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Ontario Geological Survey
Report 216

Geology of the Long Lake Area Lennox and Addington and Frontenac Counties

by
J.M. Wolff

1982

Ministry of
Natural
Resources
Ontario

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Ontario
Ministry of Natural Resources
Hon. Alan W. Pope
Minister
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Deputy Minister

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(back pocket)

Conversion Factors for Measurements in Ontario Geological Survey Publications

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

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

OTHER USEFUL CONVERSION FACTORS

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

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

ABSTRACT

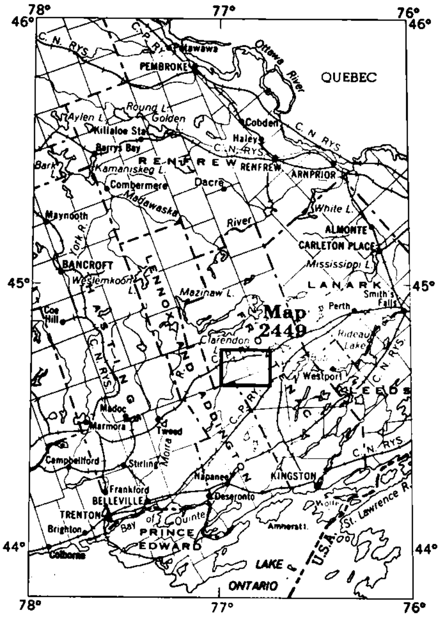
The Long Lake map-area (Figure 1) lies about 70 km north of the city of Kingston, Ontario by road and covers approximately 275 km^2.

Bedrock is of Late Precambrian age. The oldest rocks are mafic to intermediate metavolcanics and mafic to felsic gneiss and anatectite. The mafic metavolcanics are mainly of tholeiitic affinity but intermediate members are calc-alkaline. Metasediments in the map-area consist of amphibole-rich gneisses and schists, clastic siliceous gneisses and schists and carbonate metasediments. These appear to be derived from volcanogenic material and from feldspathic and quartzose wackes and carbonate sediments defining a miogeosynclinal assemblage.

Two gneiss complexes in the area are the Sheffield trondhjemite to granite gneiss and the Hinchinbrooke enderbitic granolite gneiss. The fault contact relationship of each of these with the adjacent supracrustal rocks leaves doubt of a clear cut intrusive petrogenesis and an older basement concept must be considered.

Syntectonic intrusions in the area include the composite trondhjemite to granite Northbrook Batholith, the quartz monzonite to granite Addington Pluton, and the trondhjemite to quartz monzonite Abbotts Hill Intrusion. All three bodies strike northeasterly and border the supracrustal rocks of the Clare River Synform.

Late tectonic intrusions in the map-area occur in an intra-limb axial trace position within a broad scale synform formed by metavolcanics and related gneiss and anatectite. The Mountain Grove Mafic Intrusion is a well differentiated gabbro-anorthosite-syenite body typical of closed system differentiation of a basic magma. The McLean Granitic Pluton ranges in composition from trondhjemite to granite and appears to have resulted



Scale, 1 inch to 50 miles
N.T.S. Reference 31 C/10

SMC 14627

***Figure 1**—Key map showing location of the Long Lake area.*

from partial melting of crustal material shortly after the above intrusion. Pegmatite dikes all tend to have compositions similar to the McLean Granitic Pluton and are considered to be a late manifestation of this event. The youngest late tectonic intrusions are diabase dikes.

The area is structurally divided into two different tectonic zones separated by a major shear zone exhibiting protomylonite, mylonite and mylonite gneiss plus fabric imprinting on adjacent lithologies. The western structural zone is typified by southwest plunging isoclinal and open flow folded synforms which are part of the D2 deformation event. The D1 event formed the foliation-gneissosity and evidence of D3 may be present. The eastern structural zone contains a broad open style synform which plunges shallowly eastwards and is intruded along its axial zone by late stage tectonic mafic and felsic intrusions. This synform is a D2 deformation feature. The structural style of the rocks of the map-area is variable due to the high contrasts in ductility and competency between large bodies of rock.

Metamorphic grade increases from the northwest of the map-area to the southeast. Rocks in the northwest part of the area are regionally metamorphosed to the low temperature zone of medium grade metamorphism. Metamorphism increases southeastwards through the high temperature zone of medium grade metamorphism until it reaches the regional high grade hypersthene zone in the southeast corner. This higher grade material is typical of the metamorphic grade in the Frontenac Axis.

Mineral exploration in the past has been concentrated in the metavolcanics, the gabbro-anorthosite-syenite body and the carbonate units for base metal sulphide concentrations. The most successful of these units for mineral production has been the carbonate inclusions occurring in and near the border of the gabbro-anorthosite-syenite body, where the Long Lake zinc mine is located. Other carbonate inclusions with a similar stratigraphic position in this body and a similar carbonate metasediment lithology are possible exploration targets for sphalerite concentrations.

Surficial Pleistocene deposits are most prominent in the major shear zone where they fill the valley created by the fault.

Geology of the Long Lake Area

Lennox and Addington and Frontenac Counties

by

J.M. Wolff[1]

INTRODUCTION

The Long Lake map-area lies between Latitudes 44°37'30''N and 44°45'N and Longitudes 76°45'W and 77°00'W, and is in Frontenac County and Lennox and Addington County, southern Ontario. The area covers about 275 km^2 and is about 14 km by 20 km. The villages of Arden and Mountain Grove are located in the northern half of the area. The hamlet of Long Lake is located near the centre of the east boundary of the area and is about 70 km by road north of the city of Kingston.

Mineral exploration in the map-area has been sporadically active since the turn of the century, and was chiefly concentrated around the zinc deposit at Long Lake. The most recent working of this deposit was undertaken from 1970 to 1974 and yielded 9467 tons of zinc at a market value of 1.23 million dollars (Source Mineral Deposit Files, Ontario Geological Survey, Toronto). No active staking has been carried out in the area since that time although some base metal sulphide concentrations do exist.

Present Geological Survey

Map 2449 (back pocket, scale 1:31 680) presents the results of the geological survey carried out by the author and his assistants during the summer of 1978. Preliminary map P.2246 (Wolff and Smith 1979) at a scale of 1:15 840 was released in 1979.

The field maps were prepared at the scale of 1:15 840 on the base maps produced by the Cartography Section, Ministry of Natural Resources, from the National Topographic Series, provisional map 31C/10. Field data were plotted on acetate overlays on vertical air photographs at the same scale as the base maps. The data were primarily collected along pace and compass traverse lines run approximately 400 to 500 m apart and run at right angles to strike. In areas of poor outcrop traverses were run between existing outcrops. In areas of massive outcrop (i.e. map-units 6 and 11) only areas examined in some degree of detail are outlined on the map. Mapping around the Long Lake zinc mine and similar carbonate inclusions in the vicinity were given close examination for their base metal sulphide potential. Data were also collected from roadcuts in the area.

Acknowledgments

The author was assisted in the field by D.A. Smith, D. Chen, C. Capell and J. McPherson.

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[1] Geologist, Precambrian Geology Section, Ontario Geological Survey, Toronto. Manuscript approved for publication by the Chief Geologist, May 31, 1979. This report is published with the permission of E.G. Pye, Director, Ontario Geological Survey.

Mr. Smith as senior assistant carried out independent traverses throughout the field season.

During the field season D.J. Villard (Ministry of Natural Resources, Huntsville), M. Klugman (Ministry of Natural Resources, Kemptville) and the author spent some time at the Long Lake zinc mine and both gentlemen provided valuable information concerning the operation. Mr. Villard was mine geologist at the site during production (1973-1974) and is acknowledged for his co-operation and assistance in discussions concerning the surface and underground geology of the site. M.I. Watson, Lynx-Canada Explorations Limited, was very cooperative and allowed the author access to company files dealing with various geological aspects of the deposit. Discussions with officers of the Geological Survey of Canada during the field season provided the author with information on the glacial deposits in the area (N.R. Gadd), and the current medium level gamma ray spectrometry results (K. Ford).

Except where otherwise stated, all chemical analyses that appear in this report were done by the Geoscience Laboratories, Ontario Geological Survey.

Access

Access to the map-area is excellent as provincial Highway 7 transects the map-area in the northwest corner. Stemming from this artery are a number of secondary roads cutting the area north-south and east-west. Lake access is good in the western portion of the map-area as the Salmon River system is located in this zone. Long Lake is the most prominent waterway in the eastern portion of the map-area. An abandoned railway bed (formerly belonging to the Canadian Pacific Railway and presently a Bell Canada underground communication line) essentially parallels Highway 7, transecting the northern portion of the map-area from west to east. The only zone of poor access in the map-area is the Salmon Lake-Bitch Lake area of the McLean granitic pluton.

Previous Geological Work

The earliest recorded geological survey in the Long Lake area is that of Murray (1852) under the direction of William Logan, who reported examining the rocks in the vicinity of Cross Lake (Kennebec Lake) and along the Salmon River. Murray identified the rocks of the "Metamorphic Series" (Laurentian Series) but did not attempt to subdivide them further. H.G. Vennor (1868) did some early work in Kaladar Township and this was included in a geological map of parts of eastern Ontario.

The works of Harding (1942, 1947) are the prominent geological surveys in the map-area prior to the present study. Harding assigned the metasediments in the map-area to the Grenville Series and realized the distinction between older mafic intrusions and somewhat younger granites and gneisses.

The present study area was included in the regional compilation of the Madoc-Gananoque area (Hewitt 1964). Two theses in the area which have come to the attention of the author are a study of the petrology and metamorphism of the Long Lake zinc deposit (Cone 1976) and metamorphism of siliceous carbonate rocks (Ewert 1977).

The Kaladar area (immediately to the west) was mapped by the author in 1977 and the Tichborne area (immediately to the east) was mapped by Wynne-Edwards (1964). Both works should be consulted for pertinent information relating to rocks found in the present study area.

Topography and Drainage

Elevations above sea-level in the map-area range from about 185 m around the hamlet of Wagarville, to about 260 m at the top of the ridge north of Kennebec Lake. Maximum relief is about 65 m as typified by the relief of the Kennebec Lake ridge, but the area is generally one of low relief. The bulk of the map-area represents a highland region between the Salmon River drainage pathway and the Rideau River drainage system. In this sense the map-area is a water divide between Lake Ontario and the Ottawa River.

Distribution of rock outcrop is quite variable. Exposures are abundant in the McLean Granitic Pluton, Abbotts Hill Intrusion, Northbrook Batholith, the Addington Pluton and the Hinchinbrooke and Sheffield Gneiss Complexes. These zones locally reach up to 80 percent outcrop. All other rock units have typically 20 to 30 percent exposure.

