) located on the unnamed lake 3.2 km southwest of Phinney Lake and 2) eight patented claims between Dash and Pipestone Lakes, licenced to D.R. Young (6).

Means of Access

Pipestone Lake is accessible by boat from the north end of Highway 615 on Burditt (Clearwater) Lake, 45 km northwest of Fort Frances. A mechanical portage is presently in service at the north end of Burditt Lake which for boats is the most viable method of ascent from the level of Burditt Lake to that of Bethune Lake. Once into Pipestone Lake, good access is provided to Kishkutena, Loonhaunt, Dash, Phinney, Katimiagamak, and numerous other lakes by an interconnecting chain of waterways and portages. This facilitates canoe penetration to within 2.5 km of all points in the area.

Present Geological Survey

The pace-and-compass method was employed, recording outcrop location and shape and field data on 1 inch to ¼ mile photographs. Mapping was performed by the author and assistants in the summer of 1975. Traverses were laid out in such a fashion as to attempt to see as much outcrop as possible and to cross the strike of the units. Where exposure is poor, an effort was made, using air photographs, to outline possible outcrop areas and give these areas priority when traversing. Field data were transferred to a base map prepared by the Cartography Section of the Ontario Division of Lands (scale 1 inch to ¼ mile).

A preliminary map at a scale of 1 inch to ¼ mile was published at an earlier date (Edwards and Lorsong 1976).

Previous Geological Work

Most of the Bethune Lake map-area was described by J.E. Thomson (1936). Earlier reconnaissance work was performed by A.C. Lawson (1887) and A.P. Coleman (1895, p.60-61; 1897, p.88).

Regional geological relationships were synthesized by A.M. Goodwin (1965) and were compiled in the Kenora-Fort Frances Sheet, Map 2115 (Davies and Pryslak 1967).

Recent mapping also on a reconnaissance scale (1 inch to ½ mile) was performed by C.E. Blackburn (1976a) in an area adjacent to and south of the present map-area, and on a detailed scale by L. Kaye (1974) to the northwest and by G.R. Edwards (1980) to the north.

Physiography

Topography in the map-area is typical of the Canadian Shield with about 20 percent of the area being outcrop. Locally, relief is in excess of 150 feet with maximum difference in elevation being about 400 feet. The lowest point in elevation is at Burditt Lake, close to 1,150 feet and the highest point is well over 1,500 feet south of central Dash Lake. Relief is most rugged along the northwest shore of Pipestone Lake (including the Manomin River) where resistant gabbro sills have intruded mafic flows. Elsewhere, gabbro sills are responsible for strong, local, positive relief features.

Southeast of Pipestone Lake the country is poorly drained and plateau-like, being underlain by relatively homogeneous syenodiorite. Outcrop areas here are of low relief and commonly tree covered. Between Kishkutena and Carver Lakes the country is low in relief with few outcrops but north of a line between Carver and Nightjar Lakes it rises to a 1.6 km wide outcrop plateau extending west-northwest from Nightjar Lake.

No relief features attributable to glacial deposits were found in the map-area.

North of Dash Lake west from the lake just southeast of Phinney Lake and including the area between Phinney Lake and the unnamed lake 3.2 km southwest of Phinney Lake, bedrock is largely covered by unstratified glacial drift or till. Bedrock exposed in this area indicates that much of the rock overlain by till is sheared, carbonatized, or both.

The sloping southeast shore of Pipestone Lake between Weld Lake and the Stonedam Lake channel is mainly covered with a thin veneer of till.

All natural waterways in the map-area are part of the Arctic watershed. Katimiagamak, Carver, and Kishkutena Lakes (including Nightjar and Knauf Lakes) drain westward via the Sabaskong River system into Lake of the Woods. The remaining lakes drain into Rainy Lake, which empties into Lake of the Woods via the Rainy River.

Acknowledgments

Capable assistance in the field was provided by James Lorsong, Richard Sutcliffe, Robert Boraks, and James Keay. Lorsong and Sutcliffe were responsible for part of the mapping and interpretation.

The author wishes also to thank Northwestern Flying Services Limited, Nestor Falls, for the use of their radio frequency.

GENERAL GEOLOGY

Briefly, the area mapped consists of a folded belt of metamorphosed, submarine mafic flows and subsidiary felsic flows and pyroclastic rocks which were intruded pretectonically by contemporaneous intrusions of quartz-hornblende gabbro, leucocratic gabbro, and peridotite, and later intrusions of quartz-feldspar porphyry and trondhjemite; syntectonically by quartz-feldspar porphyry, trondhjemite and hornblende diorite (Sabaskong Batholith); and both syntectonically and posttectonically by biotite-hornblende syenodiorite and pyroxene-hornblende syenodiorite (Jackfish Lake Complex). At the present level of exposure, gabbro comprises approximately 30 percent of the basalt sequence in the map-area. A sequence of homoclinal mafic flows and gabbro attain an apparent thickness of about 4600 m in the hinge of the Nightjar Lake Anticline between Nightjar Lake and Silver Lake.

The metavolcanic belt is folded in a broad anticline (Nightjar Lake Anticline) about the Sabaskong Batholith which lies to the west and is bounded to the east and southeast by the Jackfish Lake Complex (Blackburn 1976a).

Submarine, mainly pillowed, metamorphosed mafic flows comprise approximately 40 percent of the metavolcanic belt in the present area. Mafic flow breccia with associated minor hyaloclastite is conspicuous 900 to 1200 m north and west of Burditt Lake. Porphyritic (plagioclase) mafic flows are common along the south shore of Pipestone Lake, in the large peninsula northwest of Line Bay, in flows adjacent to the Sabaskong Batholith, and in a zone which extends from the west side of the peninsula east of Gates Ajar Narrows to the peninsula northwest of Ross Island. Amygdules are only common in mafic flows in the northeastern part of the map-area. Mafic and intermediate tuff is exposed on the north shore of Burditt Lake south of the portage into Pipestone Lake, and bedded mafic tuff is exposed 760 m south of Silver Lake at the tip of a point in Pipestone Lake.

Conspicuously light coloured mafic flows are along part of the north shore of Line Bay just west of a narrow 150 m band of intermediate pyroclastic rocks at the eastern edge of the map-area. Similar pyroclastic rocks are to the southwest near Weld Lake.

Felsic pyroclastic rocks, flows and associated volcaniclastic conglomerate, chert, iron formation, and ferruginous synvolcanic breccia which consists of felsic porphyry clasts suspended in a matrix of iron oxides and iron carbonate occur north and northeast of Dash Lake and are intimately associated with a felsic intrusive porphyry complex, the Phinney-Dash Lake Complex and the Dash Lake Stock. These rocks represent a felsic extrusive volcanic centre hitherto unreported. Related felsic pyroclastic rocks also occur on the small island and shore in the southern part of Phinney Lake and appear to extend westward along Phinney Creek occurring again at the long, unnamed, west-trending lake, southwest of Phinney Lake.

Poorly bedded volcaniclastic wacke is interbedded with mafic flows and is in contact with quartz-amphibole gabbro in Gates Ajar Narrows. Thin remnants of these metasediments can be found along strike at isolated locations in shoreline exposures along Bethune Lake, usually in contact with gabbro.

Three major types of gabbro are distinguished in the field; in order of abundance these are quartz-amphibole (magnetite) gabbro, leucocratic gabbro (anorthositic gabbro?), and ophitic gabbro. Quartz-amphibole (magnetite) gabbro is most common forming about 25 percent of the metavolcanic belt and having strong positive physiographic relief. Where fine-grained, the quartz gabbro is difficult to distinguish from flow (or tuff) into which it may grade but it can usually be recognized on close scrutiny by the presence of very small quartz "eyes" and commonly up to 20 percent leucoxene (see section on "Economic Geology"). Leucocratic gabbro mafic content ranges from 25 to 40 percent but in shoreline exposures on Katimiagamak Lake is as little as 20 percent. Ophitic gabbro mainly occurs near and south from Katimiagamak Lake. All three gabbro types are intimately related, forming concomitant composite sills. Discrete, concordant, ultramafic intrusions, which are associated with the gabbros but are not a result of in situ crystal settling in gabbro, are altered both to serpentinite, (rarely with chrysotile) and to a talc-carbonate rock. Talc and serpentine pseudomorphs indicate that at least some of these rocks were dunitic in composition. Continuity relates the composite mafic-ultramafic complex of Pipestone Lake to the similar, fresher appearing rocks at Kakagi Lake.

The Phinney-Dash Lake Complex (intrusive phase) is a shallow level trondhjemitic quartz-feldspar porphyry intrusion consisting mainly of sills, dikes, and small isolated stocks, closely associated with extrusive equivalents north of Dash Lake. The coarser grained Dash Lake Stock, part of which encompasses the southwest arm of Dash Lake, is similar to, and probably the lower level equivalent of, the Phinney-Dash Lake Complex, but contains well formed altered hornblende laths in addition to large quartz phenocrysts.

Leucocratic trondhjemite forms a 4.8 km long, 900 m thick intrusive body (the Silver Lake Stock) between Dash and Pipestone Lakes and appears to have intruded the Dash Lake Stock. This intrusion may be in part structurally controlled.

Sodic syenite forms a small stock 1100 m by 450 m southeast of the southwest arm of Dash Lake.

The Sabaskong Batholith (Blackburn 1976a) is represented in the map-area mainly by equigranular biotite trondhjemite. It is strictly phaneritic except for a narrow crescent of quartz-feldspar porphyry and felsite between Knauf and Nightjar Lakes. A small satellitic stock of hornblende diorite, included as part of the Sabaskong Batholith, is 1800 m north of Carver Lake.

The equigranular syenodiorite of the Jackfish Lake Complex (Blackburn 1976a) is composed of three indistinct zones in the map-area; a northern (outer) biotite hornblende zone, a middle pyroxene-hornblende zone, and a southern (inner) pyroxene zone. The north contact with the mafic metavolcanics is primarily stromatic and agmatic contact migmatite (Mehnert 1968).

At Loonhaunt Lake, the Jackfish Lake Complex is in contact with a gneiss-migmatite mass which extends out of the map-area. The contact is generally not sharp and in one locality appears to be gradational over 15 m. The gneiss-migmatite belt has two major zones, a 600 to 1500 m wide northern heterophanous (stromatic) zone consisting of biotite-rich layers interlaminated with quartzofeldspathic layers, and a southern homophanous zone of unknown extent of biotite-trondhjemite gneiss displaying relict migmatite structures.

Discontinuous, coarse-grained lamprophyric dikes intrude gneiss, Jackfish

TABLE 1 | TABLE OF LITHOLOGIC UNITS FOR BETHUNE LAKE AREA

PHANEROZOIC
CENOZOIC
QUATERNARY
RECENT
Unconsolidated swamp and lake deposits
PLEISTOCENE
Till (unconsolidated)

Unconformity

PRECAMBRIAN
MIDDLE TO LATE PRECAMBRIAN (PROTEROZOIC)
MAFIC INTRUSIVE ROCKS
Diabase

Intrusive Contact

EARLY PRECAMBRIAN (ARCHEAN)
LATE MAFIC INTRUSIVE ROCKS
Lamprophyre

Intrusive Contact

FELSIC TO MAFIC INTRUSIVE ROCKS
RAINY LAKE BATHOLITH
Jackfish Lake Complex
Biotite-hornblende syenodiorite, clinopyroxene-hornblende syenodiorite (both phases may be quartz-bearing), hornblende-clinopyroxene syenodiorite, syenogabbro

Intrusive Contact

Gneiss and Migmatite
Stromatic gneiss of intermediate composition, amphibolite pods with agmatic structures, granitic rocks with relict migmatite structures
SABASKONG BATHOLITH
Trondhjemite, quartz-feldspar porphyry, felsite, agmatite, hornblende diorite
INTRAVOLCANIC PLUTONS
Silver Lake Stock
Trondhjemite, agmatite
Dash Lake Stock and Hornberg Lake Stock
Amphibole-quartz-feldspar porphyry (hornblende trondhjemite), quartz-feldspar porphyry, oligoclase syenite
Phinney-Dash Lake Complex (Intrusive Phase)
Quartz-feldspar porphyry, feldspar porphyry, felsite, carbonatized, carbonate-sericite schist

Intrusive Contact

METAMORPHOSED MAFIC AND ULTRAMAFIC INTRUSIVE ROCKS
ULTRAMAFIC INTRUSIVE ROCKS
Talcose and serpentinized pyroxenite and peridotite (in part dunite), talc-carbonate schist, silicified-carbonatized ultramafic sills

MAFIC INTRUSIVE ROCKS

Gabbro, leucocratic gabbro, diorite, amphibole gabbro, (magnetite)-quartz-amphibole gabbro (leucoxene-bearing in part), gabbro migmatite, talcose-serpentinized gabbro, amphibolite, porphyritic (plagioclase) gabbro, diabasic gabbro, ophitic gabbro, flaser gabbro, hybrid gabbro, carbonatized gabbro, chlorite schist

Intrusive Contact

METAVOLCANICS AND METASEDIMENTS

CHEMICAL METASEDIMENTS

Chert, ferruginous chert, cherty iron formation, iron formation

CLASTIC METASEDIMENTS

Feldspathic volcanic sandstone, thin banded, ferruginous, tuffaceous interflow metasediments, sericite schist

FELSIC METAVOLCANICS

Flow, fragmental flow, tuff, lapilli-tuff, tuff-breccia, ferruginous (synvolcanic) breccia, sericite schist, carbonatized pyroclastic rocks

INTERMEDIATE METAVOLCANICS

Tuff, lapilli-tuff, tuff-breccia, volcaniclastic conglomerate, schist

MAFIC METAVOLCANICS

Flow, pillow flow, amygdaloidal flow, variolitic flow, massive flow, coarse-grained (gabbroic) flow, porphyritic flow, flow breccia, pillow breccia, tuff, chlorite schist, biotite schist, amphibolite, carbonatized flow, magnetite-bearing flow, hornblende-garnet, garnet-feldspar, feldspar-biotite, and magnetite-biotite schist, migmatite and agmatic and stromatic migmatite

---

Lake syenodiorite, amphibolites, and mafic flows. One 15 m wide dike extends north-northeastward from south of the channel between Pipestone and Stonedam Lakes to the south shore of Pipestone Lake.

A list of lithologic units encountered in the map-area is contained in Table 1.

Early Precambrian (Archean)

METAVOLCANICS AND METASEDIMENTS

Mafic Metavolcanics

Mafic metavolcanics in the area are represented primarily by flows but flow breccia, including pillow breccia and hyaloclastic pillow breccia as well as tuff are subordinate. Mafic rocks forming the homoclinal sequence between the Sabaskong Batholith and Dash Lake are the oldest or lowest identifiable stratigraphic sequence in the area. They are continuous with the homoclinal sequence between Kakagi Lake and Katimiagamak Lake as described by Edwards (1980).

Except for a band of mafic rocks varying in thickness from about 600 to 900 m adjacent to the Sabaskong Batholith, the bulk of the mafic metavolcanics in the map-area including those east of the Helena-Pipestone Lakes Fault best fit the category of Middle Mafic Group as defined by M.G. Morrice (1974). Some metavolcanics adjacent to the Sabaskong Batholith are thought by the author to be more akin to the Lower Mafic Group of Morrice (1974).

MAFIC FLOWS

Lower Mafic Group

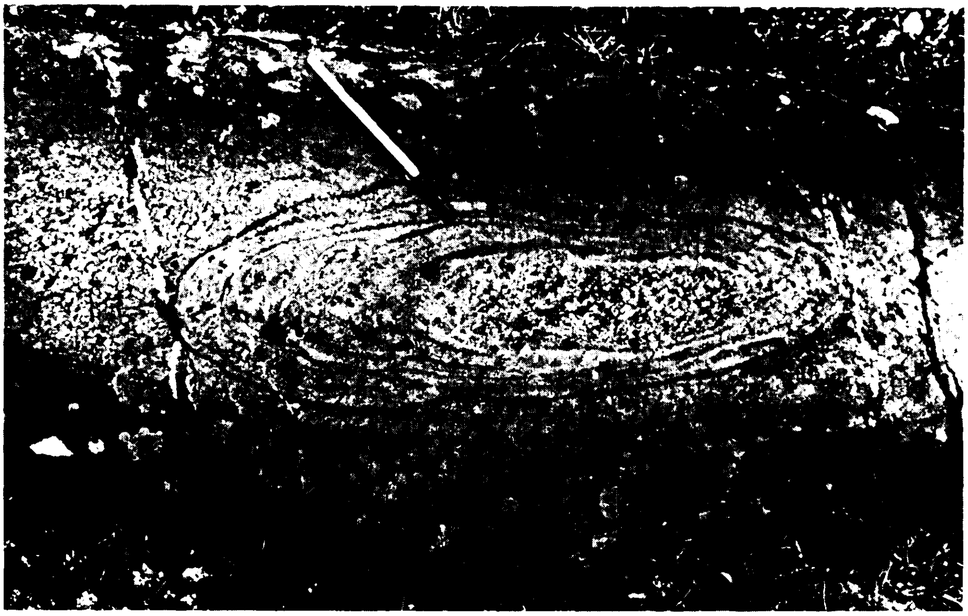
Possible lower mafic group as defined by Morrice (1974) may be represented in the map-area by a poorly defined 300 to 900 m thick sequence adjacent to the Sabaskong Batholith. This sequence is characterized by dark green- to reddish brown-weathering (dark green to blue-black fresh surface) pillowed flows, and fine to coarse massive flows commonly containing 10 to 20 percent plagioclase phenocrysts. Pillows are thinly to thickly selvaged with little or no interstitial material.

