Ontario Geological Survey

Report 179

Geology of the

Crooked Pine Lake Area

District of Rainy River

By

James Pirie

1978

Ministry of Natural Resources

Hon. James A.C. Auld
Minister

Dr. J.K. Reynolds
Deputy Minister

Ontario

Printed in Canada

Publications of the Ontario Ministry of Natural Resources
and price list are obtainable through the
Map Unit, Public Service Centre, Queen's Park, Toronto
and the
Ontario Government Bookstore, 880 Bay Street, Toronto.
Orders for publications should be accompanied by cheque or money order,
payable to the *Treasurer of Ontario*

Pirie, James
1978: Geology of the Crooked Pine Lake Area, District of Rainy River; Ontario Geological Survey Report 179, 73p. Accompanied by Map 2405, scale 1:31 680 (1 inch to ½ mile).

1000-300-78-Car.

CONTENTS

TABLES

FIGURES

PHOTOGRAPHS

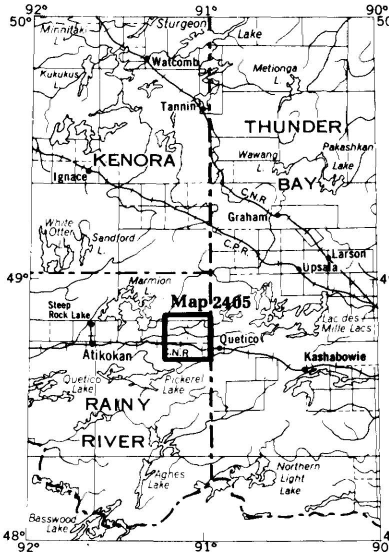
GEOLOGICAL MAP

(back pocket)

ABSTRACT

The Crooked Pine Lake area, which includes Trottier and Weaver Townships, is 140 km west-northwest of Thunder Bay, covers some 337 km², and is bounded by Latitudes 48°42′30″N to 48°52′N and Longitudes 90°57′50″W to 91°13′36″W.

The map-area is bisected by the major east-trending Quetico Fault that separates a sequence of Early Precambrian turbidite metasediments of the Quetico Subprovince to the south from Early Precambrian metavolcanic and batholithic rocks of the Wabigoon Subprovince to the north. The wacke-mudstone turbidite sequence contains primary north-facing sedimentary structures in the northern part, and has been progressively metamorphosed from lower greenschist facies assemblages in the north to upper amphibolite facies assemblages and accompanying quartz monzonite anatexite in the south. Before the metamorphic climax, a number of mafic to ultramafic hornblendic intrusions were emplaced in the sequence.



SMC 14128

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

North of the Quetico Fault, a narrow belt of metavolcanics was intruded by several mafic, intermediate, and felsic stocks and dikes before low grade metamorphism and deformation. To the north, the metavolcanics merge into the main batholith across a narrow zone that contains an increase in the amount of batholithic phases. The oldest phases in the batholith are a group of trondhjemitic and layered hornblende gneiss and amphibolite intruded by foliated quartz diorite and diorite. These oldest phases suffered later pervasive introduction of leucotrondhjemite. A number of small late trondhjemite, quartz diorite, and quartz monzonite to granodiorite stocks occur here and there in the batholith, some of which are cut by narrow diabase dikes metamorphosed under greenschist facies conditions. A few relatively fresh Middle to Late Precambrian diabase dikes cut the older rocks throughout the map-area.

Major transcurrent faulting along the Quetico, Elbow Lake, and subsidiary faults continued beyond the major deformation and metamorphism. The site of the Quetico Fault was possibly a zone of weakness from the time of volcanic activity and turbidite sedimentation.

In the metavolcanic belt, gold mineralization occurs at two locations, and, locally, minor chalcopyrite accompanies disseminated pyrite. South of Crooked Pine Lake, minor copper-nickel mineralization has been outlined within three small mafic to ultramafic bodies intruding the metasediments, and minor uranium staining has been noted within a large sheet of muscovite graphic granite pegmatite.

Geology of the Crooked Pine Lake Area

District of Rainy River

by

James Pirie[1]

INTRODUCTION

The Crooked Pine Lake map-area is located on the eastern boundary of the Rainy River District some 140 km west-northwest of Thunder Bay and 30 km east of Atikokan. It covers about 337 km^2 and is bounded by Latitudes 48°42′30″N to 48°52′N and Longitudes 90°57′50″W to 91°13′36″W.

The map-area straddles a narrow belt of Early Precambrian (Archean) metavolcanics bounded to the north by a trondhjemitic batholithic complex, and to the south by a sequence of progressively metamorphosed and migmatized turbidite-type sedimentary rocks. In the early days of the twentieth century, the metavolcanic and batholithic rocks were prospected for gold with little success. More recently, exploration work has centred on copper-nickel mineralization associated with mafic to ultramafic intrusions in the metasediments.

Aerial photographs at a scale of 1:15 840 were used in the field for control of the geological mapping and the data were transferred to base-maps of a similar scale published by the Forest Resources Inventory series, Division of Lands, Ontario Ministry of Natural Resources.

Topographically, the map-area comprises a series of low rolling hills and ridges generally trending eastwards that are separated by large lakes and streams of the Atikokan, Mercutio, Seine, and Pickerel River Systems. Elevations throughout the area vary from about 430 m to a little over 533 m above sea level.

A veneer of glacial drift covers much of the map-area, and bedrock exposure is not plentiful, especially north of Crooked Pine Lake.

Pace and compass traversing was carried out systematically at 0.4 km intervals across the metavolcanics and at approximately a 0.8 km spacing over the batholithic rocks. In the southern part of the area, outcrop has been augmented

---

[1]Geologist, Ontario Geological Survey. Manuscript approved for publication by the Chief Geologist, Precambrian Geology Section, 25 February, 1977.
This report is published with the permission of E.G. Pye, Director, Ontario Geological Survey.

by numerous exposures created during road building for recent logging operations.

Access

The Canadian National Railway crosses the southern part of the area, and Highway 11 crosses the extreme southwest corner of the map-area. A network of lumber roads which connects to Highway 633 at Kawene affords excellent access to Crooked Pine Lake and the ground to the south. Not far west of the map-area in Hutchinson Township, the Spoon Lake gravel road extends north from Highway 623 at Sapawe, and permits access to Melema, Matson, and Magnetic Lakes, and Mercutio River, as well as the Seine River in the northwestern corner of the area. From the northwestern corner of the map-area, an old lumber road, which is in a state of poor repair, passes around the northern map-area boundary to the north end of Mercutio Lake, and goes east and south past Lodge Lake as far as the unnamed lake about 1.5 km to the southwest. Several tourist camp operators maintain boats on Mercutio, Crooked Pine, and Elbow Lakes; portages between all the larger lakes are in good repair.

History of Previous Work

The first systematic geological mapping in the area was conducted by McInnes (1899) for the Geological Survey of Canada. A more detailed survey was carried out by Hawley (1929) who produced a geological map of the Sapawe Lake Area at a scale of 1:47 520 for the Ontario Department of Mines, which included the area of Trottier and Weaver Townships. Hawley (1929) summarized and provided references to the earlier prospecting and mining activities in the area.

Tanton (1940) included the present map-area in his 1:253 440 reconnaissance mapping of the Quetico Sheet for the Geological Survey of Canada, but added little to the work done by Hawley (1929) in the Sapawe Lake area.

The western Lac des Milles Lacs area, adjacent to the present map-area on the east, was mapped by Irvine (1963) at a scale similar to that of the present survey. More recently, the area immediately to the west was similarly investigated by McIlwaine and Hillary (1974). Preliminary geological maps of Crooked Pine Lake area at a scale of 1:15 840 were issued by the Division of Mines (Pirie 1976a and b).

Acknowledgments

The author was ably assisted in the field during the 1975 season by E. Hillary, M. Legault, D. Garson, and M. Wittrup. Hillary was responsible for approximately half of the mapping done, and Legault mapped the northern part of the Elbow Lake mafic to ultramafic complex in detail.

GENERAL GEOLOGY

The Crooked Pine Lake area straddles parts of the Wabigoon and Quetico Subprovinces which in this region are separated by the Quetico Fault. North of this fault, Early Precambrian rocks of the Wabigoon Subprovince include a narrow east-trending belt of interdigitated mafic to intermediate and intermediate to felsic metavolcanics intruded by several melanogabbro, quartz diorite, trondhjemite, and quartz monzonite sheets and small stocks (Table 1). All of these rocks have been deformed, folded, and largely recrystallized to low greenschist mineral assemblages, except near the northern contact zone with the batholithic rocks, where the metamorphic grade increases to the amphibolite facies.

The batholithic area to the north comprises a number of older layered trondhjemite and hornblende gneiss and amphibolite bodies intruded by younger phases of quartz diorite and diorite. These rocks were deformed and metamorphosed before, and during the intrusion of large quantities of coarse-grained leucotrondhjemite sheets, dikes, and stringers with associated pegmatites. On an outcrop scale several of the rock types occur typically together, and it is hard to outline large areas of discrete intrusive phases. A few late undeformed stocks cross-cut the main batholithic sequence, and include biotite-hornblende trondhjemite, porphyritic hornblende quartz diorite, and leucocratic granodiorite to quartz monzonite, and associated minor pegmatites. A number of narrow diabase dikes which have undergone retrograde metamorphism cross-cut all the batholithic rocks. The contact between the batholithic rocks and the metavolcanics is marked by a zone of cataclastic deformation, mylonitization, and an increase in metamorphic grade. These features make the original nature of the contact difficult to determine, although apparently the main batholithic phases such as leucotrondhjemite intrude the metavolcanics in narrow sheets and dikes that diminish in number rapidly southwards into the metavolcanic-metasedimentary belt.

The Quetico Fault forms a narrow, highly deformed, and mylonitized zone along the northern shore of Crooked Pine Lake. South of this fault a thick sequence of Early Precambrian turbidites has been progressively metamorphosed from a typical wacke and mudstone sequence to the following: biotite phyllite and schist with minor pelitic parts containing garnet, staurolite, and andalusite; and to biotite gneiss and gneiss-migmatite containing garnet, cordierite, sillimanite, and muscovite. The higher grade part of the sequence contains abundant quartz monzonite mobilizate material that increases in volume to form inhomogeneous diatexite and homogeneous diatexite units (Mehnert 1968) in the most highly mobilized zones towards the southern part of the map-area. Very coarse grained muscovite graphic granite pegmatite and associated quartz monzonite form one large sheet near Kawene and Heward Lakes and a great many other small bodies through the southern part of the area, and are closely related to anatexis and formation of migmatite.

Several mafic to ultramafic intrusive complexes cut the metasediments in an east-trending zone from Kawene to Elbow Lakes, and many small sheets and dikes of similar material occur throughout this area. The Elbow Lake Mafic Complex is the largest body of this type, and occurs in two parts separated by a strip of metasediments along the northeast arm of Elbow Lake. The complex

TABLE 1 | TABLE OF LITHOLOGIC UNITS FOR THE CROOKED PINE LAKE AREA.

PHANEROZOIC

CENOZOIC

QUATERNARY

PLEISTOCENE AND RECENT

Glacial till, sand, gravel, loess, clay, silt, and organic mud.

Unconformity

PRECAMBRIAN

MIDDLE TO LATE PRECAMBRIAN

MAFIC INTRUSIVE ROCKS

Diabase

Intrusive Contact

EARLY PRECAMBRIAN

MAFIC INTRUSIVE ROCKS

Diabase

Intrusive Contact

INTERMEDIATE TO FELSIC PLUTONIC ROCKS

MASSIVE GRANITIC ROCKS

Biotite-hornblende trondhjemite, hornblende quartz diorite, granodiorite, quartz monzonite, pegmatite

Intrusive Contact

FOLIATED AND GNEISSIC BATHOLITHIC ROCKS

Leucotrondhjemite, pegmatite, aplite, hornblende diorite, quartz diorite, amphibolite, trondhjemite gneiss, biotite trondhjemite gneiss, hornblende gneiss, biotite chlorite schist

METAMORPHOSED FELSIC INTRUSIVE ROCKS

Quartz monzonite, muscovite quartz monzonite pegmatite

METASEDIMENTARY MIGMATITE

Quartz monzonite, granodiorite, muscovite graphic granite pegmatite, biotite gneiss-migmatite, aplite

METAMORPHOSED ULTRAMAFIC TO INTERMEDIATE ITRUSIVE ROCKS

MAFIC TO ULTRAMAFIC INTRUSIVE ROCKS

Hornblende gabbro, hornblende diorite and related hybrid rocks, porphyritic quartz-diorite, hornblendite, feldspathic hornblendite, pyroxene hornblendite, pyroxenite

INTERMEDIATE AND ULTRAMAFIC INTRUSIVE ROCKS

Melanogabbro, peridotite, amphibole quartz diorite, trondhjemite

METASEDIMENTS

Wacke-mudstone, conglomerate, biotite phyllite, biotite schist, biotite gneiss, marble, clac-silicate gneiss, garnet-, andalusite-, staurolite-, cordierite-, sillimanite-, and cummingtonite-bearing rocks

METAVOLCANICS

INTERMEDIATE TO FELSIC METAVOLCANICS

Lapillistone, lapilli-tuff, tuff, flow, sericite phyllite, schist

MAFIC TO INTERMEDIATE METAVOLCANICS

Flow, tuff, lapilli-tuff, chlorite phyllite, schist, biotite-chlorite schist consists of some ultramafic phases that include coarse-grained hornblendite, porphyritic feldspathic hornblendite, and minor pyroxenite and occur as large blocks and xenoliths in hornblende gabbro, diorite, and associated hybrid rocks. Most of the other similar bodies contain the same phases in different proportions, and three of them have minor associated copper-nickel mineralization.

On the southern shore of Crooked Pine Lake in Trottier Township, a small stock of porphyritic biotite granodiorite having large grains of delicately zoned plagioclase intrudes the wacke-mudstone sequence. Otherwise, little evidence of the relative age of the stock exists.

Fairly thick, medium-grained, fresh, brown weathering quartz diabase dikes, considered to be Middle to Late Precambrian in age, occur throughout the metavolcanics and batholithic rocks. A few, narrow, fine-grained, younger diabase dikes occur sporadically in the southern metasediments, and may be of similar age.

Precambrian

EARLY PRECAMBRIAN (ARCHEAN)

Metavolcanics

Mafic, intermediate, and subsidiary felsic extrusive rocks, commonly intermixed on an outcrop scale, occupy most of the metavolcanic belt. The stratigraphic relationships within the volcanic belt were not outlined because of poor exposure, strongly developed foliation, low grade metamorphism, and the intimate mixture of rock types.

In the few places where contacts between narrow mafic flows and intermediate pyroclastic units were observed, they generally trend eastwards. This trend was used as a basis for interpreting an easterly trend to wider units of mainly mafic to intermediate or intermediate to felsic metavolcanics. A further complication in interpreting the geology of the belt is that medium- and coarse-grained mafic flows, which are common throughout the area, rarely show contact relationships with adjacent rocks. Therefore some of this material may be intrusive in origin. The distribution of metavolcanic types varies along the length of the belt: the western section comprises approximately 20 percent intermediate to felsic metavolcanics, increasing in amount eastwards to about 70 percent along the eastern boundary of the map-area.

Colour index was used to separate mafic metavolcanics ($>$35) from felsic metavolcanics ($<$15). Intermediate metavolcanics were included with either felsic or mafic metavolcanics because there appears to be a gradation of associated rock types from the mafic and felsic end members into the intermediate range. Most of the mafic to intermediate rocks are flows, and the intermediate to felsic rocks are pyroclastic.

MAFIC TO INTERMEDIATE METAVOLCANICS

The mafic to intermediate metavolcanics are generally fine-grained, homogeneous, foliated flows varying on a fresh surface from light medium green to dark green, depending on the state of alteration and mineralogy. The lighter green colour can be caused by the presence of actinolitic amphibole or by large amounts of carbonate alteration that occurs in places. The dark green colour is usually caused by chlorite being the major mafic phase. Less than one percent disseminated pyrite is commonly present throughout the mafic flow rocks.

Thin section examination reveals that the typical mafic metavolcanic rock is fine grained, and foliated. The rock consists of approximately 55 percent relict plagioclase, the lath-like outlines of which are almost opaque owing to very fine grained alteration products, such as epidote and possibly clay minerals. Pale green actinolite in fine- to medium-grained aggregates, forms 35 percent of the rock, and is vaguely aligned parallel to the foliation. Colourless chlorite composes about 10 percent of the rock, and forms thin wisps and clots in and around actinolite. A few small quartz grains, accessory irregular iron oxide, and pyrite grains are scattered throughout the rock. Some finer grained porphyritic varieties are recrystallized to a groundmass of chlorite, epidote, albite, actinolite, carbonate, and quartz; phenocrysts are completely altered to clots of coarser, decussate, pale green actinolite blades. Small knots of tiny iron-titanium oxide grains with minor sphene are scattered throughout.

Some of the less mafic metavolcanics are fine grained, foliated, and dark green. Small plagioclase laths are partly altered to epidote or are completely replaced by carbonate, and occur in a matrix of very pale green chlorite which forms irregular flaky masses in association with very fine grained plagioclase, epidote, and quartz. Quartz, present up to 10 percent volume of the rock, forms pockets of interstitial matrix.

Near the eastern boundary of the map-area, thin beds of tuff and lapilli-tuff occur within the predominantly felsic pyroclastic units. Tuff is medium to dark green and has very thin alternating chlorite-rich and felsic layers. Lapilli-tuff is similar in colour to tuff, and has fine grained, rounded, lithic fragments of intermediate composition set in the more mafic chlorite-rich matrix.

On the shores of the small bays on Crooked Pine Lake, near Upham Lake, a well-foliated, glomeroporphyritic mafic flow interdigitates with fine-grained, equigranular dark green mafic flows. Creamy white euhedral phenocrysts of plagioclase up to 3 cm across are thoroughly altered to epidote, albite, carbonate, and sericite, and are sporadically distributed throughout a medium green, fine-grained matrix of altered plagioclase, quartz, chlorite, epidote, and carbonate.

Extreme shearing and deformation along the Quetico Fault on the northern shore of Crooked Pine Lake has converted these mafic to intermediate metavolcanics, to fine-grained, chlorite phyllite or chlorite schist; no primary features remain to definitely classify the rocks as extrusive or intrusive. These rocks were mapped as Unit 1d, (Map 2405, back pocket), and consist of chlorite, carbonate, quartz, plagioclase, iron oxide and pyrite, and have a cataclastic texture. The crenulation cleavage in these rocks is at an angle of some 20° to the main foliation.

Fine- to medium-grained, dark green, well-foliated biotite-chlorite schist

(Unit 1e, Map 2405, back pocket) occurs along the irregular contact between the metavolcanic belt and the trondhjemitic batholithic rocks. The schist lacks primary igneous features, but is probably a recrystallized equivalent of the mafic to intermediate metavolcanics affected by the intrusion and deformation of the batholithic rocks.

Large areas of medium- to coarse-grained, vaguely foliated mafic rocks, probably extrusive in character, and generally lacking exposed contacts with adjacent rocks occur throughout the metavolcanic belt. These rocks are generally dark green and have a colour index between 40 and 55 (Figure 2). The texture is subophitic, and occasionally contains subhedral altered plagioclase phenocrysts up to 1 cm. The rocks have undergone low grade metamorphism and consist of highly saussuritized plagioclase, actinolitic amphibole, colourless chlorite, and minor quartz. The original igneous texture was not completely obliterated except near the batholithic contact to the north, and, with the increase in metamorphic grade, these medium- to coarse-grained mafic metavolcanics become darker in colour and more lineated. Hornblende forms aligned to decussate knots, and plagioclase generally is altered to fine-grained epidote. Minor amounts of quartz and iron-titanium oxide grains are present throughout. These hornblende-bearing rocks are more accurately termed amphibolite and bear a strong resemblance to amphibolite enclosed in the batholithic rocks to the north.

Chemical analyses of a few samples of fine-grained metavolcanic flows (Table 2) indicate that they are subalkaline basalts if plotted in the alkali versus silica and normative colour index versus normative plagioclase diagrams of Irvine and Baragar (1971). These rocks show a high-iron tholeiitic affinity in the AFM diagram and in the cation plot of Jensen (1976).

The medium-grained diabasic flows are similar in composition and affinity, but show a slight displacement towards the calc-alkaline field compared with the fine-grained flows. The low number of analyses means that this difference may not be statistically valid.

INTERMEDIATE TO FELSIC METAVOLCANICS

The intermediate to felsic metavolcanics are almost entirely pyroclastic in origin and weather to very pale greenish grey or a pale creamy buff colour. Their pyroclastic nature is obvious in outcrop, whereas the fresh rocks are darker in colour, and their fragmental nature is less apparent. These pyroclastic rocks, using the classification of Fisher (1966), are a mixture of lapillistone, lapilli-tuff, and tuff. All three rock types occur in some outcrops, with the first two the most prevalent.

The interdigitating of mafic volcanic flows up to 18 m thick with pyroclastic rocks is well exposed on the northern shore of Magnetic Lake and the small bay to the east leading to Upham Lake. Lapillistone has light coloured, thin, very fine grained, subangular, lens-shaped, lithic, felsic fragments as much as 2 cm long and minor rounded quartz phenocrysts set in a darker coloured fine-grained, more chloritic matrix, and is the most common rock-type. Microscopically, the lapilli comprise a granular aggregate of fine-grained quartz and albite

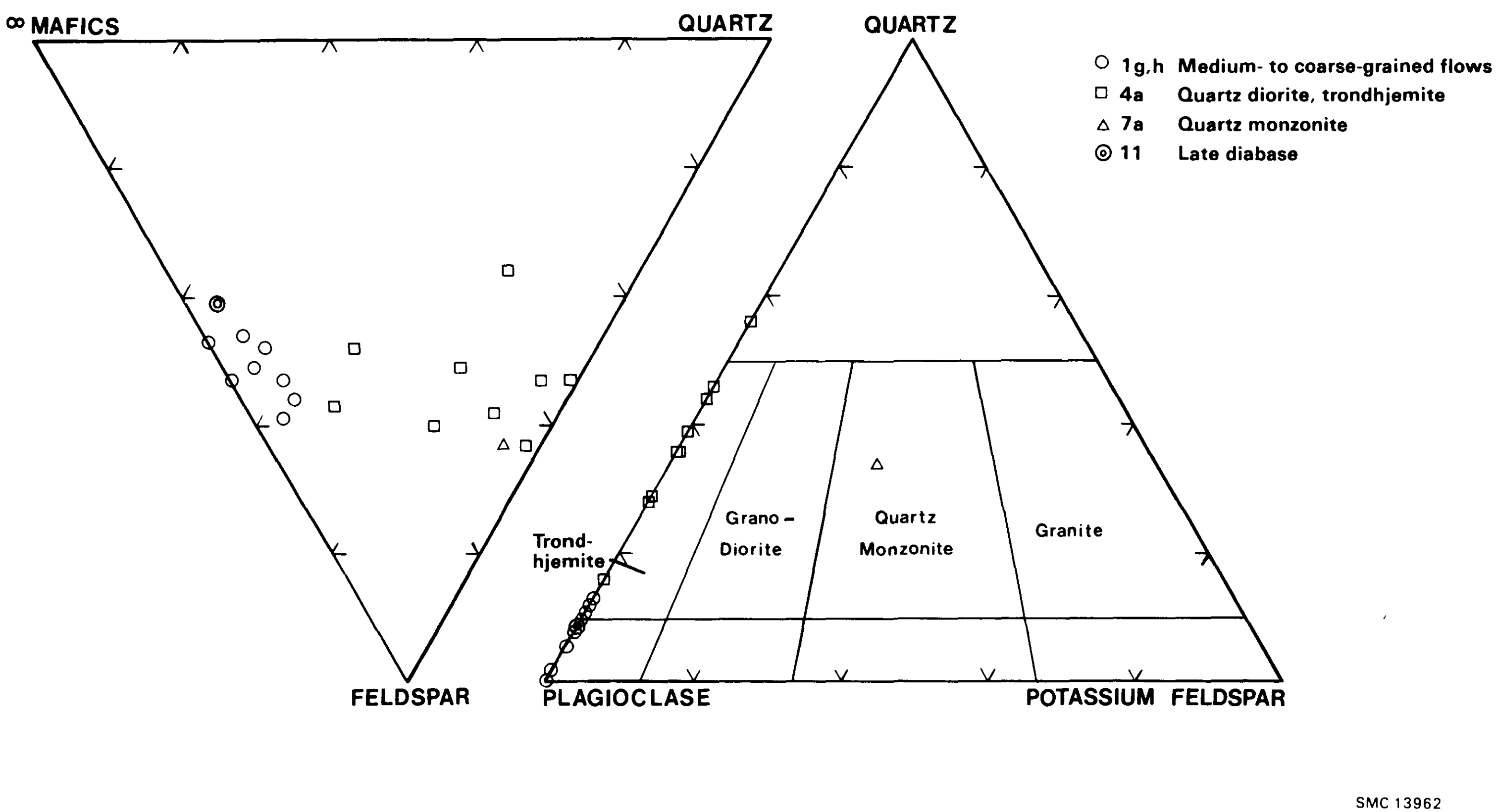


Figure 2–Triangular plot of modal mineral compositions of medium- to coarse-grained mafic flows; intermediate and felsic intrusive rocks in the metavolcanic belt of the Crooked Pine Lake Area. Modal counts were done on stained slabs using a transparent grid of 10 lines to 2.5 cm (1 inch) and a count of 500 points. Map legend code is given with rock name (see Map 2405).