GENERAL GEOLOGY

Terminology

In order to avoid confusion with usage of past authors, a number of terms used in the discussion of the general geology are defined below.

Precambrian Time Scale

The Precambrian time scale used is that suggested by Ayres *et al.* (1971), which divides Precambrian time into three eras: Early (older than 2500 m.y.), Middle (between 2500 m.y. and 1500 m.y.) and Late (younger than 1500 m.y.).

Foliation, Schistosity, Gneissosity, Cleavage

Foliation is used to describe all types of megascopically recognizable structural surfaces of metamorphic origin (Turner and Weiss 1963, p. 97). Several distinguishable types of foliation include compositional layering, preferred orientation of mineral grains and localized slip features. Gneissosity and schistosity are the most common varieties of foliation in the map-area. As used in this study, schistosity imparts a planar structure in a metamorphic rock due to abundant, preferentially oriented grains especially micas. Schistosity is accompanied by a fissility in the rock and is best developed in medium-grained rocks rich in micaceous minerals. Gneissosity denotes a layering of metamorphic origin defined by the alternation of layers, streaks or lenticles of contrasting mineralogical composition or texture. Cleavage is also developed and denotes a parting in the rock resulting from the incipient parallel growth of micaceous or elongated minerals (usually under regional metamorphism) in fine grained rocks and is most common in lower grades of metamorphism.

Metamorphic Grade, Isograd and Isoreaction-Grad

Metamorphic petrochemical terminology used in this study follows that of Winkler (1976). The term metamorphic grade is used essentially in place of the more commonly used facies terminology (Winkler 1976). Metamorphic grade refers to large pressure-temperature zones which are subdivided with respect to increasing temperature and the associated coexisting mineral assemblages which exist for a given bulk composition. Generally four metamorphic grade divisions are referred to, these are very low, low, medium, and high. The term isograd is used in its original sense (Tilley 1924) to define the line on a map joining points which designate a definite degree of metamorphism by the first appearance of an "index" mineral in rocks of a particular bulk composition. This definition is also extended to include lines which join points designating the disappearance of index minerals as well

(Thompson 1973). Isograd is a general term in the sense that the kind of reaction producing this mineral change is not necessarily observable petrographically. When the minerals involved in the reaction are observable the term isoreaction-grad is used.

Granolite, Granoblastite and Enderbitic

High grade metamorphic terminology is after Winkler (1974, 1976). Granolite is defined as a rock which is within the regional hypersthene high grade metamorphic zone and contains a mineral assemblage diagnostic of this zone. Granoblastite is a rock which belongs to the regional hypersthene high grade metamorphic zone but lacks a mineral assemblage characteristic of this zone. Enderbitic refers to those granolites which are essentially hypersthene-bearing trondhjemites. Rocks similar to this have been called charnockites by other authors.

Protomylonite, Mylonite and Mylonite Gneiss

Terminology used for dynamically metamorphosed rocks is taken from Spry (1969). The term protomylonite is used to describe those foliated rocks containing 10-50 percent crushed matrix. Mylonite defines those foliated rocks containing 50-90 percent crushed matrix. Mylonite gneiss refers to those foliated rocks with 50-90 percent crushed matrix and discrete porphyroclasts or augens which are not recrystallized material.

Gabbro, Anorthositic Gabbro, Gabbroic Anorthosite and Anorthosite

The terminology for basic intrusive rocks in the Grenville Province has lacked consistency in the past. Notably Miller (1899) and Buddington (1939) have used terminology which differs from presently used terms for these rocks. In this study gabbro refers to a mafic intrusive rock possessing a colour index greater than 30. Anorthositic gabbro is a calcic intrusive rock with a colour index of between 20 and 30. Gabbroic anorthosite is a calcic intrusive rock with a colour index between 10 and 20. Since these last two rock types were difficult to distinguish on an outcrop basis, in this study the term anorthositic gabbro-gabbroic anorthosite is used for those rocks possessing a colour index between 10 and 30. Anorthosite is used for rocks possessing a colour index less than 10 and more than 75 percent plagioclase feldspar.

Geological Summary

The map-area lies within the Central Metasedimentary Belt, as defined by Wynne-Edwards (1972). Specifically, the IVb (Hastings Basin) and the IVc Frontenac Axis segments are both included within the area. Prime units present are metavolcanics and metasediments of Late Precambrian age (Grenville Supergroup equivalents), and Late Precambrian felsic and mafic intrusive bodies. Late tectonic pegmatite dikes and irregular masses cut the supracrustal rocks locally. The general succession of the rocks is given in Table 1.

The oldest rocks in the area are considered to be the mafic to intermediate metavolcanics and the mafic to felsic gneiss and anatectites (the latter being the high grade equivalents of the first). This succession is composed of tholeiitic basalt which tends to be subalkalic and minor amounts of calc-alkaline rhyodacite. Minor amounts of intercalated carbonate and clastic siliceous metasediments are found in this unit. Although similar in composition it is difficult to correlate these rocks directly with metavolcanics of the Hermon Group as defined by Lumbers (1969), and rocks directly on strike with these metavolcanics were simply assigned to the "Grenville Series" by Wynne-Edwards (1964).

TABLE 1. TABLE OF LITHOLOGIC UNITS FOR THE LONG LAKE AREA.

CENOZOIC

QUATERNARY

RECENT

Organic swamp and alluvial deposits.

PLEISTOCENE

Outwash and interlobate deposits, sand, silt, clay and till.

Unconformity

LATE PRECAMBRIAN

LATE TECTONIC METAMORPHOSED INTRUSIVE ROCKS

MAFIC INTRUSIVE ROCKS

Mafic (diabase) dikes.

Intrusive Contact

McLEAN GRANITIC PLUTON AND RELATED PEGMATITIC ROCKS

Biotite granite and quartz monzonite; biotite granodiorite; biotite trondhjemite; leucocratic granite; syenite; porphyritic and muscovite-bearing varieties; shear zone protomylonite, mylonite and mylonite gneiss varieties; pink and white granitic pegmatite dikes and irregular masses, undifferentiated metasedimentary and metavolcanic inclusions.

Intrusive Contact

MOUNTAIN GROVE MAFIC INTRUSION

Gabbro; anorthositic gabbro to gabbroic anorthosite; anorthosite; quartz gabbro; monzonite; syenite; porphyroblastic, glomeroporphyroblastic and possible metamorphosed varieties.

Fault and/or Intrusive Contact

SYNTECTONIC METAMORPHOSED FELSIC TO INTERMEDIATE INTRUSIVE ROCKS

ABBOTTS HILL INTRUSION[a]

Biotite trondhjemite; biotite quartz monzonite; biotite granodiorite with local leucocratic phases; aplitic leucocratic quartz monzonite; garnetiferous varieties; shear zone protomylonite, mylonite and mylonite gneiss varieties.

ADDINGTON PLUTON[a]

Biotite granite; leucocratic quartz monzonite; biotite quartz monzonite; leucocratic pink granite.

NORTHBROOK BATHOLITH[a]

Biotite trondhjemite; biotite granodiorite; biotite quartz monzonite; biotite granite.

Fault and/or Intrusive Contact

HINCHINBROOKE GNEISS COMPLEX[b]

Enderbitic granolite with quartz or feldspar porphyroblasts; inclusions of mafic to felsic gneiss.

SHEFFIELD GNEISS COMPLEX

Trondhjemite to granodiorite banded with quartz monzonite to granite phases; accessory biotite and muscovite; gneissic trondhjemite to granodiorite.

Fault and/or Intrusive Contact

METASEDIMENTS AND METAVOLCANICS

AMPHIBOLE-RICH GNEISSES AND SCHISTS[cde]

Hornblende-plagioclase gneiss; plagioclase-hornblende gneiss; quartz-plagioclase-hornblende gneiss; plagioclase-hornblende gneiss (80% hornblende); K-feldspar hornblende gneiss; amphibolite (metagabbro); calcite and almandine garnet porphyroblasts; biotite-hornblende quartzofeldspathic schist; shear zone protomylonite, mylonite and mylonite gneiss varieties.

CARBONATE METASEDIMENTS[cde]

Calcite marble: laminated calcite marble; dolomite marble; dolomite-calcite marble; calc-silicate assemblages (tremolite ± scapolite ± diopside ± talc ± apatite); fragmental dolomite-calcite marble with quartzite and calc-silicate flags; quartzite with quartzofeldspathic blocks and broken beds; chert beds, mafic hornblende-rich segmented layers; coarse grained varieties; amorphous calcite marble; calcite-talc schist.

CLASTIC SILICEOUS GNEISSES AND SCHISTS[cde]

Biotite quartzofeldspathic paragneiss; biotite-hornblende-plagioclase quartz-rich paragneiss; epidote-biotite K-feldspar-plagioclase-quartz paragneiss; leucocratic biotite-magnetite-muscovite quartzofeldspathic gneiss; epidote-calcite-hornblende-biotite-plagioclase-quartz-paragneiss; pyritic varieties; garnetiferous and muscovite-bearing varieties; quartzofeldspathic layers; muscovite quartzofeldspathic schist ± garnet; shear zone protomylonite, mylonite and mylonite gneiss varieties.

MAFIC TO INTERMEDIATE METAVOLCANICS[cde]

Quartz-orthoclase-epidote-plagioclase-hornblende amphibolite and amphibolite gneiss; epidote-plagioclase-hornblende amphibolite with glomeroporphyroblasts and porphyroblasts of hornblende; biotite-hornblende-quartzofeldspathic meta-ash tuff; carbonate-bearing phases; massive phases with xenoblastic andesine grains; garnetiferous varieties; recrystallized chert; shear zone protomylonite, mylonite and mylonite gneiss varieties.

MAFIC TO FELSIC GNEISS AND RELATED ANATECTITE[cde]

Pyroxene-bearing amphibolite and hornblende-plagioclase gneiss; intercalated carbonate metasediments; hornblende-biotite granodiorite to trondhjemite anatectite; contact metamorphic and assimilated phases of pyroxene-bearing amphibolite adjacent to McLean Granitic Intrusion.

Notes

a. No relative age difference is inferred between the Abbotts Hill intrusion, Addington Pluton, and Northbrook Batholith.

b. High grade metamorphic terminology is after Winkler (1976).

c. No relative age is inferred between these units.

d. The metamorphic convention is used in naming these rocks with the least plentiful mineral placed first.

e. Metamorphic textural terminology is after Spry (1969).