Middle Mafic Group

In the homoclinal sequence, anticlinally folded around the Sabaskong Batholith, the boundary between Lower Mafic Group and Middle Mafic Group appears to be best represented by a change from dark green to light grey-green- to buff-weathering flows (and correspondingly light coloured fresh surfaces). Pillow shapes in many outcrops resemble pahoehoe toes rather than typical pillow shapes and selvages tend to be less regular in thickness. Flattened pillow forms with a horizontal elongation factor of 2 or 3 times are present in mafic flows in the contact zone of the Jackfish Lake Complex but top determinations could not be made because of deformation. Porphyritic (plagioclase) flows are less common and, where they do occur, the concentration of phenocrysts is usually less than 5 percent. Pillowed and unpillowed flows east of the Helena-Pipestone Lakes Fault have numerous plagioclase phenocryst-rich zones.

Porphyritic flows are also common along the south shore of Pipestone Lake from south of Ross Island eastward.

Amygdules in mafic flows are generally not common except in some flows east of the Helena-Pipestone Lakes Fault especially in the extreme northeastern part of the map-area, where predominantly calcite-filled amygdules are usually weathered out leaving vesicular pits accounting for up to 20 percent of the volume of the rock in some outcrops. Varioles too are found only in some flows in the northeastern part of the map-area. A discontinuous zone of variolite flow, 30 to 60 m thick, trends north-northeast along part of the east shore-



OGS 10 460

Photo 1–Elliptical, concentric laminations in a variolitic mafic dike which intrudes mafic flows in James Bay (Pipestone Lake).

line of James Bay, Pipestone Lake. Here varioles up to 5 mm form as much as 60 percent of the bulk of some pillows being sparse at the rims but coalescing toward the centre of the pillow. The incipient formation of large numbers of varioles may account for the light colour of some mafic flows in the area.

Most flows in the area are pillowed, at least in part, although many contain massive zones of a subordinate nature. Some difficulty arose in determining whether the rock is fine- to medium-grained gabbro or coarse massive flow in shoreline outcrop along the south shore of Hornberg Lake. The same problem arose along strike on the west shore of Bethune Lake as well as in some exposures between Silver Lake and Dash Lake.

Between Helena Lake and the unnamed lake at the eastern occurrence of The Freeport Canadian Exploration Company (3) and along the northwest shore of the east part of Dash Lake, some fine- to medium-grained altered mafic rocks contain small quartz "eyes" (up to 2 mm) and/or leucoxene pseudomorphs up to 3 mm in size. These were classed as gabbro because of their similarity to rocks known to be fine- to medium-grained margins of the quartz-amphibole gabbro described later. These criteria were generally used when other more obvious determinative criteria were lacking.

Minute magnetite octahedra are in amounts up to 15 percent in some rocks mapped as mafic flows as well as the gabbro in these two areas. However, coarse-grained quartz-amphibole gabbro elsewhere in the area commonly has magnetite and it is probable that some rocks mapped as magnetite-bearing massive mafic flows may be fine- to medium-grained subvolcanic gabbro.

In some shoreline exposures on Pipestone Lake, at the extreme northeastern part of the map-area, rare discordant "basalt" dikes similar in composition to the host pillowed mafic flows appear to be closely related to the extrusion of the host. One such dike (Photo 1) is variolitic, has a flow laminated contact, and shows evidence of "lava tube"-like flow in its interior.

PETROGRAPHY

Primary igneous mineralogy has not been preserved in most of the thin sections studied by the author. In general, the mafic component is represented by 40 to 65 percent secondary tremolite or actinolite exhibiting various textures from fine shreddy or felty replacement of groundmass in fine-grained flows to coarse pseudomorphic replacement of primary ophitic clinopyroxene or amphibole components in coarse-grained flows. Rarely, up to 15 percent chlorite also is a fine groundmass alteration in some flows.

Plagioclase is generally altered to epidote or clinozoisite commonly with chlorite, or to saussurite. Where plagioclase is preserved, the Michel-Levy test yielded An_{70} to An_{80} in one thin section. In altered rocks where saussuritization is more or less complete, albite representing about 30 percent by volume of the original plagioclase is commonly associated with the saussurite. Plagioclase, with its alteration products, accounts for between 20 and 50 percent of the rock in thin sections examined by the author. Plagioclase phenocrysts (up to 1.5 cm) are always completely saussuritized.

Other accessory minerals include: magnetite 4 to 10 percent; leucoxene 0 to 8 percent; quartz either as a metamorphic mineral, or more probably hydrothermally introduced, up to 7 percent; and secondary carbonate, up to 10 percent.

These mineral assemblages indicate that the mafic metavolcanics have been in part equilibrated to greenschist facies of metamorphism comparable to that defined by H.G.F. Winkler (1967).

Textures vary in the flows depending on grain size. Coarse flows (1 cm grain size) tend to have relict ophitic texture (amphibole) mimicking a similar primary texture (pyroxene). Subdiabasic texture is present in one medium-grained flow. Fine-grained flows have generally equigranular, mainly fine-grained secondary minerals.

FLOW BRECCIA

Narrow zones of flow breccia are in shoreline exposures on Tompkins and Graham Lakes, northwest of Burditt Lake.

Here, a series of breccias varying in widths from narrow, vaguely fragmental zones into zones 60 to 90 m thick containing fragmented horizons up to 5 m thick mark tops to thicker pillowed horizons. Characteristics of the breccia horizons vary; some appear to be flow brecciated in situ, whereas others are more like zones of incipient pillow formation in which contemporaneous brecciation

OGS 10 461

Photo 2–Irregularly shaped vesicular pillows in a matrix rich in aquagene tuff and larger volcanic fragments. East shore of the small lake northwest of the south tip of Slender Lake.

has taken place. These grade into zones of definite phreato-magmatic explosion breccia.

In one 4 m thick zone located on the point in the small lake southwest of Slender Lake highly vesiculated ellipsoidal pillow-like structures in the order of 10 by 20 cm in size with highly vesiculated 2 cm thick rims occur sporadically (Photo 2). Most of the fragments, which commonly have perlitic cracks, are ellipsoidal "lumps" outlined by very thin selvages of black shiny devitrified glass. The "lumps" average 5 to 10 cm in length and are aligned with the large vesicles. These forms give way to a "lumpy" form of breccia with scattered pillows to the northeast and to a hyaloclastic rock with occasional "lumps" and vugs to the southwest. The transition occurs over a distance of about 250 m along strike. Brecciated flows in shoreline exposure at Katimiagamak Lake are also of this type.

About 420 m north of the northeastern edge of the small lake 2100 m along the west boundary of the area, south of Kishkutena Lake, there is a 20 m thick sequence of four breccia units averaging 5 m thick. These breccias are characterized by light coloured angular fragments in a matrix of dark coloured devitrified glass shards (hyaloclastite). The fragments are typically 3 to 4 cm in length and are round to angular shaped. Large ellipsoidal, well rounded fragments occur within the lower part of the unit (Photo 3). Weathered colour is a rusty orange and the fresh surface is a medium green to black.

In an outcrop 210 m north of the breccia just described is a flow-top breccia,

OGS 10 462

Photo 3–Lower part of a mafic flow breccia. Irregularly shaped flow "lumps" exhibiting narrow, darker coloured reaction rims are set in a matrix of aquagene tuff and altered glass shards. 915 m south of Kishkutena Lake, 610 m east of the western boundary of the map-area.

containing angular tabular fragments up to 5 by 2 cm in size which generally display chilled margins. Siliceous cement fills the interstices (15 percent) and hyaloclastite matrix is lacking.

Locally, breccia with incipient pillows and hyaloclastite, intercalated with pillowed flows, is exposed in south-central Katimiagamak Lake (Photos 4 and 5).

TUFF

Mafic to intermediate tuff is exposed at the north end (north shore) of Burditt Lake, in thin zones along the north shore of the Manomin River and Weld Lake, in the bay of Pipestone Lake south of Silver Lake, and along part of the north shore of Line Bay. Tuffaceous-appearing zones are also present in some outcrops on the island at the extreme northeastern corner of the map-area. In the Burditt Lake-Manomin River-Weld Lake area the band of tuff is 120 m thick at Burditt Lake, but thins northeastward. This is a unit which is very fine grained, having a shardy or ashy appearance. Larger fragments up to about 15 cm are present in a narrow band extending about 15 m back from the shore at Burditt Lake. These are undoubtedly a result of the same paleoenvironment

OGS 10 463

Photo 4–Mafic flow breccia and hyaloclastite on a small island in the south-central part of Katimiagamak Lake, 1400 m east of the western boundary of the map-area.

OGS 10 464

Photo 5–Close up of central part of Photo 4 showing hyaloclastite fragments and reaction rims.

which resulted in numerous brecciated flows north of this occurrence. The tuff is rather rusty to grey and green.

The mafic (to intermediate) tuff is accompanied by felsic horizons as at the Manomin River, south of the centre of Slender Lake. Tuff along the north shore of Line Bay is similar to that just described but is intercalated with a unit of intermediate lapilli-tuff and tuff-breccia at the edge of the map-area.

A northeast-trending 45 m thick band of mafic tuff is in the aforementioned bay on Pipestone Lake south of Silver Lake. This unit is dark green on weathered and fresh surface and has two small cherty horizons less than 30 cm thick. A zone of 10 percent plagioclase phenocrysts up to 2.5 cm across occurs in similar rock in an adjacent outcrop to the south but it is uncertain if this is tuff or the fine part of a gabbro adjacent to the tuff.

CARBONATIZATION

Alteration, mainly in the form of carbonatization, has affected some mafic flows in the north-central and northeastern parts of the map-area. Flows in the peninsula at the Gates Ajar Narrows in Pipestone Lake southeast of Line Bay have numerous carbonatized zones which may render the rock unidentifiable. This carbonatization is thought by the author to be linked with deformation zones along the Pipestone-Cameron Lakes Fault (Edwards 1980) and has affected generally, rocks in a zone north of and continuous with this area under discussion.

The nature of penetration of carbonatizing medium in the present area appears mainly to be along faults parallel to strata or along rock unit contacts. Some carbonatization was effected in rocks adjacent to talcose and carbonatized ultramafic sills.

Southwest of Phinney Lake, in an area largely covered with till, much of the observed outcrop is carbonatized to some degree. This is part of a broad zone extending parallel to the Phinney Creek Fault. Some flows in the Helena-Pipestone Lakes Fault zone are also heavily carbonatized.

Intermediate and Felsic Metavolcanics

Intermediate and felsic metavolcanics though distinguished separately in the field are described together because of the intimate nature of their relationship in forming the extrusive phase of the Phinney-Dash Lake Complex.

Thin units of intermediate pyroclastic rocks do occur with mafic tuff (as previously described) in the Manomin River and Line Bay areas and associated possible felsic tuff and sericite schist 75 m thick occur on the Manomin River 600 m south-southwest of the southern tip of Campbell Lake. These occurrences, though, are not related to volcanic rocks of the Phinney-Dash Lake Complex (extrusive phase) which is described below.

PHINNEY-DASH LAKE COMPLEX: EXTRUSIVE PHASE

General Description

Felsic and intermediate pyroclastic rocks and volcaniclastic conglomerate, ferruginous carbonate-rich breccia, felsic flow, ferruginous, carbonate-rich chert, and hematitic-limonitic iron formation form the extrusive phase of the Phinney-Dash Lake Complex.

The form of the complex is roughly trilobate as described under "Structural Geology". Two arms extend roughly from east of Dash Lake where the complex apparently terminates against the Helena-Pipestone Lakes Fault and pass out of the map-area to the north (see Edwards 1980). The third arm, tangential to the first two, extends westward north of the unnamed lake southeast of Phinney Lake and interpreted by the author to extend as far west as the west end of the unnamed lake, 3.2 km southwest of Phinney Lake.

The form of the extrusive complex is further disrupted by partly dilative, contemporaneous and consanguineous quartz-feldspar porphyry intrusions. Southwest of the unnamed lake southeast of Phinney Lake, the pyroclastic rocks and porphyry intrusions are partly contextural and in some outcrops difficult to distinguish from each other. The general picture is one of a rising felsic magma intruding its own ejecta, a situation not unlike that found in some Andean volcanic plutonic sequences in Peru (Meyers 1975).

Description of Lithologies

FELSIC PYROCLASTIC ROCKS

In the vicinity of the unnamed lake southeast of Phinney Lake, Phinney Lake, the unnamed lake 3.2 km southwest of Phinney Lake, and to a lesser extent south-southeast of the unnamed lake east-southeast of Phinney Lake (at Property 3), the felsic pyroclastic rocks are light beige- to white-weathering homolithologic lapilli-tuff in which there is commonly little contrast between fragments and matrix material.

Fragments are generally similar in appearance, subangular to subrounded, feldspar, and to a lesser extent, quartz porphyritic to aphanitic containing 20 to 60 percent phenocrysts (seldom more than 10 percent quartz) and comprise anywhere from 5 percent to, in rare instances, 90 percent of the rock. Matrix material (tuff size) is commonly crystal tuff generally containing a greater percentage of plagioclase phenocrysts and is generally darker coloured than the fragments. Tuff-breccia is less common than lapilli-tuff and fragments greater than 30 cm in size were not observed. There are breccia-size fragments in some shoreline outcrops on the northern part of the unnamed lake southeast of Phinney Lake and more rarely in the band of felsic pyroclastic rocks passing through the unnamed lake, east-southeast of Phinney Lake (at Property 3).

Rocks classed as felsic metavolcanics trending roughly north-south through this latter unnamed lake are intercalated with, and in part, gradational with intermediate pyroclastic rocks and volcaniclastic conglomerate. This 150 to 900 m wide zone of mixed compositions also contains at least one felsic flow (one just south of the unnamed lake, east-southeast of Phinney Lake, at Property 3) and several smaller zones of fine-grained felsite which have been classed as flow as well as a peculiar ferruginous synvolcanic breccia. Chert, ferruginous chert, and hematitic-limonitic iron formation form minor members of this sequence.

Felsic pyroclastic rocks in this zone tend to be more of a heterolithologic variety containing felsic fragments of more varying crystallinities although fragment composition varies little. Except for a few zones, as mentioned above, fragments larger than lapilli-size were not found.

Four thin sections of felsic lapilli-tuff were studied by the author. In each, plagioclase phenocrysts in fragments and phenoclasts in the matrix, are nearly completely sericitized or in rarer instances replaced by carbonate. Quartz occurs as subangular to subrounded commonly broken clasts in the matrix, up to 6 mm across. Generally, lapilli composition is similar to that of the matrix except that the matrix is coarser grained, contains more carbonate alteration, and rarely develops small discontinuous lenses of sericite and chlorite.

In one thin section, several fragments comprising about 10 percent of the rock, contain 40 to 60 percent pale green chlorite, minor quartz and magnetite, and other fine-grained unidentified material. In the same section, chlorite and carbonate appear to replace some of the matrix material and it could be that some fragments have been selectively altered along with the matrix.

FELSIC FLOW

A felsic flow or group of felsic flows are south of the unnamed lake east-southeast of Phinney Lake at Property 3 in a zone extending south from the south shore of this lake for 600 m. From exposure the width is at least 60 m but it could be wider. The flow (or flows) is characterized by a massive aphanitic white-weathering cream rock commonly containing quartz phenocrysts up to 1 mm in size and numerous, usually barely visible flow banded and indistinct fragment zones (Photo 6). Flow banding is manifested by slightly different coloured (light cream to cream) streaks and grades into streaky nebulous fragmental horizons containing flow banded fragments, up to 45 cm in size.

Other aphanitic rocks similar to those described above may also be felsic flow. These are: a) along the creek between the unnamed lake east-southeast of Phinney Lake at Property 3 and the lake north of this lake; b) 300 m east of the centre of the lake north of the aforementioned lake at Property 3; c) on the south shore of the small lake 600 m south-southeast of this same lake at Property 3; and d) 420 m southwest of the last mentioned small lake.

Each of four thin sections of the flows exhibits some degree of brecciation in which there is little contrast between fragments and matrix. In three sections, quartzofeldspathic groundmass of the fragments is slightly coarser than the matrix (the reverse of that observed in the felsic pyroclastic rocks). Fluxion tex-

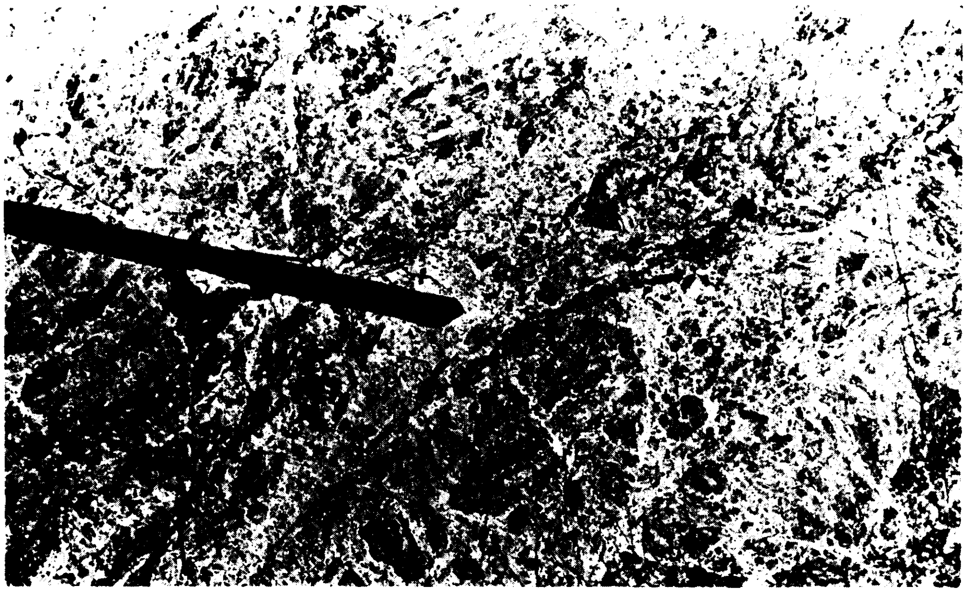


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Photo 6–Felsic flow breccia. Most fragments exhibit flow banding, 120 m east of the south tip of the unnamed lake east-southeast of Phinney Lake (at Property 3).

ture is exhibited in each section and is manifested by laminated alteration of very fine grained groundmass or by more obvious streaks and nets of sericite which in one sample outlines the fragments. Quartz forms up to 15 percent phenocrysts with sizes to a maximum of 1.5 mm. These are usually rounded and show some evidence of embayment. Anhedral to subhedral plagioclase exhibits from 70 percent to complete replacement by sericite and/or carbonate. The largest plagioclase phenocryst in thin section is 1.5 mm across but most are less than .75 mm. The plagioclase phenocrysts comprise up to 10 percent of the rock.