TABLE 2 WEIGHT PERCENT CHEMICAL ANALYSES OF SOME METAVOLCANICS FROM THE CROOKED PINE LAKE AREA.*

Sample Number	14-4	14-5B	17-5B	28-9B	20-5	27-11	28-2	14-5A	17-3B	17-3D	17-5A	27-4	46-11A
SiO_2	46.00	47.20	45.70	46.70	50.00	49.30	50.20	69.20	55.90	64.90	56.40	73.00	67.10
Al_2O_3	15.50	16.00	15.20	13.80	17.20	14.50	15.50	12.10	17.50	14.70	16.30	14.90	15.20
Fe_2O_3	14.20	15.80	4.63	16.50	12.40	14.30	12.70	5.92	12.20	9.64	2.50	1.57	5.70
FeO	—	—	8.44	—	—	—	—	—	—	—	4.88	—	—
MgO	8.15	7.06	8.11	6.51	5.66	6.80	6.90	4.60	4.69	2.43	5.18	0.64	1.62
CaO	10.10	9.42	11.40	10.40	10.50	9.75	10.10	0.35	1.09	0.74	4.66	1.43	2.58
Na_2O	1.26	1.86	1.38	1.31	2.21	2.18	2.13	3.64	4.70	4.68	4.02	1.86	4.05
K_2O	0.02	<0.05	0.01	0.23	0.17	0.52	0.41	<0.05	0.01	0.06	0.01	3.36	0.78
TiO_2	0.98	1.04	1.02	1.60	0.82	1.10	1.01	0.71	0.75	0.57	0.66	0.15	0.77
P_2O_5	0.06	0.06	0.03	0.11	0.02	0.07	0.07	0.16	0.14	0.11	0.10	0.02	0.16
S	—	—	0.02	—	—	—	—	—	—	—	0.01	—	—
MnO	0.19	0.23	0.22	0.24	0.19	0.23	0.21	0.06	0.13	0.07	0.19	0.02	0.07
CO_2	—	—	0.16	—	—	—	—	—	—	—	1.67	—	—
H_2O^+	—	—	2.68	—	—	—	—	—	—	—	3.02	—	—
H_2O^-	—	—	0.31	—	—	—	—	—	—	—	0.28	—	—
L.O.I.	3.19	2.75	—	2.71	1.40	1.99	1.25	2.35	3.11	2.03	—	2.67	1.55
TOTAL	99.60	101.40	99.30	100.10	100.60	100.70	100.50	99.10	100.20	99.90	99.90	99.70	99.60

Notes:

14-4 Mafic flow, fine-grained
14-5B Mafic flow, fine-grained
17-5B Mafic flow, fine-grained
28-9B Mafic flow, fine-grained
20-5 Mafic flow, medium-grained
27-11 Mafic flow, medium-grained
28-2 Mafic flow, medium-grained

14-5A Intermediate lapilli-tuff
17-3B Intermediate tuff
17-3D Intermediate lapillistone
17-5A Intermediate lapilli-tuff
27-4 Felsic crystal tuff
46-11A Intermediate tuff

$<$ Less than
*Analyses by Mineral Research Branch, Division of Mines, Toronto.
The locations of the above samples are indicated on Map 2405, back pocket.

Photo 1–Bomb-size fragments in well foliated, intermediate lapilli-tuff near Quetico Fault on Crooked Pine Lake.

with sparse, pale green, chlorite knots, and a few albitic plagioclase phenocrysts which are dusted with fine-grained epidote and chlorite. In one locality, small rounded fragments of medium-grained quartz porphyry are the main lapilli type. The matrix consists of similar, though less homogeneous, material with more chlorite and iron-oxide. In places, coarse-grained rounded quartz, clouded twinned plagioclase, and accessory prismatic zircon stand out in the matrix. Similar rocks are exposed on the northern shore of Upham Lake and in places along the northern shoreline of Crooked Pine Lake in Trottier Township where the rocks have not been severely deformed by the Quetico Fault. Farther east on this zone, just northeast of the narrows on Crooked Pine Lake, some good examples of bomb-size fragments of fine-grained intermediate metavolcanic material set in a fine-grained sheared tuff matrix have survived the deformation (Photo 1).

Field evidence indicates that some sections of the metavolcanic belt in Weaver Township contain a large amount of intermediate to felsic pyroclastic rocks along with thin interdigitating mafic flows. Foliated lapillistone and lapilli-tuff are the major rock types present, but bomb-size fragments and fine-grained, creamy, felsic tuff occur more frequently than in Trottier Township. Rapid alternation from coarse-grained lapilli-tuff beds into very fine grained tuff followed by coarse-grained crystal and lithic tuff beds within one outcrop is not uncommon. Typical tuff horizons tend to be less than 1 metre across, and may be vaguely bedded as well as foliated, but no graded beds were observed.

Lapilli fragments are composed of fine-grained quartz, altered plagioclase, biotite, chlorite, epidote, and iron-oxide set in a matrix of similar mineralogy, but typically layered owing to variation in mafic mineral content. One sample contains minor poikiloblastic garnet in some matrix layers. Tuff commonly contains rounded bipyramidal quartz and subhedral albitic plagioclase with or without minor, irregularly shaped fragments in a matrix of sericite, quartz, plagioclase, carbonate, and chlorite.

Minor accessory pyrite is present in small knots and disseminations in the intermediate to felsic metavolcanics. In a few restricted localities, minor specks or knots of chalcopyrite, with accompanying malachite stains, were observed as disseminations within the pyroclastic rocks, especially near the eastern boundary of the map-area.

Massive, grey, very fine grained, siliceous intermediate to felsic material which does not display any bedding structures or lapilli fragments, was mapped as intermediate to felsic flows, although the material could possibly be pyroclastic in origin.

As with the mafic metavolcanics, the intermediate to felsic pyroclastic rocks are strongly foliated, deformed, and mylonitized close to, and within the Quetico Fault, producing a very fine grained, white to pale greenish grey, sericite phyllite and schist with a greasy lustre.

Chemical analyses of the intermediate to felsic pyroclastic rocks (Table 2) show that the pyroclastic units interbedded with tholeiitic basalt flows in the western part of the area such as on Magnetic and Upham Lakes, are subalkalic andesites, and dacite. These determinations were made using the normative colour index versus normative plagioclase plot of Irvine and Baragar (1971). These analyses plot within the more basic part of the calc-alkalic fields of the AFM diagram and the cation plot of Jensen (1976).

Eastwards, throughout the rest of the metavolcanic belt, similar pyroclastic rocks are interbedded with more mafic (basaltic) flows. In a few places, near the eastern boundary of the map-area, some of the thicker pyroclastic units contain more felsic-looking tuffs which are more properly dacitic (Sample Number 46-11A, Table 2) and rhyolitic (Sample Number, 27-4, Table 2) in composition. The intimate interlayering of volcanic rocks of tholeiitic and calc-alkalic affinities seems to the author to be incongruous, but the low number of available analyses and poor understanding of the volcanic stratigraphy mitigates against further interpretation of this observation at present.

Metasediments

The metasediments in the map-area occur south of the Quetico Fault and are part of an elongate belt of similar rocks that as well as the associated migmatites and granitoid rocks form the major Quetico Metasedimentary Belt or Subprovince of the Superior Province. In the map-area, these rocks comprise a sequence of rather monotonous thin- to thick-bedded turbidites that have been deformed, progressively metamorphosed, and migmatized from north to south; the original textures and structures of the turbidites have been erased except in a zone about 2.5 km wide south of the Quetico Fault.

The metasediments were subdivided according to the amount of recrystallization, metamorphism, and granitoid mobilizate present within them. The boundaries of these lithologic units are arbitrarily located, and intended only as a broad guide to the degree of metamorphism. Lithologic units of the metasedimentary migmatite are an integral part of the higher grade equivalents of the metasediments. Although these rocks are grouped as a separate formation on the map (Map 2405, back pocket) and described later in the text, some mention of them is necessary in this section for the sake of completeness.

Wacke-Mudstone and Related Rocks

The rather monotonous sequence of turbidites throughout the area south of the Quetico Fault has a steep to vertical dip, and, where primary sedimentary structures are preserved, stratigraphic tops consistently face north so that the youngest part of the sequence is adjacent to the Quetico Fault. This map-unit is approximately 1.5 km wide, the southern limit was taken to be where original clastic features and sedimentary structures disappear because of recrystallization and deformation, which as intimated above, is a gradual process depending on the texture and composition of the original rocks.

The turbidite beds have sharp well-marked bases and generally are between 5 and 40 cm thick, the lower part of the bed consists of light to dark grey, graded or massive, weakly foliated wacke material merging into darker, fissile siltstone or shale tops (Photos 2 and 3). Generally, the bed thickness is regular over the scale of a large outcrop (Photo 2), but in places, the thickness and character of individual adjacent beds show substantial variation (Photo 3). In many places original sedimentary laminations are hard to distinguish from foliation planes related to later deformation. Locally, the later foliation can be observed at an oblique angle to the lamination and bedding. In some localities, beds contain little or no mudstone component, whereas in others, thinly laminated units of siltstone grading into shale predominate. Minor, thin arkosic layers occur sporadically throughout the sequence. In a few places at the western end of Crooked Pine Lake, pebble to granule conglomerate beds up to 30 cm thick contain mainly elongate, flat clasts, up to 4 cm long set in a wacke matrix. The clasts are mainly very fine grained, cream to grey, and appear to be derived from felsic to intermediate volcanic rocks.

The beds with lower massive or graded wacke and upper laminated mudstone are typical of turbidites and form the A, B, and D parts of the Bouma Sequence (Bouma 1962). Current-bedding structures are rarely present, and in one locality are associated with what appear to be dewatering structures and ripple-marks at the top of the bed (Photo 4). Not far northeast of Kawene Lake, where the turbidite layers are less than 10 cm thick, stratiform zones of intraformational breccia occur in which fragments of narrow, more competent wacke layers have been ripped up and mixed with finer grained silty material before deposition of the overlying bed (Photo 5).

In the same sequence of beds, slump structures, which include minor open soft sediment folds (Photo 6) and miniature thrust faults (Photo 7), are closely related to the intraformational breccia.

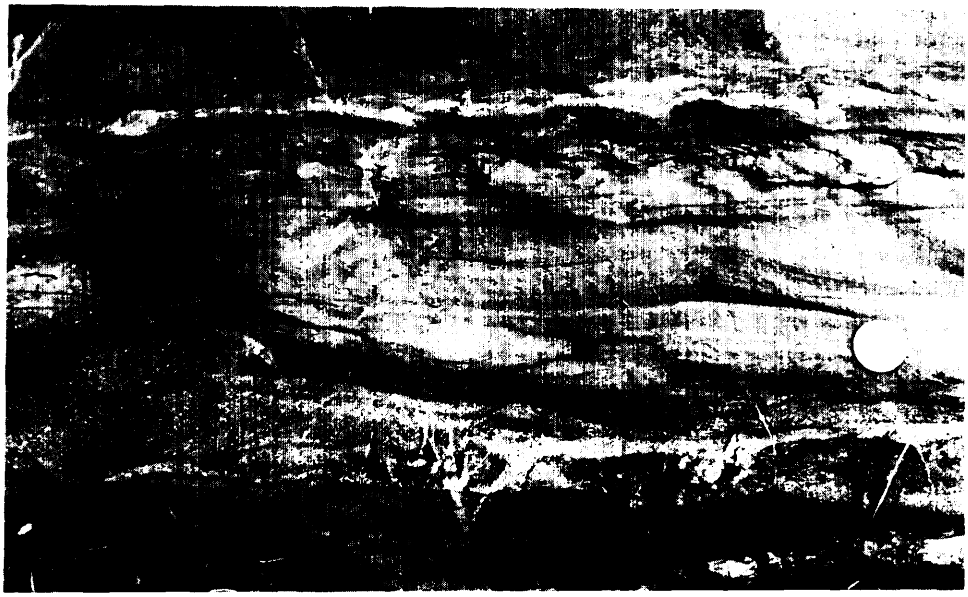
The wacke component of the turbidites contains variable proportions of quartz, plagioclase, and lithic clasts, between 0.5 and 1.5 mm in size, set in 30 to

OGS9813

Photo 2–Medium-bedded wacke layers with thin laminated mudstone tops to the right on south shore, Crooked Pine Lake.

OGS9814

Photo 3–Contrasting bed thickness in wacke-mudstone units. Pelitic layers nearby contain staurolite and garnet.

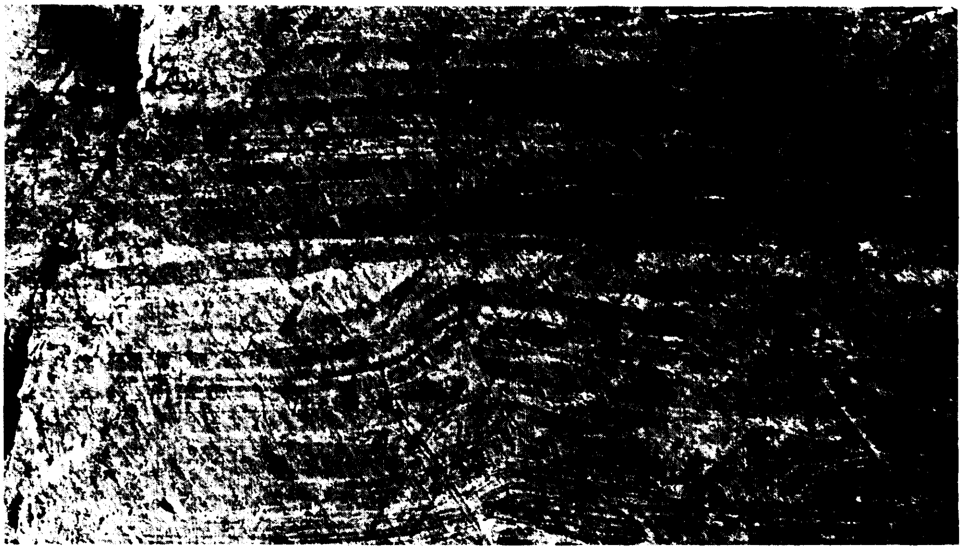


OGS9815

Photo 4–Coarse wacke bed overlain sharply by current-bedded finer silty material and narrow zone of dewatering structures with ripple marks at the top of the bed which in turn is overlain by more coarse wacke material of the next turbidite unit.

OGS9816

Photo 5–Intraformational breccia in thin- to medium-bedded wacke sequence.



ODM9817

Photo 6–Asymmetrical soft sediment slump fold preserved in medium-bedded wacke layers.

OGS9818

Photo 7–Miniature thrust in soft sediment fold continues into area of intraformational breccia.

60 percent silty matrix. Based on thin section and field estimates, most wackes are in the broad range of lithic arkosic wacke to lithic subarkosic wacke in the sandstone classification modified by Young (1967). The quartz grains are rounded to angular and slightly elongate parallel to the vague foliation and bedding in the rock. These grains typically show undulose extinction, and some are polygonized or display mortar structures. These strain features could have either been caused by deformation following deposition of the wacke, or by deformation in the source area before sedimentation. Angular plagioclase grains have albite twinning and minor amounts of fine sericite flakes. Plagioclase grain compositions were determined using the method of maximum extinction angle on albite twins and gave values in the range An_{25} to An_{32} in even the lowest metamorphic grade area that borders the Quetico Fault. These data as well as the presence of slightly zoned plagioclase grains, indicate that they may have undergone little change from their primary igneous state. Lithic clasts are difficult to distinguish from the matrix because they tend to be very fine grained. The most common type consists of very fine grained quartzofeldspathic material with sericite, and are reminiscent of some of the felsic to intermediate metavolcanics seen to the north of the Quetico Fault. Other types include chlorite-rich material and material full of fine-grained subhedral plagioclase laths, probably of mafic volcanic origin. The matrix is generally composed of silt-sized quartz, plagioclase, and sericite with chlorite and epidote common in some layers, and biotite more plentiful with increasing metamorphic grade. Sand-sized carbonate forms some 20 percent of certain thin layers, but is only an accessory mineral in much of the wacke-mudstone sequence. These carbonate-rich horizons become more apparent as calc-silicate assemblages with increasing metamorphic grade. Pyrite (about 1 percent) in deformed, elongate grains is disseminated throughout most of the sedimentary rocks. Rounded, detrital apatite and zircon are minor accessories. Euhedral tourmaline appears to have formed, or at least to have recrystallized after deposition, because in places it lies across primary sedimentary structures.

The mudstone layers are well laminated and foliated with very fine grained quartz, plagioclase, sericite, and chlorite forming most of the rock. The laminations, typically less than 5 mm across, consist of alternating shale with micas dominant and siltstone containing more quartzofeldspathic material.

Carbonate is common in some mudstone layers, and can be porphyroblastic. Biotite is more apparent with increasing grade. Fine-grained pyrite is distributed throughout the rock in irregular grains. Elongate chips of typical mudstone, apparently derived from underlying beds during passage of sediment-charged current occur locally in some wacke layers.

Despite the overprinting of low grade metamorphic features and a strong foliation related to folding of the sequence, sufficient evidence exists to indicate the relative immaturity of the turbidite sediments, and to suggest that much of the material could have originated from a source area containing a considerable variety of volcanic rocks.

As metamorphic grade increases southward from Crooked Pine Lake, the wacke-mudstone rocks become more recrystallized, phyllosilicate minerals increase in grain size, and quartz and plagioclase lose their clastic appearance especially in the mudstone part of the beds. The main foliation becomes a more dominant planar structure, though it is commonly parallel to the original sedimentary layering, and the rocks take on a phyllitic to schistose appearance. Metamorphic reactions produce porphyroblastic garnet, staurolite, and andalusite in the more pelitic layers, and actinolitic amphibole in the carbonate-rich horizons. Concordant, thin, quartz veins and stringers present in the wacke-mudstone sequence to the north, contain some coarse epidote and plagioclase in the schist zone. An interesting feature in many of these veins and stringers is that on both sides of the quartz are narrow amphibole schist layers which merge into typical biotite schist. At higher metamorphic grades, these quartz-rich veins can contain pockets of garnet, hornblende, and diopside. Similar veins have been noted elsewhere in the Quetico Metasedimentary Belt (Harris 1970, p.7). One explanation for these is that they formed as quartz veins with minor, variable amounts of carbonate before the metamorphism that aided the development of calc-silicate assemblages by local reaction between the original carbonate and the enclosing wacke material.

Microscopically in the phyllite and schist, quartz and fresh plagioclase with albite twinning in the range An_{25} to An_{30} form a granoblastic mosaic with biotite flakes giving a strong foliation to the rock and varying in amounts from 5 to 25 percent. Sericite is present in some layers and minor later chlorite flakes have grown across the main foliation. Where present, pink garnet is subhedral to euhedral with only minor small inclusions. Light brown staurolite is highly poikiloblastic, but has subhedral outlines, and bluish white andalusite forms lens-shaped poikiloblastic grains. The increase in the grain size of the schist during recrystallization is highlighted by the difference between the quartz grains within the porphyroblasts and the surrounding schist. In the amphibole schist layers, subhedral, slightly poikiloblastic, pale to blue-green actinolite is subparallel to the main foliation and has developed around the quartz, plagioclase, epidote, minor carbonate, and biotite matrix. The lack of any evidence of rotation between the matrix foliation and inclusion trains in the porphyroblasts suggests a single deformation and metamorphic event occurred in this part of the Quetico Metasedimentary Belt.

In a few places, cream-coloured, foliated, concordant layers of feldspar porphyry, generally less than 0.6 m wide, occur within the metasediments. These rocks contain medium-grained, subhedral plagioclase phenocrysts that are typically zoned and twinned, and have alteration patches and zones of sericite and minor epidote. In some places, plagioclase contains antiperthitic intergrowths of microcline.

The matrix is composed of granular to granoblastic fresh plagioclase, microcline, and quartz. The foliation is outlined by minor anhedral hornblende, or biotite and muscovite. Sphene and apatite are accessory minerals. The foliated and granoblastic character of these layers indicate that they have been intruded before or during the major period of deformation and metamorphism, and are possibly related to the small porphyritic biotite granodiorite intrusion which cuts the metasediments on the southern shore of Crooked Pine Lake.

Narrow concordant sheets and cross-cutting stringers and dikelets of granitoid mobilizate, comprising medium-grained quartz monzonite and very coarse grained muscovite graphic granite pegmatite increase in amount and volume southwards through the schist. The southern boundary of the schist was arbitrarily chosen where the mobilizate fraction attained 20 percent of the total outcrop volume. Mobilizate in the schist is considered to be of intrusive origin. The schist did not reach temperatures sufficient to produce anatexis.

Biotite Gneiss

The biotite gneiss is the high-grade equivalent of the wacke-mudstone sequence, and contains between 20 and 70 percent by volume of granitoid mobilizate similar to that seen in the schist. The metasedimentary sequence retains its layered appearance due to the sharp variation in the mafic mineral composition between 5 and 30 percent. The layering is similar in scale to that seen in the lower grade rocks to the north (Photo 8). Recrystallization has increased the grain size especially of plagioclase and quartz so that biotite, although defining the foliation parallel to the layering, tends to wrap around the granoblastic minerals giving a more gneissic fabric. Porphyroblastic garnet, hornblende, cummingtonite, muscovite, and cordierite, as well as sheaf-like knots of sillimanite are present locally in some layers.

Thin section examination reveals that granoblastic twinned plagioclase in the range An_{27} to An_{33} and generally unstrained quartz form much of the rock. Biotite flakes define the foliation parallel to the layering, and in places give an impression of a later transverse foliation. Some layers contain pale yellow-green to apple-green hornblende which is anhedral and strongly poikiloblastic and envelops the quartz-plagioclase fabric. As in the lower grade zone, amphibole is common in the gneiss close to concordant quartz veins. Subhedral to euhedral pink garnet porphyroblasts with minor quartz inclusions are scattered throughout the more pelitic layers. Poikiloblastic cordierite, visible in thin section, is slightly altered to sericite along fractures or shows small yellow pleochroic haloes. Without these indicators, cordierite is well camouflaged in the quartzofeldspathic mosaic. Elongate blades of colourless, slightly poikiloblastic cummingtonite subparallel to the biotite foliation were observed in one locality. Small aggregates of tiny acicular crystals which are almost certainly sillimanite occur within and at the boundaries of some plagioclase crystals in cordierite-garnet-biotite gneiss. Typical sheaf-like masses of fibrolitic sillimanite and coarser prismatic sillimanite occur in biotite gneiss between Nydia and Eva Lakes. Coarse elongate and stubby muscovite poikiloblasts typically randomly oriented and apparently post-tectonic, occur locally in some layers. Apatite and pyrite are common accessories, whereas allanite, mantled by epidote, and zircon occur locally.

Biotite gneiss containing 20 to 70 percent of coarse-grained biotite quartz monzonite and muscovite graphic granite pegmatite is the transition unit in which biotite quartz monzonite at the lower metamorphic grade is present as

OGS9819

Photo 8—Compositional layering and boudinaged granitoid mobilizate in metasedimentary gneiss. Small open fold has axis close to outcrop surface giving impression of tight isoclinal fold.

completely intrusive mobilizate; whereas towards the upper metamorphic limit, much of the quartz monzonite originates from *in situ* anatexis of the metasedimentary sequence. As before, a continuum into the unit containing 70 to 95 percent granitoid mobilizate is termed a gneiss-migmatite or, using the migmatite terminology of Mehnert (1968) an inhomogeneous diatexite; this unit is described in the section on "Metasedimentary Migmatite".