The metasediments of the map-area are largely confined to the Clare River Synform or the Kaladar-Dalhousie Trough (Hewitt 1956). These metasediments are largely hornblende-rich gneisses (hornblende + plagioclase + quartz ± carbonate), carbonate metasediments (calcite and dolomite marbles, and calc-silicate phases) and clastic siliceous gneisses (quartz + feldspar + biotite). "The hornblende rich gneisses show features of para-amphibolite character, are of calc-alkaline composition and may represent volcanic ash accumulates. Portions of the sequence have features of ortho-amphibolite character and approach tholeiitic compositions" (Wolff 1978). The clastic siliceous gneisses have quartzose wacke to feldspathic wacke compositions with minor phases displaying rhyolitic to rhyodacitic affinities. The carbonate metasediments contain intraformational fragmental dolomite-calcite marble, and calc-silicate assemblages. These features support the suggestion that this metasedimentary suite is miogeosynclinal in nature (Dietz 1963; Wolff 1978). Within the map-area, carbonate metasediments are abundant with respect to the other metasediments, indicating the sedimentary basin which now forms the Clare River Synform had possibly shallowed and been more stable to the northeast. Stability of the sediments was locally in flux in the carbonate bank as indicated by the fragmental marbles.

Stable carbonate basin morphology may also be indicative of back-arc basins in a eugeosyncline setting.

Two gneiss complexes exist in the map-area, the Sheffield and the Hinchinbrooke. The Sheffield Complex contains both highly contorted and continuous granitic gneissic material (trondhjemite to granite) with pegmatitic segregations in the most contorted zones. The Hinchinbrooke Complex is enderbitic granolite with rafts or inclusions of unit 1 (metavolcanics). Both complexes appear to be in fault contact with the adjacent supracrustal rocks. Since these complexes are not clearly intrusive bodies the possibility that they represent basement assemblages must not be ignored.

Intrusions in the map-area can be grouped into two groups: syntectonic and late tectonic. The syntectonic intrusions are the Northbrook Batholith, the Addington Pluton and the Abbotts Hill Intrusion. The Northbrook Batholith is a composite batholith varying from trondhjemite to granite in composition, but is chiefly trondhjemite to granodiorite. The Addington Pluton is quartz monzonite to granite and often displays a lit-par-lit relation with the supracrustal rocks it intrudes. The Abbotts Hill Intrusion ranges in composition from trondhjemite to quartz monzonite and is the least deformed of the three intrusions. All intrusions of the syntectonic group are cut by late tectonic pegmatites. Intrusive rocks of the late tectonic types are noticeably fresher than any of the above and include mafic to intermediate compositions. The oldest late tectonic intrusion is the Mountain Grove Mafic Intrusion which is a well differentiated gabbro-anorthosite-syenite body. Although lacking well defined igneous layering, rocks from this body show typical differentiation compositions and geochemical patterns. This body is economically important as it contains base metal (especially zinc) sulphide mineralization within carbonate metasediment inclusions. Intrusive into this body is the McLean Granitic Pluton. This body ranges in composition from trondhjemite to granite with minor syenite phases and is generally massive. Near the western border of this unit, xenoliths of supracrustal material are well preserved. Although the Mountain Grove Mafic Intrusion appears to have formed from the differentiation of an essentially closed system magma source, it is doubtful that the McLean Granitic Pluton is related to the same magma source, chiefly on the grounds of apparent volumes. The McLean body has an apparent volume of 1.4-1.6 times that of the Mountain Grove Mafic Intrusion. It is suggested that the McLean body represents a late stage partial melting of the crust which occurred shortly after the emplacement of the Mountain Grove Intrusion. The youngest intrusions in the map-area are diabase dikes which are not common.

The rocks in the map-area have undergone regional metamorphism during the Late Precambrian. The rocks of the Clare River Synform possess mineral assemblages indicative of the low temperature part of medium grade metamorphism (Winkler 1976). The metavolcanics indicate a somewhat higher temperature regime of medium grade metamorphism. Assemblages in the mafic to felsic anatectites and Hinchinbrooke gneiss are indicative of the regional high grade hypersthene zone of metamorphism. The metamorphic grade steadily increases from the northwest to the southeast in the map-area.

Structurally, the map-area is composed of two strikingly different zones separated by a major shear zone (Figure 2) which passes through the village of Mountain Grove and continues to the southwest and northeast. Rocks in the shear zone are strained into protomylonite, mylonite and mylonite gneiss. Rocks adjacent to the shear zone (Abbotts Hill Intrusion) show a late stage fabric imprinting paralleling the shear zone. Rocks west of the shear zone are part of the Clare River Synform and display two periods of deformation and possibly a third. The Clare River Synform is an isoclinal F2 fold which deforms the S1 foliation (apparently parallel to the S0 bedding plane). Infolding within this structure is evidenced by a secondary flow folded synformal structure between Highway 7 and Kennebec Lake. These F2 folds plunge shallowly southwest in the map-area. Minor variation in the fold hinge lineations might be indicative of a third gentle warping deformation event with a northwest trending axis. East of the shear zone the structural geometry becomes one of domal intrusions within the intra-limb zone of a broad synform plunging shallowly eastwards.

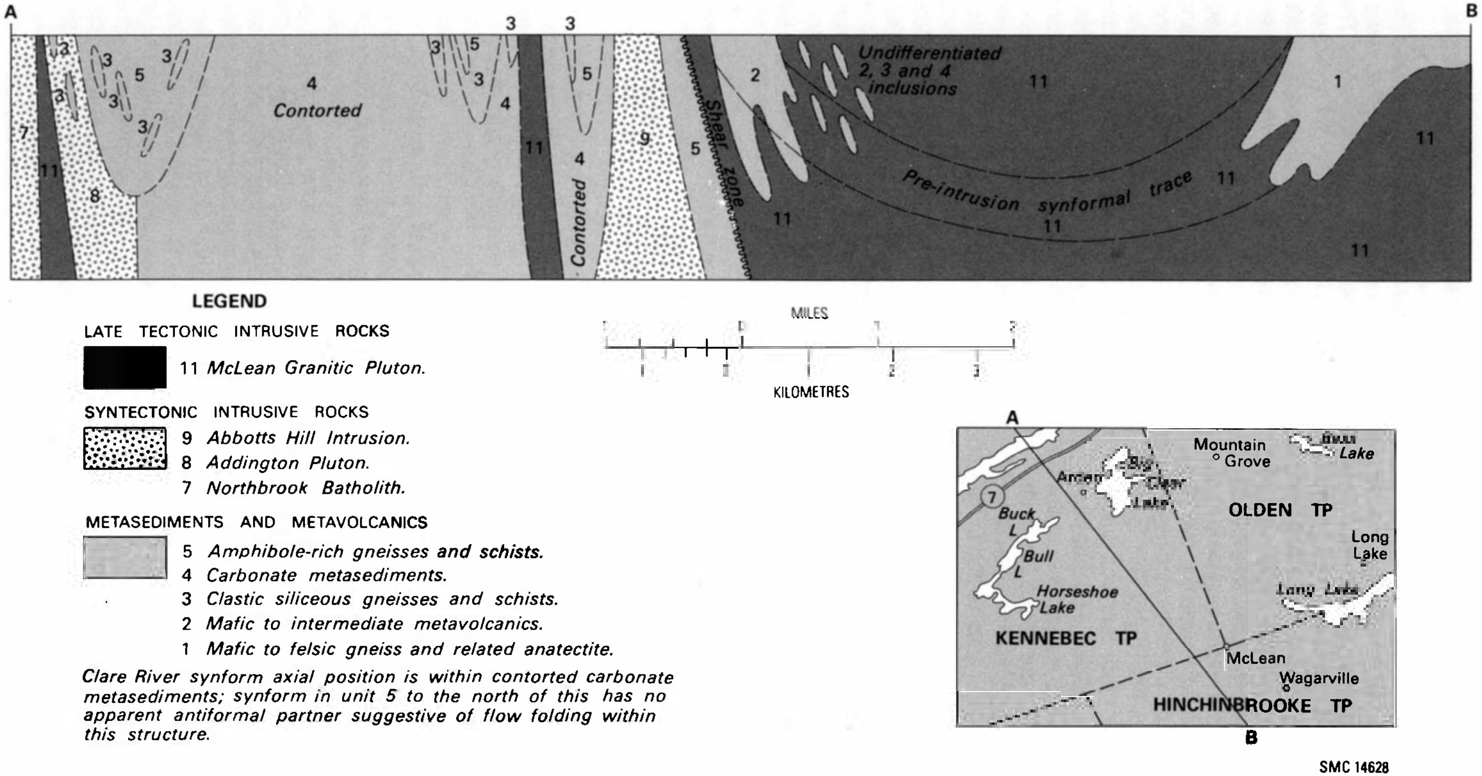

Figure 2—*Geologic cross-section of the Long Lake area. Inset map shows location of cross-section.*

This fold deforms the S1 foliation (apparently parallel to the S0 bedding plane) and is a F2 fold likely synchronous with the D2 deformation event forming the Clare River Synform.

Following the deformation episodes late tectonic pegmatite dikes and irregular masses intruded the map-area. These show similar compositions to the phases of the McLean Granitic Pluton and occur as segregations with gradational contacts within this body. These dikes are associated with the partial melting event forming the McLean Granitic Pluton. The pegmatite intrusions are essentially contemporaneous with late-stage faulting which trends southeasterly. Late-stage jointing surfaces form three sets trending N45E, S44E and north, and locally intersect one another.

Late Precambrian

METASEDIMENTS AND METAVOLCANICS

Mafic to Felsic Gneiss and Related Anatectite

Map-unit 1 is composed of mafic to felsic gneiss and related anatectite. Rocks of this map-unit outcrop in the southeast corner of the map-area in a zone running east-west through the hamlet of Wagarville. These rocks are bounded to the northwest by the McLean Granitic Pluton (map-unit 11) and to the southeast by the Hinchinbrooke Gneiss Complex.