Secondary minerals are: a ferruginous carbonate, partly altered to limonite and/or hematite, replacing plagioclase and some groundmass, and forming 15 percent of one section; quartz as secondary recrystallization of very fine groundmass in one section (15 percent); sericite replacing plagioclase completely in some sections and forming streaks and nets replacing up to 10 percent of the matrix in one section; and a trace of pyrite.

FERRUGINOUS (SYNVOLCANIC) BRECCIA

This peculiar rock generally consists of subrounded to subangular lapilli-size, mainly felsic quartz-feldspar porphyry fragments and rare chert fragments in a matrix composed mainly of iron-rich carbonate and secondary limonite. It appears to be closely associated with chert, ferruginous chert, and iron formation and is interpreted to be a mixed deposit resulting from the syndepositional disruption by volcanic explosive events of pyroclastic and chemical sedimentary horizons. It differs from the volcaniclastic conglomerate with which it is in part gradational in that it contains mainly felsic clasts, which are less rounded than in the conglomerate, and fewer chert fragments. This breccia is on the east and west shores of the unnamed lake east-southeast of Phinney Lake at Property 3. An excellent example is associated with hematitic carbonate-chert iron formation along the west shore of the south part of the unnamed lake southeast of Phinney Lake.

In thin section, this breccia resembles lapilli-tuff. It differs from those previously described in this report in that the minerals and primary textures are better preserved and the fragments are more distinct and of more variable grain size. In addition, iron-rich carbonate or its alteration product, limonite, forms much of the fine interstitial material. Breccia fragments are commonly porphyritic with subhedral phenocrysts of plagioclase (An_{30-35}) up to 2.5 mm being partly replaced by ferroan carbonate (or limonite). Quartz, commonly deeply embayed, also forms phenocrysts up to 3 mm across in some fragments. Both plagioclase and quartz are in the matrix as smaller, broken or whole phenocrysts. Rare aphyric fragments may be recrystallized chert.

INTERMEDIATE PYROCLASTIC ROCKS AND VOLCANICLASTIC CONGLOMERATE

Several bands of intermediate composition lapilli-tuff and tuff-breccia, gradational with volcaniclastic conglomerate occur east and northeast of the east part of Dash Lake. Both rock types are heterolithologic consisting of fragments of variable composition from felsic to mafic with fragments commonly being porphyritic. An attempt was made in the field to distinguish between undisturbed intermediate pyroclastic rocks and volcaniclastic conglomerate (redeposited volcanic effusive rocks) using the following criteria.

a) Subrounded chert and quartz clasts are present in volcaniclastic conglomerate and absent in the pyroclastic rock.

b) Fragments are generally better rounded in the volcaniclastic conglomerate.

c) The volcaniclastic conglomerate contains sparse relatively coarsely crystalline quartz-feldspar porphyry fragments not unlike those found in the intrusive phase of the Phinney-Dash Lake Complex.

d) The volcaniclastic conglomerate contains basaltic fragments whereas none are in the pyroclastic rock.

In both types the matrix (tuff-size fragments) is generally more mafic than the fragments. In intermediate pyroclastic rocks, the matrix appears to be intermediate crystal tuff whereas in the volcaniclastic conglomerate, a mixture of fine chlorite and larger deformed chloritic mafic clasts comprises the matrix around the more felsic clasts.

This volcaniclastic conglomerate is similar to that north of the present area and south of Schistose Lake. It is also part of the Phinney-Dash Lake Complex and has been described by Edwards (1980).

Summary and Correlation

The extrusive phase of the Phinney-Dash Lake Complex (except for the associated chemical metasediments described below) is correlative with volcaniclastic rocks identified to the north of the present area in the vicinity of Schistose Lake (Edwards 1980). In that area, volcaniclastic conglomerate is overlain by conglomeratic arkosic sandstone, arkosic sandstone, and turbidite greywacke. Much of the sediment was probably derived from the emerging Phinney-Dash Lakes Complex but some, especially in the upper stratigraphic levels as at the northwest arm of Pipestone Lake, must have been derived from the intermediate pyroclastic rocks at Kakagi Lake. Volcaniclastic detritus, then, from two separate effusive centres occupies essentially the same stratigraphic position; a stratigraphic position which would appear to mark the cessation of a major phase of submarine basaltic volcanism.

With future work the author hopes to relate the Phinney-Dash Lake Complex to the emplacement of the trondhjemite phase of the Sabaskong Batholith at Kishkutena Lake.

Clastic Metasediments

FELDSPATHIC VOLCANIC SANDSTONE

Poorly bedded, light creamy white to grey-weathering feldspathic volcanic sandstone (wacke) is interbedded with mafic flows along the east shore of the large island in the northern part of Gates Ajar Narrows. Similar metasediments are along the west shore of Gates Ajar Narrows in contact with gabbro. Here, both units are 60 to 90 m thick. Rarely, bedding is darker grey to greenish grey horizons up to 10 cm thick but more commonly the bedding is in the form of vague darker laminae. Sparse subangular granule and pebble size clasts occur in the unit to the west, giving this unit a similar appearance to some of the arkosic sandstone along the northeast shore of Schistose Lake to the northwest (Edwards 1980).

Thin remnants of feldspathic volcanic sandstone are along strike at isolated locations in shoreline exposures along Pipestone Lake, usually in contact with gabbro. One such thin remnant, 22 m thick is at the narrows on the east side of the island north-northeast of Gold Point Island. At this location three graded beds yielded an east top-direction.

In practically every outcrop, the feldspathic volcanic sandstone could be identified because of a prominent jointing giving the rock a rather blocky appearance.

INTERFLOW METASEDIMENTS

Thin (15 cm to 1 m) metasedimentary horizons between flows can be seen in shoreline exposure in the northeastern part of the map-area. Typically they consist of thin alternating carbonate-rich bands and iron-rich bands (hematite and limonite) from 0.5 to 6 mm thick. Natural staining commonly gives the rock a striped rusty yellow and reddish appearance.

Chemical Metasediments

CHERT AND FERRUGINOUS CHERT

A 30 m wide unit of dark grey to black chert and ferruginous chert occurs in the Phinney-Dash Lake Complex along the east shore of the unnamed lake east-southeast of Phinney Lake at Property 3. In some exposures just in from the shoreline, the chert is massive but the majority appears to be a brecciated rock that contains as much as 40 percent iron-rich carbonates and minor (<5 percent observed) pyrite. The brecciated part is not unlike the penecontemporaneous chert conglomerate described from the Schistose Lake area to the north (Edwards 1980).

IRON FORMATION

Two thin units of banded hematite, limonite, and siderite iron formation are in the map-area. One contorted unit is over 3 m in width at the north end of the unnamed lake east-southeast of Phinney Lake at Property 3 and consists of alternating iron-rich and cherty bands. A similar unit, of unknown width trending north-south, is below the water level in poor shoreline exposure along the west shore of the south part of the unnamed lake southeast of Phinney Lake.

METAMORPHOSED MAFIC AND ULTRAMAFIC INTRUSIVE ROCKS

Mafic Intrusive Rocks

A suite of composite mafic intrusive sheets mainly magnetite-quartz-amphibole gabbro and leucocratic gabbro intrudes mafic metavolcanics of the map-area and is continuous with gabbroic rocks described from the Katimiagamak Lake area and the area west of Pivot Point north of the present map-area (Edwards 1980).

Evidence for the contemporaneous and possible consanguineous relationship between these two main types of gabbro is mainly that they are usually intimately, spatially related (this also applies to most of the ultramafic rocks found in the map-area). Contacts between the two types of gabbros are usually vague and hybrid types of gabbro are not uncommon. A link is provided between the gabbro present in this area with mafic and ultramafic intrusive rocks at and south of Kakagi Lake (Edwards 1980; Kaye 1974) since intrusive rocks in the present area are more or less continuous with those in the Kakagi Lake area.

The mafic intrusive rocks account for one quarter to one third of the total mafic rocks in the belt and two major concentrations are evident. One extends (in the present map-area) south from Anstey and Hornberg Lakes as part of the homoclinal sequence wrapping around the Sabaskong Batholith (the Nightjar Lake Anticline) and southwest north of Manomin River and Burditt Lake. The other concentration lies between Gates Ajar Narrows, Pipestone Lake, and west of Helena Lake extending south-southeastward to the main stretch of Pipestone Lake. Gabbro is not common in flows east of Gates Ajar Narrows nor adjacent to the Sabaskong Batholith.

A generalization which can be applied to the gabbro sills that wrap around the Sabaskong Batholith is that the sills higher in the stratigraphic sequence, for example the one in the west part of Hornberg Lake extending south through Pipestone Lake and those stratigraphically above it, (north and south of Dash Lake) tend to be finer grained and may have diabasic texture. The presence of quartz and leucoxene and magnetite are parameters common to the coarser quartz-amphibole gabbro and were used as field criteria to distinguish gabbro from flow. However, many gabbro units apparently grade into flows (see also Edwards 1980).

It was found that the mafic intrusive rocks did not intrude any of the felsic intrusive or extrusive rocks in the area. One exception is the coarser grained mafic rock north of the southeast part of Schistose Lake (Edwards 1980) which may be gabbro or a thick, possibly subaerially deposited, flow.

DESCRIPTION AND PETROGRAPHY OF MAIN GABBRO TYPES

Two major types of gabbro were recognized in the field though variations of both commonly occur such that the scale and scope of the mapping did not allow study in depth of an obviously complex system of intrusions.

The two types are: (magnetite)-quartz-amphibole gabbro and leucocratic gabbro. A third, less common type, apparently gradational with the leucocratic gabbro was called "gabbro" in the field and included rocks which appear to be mesocratic and melanocratic gradations of leucocratic gabbro. A hybrid form of gabbro, which apparently crystallized both primary amphibole and pyroxene, occurs between Katimiagamak and Anstey Lakes, and extends southward halfway to Nightjar Lake. This hybrid zone is mainly at the contact between leucocratic gabbro and quartz-amphibole gabbro.

(Magnetite)-Quartz-Amphibole and Related Gabbro

In outcrop this rock is greenish beige to green and fine to coarse grained, massive to schistose. There is usually up to 15 percent quartz but in some zones called amphibole gabbro in the field, quartz is not visible in hand specimen.

The amphibole is noticeably prismatic (½ to 1 cm in length) forming 35 t0 60 percent of the rock and rarely has a tendency to form dendritic aggregates.

Magnetite is present as very fine octahedra in amounts up to 15 percent, mainly in the finer grained parts of the sheets. Rarely the rock contains up to 15 percent leucoxene which is generally only evident in altered or deformed zones where it occurs as cream coloured skeletal pseudomorphic euhedra up to 3 mm. Leucoxene is evident in some shoreline exposures on Katimiagamak Lake and Anstey Lake, south of Katimiagamak Lake, northwest of the eastern part of Dash Lake, west of Helena Lake, and in some Pipestone Lake shoreline exposures east of Silver Lake.

A peculiarity of this gabbro is that magnetite-rich zones rather than being coarser grained toward the centre have a tendency to be fine to medium grained in zones up to 60 m thick, giving a gritty feel to the surface of the outcrop. In sunlight, one can stand on these outcrops and see the rock "twinkle" as the sun glints on the numerous magnetite octahedra. These finer grained zones resemble mafic tuff, especially along parts of the western shore of Helena Lake, where the gabbro has numerous plagioclase phenocrysts. Elsewhere the finer grained magnetite-rich rock grades into (magnetite)-quartz-amphibole gabbro. This transition is present in gabbro southeast of the unnamed lake just east of Dad Lake and in other locations in the area.

In thin section the prismatic mafic mineral accounts for 35 to 60 percent of the thin section and is found to be ragged and partly fibrous green to blue-green hornblende or green actinolite. In one thin section pale green partly fibrous tremolite is the mafic mineral. Primary plagioclase is always largely replaced by saussurite, carbonate, or chlorite and commonly forms myrmekite with quartz. Secondary albite was identified in some thin sections. Quartz also occurs interstitially or as rounded aggregates up to 4 mm across. In well foliated (tectonically deformed) quartz gabbro, chlorite is present as fine-grained streaky aggregates partly replacing plagioclase, and is the only mafic mineral present forming 35 percent of the rock. Rocks with relict diabasic texture, commonly have as much as 15 percent skeletal leucoxene pseudomorphs (after ilmenite) up to 3 mm across. Some altered gabbroic rocks have up to 25 percent carbonate component.

Leucocratic Gabbro and Gabbro

In outcrop, medium grain size and a pale greenish cream colour typifies the leucocratic gabbro. As opposed to the (magnetite)-quartz-amphibole gabbro, the mafic component is generally light green, equant to ophitic and usually less distinct accounting for as little as 20 percent (southeastern shore of Katimiagamak Lake) to 45 percent of the rock.

Although not directly observed to be gradational in the field petrographic evidence suggests that the rocks called "gabbro" in the field, (including ophitic gabbro) are probably melanocratic equivalents of leucocratic gabbro in the present map-area. Ophitic gabbro which commonly is in close proximity to the leucocratic gabbro contains large poikilitic mafic crystals 0.5 to 2 cm in size comprising 30 to 80 percent of the rock (Photo 7). A good example of leucocratic and melanocratic ophitic gabbro is on the south shore of Katimiagamak Lake,

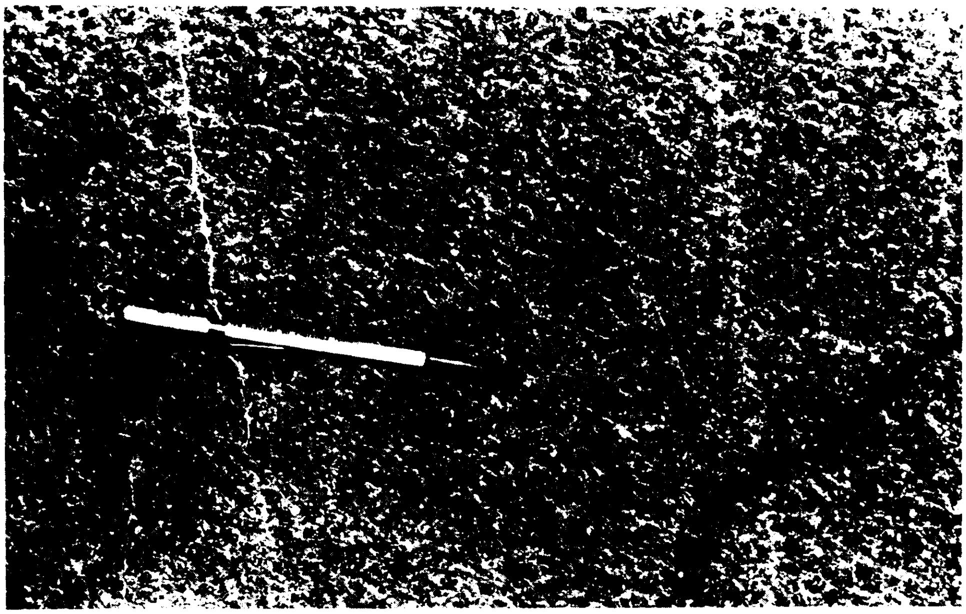

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Photo 7–Ophitic gabbro, south shore of the southwest arm of Pipestone Lake, northwet of Cobourg Lake.

southwest of Anstey Lake and on the south shore of Pipestone Lake, 1800 m southeast of Ross Island, respectively.

In thin section, the texture of leucocratic gabbro varies from intergranular to ophitic with a grain size of 2 to 3 mm. Colourless to pale green, prismatic to fibrous tremolite-actinolite generally forms the major mafic component. In some thin sections, relict colourless clinopyroxene forms the cores of pseudomorphic amphiboles. Chlorite rarely replaces clinopyroxene and generally occurs as an interstitial alteration product. Green hornblende in one thin section is in the core of some tremolite grains. Plagioclase is commonly subhedral to euhedral and almost invariably completely saussuritized. Epidote with relict parting occurs as clots up to 6 mm in size in one thin section. These clots which may have been late magmatic contain inclusions of mafic minerals and plagioclase and account for 10 percent of the rock. Skeletal leucoxene up to 10 percent is commonly present but other opaque minerals are rare. Quartz always occurs in amounts less than 5 percent and commonly rims saussuritic pseudomorphs. Primary, strained interstitial quartz is present in some specimens.

In thin section, gabbro is similar to leucocratic gabbro except that the mafic component, generally tremolite-actinolite pseudomorphs, is poikilitic, is larger in size (1 cm in thin section), and comprises a larger proportion of the rock. In one thin section, there is 20 percent primary, brown to green poikilitic hornblende. Here too, pseudomorphic, poikilitic tremolite-actinolite is present forming 30 percent of the rock and in part rimming the hornblende. One melanocratic gabbro, north of the small diorite stock north of Carver Lake, contains 80 percent actinolite pseudomorphs after clinopyroxene up to 6 mm in size. Stilpnomelane apparently replacing actinolite forms 15 percent of one reddish brown-weathering gabbro located on the north shore of the south end of Slender Lake.