Marble, Calc-Silicate Gneiss

Single boudinaged layers of coarse-grained marble, generally less than 60 cm wide outcrop in railroad cuttings on the south shore of Elbow Lake and west of a small lake about 1.5 km to the east. The close spatial relationship of these occurrences suggests that the layers are close to, or may in fact be the same stratigraphic horizon, and represent a brief period of carbonate sedimentation in the turbidite sequence. The marble is granoblastic with equigranular to slightly elongate calcite grains and dark green diopside knots and grains sprinkled throughout. Layers of very coarse grained calc-silicate skarn material occur at the contacts with both typical biotite gneiss and quartz monzonite mobilizate. In one locality, a general mineral zoning occurs outwards from the marble containing calcite and diopside into a zone almost entirely composed of subhedral garnet with minor epidote and euhedral apatite, and finally into a zone rich in apatite and epidote with subsidiary garnet and diopside. Minor euhedral sphene grains and interstitial quartz occur in the calc-silicate zones. Where the marble is in contact with, and partly intermixed with typical biotite gneiss, small stubby anhedral grains of diopside and larger poikiloblastic light to dark green actinolite occur in places to the exclusion of biotite. Euhedral sphene is common in the diopside-rich areas.

Quartz monzonite in contact with marble is also contaminated by, and has reacted with, the carbonate material. Microcline and plagioclase are severely altered to fine-grained sericite and coarse calcite networks crosscut the minerals. Quartz occurs as irregular interstitial patches in and around the feldspars, and forms only about 5 percent of the rock. Pale irregular elongate grains of tremolite are rimmed by green pleochroic actinolite, and contain inclusions of calcite and quartz. Euhedral sphene crystals are common near the amphibole-rich areas, and epidote is an alteration product near plagioclase, sphene, and allanite.

Metamorphosed Ultramafic to Intermediate Intrusive Rocks

INTERMEDIATE AND ULTRAMAFIC INTRUSIVE ROCKS

A number of small intrusive bodies were outlined in the metavolcanic belt although in general, contact relationships were not observed because of the paucity of outcrop. These intrusive rocks have undergone the same low grade metamorphism as, but tend to be less well foliated and coarser in grain size than the metavolcanics with the exception of the coarse mafic flows which also may be intrusive in part. Intermediate intrusions are quartz dioritic to trondhjemitic in composition, and have been interpreted as small, round plutons set in the metavolcanics, whereas the few intrusions of ultramafic composition are likely to be small dikes cutting the metavolcanics.

Quartz Diorite, Trondhjemite

The map-unit quartz diorite, trondhjemite covers a broad range of rock types with mafic mineral contents varying from zero up to 35 percent (Figure 2). In this report, the more mafic phases with mafic mineral contents greater than

15 and less than 25 percent quartz are termed quartz diorite (Figure 2). They have a medium- to coarse-grained hypidiomorphic granular texture and retain their relict igneous texture. Euhedral to subhedral plagioclase lath outlines are well clouded by very fine grained epidote and minor carbonate, and faint albite twinning can be observed, despite the alteration. Pale yellow-green to medium green actinolitic amphibole forms felted masses of grains within original subhedral outlines. Minor pale green chlorite, possibly after biotite, forms coarse flakes here and there. Quartz forms coarse- and fine-grained interstitial aggregates of polygonized grains. Iron-titanium oxide in skeletal grains is commonly altered to sphene. Apatite and zircon are minor accessories.

Intermediate intrusive rocks in the metavolcanic belt with greater than 25 percent quartz and less than 15 percent mafics (Figure 2) were termed trondhjemite. Apart from these modal constraints, these rocks can be separated from quartz diorite because mica instead of amphibole forms the main mafic phase. Near the batholithic contact where the metamorphic grade is higher, primary biotite survives in these rocks, but throughout most of the belt it has been completely altered to light to medium green chlorite. The trondhjemite is a medium- to coarse-grained rock having a hypidiomorphic granular texture; subhedral plagioclase is about An_{27} to An_{30} in composition, lightly dusted with epidote and sericite alteration products, and displays albite, pericline, and Carlsbad twinning. Coarse-sized grains of quartz, interstitial between plagioclase grains, are generally strained, and locally recrystallized into polygonal aggregates or mortared grains. Chlorite forms knots of small grains in and around plagioclase in the more deformed rocks, but replaces original coarse-grained biotite flakes elsewhere. Epidote occurs as coarse aggregates of irregular grains close to chlorite. Iron oxide, iron-titanium oxide, sphene, apatite, and zircon are present as accessories.

The contrast between plagioclase alteration in quartz diorite and trondhjemite is probably caused by the quartz diorite originally containing a more calcic plagioclase which has altered more to equilibrate with the greenschist facies metamorphic conditions.

Melanogabbro, Peridotite

A few minor intrusions of melanogabbro dikes with a colour index of 60 to 70 were observed cutting the mafic metavolcanics near Upham Lake. These rocks are coarse grained, dark green, and have a metamorphic assemblage of amphibole, chlorite, and altered plagioclase with minor disseminated pyrite. In one locality on the southern shore of the large eastern bay of Upham Lake, a small outcrop of medium-grained altered peridotite is cut by a thin fine-grained dike that is quartz dioritic in composition. No contacts were seen between the ultramafic material and the enclosing rocks. On the weathered surface, the rock is medium green with black phenocrysts sprinkled throughout. In thin section, primary pale pink to green pleochroic clinopyroxene phenocrysts, thickly dusted with medium- and fine-grained, partly oriented iron oxide, are rimmed by optically continuous pale green pleochroic amphibole, and are commonly surrounded by coarse- and fine-sized biotite flakes altering to chlorite. These are set in a matrix of fine-grained, almost colourless to pale green actinolitic amphibole, with minor amounts of chlorite, biotite, and iron oxide. Coarse interstitial carbonate and minor quartz may be secondary. Minor subhedral pyrite is disseminated throughout.

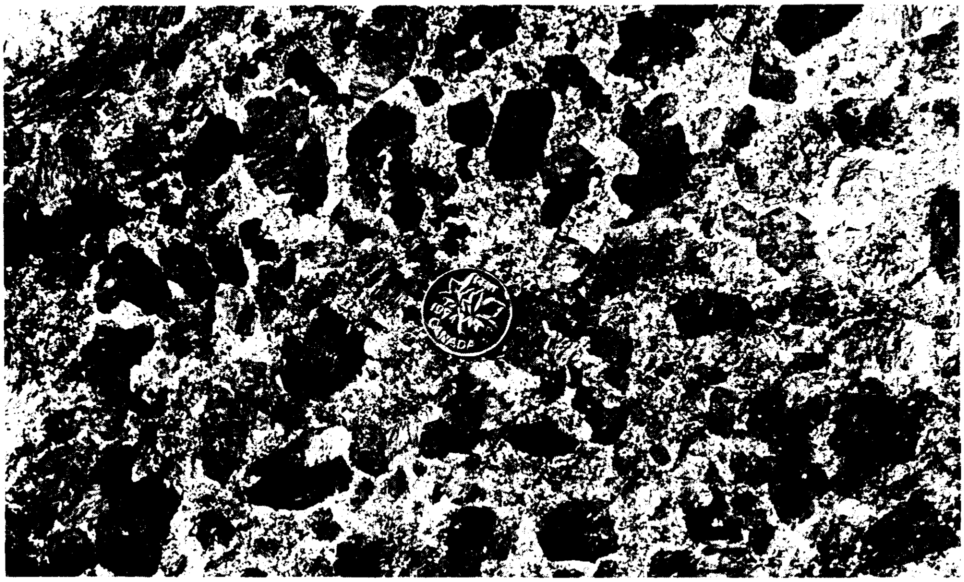
MAFIC TO ULTRAMAFIC INTRUSIVE ROCKS

A large number of mafic to ultramafic sheets, commonly no more than 2 m wide, occur throughout the metasediments. These sheets are generally concordant with the bedding and layering, and are typically boudinaged, deformed, and recrystallized, especially near their contacts. These sheets generally consist of metamorphosed gabbro (colour index 35 to 50), and contain in places feldspathic hornblendite (colour index 50 to 85). Several much larger bodies, which can be outlined at the scale of mapping, occur in a fairly narrow belt stretching from Kawene Lake to Elbow Lake.

Elbow Lake Mafic Complex

By far the largest intrusive mass of the group, the Elbow Lake Mafic Complex, forms an elliptical body some 3600 m long which is bisected by a screen of metasediments along the shore of the northeast arm of Elbow Lake. The complex has deflected the country rock metasediments, especially along the northern edge, and has a strong aeromagnetic anomaly (ODM-GSC 1961a,b,c, and d). Individual peaks are close to the centres of the two main segments. The country rocks very close to the contact display hornfelsic textures which appear to have been overprinted by the regional foliation during the climax of metamorphism. Xenolithic blocks of metasediments within the complex are generally fine grained, and less recrystallized than the nearest similar regionally metamorphosed rocks outside the complex contact zone. In these blocks, compositional layering and thin concordant quartz veins commonly outline small folds. These folds are much less common in the country rocks, and possibly indicate that the intrusion of the complex took place after the onset of deformation and metamorphism, but before the shearing and development of schistosity erased the minor folding by transposition of the original layering.

Recent logging operations have improved outcrop exposure and access to the northern part of the complex, and permitted a detailed investigation of the petrography (Legault 1976). Mapping was carried out on the basis of four map units arbitrarily defined by the author using colour index, but because most outcrops are composed of more than one intrusive phase, the areas outlined on the map (Map 2405, back pocket) only portray the general distribution of the rocks. The field units were defined as follows: hornblendite, minor pyroxenite with a colour index 85 to 100; feldspathic hornblendite with a colour index 50 to 85; hornblende gabbro with a colour index 35 to 50; and hornblende diorite with a colour index less than 35. These rocks can be divided into two groups: the earlier comprises pyroxene hornblendite, hornblendite, and mafic feldspathic horn-



OGS9820

Photo 9–Leucocratic phase of ultramafic complex at Mud Lake with very coarse euhedral hornblende phenocrysts in a medium-grained matrix of plagioclase and hornblende.

blendite commonly displaying cumulate like textures; the later comprises feldspathic hornblendite, hornblende gabbro, and diorite with more normal textures than the other group.

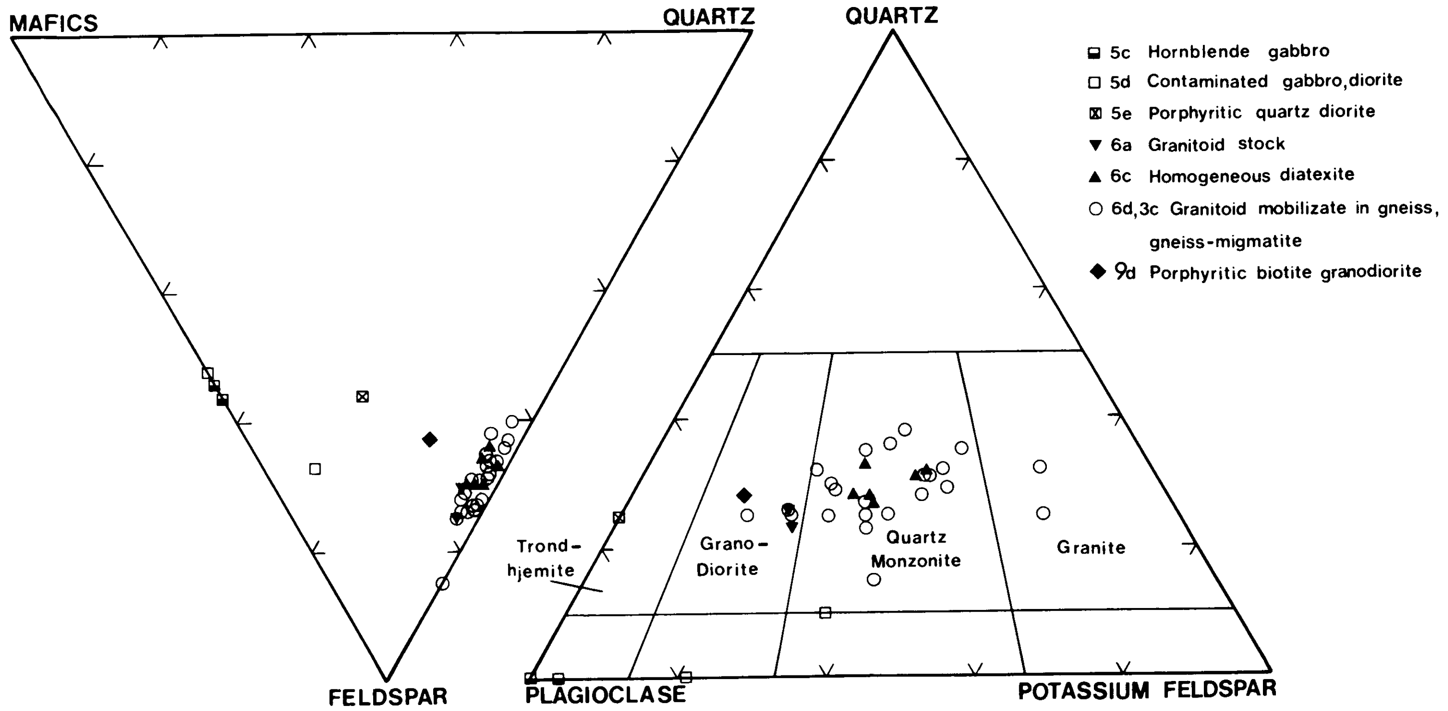
The most common type of hornblendite consists mainly of very coarse grained euhedral to subhedral hornblende crystals that form a cumulate-like texture. This rock contains rounded inclusions of augite that generally have been altered to pale tremolitic amphibole and hornblende. The matrix consists of medium-grained, rounded, colourless augite, and subhedral hornblende with skeletal plagioclase grains which are altered to sericite and epidote. In some areas, no pyroxene remains, and the rock is composed of very coarse subhedral hornblende phenocrysts set in a medium-grained matrix of hornblende with minor amounts of coarse-grained biotite and some plagioclase. In a few places, a pyroxenite phase occurs consisting of medium-grained, subhedral, faintly pleochroic hypersthene, rounded augite, and minor amounts of anhedral hornblende and biotite, as well as poikilitic plagioclase. Some 2 percent subhedral magnetite is commonly present, and can be as great as 4 percent in some localities. Scattered, rounded blebs of sulphide occur between mafic grains.

As plagioclase and porphyritic hornblende increase and augite decreases, the pyroxene hornblendite grades into the feldspathic hornblendite. In some of these rocks minor interstitial quartz and microcline occur. Actinolite is common in the matrix, and biotite can be present in variable amounts. Plagioclase is generally well sericitized throughout. The most leucocratic example of this coarse porphyritic feldspathic hornblendite coincides fairly closely with the arbitrary colour index boundary of 50, and is quite similar to the rock in Photo 9.

The hornblende gabbro and diorite group of rocks are almost invariably nonporphyritic, and have a colour index ranging from 20 to 65. These rocks are younger in age than the more mafic to ultramafic intrusive rocks and they typically contain large blocks and xenoliths of the earlier hornblendite phases. The hornblende gabbro is medium to coarse grained, and is hypidiomorphic granular to lineated owing to aligned hornblende prisms. Anhedral to subhedral plagioclase forms the framework of the rocks, and is well twinned, slightly to sharply zoned, and is generally altered in patches and zones to sericite and epidote. The plagioclase can vary in grain size. Phenocrysts of the plagioclase set in a finer grained matrix are a common feature. Compositions of the central part of zoned plagioclase crystals are in the labradorite range, and are about An_{55}. Yellowish to medium green pleochroic anhedral hornblende prisms display simple twinning, and form about 40 percent of the typical rock (Figure 3). Irregular poikilitic biotite flakes partly altered along cleavages to chlorite and epidote are scattered throughout the rock. Minor interstitial quartz occurs in places, and up to 2 percent subhedral magnetite is also present. Apatite and pyrite are common accessories. Minor amounts of garnet were observed in the gabbro as well as in the more mafic phases, particularly near the contact with the country rocks. In some areas, the mafic minerals form clots of decussate hornblende and minor biotite, these could be partly reacted xenoliths of the more mafic phases. Elsewhere, plagioclase-rich phases occur with interstitial tremolitic amphibole, biotite, and minor poikilitic hornblende. With increasing amounts of sodic plagioclase, gabbro grades into diorite; otherwise these rocks have a similar mineralogy. Some of the more felsic dioritic material, however, has more quartz and microcline than diorite, contains apatite, sphene, and allanite as accessory minerals, and seems to be the product of mixing of gabbroic magma with a partly melted fraction of the enclosing metasediments.

The southern part of the complex is poorly exposed on Elbow Lake and in the interior of the body. From the evidence available this part of the intrusion has little or none of the very coarse grained porphyritic cumulate-like hornblendite phases, and only locally are some blocks of medium- to coarse-grained biotite hornblendite observed. Much of the body is composed of hornblende gabbro to diorite phases that are highly variable in colour index because of the variation in small hornblende knots. These are probably partly assimilated xenoliths of mafic material. Some of the more dioritic material is pinkish. Staining of the samples revealed that most of the rocks contain potassic feldspar as well as plagioclase (Figure 3). Thin sections indicate these rocks contain plagioclase in the andesine range which is twinned, zoned, and highly altered to sericite, epidote, and carbonate. Hornblende forms decussate knots as well as anhedral grains altering in places to chlorite. Minor biotite is more or less altered to chlorite. Medium- to fine-grained, fresh, twinned, microcline and quartz are interstitial. Apatite, sphene, and allanite are typical accessory minerals.

The northern segment of the complex has a preponderance of very coarse grained porphyritic to cumulate-textured ultramafic and mafic phases. It is markedly different from the southern segment which comprises mainly medium- to coarse-grained gabbro and diorite having assimilated mafic clots and microcline and quartz. This may suggest that two different levels of exposure exist in the mafic complex. The northern part is exposed to a deeper level than the



SMC 13963

Figure 3–Triangular plot of modal mineral compositions of granitoid rocks in the metasedimentary belt of the Crooked Pine Lake Area, along with less mafic phases of the mafic intrusive complexes and the late pophyritic biotite granodiorite. Modal counts were done on stained slabs using a transparent grid of 10 lines to 2.5 cm (1 inch) and a count of 500 points. Map legend code is given with rock name (see Map 2405, back pocket).

southern part which is nearer the roof of the intrusion where assimilation of country rock metasediments has given the main gabbroic magma a more granitoid aspect.

Heward Lake Mafic Complex

The Heward Lake Mafic Complex is an elongate, lens-shaped body 1400 m long and 150 m wide, located just northwest of Heward Lake beside the main logging road. A strong aeromagnetic anomaly is indicated over this location (ODM-GSC 1961d), and is largely caused by the magnetite content of the rocks. Most of the complex comprises medium- to coarse-, even-grained hornblende gabbro; prismatic hornblende (40 to 55 percent) vaguely outlines a lineation direction parallel to the intrusive contact. Up to 5 percent coarse, subhedral biotite flakes as well as accessory magnetite and pyrite grains are scattered throughout the rock, the rest of which consists of subhedral plagioclase. Large xenolithic blocks of hornfelsed biotite schist and minor quartz fragments occur scattered throughout. At the extremities of the intrusion, large blocks and small nodular cognate xenoliths of very coarse grained feldspathic hornblendite containing 60 to 70 percent euhedral hornblende set in an interstitial hornblende-plagioclase matrix, and coarse grained hornblendite, consisting almost entirely of equigranular hornblende, are the predominant phases. A medium- to coarse-grained hornblende diorite phase occurs especially near the borders of the body and merges into hornblende gabbro, but in places it contains small xenoliths of the more mafic phases commonly bounded by a narrow rim of biotite. Locally, these mafic rocks are cut by narrow sheets of quartz monzonite and muscovite pegmatite related to a later period of migmatization.

Kawene Lake Mafic Complex

A similar sheet-like mafic body is exposed on the northeastern part of Kawene Lake, is 760 m long, and is disrupted by the later large body of muscovite pegmatite. On the west shore of the lake, a possible extension of the same body outcrops, but narrows westwards into a small dike. This body is composed largely of very coarse grained hornblendite and feldspathic hornblendite with minor gabbro and diorite phases. The mineralized lens-shaped body straddling the township line, along strike to the west of the Kawene Lake Intrusion, is similar in rock type distribution, but also contains local patches of pyrrhotite-chalcopyrite in fine disseminations and fracture fillings exposed by trenching. This small intrusion was the subject of a petrological investigation by Larsen (1974).

Mud Lake Ultramafic Complex

A small elongate ultramafic body on the western shore of Mud Lake consists mainly of very coarse grained hornblendite with lesser amounts of feldspathic hornblendite which in places grades into a more leucocratic phase (Photo 9). Minor amounts of gabbro occur with the hornblendite at the western end of the body, and scattered thin stringers of medium-grained diorite cut the earlier phases. Minor local concentrations of disseminated and fracture controlled pyrrhotite and chalcopyrite mineralization have been tested in small pits and diamond-drill holes.

Other Mafic To Ultramafic Intrusions

On the northern shore of the small lake at the southeastern corner of Trottier Township, a similar small, composite, mafic to ultramafic intrusive body cuts the metasediments. This body is mainly composed of very coarse grained hornblendite and feldspathic hornblendite with some lineated hornblende gabbro and diorite which contain variable amounts of medium-grained xenolithic hornblendite material. Small trenches have exposed pyrrhotite-chalcopyrite fracture fillings and disseminations here and there in the intrusive body, especially in the feldspathic hornblendite phase.

Similar bodies were mapped by Irvine (1963) in the Lac des Mille Lacs area adjoining the present map-area to the east. These bodies were the subject of a more detailed petrological and geochemical investigation by Watkinson and Irvine (1964) who indicated that the sequence of phases observed was compatible with a genesis by fractional crystallization of tholeiitic olivine basalt liquid at a high partial pressure of water which produced primary hornblende by reaction between olivine, pyroxene, and the aqueous basaltic liquid. No indication of olivine exists in the rocks of the present map-area. A similar process of initial fractional crystallization of pyroxenes followed by reaction between pyroxene and melt to form a tremolitic amphibole and, in turn, hornblende, would account for the ultramafic phases seen in the complex. The mafic phases formed from the remaining basaltic magma.

Porphyritic Quartz Diorite

On Elbow Lake, northeast of Abiwin, and along the logging road just northeast of Eva Lake, are several bodies of porphyritic quartz diorite which are generally concordant with the regional strike and are strongly foliated to lineated throughout. These bodies are cut by, and occur as blocks in coarse-grained, quartz monzonite sheets, dikes, and stringers which are related to the later period of anatexis and migmatization. The strongly foliated to lineated character of these bodies is in marked contrast to the hornblendite bodies to the north which have acted competently during deformation and metamorphism. The presence, however, of very small cognate xenoliths of hornblendite, feldspathic hornblendite, and hornblende gabbro scattered throughout these bodies is good evidence of this being a phase of the mafic to ultramafic intrusive activity. The more felsic character of this quartz diorite and its emplacement in a zone which has undergone higher grade metamorphism, anatexis, and more severe deformation, may explain why these rocks have acted in a less competent fashion.

In the map-area, the quartz diorite has a foliated cataclastic texture. Primary subhedral porphyritic plagioclase is rounded by deformation and set in a partly recrystallized medium-grained matrix of plagioclase, hornblende, chlorite, and quartz (Figure 3). The porphyritic plagioclase is thickly clouded by sericite and minor epidote alteration with only the rims remaining fresh. The matrix plagioclase is less altered, and anhedral with typical twinning, but shows strain extinction and bending of grains. Quartz occurs in medium-sized, granulated, strained or polygonized grains, and as finely mortared grains outlining planes of cataclasis throughout the rock. Minor interstitial cross-hatched microcline is present in some rocks. About 15 percent pale to medium green hornblende occurs in anhedral irregular grains distributed in a variety of grain-sizes throughout. Up to 5 percent biotite in small knots of flakes is largely altered to pale green chlorite with irregular epidote grains nearby. Sphene, apatite, zircon, and allanite mantled in epidote are accessory minerals.

Intermediate to Felsic Plutonic Rocks

METASEDIMENTARY MIGMATITE

Metamorphosed and migmatized metasedimentary sequences have been a problem for geologists mapping them because the gradual progression from low-grade schists to high-grade gneisses and associated granitoid masses cannot easily be subdivided into discrete map-units. Further, the lack of agreement between various workers about a definition of migmatite makes correlation between map-areas difficult, and in some cases impossible. However, ideas on the processes of metasedimentary migmatite formation and on anatexis have reached a point where these rocks are fairly well understood. A suitable descriptive terminology has been worked out for use in the study of these terrains (Mehnert 1968). The author thinks it is appropriate to incorporate these ideas into the mapping of migmatites.