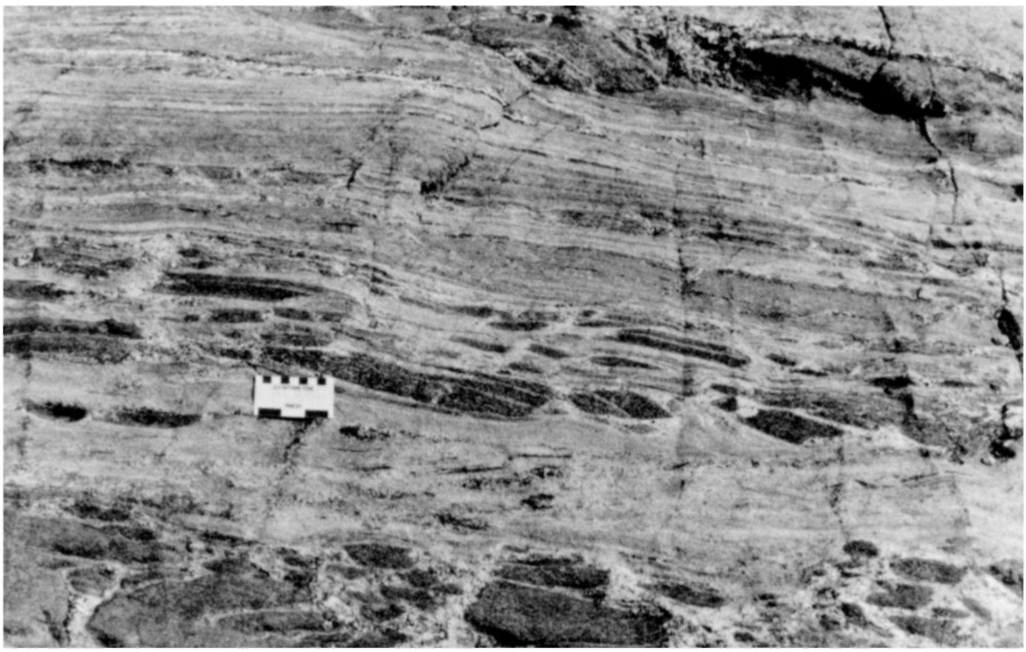

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Photo 1*—Mafic to felsic gneiss and related anatectite of map-unit 1, south of Long Lake near contact with map-unit 11 (lot 27, concession VIII, Hinchinbrooke Township). The broken blocks are amphibolite in a surrounding quartzofeldspathic + biotite + almandine garnet assemblage. Map-units present are la and c.*

The unit is composed of three rock types: 1a, foliated to gneissic, granoblastic, medium-grained, pyroxene-bearing amphibolite and hornblende-plagioclase ± pyroxene gneiss; 1b, massive to foliated, medium-grained hornblende-biotite granodiorite to trondhjemite anatectite; and 1c, contact metamorphic and assimilated phases of unit 1a adjacent to the McLean Granitic Pluton (Photo 1).

The pyroxene-bearing amphibolite and hornblende-plagioclase gneisses of map-unit 1a tend to weather grey green to olive green and contain few opaque minerals. These rocks are generally medium grained (0.5-2.0 mm) and equigranular with the more coarse grained varieties exhibiting a well developed gneissosity. Rocks of the smaller grain sizes in this range tend to be well foliated. Texturally, rocks of this unit are granoblastic equigranular, composed of subhedral to anhedral plagioclase (labradorite) and hornblende, with or without pyroxene. The pyroxene is hypersthene and occurs either as medium-grained anhedra or as coarse-grained (4.5 mm maximum) poikiloblasts which are highly fractured and disjointed. Pyroxene of the latter type is usually associated with plagioclase-free rock types within map unit la. These rocks can be described as granoblastites (Winkler 1974), diagnostic of high grade regional metamorphism but not necessarily characteristic of the regional hypersthene zone as hypersthene is not ubiquitous. Rocks containing hypersthene, however, in this unit can be considered to be granolites.

Intercalated with unit 1a are thin (less than 1 m thick) discontinuous bands of granoblastic carbonate metasediments which are composed of carbonate minerals varying in composition from calcite to dolomite, with or without the calc-silicate minerals tremolite and diopside.

Map-unit 1b, hornblende-biotite granodiorite and trondhjemite, weathers a grey-greenish colour and in outcrop appears quite massive with a weakly developed foliation. Grain size is generally medium (0.5-2.0 mm) but smaller (0.2 mm) grains can be found in thin section. The mineralogy is quartz, plagioclase and hornblende although the amount of quartz can vary from less than 5 up to 30 percent. Plagioclase compositions vary from andesine to labradorite. Accessory minerals are biotite and epidote (<5 percent) and opaques are pyrite or hematite. All minerals are subhedral to anhedral and the texture is interlocking to granoblastic. Close examination of rocks of this unit both in thin section and outcrop suggest they are anatectites of granodiorite to trondhjemite composition rather than preserved plutonic equivalents.

Map-unit 1c represents contact metamorphic phases and assimilations of unit 1a material near the border of the McLean Granitic Pluton (map-unit 11). Rocks of this zone are fine grained (0.2-0.5 mm) and tend to be more leucocratic and contain larger amounts of quartz and feldspar (<70 percent). The feldspar is often highly sericitized but laths of andesine composition are found. Hornblende is a less prominent constituent and almandine garnet is not uncommon. Epidote is a common accessory (<5 percent) and opaques consisting primarily of pyrite form 5 to 10 percent of the rock. The texture of this map-unit is generally equigranular granoblastic and exhibits a well developed foliation-gneissosity.

Mafic to Intermediate Metavolcanics

Map-unit 2 is composed essentially of mafic to intermediate metavolcanics with minor amounts of intercalated metasedimentary material (map-unit 3). Rocks of this unit outcrop east of, and southwest of, the village of Mountain Grove, and west and south of Bitch Lake. Large xenoliths of this unit are found on the western border of the McLean Granitic Pluton (map-unit 11). No rocks of map-unit 2 occur west of the major shear zone which passes through the village of Mountain Grove. The unit is bounded on the southeast by the Mountain Grove Mafic Intrusion (map-unit 10). The contact of this body and map-unit 2 passes north through Carnahan Lake then runs east, south of Bass Lake and intersects the western shore of O'Reilly Lake. Although foliation and jointing exist in map-unit 2 rocks, these structures are weakly developed except near, and within, the shear zone.

TABLE 2. MODAL ANALYSES OF MAFIC METAVOLCANICS (MAP-UNIT 2A) IN THE LONG LAKE AREA.

Sample	M530-1	M531-1	M701-1	D518-1	M884-1	M983-1
Hornblende	60	65	22	80	55	55
Plagioclase	6 andesine	10 sericitized	45 saussauritized	10 sericitized	40 sericitized	42 sericitized
K-feldspar (Orthoclase)	8	9	6			
Quartz	4	6	4	5		
Epidote	16		5			3
Calcite	5					
Biotite		5	8		3	
Sphene			5			
Opaque	3	5	5	5	2	
TOTAL	102	100	100	100	100	100

SAMPLES
Amphibolite.
M530-1 0.2 km NE of Small Clear Lake.
M531-1 0.2 km NE of Small Clear Lake.
M701-1 1 km S of Mountain Grove.
D518-1 1 km W of Bitch Lake.
Amphibolite gneiss.
M884-1 0.2 km N of Long Lake.
M983-1 W shore of Bitch Lake.

The most abundantly occurring rock type of this unit is map-unit 2a: foliated, subidioblastic, fine-grained quartz-orthoclase-epidote-plagioclase-hornblende amphibolite and amphibolite gneiss. These rocks weather green grey to dark green in outcrop, and have a colour index >35. The grain size is typically 0.1-0.2 mm although some hornblende grains are as large as 0.6 mm. The mineralogy of this unit is shown in Table 2. Subhedral to anhedral hornblende is the dominant mineral phase and plagioclase is usually heavily sericitized but andesine was determined locally. The orthoclase and quartz bearing types generally display a compositional layering defining the foliation gneissosity. Common accessory minerals are biotite and epidote with minor calcite. The opaque minerals are usually pyrite and some hematite. Since a few crystal faces are preserved in these rocks the grains are described as subidioblastic but the texture is granoblastic and generally equigranular.

Map-unit 2b, epidote-plagioclase-hornblende amphibolite, usually contains 65 percent or more hornblende and weathers dark green. The colour index is >35 but these rocks are more dense than those of unit 2a. The hornblende is medium grained (3.0 mm) and surrounded by a fine grained matrix (0.1-0.2 mm) of plagioclase (heavily saussuritized), epidote and pyrite ± quartz. The feldspar and epidote form 25 percent of the rock. Hornblende forms glomeroporphyroblasts which contain several small hornblende grains fused together. It is not uncommon for this rock to have a knobby appearance in outcrop. This rock type is found in close association with rock type 2a and is discontinuous along strike.

Map-unit 2c is composed of intermediate metavolcanics. These are fine grained (0.1-0.3 mm) and weather buff grey to white. The colour index is 15-30 and the mineralogy is principally quartz (40-45 percent), plagioclase (sericitized andesine) 30-35 percent, orthoclase (0-15 percent), hornblende and/or biotite (5-20 percent) ± muscovite ± magnetite. The grains are subidioblastic in thin section creating a granoblastic texture. In hand specimen the fine grained nature and mineralogy are suggestive of a metamorphosed ash-tuff. This rock type is not common and is discontinuous along strike.

The amphibolites of unit 2a, described above, are locally altered and contain carbonate minerals. These rocks comprise map-unit 2d. The carbonate mineral is calcite and comprises 10 percent to 70 percent of the rock. Epidote is present in this map-unit (<20 percent). Those rocks with the smaller amounts of calcite appear much like their unaltered counterparts weathering grey green to green. They are fine grained (0.2 mm) and generally subidioblastic with idioblastic calcite grains. The rocks with larger amounts of calcite are more whitish to pale green in colour, much softer and contain tremolite but are also fine grained (0.5 mm). This calcite-rich type probably represents metamorphosed carbonate sediments rather than highly altered amphibolite. These calcite-rich rocks have been included in map-unit 2 because of their thin and discontinuous nature and intimate association with other map-unit 2 rocks.

Map-unit 2e represents massive phases of unit 2a which contain medium grained (1.5 mm) xenoblastic crystals of saussuritized andesine in a fine grained (0.05-0.1 mm) groundmass of subidioblastic epidote, plagioclase and hornblende. Fine grained pyrite, sphene and biotite are accessory. The texture of the groundmass is granoblastic with the larger plagioclase crystals creating a porphyroblastic texture.

Locally, map-unit 2a contains almandine garnet poikiloblasts which are designated by map-unit 2f. Map-unit 2g represents very thin (1-10 cm) beds of fine grained recrystallized chert. These are intercalated with unit 2a and 2b material and discontinuous along strike.