TEXTURAL VARIATIONS IN GABBRO

Diabasic texture is present in gabbro in several locations, notably in the upper part of the part of the homoclinal sequence mentioned in the introduction to this section. East of the small lake between Hornberg Lake and the narrow east-west unnamed lake southeast of Hornberg Lake, both ophitic and diabasic texture is present in some zones in medium-grained gabbro.

In the bay of Pipestone Lake due south of Silver Lake, flaser structure is developed in ophitic gabbro in a zone of deformation which is part of the Helena-Pipestone Lakes Fault. Other flaser gabbro is in shoreline exposure 1200 m southwest of the south tip of Gold Point Island (Pipestone Lake) and in numerous shoreline exposures on Slender Lake, Campbell Lake, and the unnamed lake east of Dad Lake.

Porphyritic (plagioclase) gabbro is not common. It occurs in fine- to medium-grained gabbro along the west shore of Helena Lake and on the north shore of the bay in Pipestone Lake due south of Silver Lake and extends northeastward to the bay leading to Dash Lake. Leucocratic gabbro in the area around the southeastern part of Katimiagamak Lake rarely has vague equant to prismatic greenish yellow masses (1 to 2 cm across) which may have been primary calcic plagioclase phenocrysts or glomerocrysts.

Ultramafic Intrusive Rocks

Several previously unmapped ultramafic sills that have intruded mafic flows and are generally associated with gabbro have been recognized east of the Helena-Pipestone Lakes Fault and in some shoreline outcrops on Campbell and Burditt Lakes. None were found west of the fault (north of Campbell Lake) in the map-area but ultramafic rocks were mapped by Kaye (1974) in the continuation of the same sequence of mafic flows northwest of the present map-area, south of Kakagi (Crow) Lake. The possibility exists that these ultramafic sills may grade along strike into as yet unrecognized komatiitic flows. The ultramafic sills in the present area attain a thickness of 150 m at Burditt Lake. Field evidence suggests that formerly semicontinuous sills have been deformed tectonically leaving discontinuous, conformable, pods and lenses, which have been altered partly or completely to either serpentine or talc and carbonate.

Perfect pseudomorphs of talc or serpentine after olivine in some zones indicate that the original composition for at least some of the ultramafic rocks was dunite.

In general the ultramafic rocks weather rusty brown and where talcose are commonly dissected by carbonate veins giving the rock in some outcrops the appearance of being pillowed (north of Gates Ajar Narrows). The fresh surface varies from green and greenish brown to bluish green in the serpentinite. The serpentinite is considerably harder than the talcose rock. Serpentine veins are uncommon except for one occurrence discussed under "Economic Geology".

In thin section, with the exception of one sample having 5 percent hypersthene relicts, the primary ferromagnesian minerals are completely replaced. Where primary fabric is intact, serpentine commonly forms pseudomorphs after olivine and forms up to 75 percent of the rock. Usually fine magnetite outlines the original olivine shape. In one sample fine talc is within the serpentine pseudomorphs but in most samples it is interstitial to the pseudomorphs, forming up to 35 percent of the rock and probably replacing intercumulate and poikilitic orthopyroxene.

Up to 15 percent pale green chlorite is as fine shreds interstitially with talc or more rarely as aggregates. In one sample it forms the centre of the interstitial talc masses.

Tremolite with relict hypersthene cores makes up 25 percent of a sample taken from an ultramafic sill north of Gates Ajar Narrows. Fibrous tremolite also completely replaces pyroxene in a pyroxenite zone in the composite ultramafic sill located 600 m northeast of Sand Point on the south arm of Pipestone Lake.

FELSIC TO MAFIC INTRUSIVE ROCKS

Intravolcanic Plutons

DASH LAKE STOCK, HORNBERG LAKE STOCK, PHINNEY-DASH LAKE COMPLEX (INTRUSIVE PHASE)

The west arm of Dash Lake is underlain by a 2 by 4 km, oval-shaped, trondhjemitic felsic porphyry intrusion, the Dash Lake Stock. This porphyry weathers pale beige to grey and greenish grey and generally has a grey fresh surface. Macroscopically the dominant phenocryst minerals are quartz in amounts up to 15 percent averaging 0.5 cm in size and plagioclase in amounts up 50 percent averaging 0.4 cm in size but completely altered prismatic hornblende phenocrysts 1 to 2 mm long are not uncommon (up to 20 percent) and form the only foliation in the main part of the intrusion. Relatively undeformed medium-grained, pale brown, leucocratic oligoclase syenite and minor leucocratic trondhjemite form a 1000 m by 500 m apophysis adjacent to the southwest boundary of the Dash Lake Stock. Contact relations with the Dash Lake Stock were not seen so that the relative age could not be ascertained.

The Hornberg Lake Stock is similar to the Dash Lake Stock differing in that hornblende phenocrysts are less common, and the rock is more consistently schistose in a north-northeastward direction. The Hornberg Lake Stock also is lenticular, being mainly concordant to the volcanic stratigraphy.

The similar Phinney-Dash Lake Complex (intrusive phase) occupies much of the area extending from south of the east part of Dash Lake, north to Schistose Lake, and west to a point midway between Phinney and Hornberg Lakes. That part of the complex occupying the vicinity of Phinney Lake is named the Phinney Lake Stock.

North of Dash Lake the intrusive phase of the complex is intimately associated with felsic pyroclastic and flow rocks and in some outcrops because of the similarity of compositions and the pervasive east-northeast deformation and carbonatization in the area it is difficult to determine whether the rock contains fragments. The overall picture appears to be one of a rising felsic magma intruding to some degree its own ejecta in a submarine environment. This is supported by the following: chert and ferruginous exhalative deposits are associated with and partly overlie the proposed volcanic structure along the east shore of the unnamed lake at the eastern location of Property 3, along the southwest shore of the unnamed lake west of the previously mentioned lake, and in the vicinity of Schistose Lake (Edwards 1980); in shoreline exposure in the northwestern part of Dash Lake, volcanic clasts of various compositions ranging in size from granules to boulders appear to have been incorporated in an intrusive matrix; and zones of flow banded quartz-feldspar porphyry are locally exposed on the northern part of Dash Lake and north of Dash Lake (Photo 8).

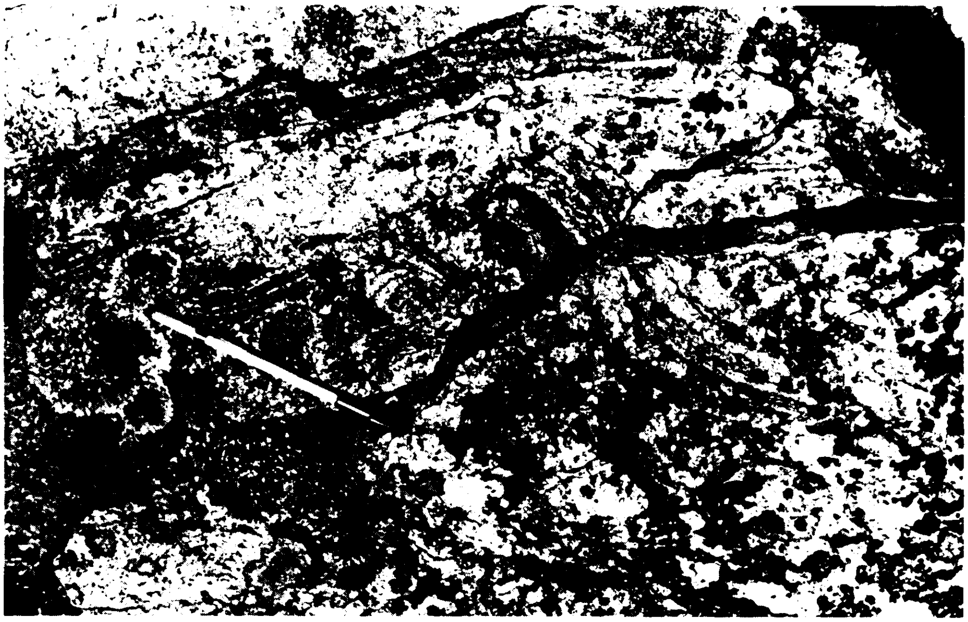
In general, the Phinney-Dash Lake Complex (intrusive phase) is finer grained than that of either the Dash or Hornberg Lake Stocks. At the intrusive contact with mafic metavolcanics south of Dash Lake the porphyry is darker grey, very fine grained, and brittle. West of the portage into Pipestone Lake this porphyry commonly has a brecciated appearance and chloritic veinlets web throughout otherwise massive rock.

Pyritic-sericitic alteration has affected some of the stock in the central part of the east arm of Dash Lake. Rock on the island in the mouth of the bay leading to the portage into Pipestone Lake is especially altered and although it weathers a dark rusty brown there is less than 10 percent pyrite in the rock.

At Phinney Lake the porphyry (the Phinney Lake Stock) is generally well foliated to schistose and carbonatized. Chloritoid porphyroblasts are up to 2 mm long and comprise up to 20 percent of carbonate-sericite schist in two exposures on and near the shore at the northeast end of Phinney Lake.

Porphyry Dikes and Sheets

Beige to light brown, sheet-like dikes of quartz and feldspar porphyries and more rarely, felsite are in the vicinity of the aforementioned porphyry stocks.



OGS 10 467

Photo 8–Flow banded quartz-feldspar porphyry showing some fragmentation, northwest shore of the east part of Dash Lake.

These appear to be parallel or subparallel to the volcanic strata and are generally well foliated to schistose. Quartz phenocrysts are much less abundant in the dikes, probably averaging less than 5 percent.

Petrography

Samples taken from the Dash Lake Stock and the Phinney-Dash Lake Complex (intrusive phase, including the Phinney Lake Stock) are similar in thin section. Plagioclase, (An_{30}), partly altered to sericite occurs as seriate subhedral to euhedral phenocrysts and glomerocrysts up to 5 mm long. Quartz is in the form of strained, commonly embayed, polyhedral phenocrysts up to 6 mm across. In the Dash Lake Stock chlorite, albite, epidote, and quartz replace prismatic hornblende phenocrysts. In many rocks these prismatic pseudomorphs are rimmed by very fine grained Ti oxides. The groundmass though coarser in the Dash Lake Stock, is invariably fine to very fine grained recrystallized quartzofeldspathic material. Carbonate occurs as an alteration of groundmass and phenocrysts in amounts up to 20 percent.

SILVER LAKE STOCK

The Silver Lake leucocratic trondhjemite stock is a northeast-trending, homogeneous 6000 m long, 900 m wide lenticular felsic intrusion located between Dash Lake and Pipestone Lake. The intrusion appears to be structurally concordant in, and parallel to, the Helena-Pipestone Lakes Fault. Lack of deformation except at its extreme northeast tip suggests the body was intruded after the main faulting. Generally the intrusion is free of inclusions except at its southwest tip where locally, agmatite is developed at the contact with mafic flows. A septum of quartz-feldspar porphyry from the Phinney-Dash Lake Complex occurs in the Silver Lake Stock near the contact between these two intrusions south of the east part of Dash Lake.

Description and Petrography

In outcrop the rock is beige to pinkish beige (rarely with epidote-greenish tones), medium grained (1 to 3 mm), equigranular to granophyric and is noticeably leucocratic generally containing less than 10 percent mafic component (biotite and/or chlorite). Quartz content and form varies from about 15 to 35 percent and from interstitial to partly square shaped, partly intergrown with plagioclase. Plagioclase is commonly greenish and subhedral to anhedral forming 55 to 75 percent of the rock.

In thin section, subhedral plagioclase was found to be of a composition near An_{35} (Michel-Levy) forms 45 percent of the rock, and is heavily sericitized and/or saussuritized. Potassic feldspar is as sericitized interstitial anhedra accounting for 10 percent of the rock. Quartz is polycrystalline, anhedral, and strained. Irregular flakes of chlorite forming 5 to 7 percent of the rock is the only mafic mineral present, usually associated with trace amounts of magnetite and carbonate. Sphene in trace amounts is the only accessory mineral.

Sabaskong Batholith

Part of the Sabaskong Batholith has been described by Blackburn (1976) in his report on the Off Lake-Burditt Lake area to the south.

EQUIGRANULAR HORNBLENDE-BIOTITE TRONDHJEMITE

In the present area the dominant phase is poorly foliated coarse-grained equigranular hornblende-biotite trondhjemite which weathers beige to pinkish beige. The fresh surface colour varies from almost white to pink. Green biotite is the predominant mafic mineral, forming books which are at the coarsest 5 mm across and comprising 10 to 15 percent of the rock. Hornblende is sparse as fine aggregates with the biotite. Quartz is 30 to 40 percent of the rock and occurs as large amorphous blebs up to 1.5 cm in size. Feldspar is cloudy white to pink and much finer grained than the quartz. Hand specimens stained for potassic feldspar show that less than 5 percent of that mineral is present.

A 2100 by 600 m subphase of fine-grained hornblende-biotite trondhjemite occurs east of Carver Lake, wholly enclosed by the coarser grained phase. Intrusive relations here are not known.

HORNBLENDE DIORITE

A 1300 m by 1000 m stock of well foliated medium-grained hornblende diorite is adjacent to the main part of the Sabaskong Batholith in metavolcanics 2000 m north of Carver Lake. In hand specimen the rock is roughly two thirds altered plagioclase and one third dark green hornblende of approximately 1 to 3 mm grain size.

QUARTZ-FELDSPAR PORPHYRY AND FELSITE

Between Knauf and Nightjar Lakes, at the eastern tip of the Sabaskong Batholith minor quartz-feldspar porphyry and felsite similar to rocks of the Dash Lake Stock and Phinney-Dash Lake Complex are the border subphase. The relationship between these fine-grained rocks and the coarse trondhjemite does not appear to be a gradational one.

CONTACT RELATIONS

In the present area, the contact of the Sabaskong Batholith with the volcanic belt is sharp with only local development of agmatite of locally derived amphibolitized volcanic rocks. Mafic metavolcanics in the vicinity of the contact are usually darker in colour than the mafic rocks outside the contact aureole. This may be because of the incipient development of secondary actinolite but the rocks lack obvious textural changes resulting from the formation of hornblende indicative of amphibolite grade of metamorphism.

In the map-area the intrusion is subconcordant with its host volcanic strata. The lack of contact migmatite and appreciable metamorphic aureole suggests that the body was intruded at a shallow enough crustal level and at a temperature low enough that assimilation of adjacent mafic country rocks or the initiation of a crustal-scale hydrothermal system was not possible.

RELATIONSHIP TO FELSIC VOLCANISM

The anticlinal attitude (Nightjar Anticline) of the metavolcanic belt around this eastern lobe of the Sabaskong Batholith appears to be a result of upwarping of a thin subhorizontal mafic volcanic platform during the emplacement of this phase of the batholith. The Dash Lake Stock (amphibole-quartz-feldspar porphyry of trondhjemitic composition) and the Phinney-Dash Lake Complex (a felsic intrusive-extrusive volcanic complex) described in this report, lie along the hinge of the Nightjar Anticline and are successively shallower magma bodies which budded from the main trondhjemite body. Felsic volcanism occurred when the Phinney-Dash Lake Complex intrusive phase breached the surface of the basalt.

Rainy Lake Batholith

JACKFISH LAKE COMPLEX

The Jackfish Lake intrusion is a relatively uniform weakly foliated to lineated, medium-grained equigranular rock which is mainly syenodioritic in composition. Weathered colour is grey to green but where epidotized, it is pink.

On the basis of field mapping the body has been arbitrarily subdivided into three main subphases: a) the biotite-hornblende syenodiorite subphase; b) the pyroxene-hornblende syenodiorite subphase; and c) the hornblende-pyroxene syenodiorite subphase. There is no evidence for intrusive contacts between these subphases and they appear for the most part to be gradational.

Biotite-Hornblende Syenodiorite

This subphase accounts for about 80 percent of the complex exposed in the map-area.

Typically, mafic content ranges between 20 and 40 percent. Hornblende comprises 25 percent of the rock, biotite 5 percent, feldspar 65 percent, and quartz 3 percent. The remainder is mainly epidote and other minor accessories. Black hornblende usually exhibiting well developed cleavage, is stumpy euhedral to subhedral prismatic grains up to 6 mm long and rarer subhedral clusters. Biotite, which is subordinate to hornblende and may account for up to 15 percent of the total rock, usually occurs as books or flaky aggregates associated with the hornblende. Where biotite content is high in the syenodiorite, the weathered surface is characteristically pitted. Small grains of epidote (<1.5 mm) invariably found as an accessory mineral commonly give the fresh surface of the rock a greenish hue. Plagioclase is generally greyish and transparent to translucent and in hand specimen little altered. Albite twins are commonly observable in hand specimen with the use of the hand lens. Potassic feldspar is interstitial in amounts up to 30 percent of the total feldspar (see section on "Petrography") and on cursory examination of hand specimens it is not easily distinguished from plagioclase. Quartz is always in small interstitial grains accounting for up to 5 percent of the rock.

Pyroxene-Hornblende Syenodiorite

The pyroxene-hornblende subphase of the Jackfish Lake Complex is in contact with and south of the main biotite hornblende subphase, west of Loonhaunt Lake.

Relative mineral proportions are similar to those of the other two subphases except that medium green pyroxene occurs in the cores of some hornblende grains as well as in rare isolated grains partly rimmed with hornblende. Pyroxene to hornblende ratio may reach 1 to 4 in this subphase. Epidote is slightly more plentiful accounting for up to 4 percent of the rock. Quartz also occurs as interstitial grains.

Hornblende-Pyroxene Syenodiorite

This subphase is in contact with the last described subphase on the southern boundary of the map-area, west of Loonhaunt Lake.

Pyroxene, the predominant mafic mineral, forms as distinct, green euhedral to subhedral prismatic grains with a habit similar to that of hornblende. In this subphase, however, it is not mantled by hornblende. Hornblende is the subordinate mafic mineral and has a prismatic habit as previously described for the other phases. Biotite and quartz are in amounts up to 5 percent.