In this study, the sequence of turbidites which underlies the area south of Crooked Pine Lake has undergone progressive metamorphism and migmatization. The volume of granitoid mobilizate present in the metasediments, which are by themselves too monotonous to subdivide was used to define arbitrary limits for several map units in the field. Despite the separation of the metasediments from the metasedimentary migmatite and related anatexites in the map-legend (Map 2405, back pocket), the two groups are intimately associated. Their present distribution and state are caused by a process which heats a sedimentary pile to form a granitoid melt where physical conditions and rock compositions permitted. In the present map-area, a mappable unit containing less than 5 percent metasedimentary gneiss material set in a granitoid host is called, in migmatite terminology, homogeneous diatexite (Mehnert 1968). A unit containing 5 to 30 percent metasedimentary gneiss in a granitoid host is an inhomogeneous diatexite or, in more descriptive terms, a gneiss-migmatite. These units are grouped in the map legend under "Metasedimentary Migmatite" and those with less granitoid material have been shown as metasediments on the map (Map 2405, back pocket).

Quartz Monzonite, Granodiorite (Intrusive Mobilizate)

The granitoid material which is intrusive into the schist and gneiss of the metasedimentary sequence is light gray, medium to coarse grained, and hypidiomorphic granular to vaguely foliated. The granitoid material occurs as slightly discordant dikes, stocks, stringers, and veins, as well as sheets of varying thickness that are concordant with the original sedimentary compositional layering. The material has a homogeneous composition spanning the arbitrary boundary between quartz monzonite and granodiorite with some 2 to 5 percent biotite. The material usually contains small lenses and stringers of very coarse grained pegmatite with more potassic feldspar than the host, and minor aplite. Near the head of the northwest arm of Elbow Lake, there is a fairly large intrusion of this material into only moderately metamorphosed biotite schist (Figure 4). Modal analyses of two samples from this stock granitoid (Figure 3) indicate that its composition lies just within the granodiorite field, suggesting that the material originated in an area of almost complete melting of typical wacke-mudstone before intrusion.

Muscovite Graphic Granite Pegmatite (Intrusive Mobilizate)

A distinctive, very coarse grained pegmatite phase has intruded all of the metasedimentary schist and gneiss in the area south of an arcuate line through the northern ends of Kawene and Heward Lakes to the northern tip of Elbow Lake. This phase reaches its maximum expression in a peneconcordant sheet up to 760 m wide, and stretches eastwards through Kawene and Heward Lakes as far as Nemo Lake beyond which it occurs as a series of smaller, generally concordant sheets, dikes, and stringers. The phase is less conspicuous in the higher grade migmatized schist and gneiss. Some smaller zones of this pegmatite are mapped separately within the gneiss, but the pegmatite mainly occurs as narrow sheets and lenses intimately associated with the typical quartz monzonite mobilizate throughout the higher grade gneiss and migmatite units.

The pegmatite typically stands out as large white outcrops in the field and on air photographs, and is composed mainly of extremely coarse-grained microcline displaying a graphic granite texture with minor free quartz and muscovite flakes or large feather-shaped intergrowths of muscovite and quartz (Photo 10). Small dark red garnets commonly occur either in small knots, or in elongate layers parallel to a vague primary foliation within the body. In a few localities, coarse, black aggregates of tourmaline or minor small bluish apatite crystals were noted. Irregular patches and lenses of coarse-grained biotite quartz monzonite are intimately associated with, and grade rapidly into pegmatite in many places along the length of the main sheet, as well as in the smaller bodies.

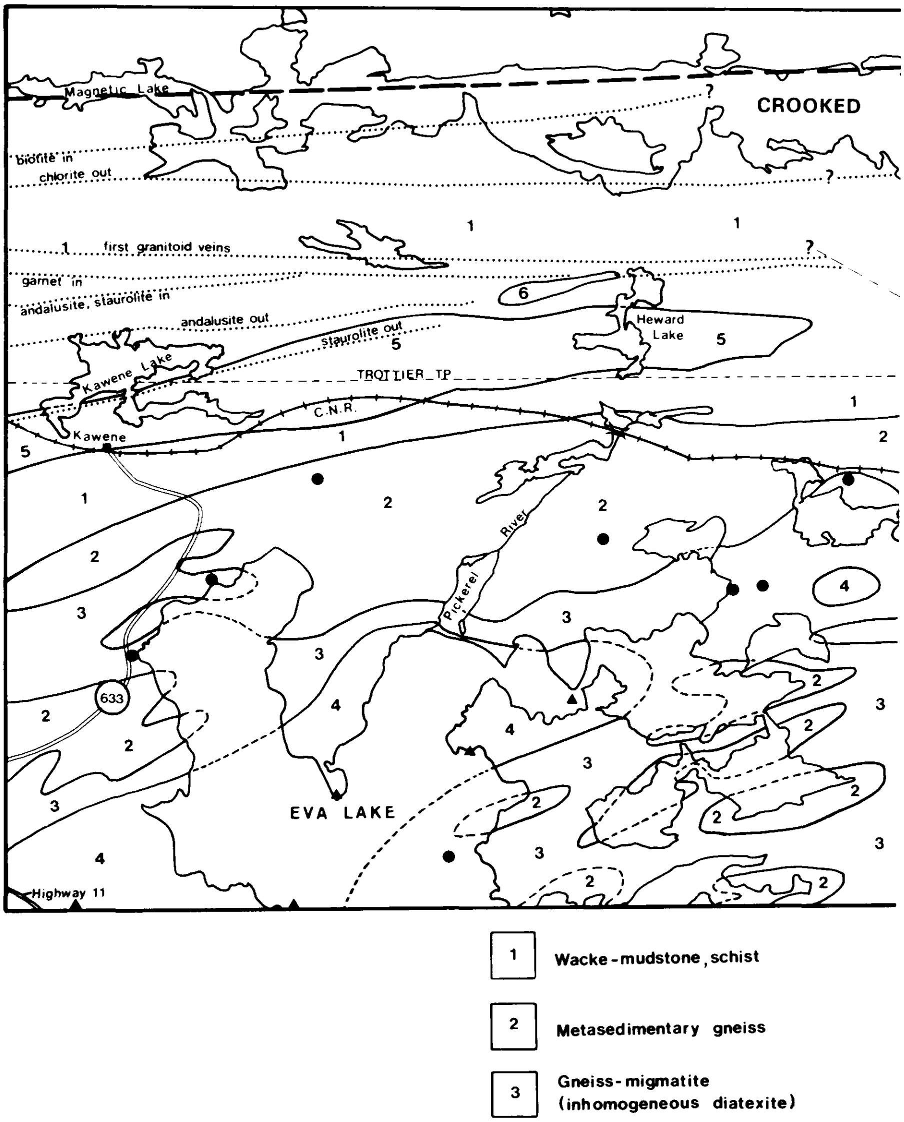
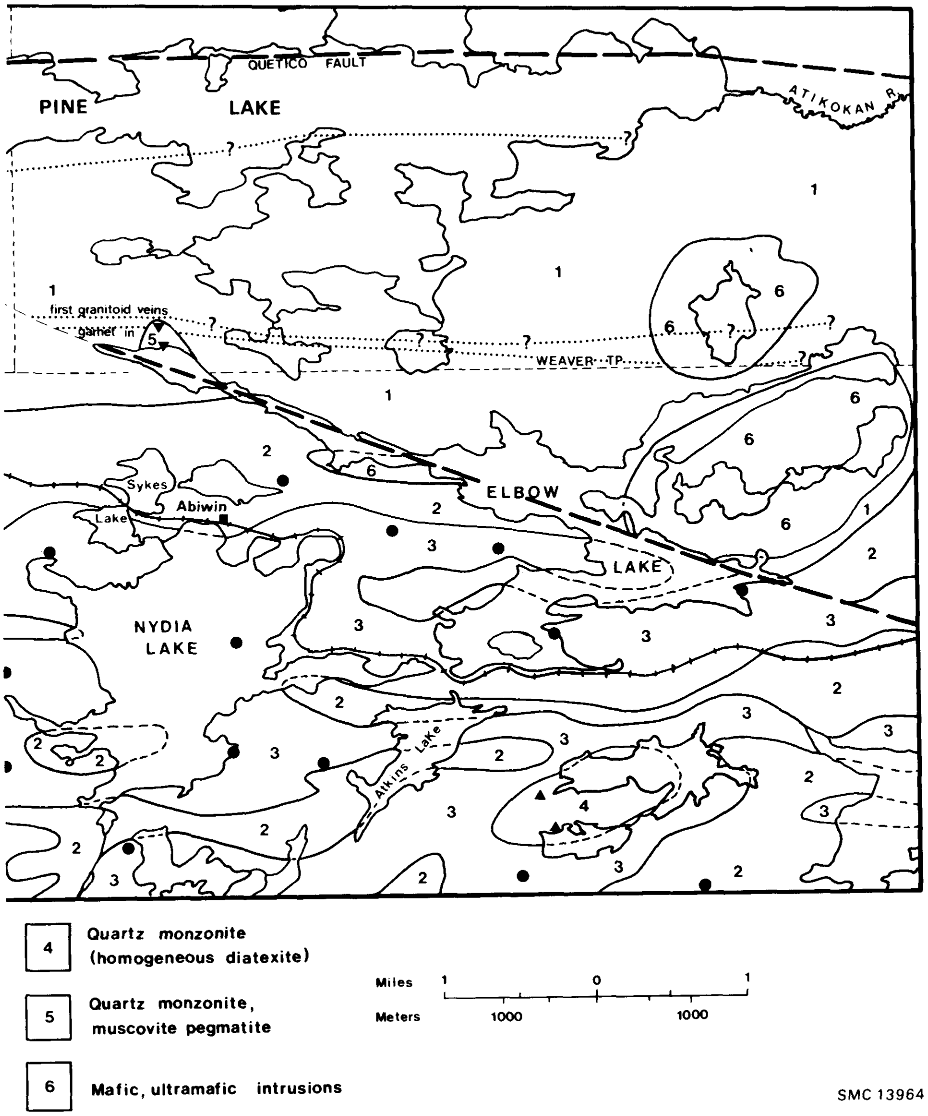


Figure 4–General geological map of the metasedimentary belt of the Crooked Pine Lake Area showing distribution of granitoid rocks used in Figure 3 and some approximate meta-



morphic isograds. Symbols are the same as used in Figure 3 except that open circles are equivalent to the dark circles on this figure.

OGS9821

Photo 10—Coarse feather-like intergrowths of muscovite and quartz in graphic granite pegmatite. Garnets occur in lighter area in lower half of photograph.

Quartz Monzonite and Pegmatite (Homogeneous Diatexite)

The ultimate products of progressive metamorphism and anatexis of a turbidite sequence are large masses of homogeneous, slightly foliated granitoid material which are virtually free of metasedimentary gneiss inclusions (Mehnert 1968). The largest body of this type extends from Eva Lake southwest across Highway 11 and out of the area. A similar smaller mass occurs not far to the northeast of Eva Lake and another was outlined between Atkins and Windigoostigwan Lakes. These are composed of medium- to coarse-grained equigranular granitoid material which is light grey and modally homogeneous (Figures 3 and 4); compositions are close to the centre of the quartz monzonite field and therefore close to the area of minimum melting in the "granite system" (Tuttle and Bowen 1958).

The rock is hypidiomorphic granular. Subhedral to anhedral typically twinned plagioclase is patchily altered to fine-grained sericite and minor epidote, especially in the centre of the grains. Fresh areas of the grains have a composition of about An_{27} with the altered areas being more albitic. Albitic rims are common against microcline, and myrmekitic intergrowths occur in places against quartz or microcline. Microcline forms coarse anhedral grains and has very fine string perthitic intergrowths. Quartz is coarse grained, interstitial; strained and polygonized grains are common. Biotite in stubby disoriented flakes and knots is evenly distributed, and is partly altered along cleavages to green chlorite and epidote. Elongate flakes of muscovite occur near biotite and on plagioclase grains.

Apatite and zircon are minor accessories.

Throughout the areas of homogeneous diatexite are dikes, lenses, and stringers of very coarse grained pegmatite comprising microcline perthite, quartz, plagioclase, and coarse "books" and knots of biotite and muscovite.

Biotite Gneiss-Migmatite (Inhomogeneous Diatexite)

The gneiss-migmatite unit shows the range of migmatization and anatexis from homogeneous masses of diatexite to biotite gneiss with up to 70 percent granitoid material. The unit differs little in appearance from the gneiss unit, apart from the larger proportions of granitoid material contained within it. This gives rise to the common appearance of blocks of gneiss, with concordant mobilizate layers, set in a virtual "sea" of granitoid material. The gneiss component is typically medium-grained, foliated, and layered compositionally due to variable biotite and hornblende contents. Modal analyses of the concordant, light grey, granitoid mobilizate parts of the gneiss-migmatite and gneiss (Figure 3) taken from widespread locations in the map-area (Figure 4) show that individual samples have substantial variations, but nearly all plot in a coherent pattern centred on quartz monzonite and have similar low mafic mineral contents. The two rocks which plot well into the granite field are anomalous: one is bright pink in colour, in contrast to most of the granitoid rocks in the area, and is a slightly later phase which occurs within typical gneiss-migmatite; the other is light grey and very similar to most of the other mobilizate layers in the gneiss-migmatite with the high microcline content only obvious on staining. Lenses and stringers of muscovite graphic granite pegmatite and the more typical pegmatite associated with the homogeneous diatexite are well represented in the mobilizate.

In thin section, the typical concordant mobilizate is more or less foliated, and is medium to coarse grained. Quartz and microcline as well as the micas are aligned in places. Locally, the granulation and mortaring of quartz and the bending of feldspar is related to later shearing. Subhedral plagioclase with a composition of about An_{28} is twinned and lightly dusted with fine sericite. Some grains of plagioclase have scalloped edges against microcline as though they had been partly replaced. Myrmekite occurs in contact with microcline in places. Microcline is anhedral, contains small subhedral plagioclase inclusions in places, as well as fine string perthite intergrowths. Interstitial quartz is commonly strained and in places has been polygonized. Biotite forms irregular disoriented flakes and is altered to chlorite in places. Muscovite appears in some rocks to be post-magmatic because it, unlike biotite, is aligned parallel to the general foliation and layering of the rock. As well as forming coarse elongate flakes here and there, muscovite also occurs as small flakes close to the mafic minerals. Accessory minerals are not observed in some of these mobilizate layers, providing a further indication of their low melting character.

METAMORPHOSED FELSIC INTRUSIVE ROCKS

Quartz Monzonite, Pegmatite

A number of small stocks and dikes of leucocratic quartz monzonite cuts the metavolcanic and related mafic intrusive rocks, especially in Trottier Township. The largest intrusion of this material, measuring over 1.6 km long and 0.8 km wide, outcrops on, and to the west of Upham Lake. The contact against mafic metavolcanics is sharp and well sheared where observed on the lake shore. The body is relatively unfoliated, except where it is cut by local shear zones. In two places it is cut by narrow, dark coloured, fine-grained hornblende trondhjemite dikes.

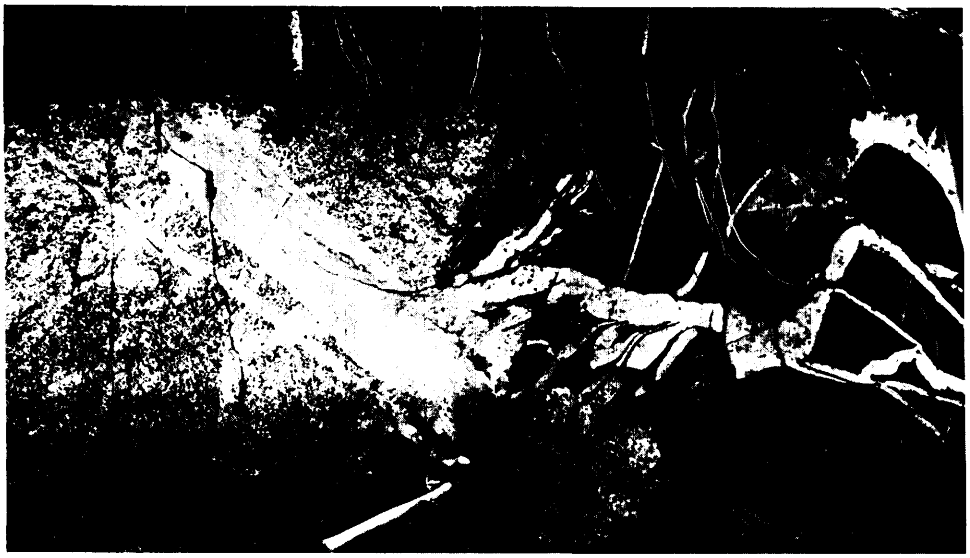
The rock is white to grey, very coarse grained (up to 1 cm), and has an hypidiomorphic granular texture and less than 5 percent mafic minerals (Figure 2). Plagioclase is subhedral and clouded by epidote and sericite alteration. Microcline forms large irregular grains that in part are interstitial, and quartz forms coarse irregular grains interstitial to the plagioclase. Mafic knots of very pale chlorite scattered throughout are probably the alteration products of primary biotite flakes. Coarse sphene is a common accessory. Where highly sheared, as on part of the small islands on Upham Lake, and at the western end of Magnetic Lake, muscovite is extremely common, and overgrows the granulated feldspar areas; coarse epidote gives a greenish colour to the plagioclase-rich areas. Quartz is severely strained with sutured and mortared rims. Secondary carbonate is common in pockets in and around the feldspar and mafic minerals.

Close to and within these quartz monzonite intrusions, are a number of thin fine-grained aplite or felsite dikes of similar composition as well as many dikes, stringers, and veins of coarse-grained, muscovite-bearing quartz monzonite pegmatite. These minor intrusions are almost certainly phases of the quartz monzonite intrusive event.

FOLIATED AND GNEISSIC BATHOLITHIC ROCKS

The northern third of the map-area is underlain by a complex sequence of mainly intermediate to felsic plutonic rocks which are part of a major east-west elongate batholith some 25 km wide, and possibly over 110 km long, the geology of which is not well known. Mapping by Woolverton (1960) overlapped the northern contact between the metavolcanics and batholithic rocks in the Lumby Lake area about 24 km to the north and similarly, mapping by Irvine (1963) and Kay (1967) to the east, and McIlwaine and Hillary (1974) to the west of the map-area, included part of the batholith and contact with the metavolcanics. Fenwick (1976) mapped the western boundary near Finlayson Lake and named it the Marmion Lake Batholith.

It is generally impossible to outline specific intrusive bodies, except in a few localities because many of the batholithic phases in the map-area are intimately mixed, even on an outcrop scale. Sufficient consistency in intrusive relationships



OGS9822

Photo 11–Coarse trondhjemite gneiss on left in contact with amphibolite which contains folded leucotrondhjemite stringers and all are cut by medium-grained leucotrondhjemite.

and textures exists on a broad scale to permit the outline of a sequence of intrusion.

Early Gneiss Types

Various kinds of trondhjemite gneiss occur throughout the batholithic rocks. The trondhjemite gneiss, Map Unit 8f (Map 2405, back pocket), which is confined to the area from around Lance Lake east across Star Island to the eastern shore of the northern arm of Mercutio Lake and south to its contact with the metavolcanics, is one of the coarsest grained rock-types in the northern batholithic area. This rock has large elongate lenses and streaks of quartz accentuating the gneissosity which is further highlighted by biotite or chlorite flakes and knots (Photo 11). The rock generally has a sheared cataclastic aspect with mafic minerals varying from 5 to 20 percent (average 12 percent) and a quartz content between 25 and 35 percent (Figure 5a). Thin section examination reveals that subhedral plagioclase can be almost totally clouded by sericite and carbonate with some grains being bent or broken. The large quartz lenses are composed of partly recrystallized aggregates of polygonized and sutured grains with a wide size variation. Original biotite has recrystallized to felted masses of pale green chlorite, muscovite, and iron oxide minerals, which are arranged around the edges of the coarse plagioclase. Microcline occurs sparingly as small interstitial

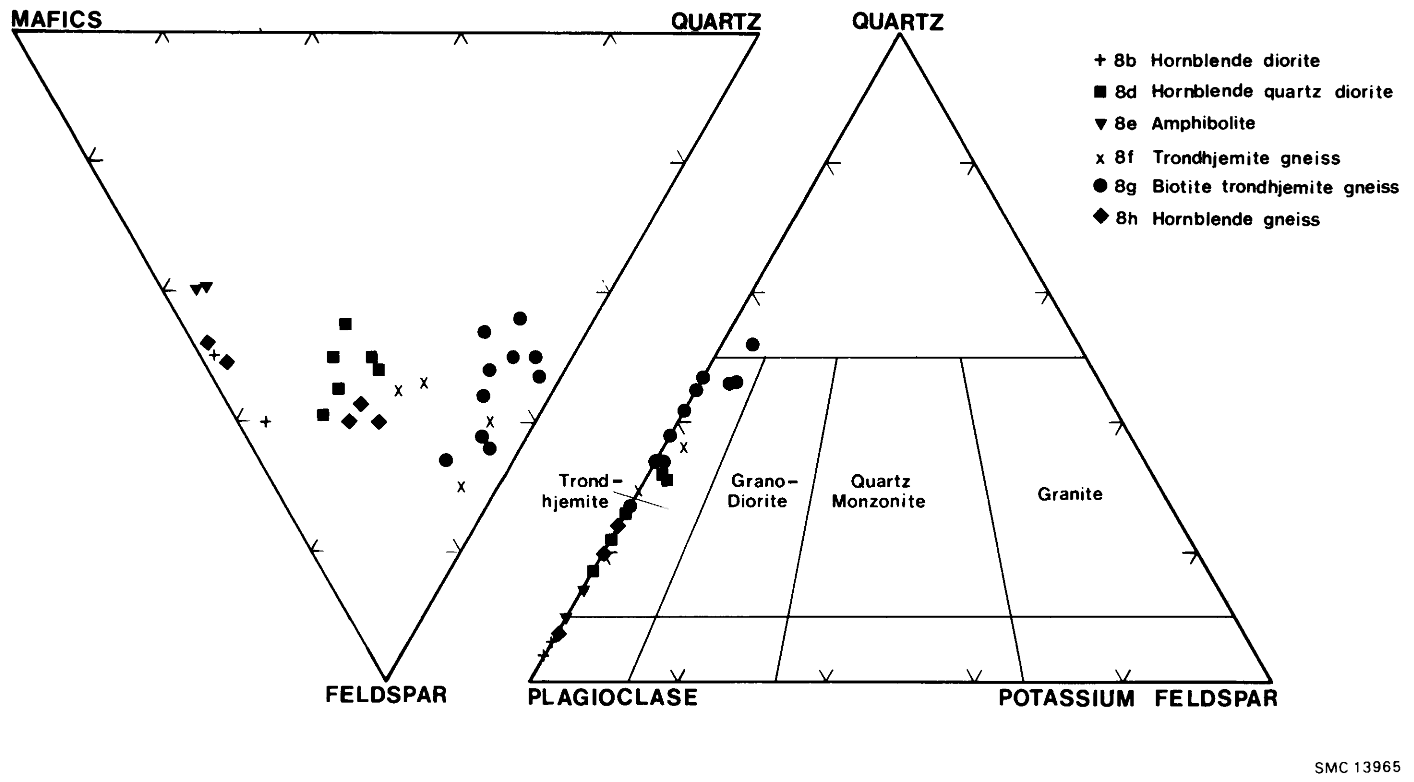


Figure 5a - Triangular plots of modal mineral compositions of earlier batholithic rocks in the Crooked Pine Lake Area. Modal counts were done on stained slabs using a transparent grid of 10 lines to 2.5 cm (1 inch) and a count of 500 points. Map legend code is given with rock name (see Map 2405, back pocket).

