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Geology of the Off Lake–Burditt Lake Area

District of Rainy River

By

C. E. Blackburn

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ABSTRACT

The Off Lake–Burditt Lake area lies between Latitudes 48°50′N and 49°00′N and Longitudes 93°35′W, and 94°10″W, and covers 306 square miles (792 km^2). Burditt Lake is 28 miles (45 km) northwest of Fort Frances.

Bedrock is of Early Precambrian (Archean) and Middle to Late Precambrian (Proterozoic) age, and is mantled by a veneer of unconsolidated Cenozoic deposits.

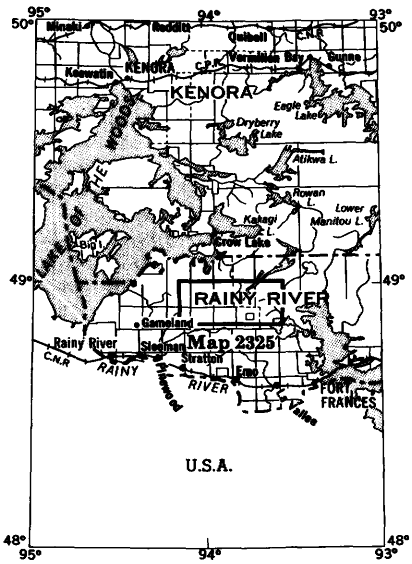

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Figure 1–Key map showing location of Off Lake–Burditt Lake area. Scale 1 inch to 50 miles (1:3,168,000).

The thick Early Precambrian metavolcanic assemblage underlies more than one-third of the map-area and occupies a northeast-southwest belt which is 5 miles (8 km) in width. On the northwestern flank of the belt, a mixed mafic sequence of massive lava, porphyritic basalt, and pillow lava is overlain by a mixed sequence of massive lava, pillow lava, porphyritic lava, and pyroclastic rocks. This sequence may be as much as 15,000 feet (4600 m) thick. This lower mafic sequence is intruded by numerous quartz-feldspar porphyry dikes. An upper sequence of mixed mafic to felsic metavolcanics outcrops extensively on the shores of Burditt and Off Lakes in the centre of the belt: felsic to intermediate metavolcanics consist of fine- to coarse-grained pyroclastic rocks, quartz-feldspar porphyry, and minor dacite and rhyolite; mafic metavolcanics consist of thin massive and pillowed lavas. A narrow mafic unit lies on the eastern flank of the belt.

Regional metamorphism increases from lower greenschist facies grade in the centre of the volcanic belt to lower amphibolite facies grade towards the belt margins. A broad migmatite zone is developed on the eastern flank of the belt.

Felsic to intermediate plutonic rocks, of Early Precambrian age and attributable to several episodes, all later than the volcanic activity, underlie less than two-thirds of the map-area. The volcanic belt lies between the trondhjemitic Sabaskong Batholith on the northwest, the heterogeneous, hybrid, granodioritic to dioritic Jackfish Lake Complex to the east, and the Fleming Township trondhjemites to the southeast. The Jackfish Lake Complex is bordered on its eastern side by granitic gneisses and migmatites. Three stocks intrude and lie completely within the volcanic belt: the Black Hawk Stock, a porphyritic granodiorite body with a monzonitic marginal zone; the Finland Stock, a heterogeneous quartz monzonitic to dioritic body; and the granodioritic Burditt Lake Stock.

A northwest-trending swarm of Middle to Late Precambrian diabase dikes crosscuts all other bedrock and postdates the major deformation.

During Pleistocene times, Wisconsin glacial activity was associated with ice originating in the Patrician and Keewatin centres, while glacial Lake Agassiz extended into the southwestern part of the map-area.

Major deformation of the metavolcanics was synchronous with plutonic activity. The main structural trend of the greenstone belt is northeast-southwest. No evidence of a major fold structure aligned parallel to this trend was found; on the contrary, all facing criteria indicate a southeast-facing homoclinal sequence. Tensional tectonics, with associated intrusion of diabase dikes, postdated the major episode of compressional tectonics.

Mineralization consists chiefly of pyrite, chalcopyrite, and minor magnetite within the mixed felsic to mafic metavolcanics, in the vicinity of Off Lake, and exploration activity in recent years has mostly been centred on this type of mineralization. Bismuthinite in association with chalcopyrite-pyrite-magnetite occurs within a mafic xenolith in the Jackfish Lake Complex. Substantial amounts of Pleistocene sand and gravel have been partially exploited.

Geology

of the

Off Lake–Burditt Lake Area

District of Rainy River

By

C. E. Blackburn[1]

INTRODUCTION

The Off Lake–Burditt Lake area lies between Latitudes 48°50′N and 49°00′N and Longitudes 93°35′W and 94°10′W, and is situated in the Rainy River District and in the Kenora Mining Division, near to the border with Minnesota. The area covers 306 square miles (792 km^2) and is 26.6 miles (42.8 km) wide and 11.5 miles (18.5 km) long. Off Lake and Burditt Lake, the latter known locally as Clearwater Lake, lie 28 miles (45 km) northwest of Fort Frances, the nearest large town. Both surveyed and unsurveyed country is included within the map-area: Rowe, Menary and Senn Townships are included; most of Richardson, Potts and Fleming Townships; parts of Dewart and Sifton Townships. The remaining country, in the east, in unsubdivided.

No mineral production had been reported from the map-area prior to the 1971 field season, though a number of mineral occurrences have been found and explored, notably at Off Lake where copper has been found along a north-northeast-trending lineament.

To the south and southeast, between the present map-area and the Ontario-Minnesota border, there has been active prospecting, staking and exploration over many years, with past-producing mines situated near Bad Vermilion Lake. Copper and nickel have been found in considerable amounts, in association with mafic intrusive rocks. Other important discoveries include gold, molybdenum, iron and titanium. The Quetico Fault (Shklanka 1972, p.39), a major structural break, separates the Off Lake–Burditt Lake area from this more southerly area. However, certain favourable geological formations extend northward into the map-area.

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Present Geological Survey

Map 2325 (back pocket) presents the results of the geological survey carried out by the author and his assistants during the summer of 1971.

The field maps were prepared at a scale of 1 inch to ¼ mile (1: 15,840), on base maps prepared by the Cartographic Unit, Ontario Division of Lands from maps of the Forestry Resources Inventory, Ontario Division of Lands. Field data were plotted on acetate overlays on vertical air photographs at the same scale as the base maps. The data were collected along lake shores, roads, and along pace-and-compass traverse lines run at or nearly at right angles to strike. The traverse interval was of the order of ½ mile (0.8 km) in those parts of the area underlain by metamorphic rocks, but considerably widened where only granitic rocks were encountered. The technique was modified somewhat in the southwestern part of the map-area, where heavy overburden limits the amount of outcrop; outcrops were pinpointed on the air photographs before the field work, and visited individually. Photo-interpretation played a large part in the preparation of the field maps and subsequent preliminary maps; areas between traverses were mostly not visited. Wherever possible the author and his senior assistant ran adjacent traverses.

Acknowledgments

The author was ably assisted in the field by D. A. Archibald, Denis Francoeur, G. F. L. Newton, and Cliff Craig. Mr. Archibald, as senior assistant, carried out independent mapping throughout the field season. Special thanks are due to Mr. and Mrs. C. D. Ross of Ross' Camp on Burditt Lake for the hospitality extended to the field party throughout the field season. Thanks are also due to Louis Cousineau and Mike Hupchuk, both of Fort Frances, and to residents at Off and Burditt Lakes, for various courtesies and help during the summer, and to the Naicatchewenin Band for permission to do geological work on Reserves 17A and 17B.

Fruitful discussions on problems relating to the geology of the area were held with H. L. King, former Resident Geologist, and J. C. Davies, former Field Geologist, Division of Mines, Ontario Ministry of Natural Resources, Kenora.

Access

Highway 71, joining with Highway 17 in the north and with Highway 11 in the south, thus linking Fort Frances and Kenora, runs north-south through the middle of the map-area. West of this highway, access is mainly by way of numerous township roads. East of Highway 71, and branching from it two miles (3 km) south of the map-area, an all-weather road, Highway 615, leads directly to Off Lake and Burditt Lake. In the southeastern part of the map-area, another all-weather road, Highway 613, connecting with Highway 11, provides access to Lake Despair, Footprint Lake, and Jackfish Lake, a system of interconnected waterways. A short mechanical portage on the Manomin River connects these lakes with Burditt Lake, and short portages, each about 200 feet (60 m) long, provide further access from Jackfish Lake to Albert and Ottertail Lakes. Panorama Lake may be reached from Burditt Lake via Cedar Lake, by way of a 150-foot (45 m) portage into Cedar Lake, and a 1,000-foot (300 m) portage into Panorama Lake. Beadle Lake, locally known as Long Lake, and Boundary Lake are best reached by float-equipped aircraft, though the former may also be reached by a quarter-mile (0.4 km) walk through the bush from the Ontario Hydro-Electric Power Commission line which crosses Highway 615 near Off Lake. Biddison Lake, in the northeastern part of the map-area, is best reached by air.

Previous Geological Work

Following field work carried out in 1885, 1886, and 1887, the general geology of the Rainy Lake region was first described by A. C. Lawson (1888a). Considerable work was carried out by Lawson within the present map-area, and a number of the map-units used in the present survey were first recognized and mapped by Lawson (1888b).

There is no published record of any significant geological work carried out in the Off Lake, Burditt Lake and surrounding country since Lawson's report, though considerable attention has been paid to areas to the south, southeast, and northeast. Between 1894 and 1897, A. P. Coleman made several excursions to northwestern Ontario to report, in particular, on the goldfields of the Kenora and Rainy River Districts for the Ontario Bureau of Mines. Among these the report of work carried out in 1894 (Coleman 1894, p.60-61) includes a brief account of geological observations made on a trip through the chain of lakes between Northwest Bay of Rainy Lake and Burditt Lake. In 1934, J. E. Thomson (1935) mapped the Rowan–Straw Lakes area which adjoins the present map-area to the northeast. In 1953, G. L. Fletcher and T. N. Irvine (1954) mapped the Emo area, which adjoins the present map-area to the south. In 1964, the Fort Frances area, immediately to the southeast of the present area, was mapped by J. C. Davies (1973). During a rapid geological reconnaissance along highways and roads for purposes of geological compilation, J. C. Davies spent a very limited time in the vicinity of the present map-area, and geological boundaries shown on the Kenora–Fort Frances sheet (Davies and Pryslak 1967) are partly based on this reconnaissance work.

Topography and Drainage

Elevation above sea level ranges from 1,100 feet (335 m), at the Rainy Lake waterlevel (Northwest Bay of Rainy Lake), to above 1,400 feet (425 m) on the hills between Potts Lake and Boundary Lake and on a number of hills to the north and west of Panorama Lake.

The map-area is divisible into two topographic regions, the boundary of which approximately parallels Highway 71 in the north of the map-area, and then follows a straight line from Off Lake to the west end of Northwest Bay. To the southwest of this boundary the country is mostly very flat, with only a few low hills, and no more than 50 feet (15 m) of relief. Drainage is by meandering rivers, two of which, the Splitrock River and Log Creek in the north, flow north, and one of which, the Pinewood River in the south, flows southwest. No lakes of any note occur southwest of the boundary, though ponds and swampy areas abound. Lawson (1888a) called this the "alluvial plain or river country".

In marked contrast, northeast of the boundary, the country is very irregular and hilly, with many large and small lakes lying in hollows between rocky hills and ridges. Ridges and valleys tend to parallel foliation directions in bedrock, but valleys also follow faults and major joint directions. Drainage in this "rocky lake country" (Lawson 1888a), is mainly by short creeks, rapids and channels connecting the larger lakes. The general drainage direction is toward the southeast into Northwest Bay of Rainy Lake. Water from Panorama and Burditt Lakes flowing via the Manomin River joins with that flowing out of Beadle, Pony and Off Lakes, to flow into Lake Despair. Connection is then made with water flowing out of Jackfish Lake via the Loonhaunt River through the Mile River. All water then enters Northwest Bay via the Footprint River exiting at the southeastern end of Footprint Lake, just outside the map-area in the southeast.

Density of rock outcrop varies considerably. Rock exposures are generally abundant east of Highway 71, owing to lack of glacial overburden. However, west of the highway lacustrine deposits cover large areas, though considerable bedrock does outcrop in Richardson Township and in the northwest. The highest ridges and hills are in general over metavolcanics, though plutonic rocks form quite rugged topography near the northeastern bay of Jackfish Lake.

Inhabitants, Natural Resources

The natural division of the map-area into two physiographically distinct regions noted in the section on topography and drainage has determined settlement and occupational development. In the southwestern part of the map-area, dairy farming has in the past supported a small population. Present economic conditions no longer make small farming ventures a viable proposition, so that many farmsteads are abandoned and the vegetation is returning to bush. The small communities of Dearlock, in the extreme southwest, and Finland on Highway 71 consist of only three or four properties each. There are two small stores at Finland, one of which has a gasoline pump.

In marked contrast with the southwestern part of the map-area, the region east of Highway 71, in which lakes abound, is a popular tourist and holiday area. Numerous lodges and cottages line the shores of Off Lake, Burditt Lake, Lake Despair, Footprint Lake, and Jackfish Lake. Boats and motors may be rented at a number of lodges on Off Lake and Burditt Lake, and at a lodge at the end of Highway 613 at the southeastern end of Lake Despair, where gasoline and provisions may also be obtained.

Gasoline, provisions, and automobile and outboard motor repairs may all be obtained at the small but thriving community of Burditt Lake. Government docks provide access for small boats to Off Lake, Burditt Lake, Lake Despair, and Lake Hope. Float-equipped aircraft may be chartered at Burditt Lake.

Rainy Lake Indian Reserves 17A and 17B are both inhabited by natives of the Naicatchewenin Band. 17A is the larger of the two, the village being outside the confines of the map-area, at the mouth of the Footprint River, where it enters Northwest Bay of Rainy Lake. A mechanical portage, operated by members of the Band, is located on the Manomin River within Reserve 17B.

Logging is carried out mainly in the northwest of the map-area, in Rowe Township. Pulpwood is hauled via road to the mills of the Ontario-Minnesota Pulp and Paper Company in Fort Frances.

GENERAL GEOLOGY

Isotopic ages obtained by various workers in the Rainy River District (Goldich *et al.* 1961; Hart and Davis 1969; Wanless 1970) indicate bedrock to be of Early Precambrian age, except for younger northwest-trending diabase dikes (Fahrig and Wanless 1963; Wanless 1970), of Middle to Late Precambrian age. By analogy with isotopic ages from surrounding localities, bedrock within the Off Lake–Burditt Lake map-area, apart from diabase dikes of Middle to Late Precambrian age, is considered to be of Early Precambrian age. A number of minor mafic dikes crosscutting granitic rocks in the southeastern part of the map-area have been assigned to the Early Precambrian, though they could be of younger age.

The oldest rocks comprise a thick metavolcanic assemblage which underlies more than one-third of the map-area, occupying a generally northeast-southwest trending belt some 5 miles (8 km) in width. The rocks consist of metamorphic derivatives of basaltic to rhyolitic lavas and porphyries, tuffs, lapilli-tuffs, tuff-breccias, and possibly minor amounts of clastic sediments. The basement to this assemblage has not been recognized.

Emplacement of felsic to intermediate plutonic rocks, probably of several ages, followed the initial volcanism. Assimilation of mafic country rock by felsic magma has produced hybrid syenodiorites and diorites on the eastern side of the volcanic belt, while granitization, producing gneisses and migmatites, occurred to the northwest and south of the belt. Regional deformation of the volcanic pile and metamorphism under greenschist to lower amphibolite facies conditions (Turner 1968) accompanied this major plutonic event. Three stock-like plutons were emplaced within the volcanic pile, probably during a late stage of regional deformation.

Intrusion of a northwest-trending swarm of diabase dikes followed the close of major deformation. Apparent offset of dikes indicates that shearing movements along a northeast-southwest direction within the volcanic belt followed intrusion of the dikes, at least in part, though most shearing had terminated prior to intrusion.

During Pleistocene times, Wisconsin ice advanced over the peneplained Precambrian rocks; extensive ground moraine was deposited by the receding glaciers, while clays were deposited by glacial Lake Agassiz (Zoltai 1961; 1965). During Recent time organic matter has been accumulating in swamps.

Table 1 TABLE OF LITHOLOGIC UNITS FOR OFF LAKE–BURDITT LAKE AREA

PHANEROZOIC
CENOZOIC
QUATERNARY
PLEISTOCENE AND RECENT
Sand, gravel, boulders, clay

Unconformity

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

Intrusive Contact

EARLY PRECAMBRIAN (ARCHEAN)
MAFIC INTRUSIVE ROCKS
Mafic dikes

Intrusive Contact

FELSIC TO INTERMEDIATE PLUTONIC ROCKS
LATE TECTONIC INTRUSIVE STOCKS
Equigranular and porphyritic granodiorite and quartz monzonite, equigranular monzonite, pegmatite, aplite

Intrusive Contact

SYNTECTONIC INTRUSIVE AND METAMORPHIC ROCKS
GRANITIC INTRUSIVE AND METAMORPHIC ROCKS
Equigranular trondhjemite and granodiorite, equigranular and porphyritic quartz monzonite, granitic gneiss and migmatite, monzonite, pegmatite, aplite, diorite
INTERMEDIATE ROCKS
Equigranular and porphyritic syenodiorite and diorite, biotitic syenodiorite

Relationship Uncertain

ULTRAMAFIC ROCKS
Serpentinite; talc schist

Intrusive Contact

METAVOLCANICS
FELSIC TO INTERMEDIATE METAVOLCANICS
Rhyolite, dacite; quartz-feldspar porphyry; felsite; tuff, tuff-breccia, lapilli-tuff, lapillistone, pyroclastic breccia; quartz-feldspar-biotite schist ($\pm$ garnet), quartz porphyry
MAFIC TO INTERMEDIATE METAVOLCANICS
Medium to fine-grained basalt and andesite, gabbro, porphyritic basalt, pillowed basalt, pillowed porphyritic basalt, tuff-breccia, tuff, lapilli-tuff, amphibolite ($\pm$ garnet), migmatitic amphibolite ($\pm$ garnet)

Precambrian

EARLY PRECAMBRIAN (ARCHEAN)

Metavolcanics

A variety of volcanic rocks and their metamorphic derivatives were encountered in the Off Lake–Burditt Lake map-area. Metamorphism and deformation vary in grade and intensity from place to place within the belt, in many instances completely obscuring, in hand specimen at least, the original mineralogy and textures. As a result it was found possible to subdivide the metavolcanics into only two broad categories (i.e. mafic to intermediate and felsic to intermediate) based primarily on a rather arbitrary colour index defined by mafic mineral content and presence or absence of visible quartz. Density, hardness and grade of metamorphism were also taken into account when assigning a rock assemblage to one or other of these map units. Colour was not regarded as being a sufficiently precise property to further subdivide these map units; further subdivision, therefore, was based mainly on textural, structural and mineralogical variations, some of which are due to variation in metamorphic grade and intensity of deformation.

Chemical analyses of selected metavolcanics from the map-area (Table 2) reveal a range in composition from rhyolite to basalt. Further reference to these analyses will be made in the following sections.

MAFIC TO INTERMEDIATE METAVOLCANICS

Rocks assigned to this broad class of metavolcanics probably make up two-thirds of the volcanic pile. They form the northwestern flank of the northeast-southwest-trending belt, with a width across strike of more than four miles (6.5 km) in the vicinity of Panorama Lake in the north, narrowing down to about one mile (1.6 km) near the boundary between Richardson and Potts Townships in the south. This same belt broadens out again in Richardson and Sifton Townships due to synclinal folding about a north-south axis. A variety of rock types is represented in this sequence which may have a true thickness in excess of 15,000 feet (4,570 m). No one type predominates throughout the sequence. For the purpose of description the sequence has been divided into several zones with arbitrary boundaries (Figure 2) but characterized by specific rock types.

Zone M1 lies on the northwestern margin of the belt (Figure 2). This zone, composed predominantly of fine- to medium-grained mafic metavolcanics, rapidly thins from a maximum width of 1⅓ miles (1.9 km) at its northern end, to disappear completely just to the east of Highway 71. Pillow lavas were occasionally found in outcrop, but individual flow sequences were not outlined. In the extreme north of the zone some porphyritic lavas were found, but this rock type is generally absent from the zone.

Zone M2 succeeds Zone M1 to the southeast. Porphyritic mafic metavolcanics abound within this zone which varies from one mile (1.6 km) in width in the northeast, adjacent to Little Kishkutena Lake, to about a quarter mile (0.4 km) in the southwest at Highway 71. These rocks also are mainly pillow lavas, though the pillow selvages can be difficult to identify.

Table 2 CHEMICAL ANALYSES AND MOLECULAR (CATION) NORMS OF SELECTED METAVOLCANIC ROCKS, OFF LAKE-BURDITT LAKE AREA

Major + Minor (%)		1	2	3	4	5	6	7	8
SiO_2	X[a]	50.2	51.1	53.0	54.0	68.0	67.0	68.7	71.1
Al_2O_3	X	14.3	14.3	13.8	15.7	15.4	15.4	17.9	15.9
Fe_2O_3	X	2.00	2.60	2.08	2.40	0.69	0.52	0.93	0.16
FeO	C	10.3	10.7	7.09	7.02	2.91	2.33	1.32	0.46
MgO	X	6.11	4.88	7.30	3.78	1.54	1.76	0.80	2.58
CaO	X	11.3	10.7	9.55	11.3	3.56	3.70	1.52	0.88
Na_2O	C	1.82	1.98	1.62	2.00	3.86	4.28	3.86	5.39
K_2O	C	0.15	0.11	0.07	0.15	1.45	1.28	2.34	1.52
H_2O^+	C	1.17	1.15	3.01	1.39	0.81	0.82	1.11	0.88
H_2O^-	C	0.06	0.09	0.04	—	—	0.06	0.05	0.23
CO_2	C	0.14	0.16	1.15	0.45	0.62	1.02	0.08	0.11
TiO_2	X	1.01	1.26	0.72	1.01	0.39	0.30	0.44	0.30
P_2O_5	C	—	0.05	0.06	0.07	0.10	0.06	0.07	0.06
S	C	0.03	0.11	0.01	0.14	0.01	0.10	—	0.01
MnO	X	0.21	0.22	0.20	0.17	0.07	0.05	0.03	0.02
Total		98.8	99.4	99.7	99.6	99.4	98.7	99.2	99.6
S.G.		3.08	3.04	2.90	3.06	2.71	2.64	2.61	2.64
Molecular Norms									
Q		3.89	6.75	10.80	12.32	27.07	24.25	30.94	26.21
C		—	—	—	—	1.40	0.44	7.19	4.30
Or		0.93	0.68	0.44	0.93	8.82	7.82	14.19	9.00
Ab		17.11	18.64	15.41	18.78	35.64	39.70	35.53	48.45
An		31.85	31.27	31.99	34.97	17.49	18.56	7.26	3.98
Di		11.97	9.74	9.91	10.61	—	—	—	—
He		9.53	9.52	4.34	7.95	—	—	—	—
En		11.68	9.26	16.40	5.61	4.37	5.02	2.26	7.13
Fs		9.30	9.05	7.18	4.20	3.68	2.82	0.85	0.20
Mt		2.19	2.85	2.31	2.63	0.74	0.56	1.00	0.17
Il		1.47	1.84	1.06	1.47	0.56	0.43	0.63	0.42
Ap		—	0.11	0.13	0.15	0.22	0.13	0.15	0.13
Py		0.08	0.30	0.03	0.38	0.03	0.27	—	0.03

a Method: X—X ray, C—chemical, S—emission, A—atomic absorption.
b Detection limits.
1. Metabasalt[1]; Lot 8, Con. 5, Richardson Township.
2. Metabasalt, coarse; Lot 9, Con. 5, Richardson Township.
3. Metabasalt, pillowed; Cedar Lake.
4. Metabasalt; one quarter mile north of Beadle Lake, Menary Township (zone 1).
5. Metadacite; Finland.
6. Metadacite; Finland.
7. Metadacite, porphyry; Lot 3, Con. 1, Richardson Township.
8. Metarhyolite; north end of Off Lake.
[1]Nomenclature according to classification of Irvine and Baragar (1971).