Contact Relations

A study and analysis of the planar and linear elements of the Jackfish Lake Complex between Lake Despair and Vane Lake by R.H. Sutcliffe (1977, Abstract) resulted in the following conclusions: "The predominant subhorizontal to shallow plunging lineation of this crescent-shaped pluton is best explained by a model for its emplacement as a plutonic sheet that has wedged upwards along the southeasterly plunging cylindrical surface of the gneiss-greenstone interface."

Where foliation is present the relationship between foliation and inclusions is quite consistent in that the foliation does not appear to have "flowed" around inclusions which implies that the foliation is a primary one.

Within 30 m of the syenodiorite-greenstone contact, amphibolite inclusions are more profuse and the syenodiorite accordingly is more mafic. Abundant inclusions in most localities south and southwest of Weld Lake either grade or abruptly become agmatic breccia at the contact in which syenodiorite almost invariably is the intrusive phase. Gneissic banding is less commonly developed and *lit-par-lit* injection is evident as the mechanism of magma invasion.

Farther to the northeast and along most of the contact, the agmatic zone is not well developed, being restricted to pods, lenses, and discontinuous layers near the contact within stromatic amphibolite migmatite which grades into *lit-par-lit* textures. Many textures discussed by Mehnert (1968), excepting augen structure, are found. Flecky gneiss is rare and dictyonitic structure is re-

OGS 10 468

Photo 9–Folded stromatic gneiss showing the plastic deformation common in these rocks, northwest shore of the east part of Dash Lake.

stricted to the intrusive phase near the contact. *Schlieren* are common in the syenodiorite but uncommon in the diorite dikes in the migmatite zone.

North from the contact, mafic rocks grade from stromatic and agmatic migmatite into banded amphibolite and hornblende-biotite schist with some zones of hornblende-garnet, garnet-feldspar, feldspar-biotite and magnetite-biotite schist and gneiss. Minor chert and pyrite-pyrrhotite mineralization is also present in the contact zone. The degree of deformation and grade of metamorphism in the aureole decreases from amphibolite to greenschist irregularly away from the contact.

The gneiss-syenodiorite contact, where observed, is in most zones gradational over distances of approximately 1 to 15 m. Generally foliation in the syenodiorite is discordant with the trend of the contact with the gneiss except within close proximity to the contact (30 m) where it bends parallel to the contact. In the contact zone, the syenodiorite has a well foliated texture and mineral segregation is evident. Biotite rather than hornblende is present in the syenodiorite and well banded structure of the stromatic gneiss is present as a result of this segregation. In one location the diorite is in sharp contact with an amphibolite pod of the gneiss.

Contact relations between these two entities are complex and deserve more study.

Inclusions

Inclusions are abundant throughout the mapped syenodiorite and vary greatly in size and composition. A belt of large volcanic xenoliths up to 300 m in length, but more commonly 60 to 90 m long occurs in a zone approximately 2400 m south of and parallel to the syenodiorite-greenstone contact. Agmatic and stromatic structures are found around these xenoliths and the diorite is commonly more mafic at the contact. Most inclusions are amphibolite. Some are fine-grained amphibolite with a colour index ranging from 50 to 70 percent. More commonly however the inclusions consist of coarse-grained hornblende with little felsic material. In some outcrops smaller mafic inclusions were smeared out from a larger mafic inclusion and is evidence for remobilization of mafic material. This process of mobilization and squeezing appears to be the origin of hornblende-rich patches within the syenodiorite.

The large, mainly basaltic inclusions in the southern part of the map-area are fine grained and show no evidence of primary structure. In one of these inclusions, there is a spinifex-like texture of secondary origin resulting from radiating needles of hornblende reaching a length of 18 mm.

In the pyroxene-bearing subphases of the syenodiorite, large xenoliths and patches of mafic to ultramafic clinopyroxene amphibolite are present. Along the contacts of these melanocratic zones there is evidence of "reverse agmatic" structures in which blocks of the more felsic host are surrounded by the melanocratic material.

Petrography

In thin section, the following minerals are present in variable amounts:

Primary minerals
- hornblende, 10 to 20 percent
- plagioclase, 10 to 40 percent
- clinopyroxene, trace to 30 percent
- biotite, trace to 30 percent
- K-feldspar, trace to 30 percent
- quartz, trace to 10 percent

Accessory minerals
- epidote, 0 to 7 percent
- magnetite, trace to 5 percent
- sphene, 0 to 2 percent
- apatite, trace to 2 percent

Secondary minerals
- chlorite (after biotite), trace to 5 percent
- tremolite (after clinopyroxenite), 0 to 10 percent

The ratio of hornblende to clinopyroxene to biotite is variable across the pluton and agrees with field evidence. Hornblende is the essential mafic component and biotite content does not seem to depend upon the presence or absence of other mafic minerals. The plagioclase to K-feldspar ratio varies from very high (rare) to what appears to be a more nearly normal variation from between 4:1 and 1:1. Subhedral to anhedral plagioclase (An_{10-15})is commonly normally or complexly zoned although, rarely, zoning is almost absent. In some samples plagioclase exhibits no albite twinning. K-feldspar and quartz, where present, are always anhedral. The normal texture for this rock is medium to coarse grained, hypidiomorphic.

The following mineral relations are common in this suite studied by the author.

a) Pale green to yellow hornblende usually forms late magmatic rims around the colourless clinopyroxene where present.

b) Green to olive coloured biotite rarely is part of the rim around clinopyroxene associated with hornblende. Biotite generally has some retrograde, probably deuteric, alteration to chlorite.

c) Small clinopyroxene euhedra are rarely included in plagioclase.

d) Plagioclase and K-feldspar commonly are both anhedral but plagioclase also exhibits subhedral form.

e) Mafic minerals tend to form clots (xenoliths). Magnetite forms up to 8 percent of the clots.

GNEISS AND MIGMATITE

Quartzofeldspathic gneiss and associated migmatite are south of the Jackfish Lake Complex at Loonhaunt Lake. These are a northern extension of the approximately oval-shaped core of that part of the Rainy Lake Batholith lying north of the Quetico Fault. Reconnaissance mapping by the author and senior assistant on the Rainy Lake Batholith indicates that the gneiss forms an oval-shaped dome with steeply dipping gneissosities at the margin and horizontal gneissosities at the core. The gneiss "dome" is surrounded on three sides by the crescent-shaped Jackfish Lake Complex. The relationship of the Jackfish Lake Complex to the gneiss-migmatite belt was studied in detail by R.H. Sutcliffe (1980) as part of a Master's thesis at the University of Toronto.

Description

The gneiss and migmatite belt can be divided into two zones on the basis of predominant structures present. The outer zone which contacts the syenodiorite is 900 to 1500 m wide. This is defined as the stromatic phase and is of overall intermediate composition. In contact with this zone and to the south is the homophonous phase which is felsic to intermediate in composition. This was mapped as far as the southern and eastern boundaries of the map-area, 900 m south from the stromatic phase.

The contact of the two gneiss zones roughly parallels the gneiss-syenodiorite contact to the north and is concordant with the gneissosity throughout. Both contacts and the gneissosity are steeply dipping. The two zones display most migmatite structures as defined by Mehnert (1968). The stromatic phase is

OGS 10 469

Photo 10–Agmatic and schollen structures in rafts of amphibolite in gneiss on a small island in Loonhaunt Lake 2745 m south of the portage into Stonedam Lake. Photo taken 150 m east of the assumed contact with the Jackfish Lake Complex.

dominated by a distinct stromatic banding. The banding is defined by biotite-rich zones in contrast to quartzofeldspathic layers. Individual melanosomes are on the scale of 3 mm to 10 cm. At the smaller extremity, the banding becomes planes of well foliated biotite crystals. Melanosomes and leucosomes are approximately equal in total volume. Typically the banding is uniform over several metres. However within the zone, drag folds and gentler sweeping fold structures are common. The tighter drag folds are commonly found in combination with shear structures. Usually deformational structures are localized. The gneissosity is relatively uniform and appears to be concordant with contacts.

The greatest variety of migmatite structures within the stromatic zone is associated with concordant pods of amphibolite. The amphibolite pods are coarse-grained units commonly 30 cm to 1 m wide and rarely up to 15 m wide. These units are commonly invaded by veins of discordant felsic material up to 5 cm wide. The veins may display ptygmatic folding and are probably the only feature of the gneisses which display a discordant relationship with the gneissosity. On the margins of the amphibolite pods, agmatic and schollen structures are common (Photo 10). The fragments occur in all states of assimilation. A prominent feature of the schollen structures is the tendency for nebulitic *schlieren* to bend around them resembling a flow of material around rafts. Leucosomes in the vicinity of amphibolite pods generally have euhedral crystals of hornblende. Concordant pegmatoid veins are also associated with amphibolite.

Certain zones of the stromatic phase contain numerous porphyroblasts of feldspar. These are potassic feldspar up to 2.5 cm in diameter and are contained within the leucosomes.

In contrast to the stromatic phase, the homophonous phase displays only nebulous relict migmatite structures. It is a comparatively monotonous biotite-trondhjemite to granodiorite gneiss containing thin 1.5 to 3 mm bands of biotite and thicker 3 to 6 mm bands of quartzofeldspathic material.

Nebulous stromatic, schollen, and fold structures predominate but rare concordant amphibolite pods are present. The pods are boudinaged, folded, sheared, and injected with felsic material. Sparse feldspar porphyroblasts similar to those encountered in the stromatic zone occur but with much less frequency.

The contact between the two described phases of the gneiss is gradational. Over a distance of approximately 60 m the migmatite structures of the stromatic phase become nebulous and a breakdown of banding accompanied by a decrease in the amount of biotite occurs.

All gneissosities are steeply dipping varying between 60 degrees and the vertical.

Intrusive Relationships

The preponderance of amphibolite pods and bands in the outer stromatic zone probably means that the gneiss intruded the metavolcanic belt prior to the emplacement of the Jackfish Lake Complex. Much of the variable metamorphic grade seen in the metavolcanic belt adjacent to (north of) the Jackfish Lake Complex cannot be attributed solely to direct contact metamorphic effects upon emplacement of that body, but may result from tectonic stacking of volcanic strata adjacent to the diapiric gneiss-migmatite terrane prior to the emplacement of the Jackfish Lake Complex. A further discussion of the relationships among the gneiss, the Jackfish Lake Complex, and the volcanic belt is in a report by the author on the Straw Lake Area (Edwards, in press).

LATE MAFIC INTRUSIVE ROCKS

Lamprophyre Dikes

Lamprophyre or lamprophyre-like dikes appear to be spatially and genetically associated with the Jackfish Lake Complex. All occurrences identified in the field are either in or adjacent to the Jackfish Lake Complex, or in the gneiss belt to the southeast. The best exposures of these rocks are on the small island in the narrows between Pipestone Lake and Stonedam Lake where they intrude banded amphibolite and mafic flows, and on the east end of the large island in Loonhaunt Lake 1065 m north of the southeast corner of the map-area, where they intrude gneiss.

OGS 10 470

Photo 11–Potassic feldspar metablasts in a medium-grained leucosome in biotite-feldspar-quartz stromatite, on large island in Loonhaunt Lake, 1215 m north of the southeast corner of the map-area.

At the former location, the rock is mainly coarse hornblende crystals attaining 2 cm in diameter which are partly replaced by patchy biotite. There is 5 to 20 percent interstitial feldspar. This dike is at least 10 m wide, apparently dips vertically, and trends approximately north from the narrows. Similar rock is encountered along strike to the north on the south shore of Pipestone Lake and a carbonatized biotitic rock of possibly the same affinity occurs on the southeast tip of the large island in Line Bay.

The occurrence at Loonhaunt Lake is similar to the first described, but here clinopyroxene is also present. In this respect, this rock also resembles pyroxene-bearing, melanocratic subphases of the Jackfish Lake Complex.

Middle to Late Precambrian (Proterozoic)

MAFIC INTRUSIVE ROCKS

Diabase Dikes

Six typically brown- to light brown-weathering, northwest- to north-northwest-trending diabase dikes are in the map-area transecting all structures and lithologies. The widest of 75 m width is present on the northwestern shore of

OGS 10 471

Photo 12–Chilled diabase in joints in quartz-feldspar porphyry, Dash Lake.

Burditt Lake and is traceable northwestward for about 1200 m. A thinner, less than 30 m, dike parallels it 150 m to the north but is only traceable over 120 m in outcrop back from the shoreline. Three thin, 30 m, discontinuous dikes are south of Weld Lake in the Jackfish Lake Complex. One north-northwest-trending diabase dike of regional proportions, is semi-continuous across the map-area from Loonhaunt Lake to Phinney Lake, and can be traced (with minor offset) north and south of the present map-area for a total length of 104 km. This dike, described by Edwards (1980) in the area to the north, is a maximum of 60 m wide north of Ross Island but in the southeastern part of Dash Lake only 5 cm to 7.5 cm wide aphanitic dikelets were found following joints in quartz-feldspar porphyry (Photo 12).

DESCRIPTION AND PETROGRAPHY

In outcrop, the following are features of the diabase: a) commonly leucocratic containing up to 65 percent translucent plagioclase; b) abundant magnetite-ilmenite averaging 10 to 15 percent but in amounts up to 20 percent in some zones; c) brownish weathering; d) variable grain size from aphanitic at contacts to coarse grained in the interiors.

Using the method of Michel-Levy, euhedral to subhedral plagioclase varies in approximate composition between An_{35} and An_{60} in different samples and is invariably partly saussuritized or sericitized. Interstitial augite is normally the major mafic component but is commonly partly rimmed by hornblende or by uralitic amphibole. The rock has up to 15 percent interstitial quartz.

Phanerozoic

CENOZOIC

Quaternary

PLEISTOCENE

The Wisconsinan stage of glaciation, approximately 12,000 years B.P., is in part responsible for the shaping of bedrock features, much of the present immature drainage pattern in the area, and variable thicknesses of till covering much of the bedrock.

Till

The glacial till (or unsorted drift) is generally silty and compact and occurs as infilling where rocks were easily eroded in sheared and altered zones. Till cover is particularly thick in the Phinney Lake area, south to Dash Lake, and again on parts of the peninsula northwest of Line Bay. Much of the south shore of Pipestone Lake is thinly covered with enough till to mask much of the bedrock. Pebbly and cobbly sandy drift at Sand Point on Pipestone Lake shows some stratification.

Direction of Ice Movement

Small- and large-scale *roches moutonnees* (stoss and lee) are present throughout the map-area, but particularly excellent examples are on Gold Point Island in Pipestone Lake (Photo 13). These features, and to a lesser extent, fluting, indicate ice movement was from the general north-northeast to northeast direction. Local variations do occur but are probably a result of local bedrock topography.

RECENT

Lake and stream deposits of clay, silt, sand, and organic material are presently being formed mainly at the expense of Pleistocene glacial deposits. Or-

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Photo 13–*Roches moutonees* and fluting, Gold Point Island, Pipestone Lake. Plucking on the far side of the "whale-back" in the centre of the photo indicates ice movement was from foreground to background.

ganic mud and peat are forming in swamps and muskegs which are abundant over the Sabaskong Batholith and common over the Jackfish Lake Complex.

STRUCTURAL GEOLOGY

The east-northeast-trending Nightjar Anticline dominates most of the belt north of Pipestone Lake. The limbs of this anticline are themselves folded into west-trending folds at Katimiagamak Lake and southwest-trending folds at Pipestone Lake. At the south part of Katimiagamak Lake, the west-trending, open anticline-syncline pair (Katimiagamak Lake Anticline and Syncline) becomes more tightly folded to the west. Tops from pillowed flows indicate that at least three southwest-trending fold axes, two synclines and one anticline, are present between Helena Lake and Line Bay. In these folds, the strata become more tightly folded to the south-southwest and the fold noses are not evident in Pipestone Lake.

The south-southwest-trending structure north and west of Line Bay is apparently convergent with the Jackfish Lake Complex contact, south of Pipestone Lake. The evidence for this is that the synclinal axis which passes through Ross Island is apparently deflected to the west. The southwest arm of

Pipestone Lake defines the northern limit of well developed foliation and of contact metamorphism in the metavolcanics adjacent to the Jackfish Lake Complex.

The Slender Lake Syncline is between Kishkutena and Weld Lakes in the southwestern part of the map-area. The axial trace passes through Slender Lake, Campbell Lake, and Dad Lake then dies out northward towards Pipestone Lake and the hinge of the Nightjar Anticline.

The strata in the west which are dominated by the Nightjar Anticline are separated from strata north and west of Line Bay by the Helena-Pipestone Lakes Fault. This fault trends northeastward, traverses the map-area from south of Dad Lake, and bifurcates east of Dash Lake into two faults. One of these trends north on the west side of Helena Lake and the other bifurcates northward into several lesser faults paralleling strata in and east of Gates Ajar Narrows.

Strike-faults, which are probably common, are marked by gullies adjacent to which the rocks have been carbonatized, sheared, or both.

Faults discordant to the strata are particularly evident in the sequence of mafic flows and gabbro adjacent to the Sabaskong Batholith.

Folding

Using facing criteria in pillowed mafic flows several fold axes are delineated in the map-area. The map-area may be divided into two discrete structural regimes on the basis of structural style. West of the Helena-Pipestone Lakes Fault, the Nightjar Anticline is a broad, northeast-trending fold in the mafic flow sequence. On the north limb of this fold is the Katimiagamak Lake Anticline-Syncline pair; on the south limb is the Slender Lake Syncline.