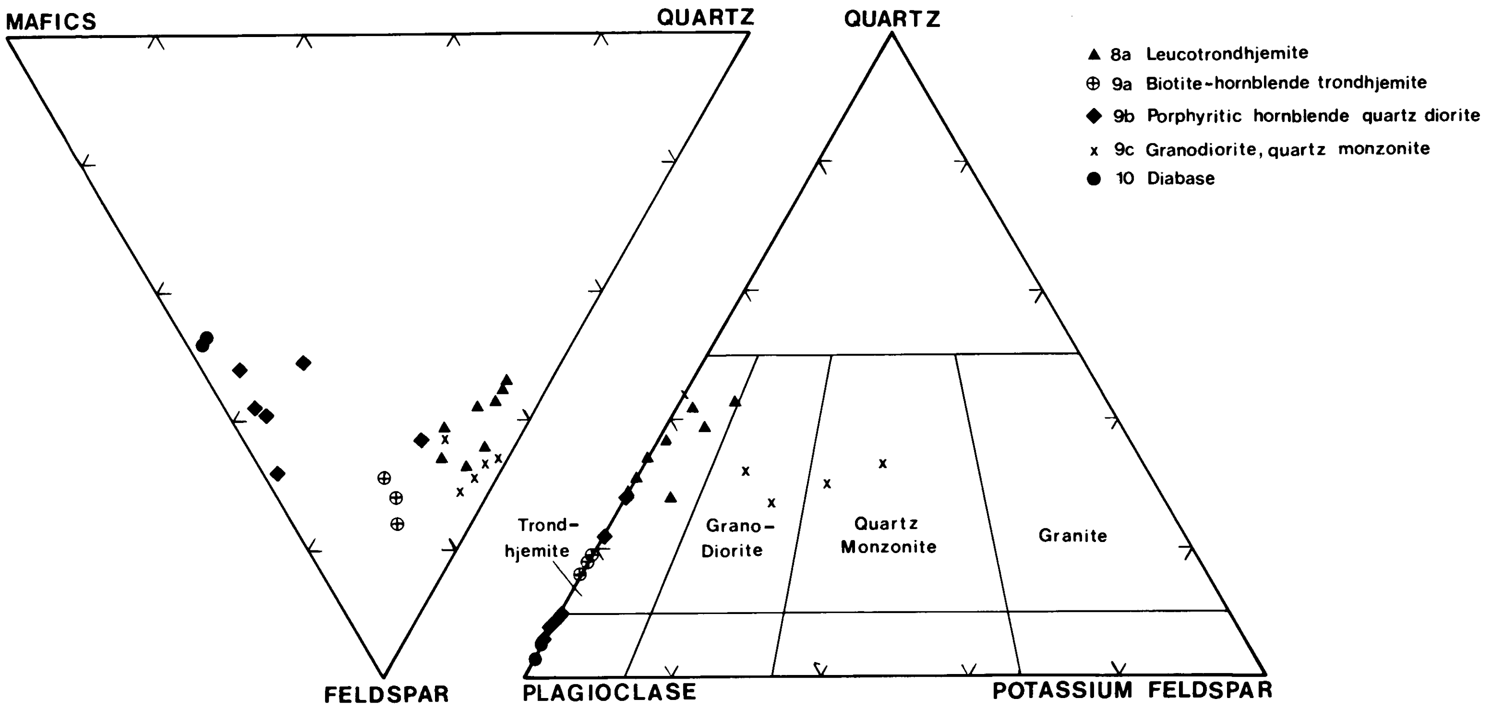


Figure 5b - Triangular plots of modal mineral compositions of later batholithic and mafic rocks in the Crooked Pine Lake Area. Modal counts were done on stained slabs, using a transparent grid of 10 lines to 2.5 cm (1 inch) and a count of 500 points. Map legend code is given with rock name (see Map 2405, back pocket).

OGS9823

Photo 12–Partly reconstituted biotite trondhjemite gneiss cut by leucotrondhjemite sheets and associated pegmatitic stringers.

grains in quartz and as irregular alteration rims on plagioclase. Sphene, allanite, and apatite are common accessories. Epidote is present as irregular grains near the mafic minerals and commonly forms wide rims around allanite.

By far the most plentiful gneiss throughout much of the northern batholithic area is biotite trondhjemite gneiss, Map Unit 8g (Map 2405, back pocket), which is typically medium-grained, granoblastic, with both mafic minerals and the quartz and feldspar vaguely outlining the gneissic foliation (Photo 12). Modal analyses of this rock type (Figure 5a) plot in the quartz-rich part of the trondhjemite field. Microscopically, the rock consists of medium-grained, slightly zoned, subhedral to anhedral plagioclase with albite and pericline twinning that is clouded by sericite and epidote alteration products which make determination of the composition difficult. Where feasible, all compositions[1] measured fall within the An_{20} to An_{30} range of oligoclase. Quartz contents vary (Figure 5a) but are typically interstitial polygonal aggregates of sutured and strained grains caused by post-consolidation deformation. Minor microcline is present in only a few places as small interstitial cross-hatched grains. Irregular light to dark brown pleochroic biotite flakes vaguely outline the foliation, and may have recrystallized since the development of the foliation. Biotite is commonly partly or wholly altered to very pale to light green pleochroic chlorite with anomalous blue birefringence. Fairly coarse irregular epidote grains are closely associated

[1]Except where stated, all plagioclase compositions in this report were determined by measurement of extinction angles on sections normal to cleavage (001) or (010).

OGS9824

Photo 13–Thin layered hornblende gneiss with minor dark amphibolite layers and lighter sheets and stringers of later leucotrondhjemite which are boudinaged and ptygmatically folded.

with the biotite-chlorite flakes as are the accessories allanite, sphene, iron oxide, and less commonly, zircon. Epidote may be a deuteric alteration product or caused by a retrograde metamorphic reaction involving breakdown of biotite.

Texturally, the gneissosity is outlined by a combination of thin quartz-rich layers and lenses and the biotite flakes. Evidence of ductile crushing is ubiquitous. Quartz-rich areas consist of polycrystalline aggregates of sutured grains showing undulose extinction and mortar texture in places, and are elongated parallel to the gneissosity. The intensity of strain does not appear, however, to have been severe enough to affect the plagioclase.

The rocks which are grouped under the heading of hornblende gneiss, Map Unit 8h (Map 2405, back pocket), occur in subordinate amounts throughout much of the northern half of the batholith in the map-area. The most striking feature of these is their well-layered and foliated character (Photo 13). The layering is caused by sharp variation in mafic mineral content (mainly hornblende) with layers generally less than 30 cm across as well as being usually enhanced by thin sheets of younger leucotrondhjemite material. Compositionally, (Figure 5a), the most common rock types are those containing about 25 and 45 percent mafic minerals and are equivalent to hornblende quartz diorite and amphibolite respectively; some layers are more leucocratic and contain more biotite than others. Where there is a large influx of later leucotrondhjemite sheets, the hornblende gneiss layers are commonly boundinaged.

Layers of hornblende quartz diorite composition (Figure 5a) are composed of medium- to coarse-grained granoblastic plagioclase and hornblende with interstitial quartz. The plagioclase is severely altered to very fine sericite, epidote, and calcite which obscures the albite twinning and interferes with the determination of anorthite content. The quartz is fine grained, interstitial, and strained. Hornblende, with typical pleochroism, is fresh, anhedral, unoriented with minor small quartz inclusions, and forms small knots of grains. Biotite, where present, is partly altered to chlorite and epidote. Epidote (up to 5 percent) occurs as irregular fresh grains close to, or within the mafic knots. Allanite, sphene, apatite, iron oxide, and zircon are present as accessories.

Layers of amphibolite composition (Figure 5a) are medium grained, granoblastic with typical pleochroic hornblende, and contain highly sericitized and saussuritized plagioclase. Minor quartz occurs as rounded grains here and there. A few coarse biotite grains, partly altered to chlorite, lie across the general foliation direction. Again, irregular medium-grained epidote occurs close to biotite and hornblende. Apatite is a common accessory, and minor iron-titanium oxide grains have thin rims of sphene.

Biotite-chlorite schist, Map Unit 8j, (Map 2405, back pocket), is generally associated with areas of hornblende gneiss, and occurs as thin layers and units of medium-grained, well foliated material with up to 25 percent biotite and/or chlorite as well as finer grained plagioclase and quartz. In a few places, small augen of plagioclase are sporadically distributed throughout this rock type.

Intermediate Plutonic Phases

A series of dioritic plutonic rocks occur throughout the batholithic area. Although individual phases are more common in some areas than in others, it is not possible to outline them as discrete plutons except in one case at the northern edge of the area about 1.6 km north of the head of Shinbone Lake, because of the later introduction of large amounts of leucotrondhjemite. This event obscures the spatial continuity of these rocks sufficiently to make their original extent uncertain, although the general impression is that they must have formed small irregular stocks, sheets, and dikes containing one or several phases. Their igneous texture is usually recognizable in outcrop and they can be more or less foliated due to alignment of mafic minerals.

The medium- to coarse-grained biotite-hornblende quartz diorite, Map Unit 8d (Map 2405, back pocket), is the most common type, and contains 25 to 30 percent hornblende with or without subordinate biotite. The modal analyses of some specimens (Figure 5a) outline a characteristic field in the Quartz-Feldspars-Mafics plot, and are overlapped only partly by some components of the hornblende gneiss unit. Microscopically, the rocks have a hypidiomorphic granular texture with subhedral, slightly zoned plagioclase well altered to sericite and epidote. This alteration makes plagioclase composition determination difficult, but values of An_{30} to An_{35} appear to be typical. Pale yellow-green to blue-green hornblende forms small knots of irregular anhedral grains, and is probably recrystallized. Biotite occurs in variable amounts and can be partly or wholly altered to pale green chlorite. Quartz forms small, interstitial, slightly polygonized grains showing strain extinction. Epidote is again common in irregular grains close to the mafic knots and plagioclase. Sphene and epidote are minor accessories.

There may be a complete spectrum of phases from hornblende to biotite quartz diorite, but from the field evidence available there is a gap between rocks with approximately equal amounts of hornblende and biotite and those with some 90 percent or more biotite in the total mafic content. Biotite quartz diorite, Map Unit 8c (Map 2405, back pocket), is coarse, hypidiomorphic granular, and has subhedral continuously zoned plagioclase, the centres of which are commonly severely sericitized. Plagioclase compositions vary from An_{34} near the centre to about An_{29} at the edge of the grains. Biotite forms coarse, randomly oriented grains associated with minor amounts of hornblende, coarse epidote (as an alteration production of biotite and plagioclase), and sphene. Quartz is interstitial and has strain extinction.

Small amounts of hornblende diorite, Map Unit 8b (Map 2405, back pocket), occur sporadically throughout the map-area, but on the northern boundary about 1.6 km north of the head of Shinbone Lake it forms an almost discrete pluton only partly injected by later leucotrondhjemite sheets. Hornblende diorite is a medium- to coarse-grained, dark coloured rock with plagioclase and hornblende aligned to give a vague foliation to the rock. Modally, the rock contains sufficient mafics to be termed gabbro (Figure 5a) but with the plagioclase composition around An_{32} the rock is more appropriately called diorite. Anhedral plagioclase is largely overprinted by coarse epidote and sericite flakes, but albite twinning is still apparent in some grains. Hornblende is subhedral with typical pleochroism and forms coarse decussate aggregates. A few flakes of almost colourless chlorite with minor sericite occur here and there, possibly after biotite. Sphene in rounded grains and small knots is a common accessory.

Where present in minor amounts on the south shore of Mercutio Lake, hornblende diorite is coarse grained with a colour index of about 35. The rocks here are quite close to the metavolcanic contact, and are more strongly foliated with elongate knots of decussate, very pale yellowish green tremolite-actinolite grains and minor colourless chlorite flakes; plagioclase retains its primary igneous outline, but is completely altered to fine-grained epidote and minor sericite. Thin chlorite flakes after biotite retain their random igneous orientation in the plagioclase-rich areas. A few minor quartz grains occur here and there.

Mafic Phases

Throughout much of the northern batholithic area, there is a substantial amount of fine- to medium-grained, dark, well-foliated to lineated amphibolite which is cut by, and appears as, huge blocks in the late leucotrondhjemite (Photo 14). Although contacts with the early gneisses have been disrupted by later deformation (Photo 11), remobilization, and intrusion, these amphibolitic rocks could be remnants of mafic metavolcanics which have been caught up in the batholithic intrusions. Near the metavolcanics these amphibolites may contain sparse relict feldspar phenocrysts, but elsewhere, the intensity of deformation and recrystallization has been sufficient to erase the igneous aspect. Thin section examination reveals that the amphibolites are even grained, almost

OGS9825

Photo 14–Amphibolite cut by leucotrondhjemite dikes and stringers with biotite trondhjemite gneiss on left.

granoblastic arrangements of vaguely aligned prismatic hornblende (55 percent) with anhedral plagioclase (40 percent) and minor quartz (Figure 5a). The plagioclase is extensively altered to fine-grained sericite, epidote, and minor calcite, and has compositions around An_{30}. Some contain minor biotite flakes usually more or less altered to chlorite. Sphene, iron-titanium oxide, pyrite, and carbonate are common minor accessories. In a few localities not far north of the metavolcanic belt, a more mafic, coarser grained amphibolite occurs with as much as 80 percent amphibole and chlorite as well as plagioclase and pyrite. The possibility of these recrystallized mafic rocks being remnants of the metavolcanic belt is considered later.

Leucotrondhjemite, Pegmatite, Aplite

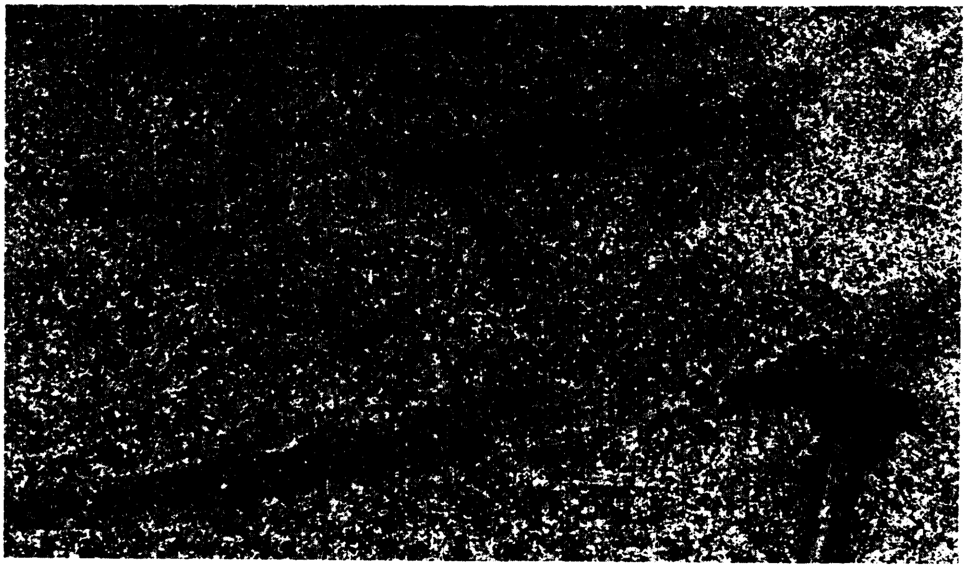
By far the most ubiquitous rock type throughout the whole batholithic area is a coarse-grained leucotrondhjemite phase which occurs as sheets, dikes, and stringers (Photos 11,13, and 14) and as well forms larger bodies which are typically intrusive. On close inspection this rock has the appearance of being the product of partial or total remobilization of the older phases with schlieren of more mafic material such as amphibolite and quartz diorite as well as wisps and narrow segregations of biotite and hornblende (Photo 15). These inclusions give the rock a foliated to gneissic appearance, but there is little alignment of the stubby, coarse, subhedral plagioclase laths set in interstitial quartz (Photo 15).

OGS9826

Photo 15–Typical leucotrondhjemite with blebby plagioclase in quartz matrix. Finer grained biotite trondhjemite gneiss schlieren outline earlier gneissosity.

Leucotrondhjemite has 5 percent or less mafic minerals, especially where it is intrusive, but where it grades into the older trondhjemite gneiss types, the amount increases to the level of that in the gneisses. Figures 5a, 5b show the close modal similarity between leucotrondhjemite and biotite trondhjemite gneiss. The texture is hypidiomorphic granular, plagioclase is patchily or completely altered to fine sericite, epidote, and calcite. Albite and pericline twinning are common and compositions are in the range An_{24} to An_{28}. The interstitial quartz is generally strained and polygonized. Biotite occurs as thin irregular unoriented flakes, and is almost totally altered to pale green chlorite. Where the intruded rock is hornblendic, leucotrondhjemite also commonly contains hornblende. Coarse irregular epidote grains and minor muscovite are common around the mafic minerals and nearby plagioclase. Sphene, apatite, and allanite occur as accessories in varying proportions throughout the map-area.

Very coarse grained pegmatitic and aplitic sheets, lenses, and stringers consisting of plagioclase and quartz with or without magnetite are closely associated with the leucotrondhjemite and are almost certainly a late-stage, more volatile-rich phase of the main leucotrondhjemite.



OGS9827

Photo 16–Typical unfoliated homogenous texture of late coarse-grained biotite-hornblende trondhjemite stock north of Star Island.

MASSIVE GRANITIC ROCKS

Biotite-Hornblende Trondhjemite

A small stock of coarse-grained biotite-hornblende trondhjemite, Map Unit 9a (Map 2405, back pocket), intrudes the earlier batholithic rocks on a group of small islands just south of the northern boundary of Trottier Township on Mercutio Lake. Dikes of the same material occur in the surrounding rocks. The contact of the stock with the country rocks is not well exposed, but the coarse, unfoliated texture of the rock (Photo 16), the lack of any cross-cutting phases, and the fact that dikes of the same material intrude the coarse leucotrondhjemite indicate its relatively late position in the intrusive sequence.

Figures 5a and 5b demonstrate that this rock type is modally distinct from the other trondhjemitic rocks because it has a measurably lower quartz content. The rock is hypidiomorphic granular in texture with subhedral plagioclase crystals up to 1 cm long which are prominent in outcrop. The mafic minerals form small clots evenly distributed throughout. In the field, the proportion of biotite to hornblende varies considerably with biotite alone present near the edges of the main body. Plagioclase is slightly zoned with albite and pericline twinning; and is fairly well altered to fine-grained sericite and epidote, especially around the edges or in certain zones or patches within grains, where the background plagioclase is more sodic because the alteration reaction apparently involves the anorthite component only. Fresh plagioclase compositions are in the range An_{20} to An_{23}. Minor antiperthitic microcline patches and accessory interstitial microcline occur in the biotitic border phase only. Quartz forms irregular interstitial patches and lenses of coarser, serrated, strained, and smaller polygonized grains. Hornblende forms small anhedral grains with narrow alteration rims of tremolite. Biotite occurs in coarse irregular flakes some of which have symplectic intergrowths of quartz, and is generally partly altered to pale green chlorite. Coarse irregular epidote is common in and around the knots of mafic minerals where also the accessories sphene, apatite, and iron-titanium oxides tend to be concentrated.

Porphyritic Hornblende Quartz Diorite

A discrete intrusive body of this rock type outcrops over much of the southern part of Star Island on Mercutio Lake, and cuts the leucotrondhjemite and earlier gneisses. Several phases may be present within the outline of the intrusion, because there is a rather wide variation in mafic mineral content from place to place (Figure 5b) with a median value around 35 percent. In some places near the contact of the intrusion, quartz diorite is cataclastically sheared and the mafic minerals are badly altered and streaked out, but generally the rock has a characteristic unfoliated, coarse-grained, hypidiomorphic to porphyritic appearance. Plagioclase is commonly porphyritic, but in some localities coarse euhedral hornblende phenocrysts are set in a finer grained plagioclase, hornblende, and quartz matrix giving the rock a colour index of up to sixty percent. In the typical rock, subhedral plagioclase is well clouded by alteration to fine-grained epidote, sericite, and minor carbonate, behind which albite twinning is visible and gives a composition of An_{29} using the maximum extinction angle method. Pale yellow-green to brownish green pleochroic actinolitic hornblende occurs in irregular, sieved grains and prisms, and is rimmed by very pale green tremolitic amphibole. Chlorite occurs in large, almost colourless flakes which contain lenses of sericite and is in places intergrown with amphibole. Coarse irregular epidote grains occur in and around the mafic minerals. Quartz is interstitial and broken into aggregates of smaller sutured grains. Zircon and apatite are minor accessories.

A minor pegmatitic phase of the hornblende quartz diorite cuts the main body and is well seen at one point on the western shore of Star Island, opposite the outflow of the Mercutio River, where very coarse euhedral hornblende prisms up to 8 cm long and partly altered to chlorite are set in a plagioclase-quartz matrix with accessory euhedral sphene crystals up to 4 mm long. A few mafic dikes containing rounded knots of mafic minerals, about 1 cm across, in a finer grained matrix very similar to the mafic hornblende quartz diorite phase, outcrop on the east shore of Star Island and sharply cross-cut leucotrondhjemite sheets in older gneiss. The dikes in turn are cut by a few thin slightly folded stringers of pink medium-grained granodioritic aplite. The mafic knots comprise fine- to medium-grained aggregates of hornblende with minor sphene-rimmed iron-titanium oxide grains set in a matrix of fine saussuritized plagioclase.

Granodiorite, Quartz Monzonite, Pegmatite

The only rocks in the batholithic area with substantial potassium feldspar are a number of late granodiorite to quartz monzonite intrusions, sheets, and dikes with associated stringers and dikelets of pegmatite and aplite. All batholithic rocks along the contact with the metavolcanics are more strongly foliated than they are farther north, and the granodiorite phases (Figure 5b) which are commonly present in this zone in Trottier Township are no exception. Their foliated nature and grey appearance make them almost indistinguishable from the typical trondhjemitic rocks unless stained with sodium cobaltinitrate. Therefore, the placing of these rocks as individual intrusions on the geological map is schematic and outline zones containing mainly granodiorite sheets and dikes which locally can be observed to cross-cut the main leucotrondhjemite batholithic phase. Subhedral plagioclase is surrounded by interstitial microcline and quartz; biotite, more or less altered to chlorite, outlines the foliation.

The quartz monzonite phases of this later suite tend to be pink and form more discrete small bodies, but also form accompanying sheets and dikes as in the extreme northwestern corner of Weaver Township and along the rapids between Union and Mercutio Lakes. Very coarse grained muscovite pegmatite and medium-grained aplite typically of granite composition, are considered to be the final phase of the quartz monzonite intrusive sequence. The quartz monzonite itself is coarse grained, leucocratic, hypidiomorphic granular, and unfoliated in outcrop. Subhedral, slightly zoned plagioclase (An_{22}) with albite, pericline, and, less commonly, Carlsbad twinning is patchily sericitized, and may have myrmekitic intergrowths against microcline grains. Microcline forms coarse, fresh, anhedral, cross-hatch-twinned grains with fine string perthitic intergrowths. Interstitial quartz, as in virtually all the batholithic phases, is strained, sutured, and polygonized. Biotite, in irregular flakes, forms small knots with minor muscovite, and may be slightly altered to pale green chlorite. Small aggregates and irregular grains of epidote are common near the biotite, as are the accessories allanite and apatite.

Porphyritic Biotite Granodiorite

A single small stock of distinctive porphyritic biotite granodiorite has intruded and hornfelsed the low grade metasediments on the south shore of Crooked Pine Lake in Trottier Township. The stock forms a sheet-like or oval body 90 m wide and a minimum of 120 m long that disappears under the lake on both sides of the headland. The granodiorite and nearby metasediments are cut by vertical quartz veins up to 60 cm across, and by narrow quartz vein stockworks trending about an azimuthal bearing of 105°, roughly parallel to the north and south contacts. Around the quartz veining are pervasive alteration zones which contain up to 5 percent disseminated pyrite. Specular hematite was noted within the quartz veins. Assays of alteration zone and quartz vein material returned only trace amounts of gold, silver, copper, and molybdenum (Sample taken by author and analysed by Geoscience Laboratories, Ontario Geological Survey).

Where fresh, the granodiorite is porphyritic hypidiomorphic granular with subhedral, elongate plagioclase phenocrysts up to 6 mm long which are delicately and sharply zoned. In some crystals, certain zones have been selectively altered to sericite whereas in others sericite clouds the whole grain. In the matrix, subhedral plagioclase is twinned and similarly altered, with microcline and strained quartz being interstitial. Biotite forms coarse stubby flakes and knots which are well altered to muscovite, chlorite, and minor carbonate. Apatite and pyrite are common euhedral accessories. A modal analysis of typical granodiorite is plotted on Figure 3.

Evidence is lacking about the age of the intrusion, especially about its age relative to the regional metamorphism which in the area was not severe. Shearing and fracturing in the body can be more easily related to movements on the nearby Quetico Fault than to earlier regional deformation, which would have superimposed a more penetrative foliation. Well foliated feldspar porphyry layers observed here and there in the metasediments to the south may be of similar age and origin but are now highly deformed in comparison with the rocks in this small stock. These are briefly described in the section "Biotite phyllite, schist".