Zone M3, succeeding Zone M2 to the southeast, is essentially a transition zone from Zone M2 into Zone M4. The northwestern boundary has been defined where there is a transition from porphyritic lavas into non-porphyritic types, and the southeastern boundary is located at the passage across strike into predominantly coarse-grained metavolcanics. In this zone which is about a mile (1.6 km) wide

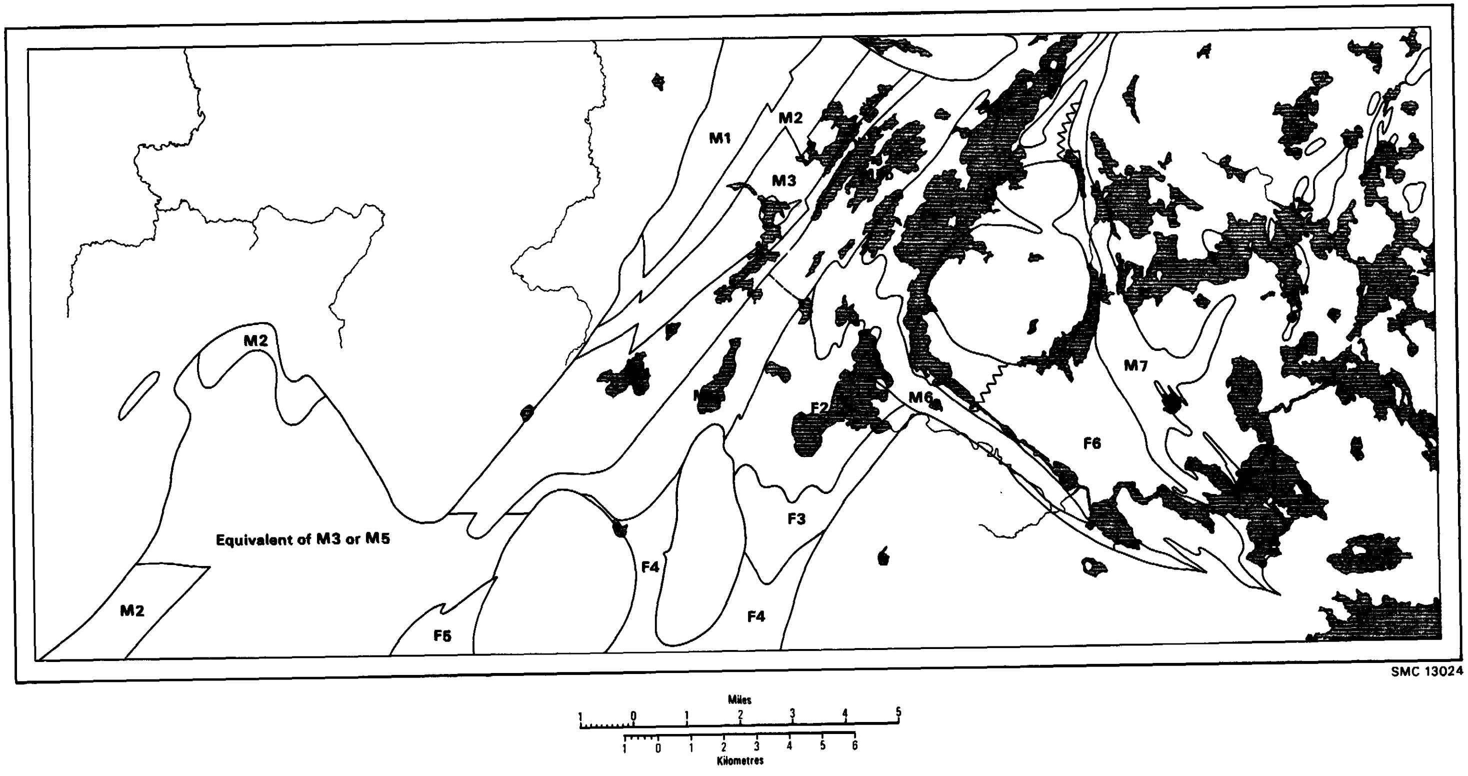


Figure 2–Zonal distribution of metavolcanic rocks, Off Lake–Burditt Lake area.

near Beadle Lake, narrowing to a quarter mile (0.4 km) at Highway 71, the predominant rock types are massive and pillowed, medium-grained mafic metavolcanics, with minor amounts of coarser grained, gabbroic lavas. Individual flow units could possibly be mapped out in the field, but no attempt was made to do so in the present survey.

Zone M4 is southeast of Zone M3. It differs from the first three zones in that it is widest in the southwest, measuring one and a half miles (2.4 km) across strike where it is crossed by Highway 17, and only one quarter of a mile (0.4 km) wide in the northeast, near Panorama Lake. The dominant rock type is very well exposed along Highway 17 at Potts Lake, where road-cuts expose massive, coarse, gabbroic mafic metavolcanics. Neither pillow lavas nor porphyritic rock types are found in this zone, and the coarse granularity would suggest an intrusive nature for these rocks. However, they are considered by the author to be part of the flow sequence, whether or not they were emplaced as flows or sills. The transition between this zone and Zone M3 is quite sharp at Panorama Lake but elsewhere is rather difficult to define.

The transition southeastward from Zone M4 to Zone M5 has been located where pillowed lavas appear again in the sequence, or where there is a transition into finer grained metavolcanics. This transition is quite abrupt at the north end of Panorama Lake, but apparently gradual elsewhere. Along Highway 71, outcrop is rather poor, but the transition can be located with some precision.

Within Zone M5 there appears to be a gradation along strike from medium-grained and pillowed flow facies in the southwest (Zone M5a) to coarser grained, pillowed, pyroclastic (Photo 1) and porphyritic facies (Photo 2) in the northeast (Zone M5b). The zone generally maintains its width of approximately one mile (1.6 km) along strike, but its southeastern margin is rather difficult to define, due to structural complications.

West of Highway 71 the zonal scheme breaks down, partly due to lack of outcrop and partly due to structural complications. However, an attempt has been made to equate areas with zones in the east, as shown in Figure 2. As Zone M4 is traced to the southwest, it narrows, and terminates somewhere northwest of the Black Hawk Stock. At the same place, finer grained and pillowed lavas are evident, which may be the lateral equivalent of similar lavas of Zone M5a, at Highway 71. Paucity of outcrop in Richardson Township makes it difficult to ascertain whether the zone can be traced around the Dearlock Syncline. Thus, most of the rocks in the syncline could belong to either Zone M3 or Zone M5.

Pillowed porphyritic mafic metavolcanics occur in the nose of the Dearlock Syncline (Photo 3). Deformation and migmatization have been intense here, but a more or less precise zone can be traced. This may be the lateral equivalent of Zone M2, east of Highway 71. Intrusion of the Sabaskong Batholith would account for discontinuity of this zone along strike. A further occurrence of this rock type is in the southwest, on the west limb of the syncline. Flow tops can be ascertained at this locality, and the abrupt termination of the porphyritic lavas against an east-west trending linear suggests the presence of a fault, thus accounting for their non-continuance with those in the nose of the fold.

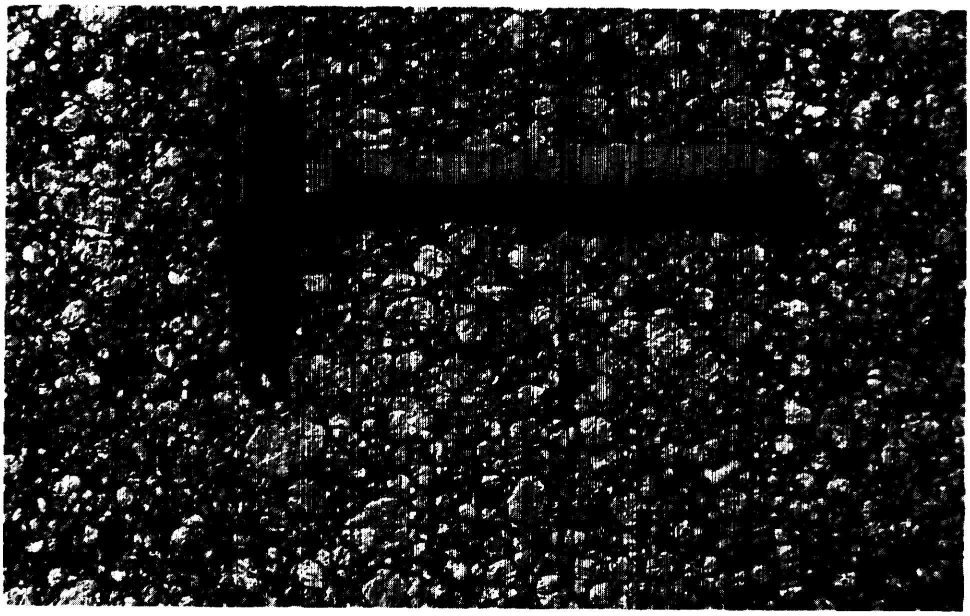
Mafic to intermediate metavolcanics, now metamorphosed to amphibolites and in places extensively migmatized, underlie the eastern flank of the metavolcanic belt (Zone M7). They are separated from the western zones by felsic to

ODM9301

Photo 1–Mafic pyroclastic breccia in vertical rock face, strongly sheared. Note fragments define a steep plunging lineation. Islands at southern end of Panorama Lake.

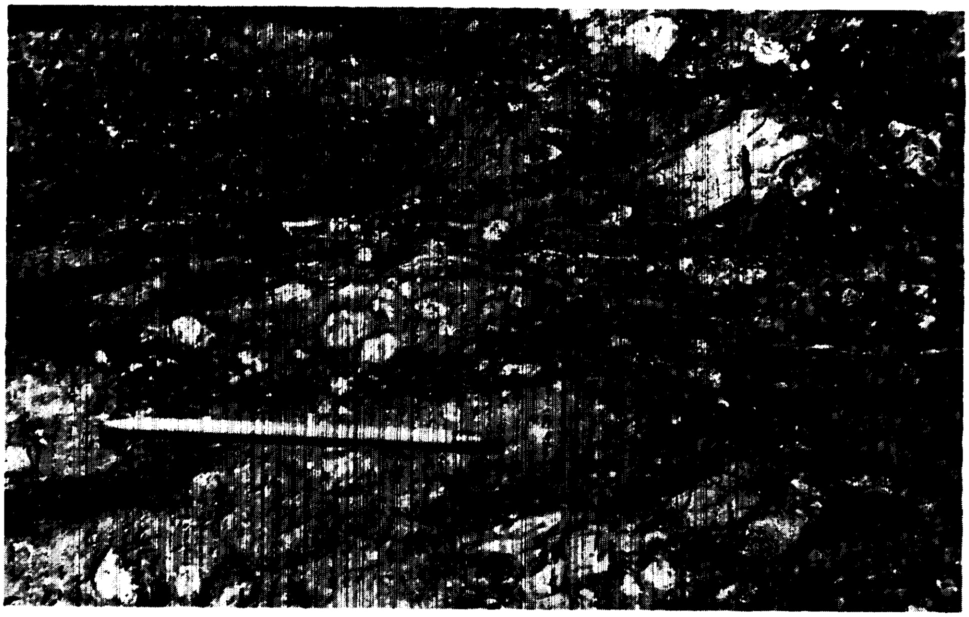
intermediate metavolcanics. This eastern sequence reaches a maximum width across strike of one mile (1.6 km), east of Albert Lake, but for most of its length it is little more than a quarter mile (0.4 km) in width. The large, isolated, xenolithic bodies of amphibolite within the Jackfish Lake Complex, many of which contain remnants of porphyritic mafic and pillowed lavas, (Photo 4) are remnants of this eastern belt, much of which was assimilated by the invading magma. West of Lake Despair, the band has been extensively migmatized and invaded by magma.

In the vicinity of Preachers Lake a salient of the main belt of mafic to intermediate metavolcanics branches off from Zone M5. This arm, Zone M6, passes in a southeasterly direction between Off Lake and the southern end of Burditt Lake, and lies between the Manomin River and Bremner Creek. At its northwestern end a number of different rock types can be recognized (viz. fine-, medium-, and coarse-grained metavolcanics, porphyritic lavas, pillowed lavas), but toward the southeast end of the zone metamorphism has converted all of these to amphibolites. The zone thins towards the southeast and terminates near Manomin Lake.



ODM9302

Photo 2–Porphyritic mafic volcanics. Densely packed saussuritized plagioclase feldspars in a dominantly chloritic matrix. East shore of Panorama Lake.



ODM9303

Photo 3–Pillowed porphyritic mafic metavolcanics. Rock has been metamorphosed to the amphibolite facies and partially migmatised, near the contact with granitic rocks in the nose of the Dearlock syncline. Southwest corner of Rowe Township.

ODM9304

Photo 4—Pillow lava remnants, occurring within a xenolith in the Jackfish Lake Complex. Note deformed nature of usually bun-shaped pillows. Northeast arm of Jackfish Lake.

The petrography of the mafic metavolcanics is predominantly metamorphic. Little trace of the original textures remain, except in the coarser mafic flow or sill rocks, the centres of which, due to their massive nature, were probably protected from complete recrystalization; these retain some of their gabbroic texture, such as ophitic intergrowths between plagioclases and mafic minerals, but the original mafic minerals are all converted to amphibole.

Mineralogy is strongly dependent on the grade of metamorphism, and the intensity of shearing, with attendant carbonatization. Mineral assemblages show that grade of metamorphism varies from lower greenschist facies, predominantly in the central parts of the belt, through upper greenschist facies, near the edges of the belt, to amphibolite facies where the metavolcanics have been migmatized and occur as xenoliths within the Jackfish Lake Complex. Lower greenschist facies assemblages are characterized by the mineral association plagioclase-epidote-chlorite, and in addition commonly contain carbonate. Typical examples examined in thin section are a scoriaceous mafic metavolcanic from the eastern shore of Off Lake, and a porphyritic mafic metavolcanic from the east shore of Panorama Lake. Both rocks are intensely sheared and contain much carbonate and opaque minerals, chiefly pyrite. Plagioclase phenocrysts in the porphyritic rock have been completely converted to zoisite (X-ray diffraction determination by Mineral Research Branch, Ontario Division of Mines).

In rocks of slightly higher metamorphic grade, but still well within the greenschist facies, actinolitic, usually pale green, amphibole is developed. Characteristic is the assemblage actinolite-plagioclase-epidote-chlorite. In hand specimen these rocks vary considerably in colour depending on mineral content. Where amphibole is dominant they are dark green; where epidote and plagioclase are dominant the rock is proportionately lighter in colour. Many of the coarser mafic flow rocks present a mottled "pepper and salt" appearance in hand specimen, due to saussuritization of feldspar and uralitization of pyroxene. Chlorite is almost always present at this grade of metamorphism but usually is not the dominant mafic mineral. Carbonate may be present also at this slightly higher metamorphic grade, but it seems to be confined to central areas of the belt, and is less well developed than in rocks of lower grade.

In mafic rocks metamorphosed to upper greenschist facies grade the amphibole is a hornblende, which in thin section shows pronounced pleochroism in green and yellow. No sharp boundary can be placed between actinolitic amphibole and hornblende, but hornblende tends to be coarser grained and prismatic, as compared with fibrous actinolite. Also at this grade little remains of the original texture of the volcanic rock; pyroxene pseudomorphs have been virtually eliminated during the recrystallization process and plagioclase is mostly recrystallized. However, in the coarser gabbroic varieties ophitic textures are still occasionally preserved. Typical assemblages consist of hornblende-plagioclase-epidote-chlorite. Epidote is commonly granular, and approaches euhedral form. Chlorite is commonly poorly developed. Rocks of this grade are mostly confined to marginal parts of the belt.

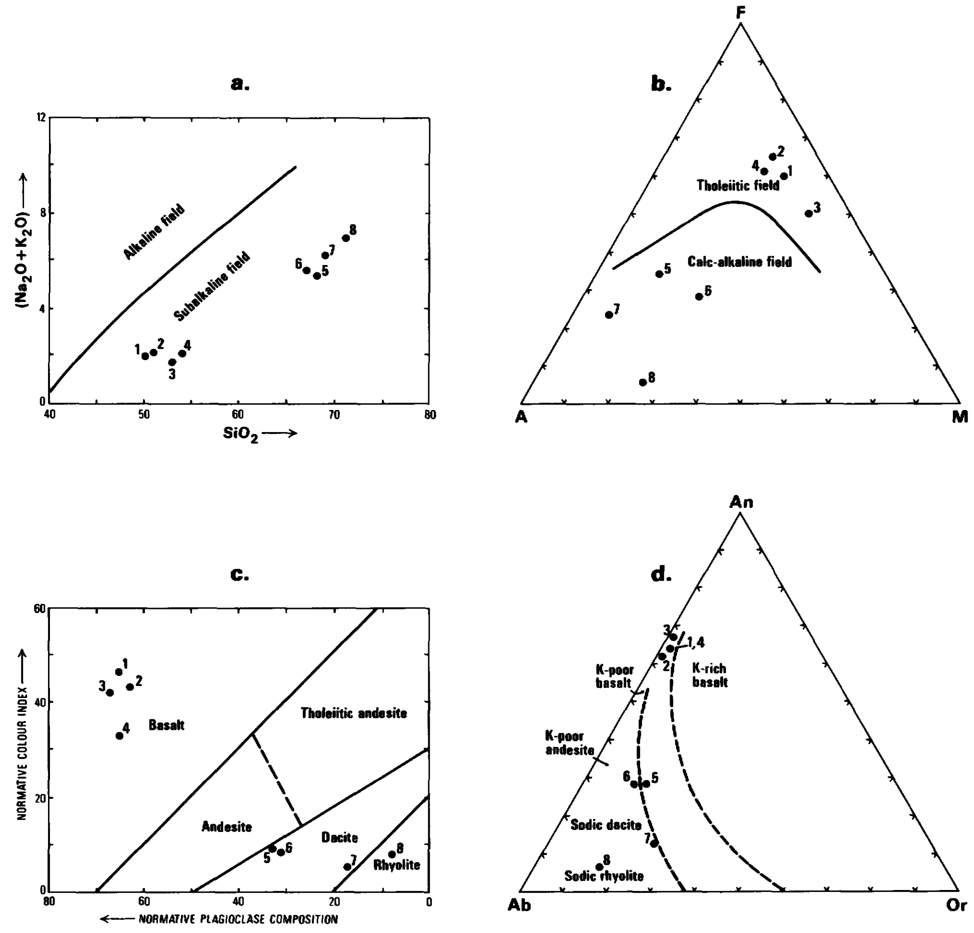
Along the eastern margin of the belt, mafic metavolcanics are predominantly amphibolites, as are rocks of the xenoliths within the Jackfish Lake Complex. In hand specimen they are almost black in colour due to the high proportion of hornblende in the rock, and flecked with white andesine plagioclase. No chlorite occurs in these rocks, and epidote is commonly absent; the typical assemblage is hornblende-andesine. They are often markedly gneissose, and may form discontinuous bands and lenses in migmatite terrain.

Trace amounts of opaque minerals are common in mafic metavolcanics of all grades of metamorphism except amphibolite facies. Pyrite is the usual sulphide mineral, and leucoxene is representative of titanium minerals. Hematite and limonite may occupy minute fractures, or are alteration products of sulphide minerals.

Chemical analyses of metavolcanics selected in the field as being of mafic to intermediate composition (Table 2, samples 1, 2, 3 and 4) show remarkable similarities in chemistry, particularly in SiO_2 content. All could be classed as basalts (Manson 1967), though samples 3 and 4 could also be classed as andesites (Goodwin 1967). According to the classification of Irvine and Baragar (1971), they are all subalkaline, tholeiitic, low potash basalts (Figure 3).

FELSIC TO INTERMEDIATE METAVOLCANICS

Volcanic or subvolcanic felsic to intermediate rocks and their dike-phase equivalents, comprise about one-third of the volcanic pile. They outcrop extensively on the shores of Burditt, Off, Cedar, and Pony Lakes. Other areas of im-



SMC 13025

Figure 3–Chemical Classification of selected metavolcanic rocks, Off Lake–Burditt Lake area.

a. Alkalies–silica plot. **b.** AFM plot (A = $Na_2O + K_2O$; F = $FeO + 0.8998\ Fe_2O_3$; M = MgO). **c.** Plot of normative colour index versus normative plagioclase composition for subalkaline rock suites (Normative colour index = Di + He + En + Fs + Mt + Il; Normative plagioclase composition = 100 An/An + Ab). **d.** An–Ab–Or plot for subalkaline rock suites (dashed lines are boundaries between K–poor, "common", and K–rich variants). Sample numbers and molecular norm symbols refer to Table 2.
After Irvine and Baragar (1971).

portance are those in the southeast corner of Richardson Township, the area close to Highway 71 between the Black Hawk and Finland Stocks, the area extending south from Off Lake to the southern edge of the map-area, the narrow north-south strip on the east side of the Burditt Lake Stock, and the rather broad area along and to the northeast of the Manomin River. All these areas are rather irregular in shape, due both to the nature of the volcanism and to later deformation. Substantial amounts of mafic to intermediate metavolcanics occur within the predominantly felsic pile, particularly near Off and Pony Lakes. An arm of the more mafic rock cuts across the felsic metavolcanics, between Off and Burditt Lakes, and thence along and to the southwest of the Manomin River.

As in the section on mafic to intermediate metavolcanics, the areas underlain by essentially felsic metavolcanics have been divided up into zones, with rather arbitrary boundaries between these zones (Figure 2). An attempt was made within Zones F1 to F5 to encompass broad lithologic grouping, independent of metamorphic grade. Zone F6 essentially encompasses rocks of a higher metamorphic grade than preceding zones, which are grouped together because original textures have mostly been obliterated.