Most of the strike length of map-unit 2 in the map-area is bounded on the west by the major shear zone which runs through the village of Mountain Grove. Toward the shear zone (from the south, across strike), in map-unit 2 lithologies, the rocks become more gneissic, and contain high shear strain features which progressively develop protomylonite, mylonite and mylonite gneiss ± porphyroclasts. These rocks types are delineated on the map by unit 2h. The mineralogy of rocks of this map-unit varies according to the original map-unit 2 material involved in the shearing. However, important minerals unique to this zone are chlorite and an increased amount of biotite plus more K-feldspar (orthoclase). Compositional layering is well defined and may include epidote-rich layers, biotite-rich layers and quartz-feldspar rich layers. In the mylonite gneiss zones plagioclase grains tend to become resistant blocks while quartz tends to become pulverized and to flow, creating quartz-rich ribbons, spotted with biotite. The grain size is usually fine grained (1.0 mm) in this map-unit.

Table 3 shows the chemical composition of a sample suite from the metavolcanics of map-unit 2 in the map-area. Samples for this study were taken from mafic, intermediate and carbonate-bearing phases. The analyses have been plotted on several geochemical variation diagrams (Figure 3). Figure 3a is the AFM plot (Irvine and Baragar 1971) which clearly shows the mafic members of the suite to fall in the tholeiitic field. (Two mafic samples do fall in the calc-alkaline field but close to the tholeiitic boundary and are considered tholeiitic.) The intermediate samples fall within the calc-alkaline field. Carbonate-bearing phases fall in each field. The geochemical significance of these two samples in their wide dispersion from the dominant tholeiitic trend of the mafic samples is suggestive of an open chemical system in the carbonate-bearing phases. Figure 3b, the $Na_2O + K_2O$ vs. SiO_2 plot, indicates that all samples in this suite fall in the subalkaline field as defined by Irvine and Baragar (1971). Carbonate-bearing phases could not be uniquely distinguished in this plot. The SiO_2 vs. FeO/MgO plot (Miyashiro 1974) is given in Figure 3c. This plot clearly delineates the tholeiitic nature of the mafic metavolcanics and the calc-alkaline affinity of the intermediate metavolcanic samples. Again the carbonate-bearing phases could not be uniquely distinguished on this plot. Figure 3d depicts the distribution of these samples in FeO vs. FeO/MgO plane (Miyashiro 1974). The mafic members are clearly tholeiitic and the intermediate members calc-alkaline. The carbonate-bearing phases appear to be calc-alkaline but may represent altered mafic samples.

Map-unit 2 metavolcanics are very similar in chemistry to the Tudor metavolcanics of

TABLE 3. CHEMICAL ANALYSES OF METAVOLCANICS (MAP-UNIT 2) IN THE LONG LAKE AREA.

MAJOR ELEMENT OXIDES	D467-1	D518-1	D525-1	D530-1	M530-1	M531-1	M607-1	M537-1	D485-1	M559-1	M574-1
	WEIGHT PERCENT										
SiO_2	56.0	46.2	46.3	47.7	45.9	45.6	47.1	61.7	75.5	45.6	55.7
Al_2O_3	15.6	17.4	16.6	15.4	17.8	16.0	16.5	16.7	13.0	14.5	13.2
Fe_2O_3	3.27	4.52	2.67	3.47	2.96	2.12	5.68	2.07	0.08	1.07	4.07
FeO	6.93	7.99	8.22	8.76	7.60	9.52	6.14	3.53	0.54	5.61	3.00
MgO	4.43	8.05	8.51	7.49	4.14	10.1	4.61	2.30	0.92	9.01	2.51
CaO	7.48	8.96	11.3	10.2	13.1	9.14	8.14	6.03	1.12	16.2	16.0
Na_2O	1.80	3.39	2.16	3.23	3.17	1.87	3.27	5.28	4.23	1.39	0.10
K_2O	2.17	0.60	0.94	0.63	0.72	1.16	1.60	0.60	1.76	2.33	0.37
H_2O^+	2.77	1.21	1.63	0.83	0.68	1.09	2.77	0.20	0.40	1.06	0.77
H_2O^-	0.38	0.36	0.24	0.19	0.21	0.19	0.62	0.26	0.24	0.30	0.42
CO_2	0.80	0.41	0.76	0.59	1.84	0.24	1.58	0.13	0.18	2.13	3.64
TiO_2	1.60	0.95	0.81	1.15	1.52	1.20	2.05	0.20	0.07	0.48	0.43
P_2O_5	0.45	0.11	0.08	0.09	0.15	0.11	0.41	0.26	0.04	0.17	0.12
S	0.01	0.23	0.07	0.01	0.02	0.03	<0.01	<0.01	<0.01	0.07	0.02
MnO	0.17	0.16	0.18	0.22	0.18	0.20	0.16	0.11	0.01	0.15	0.10
TOTAL	98.9	100.5	100.5	100.0	100.0	98.6	100.6	99.9	98.1	100.1	100.4
TRACE ELEMENTS	PPM										
Ba	550	60	120	70	90	220	430	270	100	350	80
Co	30	45	50	40	45	55	30	20	<5	60	20
Cr	20	230	380	290	175	145	55	65	<5	670	660
Cu	135	35	90	8	30	15	6	60	6	35	20
Li	15	15	20	10	15	30	20	7	15	30	15
Ni	30	70	105	55	75	95	40	20	<5	245	100
Pb	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	10
Rb	60	10	20	10	20	50	40	10	30	80	10
Sr	380	200	380	290	210	330	404	530	90	240	200
Y	40	30	30	30	30	30	40	30	60	20	30
Zn	100	80	90	115	175	115	60	60	40	55	45
Zr	210	30	30	40	20	51	190	80	150	30	20

SAMPLES

Amphibolite and amphibolite gneiss. Map-units 2a and 2b.
- D467-1 2.3 km SW of Kellar Lake.
- D518-1 1.0 km W of Bitch Lake.
- D525-1 2.3 km W of Scanlin Lake.
- D530-1 1.6 km W of Scanlin Lake.
- M530-1 0.2 km NE of Small Clear Lake.
- M531-1 0.2 km NE of Small Clear Lake.
- M607-1 2.7 km SW of Kellar Lake.

Intermediate tuff. Map-unit 2c.
- M537-1 1.6 km ENE of Small Clear Lake.
- D485-1 1.8 km SSW of Kellar Lake.

Carbonate-bearing amphibolite. Map-unit 2d.
- M559-1 1.2 km SW of Kellar Lake.
- M574-1 0.8 km S of Kellar Lake.

NOTE: Analyses by Geoscience Laboratories, Ontario Geological Survey, Toronto.

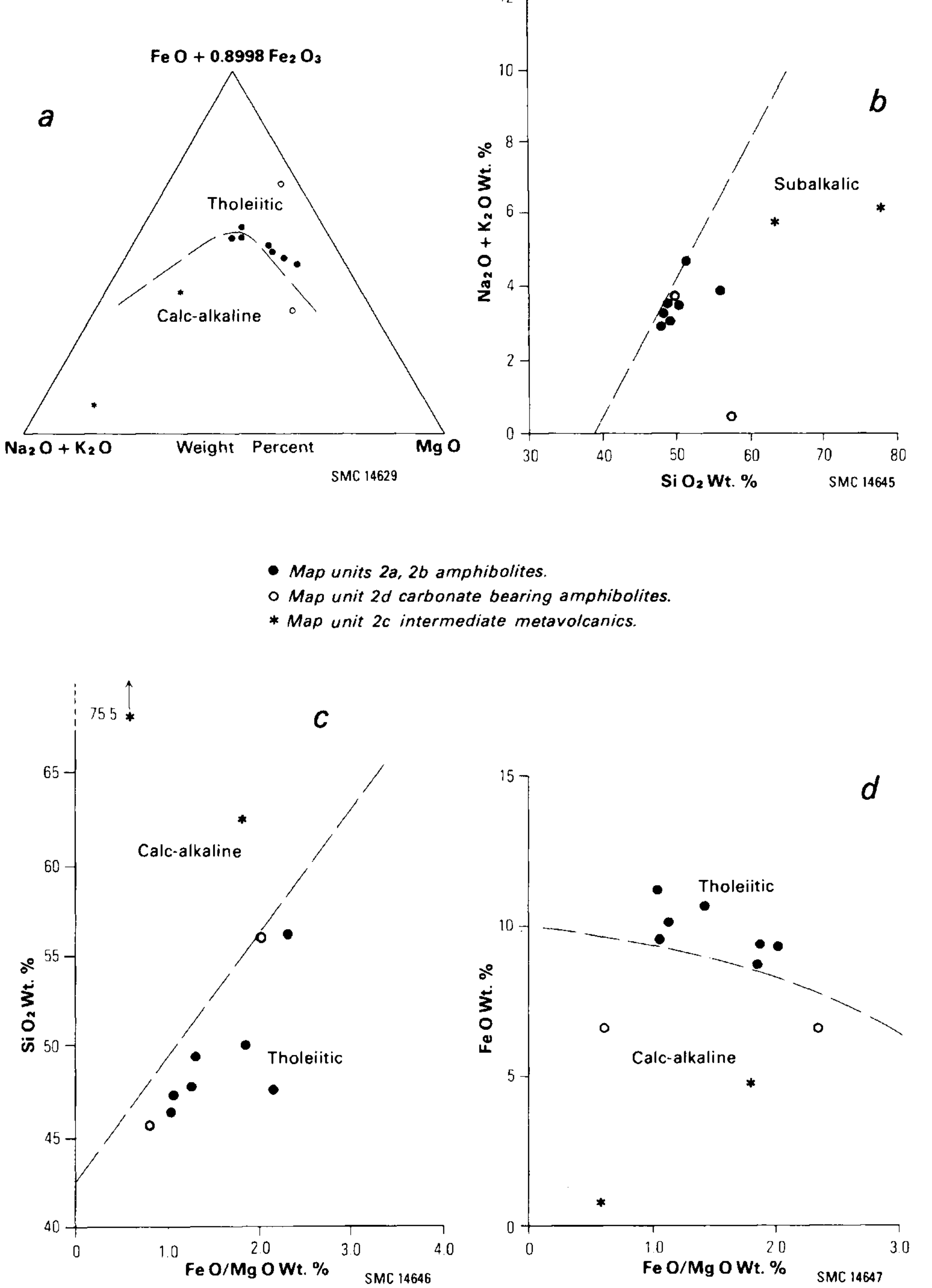

Figure 3—*Chemical classification of mafic and intermediate metavolcanics (map-unit 2).* ***a*** *and* ***b*** *after Irvine and Baragar (1971);* ***c*** *and* ***d*** *after Miyashiro (1974). Map-units 2a and b are subalkalic and tholeiitic, whereas map-units 2c and d are subalkalic and calc-alkaline.*

TABLE 4. COMPARISON OF CHEMICAL COMPOSITIONS OF AMPHIBOLE-RICH ROCKS IN THE LONG LAKE AND KALADAR AREAS.