Mafic Intrusive Rocks

Diabase

A number of late, narrow diabase dikes are present on Star Island and the mainland to the east. These trend generally northeast and are steeply dipping with rather sharp, cross-cutting contacts and have more or less sheared, chilled margins against the other late batholithic intrusive rocks. The dikes are generally medium, even grained, dark green, and unfoliated. They have undergone static low grade metamorphism with the relict subophitic laths of plagioclase remaining intact but almost completely clouded and altered to epidote, sericite, and calcite.

Minor interstitial quartz is present and may be secondary. The original mafic minerals are now coarse- and fine-grained decussate aggregates of pale to medium green, pleochroic actinolite and light brownish yellow to blue-green hornblende. Skeletal grains of iron-titanium oxide rimmed by sphene are common accessories. Two modal analyses of typical samples are plotted on Figure 5b.

MIDDLE TO LATE PRECAMBRIAN

Mafic Intrusive Rocks

Diabase

Throughout the area occupied by metavolcanic and batholithic rocks are a number of sharply cross-cutting medium-grained diabase dikes which are considered to be much younger than their Early Precambrian (Archean) host rocks. Most outcrops of the diabase, however, do not display contacts with the country rocks, and it is difficult to say whether they all have a consistent trend, although one at least, located on a small island in the northeast arm of Mercutio Lake, has a northwest trend. The diabase has a characteristic light brown weathered surface and a typical subophitic texture. Thin section examination reveals that elongate laths of twinned subhedral plagioclase, severely altered to epidote and sericite, form over 40 percent of the rock (Figure 2). Neutral coloured, irregular, anhedral, and poikilitic augite in places replaced and rimmed by amphibole is the main mafic mineral. Some 10 percent of the rock consists of irregular pockets of finely divided chlorite, amphibole, and "chlorophaeite" which are likely the products of trapped devitrified glass. A brownish green hornblende similar to the late magmatic alteration product of the augite forms small anhedral grains. Up to 5 percent euhedral skeletal magnetite is present as well as minor interstitial quartz.

In the southern metasedimentary belt, narrow, cross-cutting, medium- to fine-grained diabase dikes were noted only in four localities. Near Highway 633 and on the main logging road just northeast of Eva Lake, narrow diabase dikes and stringers sharply cross-cut the metasedimentary gneiss layering in step-like fashion, whereas two peneconcordant medium-grained sheets of diabase were observed just southeast of Nydia Lake.

Phanerozoic

CENOZOIC

Quaternary

PLEISTOCENE AND RECENT

During the Wisconsin glaciation (Zoltai 1965), continental ice sheets deposited a discontinuous thin veneer of sandy till throughout the map-area. Glacial striae which are fairly common on lake-shore outcrops throughout the area, indicate that the main ice movement during this period was from the northeast with all measurements within the range N25°E to N55°E. The surficial geology of the region has been mapped by Zoltai (1965) who indicated that much of the ground moraine has been overlain by fine sandy and silty loess north of Crooked Pine Lake. The Seine River valley in the extreme northwest corner of the area, is filled with fine sand which was taken by Zoltai (1965) to be part of a large lacustrine deposit of deltaic sand and valley train, filling the river valley to the northeast. The low-lying area of sand plain north of Eva Lake is an outwash deposit which has been reworked by the lake to form sand beaches.

Recent deposits are associated with the rivers and lakes in the area, and include clay, silt, and sand, some of which are reworked from glacial material. Organic mud has accumulated in swamps, and around shallow lake shores and sluggish rivers such as the Atikokan River which drains westwards through its own deposits in wide meanders and oxbow lakes at the east end of Crooked Pine Lake.

STRUCTURAL GEOLOGY

The Quetico Fault, which trends eastwards through the centre of the Crooked Pine Lake area, marks the boundary between the metavolcanic and batholithic rocks of the Wabigoon Subprovince to the north and the metasedimentary and related rocks of the Quetico Subprovince to the south (Ayres *et al.* 1971). None of the lithologic units in the map-area can be correlated across the fault which may have right lateral displacement of several tens of kilometres (Mackasey *et al.* 1974). For this reason the older structural elements in each domain north and south of the Quetico Fault are described separately.

Minor Structures North of Quetico Fault

In the metavolcanic belt, primary lithologic interfaces between flows and beds are well sheared and generally trend parallel to the main foliation which strikes N70°E to N90°E and dips 70°N to 90°N. This foliation, mainly defined by chlorite or sericite, is best developed in fine-grained metavolcanic tuff and lapilli-tuff in which the elongate fragments are also aligned. The foliation is also present in some of the mafic flows and medium- to coarse-grained metamorphosed intermediate and felsic intrusive rocks. In a few places, a later crenulation cleavage has been superimposed on the main foliation, and since it becomes more apparent towards Crooked Pine Lake, it may be related to movement on the Quetico Fault. Northwards towards the contact with the batholithic rocks, an increase in metamorphic grade is accompanied by a stronger development of lineation as well as foliation, especially in the mafic rocks. In the contact zone all rocks are strongly cataclastically deformed and foliated with quartz streaked out and displaying mortar structure, chlorite again is more common and plagioclase grains are bent and severely altered to epidote and sericite. This deformation is likely caused by late differential vertical movement between the batholithic terrain and the more dense metavolcanic sequence.

In the batholithic area, the older trondhjemite and hornblende gneisses commonly show compositional layering which has been accentuated by intrusion of later peneconcordant sheets of leucotrondhjemite (Photos 12 and 13). Quartz diorite and amphibolite are typically foliated to lineated, and these rocks are cut by the leucotrondhjemite and related pegmatites which contain elongate nebulitic xenoliths of the earlier foliated rocks (Photo 15). Some or all of these planar structures commonly occur in individual outcrops. Since these structures are invariably parallel to each other, and the later features appear to be controlled by the early gneissic structure, they have been recorded under the heading of gneissosity. This gneissosity is generally curvilinear to folded in small-scale swirls which have moderate, variable plunges. Over the scale of a large outcrop, a consistent trend generally occurs which is around N70°E to N100°E, and moderately to steeply dipping north; but in a fairly wide belt from the northwest corner of the map-area southeast through Lance Lake and Star Island, the gneissosity has a distinctive southeasterly strike.

All of the main batholithic intrusive and related rocks have been deformed and slightly recrystallized during a later event, because the leucotrondhjemite sheets are plastically folded, pinched, and boudinaged within the more gneissic host rocks. Cross-cutting veins and stringers are ptygmatically folded by differential movement on the foliation planes of the gneisses (Photo 13). Late local shear zones occur throughout the area, and have been distinguished by foliation symbols on Map 2405 (back pocket).

Minor Structures South of Quetico Fault

Throughout the northern part of the metasediments, primary sedimentary structures such as graded bedding, slump features, and intraformational breccias are preserved within the regular, thin to thick-bedded wacke-mudstone sequence, and all give an indication of younging towards the north. In general, the bedding strikes N75°E to N95°E and dips 70 to 90°N, except where it has been forcefully deflected by the intrusion of the Elbow Lake Mafic Complex in the eastern part of Weaver Township. Recrystallization and deformation accompanying the main metamorphism of the sequence imparted a strong foliation or schistosity which is generally subparallel or parallel to the primary lithologic layering. Locally, this primary layering is cross-cut by the main foliation where the remnants of a drag fold remain. Generally the deformation has transposed, by folding and shearing, original bedding into alignment with the main foliation so that folding is not commonly observed. The survival of delicate sedimentary structures such as soft sediment folds and intraformational breccias in rocks which have been recrystallized to staurolite-garnet-biotite schists, indicates that slip during folding took place on planes which locally must have been spaced 1 to 2 m apart. Here and there, in the biotite schist, a late crenulation cleavage has been developed across the main foliation. Sheets and dikes of hornblende gabbro and related rocks which are present throughout the metasediments, are invariably pinched and boudinaged owing to their differing competence during deformation. Among late structures observed in the northern section of metasediments, are a set of conjugate kink folds and related minor faults which have a dominant right lateral set trending approximately N40°W and are vertical. It is possible that these are related to the Quetico Fault stress pattern.

Farther south, in the biotite gneiss and related granitoid mobilizate sheets and dikes, the compositional layering of the original wacke-mudstone beds is the major planar structure with the layers having an internal parallel foliation. This structure, as well as the accompanying concordant granitoid mobilizate sheets, which are also vaguely foliated, were combined and recorded as gneissosity. The strike of the gneissosity attitudes is more variable than the bedding and schistosity farther north. Dips range from gentle to steep, and probably outline large scale open asymmetrical folds with axes trending approximately N70°E and variable in plunge. Two such structures have been outlined southeast of Nydia Lake on the basis of gneissosity attitudes, and more detailed measurement would undoubtedly reveal more. Small folds are common in most outcrops, and tend to be open with fairly consistent axial plunges on a local scale, but highly variable on the scale of the map-area. As well as being infolded with the metasedimentary gneisses, the granitoid mobilizate sheets are commonly pinched and boudinaged (Photo 8), indicating that the major deformation continued beyond the period of anatexis. The presence of a vague foliation outlined by biotite flakes throughout the areas of homogeneous diatexite may also be caused by the continuing deformation or possibly to flow during accumulation of mobilizate material.

Faults

The Quetico Fault, which is a major regional structure stretching from Lac des Mille Lacs to the east of the map-area through the Fort Frances area into Minnesota to the west, occurs as a highly deformed, vertically dipping zone up to some 100 m wide which is exposed in places along the south shore of Magnetic Lake and the north shore of Crooked Pine Lake. The fault marks the contact between the metavolcanic belt to the north, and the metasedimentary sequence to the south. Within the zone, mafic metavolcanic and intrusive rocks have been converted to chloritic phyllite, whereas intermediate to felsic metavolcanics and wacke material have been converted to sericite phyllite or, where less micaceous, mylonite with mortared and comminuted matrix containing elongate strained quartz augen. Quartz and minor carbonate form lenses, stringers, and veins throughout the zone. The foliation in both the metavolcanics and metasediments near the zone trends around N80°E, is vertical, oblique to the east-trending fault, and possibly indicative of dextral movement. A later vertical crenulation cleavage observed on both sides of the fault and trending in a more northeasterly direction, also appears related to fault movements.

Mackasey *et al.* (1974) have postulated a major horizontal right lateral dislocation on the Quetico Fault. Hawley (1929) suggested a similar net movement direction from examination of the minor structures. In the map-area, minor structures such as drag folds and slickensides indicate oblique senses of movement with either dextral or sinistral components and in a few instances near vertical movements. These movements are probably related to minor displacements late in the history of the fault.

Indirect evidence of at least moderate movement on the fault zone comes from the observation that the grade of metamorphism differs across the fault. Turbidites just south of the fault contain lithic clasts with plagioclase feldspars which appear to have retained their primary igneous composition and character, whereas just to the north of the fault, all plagioclase in the metavolcanics is generally altered to epidote, carbonate, and sericite.

The Elbow Lake Fault trends southeast through Boundary Lake out of the area. Its topographic expression can be traced through Huronian Lake and the Kashabowie area as far as the Shebandowan Mine some 54 km away where it is termed the Crayfish Creek Fault (Morin 1973). To the northwest, good evidence of its existence is lacking, but it is considered to have deflected westwards into parallelism with bedding and foliation in the wacke-mudstone towards the end of the major movement, although, earlier in its history, the Elbow Lake Fault may have followed the lineament outlined by the narrow, northwest-trending bay on Crooked Pine Lake, and joined up with the Quetico Fault System.

There is undoubtedly a major displacement across the fault at Elbow Lake. The metasediments on the southwest side of the fault are more strongly metamorphosed and contain a much greater percentage of granitoid mobilizate than the adjacent rocks to the northeast. The low angle between the metamorphic isograds and the fault trace, and the presence of the southern half of the Elbow Lake Mafic Complex close to the fault, make accurate correlation across the fault difficult. Nevertheless, the horizontal dextral displacement on the Elbow Lake Fault is of the order of 3 to 6 km, and this trend and sense of movement suggests that it is a major second order right-lateral wrench fault compatible with a similar movement sense on the first order Quetico Fault. Minor segments of the fault zone outcrop on promontories in Elbow Lake where it consists of a massive quartz vein stockwork up to 40 m wide enclosing fine-grained altered siliceous country rock. At the northwest end of the lake, the biotite schist has been dragged into parallelism with the fault trace, cataclastically deformed and retrograded, with chlorite the main mafic mineral present.

A series of fault lineaments, which in a few places outcrop as shear zones with quartz stockwork, occur parallel to and south of the Elbow Lake Fault. These lineaments also deflect westwards into the main bedding and foliation alignment where they are hard to identify on the ground. The severe shearing and foliation which commonly occurs throughout the main graphic granite pegmatite body from west of Elbow Lake through Heward and Kawene Lakes is likely to be related to these fault movements.

In the northern metavolcanics and batholithic rocks a number of north-northeast-trending lineaments exist which are possibly fault zones, but the lack of stratigraphic markers precluded any measurement of displacement. These are part of a regional set of faults and lineaments outlined by Pye and Fenwick (1965) throughout the Marmion Lake Batholith and surrounding rocks.

METAMORPHISM

North of the Quetico Fault, the Early Precambrian rocks of the metavolcanic belt have undergone low grade metamorphism. The mafic rocks comprise varying proportions of actinolite, chlorite, epidote, albitized plagioclase, and quartz, minerals typical of greenschist facies conditions. At the contact with the batholithic rocks to the north, a general increase in metamorphic rank to lower amphibolite facies occurs and is marked by the appearance of a darker hornblendic amphibole in place of actinolite, although plagioclase may continue to be badly altered to sericite or epidote. Within the batholith, biotite and hornblende along with oligoclase, are common, and although they do show signs of retrogressive alteration, the bulk of the rocks have not undergone complete greenschist facies recrystallization.

South of the Quetico Fault, within the metasedimentary belt, the grade of metamorphism increases rapidly from low greenschist facies just south of the Quetico Fault to upper amphibolite facies with concomitant anatexis below the southern boundary of Trottier and Weaver Townships, a distance of some 5.5 km. From the evidence available, metamorphic isograds (Figure 4) trend roughly easterly parallel to the main layering and foliation in the turbidite metasediments, but these may be displaced in the eastern part of the area by the Elbow Lake Mafic Complex and by movement on the Elbow Lake Fault. The combination of variable outcrop pattern, variation in bulk composition of pelitic layers, intrusion of large pegmatite bodies, and difficulty in positively identifying phases such as cordierite in the field, mitigate against complete unravelling of the metamorphic relationships, but from the data available some observations can be made. In the more pelitic tops of turbidite units around the south shore of Crooked Pine Lake, only chlorite, sericite, and carbonate accompany plagioclase and quartz; but within a short distance to the south, biotite and epidote appear, with chlorite and carbonate decreasing in amount. Albite-twinned plagioclase clasts are lightly dusted with sericite, and can be different in composition within the same sample (generally between An_{15} and An_{30}) reflecting variety in source material. Southwards, the plagioclase becomes more equigranular and recrystallized with the rest of the minerals and it is difficult to determine the composition. Garnet can be identified in the rocks south of an east-trending line south of Tower Lake (Figure 4) and within as little as 90 m to the south staurolite and andalusite appear with garnet and biotite for some 360 m before andalusite disappears. At about the same location, the clastic nature of the rocks can no longer be distinguished. Staurolite persists with garnet and biotite for about a further 920 m before it also disappears (Figure 4). At about this horizon south of Heward Lake, cordierite occurs with garnet, and this assemblage was again observed some 2000 m south where some layers contain coarse sillimanite and biotite assemblages and there are considerable volumes of coarse-grained quartz monzonite sheets, veins, and stringers.

As well as the changes in the mineralogy of the pelites, the granitoid rocks also show progressive changes from north to south with the first indication of quartz monzonite, pegmatite veins, and stringers occurring just north of the appearance of garnet. The proportion increases steadily southwards, larger sheets and bodies occur in the biotite gneiss until the quartz monzonite material becomes the major phase containing rafts and blocks of the layered biotite gneiss. Finally, large elongate bodies of homogeneous, slightly foliated quartz monzonite diatexite over 1 km across occur within zones of biotite gneiss-migmatite around Eva Lake.

Carbonate-bearing layers are not common in the turbidites, and are hard to distinguish from the typical semi-pelites around Crooked Pine Lake, but they manifest themselves by the formation of tremolitic amphibole porphyroblasts as biotite becomes established in the surrounding rocks. Southwards into the migmatite zone, these rocks are observed as hornblende biotite schist. The only occurrences of thin marble units are at the southern end of Elbow Lake. The calc-silicate assemblage associated with these units, comprises actinolite, diopside, grossularite, wollastonite, and calcite, and is consistent with the upper amphibolite facies level of metamorphism in the pelitic rocks and the amount of anatectically derived quartz monzonite in the surrounding rocks.

Comparison of the regional metamorphic features of the Quetico Metasedimentary Belt in the Crooked Pine Lake area with other areas along the length of the belt (Pirie and Mackasey 1978) suggests that the pattern outlined here is fairly typical of the belt as a whole. On the basis of the metamorphic mineral assemblages observed along the belt, the path of metamorphism followed that of a curve from very low grade conditions through the andalusite stability field and culminated in granulite facies conditions around 720°C and 4.2kb.

HISTORICAL GEOLOGY

The major lithologic belts in the Crooked Pine Lake area are separated from each other by zones of faulting or deformation. Each belt apparently underwent a different sequence of geological events which is difficult to correlate across their boundaries (Table 3).

In the metasedimentary belt, there are no Early Precambrian rocks which can be correlated with any north of the Quetico Fault in the map-area. All evidence points to there having been substantial lateral displacement on the fault itself. The monotonous sequence of variable , thin- to thick-bedded, wacke-mudstone exposed suggests that it was deposited as a distal facies of turbidite sedimentation. The presence of granule to pebble conglomerate beds along the shore of the small bays at the western end of Crooked Pine Lake may indicate an upward coarsening of the sequence as the depositional basin was filled. Clasts in the wacke layers include a variety of fresh volcanic types indicating that the source of sediment was a volcanic pile similar to the rocks seen north of the fault. From this evidence, the suggestion of Mackasey *et al.* (1974) that the turbidite deposition was contemporaneous with the waning stages of volcanism seems reasonable.

Following the infilling of the depositional basin with several kilometres of turbidite material, deformation and folding began and was briefly interrupted by the intrusion of mafic to ultramafic stocks, sheets and dikes especially in a zone parallel to and some 2 to 3 km south of, the Quetico Fault.

The progressive nature of the regional metamorphism is well exhibited by the change in the turbidites from the wacke-mudstone units with primary sedimentary structures and mineralogy along Crooked Pine Lake, through the zone of recrystallized biotite phyllite and schist into biotite gneiss with associated anatexis of the low melting fraction, and culminating in the formation of bodies of homogeneous quartz monzonite diatexite towards the southern map-area boundary. Evidence that deformation continued beyond the period of crystallization of the granitoid fraction is provided by the common occurrence of boudinage, the granitoid material having reacted more competently than the enclosing gneiss.

The lack of penetrative deformation in the small stock of porphyritic biotite granodiorite which intrudes the metasediments on the south shore of Crooked Pine Lake suggests that it is a late igneous phase. Possibly it may be related to the narrow porphyry sheets noted in the metasediments, which appear to have been deformed with their enclosing rocks. No evidence for the correlation of these rocks exists apart from the porphyritic nature of the plagioclase in them.

North of the Quetico Fault, the intermediate intrusions within the metavolcanic belt cover the field from quartz diorite to trondhjemite (Figure 2). These rocks are modally similar to the group of foliated quartz diorite, diorite, and trondhjemite gneiss rocks (Figure 5a) as well as leucotrondhjemite (Figure 5b) in the batholith. Similarly, the quartz monzonite bodies in the metavolcanics (Figure 2) are close modally to those in the sequence of late batholithic intrusive rocks. The small number of modal analyses of these various intrusive rocks makes this a tentative correlation which can only be more accurately assessed after detailed trace element and geochronological studies have been done. If it is taken as a working hypothesis then several interesting points follow (Table 3).

The "epizonal" (Buddington 1959) quartz monzonite and trondhjemite to quartz diorite sequence as well as the host mafic to felsic volcanic rocks in the metavolcanic belt have all undergone minor deformation and greenschist metamorphism together. The presence of relict igneous textures and mineralogy in some places, suggests that there was no earlier deformation or recrystallization. In contrast, the quartz diorite, diorite, and amphibolite phases in the batholith were deformed, foliated, and partly recrystallized before the massive introduction of leucotrondhjemite, the ubiquitous distribution of which suggests intrusion at "catazonal" depths compared with the later stocks, including the quartz monzonite, which are more "mesozonal to epizonal" in character.

The batholithic biotite trondhjemite and trondhjemite gneisses all have modal and mineralogical compositions of typical plutonic igneous rocks. The strong gneissic structure and layering in these rocks must have been developed before the intrusion of the foliated diorite and quartz diorite. Contacts between these rocks and amphibolite tend to be concordant. If the amphibolites represent remnants of metavolcanics, then the gneisses are younger than the period of volcanism, and the trondhjemitic rocks would have invaded the deepest parts of the volcanic pile before deformation formed their gneissic character. An alternative possibility is that the amphibolite remnants represent dismembered feeder dikes related to the period of volcanism that would make the gneisses part of an earlier granitoid basement on which the volcanic rocks were deposited. The intimate interlayering of hornblende quartz diorite and amphibolite material in the hornblende gneiss unit suggests an origin by deposition at the earth's surface, rather than by intrusive processes, and therefore these rocks also are probable remnants of a volcanic sequence.

Upward movement of the batholithic rocks relative to the slightly denser metavolcanics along the contact zone has blurred any good evidence of a gradual progression from the "epizonal" conditions in the metavolcanics to the "catazonal" conditions during the climax of the main batholithic event. The low grade metamorphism of the main part of the metavolcanic belt and the forma-

TABLE 3 SEQUENCE OF EVENTS IN EACH OF THE THREE MAIN GEOLOGICAL AND TECTONIC DOMAINS WITH TENTATIVE CORRELATION OF SOME EVENTS IN ADJACENT DOMAINS.

Batholith	*Metavolcanic Belt*	*Metasedimentary Belt*
MIDDLE TO LATE PRECAMBRIAN DIABASE (cratonic)	DIABASE (cratonic)	DIABASE (cratonic)
EARLY PRECAMBRIAN		
Uplift completed		
Greenschist facies conditions	Deformation and greenschist facies metamorphism	
		PORPHYRITIC BIOTITE GRANODIORITE
DIABASE DIKES (epizonal)		
Uplift		Uplift
LATE BATHOLITHIC STOCKS (mesozonal to epizonal)	QUARTZ MONZONITE*	
		QUARTZ MONZONITE PEGMATITES & MIGMATITES
Major Uplift begins		
LEUCOTRONDHJEMITE (catazonal)	TRONDHJEMITE*	Climax of metamorphism, anatexis and deformation
Deformation & recrystallization under amphibolite facies conditions		MAFIC TO ULTRAMAFIC COMPLEXES
DIORITE, QUARTZ DIORITE	QUARTZ DIORITE*	
Major deformation & recrystallization to give gneisses		Burial, deformation & metamorphism begins
TRONDHJEMITE GNEISS		
BIOTITE TRONDHJEMITE GNEISS		WACKE-MUDSTONE
Intrusion of trondhjemites into base of metavolcanic belt	INTERMEDIATE TO FELSIC VOLCANICS	TURBIDITES
AMPHIBOLITE HORNBLENDE GNEISS	MAFIC TO INTERMEDIATE VOLCANICS	

*no cutting relationships observed in field, some or all may be subvolcanic tion of lower amphibolite facies assemblages noted close to the batholithic rocks could have taken place during this period of isostatic readjustment.

The diabase dikes which cut the late batholithic stocks are totally recrystallized to greenschist facies assemblages and appear to represent a late minor phase of mafic magmatism before completion of the uplift of the batholithic area. The fresher pyroxene-bearing diabase dikes which have been categorized as Middle to Late Precambrian in age, have cut batholithic rocks and metavolcanics alike during a period of tensional stress following the cessation of all movement and the development of the Superior cratonic block.