Zone F1 encompasses all of Burditt Lake except the extreme northern end. At no place does the boundary of the zone occur more than a half mile (0.8 km) in from the shore; in fact, the shore line is the boundary for much of its length along the east shore of the lake, where rocks of the Burditt Lake Stock outcrop along the shoreline. The zone achieves its maximum width in the central part of the lake, where it is approximately one and a half miles (2.4 km) wide. At all points along its northwestern margin it is in contact with mafic to intermediate pillowed, pyroclastic, and porphyritic rocks of Zone M5b. The contact is fairly sharp and can be located with some certainty in the field to within 100 feet (30 m); it is sheared in most places, as are rocks on both sides of the contact. To the southwest, the western margin is with mafic to intermediate rocks of Zone M6. The boundary is arbitrarily placed here, since a precise contact could not be placed in the field between the felsic and mafic rocks; it is a gradational boundary through intermediate rock types. The southern boundary of the zone has been arbitrarily placed where volcanic textures become obscure in passing southeast along foliation strike. This boundary may coincide approximately with a metamorphic facies boundary, in that garnet-bearing quartz-feldspar-biotite schists have not been recognized to the northwest of it; however, presence of garnet may be controlled by bulk rock chemistry. Similarly, the northeastern boundary is a metamorphic boundary. Rocks within Zone F1 were interpreted in the field as being predominantly of pyroclastic origin. In any event, they are fragmental, and can be subdivided on the basis of fragment size and sorting. It was found most convenient, in terms of the present survey, to subdivide the pyroclastic rocks into two groups, first those in which blocks and coarse fragments predominated, constituting pyroclastic breccia and tuff-breccia, and second those in which ash- or lapilli-size fragments predominated, constituting tuff, lapilli-tuff, and lapillistone (Fisher 1966). In the central part of Burditt Lake the sequence is quite heterogeneous, with tuff, lapilli-tuff, lapillistone, and breccia (Photo 5) outcropping along the shores and on the islands. Intense shearing accompanied by strong, nearly vertical, linear deformation, is characteristic. However, excellent outcrop conditions in which erosion surfaces cut the lineation at high angles, allow observation that deformation has not obliterated original textures.

ODM9305

Photo 5–Pyroclastic breccia, composed of quartz-feldspar porphyry blocks and fragments in a greenish matrix of similar composition, but with a high amount of chlorite. West shore of Burditt Lake, quarter mile south of the portage to Cedar Lake.

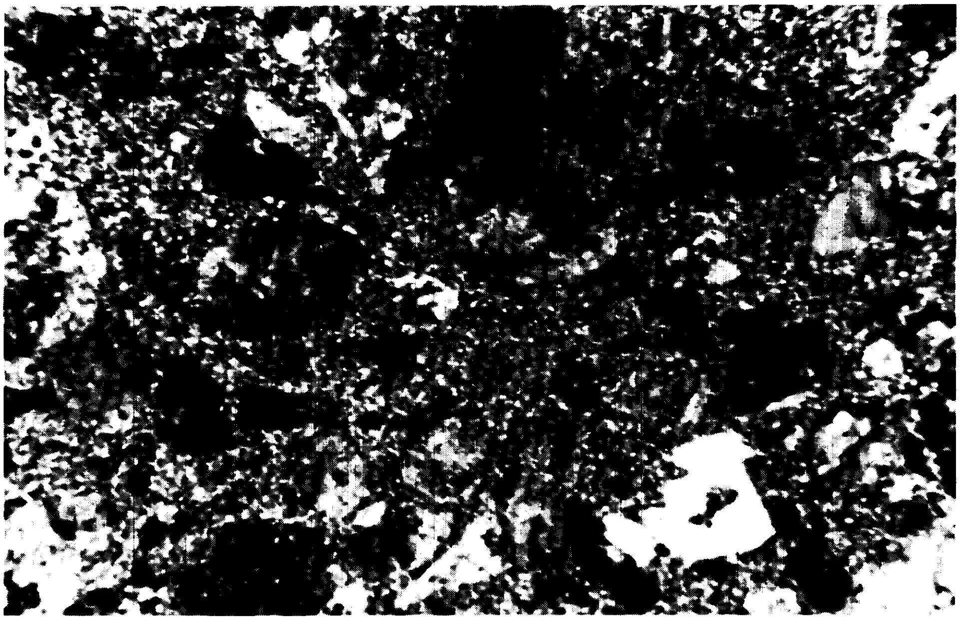
Toward the south end of Zone F1, shearing, which obscured original textures, is more intense. South of Burnt Narrows the pyroclastic rocks are finer grained, and no definite pyroclastic or tuff-breccia was mapped along strike south of this point.

In thin-section, evidence for pyroclastic origin of these rocks is difficult to find. Quartz and feldspar crystals, varying in size from 1 mm to 1 cm are set in a fine-grained matrix, which is often sheared, and composed of quartz, feldspar and chlorite. The large quartz grains are strained, and often embayed, but large feldspar crystals are usually completely recrystallized as a finer grained mosaic so that in hand-specimen they are often not evident. These megacrysts are only very rarely fractured. Plagioclase megacrysts are commonly euhedral, and the quartz megacrysts sometimes display perfect hexagonal faces. In thin-section the major difference between large felsic, blocky fragments and the green-coloured matrix is in the comminution of the originally fine-grained matrix and a much higher proportion of chlorite. It appears that tectonic fracturing has produced the lapilli-size fragments in some of these quartz-feldspar megacrystic rocks. However, on a small headland on the east shore of Burditt Lake, one half mile (0.8 km) north of Gill's Bay convincing field evidence was found that at least some of these rocks are of pyroclastic origin. Bedded tuffs were found at this locality, and one bed about one foot (0.3 m) thick appeared to be graded. Pyroclastic breccia and tuff-breccia also are present on the headland, with textures very similar to those exposed elsewhere around the lakeshore.

ODM9306

Photo 6–Photomicrograph of fresh quartz-feldspar porphyry typical of the Off Lake-Pony Lake area. Note hexagonal faces of quartz grains, twinning in plagioclase, and strain shadows in anhedral quartz grains. North end of Off Lake. Large plagioclase grain is approximately 1 mm long.

Zone F2 is situated in the vicinity of Off Lake and Pony Lake. The boundary between Zone F2 and Zone M5a has been placed where felsic to intermediate rocks, in traversing southeastward, become dominant. Substantial amounts of mafic to intermediate metavolcanics occur within the zone, and particularly in the area adjacent to the boundary with Zone M5a. The boundary with Zone F3 to the south is difficult to place precisely, due to lack of outcrop and also of sufficiently rigorous field criteria, as discussed below. To the north and northeast the zone is bounded by mafic to intermediate rocks of Zone M6. In the field, rocks of Zone F2 were mapped as quartz-feldspar porphyries (Photo 6). Evidence of intrusive origin was not found: individual bodies, mapped between outcrops of mafic rock, appeared to be quite thick. On the other hand, evidence of flow or pyroclastic origin seems to be lacking: the rocks are quite homogeneous over large areas, and only in the northeast, adjacent to Zone M5a, is there any evidence of layering, or banding. Variation in intensity of alteration (Photo 7) can mislead the observer into thinking he is dealing with differing volcanic types: in some samples quartz and feldspar phenocrysts are quite evident in hand specimen, are usually of similar grain size, and constitute 50-90 percent of the rock; in others only quartz phenocrysts can be seen in hand specimen, and constitute less than 50 percent of the rock, the groundmass of which appears to be very fine grained. Thin-section examination reveals that the latter rock type is more altered than the former, the feldspars having been altered substantially to epidote, along with the groundmass. On the weathered surface the feldspars can commonly still be seen, but on the



ODM9307

Photo 7–Photomicrograph of altered quartz-feldspar porphyry from the Off Lake–Pony Lake area. Note embayed, resorbed margin of quartz grain in lower left corner and indistinct nature of altered feldspars. Near Pony Lake. Quartz grain is approximately .5 mm in size.

fresh surface they merge with the groundmass. Chlorite or biotite occur as accessories in these rocks, but not together in the same sample, indicating variations in metamorphic grade. Both define a crude foliation, usually only visible in thin-section. Interlayered with the quartz-feldspar porphyries are a variety of mafic to intermediate volcanic rocks, including fine-, medium-, coarse-grained pillowed, porphyritic and scoriaceous types. The scale of mapping precluded the delineating of these bodies in detail and thus they are generalised on Map 2325 (back pocket). Contact relationships with the more felsic rocks of this zone may be observed along the shores of Pony Lake, where they are clearly seen to be interbedded in a succession of flows. However, elsewhere contact relationships were not observed in detail, and could be of differing types. Some of these mafic rocks may be intrusive into the felsic rocks, particularly in the area between Highway 615 and Off Lake, and to the northeast of Pony Lake. Two such localities are the sites of exploration activity: one is on the west shore of Off Lake, close to a cross-cutting diabase dike; the other is a quarter mile (0.4 km) southeast of the southern end of Off Lake. Both of these localities are further discussed in "Economic Geology", under "A. F. Young".

Difficulty in placing a boundary between Zones F2 and F3 was noted above. This is partly because it appears to be a gradational boundary, marked by increase in grain size of the groundmass, though quartz phenocrysts remain the same in size. In rocks of Zone F3, feldspar phenocrysts commonly cannot be distinguished, as groundmass material approaches the same size as the feldspar. Quartz stands out in hand specimen particularly on weathered surfaces as small "eyes". A sample taken from an outcrop a quarter mile (0.4 km) east of Highway 615, about a mile (1.6 km) south of Off Lake is typical of felsic rocks in this zone. Grain size is about 2 mm for the quartz and feldspar grains, but interstitial quartz seen in thin-section is finer grained. Abundant chlorite mottles the rock, and in thin-section is seen to be associated with epidote and muscovite derived from breakdown of feldspars. The feldspars are primary, and the granular texture is interpreted as being igneous and possibly sub-volcanic in origin. A body of mafic rock occurs in the middle of the zone, west of Highway 615.

Lack of good, continuous outcrop south of the road between Finland and Highway 615 prevents a complete interpretation of this area, here called Zone F4. Three areas of outcrop occur close to the southern edge of the map-area in lots 4 and 5, concession I, and lot 4, concession II, Potts Township. A complex association of strongly sheared and brecciated tuffs, felsic volcanic rocks, amphibolites, some of which are garnet-bearing, and porphyritic mafic remnants, is cut by pegmatites. Similar rock types are seen at two outcrops close to Highway 71 at the southern edge of the map-area in lots 8 and 9, concession I, Potts Township. At Finland an excellent sequence of mafic and felsic rocks is exposed. Some, if not all, of the quartz-feldspar porphyries at this locality are of flow origin, since flow banding (Photo 8) and autoclastic breccia (Photo 9) are present in these rocks. Sharp contacts with mafic rocks can be observed; these may or may not be flow contacts. The sequence is intruded on its eastern side by quartz monzonite and pegmatite of the Finland Stock.

Felsic metavolcanics occupy a wedge-shaped area (Zone F5) adjacent to the Black Hawk Stock, in southeastern Richardson Township. They are massive, whitish to grey weathering rocks, somewhat sheared and fractured. They are mostly quartz-feldspar porphyries, with a faint green tint imparted by chlorite. Pyrite grains are frequently found disseminated through the rocks. Insufficient outcrop was found to determine their contact relationship with mafic to intermediate pillowed lavas to the northwest, but the monzonites of the Black Hawk Stock were observed to intrude these felsic metavolcanics in an outcrop on lot 2, concession II, Richardson Township.

As rocks belonging to Zone F1 are traced southeastward from Burditt Lake, parallel to the Manomin River, they become more schistose, and primary volcanic textures and structures are destroyed. In mapping, it was found that a point was reached somewhere between the northern boundary of Fleming Township and the mechanical portage on Manomin River where no confidence could be placed in the interpretation of the felsic to intermediate volcanic rocks as being of a particular type (i.e. tuff, porphyry, etc.) and the metamorphic terminology quartz-feldspar-biotite schist had to be used. However, in places, faint relics of either a tuffaceous texture, or presence of quartz eyes, gave a hint to the original rock type. On Albert Lake, distinct volcaniclastic fragments, now severely stretched and lineated, could be seen in the schists, some of which also contain amphibole, either with or without biotite. Garnet, not observed in hand specimen, was found in thin-sections of a number of rocks sampled close to the diabase dike one half mile (0.8 km) east of the northeastern corner of Rainy Lake Indian Reserve No. 17B. Garnet was nowhere observed during field mapping, but due to the fine-grain size of these rocks would not have been seen in hand specimen, and so may well be present elsewhere. Increase in metamorphic grade, both southeastward, and

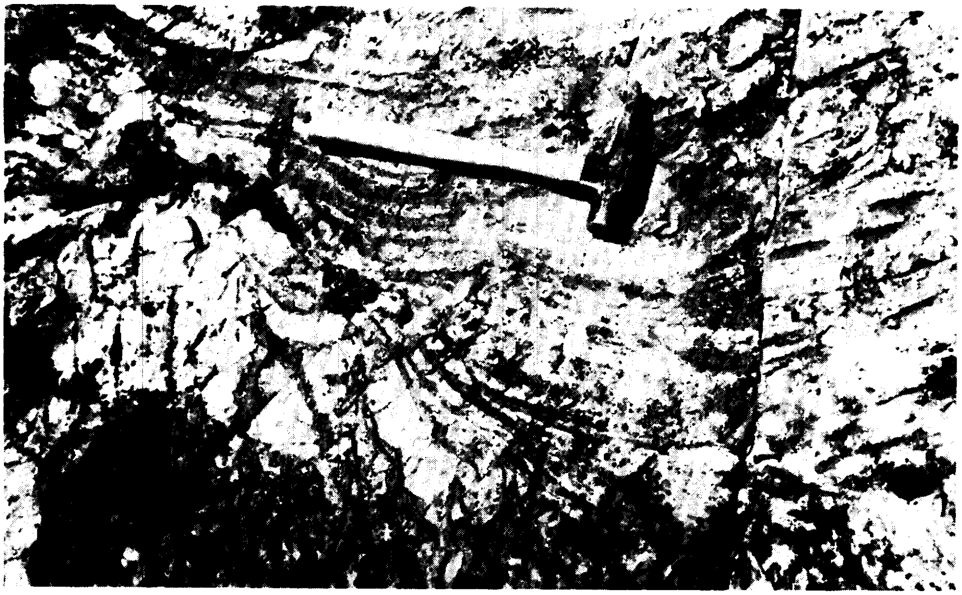


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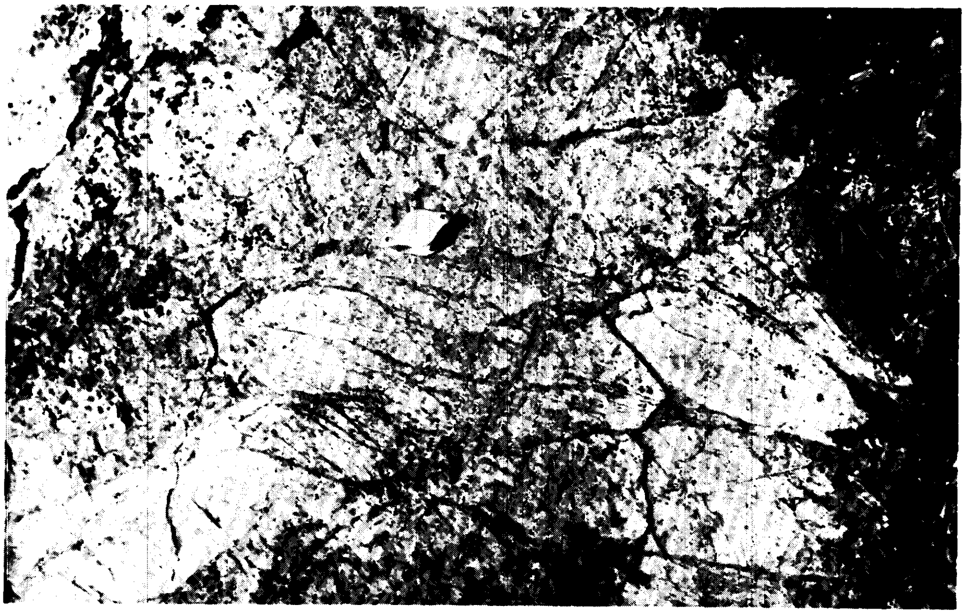
Photo 8–Flow-banding in quartz-feldspar porphyry. Potts Township, near Finland.



ODM9309

Photo 9–Autoclastic breccia in quartz-feldspar porphyry. Potts Township, near Finland.

northeastward toward the amphibolites of Zone M7, could account for the appearance of garnet at this locality. Zone F6 pinches out to the southeast, close to the point where amphibolites of Zone M7 are cut out against the Northwest Bay fault. Locally within the zone there occur patches of rock that no longer can be classed as schist, since due to their intense recrystallization and (or) metamorphism they approach the plutonic rocks in texture and structure. This effect becomes more and more pronounced toward the southeast, the rocks in effect becoming granitized.

Chemical analyses of rocks chosen in the field as representative of felsic to intermediate metavolcanics (Table 2, samples 5, 6, 7, and 8) show a remarkably similar SiO_2 content. They are dominantly rhyodacites (classification of Goodwin 1967) or dacites (classification of Irvine and Baragar 1971) in composition, though one of them (sample 8) could be classed as a rhyolite (Figure 3). Chemically, all contain oxide amounts typical of their class, though it should be noted that sample 8 is abnormally high in MgO; this is accounted for by the presence of abundant chlorite, seen to be very fine grained in thin-section, which imparts a pale green tint to the whitish rock. Samples 5 and 6 both come from the same locality, in the sequence of felsic and mafic flows one quarter mile (0.4 km) northeast of Finland; sample 7 comes from Zone F5; sample 8 comes from an outcrop on Highway 615 at the extreme north end of Off Lake.

FELSIC DIKE ROCKS

Felsic dike rocks intrude the mafic metavolcanics (Photo 10). Their age relationship relative to the felsic and intermediate flows and pyroclastics has not been ascertained in the field. For the purposes of the present report the dikes have been grouped with the felsic to intermediate metavolcanics, since in no place were they seen to be definitely related to later plutonic rocks. Petrographically these dike rocks are similar to the felsic flows, the majority being quartz-feldspar porphyries. The dikes vary in width from a few inches to tens of feet, and the narrower dikes are commonly finer grained and felsitic in character. Some of the larger porphyry dikes have distinct fine-grained margins, indicative of chilling. The dikes are commonly discontinuous along strike, and irregular in form. Metamorphic grade appears to be the same as that of the host rocks.

The dikes are more abundant in the upper part of the mafic to intermediate sequence, especially near the transition into the upper, felsic to intermediate sequence. It is often difficult to distinguish dikes from flows near the transition from predominantly mafic to predominantly felsic metavolcanics, and dikes may inadvertently have been mapped as flows, and vice versa. Well-defined felsic dikes intrude pillowed lavas along Highway 71, about two miles (3 km) north of Finland (Photo 10).

At Beadle Lake, the felsic dikes may be offshoots of the small felsic plutonic, brecciated, plug underlying the northeast end of the lake. However, neither gradational nor cross-cutting relationships between the dikes and plutonic rocks were observed in the field.

ODM9310

Photo 10–Felsic dike intruding mafic lavas. Note fracture pattern within dike, and shearing at the margins. Road cut on Highway 17, two miles north of Finland.

Ultramafic Rocks

Rocks of ultramafic composition were found at three, rather widely scattered, localities. Rocks at two of these localities were originally described by Lawson (1888a, p.98). The first of these two localities is at the extreme northern end of Burditt Lake. The ultramafic rocks occur on the western shore of the lake, and appear to have a strike length of no more than a quarter mile (0.4 km) beyond the map-area. The precise boundaries of the body were not mapped, but it appears to be elongated parallel to the shore line, and thus parallel to the regional foliation, and lies completely within mafic metavolcanics. Large crystals of brittle asbestos (picrolite) occur within veins in a massive fine-grained, green to almost black rock. In thin-section the massive rock is seen to be composed predominantly of serpentine, pseudomorphing original rounded or subangular grains, probably of olivine, though none remains. The outlines of the "grains" are defined by interstitial magnetite and calcite and fractures cross-cutting the "grains" contain the same minerals.

The second locality described by Lawson is at the bottom of South Bay of Lake Despair. Lawson stated that it "occupies the shore for the space of between a quarter and a half a mile [0.4 to 0.8 km]", but the author found only two small outcrops, both at the water's edge and partly under water, and within one eighth of a mile (0.2 km) of each other. As Lawson states, there are "black hornblende schists on either side", but the author observed that they also occur back from the shore, so that there is no possibility of this being as large a body as Lawson implied, and as subsequently shown on the Kenora–Fort Frances compilation map (Davies and Pryslak 1967). Contacts with the amphibolites cannot be seen. In hand specimen the rock can be a dull red to whitish colour on weathered surfaces, but quite dark and greenish on fresh surfaces. No asbestiform minerals were found at this locality. In thin-section it is very similar to that from the Burditt Lake locality, but pseudomorphs are not as well preserved, the magnetite being more abundant and not confined to edges of the grains. Hematite and leucoxene occur in addition. Also calcite is only minor, and there are small areas composed of chlorite. The magnetite appears to occur along ill-defined bands up to 1 mm in width.

The third locality, in the southeastern corner of Preachers Lake, is a talc schist outcrop. The rock is highly sheared and very soft, so that when hit with a hammer it will not fracture, but falls apart in small flakes. The body is about 10 feet (3 m) wide, no more than 20 feet (6 m) long, and enclosed within felsic metavolcanics. It may be of ultramafic origin, though no precise data are available.

The ultramafic rocks of the Rainy Lake region, which include those of the present map-area, were considered by Lawson (1888, p.97F) "to be the alteration products of igneous masses which are of the same geological age as the . . . volcanic rocks". With respect to the bodies at Burditt Lake and Lake Despair in particular, he states (p.45F) that "They are, probably, the altered remains of olivine rocks which were formed antecedent to the folding of the Keewatin rocks, though irruptive through them". No evidence could be found in the field to substantiate this statement, neither could strong evidence be found to support the idea that they may have been emplaced during or after deformation. The author considers the latter possibility more likely, in view of the fact that in both areas strong metamorphic and deformation textures are observed in the surrounding amphibolites and mafic metavolcanics, but absent in the serpentinites.

Felsic to Intermediate Plutonic Rocks

Plutonic rocks of felsic and intermediate composition and granitic texture underlie approximately two-thirds of the map-area. They comprise several discrete map-units, intruded or produced at differing times in the plutonic cycle. These units can be grouped under two broad headings according to whether they were intruded early in the plutonic cycle and syntectonically, or late in the cycle, and late-tectonically or post-tectonically. The early rocks are the more voluminous, and occur exterior to the volcanic belt, but the late plutonic rocks, at least those that have been recognized, intrude the central parts of the belt. The Jackfish Lake Complex predominantly of intermediate composition, and the gneisses, migmatites, and foliated magmatic rocks exterior to the volcanic belt, are all grouped as early plutonic rocks. The Black Hawk Stock west of Finland, on Highway 71, and the Burditt Lake Stock between Burditt and Albert Lakes, are grouped as late plutonic or post-tectonic, while the Finland Stock is tentatively grouped as late tectonic, though it may be of early plutonic age.

SYNTECTONIC INTRUSIVE AND METAMORPHIC ROCKS

Intermediate Rocks of the Jackfish Lake Complex

Rocks of syenodioritic, dioritic (Table 3, samples 1 to 8), and granodioritic (Figure 4) type (Ayres 1972), grouped together as the Jackfish Lake Complex, underlie much of the eastern part of the map-area, in the vicinity of Jackfish Lake. On the west the complex is bounded by mafic to intermediate metavolcanics extending from close to the northern end of Burditt Lake in the north, to Lake Despair in the south, and the eastern boundary, against gneisses and migmatites, extends from northeast of West Jackfish Narrows in the north to the north shore of Lake Hope in the south. The belt is widest in the north, where it is about 6 miles (9 km) wide across strike, and thins rapidly to the south, where it is only three quarters of a mile (1.2 km) wide at Lake Despair. A tongue of amphibolite projects from the metavolcanics at the western margin into the complex, and a number of large elongate xenolithic bodies of amphibolite occur close to the eastern margin, oriented with their long axes in a northeasterly direction. Smaller xenoliths, too small to indicate on the map, occur scattered throughout the complex, ranging in size down to a few inches. The larger of these xenoliths mostly occur in proximity to the mappable xenoliths and to the main contacts. The amphibolites of the xenoliths are similar in mineralogy and composition to the amphibolites of the main belt. Greatly deformed and migmatized remnants of pillow lavas (Photo 4) and porphyritic lavas occur within the xenoliths, substantiating the conclusion that these bodies were derived from volcanic rocks.