	1	2	3
SiO_2	47.8	49.1	54.8
Al_2O_3	16.5	13.9	16.0
Fe_2O_3	3.53	1.83	5.49
FeO	7.88	9.77	3.94
MgO	6.76	8.38	4.91
CaO	9.76	9.14	6.35
Na_2O	2.70	2.44	3.79
K_2O	1.12	0.24	1.11
TiO_2	1.32	1.32	1.20
P_2O_5	0.20	0.12	0.30
MnO	0.18	0.18	0.13
CO_2	0.89	0.69	0.38

1. Average of 7 mafic metavolcanics (map-units 2a, 2b) this study.
2. Average of 10 Tudor mafic metavolcanics from the Kaladar area (map-units 1a, b, d, g, Wolff 1978, Table 3).
3. Average of 7 amphibole-rich gneisses from the Kaladar area (map-units 5a, b, f, Wolff 1978, Table 7) (same rocks as map-unit 5 this study).
NOTE. Analyses in weight percent.

the Kaladar area (Wolff 1978). The mafic members of the Tudor metavolcanics are also tholeiitic and subalkalic in nature. A comparison of the major element chemistries of the Tudor metavolcanics, the amphibole-rich gneisses (map-unit 5, Kaladar area, Wolff 1978) and map-unit 2 metavolcanics of the present study is presented in Table 4. The Tudor metavolcanics and the map-unit 2 metavolcanics have major elemental abundances which are similar except for Al_2O_3, and are collectively dissimilar from the amphibole-rich gneisses. The Al_2O_3 and K_2O contents of the map-unit 2 metavolcanics are more like those of the amphibole-rich gneisses. Similarity in K_2O values in the amphibole-rich gneisses and the map-unit 2 metavolcanics is not suprising as map-unit 2 metavolcanics show definite alteration tendencies when tested using the Fe_2O_3-TiO_2 relationship (Figure 4) proposed by Irvine and Baragar (1971).

In considering the nature of the above suites in outcrop, hand specimen, thin section and chemistry, the map-unit 2 metavolcanics of this study are most similar to the Tudor metavolcanics. The lack of preserved primary volcanic textures (save in map-units 2b and 2e) may be explained by a somewhat higher degree of metamorphism, or by a more distal location from the original vent. Certainly, the intimate occurrence of intermediate metavolcanic material (map-unit 2c) would suggest the latter to be a plausible explanation. The provenance of map-unit 5 (both present study and Kaladar area) amphibole-rich gneisses is likely a sedimentary sequence in which volcanic ash deposition was concurrent with siliceous clastic deposition of feldspathic wacke and arkosic wacke. The sedimentary pile was periodically interrupted by calc-alkaline volcanism similar to the higher parts of the Tudor metavolcanics (Wolff 1978). Map-unit 2 metavolcanics then may represent older but essentially contemporaneous primarily mafic volcanic rocks in fault contact with somewhat younger calc-alkaline volcanic rocks and immature sedimentary rocks (map-unit 5).

Clastic Siliceous Gneisses and Schists

Map-unit 3 is composed of clastic siliceous gneisses and schists which outcrop in discontinuous lenses in association with larger areas of map-units 4, 5, and to a lesser extent, map-unit 2. The largest areas of outcrop of the map-unit occur: 1) directly south of the village of Arden northeast of Thompson Lake; 2) northwest of Abbotts Hill (northwest of the village of Mountain Grove); 3) south of Bull Lake; and 4) east of McNeil Lakes along the Tamworth

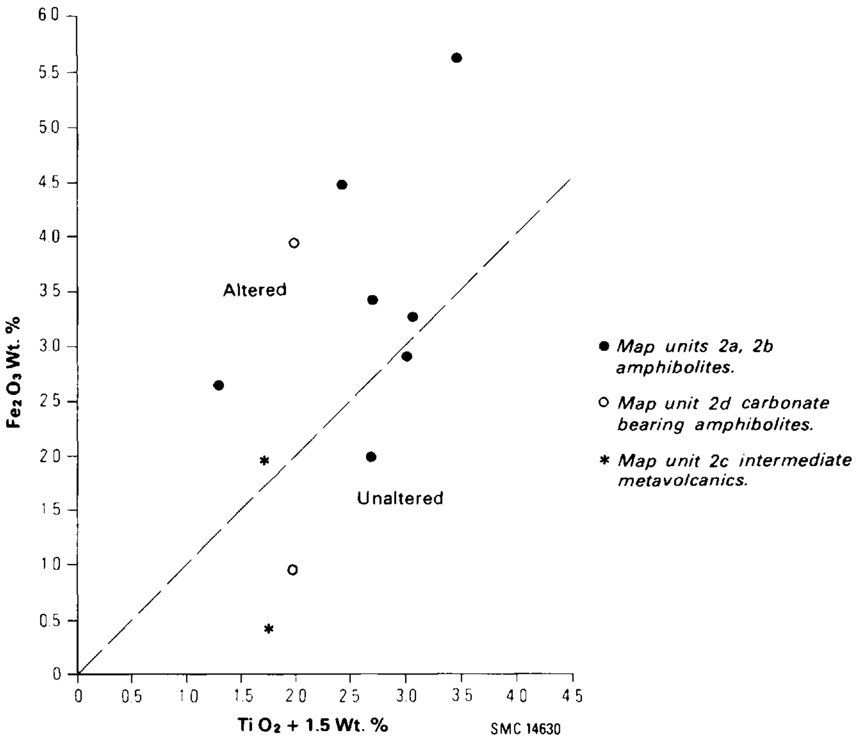

***Figure 4**—Plot of Fe_2O_3 vs. TiO_2 + 1.5 to show alteration of metavolcanics (map-unit 2).*

road. Similar rocks are on strike in the Kaladar area (map-unit 3, Wolff 1978). Rocks of map-unit 3 display a weak to well developed foliation, minor pinch and swell structures and minor fold structures.

The two most abundant rock types of map-unit 3 are 3a and 3b. Map-unit 3a is foliated, granoblastic, fine- to medium-grained biotite quartzofeldspathic gneiss. This map-unit weathers a whitish grey-buff with rusty weathering of the biotite. The biotite and quartzofeldspathic layers define the compositional layering and the biotite defines the preferred mineral orientation. The layering is generally 1 cm or more in thickness. Much repetition of the layering was observed across strike on the outcrop scale, and discontinuous garnetiferous horizons are found. The grain size varies from 0.1 mm to 2.0 mm and the texture is well foliated granoblastic with garnetiferous varieties exhibiting poikiloblasts. Table 5 summarizes the mineral abundances of this rock type. It should be noted that quartz is usually 30-35 percent, plagioclase (andesine) 10-45 percent and biotite 10-25 percent. Hornblende, almandine garnet, muscovite, epidote and tourmaline are accessory and opaques are either pyrite or Fe oxide. This rock type likely represents a metamorphosed feldspathic wacke.

Map-unit 3b has a similar mode of occurrence and both map-unit 3a and map-unit 3b can occur in the same outcrop. Map-unit 3b has substantially more quartz and less biotite and is defined as a foliated, granoblastic, fine- to medium-grained biotite-hornblende quartz-rich paragneiss. This map-unit weathers a bright whitish grey with green-brown

TABLE 5. MODAL ANALYSES OF CLASTIC SILICEOUS METASEDIMENTS (MAP-UNIT 3) IN THE LONG LAKE AREA.

Sample	M044-1	M046-1	M887-1	D011-1	DC257-1	D339-1	M331-1	M431-2	D046-2	D417-1	D419-1	D423-1A
Quartz	53	45	30	35	32	33	58	58	61	68	60	42
Plagioclase	8	15	25	22	45	30	29	18	25	25	25	27
	andesine	untwinned	sericitized	andesine	andesine	sericitized	andesine	andesine	sericitized	andesine	sericitized	andesine
K-feldspar			15				5					
			microcline				orthoclase					
Biotite	25	12	15	15	15	15	5	8	10		12	5
Hornblende		14		15						5		
Almandine Garnet	5	6			8	8		8				25
Epidote				8					<1			
Muscovite	4	2	10			10	2		4			
Tourmaline	2											
Opaque	2	5	5	5		2	2	8		2	3	1
TOTAL	99	99	100	100	100	98	101	100	100	100	100	100

SAMPLES

Biotite-quartzofeldspathic paragneiss. Map-unit 3a.

M044-1 0.3 km NW of Garrison Lake.
M046-1 1.0 km NE of Garrison Lake.
M887-1 0.6 km N of O'Reilly Lake.
D011-1 1.3 km NNW of Wallbridge Lake.
DC257-1 1.0 km E of Big Clear Lake.
D339-1 0.2 km E of Crotch Lake.

Biotite-hornblende-plagioclase-quartz-rich paragneiss. Map-unit 3b.

M331-1 0.4 km NW of Thompson Lake.
M431-1 0.1 km NW of Cranberry Lake.
D046-2 1.0 km NE of Garrison Lake.
D417-1 2.4 km W of Small Clear Lake.
D419-1 2.5 km W of Small Clear Lake.
D423-1A 1.7 km WNW of Small Clear Lake.

streaks. The foliation and compositional layering are less well defined because of the lack of contrasting mineralogy, but the rocks exhibit a definite granoblastic texture in thin section with local almandine garnet poikiloblasts. Typical grain sizes are 0.1 mm to 2.0 mm. As shown on Table 5 quartz is usually more than 55 percent and biotite less than 10 percent. Plagioclase (andesine) is typically 20-30 percent and garnet and muscovite are minor phases. Opaques are pyrite and/or magnetite. This map-unit likely represents metamorphosed quartzose wacke.

Map-unit 3c is foliated, granoblastic, fine- to medium-grained epidote-biotite-K-feldspar-plagioclase-quartz paragneiss. This rock type weathers buff-grey to pinkish grey with green streaks. It has been mapped as a different rock type because of its small amount of biotite (<10 percent), but near equal amounts of quartz (40-50 percent) and total feldspar (30-40 percent), plus prominent amounts of epidote (5-10 percent). The grain size is 0.1-1.0 mm. Layering is weakly defined and the texture is granoblastic with a well developed foliation. The plagioclase is usually saussuritized andesine, and K-feldspar is well preserved microcline. Minor phases are anhedral rutile and opaques. Although a feldspathic wacke this rock is more leucocratic than map-unit 3a and more quartz-poor than map-unit 3b.