ECONOMIC GEOLOGY

Much of the metavolcanic belt and adjacent batholithic rocks in the region of Crooked Pine Lake were prospected for gold in the latter part of the last century and early part of the present century with little success. Minor chalcopyrite occurs with pyrite in disseminations within mafic to intermediate metavolcanics, especially in the eastern part of Weaver Township. No base-metal showings as such are known, except at one locality towards the west end of the Quetico Fault where minor chalcopyrite occurs in quartz veins and lenses in the fault zone. South of Crooked Pine Lake, minor copper-nickel mineralization has been outlined within the mafic to ultramafic bodies intruding the metasediments, and minor uranium staining has been noted within a large body of muscovite graphic granite pegmatite.

Gold

McInnes (1899) reported that gold-bearing quartz veins were discovered on a small island in Partridge Lake (now Mercutio Lake) by Archibald McKellar in 1872. Coleman (1894, p.58) described the same showing in more detail, but mentioned Partridge Lake being east of Lac des Mille Lacs. Since there is no accurate location map for the deposit it may, in fact, not be in the Crooked Pine Lake area, and certainly no locality on Mercutio Lake was found which fits the descriptions in the literature.

Only two other gold occurrences are present in the map-area, both of which are in the metavolcanic belt with the White Lily Showing reported to have minor gold values in otherwise unmineralized quartz vein material at a contact between metavolcanics and porphyry. The Pothole Occurrence,however, carries gold values in arsenopyrite, chalcopyrite, and pyrite stringers within the quartz veins which cut intermediate tuffs. Hawley (1929) concluded from his examination of the gold-bearing veins in the area to the west that they tend to be closely associated with the abundant lenticular porphyritic intrusions in the metavolcanics.

Base-Metal Sulphide Minerals

Minor disseminated pyrite is widespread throughout the metavolcanic belt, minor chalcopyrite occurs with the pyrite locally in some fragmental units, especially in the eastern part of Weaver Township. At the western end of Crooked Pine Lake, some coarse chalcopyrite occurs in quartz-calcite lenses and as fracture coatings within a 30 cm wide zone some 6 m long in chlorite-sericite phyllite parallel to the Quetico Fault. A well mineralized grab sample taken by the author contained 1.12 percent copper and 0.26 ounce silver per ton (assay by Geoscience Laboratories, Ontario Geological Survey), but the mineralization appears to be localized and spotty. Similar zones mineralized only with pyrite occur here and there along the fault zone and all may be due to redistribution of minor sulphides from the metavolcanics close to and within the fault zone.

Copper and Nickel

Minor pyrrhotite and chalcopyrite form irregular sulphide blebs and disseminations interstitial to, and within coarse hornblende in hornblendite and feldspathic hornblendite phases of several small mafic to ultramafic composite intrusions which occur as elongate bodies in the metasediments aligned along the southern boundaries of Trottier and Weaver Townships. Similar intrusions with associated minor sulphide mineralization were noted by Irvine (1963) in the adjacent area to the east. The general geology of the Abiwin Occurrence, Mud Lake Deposit, and F.O.B. Mining Exploration Limited (Kawene) property is described in the section on mafic to ultramafic rocks and the history of exploration is outlined in the description of properties.

None of the properties have sustained interest owing to the extremely localized nature and small size of sulphide concentrations located to date. The best values found over a few metres in diamond-drill holes and in well mineralized grab samples are in the order of 1 percent combined copper and nickel; copper concentrations are generally greater than nickel, which appears to be almost entirely contained in pyrrhotite. On analysis for platinum group metals, mineralized grab samples from the Kawene and Abiwin properties taken by the author contained only trace amounts of palladium (Geoscience Laboratories, Ontario Geological Survey). The textures of the sulphides reveal that minute chalcopyrite and pyrrhotite grains were trapped within the coarse hornblende crystals during their crystallization, and that larger sulphide blebs and segregations which occur between hornblende crystals formed as immiscible sulphide droplets which coalesced later in the crystallization history of the hornblendite phases. From the analytical data available (Legault 1976), the background nickel content of these hornblende-rich ultramafic phases appears to be much lower than that of typical serpentinite bodies (Watkinson and Irvine 1964) which can have associated nickel deposits. This suggests either different mantle sources for the respective magmas or the fractional crystallization of a nickel-preferring phase such as olivine prior to intrusion.

The larger mafic to ultramafic complexes at Elbow and Heward Lakes contain only minor disseminated pyrrhotite and pyrite here and there. No sign to date has been found of any sulphide concentrations similar to those found in the smaller bodies, but the same rock types are present in all.

Uranium

Only one minor occurrence having a yellow uranium stain has been noted in the area, and it is associated with the large muscovite graphic granite pegmatite body in the metasediments on the Heward Lake Occurrence of W.D. Morehouse.

DESCRIPTION OF PROPERTIES

Atikokan Iron Lands Limited (1)[1]

Claims E-27 and E-86 were patented in 1889 and 1890 respectively and are presently in good standing with taxes being paid by Atikokan Iron Lands Limited, 121 South May Street, Thunder Bay. No record of work on the claims has been found.

F.O.B. Mining Explorations Limited (Kawene) (2)

Minor sulphide mineralization occurs in a small mafic to ultramafic body which straddles the map-area boundary some 1400 m N55°W of Kawene Station on what is known as the Kawene Copper Occurrence. The Hanna Mining Company carried out magnetometer, electromagnetic, and geological surveys over the area in 1965, and uncovered chalcopyrite and pyrrhotite in coarse disseminations by trenching at several locations within the body. A grab sample of mineralized material taken during the work contained 0.49 percent copper and 0.22 percent nickel (Assessment Files Research Office, Ontario Geological Survey, Toronto). In 1970, Canadian-Addicks Mining Corporation diamond drilled one hole for a length of 57 m and carried out a limited airborne electromagnetic survey over the showing and its extension to the east and outlined two elongate anomalies along strike on Kawene Lake and farther east. These anomalies coincide with a discontinuous elongate sheet of mafic to ultramafic rocks outlined during the present survey. The best intersection in the diamond-drill hole was between the 5.2 m and 7.6 m lengths containing 0.28 percent copper and 0.14 percent nickel (Assessment Files Research Office, Ontario Geological Survey, Toronto). A grab sample taken by the author from a well mineralized trench just outside the map-area boundary contained disseminated blebs and knots of pyrrhotite

[1]Number in parentheses refers to property list on Map 2405, back pocket.

and chalcopyrite and gave 0.49 percent copper, 0.06 percent nickel, and trace palladium (Geoscience Laboratories, Ontario Geological Survey). In 1975, F.O.B. Mining Explorations Limited held claims TB404236 to TB404240 inclusive, and TB406298 to TB406309 inclusive, which covered the mineralized zone and surrounding area.

Kemins Explorations Limited [1970] (3)

In 1970, Kemins Explorations Limited conducted an airborne electromagnetic survey which straddled an area some 3.2 km wide centred on the Quetico Fault midway between the west to east boundaries of Trottier Township (Assessment Files Research Office, Ontaio Geological Survey, Toronto). This area covers most of the metavolcanic belt in Trottier Township and the sequence of metasediments north of a line from Kawene Lake east beyond Heward Lake. No anomalies were outlined and no further work was reported.

The Pothole Occurrence (4)

By the east shore of The Pothole, some 820 m north of Crooked Pine Lake, two separate quartz veins up to 1 m wide, trending N80°W, and dipping vertically, are exposed over a length of about 1 m, and contain up to 2 percent chalcopyrite with pyrite in small knots. One of the veins which appeared to have been previously sampled in a small pit contains central stringers some 4 cm wide of arsenopyrite, pyrite, and chalcopyrite, a grab sample of which collected by the author and assayed by Geoscience Laboratories, Ontario Geological Survey, Toronto contained up to 0.11 ounce gold per ton, 0.25 ounce silver per ton, and 0.73 percent copper. The veins cut intermediate tuff and lapilli-tuff units of the metavolcanics, and during the survey in 1975 showed little sign of working apart from one small area of broken rock. No record of work done in the area has been found, although the showing area has been known and staked intermittently since before 1960.

W.D. Morehouse (5,6, and 7)

W.D. Morehouse staked and held several properties in the map-area as follows: i) Abiwin Occurrence (5); ii)Heward Lake Occurrence (6); and iii) Mud Lake Deposit (7).

ABIWIN OCCURRENCE (5)

Several small zones of sulphide mineralization are associated with a small mafic to ultramafic intrusion on the northern shore of a small lake some 3.2 km

N55°W of Abiwin, where, in 1955, geological mapping, and a magnetometer survey were carried out and five holes were diamond drilled for a total of 26 m by M.W. Bartley (Assessment Files Research Office, Ontario Geological Survey, Toronto). In 1956, The International Nickel Company of Canada Limited conducted detailed magnetometer, electromagnetic, and geological surveys over a large area, and ascertained that the mineralization was confined to zones just within the southern contact of an elongate mafic intrusion measuring some 200 m long and 45 m wide. Pyrrhotite, pyrite, and chalcopyrite occur as disseminations and narrow stringers in three small lenses which have been exposed by trenching in the coarsely porphyritic hornblendite host. The lack of significant magnetic anomalies or conductors associated with the patchy mineralization discouraged further work (Assessment Files Research Office, Ontario Geological Survey, Toronto). A grab sample of well-mineralized material collected by the author from the most westerly pit contained 0.75 percent copper, 0.11 percent nickel and trace palladium (Geoscience Research Laboratories, Ontario Geological Survey, Toronto). In 1975, W.D. Morehouse held claims TB445238 and TB434076 which included the mineralized intrusion.

HEWARD LAKE OCCURRENCE (6)

Minor yellow staining on feldspar and thin coatings on small fractures within the large muscovite graphic granite pegmatite sheet at the south end of Heward Lake were recently discovered by W.D. Morehouse. It is likely that these are derived from weathering of primary uranium minerals, although none were observed by the field party in 1975. Isolated points along fractures gave geiger counter readings as high as one hundred times background. In 1975, W.D. Morehouse held claims TB406178, and TB406179, which included the mineralized area.

MUD LAKE DEPOSIT (7)

Copper mineralization was first discovered on the small island in Mud Lake some 2400 m N37°E of Abiwin Station by W.D. Morehouse in 1960. Noranda Exploration Company Limited conducted a magnetometer survey over the property in 1963, but did no further work. In 1971, Ardel Explorations Limited carried out electromagnetic and induced polarization surveys and diamond drilled a total length of 880.3 m in eight holes to test the main mineralized structure.

Examination of the property by the author in 1975 indicated that scattered disseminations and minor stringers of sulphide mineralization are present in lenses throughout a small elongate mafic to ultramafic intrusion which is some 450 m long trending N70°E, and has a fairly straight southern contact against the metasediments, but a sharply curved northern contact. In a few places, vague, lens-like areas of coarse-grained fresh hornblendite contain minor disseminations of pyrrhotite with chalcopyrite and secondary pyrite which locally coalesce into thin stringers. The diamond-drill logs reveal that the best intersections were found in hole number 6 where 2.8 m assayed 0.60 percent copper and 0.53 percent nickel at a length of 83.8 m and 0.62 percent copper and 0.69 percent nickel over 1.5 m at a length of 108.5 m, and the report correlates the better grades with severe shearing and alteration of the hornblendite. Assays on the well mineralized material returned only trace amounts of platinum, palladium, and gold with minor silver values (Assessment Files Research Office, Ontario Geological Survey, Toronto). In 1975, W.D. Morehouse held claims FF15436, K286419 to K286424 inclusive, K222197, K222198, and TB434071, which covered the mineralized zone and surrounding area.

Noranda Exploration Company Limited (8)

In 1975, Noranda Exploration Company Limited held a block of 16 claims, TB432971 to TB432986 inclusive, which covered the northern part of the Elbow Lake Mafic Complex. Following prospecting work, evidence for the existence of platinum group metals there was not found, and the claims were allowed to lapse (Noranda Exploration Company Limited, Thunder Bay Office).

White Lily Mines Syndicate (9)

In 1906-1907, a shaft 24 m deep was sunk on a narrow quartz vein on claim BJ101 just west of Upham Lake in Trottier Township. The showing was visited by Hawley (1929) who indicated the presence of a mill and other equipment, but no record of production. According to Hawley (1929, p.37), the vein occurred "between quartz porphyry and carbonated green schist", had a maximum width of 0.9 m in the shaft, and had a strike length of 12 m. A sample taken by Hawley over 30 cm of quartz vein near the shaft gave low gold values although no visible mineralization was present.

According to Ferguson *et al.* (1971, p. 253), in the year 1933, 2 ounces of gold and 4 ounces of silver with a total value of 53 dollars were produced from the mine, but there is no indication of any production since then. In 1975 no sign of buildings remained and the shaft was not located despite a search of the area by the field party. Claims BJ101 to BJ103 inclusive, WT 16 and WT 17 were held by White Lily Mines Syndicate in 1975.

J.M. Wilkinson (10)

Claims FF-1089 to FF-1094 inclusive were patented in 1935, and are presently in good standing with taxes being paid by J.M. Wilkinson, 10545 West 74th Street, La Grange, Illinois. No record of work on the claims has been found.

SUGGESTIONS FOR FUTURE MINERAL EXPLORATION

The metavolcanic belt in the Crooked Pine Lake area is narrow and poorly exposed. The present survey indicates an increase in the volume of intermediate to felsic pyroclastic rocks, and, to some extent in fragment size from west to east, and also an increase in the number of observations of minor chalcopyrite within these rocks. These increases suggest that the eastern end is closer to an intermediate to felsic volcanic centre, and has a concomitant higher potential for associated base-metal mineralization. The occurrence of gold and silver values with arsenopyrite and chalcopyrite in The Pothole Occurrence suggests that a geochemical soil or basal till orientation survey with samples analysed for arsenic and copper may be worth checking as a potential exploration tool for locating larger gold deposits in the area. Mineral deposits of economic potential have not been discovered in any of the mafic to ultramafic hornblendite intrusions here or in the adjoining areas despite their containing small copper-nickel mineralized lenses here and there; the large Elbow Lake Mafic Complex could possibly have larger zones of associated copper-nickel mineralization. Combined magnetic and electromagnetic surveys would identify any massive to submassive sulphide zones.

The muscovite graphic granite pegmatite that hosts the minor uranium staining at Heward Lake, forms a large sheet which continues out of the map-area to the west of Kawene, and also occurs in smaller bodies throughout much of the southern area of the metasedimentary gneiss. If further work indicates that this type of showing is significant, these areas could have some potential.

MEASUREMENTS IN ONTARIO GEOLOGICAL SURVEY PUBLICATIONS

All the measurements in this report are given in the units used in the source materials or in the original measuring. If the reader wishes to convert Imperial Units to Metric or SI Units or SI Units to Imperial Units the following multipliers should be used:

Unit	*Multiplied by*	*Gives*	*Unit*	*Multiplied by*	*Gives*
		LENGTH			
1 mm	0.039	inches	1 inch	25.4	mm
1 cm	0.394	inches	1 inch	2.54	cm
1 m	3.281	feet	1 foot	0.3048	m
1 km	0.621	miles (statute)	1 mile (statute)	1.609	km
		AREA			
1 cm^2	0.155	square inches	1 square inch	6.452	cm^2
1 m^2	10.764	square feet	1 square foot	0.093	m^2
1 km^2	0.386	square miles	1 square mile	2.590	km^2
1 m^2	0.000247	acres	1 acre	4046.686	m^2
1 h	2.471	acres	1 acre	0.405	h
		VOLUME			
1 cm^3	0.061	cubic inches	1 cubic inch	16.387	cm^3
1 m^3	35.315	cubic feet	1 cubic foot	0.028	m^3
		CAPACITY			
1 l	1.760	pints	1 pint	0.568	l
1 l	0.880	quarts	1 quart	1.137	l
1 l	0.220	gallons	1 gallon	4.546	l
		MASS			
1 g	0.035	ounces (avdp)	1 ounce (avdp)	28.350	g
1 g	0.032	ounces (troy)	1 ounce (troy)	31.103	g
1 kg	2.205	pounds (avdp)	1 pound (avdp)	0.454	kg
1 kg	0.0011	tons (short)	1 ton (short)	907.185	kg
1 t	1.102	tons (short)	1 ton (short)	0.907	t
1 kg	0.000984	tons (long)	1 ton (long)	1016.047	kg
1 t	0.984	tons (long)	1 ton (long)	1.016	t
		CONCENTRATION			
1 gm/t	0.029	ounce (troy)/ ton (short)	1 ounce (troy)/ ton (short)	34.292	gm/t
1 gm/t	0.583	pennyweights/ ton (short)	1 pennyweight/ ton (short)	1.715	gm/t
1 ounce (troy)/ ton (short)	20.0	pennyweights/ ton (short)	1 pennyweight/ ton (short)	0.05	ounce (troy)/ ton (short)

Suggestion: Although the above conversion factors are given to several decimal places for your convenience, do not attempt to convert an approximate measurement to a precise measurement. For example, "about 1000 feet" should be converted to "about 300 m" rather than "304.8 m".

REFERENCES

Ayres, L.D., Lumbers, S.B., Milne, V.G., and Robeson, D.W.
1971: Explanatory text, Legend, Diagrams, Title, Scale *for* Ontario Geological Map; Ont. Dept. Mines and Northern Affairs, Map 2196, scale 1 inch to 16 miles. Compilation 1970.

Bouma, A.H.
1962: Sedimentology of Some Flysch Deposits, a Graphic Approach to Facies Interpretation; Elsevier Publishing Company, Amsterdam, London, New York, 168p.

Buddington, A.F.
1959: Granite Emplacement with Special Reference to North America; Geol. Soc. Am., Bull. Vol.70, p.671-747.

Coleman, A.P.
1894: Gold in Ontario: Its Associated Rocks and Minerals; Ont. Bur. Mines, Vol.4, p35-100.

Fenwick, K.R.
1976: Geology of the Finlayson Lake Area, District of Rainy River; Ont. Div. Mines, GR145, 86p. Accompanied by Maps 2297, 2298, scale 1 inch to ½ mile (1:31,680).

Ferguson, S.A., Groen, H.A., and Haynes, R.
1971: Gold Deposits of Ontario Part 1; Ont. Dept. Mines, MRC13, 315p.

Fisher, R.V.
1966: Rocks Composed of Volcanic Fragments and Their Classification; Earth Sci. Rev., Vol.1, p.287-298.

Harris, F.R.
1970: Geology of the Moss Lake Area, District of Thunder Bay; Ont. Div. Mines, GR85, 61p. Accompanied by Map 2203, scale 1 inch to ½ mile, and Map 2204, scale 1 inch to ½ mile.

Hawley, J.E.
1929: Geology of the Sapawe Lake Area, with Notes on Some Iron and Gold Deposits of Rainy River District; Ont. Dept. Mines, Vol.38, Pt.6, p.1-58 (published 1930). Accompanied by Map No. 38e, scale 1 inch to ¾ mile.

Irvine, T.N.
1963: Geology of Western Lac des Mille Lacs Area, District of Thunder Bay; Ont. Dept. Mines, GR12, 24p. Accompanied by Map 2022, scale 1 inch to 1 mile.

Irvine, T.N., and Baragar, W.R.A.
1971: A Guide to the Chemical Classification of the Common Volcanic Rocks; Can. J. Earth Sci., Vol.8, p.523-548.

Jensen, L.S.
1976: A New Cation Plot for Classifying Subalkalic Volcanic Rocks; Ont. Div. Mines, MP66, 22p.

Kay, L.
1967: Geology of Eastern Lac des Mille Lacs Area; Ont. Dept. Mines, GR48, 30p. Accompanied by Maps 2104 and 2105, scale 1 inch to ½ mile.

Larsen, C.R.
1974: The Silicate and Sulphide Petrology of the Kawene Lake Intrusion; Unpublished B.Sc. Thesis, Lakehead University, 93p.

Legault, M.
1976: A Petrographic Study of the Elbow Lake Mafic Intrusion; Unpublished B.Sc. Thesis, Univ. of Ottawa, 19p.

Mackasey, W.O., Blackburn, C.E. and Trowell, N.F.
1974: A Regional Approach to the Wabigoon-Quetico Belts and its Bearing on Exploration in Northwestern Ontario; Ont. Div. Mines, MP58, 30p.

McIlwaine, W.H., and Hillary, E.M.
1974: West Half of Sapawe Lake Area, District of Rainy River; p.65-69 *in* Summary of Field Work, 1974, by the Geological Branch, Edited by V.G. Milne, D.F. Hewitt, and K.D. Card, Ont. Div. Mines, MP59, 206p.

McInnes, W.
1899: Report on the Geology of the Area Covered by the Seine River and Lake Shebandowan Map-Sheets, comprising Portions of Rainy River and Thunder Bay Districts, Ontario; Can., Geol. Surv., Summary Report for 1897, Vol. 10. Report H, 65p.

Mehnert, K.R.
1968: Migmatites and the Origin of Granitic Rocks; Elsevier, Amsterdam-New York, p.353-357.

Morin, J.A.
1973: Geology of the Lower Shebandowan Lake Area, District of Thunder Bay; Ont. Div. Mines, GR110, 45p. Accompanied by Map 2267, scale 1 inch to ½ mile.

ODM-GSC
1961a: Huronian Sheet, Rainy River and Thunder Bay Districts, Ontario; Ont. Dept. Mines-Can., Geol. Surv., Aeromagnetic Map 1112G, scale 1:63,360 (1 inch to 1 mile). Survey May to October 1961.
1961b: Bedivere Lake Sheet, Rainy River and Thunder Bay Districts, Ontario; Ont. Dept. Mines-Can., Geol. Surv., Aeromagnetic Map 1113G, scale 1:63,360 (1 inch to 1 mile). Survey May to October 1961.
1961c: Pickerel Lake Sheet, Rainy River District, Ontario; Ont. Dept. Mines-Can., Geol. Surv., Aeromagnetic Map, 1122G, scale 1:63,360 (1 inch to 1 mile). Survey May to October 1961.
1961d: Sapawe Sheet, Rainy River District, Ontario; Ont. Dept. Mines-Can., Geol. Surv., Aeromagnetic Map 1123G, scale 1:63,360 (1 inch to 1 mile), Survey May to October 1961.

Pirie, J.
1976a: Crooked Pine Lake Area, West Half, District of Rainy River; Ont. Div. Mines, Prelim. Geol. Map No. P.1101, scale 1 inch to ¼ mile. Geology 1975.
1976b: Crooked Pine Lake Area, East Half, District of Rainy River; Ont. Div. Mines, Prelim. Geol. Map No. P.1102 scale 1 inch to ¼ mile. Geology 1975.

Pirie, J. and Mackasey, W.O.
1978: Preliminary Examination of Regional Metamorphism in Parts of Quetico Metasedimentary Belt, Superior Province, Ontario; *in* "Metamorphism in the Canadian Shield", Can., Geol. Surv. Pap. Ser., 78-10.

Pye,E.G. and Fenwick, K.G.
1965: Atikokan-Lakehead Sheet, Districts of Kenora, Rainy River and Thunder Bay; Ont. Dept. Mines, Geol. Map 2065, Geol. Comp. Ser., scale 1 inch to 4 miles. Compilation 1962-1963.

Tanton, T.L.
1940: Quetico (West Half); Map 534A, Dept. of Mines and Resources, Can., Geol. Surv., Scale 1:253,440 (1 inch to 4 miles). Geology 1937.

Tuttle, O.F., and Bowen, N.L.
1958: Origin of Granite in the Light of Experimental Studies in the System $NaAlSi_3O_8$-$KAlSi_3O_8$-SiO_2-H_2O; Geol. Soc. Am., Mem. 74, 153p.

Watkinson, D.H., and Irvine, T.N.
1964: Peridotitic Intrusions near Quetico and Shebandowan, Northwestern Ontario: a Contribution to the Petrology and Geochemistry of Ultramafic Rocks; Can. J. Earth Sci., Vol.1, No.1, p.63-97.

Winkler, H.G.F.
1975: Petrogenesis of Metamorphic Rocks, 3rd Edition; Springer-Verlag, New York-Berlin, 320p.