Hybrid rocks of the complex display a marked similarity in mineralogy, but a wide range in content (Table 3, samples 1 to 8; Figure 4), though most are syenodiorites. In the field the hybrid rocks are of distinctively coarse, mottled, black and white appearance, due respectively to amphiboles and feldspars of grain size of the order of one centimeter (Photo 11). Although the predominant mafic mineral is in almost all cases a deep green amphibole (hornblende), biotite is usually present in addition, while pyroxene occasionally occurs within amphibole grains, often showing evidence of breakdown to amphibole. In sample 8, a diorite, pyroxene is the predominant mafic mineral. The hand specimen is distinctly pinkish, a characteristic of rocks of the complex containing dominant pyroxene. Feldspar, usually constituting over 50 percent of the rock, is dominantly plagioclase of oligoclase composition. It occurs as subhedral to anhedral grains, either untwinned or twinned according to the carlsbad, albite or pericline laws, either separately or in various combinations of two or three. All variations may occur in one rock sample. Antiperthitic and interstitial microcline is usually present. Quartz is everywhere present in minor amounts, and is interstitial and strained. Alteration of plagioclase to epidote minerals and sericite is usually not very evident, though some minor primary epidote occurs. Sphene and zircon are common accessories. Chlorite is usually only accessory, and derived by alteration of hornblende.

Felsic to Intermediate Plutonic Rocks, Gneisses, and Migmatites

The northwestern portion of the map-area, which is part of the Sabaskong Batholith, referred to by Lawson as the Sabaskong area (Lawson 1888a), the

Table 3 MODAL ANALYSES OF SELECTED FELSIC AND INTERMEDIATE PLUTONIC

Sample No.	1	2	3	4	5	6	7	8	9	10	11
Plagioclase	61.8	63.0	50.6	70.2	58.2	47.1	49.0	63.4	47.0	54.8	53.
Potassic feldspar[a]	1.6	17.8	13.6	3.0	9.8	18.2	14.2	5.6	0.5	2.0	5.
Amphibole[b]	27.6	15.4	10.2	19.8	16.8	31.6	13.2	1.2	—	—	Tr
Biotite	5.8	—	7.6	0.2	5.0	—	Tr	8.2	12.2	12.0	5.
Quartz	1.0	—	8.4	5.4	5.4	Tr	8.7	2.4	35.7	26.2	33.
Epidote group	1.2	1.2	0.4	0.6	1.4	0.8	0.5	0.2	3.0	3.8	1.
Sphene	0.6	0.6	—	0.4	1.0	1.2	0.5	—	0.3	0.2	0.
Pyroxene	—	—	8.6	—	1.6	Tr	4.5	16.6	—	—	—
Opaque minerals	0.2	—	0.2	—	0.2	—	0.7	2.0	—	0.3	—
Apatite	—	—	—	—	0.2	—	—	—	—	—	—
Zircon	Tr[e]	0.2	0.4	0.2	0.4	—	—	0.2	0.3	—	0.
White mica	—	—	—	—	Tr	0.1	—	0.2	1.0	0.7	0.
Chlorite	0.2	1.8	—	0.2	—	1.0	8.7	—	—	—	—
Myrmekite	—	—	—	—	—	—	—	—	Tr	Tr	—
Plagioclase Composition	prim. Oligo-clase (An17)	2ndry Albite	Oligo-clase	Calcic Oligo-c.ase (An24)	Oligo-clase	? Andesine	? Oligo-clase	Sodic Andesine	Osc. zoning; Oligo-clase	Weak zoning; Albite	Zon son osc; dete
Number of points counted	500	500	500	500	500	1000	600	500	400	600	5(

a Predominantly microcline.
b Predominantly hornblende.
c Trace indicates that the mineral was seen in thin section, but not encountered in the modal analysis.
d Including a trace of allanite.
e Probably thorite.

1. N43 Syenodiorite, Jackfish Lake Complex.
2. N29 Albite syenodiorite, Jackfish Lake Complex.
3. A277 Syenodiorite, Jackfish Lake Complex.
4. N44 Syenodiorite, Jackfish Lake Complex.
5. B235 Syenodiorite, Jackfish Lake Complex.
6. B192 Syenodiorite, Jackfish Lake Complex.
7. A241 Syenodiorite, Jackfish Lake Complex.
8. B243 Diorite, Jackfish Lake Complex.
9. A16 Trondhjemite, Sabaskong Batholith.
10. N25 Albite trondhjemite, Sabaskong Batholith.
11. A21 Trondhjemite, Sabaskong Batholith.

OCKS, OFF LAKE–BURDITT LAKE AREA

	12	13	14	15	16	17	18	19	20	21	22
agioclase	59.8	54.4	59.0	54.5	37.6	56.6	55.0	53.2	40.4	45.4	64.0
tassic feldspar[a]	Tr	9.6	Tr	4.2	35.0	20.4	9.4	16.2	26.2	27.8	7.6
nphibole[b]	—	—	—	—	17.8	5.2	—	—	1.4	—	—
otite	1.8	2.8	10.2	10.3	0.2	0.8	1.8	3.2	0.6	1.2	11.0
ıartz	30.2	31.6	26.0	27.8	—	13.8	32.4	24.6	27.0	20.8	9.0
›idote group	2.2	0.2	4.4	3.0	1.4	2.2	0.4	1.2[d]	2.8	2.4	4.0
hene	Tr	Tr	0.2	—	1.0	0.8	0.2	—	0.2	Tr	—
roxene	—	—	—	—	5.0	—	—	—	—	—	—
›aque minerals	Tr	1.0	Tr	Tr	1.2	0.2	0.2	—	Tr	0.2	0.8
›atite	—	—	—	—	—	—	—	—	Tr	—	—
rcon	—	0.4	—	0.2	0.6	—	0.4	—	—	—	Tr[e]
hite mica	1.6	—	—	—	—	Tr	0.2	0.8	Tr	3.2	3.0
ılorite	4.2	—	0.2	—	0.2	—	—	0.8	1.4	—	0.6
yrmekite	Tr	Tr	—	Tr	—	—					
agioclase ›mposition	Zoned; ? Oligoclase	Some zoned; Oligoclase	No determ.	No determ.	Sodic Oligoclase	Albite (An10)	Zoned Oligoclase	Weakly zoned; Oligoclase (An14)	Weakly zoned; Oligoclase (An14)	Albite (An8)	Weak zoning; Andesine (An32)
ımber of points counted	500	500	500	400	500	500	500	500	500	500	500

. B150 Trondhjemite, Sabaskong Batholith.
. B38 Granodiorite, Sabaskong Batholith.
. A185 Trondhjemite, Fleming Township.
. A303 Trondhjemite, Fleming Township.
. B52 Albite quartz monzonite, Finland Stock.
. B50 Diorite, Finland Stock.
. B69 Monzonite, Black Hawk Stock.
. B70 Porphyritic albite granodiorite, Black Hawk Stock.
. A121 Granodiorite, Burditt Lake Stock.
. A197 Granodiorite, Burditt Lake Stock.
. A161 Porphyritic quartz monzonite, Burditt Lake Stock.
term.—determination.
:. —oscillatory.
m. —primary.
. —trace.

ODM9311

Photo 11–Typical syenodioritic hybrid rock of the Jackfish Lake Complex. Note mafic xenolith under the coin.

south-central Fleming Township area, and the Footprint Lake area in the east, are all underlain by predominantly felsic plutonic rocks. Modal analyses, available only for the first two areas (Table 3, samples 9 to 15), indicate them to be predominantly of trondhjemitic and granodioritic type (Figure 4). The Sabaskong Batholith is at least 400 square miles (1030 km^2) in area, of which less than 100 square miles (260 km^2) occurs in the map-area. The central parts of the batholith are exposed in the extreme northwestern corner of the map-area, but a good portion of its margin is located in contact with the mafic rocks of the metavolcanic belt. Outcrop density is poor within the map-area, but from field evidence the batholith appears homogeneous at the periphery, dominantly trondhjemitic and only weakly foliated, but near its centre it is gneissic, with mafic schlieren and rather chaotic folding. Biotite is the dominant and usually the only mafic mineral, and in the peripheral zone biotite occurs in "books" of up to 1 cm size. In hand specimen the rock has a greyish appearance on the weathered surface. On fresh surfaces, biotite, quartz, plagioclase, and minor amounts of epidote are easily seen. In thin-section, the typical granitic texture is seen. Plagioclase is usually subhedral, and twinned according to carlsbad, albite, and pericline laws. Zoning, usually weak, is common in both twinned and untwinned individuals, and occasionally is of oscillatory type; the range seems to be confined within the limits of oligoclase. Quartz occurs in discrete areas of sutured, strained grains, and also interstitially. Biotite occurs usually as ragged anhedral to subhedral laths, commonly bent and strained, and varies from brown to olive green in colour. Epidote is often present, both as a secondary product, associated with sericite, of alteration of plagioclase, and in euhedral grains of probable primary origin. Microcline, though always

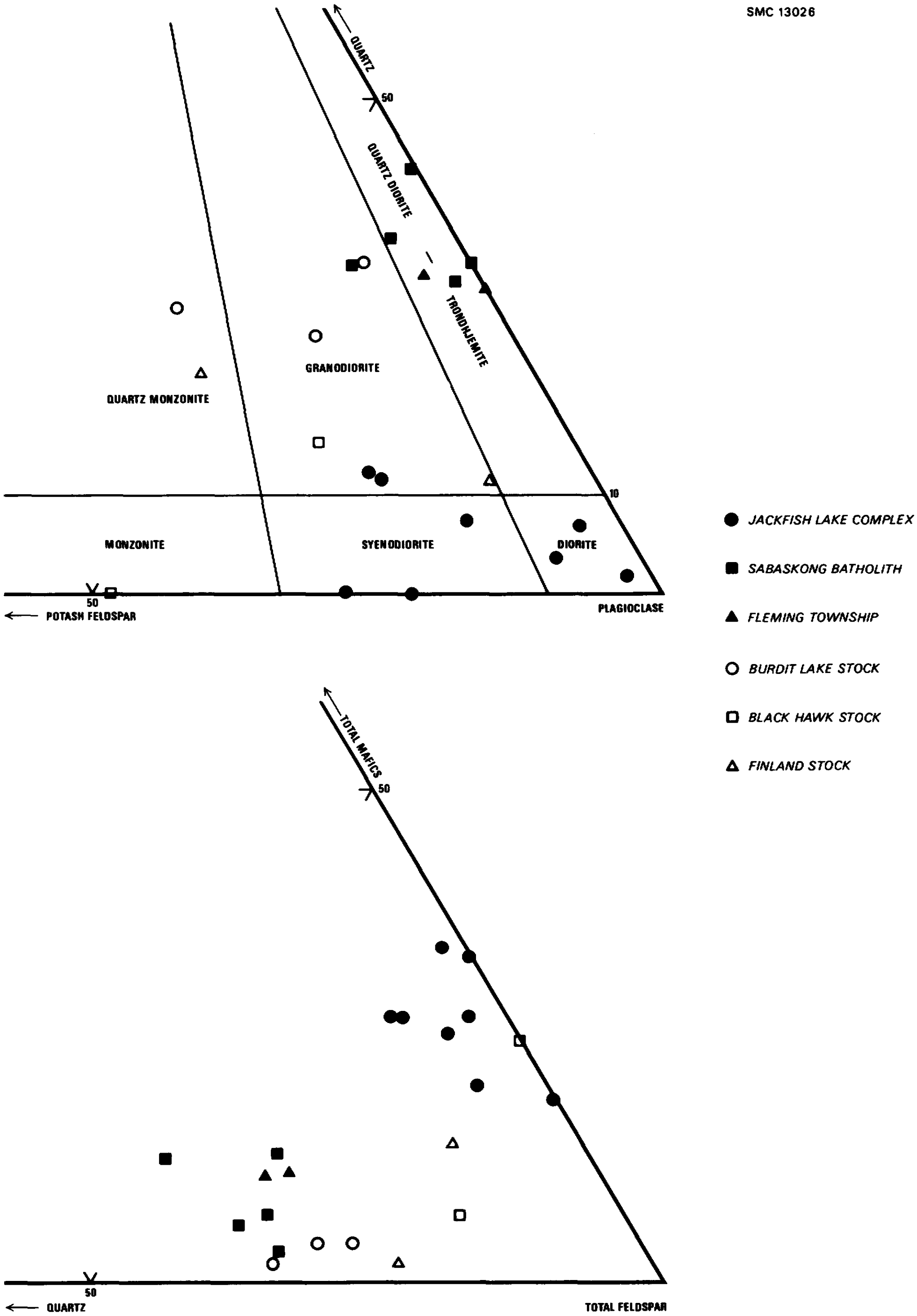


Figure 4—Compositional ranges of selected felsic and intermediate plutonic rocks, Off Lake–Burditt Lake area.

Percentages determined by modal analysis (see Table 3).
a. Quartz + Potash feldspar + Plagioclase = 100. b. Total mafics + Quartz + Total feldspar = 100, where Total mafics = Amphibole + biotite + chlorite + pyroxene. Total feldspar = Plagioclase + potash feldspar.

minor, is invariably present, interstitial to the plagioclase, and associated with myrmekite.

In Fleming Township trondhjemites, very similar to those of the Sabaskong Batholith, are the major rock type. At the periphery the trondhjemitic rocks pass into a zone of migmatites adjacent to the volcanic belt. Mafic xenoliths occur within the trondhjemites.

Gneisses and migmatites in the vicinity of Footprint Lake have been grouped together with rocks of the Sabaskong Batholith and the Fleming Township area, primarily because of their dominantly felsic nature, and also because similar migmatitic and gneissic rocks occur, though in smaller amounts, within these other areas. In the Footprint Lake area all rocks are well-foliated, gneissic to migmatitic in structure. They are bounded both to the west and east by syenodioritic rocks, with which they have a gradational contact across strike; their age relationship is therefore difficult to ascertain, but it appears that the last major plutonic or tectonic event was coeval in both rock groups. Banding is formed by alternation of mafic- (usually hornblende) rich bands with quartzose or feldspathic bands, a few centimeters in width. Minor folds, and lineation defined by rodding of mafic and felsic minerals, are evident throughout the migmatite terrain.

LATE TECTONIC INTRUSIVE ROCKS

Black Hawk Stock

The Black Hawk Stock occurs in the southern part of the map-area, immediately west of Highway 71. It is elliptical in shape with the long axis of the ellipse, oriented in a north-northeast direction, a little less than 5 miles (8 km) long, and the short axis 2½ miles (4 km) long. About a third of the surface area of the stock lies outside and to the south of the map-area (Fletcher and Irvine 1954).

The stock is distinctly zoned. Outcrop density is poor but sufficient when combined with evidence from aeromagnetic maps (ODM-GSC 1962a), and the account of Fletcher and Irvine (1954, p.21, Map 1954-2), to outline a marginal equigranular monzonite zone about ½ mile (0.8 km) in width. The interior of the stock is predominantly granodioritic and porphyritic. Contact between the two zones is gradational, and the rocks are clearly of the same age, there being no evidence of any sharp, discordant contacts. Modal analyses of one sample each from the outer and inner zones (Table 3, samples 18 and 19) indicate a marked chemical difference between the zones (Figure 4). The most notable difference is in the quartz content, there being no quartz in the sample from the outer zone, compared with 13.8 percent quartz in the sample from the inner zone. In both rock types hornblende is the major mafic mineral. Plagioclase occurs as subhedral to anhedral stubby laths in both rock types, and twinning is very well developed, predominantly according to the albite law, and often combined with carlsbad twinning. Excellent twin specimens allowed accurate determination of the composition of the plagioclases in both cases, their compositions being almost identical at An 10. Microcline is the potash feldspar in both cases; in the sample from the central zone it forms rather poorly defined, poikilitic phenocrysts, but in the sample from the periphery it is more interstitial in character.

Burditt Lake Stock

The bi-lobed Burditt Lake Stock, intrusive into the metavolcanic belt, is bounded by Burditt Lake and Albert Lake on its west and east respectively. The southern lobe, the larger of the two, is almost circular, with a diameter of approximately 3 miles (5 km). The northern lobe is more irregular in plan, little more than a mile (1.6 km) across, and appears to be joined by a narrow "neck" to the southern lobe.

In the field, rocks of the stock appear to be homogeneous in composition, with rocks of the northern lobe a little more porphyritic in texture. The mineralogy is relatively uniform, but percentage distribution does vary, according to the three samples investigated (Table 3, samples 20, 21, and 22; Figure 4), all of which were taken from the southern lobe of the stock. Mafic mineral content is low in all these samples, a typical feature of rocks of the stock, and green biotite is the most common mafic mineral. Plagioclases are twinned according to the albite and carlsbad laws, both separately and combined, and are of oligoclase composition, often weakly zoned. Microcline is interstitial and occasionally antiperthitic in equigranular samples, but it also occurs as poikilitic phenocrysts in the porphyritic rocks.

Pegmatites were noted in abundance along the shores of Burditt Lake, where rock outcrop is excellent. There may be considerable pegmatite back from the shore, but its abundance is difficult to estimate because of heavy moss and lichen cover.

Finland Stock

The Finland Stock is a rather poorly defined body occurring in central Potts Township, between Highways 71 and 615, and is interpreted as extending from about a quarter of a mile (0.4 km) south of Boundary Lake to the southern edge of the map-area. Outcrop density is poor in this general area. There is no outcrop southeast of Finland, and the existence of plutonic rocks in this area is conjectural; aeromagnetic data (ODM-GSC, 1962; see also Figure 8) suggest their existence, but felsic metavolcanics of similar magnetic response occur immediately south of the southern map boundary (Fletcher and Irvine 1954).

In the field, rocks of the stock were mapped as quartz monzonites and granodiorites. Two samples examined in thin-section (Table 3, samples 16 and 17), a quartz monzonite from the north end, and a leucocratic diorite from the south end of the body show a rather dissimilar mineralogy and composition (Figure 4). Other information is not available, but it is probable that the body is rather heterogeneous. At least one large, mafic xenolith occurs within the stock; there also appear to be inclusions of a more felsic type. Contamination of the primary magmatic phase by country rock is therefore likely.

Mafic Intrusive Rocks (Minor Dikes)

A number of minor mafic dikes, all similar in character and mapped in the field as lamprophyre dikes, but on petrographic examination better termed metadiabase, outcrop in the vicinity of Footprint Lake and the eastern end of Jackfish Lake. They are all of the order of a few inches to a few feet wide, and crosscut gneisses at varying angles. They occur mostly to the east of the main body of the Jackfish Lake Complex, though one dike was found within hybrid rocks of similar type to those of the complex at the extreme east margin of the map-area.

Structural evidence that all these dikes are of Early Precambrian rather than Middle to Late Precambrian age was found in the field, in that the dikes are themselves commonly contorted and boudinaged within the gneissic terrain. Also most of these dikes are metamorphosed and appear to be amphibolitic in general.

A thin-section of a sample taken from one of the dikes confirms the metamorphosed nature of the dikes. The hand specimen is dark in colour, very fine grained, with small phenocrysts of a dull buff colour, up to 1 mm in size, scattered throughout. In thin-section these are seen to be altered calcic plagioclases, mostly euhedral, and twinned on the albite law. The groundmass shows typical diabasic texture between feldspar laths and dark green amphiboles, probably pseudomorphing original pyroxene. Subhedral to euhedral magnetite is common throughout the ground mass. A few larger, porphyritic, amphibole crystals occur in the section.

MIDDLE TO LATE PRECAMBRIAN (PROTEROZOIC)

Mafic Intrusive Rocks (Diabase dikes)

Diabase dikes outcropping in the Off Lake–Burditt Lake area belong to a northwest-trending swarm cross-cutting Archean rocks from Lake of the Woods to Rainy Lake (Davies and Pryslak 1967). Dikes of this type were first mapped by Lawson (1888b). The dikes are invariably vertical, have sharp contacts with country rock (Photo 12), but vary considerably in width and extent, and also in consistency of orientation. The widest, largest, and most consistently oriented dike can be traced from the north end of Burditt Lake, where it passes northwestward out of the map-area, to Totem Point of Jackfish Lake, and thence to the west shore of the eastern arm of Jackfish Lake, where it terminates rather abruptly. The dike maintains a consistent northwest orientation, and is on the order of 150 to 200 feet (45 to 60 m) wide.

Another uniformly wide, consistently oriented, but seemingly discontinuous dike outcrops near Highway 71 about 1½ miles (2.5 km) south of the northern edge of the map-area, and can be traced intermittently, with minor offsets probably due to post-diabase faulting, as far as Off Lake. It is well exposed on the western shore of Off Lake, where it is about 150 feet (45 m) wide. South of Off Lake a number of narrower, but usually parallel dikes have been mapped, and these are probably a continuation of the dike at Off Lake. They do not maintain a consistent orientation, and appear to be offset by a number of north-northeast-trending faults (see "Structural Geology", and Figure 7).

A third dike, or group of dikes, can be traced, allowing for fault offsets, from Little Kishkutena Lake in the north, across Burditt Lake, and to a point about half way between Albert Lake and Lake Despair. The widths of these dike portions vary considerably, but generally tend to become narrower as the dike is traced southeastward.

ODM9312

Photo 12–Diabase dike intruding granitic rocks. Note typical jointing at right angles to dike margins. Birch Point, Northwest Bay of Rainy Lake.

A number of isolated dikes, with no apparent continuity, occur scattered throughout the map-area. Quite probably, many are in fact more continuous than shown on Map 2325 (back pocket), but were not traceable at the scale of mapping employed. In many locations clusters of narrow dikes, all with similar trend, were encountered. These have been shown as single dikes for mapping purposes. Also, narrow dikes commonly accompany the wide dikes, and occasionally can be shown to be offshoots of the latter.

The dikes are easily recognized in the field, as they have a typical brownish weathering, and stand out in marked colour contrast against other rocks (Photo 12). The fresh rock is dark green in colour. Grain size varies from 5 mm to markedly aphanatic close to the margins of many of the dikes.

Francoeur (1972) studied the petrography and chemistry of some of the dikes from the Off Lake–Burditt Lake area, and the following observations are mostly taken from his thesis.

The essential components of the rock are a calcic plagioclase and an augitic pyroxene, each of which constitute about 45 percent of the rock where it is unaltered, and which, in the coarser phases, define a subophitic texture. Interstitial quartz is invariably present, constituting between 5 and 10 percent of the rock, so that these rocks may be termed quartz diabases. There is no marked difference in mineralogy or amounts of major minerals from one dike to another. Accessories include ilmenite, titaniferous magnetite, pyrite, apatite, leucoxene, and minor amounts of biotite.