The Katimiagamak folds are rapidly transitional from very open-style folds at and south of Anstey and Hornberg Lakes to very tight folds at Katimiagamak Lake. The northeast-trending Slender Lake synclinal axial trace is identifiable only as far as Dad Lake where it approaches the hinge of the Nightjar Anticline. In contrast to this the sequence between the tip of the Sabaskong Batholith (at Knauf Lake) along the length of the Nightjar anticlinal axial trace is apparently homoclinal and northeast- to east-facing. This sequence is the southern continuation of the homoclinal sequence of mafic flows lying between Kakagi Lake and Katimiagamak Lake (Edwards 1980).

North of Dash Lake between Helena Lake and Phinney Lake, facing criteria are lacking but the Phinney-Dash Lake Complex which occupies this area and is south- to southeast-trending in a general sense, is continuous with similar east-southeast-trending rocks in the vicinity of Schistose Lake north of the present map-area (Edwards 1980). At Schistose Lake, this sequence overlies and appears to mark the cessation of mafic volcanism. The relationship between the Phinney-Dash Lake Complex and the mafic rocks east of the complex in the present map-area is uncertain because of faulting.

Structures east of the Helena-Pipestone Lakes Fault (zone) are separate from those west of the fault because most of the mafic flow and gabbro sequence east of the fault is tightly isoclinally folded in accordion-like fashion. Alternatively, this style of deformation may be attributed to tectonic stacking during gravity sliding. However, the more traditional folding interpretation of folding is described here due to the lack of sufficient evidence to the contrary.

At least three folds (or fault slices) of short wavelength are present between the Helena-Pipestone Lakes Fault and Line Bay. General facings and strikes derived from pillowed mafic flow units in the block east of the Helena-Pipestone Lakes Fault indicate that these folds are open at the extreme northeastern part of the area but close rapidly to the south-southwest into a tight style of folding. This may be a result of either a) increasing compressional strain to the south-southwest, or b) a change of attitude of the plunge of the axis of the folds, the plunge being steeper in the north-northeast part of the area. In the vicinity of Gates Ajar Narrows, the shorter wavelength of the folding is much shOrter, a phenomenon which is probably concomitant with increasing strain adjacent to the Helena-Pipestone Lakes Fault.

Faulting

MAJOR FAULTS

Helena-Pipestone Lakes Fault

The Helena-Pipestone Lakes Fault extends from an area south of Dad Lake. It trends northeastward along the southeast contact of the Silver Lake trondhjemite stock. South of Silver Lake, it bifurcates into several carbonatized fractures in a zone roughly subparallel to the northwest shore of Pipestone Lake, and extends into the vicinity of Gates Ajar Narrows and west of Helena Lake. In the sense that it marks a zone of disrupted strata and small separated allochthonous blocks as a result of long, strike-parallel faulting and smaller cross faulting, the fault could be called a fault system. The Helena-Pipestone Lakes Fault also appears to mark the boundary between the tightly isoclinally folded block in the northeastern part of the map-area and the basically homoclinal sequence to the northwest of the fault.

The lenticular, Silver Lake trondhjemite stock appears to have been intruded along part of the Helena-Pipestone Lakes Fault. Some faulting must have occurred after the intrusion since that part of the stock 150 m east of the portage from Pipestone Lake into Dash Lake has been sheared and carbonatized.

OTHER FAULTS

Several faults of local proportions are in the map-area. Many are located only because of the offset of units and the presence of a lineament in the form of a gully or line of trees or similar feature. Especially in the northeast quadrant of the map-area, fault zones are commonly marked by heavy carbonatization. This carbonate permeation of fault zones is associated with, and continuous with, a carbonate affected zone lying north of the present map-area in the southeast quadrant of the Schistose Lake Area (Edwards 1980) and is probably from hydrothermal activity during the emplacement of the Phinney-Dash Lake Complex. One example is the approximately 600 m wide Phinney Creek Fault zone which is marked by strong shearing and carbonatization. It extends from Phinney Lake, southwestward along Phinney Creek, and pinches out just east of the narrow unnamed east-west lake southwest of Phinney Lake. This fault zone which was diamond drilled at this unnamed lake for Freeport Canadian Exploration Company (see section on "Economic Geology") may be a manifestation of subsidence or resurgence during the emplacement of the Phinney-Dash Lake Complex.

Several small right- and left-lateral faults trend almost perpendicular to the contact between mafic flows and the Sabaskong Batholith north of Carver Lake, and offset the contact by as much as 150 m.

Faulting parallel to strata is not obvious though it is undoubtedly present. Routine evidence for these faults such as sheared contacts is not commonly observed since these zones tend to weather down. Indirect evidence such as strata-parallel gullies with carbonatized exposure on each side, is especially evident in the area between Line Bay and Gates Ajar Narrows.

Strike-parallel deformation commonly marks contacts within the gabbro sills but much of this may have occurred during the emplacement of the separate subphases of the gabbro.

One of the most striking physiographic features of the area is the fault-like straightness of the southeast shore of Pipestone Lake. However, no evidence for the existence of such a fault was found. Instead, deformation in the mafic metavolcanics along the south shore increases southward in a 300 to 900 m thick zone which grades from chlorite and rarer biotite schist through banded amphibolite into stromatic migmatite at the contact with the Jackfish Lake Complex. Some of this deformation could be attributed to emplacement of the Jackfish Lake (syenodiorite) Complex but the syenodiorite itself is poorly foliated parallel to the contact (and elsewhere) and the stromatic or *lit-par-lit* and agmatic nature of the contact indicate a passive mode for at least the final stage of emplacement for the body. As well, gneiss and migmatite generally more leucocratic than the contact migmatite previously mentioned are in contact with the Jackfish Lake syenodiorite at Loonhaunt Lake (see section "Gneiss and Migmatite"). These features probably mean that the Jackfish Lake syenodiorite was emplaced along a pre-existing zone of regional deformation, namely, the contact between the volcanic belt and the diapirically intruded gneiss-migmatite terrain. For these reasons, the mode of emplacement of the Jackfish Lake Complex and its relationship to the greenstone belt differs markedly from that of the Sabaskong Batholith.

Foliation and Schistosity

Foliation is strongly to moderately developed in the following areas: a) along the south shore of Pipestone Lake; b) north of the west part of Dash Lake where mafic volcanic rocks have been stretched by the dilative nature of the Phinney and Dash Lake porphyry bodies; c) adjacent to major fault zones and other smaller sheared zones in the map-area; d) in mafic rocks in the vicinity of Line Bay and in the tightly folded sequence between Line Bay and the Helena-Pipestone Lakes Fault. The Jackfish Lake syenodiorite and the Sabaskong Batholith within the map-area exhibit very weak foliation in the form of alignment of biotite and/or hornblende. The Dash Lake Stock exhibits a weak foliation manifested by poor to good alignment of altered amphibole phenocrysts.

Massive mafic flows adjacent to the Sabaskong Batholith in a zone up to 1800 m thick (northwest of Nightjar Lake) are noticeably undeformed.

Schistosity is gradational with foliation and banded amphibolite and gneiss south of Pipestone Lake, north of the contact zone of the Jackfish Lake syenodiorite. The Helena-Pipestone Lakes Fault and the Phinney Creek Fault are the major zones of schistosity but several smaller zones exist especially in the vicinity of and south of Katimiagamak Lake.

Flaser texture is developed in some ophitic gabbros and in rare places gives the rock an appearance not unlike that of mafic agglomerate. This texture is particularly well developed on the north shore of the bay of Pipestone Lake 600 m due south of Silver Lake. In this location, deformation is related to the Helena-Pipestone Lakes Fault. Rarely, the contact between quartz-amphibole gabbro and leucogabbro may be so deformed that it is difficult to determine exactly where the contact is.

Gneissosity, Banding, Migmatite

Mafic amphibolites in a zone 300 to 900 m thick adjacent to the Jackfish Lake Complex exhibit increasing degrees of gneissosity grading into banding (Photo 14) and *lit-par-lit* migmatization (Photos 15, 16) approaching the contact. The gneissosity is thin alternating bands of light and dark material usually on a scale of less than 2 cm and is attributed to incomplete metamorphic segregation in sheared mafic rocks. In some areas the gneissosity resembles bedding as in the outcrop 150 m north of the old shaft on the east shore of the channel from Pipestone Lake into Stonedam Lake. Banding several centimetres thick is attributed to more complete metamorphic segregation with the introduction of some leucocratic remobilization and grades into *lit-par-lit* injection migmatite commonly with stromatic, ptygmatic, and schollen structures, boudinage, and in the syenodiorite, agmatite and rarely dictyonitic structures (Mehnert 1968). Contacts between biotite and hornblende schist, banded amphibolite and stromatic and agmatic migmatite are more sharply defined along the contact zones southeast of Weld and Feather Lakes.

Gneissosity and banding in the gneiss and migmatite at Loonhaunt Lake roughly parallels the contact with the Jackfish Lake Complex (Blackburn 1976a). Banding at all scales exists from fine gneissic to very broad compositional banding. Most of the structures attributed by Mehnert (1968) to anatexis or partial anatexis and assimilation are present in the gneiss in the map-area.

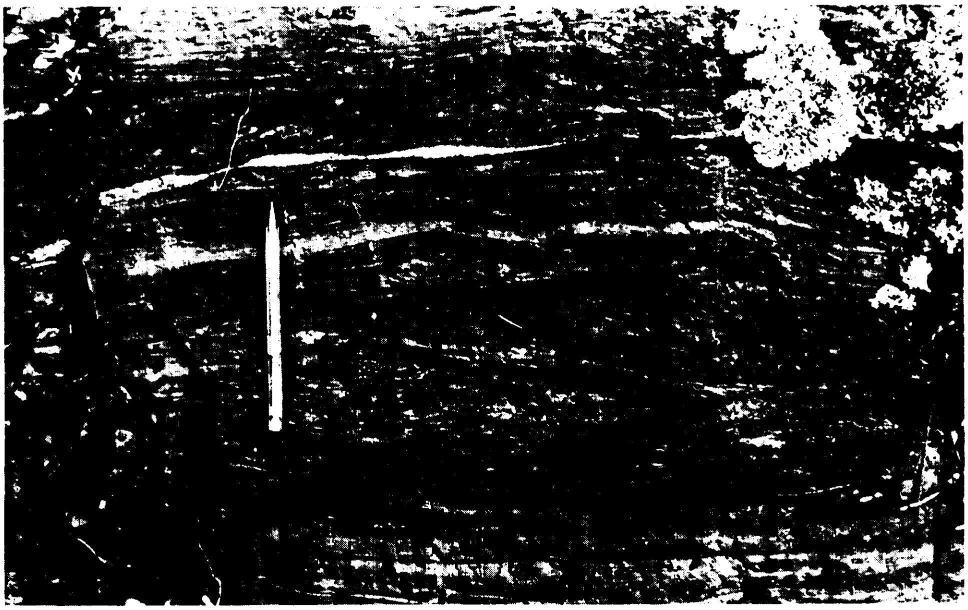

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Photo 14–Banded amphibolite 365 m southeast of the channel between Pipestone Lake and Weld Lake. Similar rocks are present along most of the length of the endocontact zone of the Jackfish Lake Complex in the map-area.

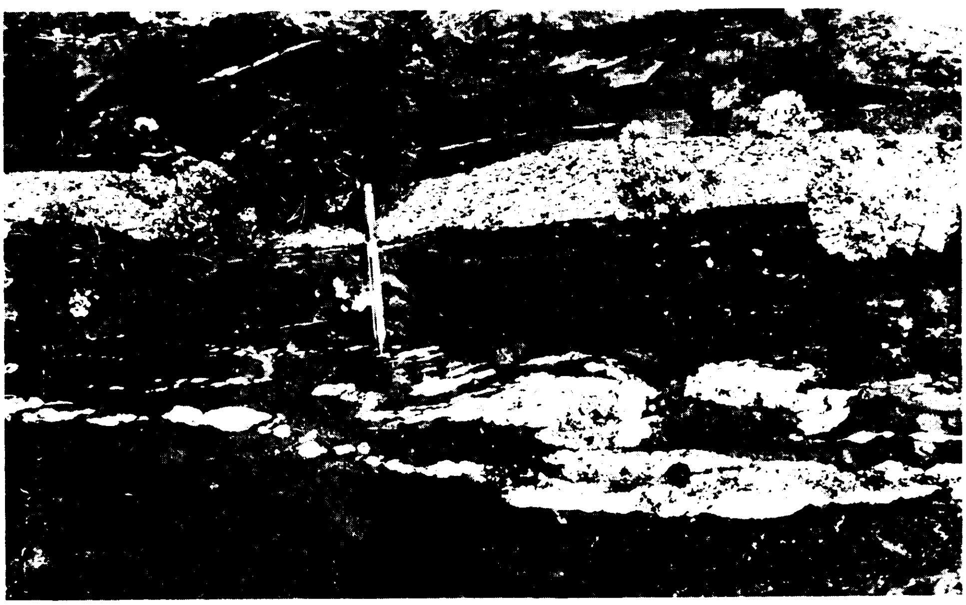

Photo 15–Migmatite structures in endocontact zone of the Jackfish Lake Complex, 1000 m. Folding and boundinage may have formed as a result of injection of magma under tension.

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Photo 16–Similar structures as in Photo 15, taken at the same location. Notice the different degrees of deformation in the two injected sills.

Lineation

Along the contact zone southeast of Pipestone Lake, lineation of phenocrysts, boudinage structure, and ptygmatic folds tend to be subvertical or plunge steeply in a general eastward direction. This concurs with the vertical contact of the Jackfish Lake Complex. Elongation of amygdules and phenocrysts in strongly folded mafic flows in the northeastern part of the map-area is evident in some outcrops. The trend is east generally, with a plunge of 70 to 80 degrees. Farther south, especially in rocks west of Gold Point Island relatively shallow plunges of 50 to 60 degrees in crenulated schists of the Helena-Pipestone Lakes Fault zone trend northeast to southeast.

Lineation is not a dominant feature of the rocks elsewhere in the map-area.

Fracture Cleavage

Fine fracturing or cleavage has affected much of the rock in the tightly folded sequence in the northeastern part of the map-area in a zone extending from the east edge of the map-area as far west as Phinney Lake. The fracturing generally is at two slightly divergent angles (10° to 30°) causing a rhombohedral-like brecciation of some rocks. Cleavage symbols have been used to denote the average trend of the long axes of the brecciation which is generally found to be near N45E. The fracturing may represent the intersection of foliations related to two interfering episodes of dynamic metamorphism since it is present in the area where the Pipestone Lake, Kakagi Lake, and Manitou Lake "Arms" of the Wabigoon Belt converge.

ECONOMIC GEOLOGY

Gold occurrences have been known in the area since the early 1930s and present mapping has revealed new exploration possibilities in an area that by present economic standards has not been considered a prime target. These possibilities are discussed under the heading "Suggestions for Exploration" later in this section.

Several quartz veins, sheared, carbonatized, and otherwise mineralized zones as well as pegmatites in the Jackfish Lake Complex and iron-rich zones in the effusive subphase of Phinney-Dash Lake Complex were sampled for qualitative spectrographic analysis and assay. Records of the Assessment Files Research Office, Ontario Geological Survey, Toronto suggest that the Bethune Lake area has not been extensively explored for base metals. These files contain only work that was submitted for assessment credit.

Presently there are seven mineral showings of significance in the map-area, three of which are described under "Description of Properties" later in this section. These three are the Bethune Occurrence (1) (gold), the Freeport Canadian Exploration Company (3) zinc showing at the narrow east-west-trending unnamed lake southwest of Phinney Lake, and the Lun-Echo Gold Mine Limited (4) gold showing west of Helena Lake.

During the field season, one asbestos occurrence was recognized and three mineral occurrences were discovered as a result of qualitative spectrographic analysis and assay of grab samples. These are described below.

Asbestos

A poorly exposed, narrow (less than 30 cm) vein of talcose, slip-fibre asbestos was found in metaperidotite (now talc, carbonate, and serpentine), 240 m from the west end of the south shore of Ross Island in Pipestone Lake.

Copper

Analyses of two grab samples collected by the author yielded anomalous copper values. One grab sample which contains 0.4 percent copper and trace amounts of zinc (Geoscience Laboratories, Ontario Geological Survey, Toronto) was taken from a poor exposure in a narrow, rusty-weathering zone of uncertain dimensions in mafic flow on the south shore of the point 610 m west-northwest of the tip of Gold Point Island in Pipestone Lake. The hand specimen contains minor disseminated pyrite. This zone extends parallel to the south shore of the peninsula and appears to be at least 5 m wide and observable over a length of 8 m. The other copper-bearing sample was taken by the author from a 0.6 m wide steeply dipping gossan zone trending N50W in mafic flows and contains 0.28 percent copper and a trace of zinc (Geoscience Laboratories, Ontario Geological Survey, Toronto). This occurrence located 610 m northwest of Sand Point in Pipestone Lake is within 2 m of the contact between mafic flow and metaperidotite and suggests that the ultramafic sills in the area may locally have been sources of mineralizing solutions (Pyke 1975).

Gold

A grab sample taken by the author from an irregular 5 to 10 cm wide quartz vein containing minor visible pyrite mineralization assayed 0.04 oz./ton gold and 0.14 oz./ton silver (Geoscience Laboratories, Ontario Geological Survey, Toronto). This occurrence is located in mafic flow at the north tip of the largest island in the north part of Gates Ajar Narrows (60 m south of the northern boundary of the map-area).

Suggestions for Exploration

As a result of present mapping there appear to be several exploration possibilities which may or may not lead to economically significant deposits. The stratigraphy and geological features of the area were mapped as accurately as possible in the one field season alloted in the hope that stratigraphic relationships might be used as an aid to exploration companies in outlining exploration target areas.