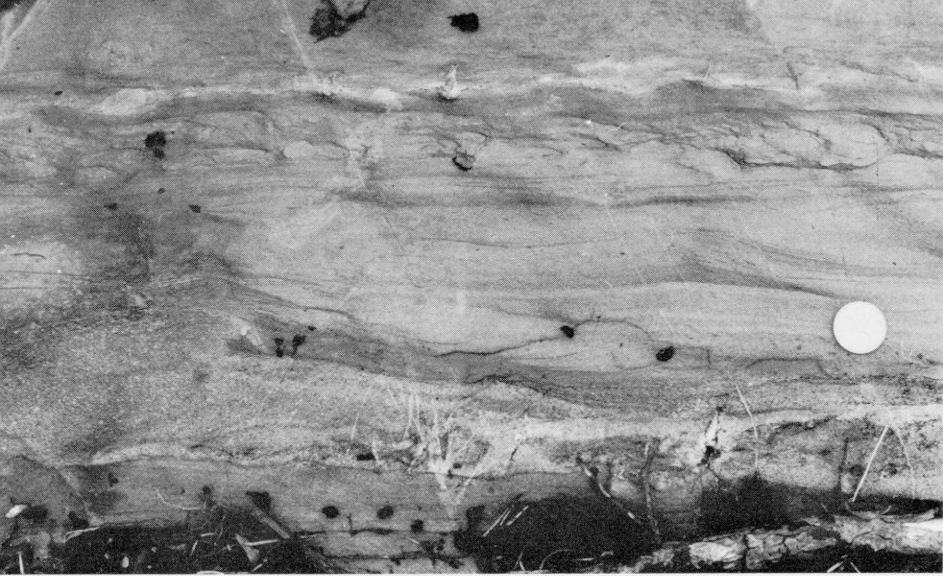
Woolverton, R.S.
1960: Geology of the Lumby Lake Area; Ont. Div. Mines, Vol.69, Pt.5, 52p. Accompanied by Map 1960g, scale 1 inch to ½ mile.

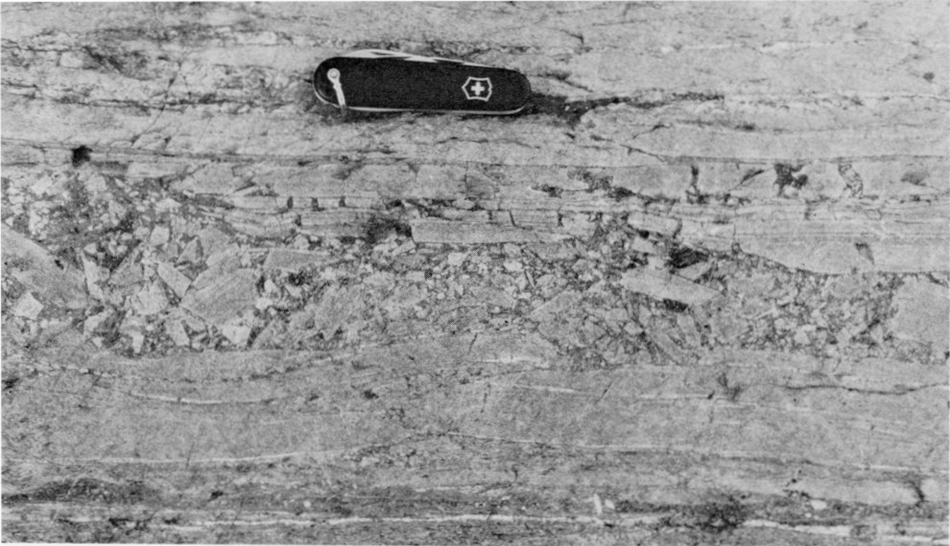
Young, G.M.
1967: Sedimentology of Lower Visean? Rocks in the Western Part of the Ballina and Donegal Synclines, Northwest Ireland; Unpublished Ph.D. Thesis, Univ. of Glasgow, 204p.

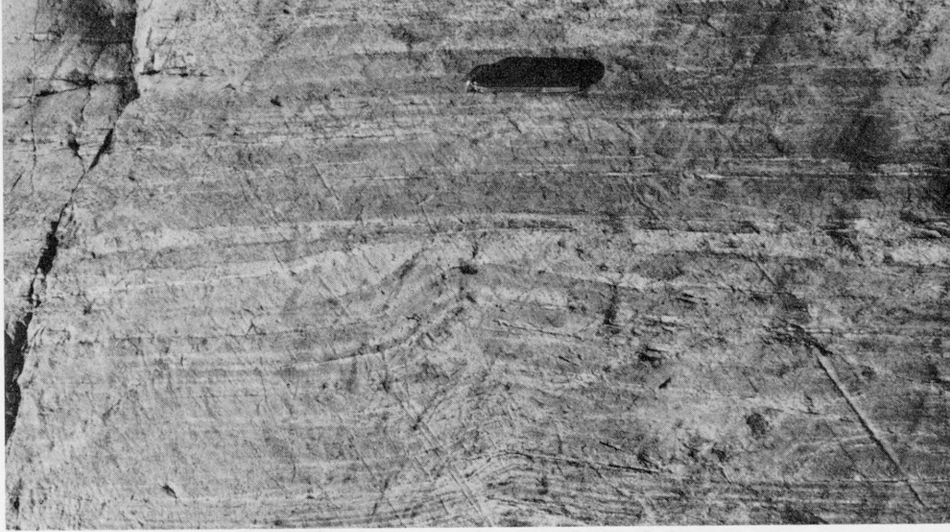
Zoltai, S.C.
1965: Surficial Geology: Kenora-Rainy River; Map S165, Ont. Dept. Lands and Forests, scale 1 inch to 8 miles. Geology 1958 to 1960.

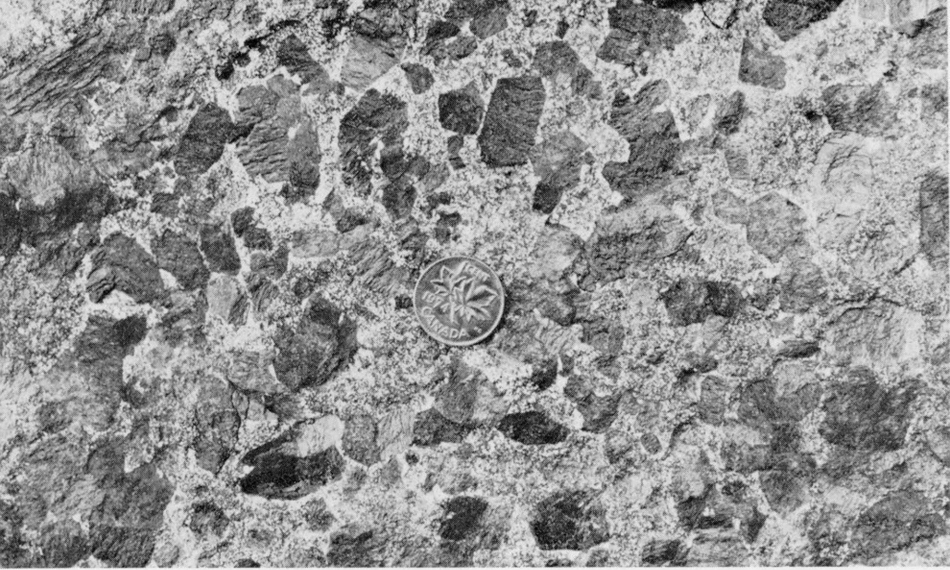
INDEX

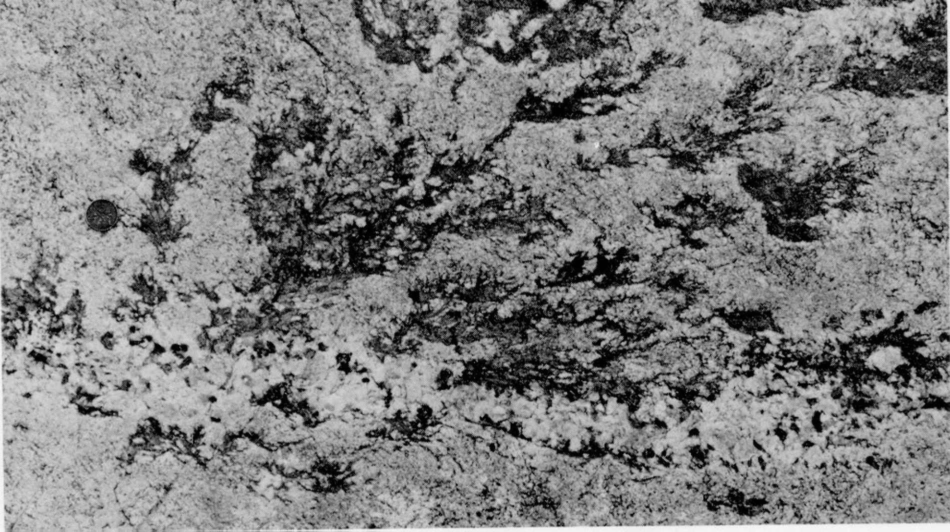
OGS9814

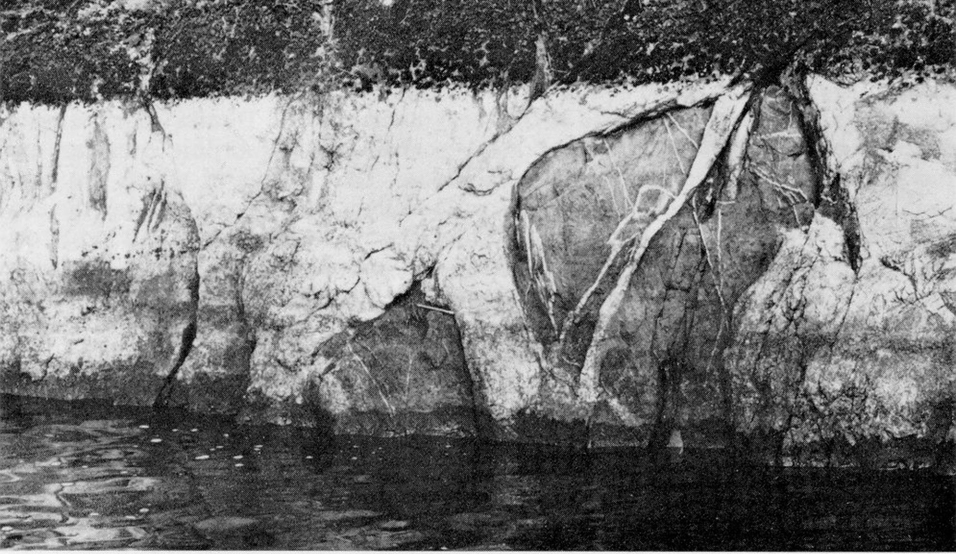


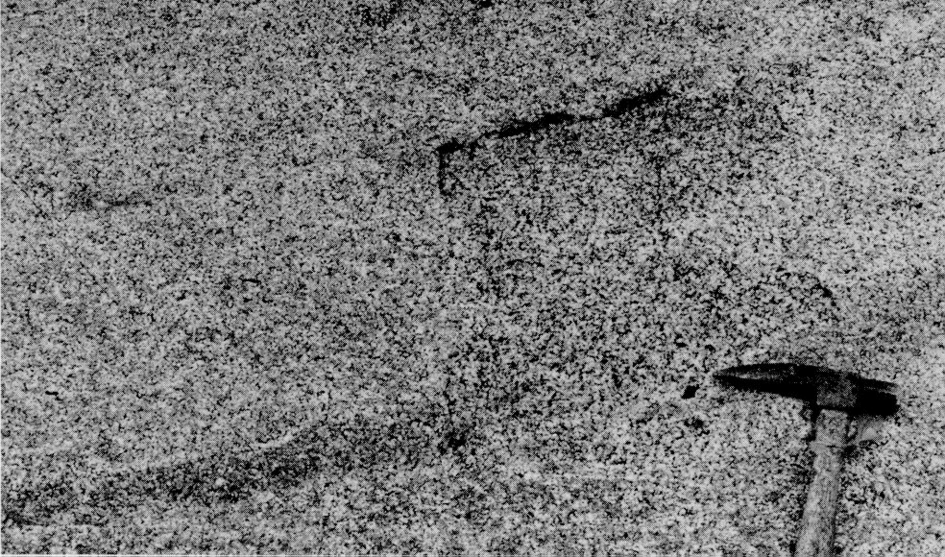


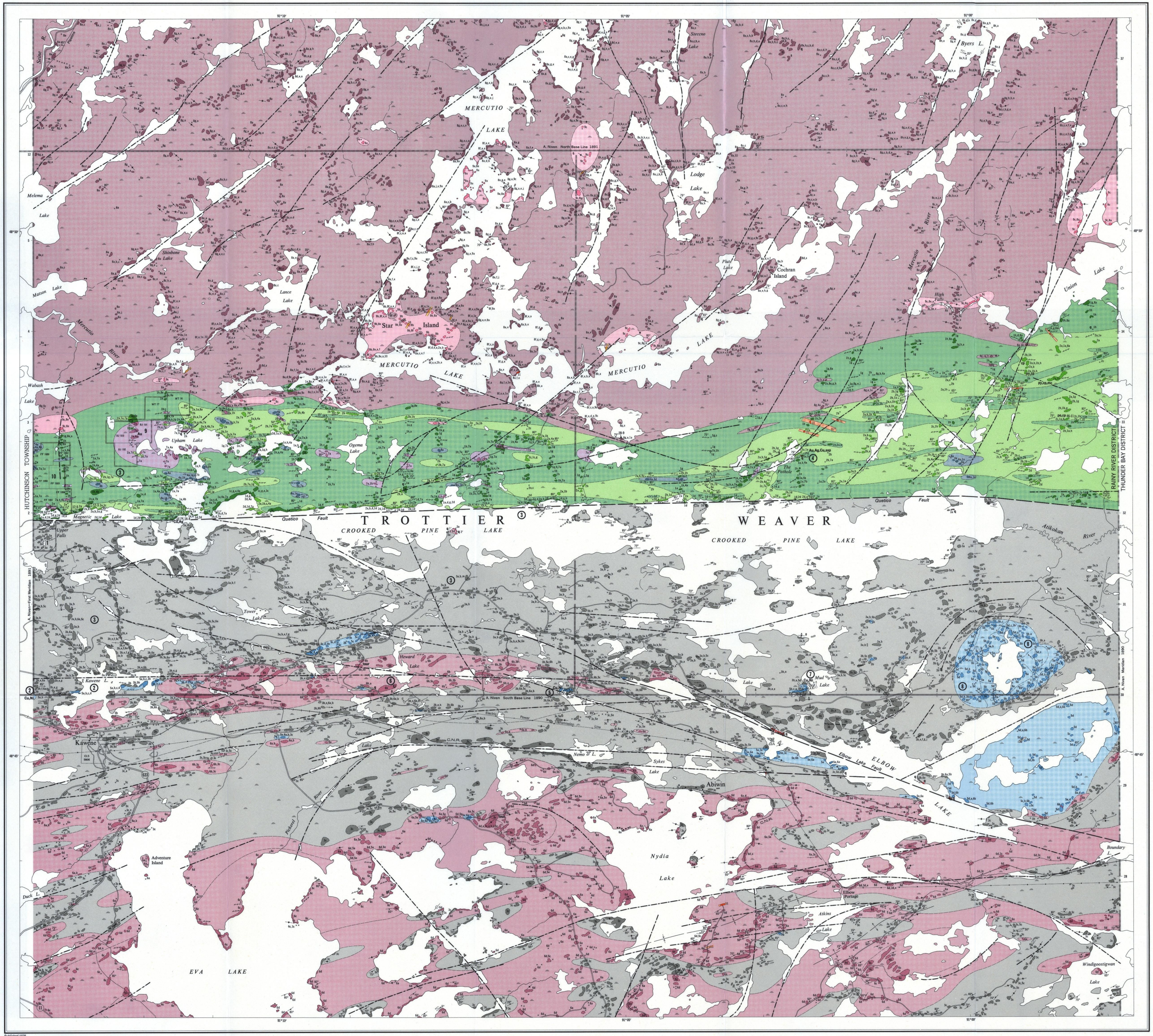












Published 1978

LEGEND

PHANEROZOIC

CENOZOIC[a]

QUATERNARY

PLEISTOCENE AND RECENT

Glacial till, sand, gravel, loess, clay, silt and organic mud.

UNCONFORMITY

PRECAMBRIAN[b]

MIDDLE TO LATE PRECAMBRIAN

MAFIC INTRUSIVE ROCKS

11 *Diabase.*

INTRUSIVE CONTACT

EARLY PRECAMBRIAN[c]

MAFIC INTRUSIVE ROCKS

10 *Diabase.*

INTRUSIVE CONTACT

INTERMEDIATE TO FELSIC PLUTONIC ROCKS

MASSIVE GRANITIC ROCKS

- 9a *Biotite-hornblende trondhjemite.*
- 9b *Porphyritic hornblende quartz diorite.*
- 9c *Granodiorite, quartz monzonite, pegmatite.*
- 9d *Porphyritic biotite granodiorite.*

INTRUSIVE CONTACT

FOLIATED AND GNEISSIC BATHOLITHIC ROCKS

- 8 *Unsubdivided.*
- 8a *Leucotrondhjemite, pegmatite, aplite.*
- 8b *Hornblende diorite.*
- 8c *Biotite quartz diorite.*
- 8d *Biotite-hornblende quartz diorite.*
- 8e *Amphibolite.*
- 8f *Trondhjemite gneiss.*
- 8g *Biotite trondhjemite gneiss.*
- 8h *Hornblende gneiss.*
- 8j *Biotite-chlorite schist.*

METAMORPHOSED FELSIC INTRUSIVE ROCKS

- 7a *Leucocratic quartz monzonite.*
- 7b *Muscovite quartz monzonite pegmatite.*

METASEDIMENTARY MIGMATITE

- 6a *Quartz monzonite, granodiorite, pegmatite, aplite.*[d]
- 6b *Muscovite graphic granite pegmatite.*[d]
- 6c *Quartz monzonite, pegmatite (homogenous diatexite).*
- 6d *Biotite gneiss-migmatite*[e] *(inhomogenous diatexite).*

METAMORPHOSED ULTRAMAFIC TO INTERMEDIATE INTRUSIVE ROCKS

MAFIC TO ULTRAMAFIC INTRUSIVE ROCKS

- 5a *Hornblendite, pyroxene hornblendite, minor pyroxenite.*
- 5b *Feldspathic hornblendite.*
- 5c *Hornblende gabbro.*
- 5d *Hornblende diorite and related hybrid rocks.*
- 5e *Porphyritic quartz diorite.*

INTERMEDIATE AND ULTRAMAFIC INTRUSIVE ROCKS

- 4a *Amphibole quartz diorite, chloritic trondhjemite.*
- 4b *Melanogabbro, peridotite.*

METASEDIMENTS

- 3a *Wacke, mudstone.*
- 3b *Biotite phyllite, schist.*[f]
- 3c *Biotite gneiss.*[g]
- 3d *Marble, calc-silicate gneiss.*
- 3e *Garnet.*
- 3f *Andalusite.*
- 3g *Staurolite.*
- 3h *Cordierite.*
- 3j *Sillimanite.*
- 3k *Cummingtonite.*
- 3m *Pebble to granule conglomerate.*

METAVOLCANICS

INTERMEDIATE TO FELSIC METAVOLCANICS

- 2a *Lapillistone, lapilli-tuff.*
- 2b *Tuff.*
- 2c *Flow.*
- 2d *Sericite phyllite, schist.*

MAFIC TO INTERMEDIATE METAVOLCANICS

- 1a *Flow, fine grained.*[h]
- 1b *Tuff, lapilli-tuff.*
- 1c *Porphyritic flow.*[h]
- 1d *Chlorite phyllite, schist.*
- 1e *Biotite-chlorite schist.*
- 1g *Flow, coarse grained, gabbroic.*[h]
- 1h *Flow, medium grained, diabasic.*[h]

Ag	*Silver.*
asp	*Arsenopyrite.*
Au	*Gold.*
cp	*Chalcopyrite.*
Cu	*Copper.*
gt	*Garnet.*
mc	*Malachite.*
Ni	*Nickel.*
po	*Pyrrhotite.*
py	*Pyrite*
q	*Quartz.*
tour	*Tourmaline.*
U	*Uranium.*

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

[b] *Bedrock geology. Outcrops and inferred extensions of each map rock 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 order does not necessarily imply age relationship between groups.*

[d] *Intrusive mobilizate in 3b.*

[e] *Contains 70 to 95 percent 6a,b,c.*

[f] *May contain up to 20 percent 6a,b.*

[g] *Contains 20 to 70 percent 6a,b.*

[h] *May be intrusive in part.*

PROPERTIES, MINERAL DEPOSITS

1. *Atikokan Iron Lands Ltd.*
2. *F.O.B. Mining Explorations Ltd. (Kawene).*
3. *Kemins Explorations Ltd. [1970]*
4. *The Pothole occurrence.*

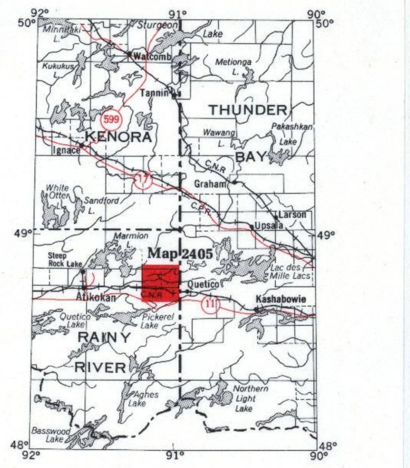
Morehouse, W. D.—

5. *Abiwin occurrence.*
6. *Heward Lake occurrence.*
7. *Mud Lake deposit.*
8. *Noranda Exploration Co. Ltd.*
9. *White Lily Mines Syndicate.*
10. *Wilkinson, J. M.*

Only former properties on ground now open for staking are shown where exploration information is available — a date in square brackets indicates last year of exploration activity. For further information see report.

Information current to December 31st, 1975.

Ontario Geological Survey
Map 2405
Crooked Pine Lake



Scale 1 inch to 50 miles
N.T.S. reference 52 B/10, B/11, B/14, B/15

SYMBOLS

- *Glacial striae.*
- *Small bedrock outcrop.*
- *Area of bedrock outcrop.*
- *Bedding, top unknown; (inclined, vertical).*
- *Bedding, top indicated by arrow; (inclined, vertical, overturned).*
- *Bedding, top (arrow) from grain gradation; (inclined, vertical, overturned).*
- *Schistosity; (horizontal, inclined, vertical).*
- *Gneissosity, (horizontal, inclined, vertical).*
- *Foliation; (horizontal, inclined, vertical).*
- *Banding; (horizontal, inclined, vertical).*
- *Lineation with plunge.*
- *Geological boundary, observed.*
- *Geological boundary, position interpreted.*
- *Fault; (observed, assumed). Spot indicates down throw side, arrows indicate horizontal movement.*
- *Lineament.*
- *Drag folds with plunge.*
- *Anticline, syncline, with plunge.*
- *Drill hole; (vertical, inclined).*
- *Vein, vein network. Width in feet.*
- 46-11 *Location of chemical analyses samples. See report.*
- *Swamp.*
- *Building.*
- *Motor road. Provincial highway number encircled where applicable.*
- *Other road.*
- *Trail, portage, winter road.*
- *District boundary with milepost, approximate position only.*
- *Township boundary, base or meridian line with mileposts, approximate position only.*
- *Township boundary, unsurveyed, approximate position only.*
- 10 *Mining property, surveyed. Boundary approximate position only.*
- (4) *Mineral deposit; mining property, unsurveyed.*
- *Surveyed line, approximate position only.*

SOURCES OF INFORMATION

Geology by J. Pirie and assistants, 1975. Geology is not tied to survey lines.

Ontario Department of Mines:
Map 2065 Atikokan—Lakehead. Sheet, Geological Compilation Series, 1964.
Map 38e. Sapawe Lake Area, District of Rainy River, 1929.

Ontario Department of Lands and Forest; Map S165 Kenora-Rainy River Surficial Geology, 1965.

Geological Survey of Canada, Department of Mines and Resources; Map 534A Quetico (West Half), Rainy River District, 1940.

ODM-GSC Aeromagnetic maps 1112G, 1113G, 1122G, 1123G, 1961.

Preliminary maps (ODM) P.1101 and P.1102, Crooked Pine Lake Area, Western Half and Eastern Half, respectively, scale 1 inch to ¼ mile, issued 1976.

Cartography by M. J. Colman and assistants, Ministry of Natural Resources, 1977.

Basemap derived from maps of the Forest Resources Inventory, Ministry of Natural Resources, with additional information by J. Pirie.

Magnetic declination in the area was 2°45'E, 1975.

Ministry of Natural Resources
Ontario

Hon. Frank S. Miller
Minister

Dr. J. K. Reynolds
Deputy Minister

Ontario Geological Survey
Map 2405

CROOKED PINE LAKE

RAINY RIVER DISTRICT

Scale 1:31,680 or 1 Inch to ½ Mile

Chains 80 60 40 20 0 1 2 Miles

Metres 1000 0 1 2 3 Kilometres

Feet 1000 0 5,000 10,000 Feet