Plagioclases are euhedral, and twinned on the combined albite and carlsbad laws, with occasional combined pericline twinning. The plagioclase is of labradorite composition, though normal zoning and occasional oscillatory zoning were observed. Plagioclases are commonly sericitised. Augite is very pale brown and non-pleochroic in thin-section, with a 2v angle of between 56 and 60 degrees. The augite usually occurs in equidimensional aggregates of small grains giving rise to a mosaic pattern. Lawson (1888a) described these aggregates as polysomatic. Twinning is usually absent. The augite also occurs as large, elongate grains, which are always twinned. Quartz is usually interstitial, and also occurs in myrmekitic intergrowth with plagioclase. Interstitial grains are angular and undeformed.

Coarser, pegmatitic, phases are occasionally found, especially within the wider dikes. These pegmatites are richer in quartz than the host dikes, and have rather vague and irregular margins. Francoeur interprets these pegmatites to have been formed by crystallization from hydrothermal solutions.

Augite is commonly altered to hornblende and chlorite along cleavages and crystal boundaries. Francoeur was able to show, by modal analysis, that the sum of augite plus hornblende plus chlorite for three samples from the same dike was constant, even though individual amounts varied considerably, thus supporting the conclusion based on textural evidence that hornblende and chlorite are secondary after augite. Chilled margins are common in all the dikes. Studies of the dike at Potts Lake show that the grain size of major minerals increases most rapidly over the first 10 feet (3 m) from the margins, and that plagioclase tends to occur as phenocrysts, both in the marginal, fine-grained phases, and in the coarser phases. At the contact the rock is so fine-grained as to be almost glassy in texture and tabular plagioclase phenocrysts are aligned parallel to the walls of the dike.

Francoeur (1972) analysed 6 samples, taken at 0, 3, 5, 10, 20, and 50 feet (0, 1, 1.5, 3, 6, 15 m) from the contact in the dike at Potts Lake, by atomic absorption spectrometry. Weight percentages of the oxides of Fe, Mg, Ca, Na, and K were determined (Figure 5). Francoeur attributes variations in oxide percentages to compositional variations in plagioclase and augite. He concludes, after Archbold (1962) who carried out similar work on diabases from eastern Ontario and western Quebec, that the dike progressively cooled from edge to centre, so that initial higher temperature phases crystallized near the edge. Later crystallizing, lower temperature minerals in the more interior parts of the dike would be slightly richer on constituents not taken up in the earlier minerals. According to Francoeur, this is reflected in the variation diagram in that iron increases and magnesium decreases from 20 feet to 50 feet (6 m to 15 m), and calcium decreases and sodium increases over the same distances. Thus, progressive chemical change across the dike represents slight magmatic differentiation due to progressive crystallization inward from the edges. Francoeur explains the variations within the first 5 feet (1.5 m) of the contact to ground waters circulating in fissures through which the dike was injected, rather than to assimilation of host rock material. He concludes also that the low and constant amounts of potassium in samples across the dike indicate that introduction of chemical elements during alteration (e.g. of plagioclase to sericite) was negligible.

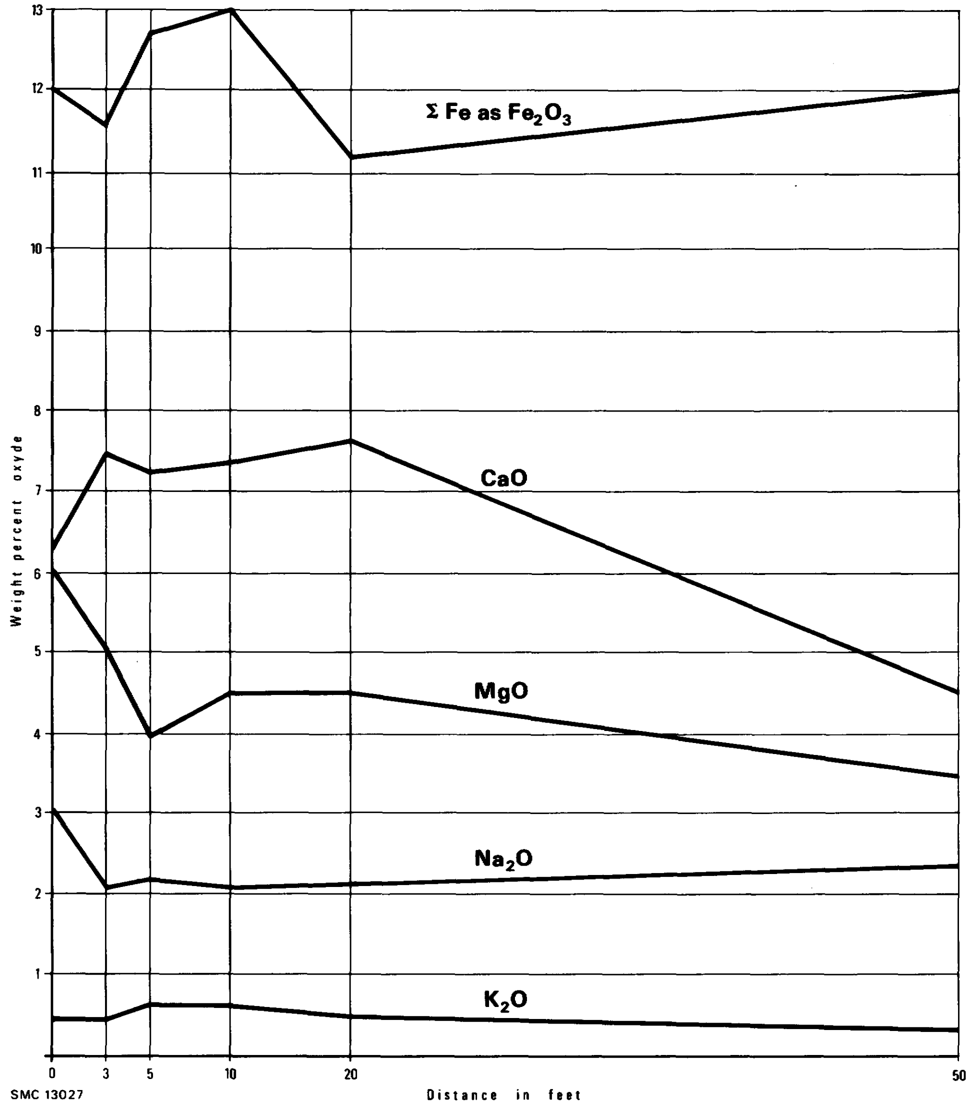


Figure 5–Variation in bulk chemistry across (edge to centre) a diabase dike at Potts Lake, Off Lake–Burditt Lake area (from Francoeur (1972)).

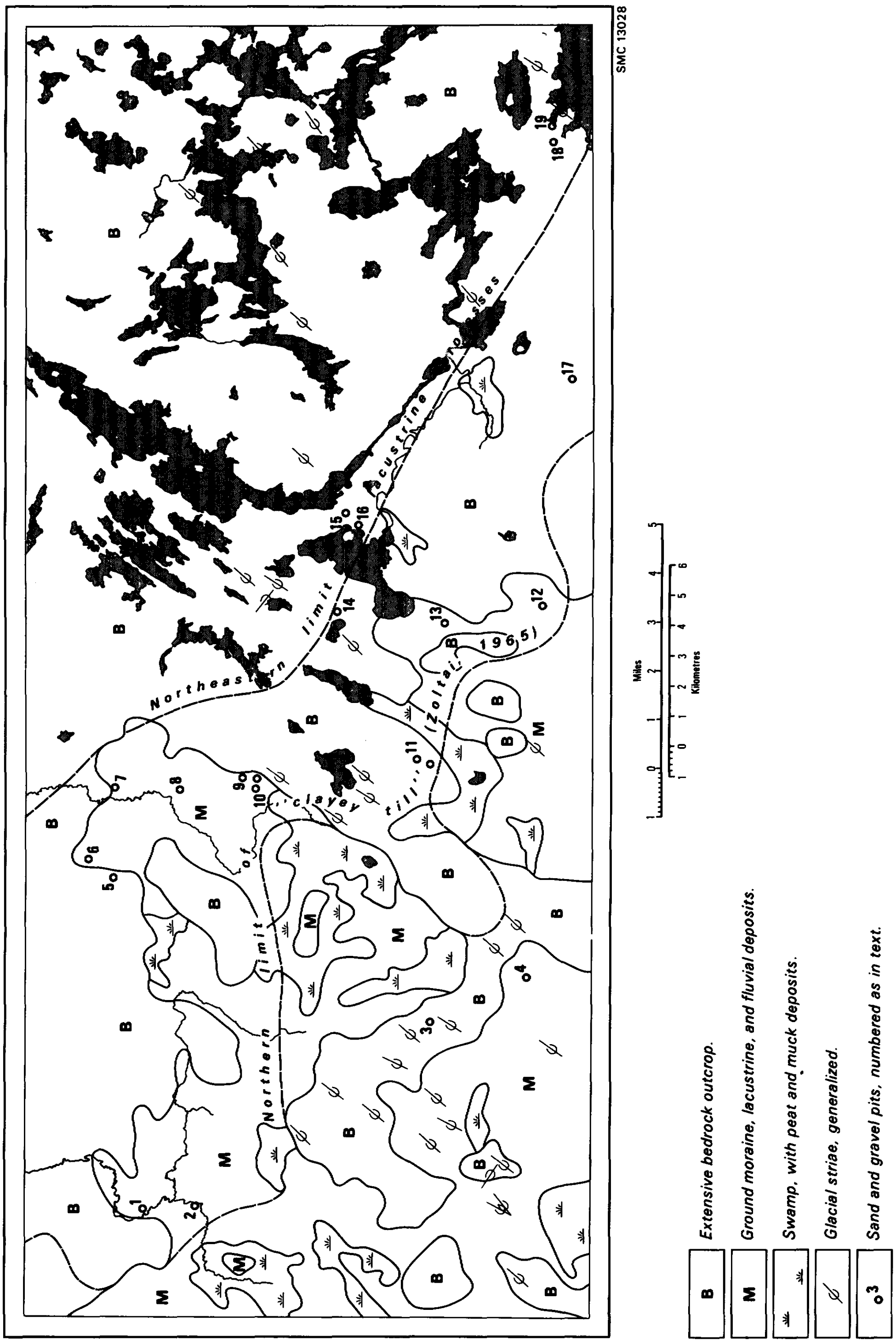


Figure 6–Cenozoic geology, Off Lake–Burditt Lake area.

Cenozoic

QUATERNARY

Pleistocene and Recent

Geological events of Pleistocene age are mostly responsible for variations in topography in the Off Lake–Burditt Lake map-area. The two topographic regions outlined in the section on topography and drainage are a direct result of glacial and lacustrine processes. Each process interacted with the other in the region southwest of a line drawn from Highway 71 in the north, through Beadle and Off Lakes, the Manomin River, and thence to Northwest Bay in the southeast. Northeast of this line there is evidence that only glacial processes were active during Pleistocene time.

In the northeastern region, the rocky lake country of Lawson (1888a), bedrock is extensively exposed (Figure 6). Morainic and more recent material is limited to hollows between rocky, rolling bedrock. Bedrock displays the effects of ice action: glacial striae, chatter marks, and smoothing and rounding of rocky protuberances. These features are especially apparent along the shore-lines and on the islands of the many lakes in the region. Little deposition occurred here during the Pleistocene epoch.

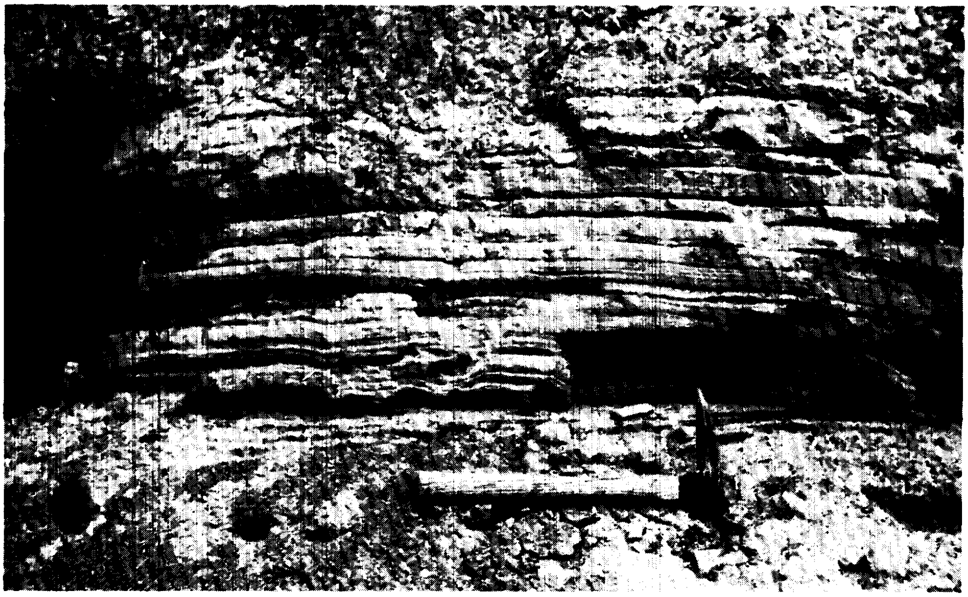
In the southwestern region, the alluvial plain or river country of Lawson (1888a), bedrock is only extensively exposed in a few isolated areas. Elsewhere it is covered by varying thicknesses of morainic and lacustrine material, through which small, low, isolated outcrops commonly protrude. Striations, chatter marks, and rounding and smoothing of rock outcrops indicate that this part of the region was scoured by ice action. However, moraine material is abundant, in the form of boulders (Photo 13), gravel, and sandy till, indicating extensive deposition by ice. Lacustrine and fluvial material is also abundant, the former consisting of clay and silt, observed by the author in recently excavated drainage ditches in Sifton Township, and the latter, mostly confined to the more northwestern edge of the region, of sand (Photo 14), gravel (Photo 15), and boulders (Photo 16) in deposits of outwash type, containing abundant evidence of strong current action in the presence of cross bedding (Photo 17) and scour channels. These features may be seen in both active and disused sand and gravel pits.

During the present field survey brief notes were made at all active and disused sand and gravel pits in the area, and following are the main points edited from the field notes. The pits are numbered according to the sequence shown in Figure 6.

1. Boulder till (Photo 13), capped by gravels with cross bedding, and a thin sand to gravel bed at the top. Clast size distribution in boulder till markedly bimodal: boulders 1 foot to 6 feet (0.3 to 2 m) in diameter; matrix of pebbles and sand, very poorly sorted. Not in use.
2. Deep pit, now in disuse, in predominantly sandy sequence, with a number of intercalated gravel units. At the top is a capping of gravely till (i.e. mostly sandy, containing pebbles up to 1 inch (2.5 cm) in diameter). Sands coarsely bedded, with little gradation in grain size. At least one finely laminated argillaceous to fine sandy unit (Photo 14), intercalated near the top of the sands, about two to three feet (0.6 to 1 m) thick; contains larger grains, up to a half-inch (13 mm) in size (drop stones?). Complete section possibly 50 feet (15 m) thick but obscured by slumping.

ODM9313

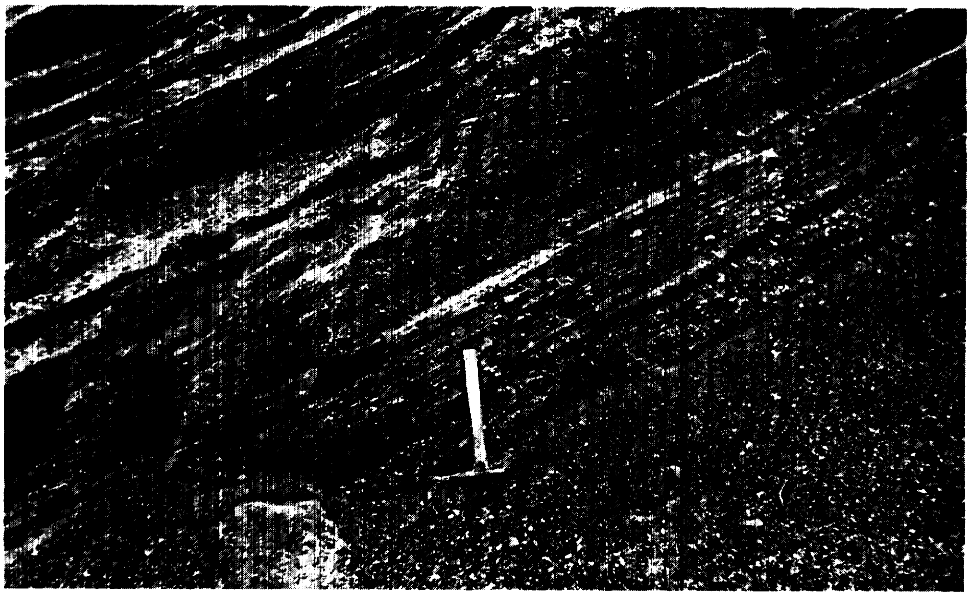
Photo 13–Boulder till. Note hammer for scale, in centre of picture. Pit 1 (Fig. 6), Dewart Township.



ODM9314

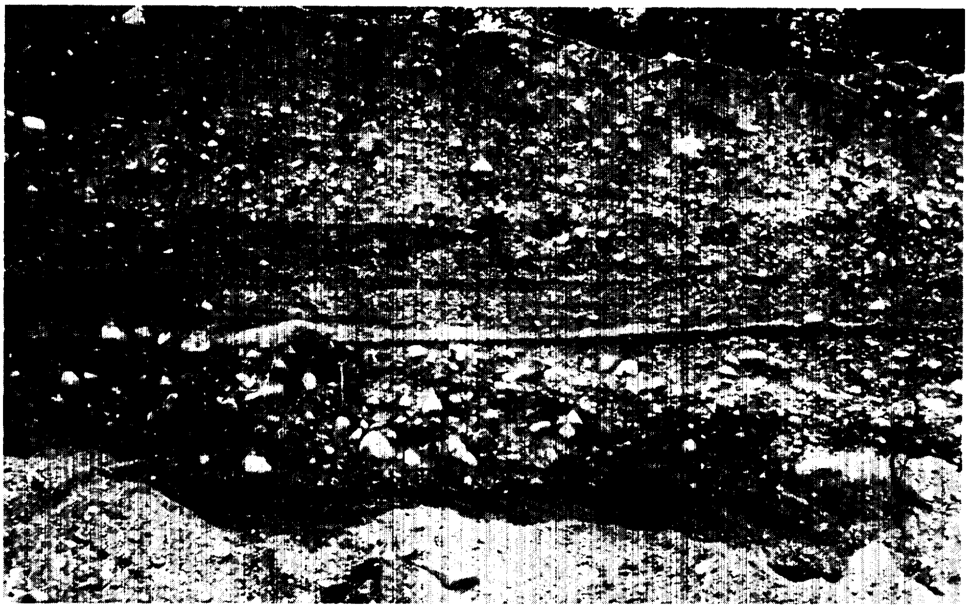
Photo 14–Laminated fine-grained sandy beds, of probable lacustrine origin, within a predominantly coarse-grained, massive bedded, sandy sequence. Pit 2 (Fig. 6), Dewart Township.

3. Very poorly sorted gravel till. Heterogeneous lithology, rather angular fragments; pebbles one to two inches (2.5 to 5 cm) in diameter, in a fine, sandy matrix; bi-modal. Not in use, and poorly exposed.
4. Extensive areal development, only part in use, for sand and gravel. East end of pit is mostly coarse, boulder till: boulders average 1 foot (30 cm) in diameter, but a few up to 4 or 5 feet (1.3 to 1.6 m). Mostly felsic plutonic boulders, and all well rounded. Very poorly sorted. West end of pit, sand and gravel, which appears to overlie the boulder till. Cross bedding in the gravels, fine bedding in the sands. Probably glaciofluvial.
5. Sand and gravel, with occasional cobbles and a few boulders. Poorly sorted. Gravel fragments subangular, while coarser material is subrounded. May be in use.
6. Graded bedding, from cobble to coarse sand size. Subrounded fragments, moderately well sorted. Some cross bedding. In use for gravel.
7. Boulder till, poorly sorted. Not in use, and overgrown.
8. Poorly sorted boulder till; subangular to subrounded fragments. Not in use.
9. Boulder till, with abundant cobbles in a sandy matrix. Some sand and gravel. In use.
10. Boulder till, similar to pit number 9. Sand and gravel more abundant east of Highway 71. Not in use, and overgrown.
11. Two gravel pits, not in use. No notes.
12. Extensive use, mostly for sand, with minor gravel. West end of pit is in a predominantly sand sequence, with minor gravels. All cross-bedded, on a large scale, with dips of 45 degrees to the west. East end of pit is in a bouldery till; varying amounts of very fine sand to silt in the matrix, with some clay. Pebbles and boulders mostly of felsic plutonic rocks, but some hornblende-bearing granodiorites and diorites, very deeply weathered. Boulders usually not more than 1 foot (0.3 m) in diameter, but a few up to 3 feet (1 m). The till appears to overlie the sand sequence.
13. Fairly well sorted cobbles, gravels, and sands. Subangular fragments. Bedded. In use for sand and gravel.
14. Extensive development at two elevations, one close to the highway (Photo 15), the other higher up (Photos 16, 17). Thick sequence, perhaps 100 feet (30 m) of material. Deposits in the lower pit commence at base with gravels (Photo 15) and pass upward into successively finer material. Cross bedding and graded bedding throughout. Lower sequence is draped over bedrock, with gravels and sands, cross bedded, dipping steeply westward (Photo 15). Suggests outwash deposits. Deposits in upper pit more uniform, with gravel and sandy beds intercalated (Photos 16, 17), though a few very large boulders, some 6 feet (2 m) in diameter, occur in the gravels. Bedrock underlies the upper pit also. To the east, is bouldery till. In use for gravel.
15. Sand and gravel, cross-bedded, and graded. Evidence of scouring, current direction to the south. In use for sand and gravel.
16. Similar to pit number 15, with cross-bedding indicating a southeastward current direction. In use for gravel.
17. Cobble- and gravel-size fragments in medium-grained sand; subangular fragments, and well sorted. Not in use.
18. Sandy layer overlain by cobble and gravel layer, with a sandy matrix. Some cross bedding. Well sorted. In use for sand.



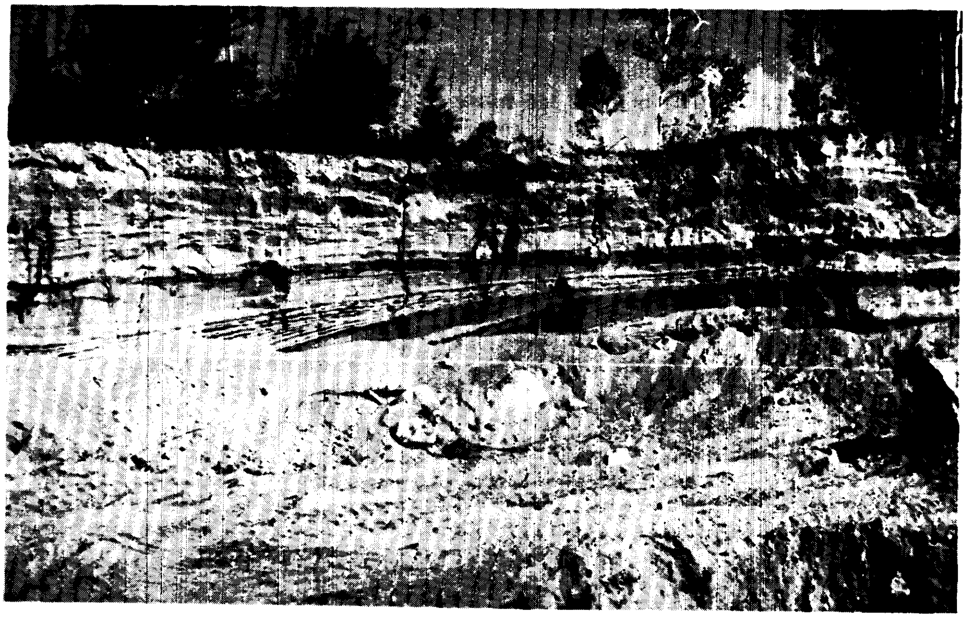
ODM9315

Photo 15—Gravel, probably of outwash origin. Deposit is draped over bedrock, which outcrops immediately to the right of the picture. Pit 14 (Fig. 6). Highway 615, near Pony Lake.