PHINNEY-DASH LAKE COMPLEX

The area occupied by the Phinney-Dash Lake Complex, extending north of the eastern part of Dash Lake to Phinney Lake, west to the narrow east-west-trending unnamed lake southwest of Phinney Lake, and north into Schistose Lake (north of the present map-area) (Edwards 1980) was previously mapped as intrusive porphyry though some pyroclastic rocks were identified by Thomson (1936) in the Dash Lake area. The complex now is interpreted to be largely a submarine felsic volcanic centre where a rising felsic magma intruded its own ejecta. The result is a complex assortment of felsic pyroclastic rocks and minor flows, volcanic conglomerate, chert, ferruginous synvolcanic breccia, iron formation, intrusive porphyry, and felsite. Chemical sediments, interdigitated with the felsic volcanics are present in the form of chert, ferruginous chert, iron formation, and ferruginous synvolcanic breccia. Iron-rich carbonate is an important constituent of these exhalative units, forming much of the matrix of the ferruginous chert, breccia, and iron formation. The Phinney Creek Fault, a probable avenue for the transport of iron-rich hydrothermal fluids extends from Phinney Lake along Phinney Creek to the west of the narrow unnamed, east-trending lake southwest of Phinney Lake. Two electromagnetic anomalies were diamond drilled in this fault for Freeport Canadian Exploration Company Limited and minor amounts of copper and zinc were reported from some sections of the core (see section on "Description of Properties"). Freeport also diamond drilled at the north end of the unnamed lake east-southeast of Phinney Lake, intersecting pyrite and graphite in iron-carbonate-rich ferruginous chert and argillite respectively.

The assemblage and paleoenvironment of the Phinney-Dash Lake Complex is not unlike that which could give rise to mineral deposits of the Kuroko type (Sato 1974). For this reason this complex should be explored in more detail.

MAFIC-ULTRAMAFIC INTRUSIONS

The ultramafic intrusions should be checked for asbestos and/or talc, primary sulphide precipitate mineralization as well as sulphide and/or gold mineralization. The latter might be associated with hydrothermal fluids (Pyke 1975) which may have affected the host rock either during intrusion or during the serpentinization and talc-carbonate alterations which have affected most of the peridotites. The copper occurrence located 610 m northwest of Sand Point (see "Copper") is within 2 m of the contact between mafic flow and serpentinized peridotite and may be an example of this latter type of mineralization. The Lun-Echo Gold Mine Limited property is mainly in carbonate-talc schist, presumably altered peridotite, in the Helena-Pipestone Lakes Fault zone but this could be associated with the fault rather than the lithology. Green mica-bearing altered ultramafic rocks in the northeastern part of the map-area should be examined for possible gold mineralization.

Evidence of in situ gravity fractionation in mafic and ultramafic intrusions is scant but the possibility cannot be ignored. The quartz-amphibole (magnetite) gabbro locally contains up to 15 percent leucoxene (after ilmenite). One qualitatively analyzed grab sample of quartz-amphibole (magnetite) gabbro contains 10 percent visible magnetite and yielded titanium values from 0.5 to 5 percent as well as a trace of vanadium (Geoscience Laboratories, Ontario Geological Survey, Toronto). The sample was taken from the west shore of Helena Lake, 430 m north-northeast of the portage from Pipestone Lake. If a crystal settling process operated within the gabbro sills, TiO_2 may locally have been enriched sufficiently to warrant exploration.

HYDROTHERMAL-TYPE DEPOSITS

Fractures resulting from folding of the volcanic belt around the Sabaskong Batholith during its emplacement may have provided loci for gold and/or base metal hydrothermal deposits. Gold mineralization in quartz veins on the Bethune occurrence may be of this type (see section "Description of Properties"). Similarly, deformation zones associated with the emplacement of the Dash Lake Stock, the Phinney-Dash Lake Complex, and the Silver Lake Stock should also be examined.

The Helena-Pipestone Lakes Fault may be a good target for gold exploration considering that gold mineralization, for example the Lun-Echo Gold Mine Limited occurrence, is associated with this fault system.

OTHER EXPLORATION TARGETS

Scattered disseminated pyrite and pyrrhotite mineralization in amounts up to 20 percent occurs in mafic flows and gabbro in a west-trending structurally controlled mineralized zone (transverse to strike) at least 1500 m long and 450 m wide lying just south and southwest of the narrow unnamed lake southwest of Phinney Lake. Judging by the presence of picket lines and flagging tape, some work for which there is no recorded assessment has been done on this zone. Similar mineralization was found in quartz-amphibole gabbro on the north shore of a small lake 1200 m south of Anstey Lake.

The copper occurrence located on the south shore of the peninsula 610 m west-northwest of the north tip of Gold Point Island in Pipestone Lake (see "Copper") should be investigated.

Property Descriptions

BETHUNE OCCURRENCE (1)

The Bethune occurrence (Thomson 1936) is between Pipestone and Nightjar Lakes but was not found by the field party. Work on this occurrence appears to have been mainly stripping and trenching of a quartz vein (as described as follows in Thomson 1936, p.24).

> A group of claims located between Pipestone and Nightjar Lakes is owned by F.H. Bethune and sons, of Emo. The showing consists of a quartz vein, which lies between a quartz porphyry dike and massive greenstone. The largest exposure of the vein is 110 feet in length and from 3 to 16 inches in width. To the west this exposure disappears under a swamp, but some quartz occurs along the strike to the east. The basaltic wall rock is slightly mineralized but the porphyry is not. The porphyry is cut by small unmineralized quartz stringers. Two kinds of quartz are found in the vein, a white sugary variety, which contains rather fine visible gold, and a dark coloured quartz, which is mineralized with pyrite and chalcopyrite along fractures. Five channel samples across 2 feet, at intervals over a length of 200 feet, are reported to show from 0.02 to 0.98 ounces gold per ton.

CANADIAN NICKEL COMPANY [1969] (2)

Pyrite-Pyrrhotite Occurrence

Two diamond drill holes one 213 feet and the other 150 feet long were drilled by the Canadian Nickel Company Limited in 1967 and 1969 respectively on one claim (FF19142) of a multiple claim group approximately 550 m west-southwest of the channel between Pipestone and Stonedam Lakes.

Both holes were drilled in an area which coincides with a low to medium intensity positive aeromagnetic anomaly shown on Aeromagnetic Map 1168G (ODM-GSC 1962) and which trends parallel to Pipestone Lake between the lake and the Jackfish Lake Complex. Disseminated to massive pyrite and pyrrhotite were intersected throughout the length of both the holes which were drilled in a felsic to intermediate tuffaceous rock containing minor chert.

A third hole, 101 feet in length, drilled on a claim (FF19162) 3.2 km along strike to the southwest in a high of the same aeromagnetic anomaly, 1800 m west-southwest of the north tip of Cobourg Lake, intersected approximately 13 feet of massive pyrrhotite with minor pyrite and a trace of chalcopyrite associated again with a cherty horizon in alternating amphibolite and a felsic intrusive rock (migmatite).

No work has been submitted for assessment since 1969 and the claims were allowed to lapse.

FREEPORT CANADIAN EXPLORATION COMPANY (3)

In 1971 and 1972, Freeport Canadian Exploration Company conducted an airborne EM survey over a large area in the northern and eastern part of the present map-area. Five holes were diamond drilled in the northern part for Freeport Canadian Exploration Company as a result of that survey. Three of the holes totalling 1,097 feet in length, were located at the narrow unnamed lake southwest of Phinney Lake in a poorly exposed zone of schistose felsic lapilli-tuff in the Phinney Creek Fault. The diamond drilling intersected mainly felsic pyroclastic rocks. One 307-foot long hole, located in the small peninsula on the south shore of the above mentioned unnamed lake intersected a 1-foot zone at 185 feet which yielded copper values of 0.18 percent and zinc values of 0.25 percent; a 1-foot zone at 225.5 feet which yielded copper values of 0.03 percent and zinc values of 0.25 percent; and a 2-foot zone at 273 feet which yielded copper and zinc values of 0.18 and 0.035 percent respectively. Specks of chalcopyrite were reportedly visible in several sections of the core (Assessment Files Research Office, Ontario Geological Survey, Toronto). The 370-foot long hole diamond drilled southward in the same unnamed lake on the property intersected disseminated pyrite in varying amounts. The 420-foot long north-trending diamond drill hole in this same unnamed lake intersected up to 50 percent pyrite in some sections. A 2.5-foot zone at 297.5 feet containing specks of visible chalcopyrite analyzed 0.20 percent copper (Assessment Files Research Office, Ontario Geological Survey, Toronto).

Two of the five holes were drilled at the north end of the unnamed lake east-southeast of Phinney Lake to determine the source of a north-northeast-striking EM anomaly in that area. One 62-foot hole was abandoned after intersecting brecciated chert containing variable amounts of pyrite up to 25 percent. The other hole was drilled to 301 feet in a westward direction in carbonate-rich pyritic (rarely up to 50 percent) chert, felsic pyroclastic rocks, argillite, and quartz-feldspar porphyry. Numerous graphitic sections were present between 106 and 142.5 feet.

Claims upon which drilling was performed in both areas are still held by Freeport (December 31, 1975). These are claims K269345 and K268877.

LUN-ECHO GOLD MINES LIMITED [1960] (4)

In 1960, diamond drilling was performed on claim K29656 owned by Lun-Echo Gold Mines Limited and located 210 m west of Helena Lake (600 m north-northwest of the creek into Pipestone Lake). Grab samples taken from surface trenching assayed gold values significant enough to warrant the drilling (values unknown). Two holes were drilled from the same location both bearing N75W at dips 45 degrees and 65 degrees respectively. The drill intersected mainly chlorite schist and minor carbonate-talc schist in both holes. Low values of gold (0.005 to 0.02 ounces per ton) were found in three zones up to 5 feet wide in the 415-foot hole drilled at 45 degrees azimuth. Higher gold values were obtained from core over a 15-foot zone between 165.0 and 180.0 feet in carbonate-talc schist from the 204.0-foot long second hole. These values are: 0.05 ounces Au per ton between 165 and 170 feet; 0.025 ounces Au per ton between 170 and 175 feet; 0.04 ounces Au per ton between 175 and 180 feet (Assessment Files Research Office, Ontario Geological Survey, Toronto).

No work has since been submitted for assessment and the claim was allowed to lapse.

NORANDA MINES LIMITED [1968] (5)

In 1968, ground electromagnetic and magnetometer surveys apparently following an airborne survey were performed by Noranda Mines Limited over a six-claim property (claims FF18620, FF18621, FF18622, FF18623, FF18624, and FF18625) between Weld Lake and Slender Lake. The survey detected three distinct and separate anomalies of fair conductivity lying under water (Assessment Files Research Office, Ontario Geological Survey, Toronto). No follow up work was performed and the claims were subsequently let go.

D.R. YOUNG (6).

Eight patented claims (FF4453, FF4454, FF4457, FF4458, FF4459, FF4460, FF4544, and FF4545) occupy an area between Silver Lake and the bay of Pipestone Lake leading into Dash Lake. The claims presently are under Licence of Occupation to D.R. Young. Reasons for original staking and surveying of these claims are unknown to the author though they do occupy part of the Helena-Pipestone Lakes Fault which in this area forms the contact between sheared mafic flows and gabbros and the Silver Lake Stock. The northern part of the Silver Lake Stock is also sheared and is included in the property. There are heavily carbonatized rocks in the patented area near the shore of Pipestone Lake southwest from the diabase dike.

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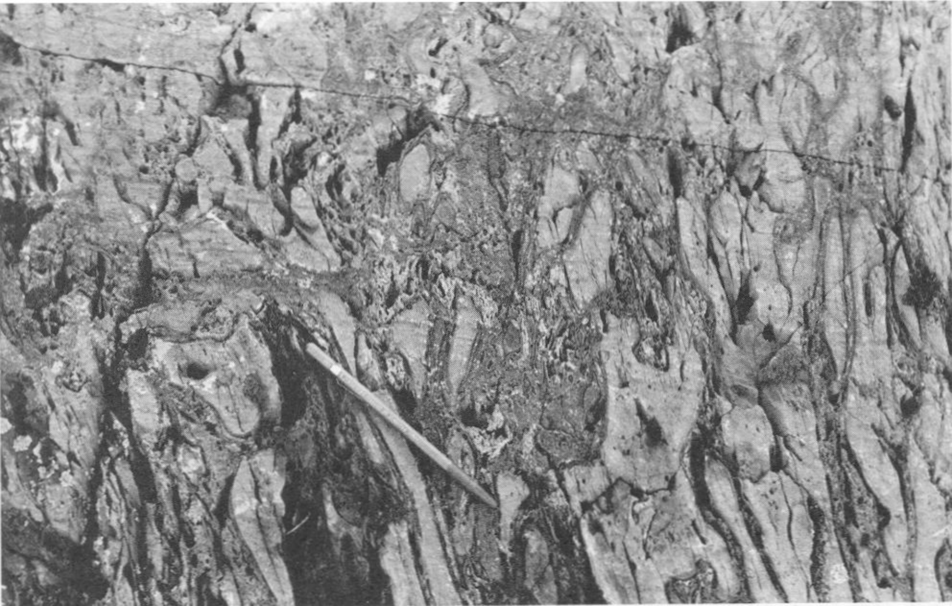
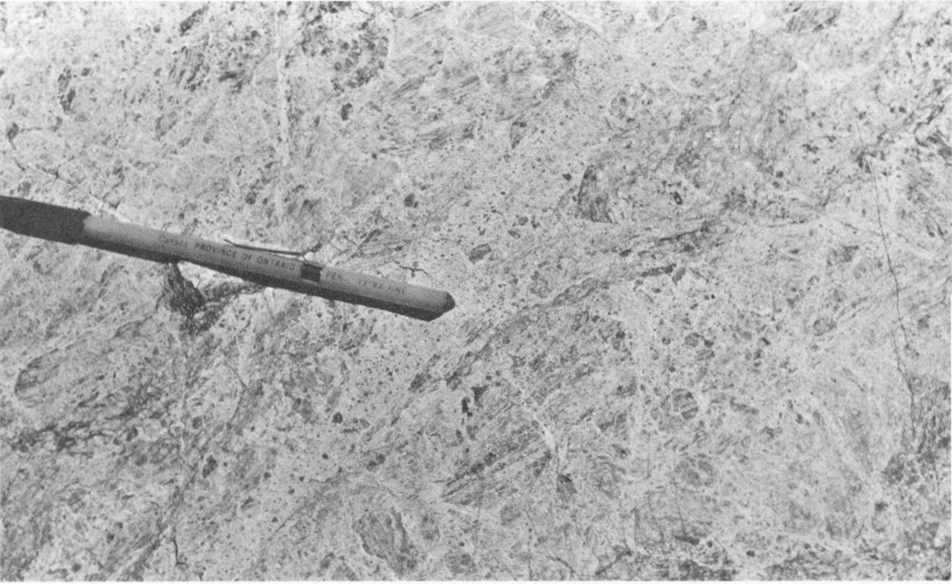
INDEX