Map-unit 3d is leucocratic, foliated, granoblastic, fine-grained biotite-magnetite-muscovite-quartzofeldspathic gneiss. This unit is very fine grained (<0.5 mm) hence it is often difficult to detect any layering except on close examination of the weathered surface which reveals very thin laminations (<0.5 mm). In hand specimen, magnetite can be observed in these laminations. The dominant mineral phases are quartz, plagioclase (andesine, highly sericitized), K-feldspar (microcline and orthoclase), muscovite and biotite. Minor phases are magnetite and zircon. Texturally, these rocks are granoblastic to granoblastic polygonal with quartz grains displaying interlocking textures. The fine grained and thinly laminated nature of this unit implies that this rock type may be in part a volcanogenic sediment, perhaps representing recrystalized varieties of andesitic and rhyolitic to rhyodacitic tuffs.

Map-unit 3e is foliated, granoblastic, fine- to medium-grained epidote-calcite-hornblende-biotite-plagioclase-quartz paragneiss. This unit has a distinctive pitted weathering, caused by dissolved calcite grains. The weathered surface is greyish green with bluish hues. The dominant mineral phases are quartz, plagioclase, biotite and hornblende. The plagioclase is heavily sericitized although remnant twins locally create a seriate texture. Minor phases are calcite, epidote, and sphene plus opaques. All grains are subidioblastic and the dominant texture is granoblastic. Biotite weakly defines two foliation orientations at shallow angles to one another.

Significant modifers to the above units, especially map-units 3a and 3c have been included in the legend. Map-unit 3f represents pyritic varieties. Pyrite may reach proportions of 33 percent but the high degree of weathering creates massive rusty staining on the weathered surface. Map-unit 3g is used to delineate almandine garnet-bearing varieties. Invariably the garnet is poikiloblastic and no rotated examples were observed. Occasionally muscovite may comprise 10-20 percent of the rock, in such cases the 3h code is employed. Occasionally the outcrops of map-unit 3 contain thin (5 cm thick), but continuous over the outcrop, segregations of quartz and feldspar. These segregations are medium grained, parallel the foliation, are deformed with adjacent beds and usually have a slightly positive relief. These may represent granitic injecta, or possibly sedimentary material of a composition close to the minimum melting point of granite (Luth *et al.* 1964), which recrystallized during metamorphism.

Locally within map-unit 3 aluminous schists contain muscovite (<50 percent) and quartz (20-35 percent) as the major phases and plagioclase, epidote, almandine garnet and magnetite as minor phases. This rock type is discontinuous along strike and is represented by map-unit 3k.

Bordering on the McLean Granitic Pluton (map-unit 11) in the major NE-trending shear zone are a number of outcrops of unit 3. The high shear stress has created local protomylonite, mylonite and mylonite gneiss. These are labelled as map-unit 3m. The sample thin sectioned contained 60 percent quartz and 24 percent plagioclase (andesine). Biotite was

10 percent of the rock and rutile, epidote, tourmaline and sphene the remainder. This sample is generally fine grained (0.03-0.20 mm) but quartz forms large (0.6 mm) rafts around which the finer material flowed. The smaller quartz grains display a mortar texture. In outcrop these rocks show high shear strain features typical of dynamically metamorphosed rocks, as described by Spry (1969).

Carbonate Metasediments

Map-unit 4 is composed of carbonate metasediments. The largest area of outcrop for rocks of this map-unit is a 5 km wide zone running northeast through the village of Arden. This unit is bounded to the northwest by amphibole-rich gneisses and schists (map-unit 5) and to the southeast by the Abbotts Hill Intrusion (map-unit 9). A thin unit of amphibole-rich gneiss and clastic siliceous gneiss separates the carbonate metasediments from the Abbotts Hill Intrusion. A small zone of carbonate metasediment covering approximately 6 km^2 occurs on the western border of the Mountain Grove Mafic Intrusion southeast of Mountain Grove. Smaller inclusions of carbonate metasediment in this body located west of the hamlet of Long Lake have proved to contain economic concentrations of Zn and Pb. Rocks of

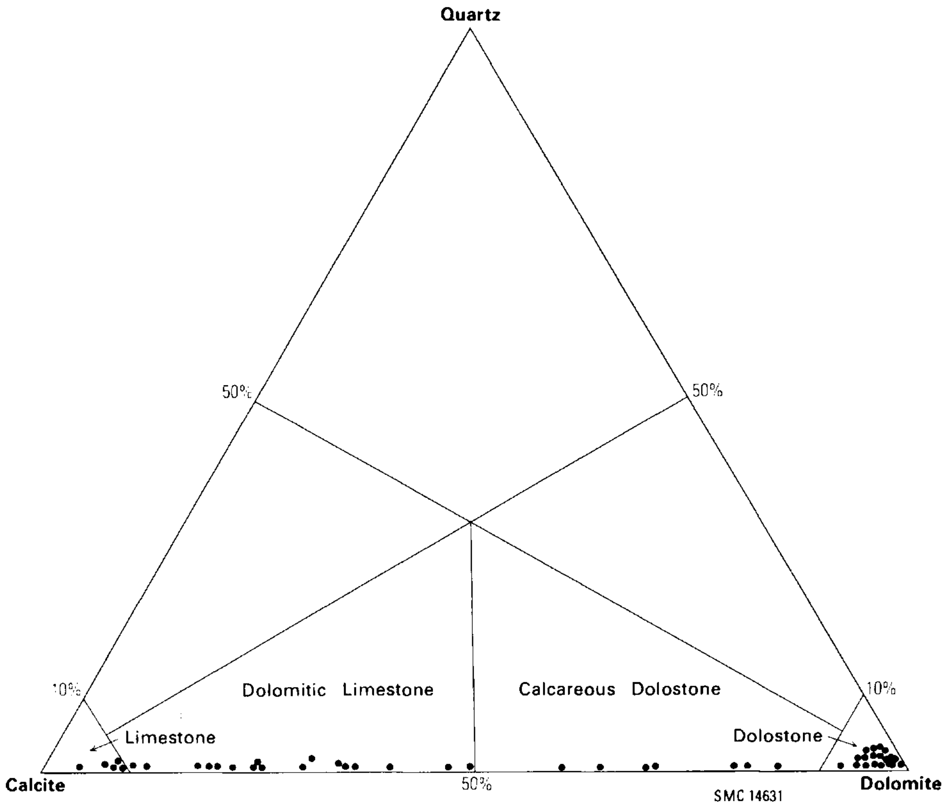

***Figure 5**—Classification of carbonate metasediments (map-unit 4) in terms of quartz-calcite-dolomite components.*

map-unit 4 are best exposed where farmland has been cleared but otherwise are densely vegetated. This unit is typically highly deformed, locally exhibiting flowage-type structures.

The carbonate metasediments have been divided into three main groups, calcite marble (map-unit 4a), dolomite marble (map-unit 4c) and dolomite-calcite marble (map-unit 4d). Forty-eight slabbed samples of these units were stained for calcite and the results are depicted in the quartz-dolomite-calcite plane (Figure 5). Although dolomitic limestone and calcareous dolostone compositions can be delineated by this process these two rock types were combined and mapped as dolomite-calcite marble in the field. Disseminated quartz is generally absent in the carbonate metasediments encountered.

Map-unit 4a is white-grey weathering calcite marble. It is usually medium to coarse grained (3 mm to 5 mm) with a granoblastic texture. In general, this unit is quite massive. Locally it is thinly laminated (0.5-2.0 cm thick). These are quite continuous and this feature has been coded as map-unit 4b. The calcite rhombs are idioblastic to subidioblastic in form.

Map-unit 4c represents the dolomite marble. This unit is medium grained (1-5 mm) and is quite massive displaying a granoblastic texture. This unit tends to weather snow-white to blue. The dolomite rhombs are idioblastic to subidioblastic.

Map-unit 4d is very similar to map-units 4a and 4c and is really a combination of each end member. This unit has a somewhat mottled grey colour and is medium grained (1-5 mm) with a granoblastic texture. It should be noted that map-units 4a, c and d in places occur on the same outcrop over short distances both along and across strike and the dominant phase or phases are shown on the map.

The remaining map-units in this category represent various mineral groupings and intercalated rock types which occur in any of the above lithologies.

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***Photo 2**—Massive radiating clusters of tremolite in map-unit 4 carbonate metasediments south of Highway 7 between Garrison and Wallbridge Lakes (lot 17, concession VI, Kennebec Township). Map units present are 4 a, e.*

Map-unit 4e is used to distinguish calc-silicate mineral assemblages. These are fine grained (0.5 mm) to medium grained (5 mm) subidioblastic groupings of tremolite ± scapolite ± diopside ± talc ± apatite. Tremolite is by far the most common calc-silicate encountered. It is green-whitish grey in colour and occurs in randomly oriented needles and radiating bundles typically less than 2.5 cm in length but 5 cm long blades do occur (Photo 2). The other calc-silicates include idioblasts of scapolite (1 cm) and usually brownish-grey in colour, but a jet black variety is also present. Diopside idioblasts are very well preserved and are 5 mm in size and brownish green in colour. Talc and apatite are the least common calc-silicates, both are green in colour and less than 1 cm in size, and typically subidioblastic to idioblastic in form. Calc-silicate mineral assemblages especially tremolite are locally found interlaminated with calcite marble (map-unit 4a). Such laminations are continuous along strike and traceable for up to 50 m. These units, in thin section, are seen to typically contain quartz and are representative of the fine interlayering of quartz sandstone and carbonate units which upon metamorphism produced calc-silicate minerals (see "Metamorphism").

Map-unit 4f is fragmental dolomite-calcite marble containing flags of quartzite, quartz and calc-silicates (map-unit 4e). This map-unit usually forms a continuous layer on the outcrop scale. The quartzite zones are medium grained (1-5 mm) and usually contain some areas of massive quartz. The contact between this material and the adjacent dolomite-calcite marble is heavily masked by pervasive calc-silicate material (map-unit 4e). The formation of these calc-silicate phases occurred during the metamorphism of these units and the intermixing of carbonate and quartz-rich chemistries. The quartzite blocks and flags are separated and flowage of the carbonate material between flags is intimate. Quartzite blocks are typically 15-20 cm thick and 20-30 cm in length, however, some of the quartzite

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***Photo 3**—Resistant block of quartzofeldspathic material (map-unit 4g) in laminated calcite marble (map-unit 4b), lot 16, concession V, Kennebec Township.*

beds reach 0.5 m in thickness locally. This map-unit is significant in that it represents local topographic highs and instabilities in the carbonate bank during deposition (Wolff 1978).