ODM9316

Photo 16—Bouldery gravels, probably of outwash origin. Note hammer for scale, near centre of picture. Pit 14 (Fig. 6). Highway 615, near Pony Lake.



ODM9317

Photo 17–Gravel and sand, probably of outwash origin. Note cross-beds, and hammer for scale, in centre of photo. Pit 14 (Fig. 6). Highway 615, near Pony Lake.

19. Boulder till (?). Poorly sorted, but occasional graded bedding. Fragments vary from rounded to subangular. Not in use.

Moraine and glaciofluvial material constitute most of the commercially worked deposits, and the two types of material are interbedded, indicating contemporaneous glacial and fluvial action. Deposits of indisputable lacustrine type were not found in any of the pits; however, silty, finely bedded sediments in pit number 2, in the extreme west, may be of lacustrine origin. A previous interpretation of Cenozoic geology in the Rainy River District (Zoltai 1961) indicated an early shoreline of glacial Lake Agassiz to have run in a west northwest–east southeast direction through the present map-area, approximately along the line dividing the two topographic regions outlined in this report. Such an interpretation would account for the mixed glaciofluvial/morainic material deposited at a glacial/lacustrine interface. In particular, the deposits at pit 14 are of interest, in that they seem to be glaciofluvial and deposited directly on bedrock. Bedrock is exposed both in the base of the pit and, northeast of the pit, at a higher level than the unconsolidated deposits.

Glacial striations within the map-area were first measured by Lawson (1888a, b), and later by Zoltai (1965). Striations measured during the present survey, generalized somewhat in Figure 6, indicate a major movement of ice from approximately N40E. Evidence of a much weaker glacial advance from approximately N55W was noted at two localities only, one about 1½ miles (2.5 km) north of Dearlock in the southwest of the map-area, and the other near Preachers Lake in the centre of the map-area. At both localities the northwesterly trending striations clearly cross-cut the northeasterly set; the northwesterly striations are rather weakly developed and cross the sharply incised ridges and furrows of the northeasterly set. Zoltai (1961) attributes striations with the northeasterly trend to the second and fourth of four ice movements into the Rainy River District, the ice having come from the Patrician centre (Tyrell 1913). Striations with the northwesterly trend are probably attributable to the third of these four ice movements; striations with a similar trend have been noted by Johnston (1915), Burwash (1933), and Zoltai (1961), but some of them predate northeasterly-trending striae, and these have been attributed to the first of the four ice movements. The ice which produced striations with this northwesterly trend is inferred by Zoltai (1961) to have originated in the Keewatin centre (Tyrell 1913).

Patrician ice deposited ground moraine within the present map-area. All till deposits noted by the present author best fit the description of Patrician "red" drift (Elson 1961) given by Zoltai (1961, p.65):

The texture ... is generally very sandy, containing little silt and clay. Stones account for about half the volume of the till, locally the stone and gravel content may be appreciably higher. Many of the stones are well rounded, showing signs of excessive wear.
The material of the Patrician till is mainly of local provenance, having been derived almost exclusively from Precambrian rocks, mainly granite and other acid rocks.

Till deposits of the kind described as Keewatin "grey" drift (Elson 1961), and known to underlie the Rainy River area, were not recognized by the present author. According to Zoltai (1961, p.66) the characteristics of these deposits are as follows:

In the fine matrix of the till (material less than 2mm in diameter), clay and silt predominate over the sand size particles. Stones are not very abundant, contributing usually less than 15% to the volume of the till. It is estimated that only about half of the stones were derived from the underlying Precambrian bedrock. The other stones are buff coloured Palaeozoic limestone.... This till contains a high percentage of carbonates.... In contrast, the Patrician till in this region contains no calcium carbonate.

From Figure 6 it can be seen that all sand and gravel pits examined during the present survey, with the exception of pits 3 and 4, lie to the north of the northern limit of "Clayey till" indicated by Zoltai (1965).

Areas of extensive swamp, with peat and muck deposits of Recent age, are confined largely to areas underlain by moraine deposits, that is to say, mostly in the southwestern topographic region, and are indicated in Figure 6. It is notable that these swamps are mostly underlain by clayey till.

No evidence was found by the author for the existence of the terminal moraine postulated by Zoltai (1961; 1965) to cross the present map-area approximately along the line of contact of the northeastern and southwestern topographic regions. High ground corresponding in position to this postulated Lake of the Woods–Rainy Lake moraine (Zoltai 1961, p.80) in fact is a ridge of bedrock outcrop, parallel to and immediately southwest of the Manomin River, at its southeastern end. At its northwestern end, in the vicinity of Highway 71, there is no topographic or lithologic evidence on which to base its existence; there is no ridge of any kind, and deposits of mostly boulder till are identical to those in the surrounding areas.

STRUCTURAL GEOLOGY

Facing Criteria

Only where criteria indicative of the facing of strata were recognized in the field could a reliable structural, and therefore also stratigraphical, interpretation of the metavolcanic belt be made. It was found impossible to satisfactorily resolve stratigraphy and structure of the belt east of a line through Burditt and Off Lakes, due to obliteration of original structures and textures by deformation, metamorphism, and migmatization.

In the mafic metavolcanics, two facing criteria were found to be of help: the shape and packing of pillows; and the distribution of plagioclase phenocrysts within flow units. The former criterion needs no further comment; however, the latter is not generally discussed in the literature, and a number of assumptions which need explanation were made by the author.

Mafic metavolcanics containing plagioclase phenocrysts were encountered at many localities with the metavolcanic belt. These phenocrysts, usually completely altered to zoisite, are generally two or three centimeters (0.75 or 1 inch) in diameter, but may reach four or five centimeters (1.5 or 2 inches). They vary in abundance from isolated phenocrysts, scattered through the rock to phenocrysts so closely packed as to be touching each other. As a rule, they are separated each from the other by distances of 2 to 6 inches (5 to 15 cm). In Zone M2, rocks of this type are abundant, and frequently pillowed. Phenocrysts are mostly confined to the interiors of the pillows, but occasionally can be found within pillow selvages (Photo 3). Porphyritic mafic metavolcanics cannot, however, be used to determine facing in such cases. Only where definite individual flows can be identified in outcrop are they of assistance. In these cases it is often found that there is a gradation from one side of the flow to the other from rock poor in phenocrysts to rock rich in phenocrysts, and that there is often a sharp boundary at the side rich in phenocrysts against phenocryst-poor rock of an adjoining flow. It was assumed in the field that plagioclase phenocrysts, even of calcic type, would have been less dense than the mafic magma from which they crystallized, and that therefore, given necessary conditions of slow cooling after emplacement, would tend to rise through the viscous magma toward the top of the flow. The top of the flow, observed in the field, would thus be the side containing abundant plagioclase phenocrysts, and the sharp contact between phenocryst-rich and phenocryst-poor rock would thus be a contact between a lower and upper flow respectively. The assumption of facing was supported in the field by the fact that such facings agreed with those given by the more conventional pillow-top criteria. Unfortunately no pillow lavas were found in close stratigraphic proximity to porphyritic flow units, so the corroboration depends on the assumption that no reversals in sequence occur within the distance between pillows and porphyritic flows. At Panorama Lake, a porphyritic flow was determined by the above method to face southeastward (Figure 7). All available facing data from pillows indicates the same southeastward facing of the sequence. The nearest pillows to the porphyritic flow are a mile (1.6 km) across strike to the northwest, and over a mile (1.6 km) to the southwest along strike.

In the felsic metavolcanics, recognisable facing criteria were rarely found.

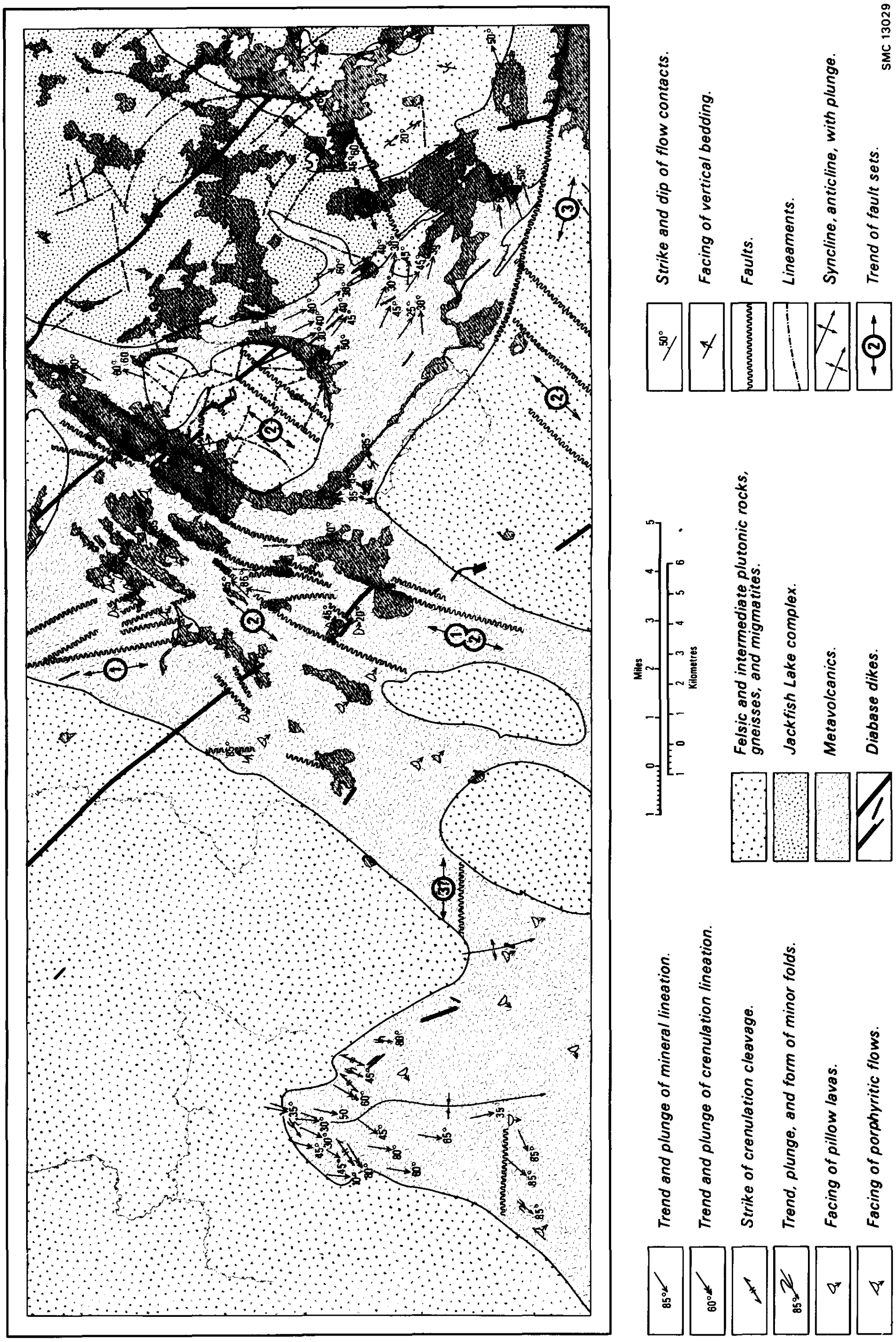


Figure 7–Structural interpretation, Off Lake–Burditt Lake area.

However, some of the pyroclastic rocks and particularly the finer grained, tuffaceous variety do seem to show a gradation in grain size. At only one locality, opposite Buckhorn Point on Burditt Lake, could a definite gradation toward finer material be substantiated in a sequence of alternating tuffs and tuff breccia.

Folding

It has frequently been assumed that the major structural form of most, if not all, metavolcanic-metasedimentary greenstone belts is synclinal, the axis of the syncline occurring in the centre of and following the regional, elongate trend of the belt. Very little evidence can be found to substantiate such an assumption in the greenstone belt of the Off Lake–Burditt Lake area. No central fold axis has been recognized, by gross repetition of lithologic units, by inferences from minor deformational structures, or by reversal of facing criteria.

The metavolcanic-metasedimentary belt has been folded about a north-south axis. Only one such regional fold structure has been recognized, the Dearlock Syncline, with its attendant anticline connecting it with the main belt to the east. There is no evidence of other fold structures of the same kind within the area; the Dearlock Syncline appears to be a unique case.

The form of the Dearlock Syncline (Figure 7) is a southward plunging, open, structure, the axis of which is shallow (30 to 50 degrees) in the north, and steep (about 80 degrees) in the south. A cross-folding of the syncline, about northeast-southwest axes has strongly deformed the nose of the fold in the north, but left the more southern parts relatively undeformed. Primary definition of the Dearlock Syncline and its attendant anticline is made by the criteria of facing of pillow lavas within the area underlain by the mafic metavolcanics comprising the fold, and in addition by the facing of porphyritic mafic flows at one locality on the western limb of the syncline. The presence of the fold is substantiated by foliation, lineation, and minor fold information. Foliation appears to be more strongly developed on the western limb of the fold, where it is generally oriented in a northeast direction. On the east limb, foliation is generally oriented in a northwest direction, and it is probable that the foliation is approximately parallel to original planar structures, such as bedding and flow tops. The foliation appears to wrap around the nose of the eastern anticline. Lineation is best developed on the west limb of the syncline and, everywhere observed, it plunges southward. The plunge of the lineation probably provides a good indication of the plunge of the fold.

Cross-folding of the nose of the fold has produced crenulation cleavages and attendant lineations defined by intersection of crenulation cleavage and primary foliation. Much of the foliation with a northeast trend may have been either developed or re-activated as a shear component during this later deformation phase. Minor folds within the Dearlock Syncline were produced during both the first and second deformation phases.

In the middle of the map-area folding is not in general evident, either on the regional scale, or the minor scale. All the available evidence, from top determinations in pillow lavas, in porphyritic flows, and graded sequences in tuffaceous rocks indicates a homoclinal sequence facing southeastward. Pillow attitudes are usually difficult or impossible to ascertain accurately, but are mostly very steep. In a number of instances, notably where they are shallow, they could be measured. No overturning was noted, though steep attitudes generally conformable with regional foliation attitudes are the rule, but exceptions occur in the centre of the map-area, most notably at Pony Lake, where shallow dips to the east were noted in rapidly alternating felsic and mafic flows, and on the east shore of Off Lake, where the contact between felsic metavolcanics and overlying scoriaceous lavas dips at 50 degrees to the east. Foliation and lineation in this central part of the map-area vary considerably in development. Foliation is strongly developed in the vicinity of Burditt Lake, especially within the more felsic metavolcanics where it takes the character of a brittle shear. Lineation is also quite marked in this area, and defined by elongate felsic volcanic fragments, most of which dip very steeply in the plane of the foliation, but consistently to the northwest. In the more peripheral mafic metavolcanics foliation is less intense and frequently absent, and lineation was not observed. The excellent pillows found on Panorama Lake are comparatively undeformed.

East of Off and Burditt Lakes deformation and metamorphism have destroyed facing criteria. At the southern end of Burditt Lake a number of minor folds, not observed by the author, seem to indicate a predominantly kink type of deformation. Southeast of Albert Lake, strong planar and linear deformation is evident within amphibolites and migmatites of metavolcanic origin. Lineation is defined by amphibole prisms, and in general plunges between 30 degrees and 50 degrees to the southeast.

Gneisses and migmatites in the east of the map-area are in general folded on a minor scale only; no regional fold axes were detected. Little consistency in fold pattern was noted, though many folds appear to have the same sense, particularly adjacent to the contact with rocks of the Jackfish Lake Complex, perhaps indicating that a dextral movement component acted along the contact at some stage in the deformation history.

Foliation within plutonic rocks of the Sabaskong Batholith, the Jackfish Lake Complex and in the Fleming Township area is usually not well developed. It is defined by orientation of mafic and felsic minerals. In the Sabaskong Batholith, and the Fleming Township rocks the foliation is locally gneissose, particularly toward the northwest of the map-area within the Sabaskong Batholith, and close to the margins of the plutonic body in the Fleming Township area. In the Jackfish Lake Complex, foliation is absent or weak over large areas north of Jackfish Lake.

Faulting

There appear to be at least three sets of faults within the Off Lake–Burditt Lake map-area, each of which may have been activated and re-activated at various times in the deformational evolution of the area. However, cross-cutting relationships are evident, and it is on this basis that a three-fold classification based on relative age and on orientation has been established (Figure 7). It should be emphasized that most of the faults were not directly observed in the field; evidence for faulting has been gathered from offset of dikes and geologic contacts, orientation of shear zones, and from lineaments on aerial photographs. On Map 2325 (back pocket) only the more obvious faults have been indicated; other interpreted faults indicated in Figure 7 appear as lineaments on the geologic map.

Faults of Set 1 have an orientation a little to the west of north, and have been recognized only in the middle of the map-area, and notably to the west of Burnt Bay, and to the north of Off Lake. These faults appear to offset the contacts between lithologic zones.

Faults of Set 2 are better developed than those of Set 1, which they appear to truncate and possibly offset, for example, northwest of Preachers Lake. Set 2 faults trend northeasterly, parallel to the regional foliation trend, and also parallel to contacts between lithologic units and zones. As a result these faults are difficult to recognize. However, very strong negative topographic lineaments within metavolcanics, commonly occupied by arms of lakes, and offset of diabase dikes which were presumably originally continuous, attest to their presence. It is quite possible that many such faults within the metavolcanics are in fact quite wide zones of shearing, parallel to and identical with the regional foliation, which in such a case would be defined by shear or schistosity surfaces. Strong shear zones, with attendant carbonatization, are quite commonly observed at Panorama and Cedar Lakes, and at the north end of Off Lake. Movement along these shear zones probably took place at a number of different times during structural evolution, since the diabase dikes were emplaced late in the sequence of events, and these, although displaced, cross-cut regional foliation, and contain no evidence of superimposed tectonic foliation themselves. It is also arguable that the dikes themselves were not displaced, but that they occupy regional tension fractures. Such tension fractures themselves may have been displaced by late movement along former shear zones. South of Off Lake, faults interpreted as belonging to Set 1 bend from their northerly trend, and appear to pass into faults interpreted as belonging to Set 2. Faults in the southeastern part of the map-area with an approximately northeasterly trend are interpreted here as being associated with those of Set 2, as are similarly-oriented faults within the Burditt Lake Stock. There appears to be no offset of contacts of the stock with the surrounding metavolcanics, whereas there is a definite discontinuity along the length of a diabase dike which crosses the stock. This suggests that in fact the dike was not faulted, but has been injected into tension joints opened up in the stock. The pattern of lineaments observed on air photographs within the stock is quite complex, suggesting a profound fracturing of the stock.

A linear zone of mylonitization trending south of east, here named the Northwest Bay Fault, enters the map-area in the extreme southeast, and appears to die out as it is traced westward. It truncates lithologic units on its north side, south of Lake Despair, and is probably an offshoot of the east-west Quetico Fault (Shklanka 1972, p.39), a half-mile (0.8 km) wide mylonite zone, which occurs some two miles (3 km) south of the map-area (Davies 1973). Magnitude and direction of movement on the fault has not been determined. The mylonite zone appears to truncate faults of Set 2, and so has been assigned to Set 3. Other possible faults of Set 3 include two east-west faults interpreted to offset mafic metavolcanic zones in the southwest part of the map-area.

Tensional forces acted on the area following Archean tectonism, allowing injection of diabase dikes as a northwest-trending swarm. Strong linear patterns within the plutonic rocks east of the volcanic belt parallel the trend of the diabase dikes, and are probably associated with jointing developed during this tensional activity. Other lineaments have a northeasterly trend, probably associated with deformation which produced faults belonging to Set 2.

Synthesis

Folding, faulting, and invasion of plutonic magma must be considered together in a synthesis of the structural geology of the Off Lake–Burditt Lake area. The information available suggests that major deformation within the metavolcanics occurred synchronously with plutonism. During intrusion and migmatization associated with formation of the Sabaskong Batholith, the plutonic rocks of the Fleming Township area, the Jackfish Lake Complex, and the gneisses and migmatites at Footprint Lake, the volcanic rocks were strongly deformed, both by folding and faulting. The cross-folding was about axial planes oriented northeast-southwest, that is to say, parallel to shearing within the main part of the metavolcanic belt; probably, faulting and folding were synchronous. The salient of metavolcanics projecting from the main body of metavolcanics parallel to the Manomim River, was drawn out or separated from the belt during this first plutonic phase.

Intrusion of the Black Hawk, Finland, and Burditt Lake Stocks probably postdated the first major plutonic event and thus also the period of most intense deformation of the metavolcanics. Fault movements in a northeast direction, parallel to faults of Set 2, continued following emplacement and cooling of the stocks, probably both within the stocks and the metavolcanics, but also in the rocks of the first plutonic phase.