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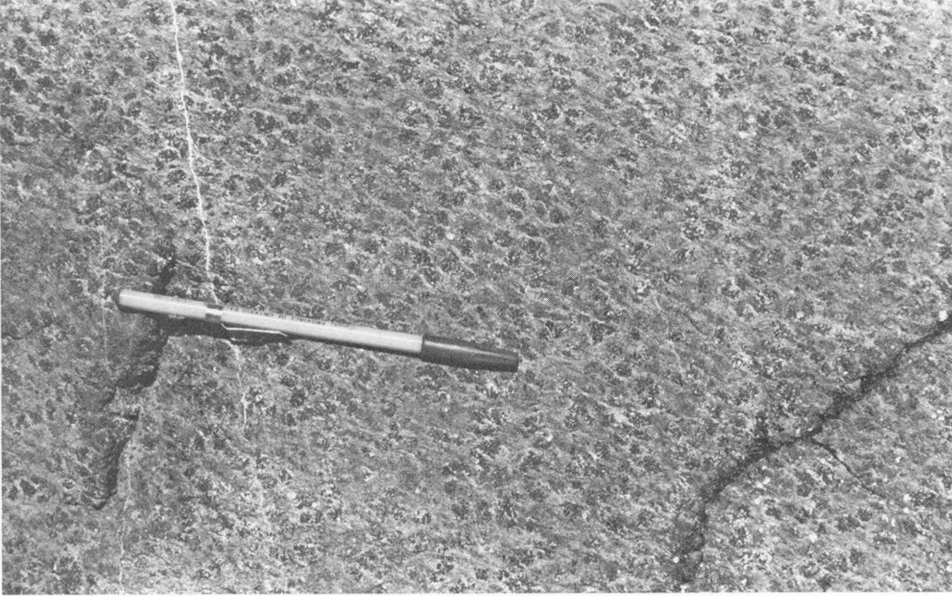
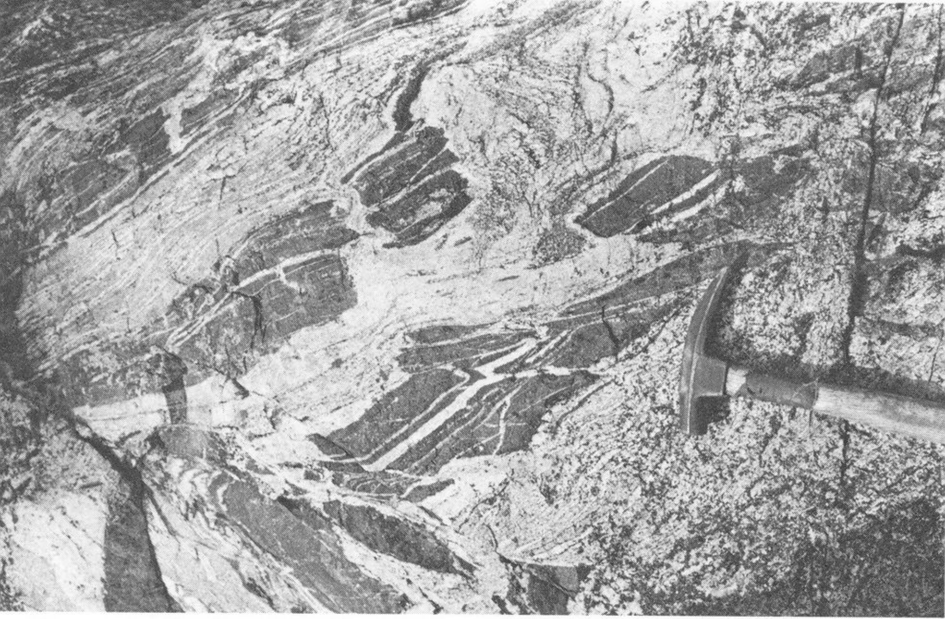
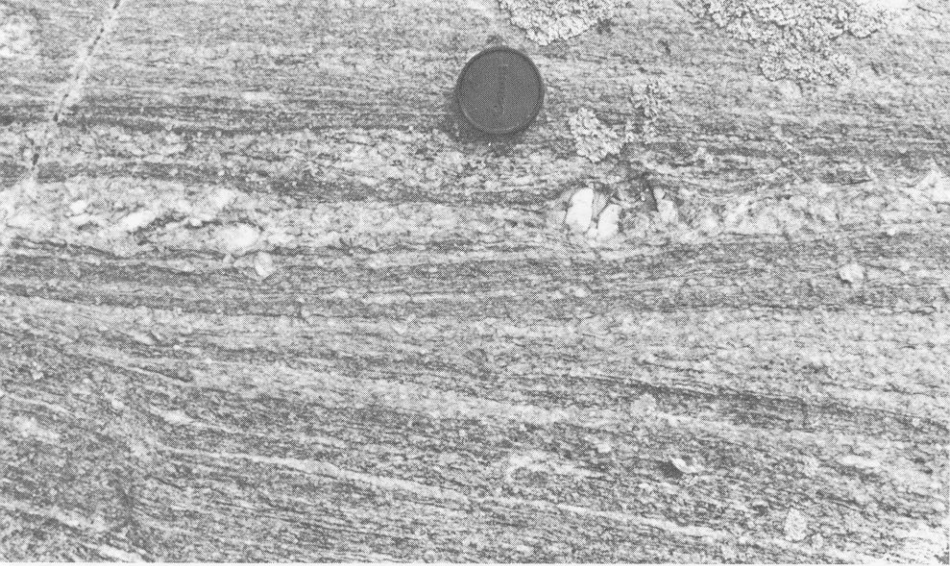
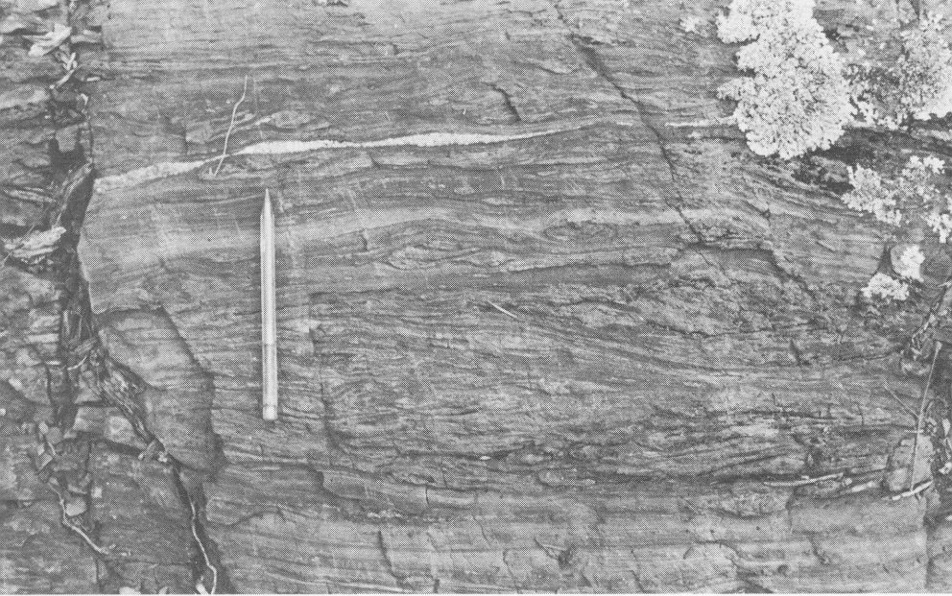


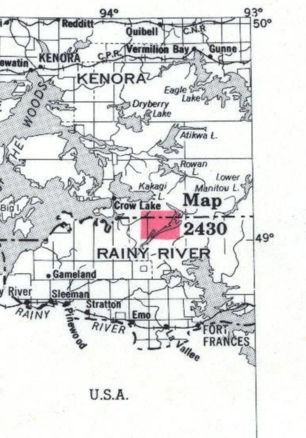






Ontario
Ministry of Natural Resources

Ontario Geological Survey
Map 2430
Bethune Lake

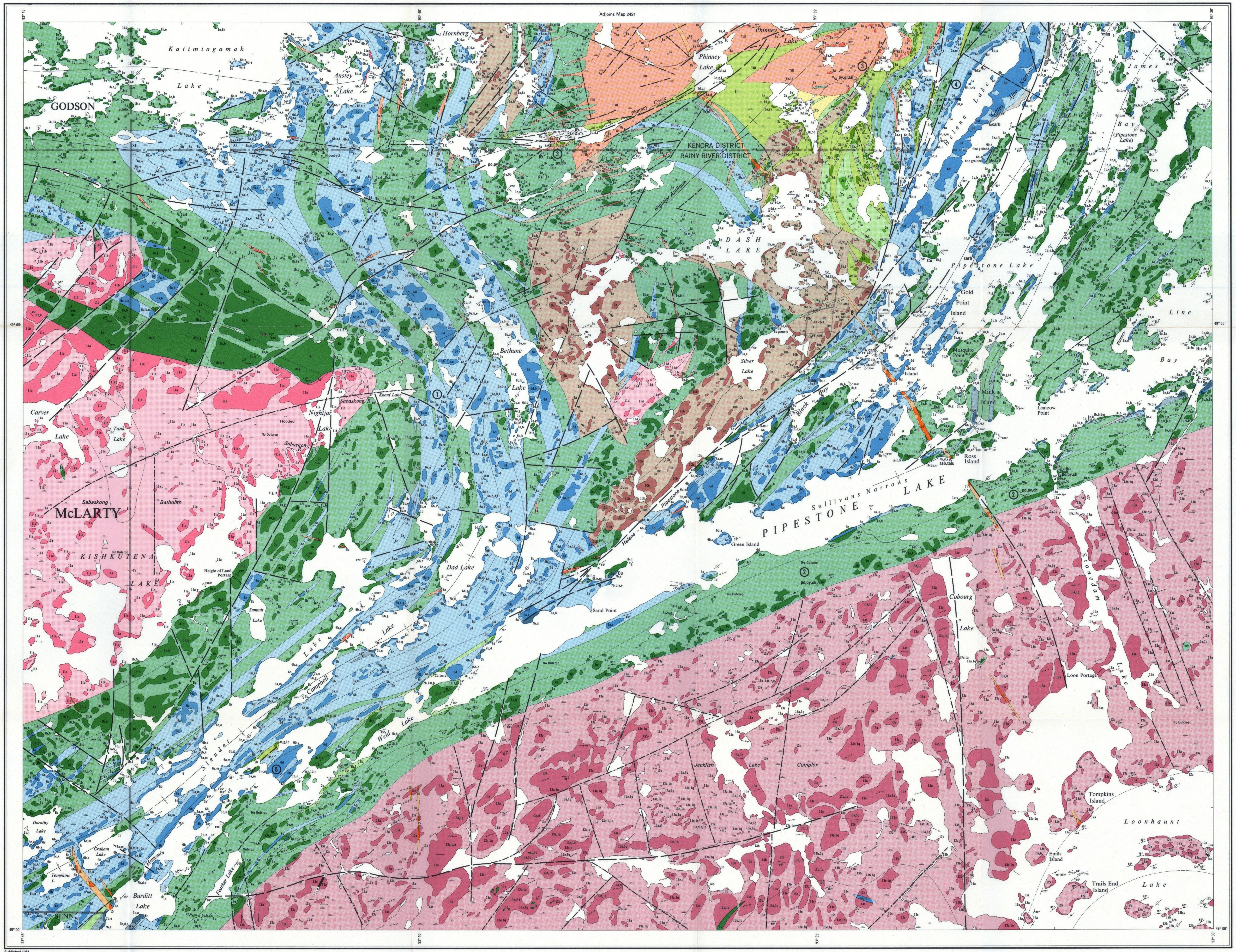


Scale 1 inch to 50 miles

N.T.S. reference 52 F/4

SYMBOLS

- Glacial striae.
- Glacial fluting.
- Small bedrock outcrop.
- Area of bedrock outcrop.
- Bedding, top unknown; (inclined, vertical).
- Lava flow; top (arrow) from pillows shape and packing.
- Schistosity; (horizontal, inclined, vertical).
- Gneissosity; (horizontal, inclined, vertical).
- Foliation; (horizontal, inclined, vertical).
- Banding; (horizontal, inclined, vertical).
- Lineation with plunge.
- Geological boundary, observed.
- Geological boundary, position interpreted.
- Fault; (observed, assumed). Spot indicates down throw side, arrows indicate horizontal movement.
- Lineament.
- Jointing; (horizontal, inclined, vertical).
- Drag folds with plunge.
- Anticline, syncline, with plunge.
- DH Drill hole; (vertical, inclined).
- MA Magnetic attraction.
- Muskeg or swamp.
- Building.
- Road.
- Trail, portage, winter road.
- District boundary with milepost, approximate position only.
- Township boundary, base or meridian line, with mileposts, approximate position only.
- Township boundary, unsurveyed; approximate position only.
- Mining property, surveyed. Boundary approximate position only.
- Mineral deposit; mining property, unsurveyed.
- Surveyed line, approximate position only.



Published 1981

PROPERTIES, MINERAL DEPOSITS

1. Bethune occurrence.
2. Canadian Nickel Co. [1969].
3. Freeport Canadian Exploration Co.
4. Lun-Echo Gold Mines Ltd. [1960].
5. Noranda Mines Ltd. [1968].
6. Young, D. R.

Information current to December 31st, 1975. Former properties on ground now open for staking are only shown if exploration data is available—a date in square brackets indicates last year of exploration activity. For further information see report.

SOURCES OF INFORMATION

Geology by G. R. Edwards and assistants, 1975. Geology is not tied to survey lines.

ODM-GSC Aeromagnetic map 1168G, Kakagi Lake.

Preliminary map P.1103, Pipestone Lake Area (Southern Half), scale 1 inch to ¼ mile, issued 1976.

Cartography by M. J. Colman and assistants, Ministry of Natural Resources, 1979.

Basemap derived from maps of the Forest Resources Inventory, Ministry of Natural Resources, with minor revisions by G. R. Edwards.

Magnetic declination in the area was approximately 5°30′E, 1975, decreasing annually 15″W approximately.

Parts of this publication may be quoted if credit is given. It is recommended that reference to this map be made in the following form:

Edwards, G. R.
1981: Bethune Lake; Ontario Geological Survey Map 2430, Precambrian Geology Series, scale 1 inch to ½ mile. Geology 1975.

LEGEND

PHANEROZOIC

CENOZOIC[a]

QUATERNARY

RECENT

Swamp, stream, and lake deposits.

PLEISTOCENE

Till.

UNCONFORMITY

PRECAMBRIAN[b]

MIDDLE TO LATE PRECAMBRIAN (PROTEROZOIC)

MAFIC INTRUSIVE ROCKS

15 *Diabase.*

INTRUSIVE CONTACT

EARLY PRECAMBRIAN (ARCHEAN)

LATE MAFIC INTRUSIVE ROCKS

14 *Unsubdivided.*
14a *Amphibole-pyroxene lamprophyre.*
14b *Mica lamprophyre.*
14c *Mica-pyroxene lamprophyre.*

INTRUSIVE CONTACT

FELSIC TO INTERMEDIATE PLUTONIC ROCKS[c]

RAINY LAKE BATHOLITH

Jackfish Lake Complex

13a *Biotite-hornblende syenodiorite.*
13b *Pyroxene-hornblende syenodiorite.*
13c *Pyroxene syenodiorite, gabbro.*
13d *Aplite.*
13e *Pegmatite.*

INTRUSIVE CONTACT

Gneiss, Migmatite

12a *Stromatic gneisses of trondhjemitic and granodioritic composition.*
12b *Trondhjemitic, granodioritic rocks, migmatitic structures.*
12c *Amphibolite pods, agmatic structures.*

SABASKONG BATHOLITH

11a *Coarse-grained hornblende-biotite trondhjemite.*
11b *Hornblende diorite, gabbro.*
11c *Fine-grained equigranular, hornblende-biotite trondhjemite.*
11d *Syenite.*
11e *Felsite.*
11f *Quartz-feldspar porphyry.*
11g *Agmatic migmatite.*

INTRAVOLCANIC PLUTONS

Silver Lake Intrusion

10a *Agmatic migmatite.*
10b *Leucocratic biotite trondhjemite.*
10c *Quartz-sericite schist.*

Dash Lake Stock

9a *Hornblende trondhjemite.*
9b *Quartz-feldspar porphyry dikes.*
9c *Felsite.*
9d *Porphyritic (quartz) leucocratic trondhjemite.*
9e *Intrusive flow banded.*
9f *Chloritic fracture veins.*
9g *Pyritic.*
9h *Carbonatized.*

Phinney-Dash Lake Complex

8a *Quartz-feldspar porphyry.[d]*
8b *Feldspar porphyry.*
8c *Carbonate-sericite schist.*
8d *Carbonatized.*

INTRUSIVE CONTACT

METAMORPHOSED MAFIC AND ULTRAMAFIC INTRUSIVE ROCKS[c]

ULTRAMAFIC INTRUSIVE ROCKS

7a *Pyroxenite.*
7b *Peridotite (in part dunite).*
7c *Talc-carbonate schist.*
7d *Talcose, carbonatized.*
7e *Serpentinized.*
7f *Silicified, carbonatized.*

MAFIC INTRUSIVE ROCKS

6a *Gabbro.*
6b *Leucocratic gabbro, diorite.*
6c *Amphibole gabbro.*
6d *Quartz-amphibole (magnetite) gabbro.*
6e *Ophitic gabbro.*
6f *Hybrid gabbro.*
6g *Flaser gabbro.*
6h *Fine-grained magnetite-leucoxene-bearing gabbro.*
6j *Diabasic gabbro.*
6k *Gabbro migmatite.[e]*
6m *Quartz-bearing.[f]*
6n *Porphyritic (plagioclase).*
6p *Carbonatized.*
6q *Chlorite schist.*
6r *Talcose, serpentinized.*
6s *Amphibolite.*

INTRUSIVE CONTACT

METAVOLCANICS AND METASEDIMENTS[c]

CHEMICAL METASEDIMENTS

5a *Chert, ferruginous chert.*
5b *Pyrite-limonite iron formation.*
5c *Cherty iron formation.*
5d *Hematite iron formation.*

CLASTIC METASEDIMENTS

4a *Feldspathic volcanic sandstone.*
4b *Banded, ferruginous, tuffaceous sediments.*
4c *Sericite schist.*

FELSIC METAVOLCANICS

3a *Flow.*
3b *Fragmental flow.*
3c *Tuff.*
3d *Lapilli-tuff.*
3e *Tuff-breccia.*
3f *Bedded tuff.*
3g *Sericite schist.*
3h *Flow banding.*
3j *Carbonatized.*
3k *Ferruginous (synvolcanic) breccia.*

INTERMEDIATE METAVOLCANICS

2a *Flow.*
2b *Tuff.*
2c *Lapilli-tuff.*
2d *Tuff-breccia.*
2e *Volcaniclastic conglomerate.*
2f *Schistose.*

MAFIC METAVOLCANICS

1a *Flow (unsubdivided).*
1b *Pillow flow.*
1c *Amygdaloidal flow.*
1d *Variolitic.*
1e *Massive flow.*
1g *Coarse-grained flow.[g]*
1h *Porphyritic flow (plagioclase).*
1j *Flow Breccia.*
1k *Pillow breccia.*
1m *Tuff.*
1n *Chlorite schist.*
1p *Hornblende-garnet, garnet-feldspar, feldspar and magnetite biotite schist, minor chert with migmatite and sulphide mineralization.*
1q *Amphibolite, garnetiferous amphibolite.*
1r *Carbonatized.*
1s *Magnetite bearing.[g]*
1t *Agmatic migmatite.*
1u *Stromatic migmatite.*

---

asb	*Asbestos.*
Au	*Gold.*
carb	*Carbonate.*
ch	*Chert.*
Cu	*Copper.*
gf	*Graphite.*
mag	*Magnetite.*
po	*Pyrrhotite.*
py	*Pyrite.*
q	*Quartz.*
talc	*Talc.*
Zn	*Zinc.*

---

[a] *Unconsolidated deposits. Cenozoic deposits are represented by the lighter coloured parts of the map.*

[b] *Bedrock geology. Outcrops and inferred extensions of each rock map-unit are shown respectively in deep and light tones of the same colour. Where in places a formation is too narrow to show colour and must be represented in black, a short black bar appears in the appropriate block.*

[c] *Rocks in these groups are subdivided lithologically; the order within a group does not imply age relationships.*

[d] *May be in part extrusive.*

[e] *Both subphases are gabbro or leucogabbro.*

[f] *Probably fine grained 6d.*

[g] *May be in part intrusive.*

Ontario Geological Survey
Map 2430

BETHUNE LAKE

KENORA and RAINY RIVER DISTRICTS

Scale 1:31,680 or 1 Inch to ½ Mile

Chains 80 60 40 20 0 1 2 Miles

Metres 1000 0 1 2 3 Kilometres

Feet 1000 0 5,000 10,000 Feet