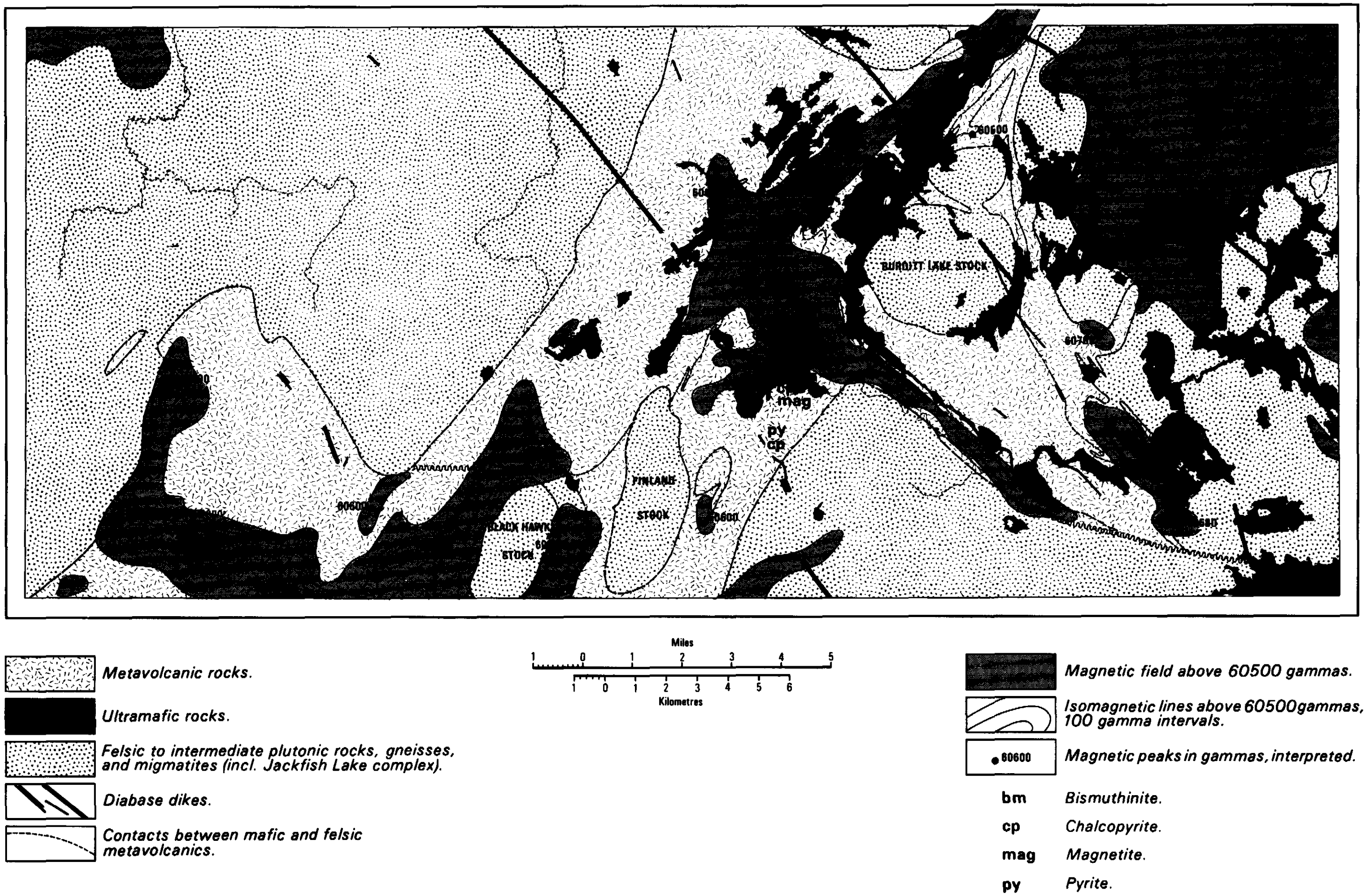
Mylonitization along the Northwest Bay Fault was probably either a late phase in or postdated the compressional tectonic evolution of the area. Reactivation of the Northwest Bay Fault possibly occurred in Middle to Late Precambrian time since there is some evidence for offset of a diabase dike at Northwest Bay.

Tensional tectonics postdated major compressional tectonics, and opened up northwest-trending tensional fractures into which diabase dikes were intruded during Middle to Late Precambrian time. Further compressional, or at least shear, deformation probably acted within the metavolcanics, offsetting the diabase dikes.

DISCUSSION OF AEROMAGNETIC DATA

Comparison of Map 2325 (back pocket) with published aeromagnetic maps (ODM–GSC 1962a, b) shows a number of correlations between magnetic intensity and geology. These are summarised in Figure 8.

Magnetic intensity is generally higher over metavolcanics than over adjacent felsic and intermediate plutonic rocks. Thus, magnetic intensities over the Sabaskong Batholith, the Finland Stock, the Burditt Lake Stock, and the felsic gneisses at Footprint Lake, are below 60,500γ, and isomagnetic lines define a rather low magnetic gradient, indicating uniform lithologies to be likely. However, there are areas within the metavolcanic belt where magnetic intensities are



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Aeromagnetic data adapted from ODM-GSC maps 1167G, 1168G, 1175G, and 1176G.

Figure 8–Relationship of aeromagnetic data to geology, Off Lake–Burditt Lake area.

low. These include the area underlain by the northern part of the Dearlock Syncline, much of Menary and Potts Townships, the area underlain by felsic pyroclastics at Burditt Lake, and the area southeast of Albert Lake underlain by metavolcanics metamorphosed to the amphibolite facies. Since magnetic intensity is attributable to presence of magnetic minerals, notably magnetite and pyrrhotite, it must be concluded that these are of low concentration in these areas. Metamorphic grade appears to have some control over development of pyrrhotite on a regional scale in metavolcanics, occurring characteristically in rocks above greenschist facies, its non-magnetic paramorph, pyrite, being stable at lower grades. Field observations coupled with analysis of mineral assemblages in thin-section suggest that over most of the metavolcanic belt rocks were metamorphosed under greenschist facies conditions, except at the eastern edge of the belt, where amphibolite facies conditions prevailed. Thus, the high magnetic values within the metavolcanic belt must in general be attributable to magnetite rather than pyrrhotite. Exceptions may be the anomaly reaching a peak of 61,000γ on the west flank of the Dearlock Syncline, where amphibolite is extensively developed, and the continuation of the southeastward-extending anomaly southwest of and parallel to the Manomin River. It will be noted that, in general, magnetic intensity is low over the amphibolites at the eastern edge of the metavolcanic belt; pyrrhotite must be poorly represented in these rocks.

Within areas interpreted to be underlain by felsic metavolcanics, both of greenschist and amphibolite facies, magnetic intensity is as a rule low except where concentrations of magnetic minerals, often associated with ore minerals, are present (e.g. Off Lake). In this context it should be noted however that no anomaly occurs over the pyrite-chalcopyrite prospect immediately south of Off Lake. A fairly pronounced magnetic high (60,750γ maximum) occurs over the contact between felsic and mafic metavolcanics west of the Black Hawk Stock, whereas a "ridge" of anomalous magnetic values, with maxima at 60,850γ and 60,630γ, occurs over the felsic/mafic contact northwest of Burditt Lake.

North of Dearlock occurs an approximately east-west trending "ridge" of high magnetic value, with two maxima at 60,900γ and 61,500γ. The north side of the "ridge" may be related to an east-west trending fault. The maximum at 60,900γ is centred over an outcrop of porphyritic mafic metavolcanics. The maximum at 61,500γ is centred over an area with no outcrop at surface, but interpreted to be underlain by mafic metavolcanics; however, there is sufficient lack of outcrop in this vicinity to allow for considerable amounts of differing rock types.

Plutonic intrusions into the volcanic belt are each accompanied by quite different magnetic anomaly patterns. A distinct zone of anomalously high magnetic values almost encircles the Black Hawk Stock. Three pronounced maxima (60,900γ, 60,680γ and 60,680γ) occur directly over the contact of the stock with surrounding metavolcanics within the Off Lake–Burditt Lake map-area. A fourth maximum at 61,000γ occurs within, but very close to the edge of, the Black Hawk Stock just south of the map-area. No anomalies are associated with the Finland and Burditt Lake Stocks. At the north end of Beadle Lake a small, stock-like body intrudes the mafic metavolcanics. Intrusion breccias, composed of country rock fragments in a granitic matrix, are ubiquitous within this body, and it appears to be associated with a general zone of brecciation extending northward. A magnetic anomaly with a high value of 60,650γ is centred over this body. Magnetic anomalies with highs at 60,660γ and 60,680γ are almost centred over the ultramafic bodies at the north end of Burditt Lake and at South Bay of Lake Despair respectively. Ubiquitous magnetite in these two bodies accounts for the anomalies.

Most rocks of the Jackfish Lake Complex have magnetic expressions above 60,500γ, some 100γ higher than backround values elsewhere in the map-area. Where xenolithic blocks of amphibolite are abundant within the complex, particularly near to its eastern margin, anomalously high magnetic values occur, the highest maximum at 61,200γ being situated almost directly over the bismuthinite-chalcopyrite-magnetite-pyrite prospect at the northeastern end of Jackfish Lake.

The diabase dikes belonging to the northwest-trending swarm appear to exhibit no magnetic expression. However, within the area underlain by rocks of the Sabaskong Batholith, there is a weak "ridge" of anomalous values, lower than 60,500γ and not shown in Figure 8, directly over a diabase dike, to which it is possibly related.

ECONOMIC GEOLOGY

The search for economic mineral deposits in the Off Lake–Burditt Lake area was first documented in the 1930s, but probably extends back beyond that time to at least the turn of the century. Lawson (1888a, p.180), noting that at that time extremely little search had been made for mineral deposits, briefly set out guidelines for the prospector in the Rainy Lake area. Evidence of early prospecting, for which no records exist, is seen in the old pits and trenches at the north end of Off Lake.

In 1938, H. Vinall staked three claims at the northeastern end of Jackfish Lake, encompassing a gold and copper showing. Mr. Vinall continued to work on this property for many years, but no economically viable deposits have been found to date.

In the vicinity of Off Lake, the first recorded work is that of diamond drilling in 1956 by E. Corrigan and D. R. Young, and later, in 1960, by E. Corrigan. In 1967, a minor staking rush was precipitated by the discovery by A. Dunge of copper mineralization in a hole drilled for a water-well. Noranda Exploration Company Limited carried out most of the subsequent exploration and development work.

During the summer of 1971, The International Nickel Company of Canada Limited carried out ground electromagnetic surveys as a follow-up to airborne surveys, in the general region south from the present map-area to the Minnesota border. Considerable work was done by the geophysical crew in the southwestern corner of the map-area.

Following an airborne geophysical survey, Phelps Dodge Corporation of Canada, Limited, in August of 1971, staked claim groups in the vicinity of Burditt and Off Lakes, north of the Manomin River, and southwest of Lake Despair.

Description of Properties

Information on properties within the Off Lake–Burditt Lake areas was extracted from File 52 C/13 NW (Corrigan E., and D. R. Young; Noranda Exploration Company Limited) and File 52 C/13 NE (Noranda Exploration Company Limited; Vinall, H.), Resident Geologist's Files, Ministry of Natural Resources, Kenora, Ontario; and from Files 2-3-9, 2-2-10, and 2-6-11, Potts Township (Corrigan, E., and D. R. Young), and Files 10, Senn Township, and 63-2435 (Noranda Exploration Company Limited), Assessment Files Research Office, Ontario Division of Mines, Toronto. M. Hupchuk, prospector, of Fort Frances, made available results of geophysical work carried out under option by Noranda Exploration Company Limited, and presently available in File 52 C/13 NW, Kenora office.

NORANDA EXPLORATION COMPANY LIMITED [1968] (1)

In 1967, A. Dunge of Fort Frances sunk a drill hole to procure well-water on the property of F. Helseth, on the west shore of Off Lake, close to the north end. The discovery of chalcopyrite in the core led to the staking of open ground in the vicinity of Off Lake and Preachers Lake, and the resultant optioning of these claims to Noranda Exploration Company Limited by F. Helseth, A. Dunge, and M. Hupchuk.

During the period December 3 to 20, 1967, Noranda Exploration Company Limited carried out a combined magnetometer, induced polarization, and resistivity survey on a group of 50 contiguous unpatented claims (FF18306 to FF18333; FF18336 to FF18342; FF18366; FF18379 to FF18388; FF18248 to FF18251) covering an area centred over Preachers (or Spring) Lake and the northwest shore of Off Lake. The surveys were done with a McPhar Variable Frequency I.P. unit and a Sharpe MF-1 Fluxgate Magnetometer. The induced polarization survey indicated two areas of anomalous response, one between Spring Lake and Off Lake, and the other in the vicinity of A. Dunge's drill hole. The first area is close to an outcrop heavily mineralized with pyrite exposed in a road cut on the north shore of Off Lake. According to D. K. Fountain, the engineer in charge, the outcrop may have been the source of the I.P. response, but is barren of sulphides of economic potential. The magnetometer survey corroborated information presented on the published aeromagnetic map (ODM—GSC 1962a), namely, that a distinct magnetic high trends from due north to slightly west of north in the survey area. The ground magnetic survey showed the anomaly to be made up of a series of narrow, nearly parallel, magnetic highs. The area of anomalous I.P. response located close to the discovery hole of A. Dunge is associated with two adjacent magnetic highs, and a sharp, narrow, magnetic high cuts across the apparent trend of the anomalous I.P. response between Spring and Off Lakes.

Detailed geologic mapping of the area was carried out in 1968. During the month of May, 1968, two diamond drill holes were put down to test a weak I.P. conductor in the immediate vicinity of the original discovery hole, within Senn Township. A third was put down a little to the south, within Fleming Township, to test a stronger I.P. conductor associated with the strongest portion of the magnetic anomaly. The first two holes were 364 feet (113 m) and 101 feet (30.7 m) long, both dipping at about 50 degrees toward the southwest, and put down in felsic metavolcanics. According to the diamond drill records, signed by D. Cross, rhyolite, rhyolite-tuff, and rhyolite porphyry were predominant rock types encountered in the core, with minor amounts of diabase, and toward the bottom of the deeper hole andesite and quartz-feldspar porphyry. Disseminated pyrite, chalcopyrite, and pyrrhotite were found associated mostly with the felsic rocks. The highest copper assay recorded amounted to 0.36 percent over a 6-foot (2 m) length, in rhyolite.

The third hole, 302 feet (95 m) long, and dipping at 50 degrees toward the south-southwest, according to the diamond drill record signed by D. Cross, was put down in basalt, and encountered felsite porphyry, rhyolite porphyry, andesite, and diabase at depth. The basalt at the top of the hole was found to be heavily mineralized with magnetite, and to contain slight amounts of pyrite, pyrrhotite, and chalcopyrite. Slight amounts of pyrite, chalcopyrite, pyrrhotite, and magnetite were noted at various points throughout the core, and minor molybdenite at one point in rhyolite porphyry. No assays are available.

During the same period as that described above, Noranda Exploration Company Limited also did work on a number of claim groups between Highway 71 and Jackfish Lake. A combined electromagnetic and magnetometer survey was done on a group of eight unpatented claims (FF18507 to FF18514) immediately southeast of Boundary Lake using a Noranda Dual Junior Electromagnetic Unit (J.E.M.), and a Sharpe MF-1 Fluxgate Magnetometer. No electromagnetic anomalies were found, but the magnetic survey showed a general northeast trend similar to that recorded on the published aeromagnetic map (ODM–GSC 1962).

To the west of Cedar Lake, on a group of 20 unpatented claims (FF18479 to FF18497; FF18611) two diamond drill holes were put down, about a quarter mile (0.4 km) apart, during March, 1968. Both dip west at 45 degrees, are about 250 feet (75 m) long, and were drilled to test an electromagnetic conductor at depth. A magnetic anomaly coincided with the electromagnetic anomaly tested in the northern hole. According to the diamond drill records, signed by D. Cross, the more northerly hole on claim FF18484 intersected 175 feet (55 m) of banded and sheared acid tuff before passing into basalt, and the southern hole on claim FF18481 intersected alternating bands of andesite, talc schist, tuff and agglomerate, and graphitic schist. Pyrite and pyrrhotite were encountered in both holes, mostly in slight amounts. Minor graphite was also recorded in the acid tuffs of the northern hole.

In April, 1968, a 300-foot (90 m) long drill hole was put down on a group of nine contiguous unpatented claims (FF18685 to 18693) at the small lake a quarter mile (0.4 km) west of Ottertail Lake. The hole on claim FF18690 dipped west at 45 degrees, and was intended to cut an electromagnetic conductor at depth. According to the diamond drill record, signed by D. Cross, the drill intersected felsic and intermediate tuffs and minor agglomerate. Only traces of pyrite were found in the core.

Noranda Exploration Company Limited has since dropped the option on the Off Lake–Spring Lake group of claims. The claim groups at Boundary Lake, Cedar Lake, and west of Ottertail Lake have been allowed to lapse.

MRS. J. VINALL (2)

Three patented claims (FF3351, FF3352, and FF3356), still in good standing as of December 31st, 1971, located at the north end of the northeast arm of Jackfish Lake, were examined by E. O. Chisholm, then Resident Geologist, Ontario Department of Mines, Kenora, over a period of two days in May, 1948. He prepared geological sketch maps of the locality, collected grab samples, and prepared a report, (Resident Geologist's Files, Kenora) from which the following is extracted:

GEOLOGICAL CONDITIONS

No detailed geological survey has been made of the district. Reconnaissance of the water routs had indicated that the surrounding rocks are mainly granites.

A brief reconnaissance survey by the writer of the rock types occurring on the claims showed the predominant rock to be massive granodiorite containing frequent small inclusions of greenstone. The composition of the granitic rock varies between massive hornblende granite and granodiorite. Occasional small lamprophyre and pegmatite dikes intrude the granitic rocks.

Towards the north the granodiorite mass appears to [be] noticeably more basic than the south end of the claim group. The hornblende content and the number of basic inclusions increase.

A "spotted dog" type of porphyry with large phenocrysts of white feldspar about the size of a twenty five cent piece, is exposed at the top of a ridge on the west boundary of claim FF3356.

The schlieren in the granitic rock types trends in a direction North 50 degrees East.

Amphibolite, which appears to be a roof pendant fragment in the low ground between two granitic ridges, outcrops on claim FF3351 near the southeast corner. The contact with the granite mass to the west is exposed here. The amphibolite is altered and mineralized with scattered sulphides for several feet inside the contact for a distance of 150 feet [45 m]. This mineralized zone represents the main showing.

ECONOMIC GEOLOGY

The claims were staked by H. Vinall in 1938 and prospected for gold from 1938 to 1944. Only low values were obtained. A pit 8 feet [2 m] wide by 12 feet [3.5 m] long by 8 feet [2 m] deep was put down on the sulphide zone at the main showing. Grab samples of the well mineralized material taken by H. Vinall were reported to have given assays as follows. Surface sample 0.5% copper; sample at a depth of 4 feet [1.3 m], 0.96% copper; sample at a depth of 8 feet [2 m], 4.68% copper. Two grab samples of well mineralized material were taken by the writer. The blue quartz vein material assayed 0.01 oz. of gold per ton, copper 0.59%. A sample of massive sulphides containing considerable black magnetite oxidation product assayed the same in copper and gold. A trace of nickel was also obtained in the samples. The pyrite zone is approximately 8 feet [2 m] wide at the bottom of the pit. It extends for about 180 feet [55 m] along the contact of the granite and the amphibolite. It narrows down to a zone of scattered pyrite averaging about three feet [1 m] in width on surface. Towards the north end of the trenching it appears to pinch out. The south end is covered by overburden.

The pyrite mineralization occurs in a fracture zone along the contact of the amphibolite and the granite to the west. It strikes North 50 degrees East and dips to the East at 60 degrees. Blue quartz stringers several inches in width are associated with the mineralization. The sulphides appear to occupy joint planes in the amphibolite and fractures along the contact. They replace both the amphibolite and the granitic wall rock. In places scattered pyrite spreads outward into the amphibolite for a distance of 15 feet [5 m] from the contact.

The mineralization consists of pyrite mainly with minor chalcopyrite, pyrrhotite and magnetite. A narrow seam of bismuthinite was also reported in the east wall of the pit but was not observed by the writer. The gangue material is quartz and altered amphibolite.

The amphibolite has been altered to epidote and chlorite near the sulphide zone. To the east of the main pit a few feet, a flat 6-inch [15 cm] white quartz vein is exposed which contains frequent coarse crystals of pyrite and occasional inch [2.5 cm] long crystals of bismuthinite. These occur in small vugs in the quartz and are associated with a small amount of pink orthoclase.

The pyrite and bismuthinite occupy less than 10% of the volume of the vein. A small pegmatite veinlet with large quartz and orthoclase crystals occurs near the quartz vein.

A grab sample of the mineralized quartz vein taken by the writer gave an assay of 1.53% bismuth. This sample represented the best mineralized portion of the vein exposed.

The flat vein containing the bismuthinite pinches out in a few feet and appeared to emanate from the sulphide zone in the pit as a tension crack.

An assay of 0.50 oz. per ton in silver was reported from a lamprophyre dike along the west boundary of claim FF3356.

During the present survey, the author visited the pit, which is easily found by following a south-flowing creek upstream from Jackfish Lake, and was able to substantiate most of the observations of E. O. Chisholm. However, a sketch map accompanying the report shows the pit to be located over a contact zone, between amphibolite on the east and granite or granodiorite on the west. The author found only a minor amount of granitic rock in the west wall of the pit: the rest of the main showing area is underlain by amphibolite. Also, substantial amounts of amphibolite occur on the ridge to the east of the creek. These observations strongly affect the conclusions presented in the report:

CONCLUSION

The sulphide deposit appears to be a replacement type occurring at the contact of a granodiorite mass and a small roof pendant remnant of earlier volcanic rock. The possible width of the greenstone remnant would be a maximum of 400 feet [120 m] before it is cut off by the granodioritic masses on the east and west sides. This suggests that contact conditions would not extend to any great depth and limits the size of any deposit associated with the contacts. Nothing is known of the length of the favorable greenstone beyond the exposed outcrop due to the heavy overburden on the valley floor.

The values obtained in copper, nickel and gold so far are insufficient to warrant any heavy expenditure in opening up the deposit any further. The bismuthinite mineralization appears to be erratic, and confined to narrow stringers.

The greenstone remnant could be more extensive than E. O. Chisholm indicates.

The Resident Geologist's Files, Kenora contain no record of any further work done on the Vinall property, as of December 31st, 1971.

A. F. YOUNG (3)

In November and December of 1956, 2000 feet (600 m) of diamond drilling, over nine holes, was done on the property of E. Corrigan and D. R. Young, both of Emo, Ontario. Work commenced on claim FF10221 close to the number 4 post, about a quarter mile (0.4 km) southeast of the southern end of Off Lake. A total of six holes were put down, all spaced along a north-south line along a length of about 100 feet (30 m), radiating out in different directions, and all dipping at 45 degrees from the horizontal. The first five holes were of similar length, about 160 feet (55 m), and the final hole was 54 feet (16 m) long. The diamond drill records (Resident Geologist's Files, Ontario Ministry of Natural Resources, Kenora) signed by H. D. McLeod of Fort Frances, Ontario, state that the holes were put down in diorite, with lamprophyre and feldspar porphyry the other rock types encountered. These latter two rock types occurred only in short sections, and were interpreted as being dike-rocks. No mineralization was found in the lamprophyres, but both diorite and porphyry contained minor amounts of disseminated pyrite and chalcopyrite, and in one hole molybdenite was found in a porphyry dike.

Three holes were then drilled on claims FF10199 and FF10201 on the west shore of Off Lake, just north of the narrows at its southern end. All these holes dipped eastward at about 45 degrees, thus extending beneath the waters of the lake. The first hole, 297 feet (90.5 m) long, was reported in the diamond drill record (Resident Geologist's Files, Ontario Ministry of Natural Resources, Kenora) to be sunk in diabase, presumably the wide dike shown on Map 2325 (back pocket). Other rocks reported (Resident Geologist's Files, Kenora) in this hole were granite, andesite, and lamprophyre and feldspar porphyry dike rocks. Narrow seams and disseminated minor amounts of pyrite, chalcopyrite, and magnetite were reported to have been present, mostly within the andesite and porphyry. The second hole, 388.5 feet (118.5 m) long, reportedly sunk in granite, encountered similar rock types and mineralization to those found in the first hole. The third hole, 453 feet (138 m) long, again reported to have been put down in granite, again encountered similar rock types and mineralization to those found in the first hole, together with considerable amounts of chlorite schist, sheared and altered greenstones, and quartz veins.

In July of 1960, further drilling was done on claim FF10201 on the shore of Off Lake. Two holes, 115 feet (35 m) and 125 feet (38 m) long respectively, were put down a little to the north of the first three holes drilled in 1956, and close together. Both the first, dipping at 65 degrees to the east, and the second, dipping vertically, encountered similar rock types and mineralization to those in the first three holes, according to the diamond drill records signed by Elmer Corrigan of Emo, Ontario.

As of December 31st, 1971, no further work has been filed for assessment credit on these three claims, which have been brought to patent and lease hold.

Considerations for Future Exploration

In considering the geologic setting and current exploration trends, copper-zinc mineralization would seem to be the most promising prospecting target within the volcanic belt. Several samples of felsic metavolcanics taken during the present survey from outcrops where malachite staining and/or chalcopyrite was present were submitted to the Mineral Research Branch, Ontario Division of Mines for analysis. However, none of these showed more than trace to low amounts of copper, and no zinc was detected. A sample of quartz porphyry taken by the author from the pit at the north end of Off Lake, close to the drill hole in which copper mineralization was found by A. Dunge in 1967, was found by the Mineral Research Branch to contain 0.30 percent copper. A similar sample taken by the author from an outcrop, stained with malachite, at the north end of the east shore of Off Lake, close to the trench to the south of Highway 615 was found to contain

0.09 percent copper (Mineral Research Branch). A sample from the possible subvolcanic quartz-porphyry body outcropping along Highway 615, about one mile (1.6 km) south of Off Lake, was found by the Mineral Research Branch to contain only 0.01 percent copper. A trace of copper was found in a sample of malachite-stained felsic metavolcanics taken from the southeast shore of Cedar Lake. Minor malachite staining and occasional chalcopyrite grains were noted in association with pyrite mineralization at a number of localities at the southern end of Burditt Lake and in the vicinity of Off Lake.

The major centre of interest within the Off Lake–Burditt Lake area has undoubtedly been within the triangular area between Off Lake, Boundary Lake, and Cedar Lake. However, the entire area of the metavolcanic belt is potentially ore-bearing, in particular those areas where mixed felsic to intermediate and mafic sequences are present. Amphibolite-grade metamorphism has obscured the probable original volcanic or volcaniclastic origin of rocks northeast of the Manomim River, and although no anomalous magnetic features are associated with these rocks (ODM—GSC 1962a; Fig. 7) they should not be ignored in prospecting.

Copper-nickel associations in mafic bodies should not be discounted, even though no definite mafic plutonic bodies have been identified during the present survey. Within the mafic metavolcanics there is a very good chance that small mafic intrusive bodies may occur.

The association chalcopyrite-pyrite-magnetite-bismuthinite found at the Vinall showing may not be unique for the area. In the northeast of the map-area much amphibolitic rock occurs as xenoliths and remnants within the Jackfish Lake Complex. A pronounced magnetic anomaly occurs over the Vinall showing (Figure 7), and is only one of at least four peaks occurring along a northeast-trending zone of anomalies. Contrary to the report of E. O. Chisholm, there is a good possibility that the mafic, amphibolitic, body within which the Vinall showing is located is quite extensive, both on and below surface.

The occurrence of molybdenite in very minor amounts in drill holes put down in the vicinity of Off Lake indicates the possibility of more extensive deposits. In this connection, peripheral zones of felsic plutonic bodies might warrant prospecting.

No mineralization, other than magnetite, was found in association with the ultramafic bodies at the north end of Burditt Lake and at South Bay of Lake Despair. The asbestos fibre associated with the Burditt Lake occurrence is too brittle to be of commercial value.

It should be noted that lack of outcrop in the southwest, in the Dearlock Syncline, makes this area a good site for further geophysical work, to locate possible conductors at depth beneath Cenozoic overburden. A number of pronounced aeromagnetic anomalies in this area (Figure 8) could be further investigated.

Pervasive green coloration in felsic metavolcanics heavily mineralized with pyrite but devoid of sulphides of economic potential (see "Noranda Exploration Company Limited") in an outcrop on Highway 615 at the north tip of Off Lake was found on analysis by the Mineral Research Branch to be due to fuchsite, a chromium-bearing muscovite.

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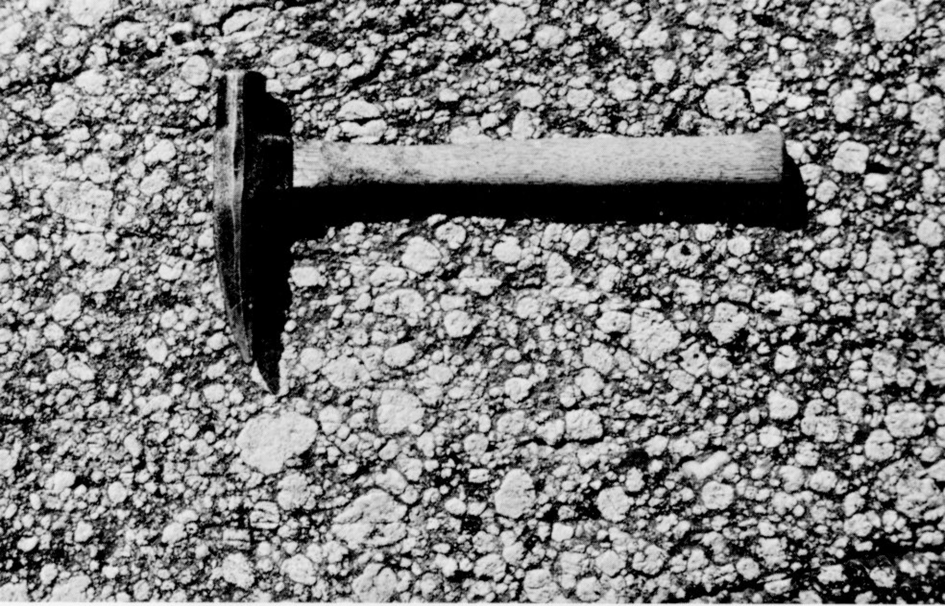

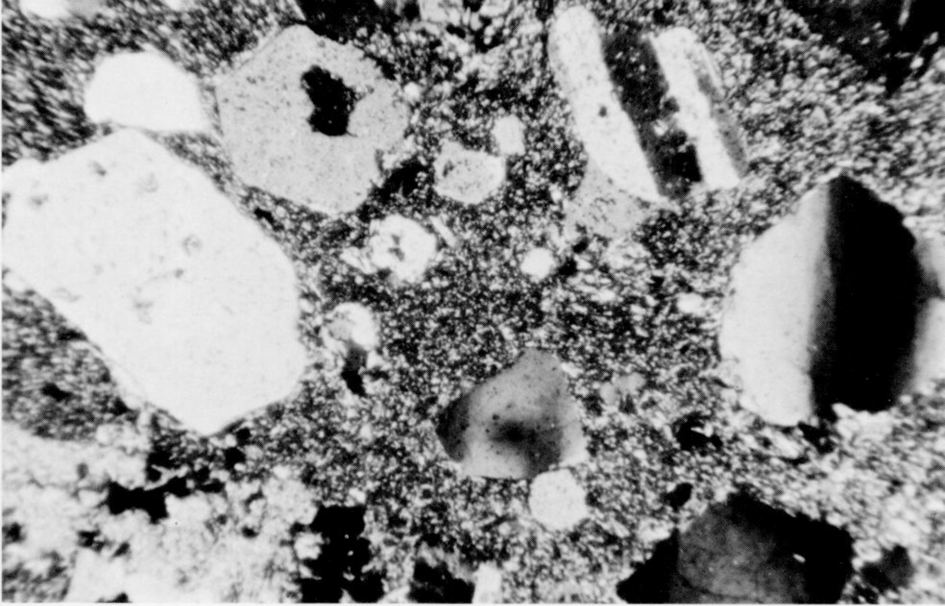

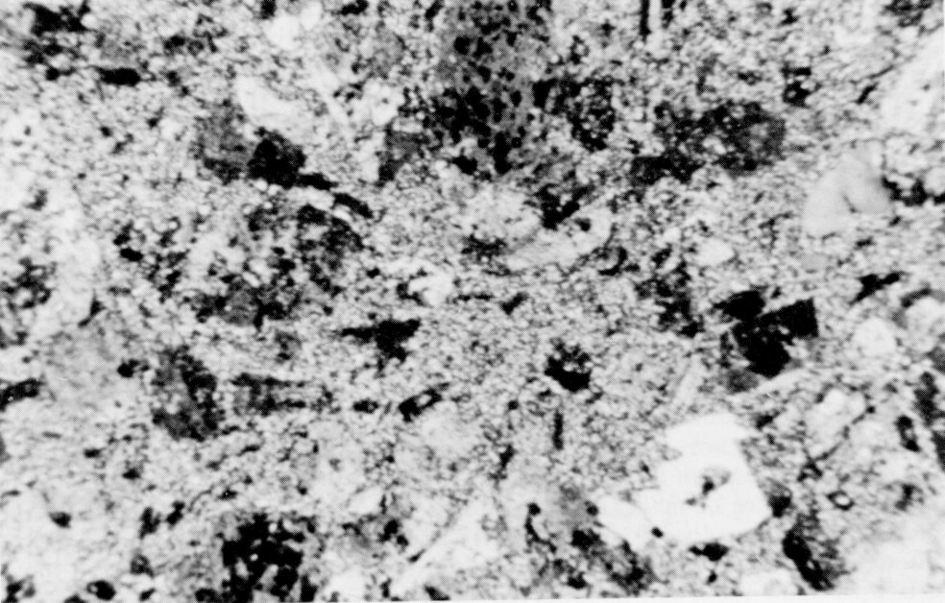

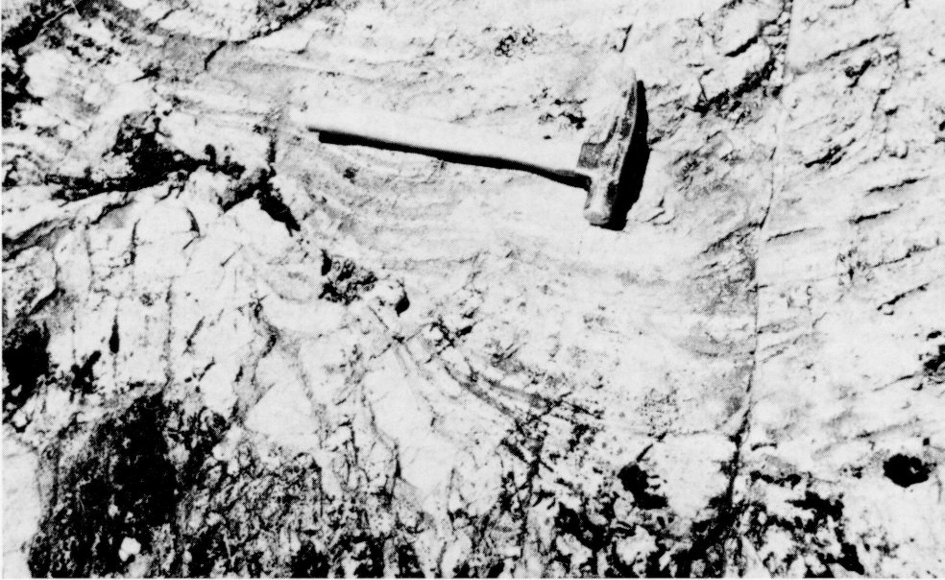

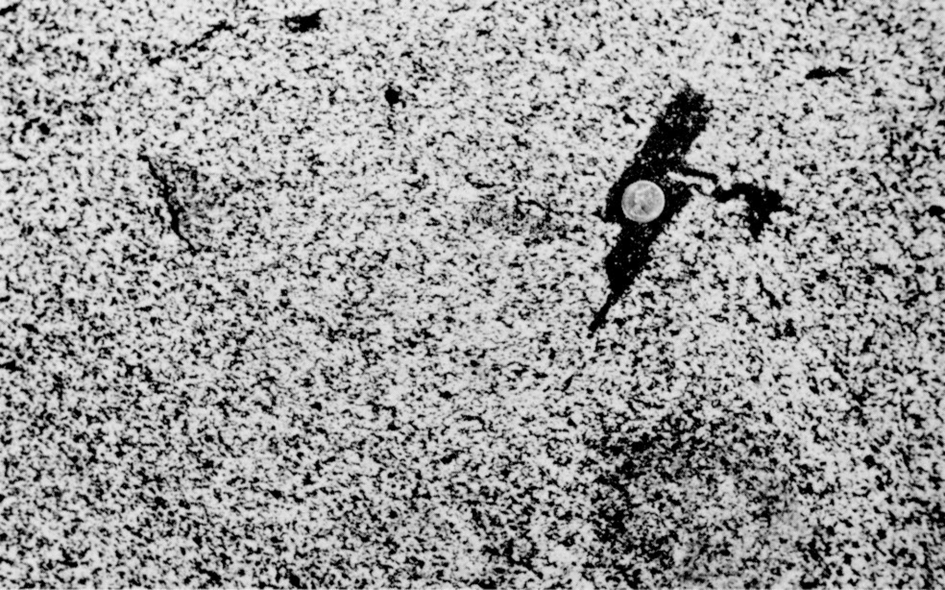

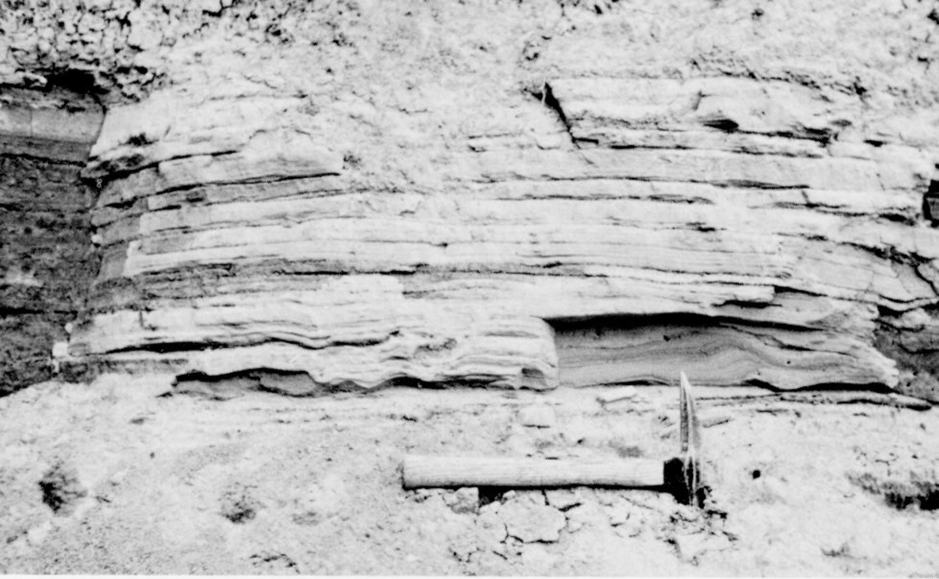

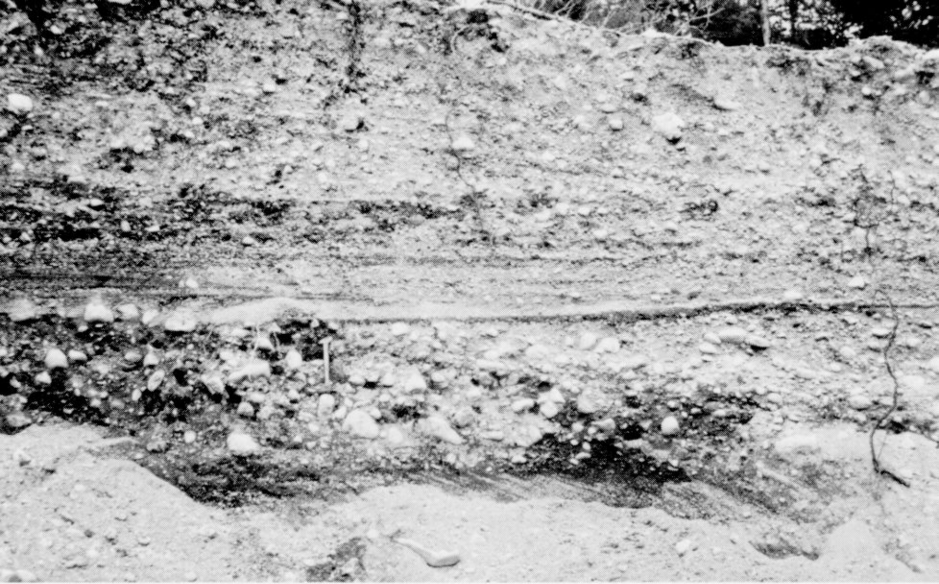

ONTARIO
DIVISION OF MINES
HONOURABLE LEO BERNIER, *Minister of Natural Resources*
DR. J. K. REYNOLDS, *Deputy Minister of Natural Resources*
G. A. Jewett, *Executive Director, Division of Mines* E. G. Pye, *Director, Geological Branch*

LEGEND

CENOZOIC[a]

QUATERNARY

PLEISTOCENE AND RECENT

Sand, gravel, boulders.

UNCONFORMITY

PRECAMBRIAN[b]

MIDDLE TO LATE PRECAMBRIAN (PROTEROZOIC)

MAFIC INTRUSIVE ROCKS

8 *Diabase dikes.*

INTRUSIVE CONTACT

EARLY PRECAMBRIAN (ARCHEAN)

MAFIC INTRUSIVE ROCKS

7 *Mafic dikes.*

INTRUSIVE CONTACT

FELSIC TO INTERMEDIATE PLUTONIC ROCKS

LATE TECTONIC INTRUSIVE ROCKS

6 *Unsubdivided.*
6a *Porphyritic quartz monzonite and granodiorite (Black Hawk and Burditt Lake stocks).*
6b *Quartz monzonite and granodiorite, equigranular (Black Hawk, Finland and Burditt Lake stocks).*
6c *Monzonite, equigranular (Black Hawk Stock).*
6d *Pegmatite and aplite.*

INTRUSIVE CONTACT

SYNTECTONIC INTRUSIVE AND METAMORPHIC ROCKS[c]

GRANITIC INTRUSIVE AND METAMORPHIC ROCKS

5 *Unsubdivided.*
5a *Trondhjemite, granodiorite, and quartz monzonite (equigranular).*
5b *Granitic gneiss and migmatite.*
5c *Porphyritic quartz monzonite.*
5d *Monzonite.*
5e *Pegmatite and aplite.*
5f *Diorite.*

INTERMEDIATE ROCKS[d]

4 *Unsubdivided.*
4a *Syenodiorite.*
4b *Diorite.*
4c *Porphyritic syenodiorite and diorite.*
4d *Biotitic syenodiorite.*

RELATIONSHIP UNCERTAIN

ULTRAMAFIC ROCKS

3a *Serpentinite.*
3b *Talc schist.*

INTRUSIVE CONTACT

METAVOLCANICS[c]

FELSIC TO INTERMEDIATE METAVOLCANICS[e]

2 *Unsubdivided.*
2a *Rhyolitic and dacitic lavas.[f]*
2b *Porphyritic, rhyolitic, and dacitic lavas (quartz-feldspar porphyry).[g]*
2c *Quartz-feldspar porphyry dike rocks.*
2d *Felsite dike rocks.[h]*
2e *Tuff, lapilli-tuff, and lapillistone.*
2f *Tuff-breccia and pyroclastic breccia.*
2g *Quartz-feldspar-biotite schist.[i]*
2h *Quartz porphyry, medium-grained matrix.[j]*

MAFIC TO INTERMEDIATE METAVOLCANICS[e]

1 *Unsubdivided.*
1a *Medium-to fine-grained basaltic and andesitic lavas.*
1b *Coarse-grained gabbroic lavas.[k]*
1c *Porphyritic mafic lavas.*
1d *Pillowed mafic lavas.*
1e *Pillowed porphyritic mafic lavas.*
1f *Tuff-breccia, lapilli-tuff, and tuff.*
1g *Amphibolite (± garnet).*
1h *Migmatitic amphibolite (± garnet).*

Breccia.

bm *Bismuthinite.*
cp *Chalcopyrite.*
mag *Magnetite.*
py *Pyrite.*

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[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 and the numerical order does not imply age relationships within groups.*

[d] *Belong predominantly to the Jackfish Lake Complex.*

[e] *Mafic to felsic metavolcanics are intercalated in part.*

[f] *Including minor andesite.*

[g] *Probably subvolcanic in part.*

[h] *Probably includes some flow rocks.*

[i] *Mostly derived from pyroclastic rocks; may include some metasediments.*

[j] *Probably subvolcanic.*

[k] *Probably in part intrusive.*

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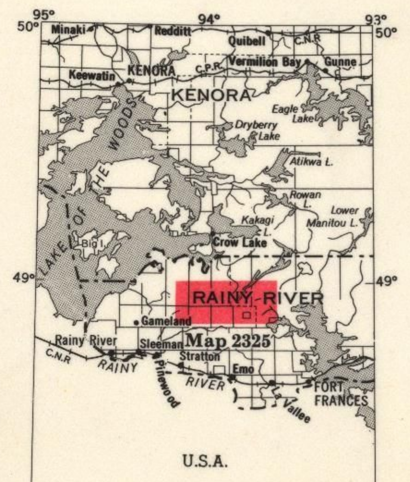

Scale, 1 Inch to 50 miles

N.T.S. Reference 52C/13, 52D/16

SYMBOLS

Glacial striae.
Small bedrock outcrop.
Area of bedrock outcrop.
Bedding, top unknown; (inclined, vertical).
Bedding, top indicated by arrow; (inclined, vertical, overturned).
Lava flow; top (arrow) from pillows shape and packing.
Lava flow; top in direction of arrow.
Gneissosity, (horizontal, inclined, vertical).
Foliation; (horizontal, inclined, vertical).
Banding; (horizontal, inclined, vertical).
Lineation with plunge.
Geological boundary, observed.
Geological boundary, position interpreted.
Geological boundary, deduced from geophysics.
Fault; (observed, assumed). Spot indicates down throw side, arrows indicate horizontal movement.
Lineament.
Minor folds with plunge.
Anticline, syncline, with plunge.
Drill hole; (vertical, inclined).
Shaft; depth in feet.
Swamp.
Motor road. Provincial highway number encircled where applicable.
Other road.
Trail, portage, winter road.
Building.
Township boundary with mileposts, approximate position only.
Township boundary, unsurveyed.
Mineral deposit; mining property.
Surveyed line, approximate position only.

MAP 2325

OFF LAKE – BURDITT LAKE

RAINY RIVER DISTRICT

Scale 1 : 63,360 or 1 Inch to 1 Mile

Chains 80 40 0 1 2 3 4 5 Miles
Feet 10,000 0 10,000 20,000 Feet
Metres 1000 0 1 2 3 4 5 6 Kilometres

SOURCES OF INFORMATION

Geology by C. E. Blackburn and assistants, Geological Branch, 1971.
Geology is not tied to surveyed lines.

Aeromagnetic maps 1167G, 1175G, ODM-GSC.

Preliminary maps;
P741, Off Lake–Burditt Lake Area, West.
P742, Off Lake–Burditt Lake Area, East.
Scale 1 inch to ½ mile, issued 1972.

Cartography by D. Laroche and assistants, Surveys and Mapping Branch, 1974.

Base map derived from maps of the Forest Resources Inventory, Surveys and Mapping Branch.

Magnetic declination in the area was approximately 6°E, 1971.

PROPERTIES, MINERAL DEPOSITS

1. *Noranda Exploration Co. Ltd. [1968].*
2. *Vinall, J. Mrs.*
3. *Young, A. F.*

Information current to 31 December 1971.
Date in square brackets indicates year of last major work.
For further information see report.