Map-unit 4g is composed of quartzite and quartzofeldspathic blocks, broken beds and flags. These are very different from map-unit 4f in size, mineralogy and habit. The beds in map-unit 4g are never greater than 10-15 cm in thickness and individual grains are fine grained (< 1 mm). The mineralogy includes feldspar and appears more like clean feldspathic wacke and quartzose wacke of map-unit 3. In habit, the blocks are angular with clear cut contacts, possess a positive relief and are essentially equidimensional and discontinuous along strike (Photo 3). Broken beds of this material tend to be thin (<2 cm thick) and parallel to foliation in the surrounding carbonate metasediments (Photo 4).

Map-unit 4h represents recrystallized chert beds. These are less than 5 cm thick and discontinuous along strike.

Map-unit 4j contains mafic hornblende-rich segmented layers. These are typically less than 25 cm thick and discontinuous along strike. In all likelihood these are related to map-unit 5 amphibole-rich gneisses and schists.

Map-unit 4k comprises very coarse grained (>2 cm) varieties of map-units 4a, c, and d. Spatially these only occur in those carbonates bordering the Mountain Grove Mafic Intrusion. The calcite rhombs are extremely large yet idioblastic (Photo 5).

Map-unit 4m is extremely amorphous calcite marble. This map-unit occurs only near the Mountain Grove Mafic Intrusion as well.

Poorly developed calcite-talc schist occurs locally. A very friable and greasy feeling rock, it weathers greenish streaky grey and has been pulverized during deformation.

Not included in the legend but noted on the map-face are a number of occurrences of phlogopite, graphite, pyrite, sphalerite and galena in map-unit 4 rocks. Sphalerite, galena and graphite were not located in the main carbonate metasediment zone which runs through Arden, although pyrite is a common sulphide mineral in this zone.

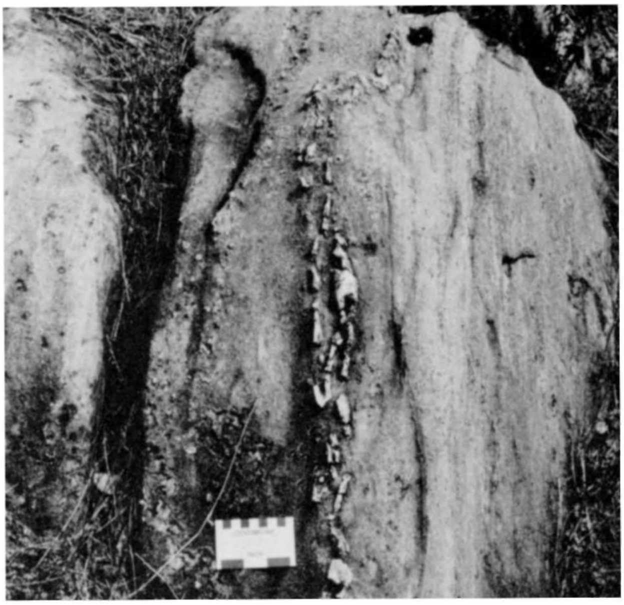

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Photo 4*—Thin segmented beds of quartzite (map-unit 4g) in laminated calcite marble (map-unit 4b). Quartzite bed is deformed with surrounding marble. Lot 16, concession VI, Kennebec Township.*

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***Photo 5**—Very coarse grained calcite-dolomite marble (map-unit 4k) at the Long Lake zinc mine, lot 3, concession V, Olden Township. Map-unit 4k is only found in carbonate inclusions within the Mountain Grove Mafic Intrusion (map-unit 10).*

Amphibole-Rich Gneisses and Schists

Map-unit 5 is composed of amphibole-rich gneisses and schists. These units outcrop primarily between Kennebec Lake and Highway 7. Smaller outcroppings of this unit exist: 1) between Thompson and Horseshoe Lakes; 2) east of the Arden-Tamworth road; and 3) along the western boundary of the major shear zone which passes through the village of Mountain Grove. Compositional layering is well developed in these rocks and is continuous along strike. Rock types of this group often grade into one another along strike and can quickly change along strike. Map-unit 3 material is often intercalated within this map-unit (Photo 6). The majority of outcrops of this map-unit lie directly on strike with those of the Kaladar area which have been described in some detail (Wolff 1978).

Map-unit 5a is composed of foliated fine grained (0.5 mm) hornblende, plagioclase ± biotite ± epidote. This unit weathers greenish grey as plagioclase and quartz are in greater abundance than hornblende. The major phases are subidioblastic plagioclase (andesine), hornblende and quartz. Hornblende is typically 20-40 percent of the rock and plagioclase/quartz ratios vary. Minor phases are biotite, epidote, calcite, talc, clinozoisite and magnetite and pyrite. These possess a gneissosity defined by the compositional layering and are granoblastic in texture. This map-unit is locally highly boudinaged.

Map-unit 5b is foliated, fine- to medium-grained, subidioblastic plagioclase-hornblende gneiss ± biotite ± epidote. Rocks of this unit weather greyish green with local apple green concentrations of epidote. These rocks contain 50-75 percent hornblende, 25-40 percent plagioclase (andesine), and minor biotite, epidote, clinozoisite, calcite and magnetite. Epidote-rich phases usually are quartz- and calcite-bearing and likely represent the prograde metamorphism of chlorite, calcite and quartz to epidote and amphibole. Texturally, these units are granoblastic and possess a gneissosity defined by the compositional layering. Locally this unit is boudinaged.

Map-unit 5c is fine- to medium-grained granoblastic quartz-plagioclase-hornblende gneiss. This rock weathers grey-whitish green, often displays a "salt and pepper" weathering and possesses a definite hornblende foliation. It differs from map-unit 5a in that the granoblastic texture is clearly visible in hand specimen, and the grains appear less deformed. Mineralogically, the main phases are quartz (15-30 percent), plagioclase (andesine) (20-45 percent) and hornblende (15-40 percent). The hornblende-poor varieties have biotite (15 percent), and pyrite is the main opaque mineral. Epidote and calcite seldom occur in this rock type and if present are less than 5 percent. This rock is usually fine- to medium-grained (0.1-1.0 mm). The well developed compositional layering of map-units 5a and 5b is generally poorly developed in this map-unit and boudinage is lacking.

Map-unit 5d is composed of foliated subidioblastic fine- to medium-grained plagioclase-hornblende gneiss with more than 80 percent hornblende. This unit weathers a dark green-brownish colour and grain size ranges from 0.5 to 5.0 mm. Biotite and epidote are minor phases. This unit is only mappable over short distances and often associated with map-unit 5b.

Map-unit 5e is foliated, fine- to medium-grained K-feldspar-hornblende gneiss. It is similar to map-unit 5b but contains up to 20 percent orthoclase. Quartz and plagioclase (albite) are also present. This unit is only mappable over short distances.

Map-unit 5f is massive, medium- to coarse-grained idioblastic amphibolite with or without plagioclase. This unit is continuous along strike and forms topographic highs with

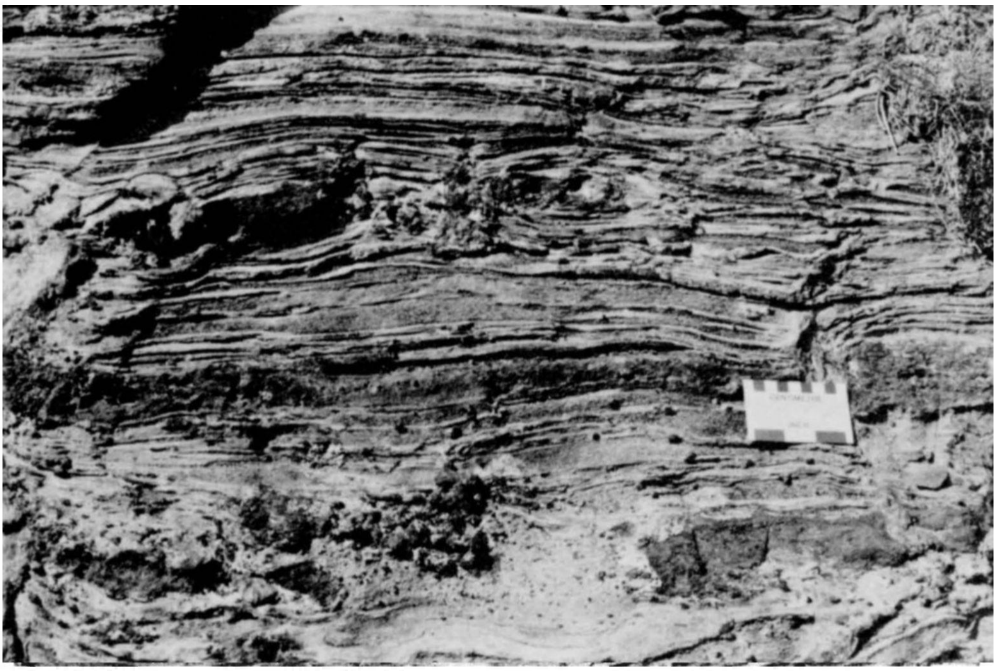

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***Photo 6**—Intercalated clastic siliceous gneiss plus garnets (map-unit 3agh) and amphibole-rich gneiss (map-unit 5b) north of Highway 7 (lot 18, concession 7, Kennebec Township). The boudinaged zone is unit 5 material.*

respect to the other rock types in unit 5. The most well developed outcrops of this rock type occur very near and sometimes within the carbonate metasediments main zone of exposure (map-unit 4). Grain sizes range from 0.5 mm to 4.5 mm for hornblende which often creates a knobby dark green weathering surface. The plagioclase composition varies from andesine to labradorite. Minor phases are typically pyrite and epidote but quartz and calcite were noted in this rock type to the southwest (Wolff 1978). The grain size of plagioclase and the minor mineral phases is usually 1.0 mm. The dominant texture of this rock is granoblastic with hornblende glomeroporphyroblasts and fractured porphyroblasts. The coarse grained and mafic nature of this unit suggest it may be a metagabbro, or remnant of a mafic flow or sill.

Map-unit 5g is a qualifier to distinguish the presence of calcite porphyroblasts occurring in map-units 5a and 5b. These are typically idioblastic to subidioblastic and medium grained (1-5 mm). Map-unit 5h is used to distinguish the occurrence of almandine garnet porphyroblasts in this map-unit. The porphyroblasts contain inclusions of quartz in thin section, but no apparent rotation was noted.

Occurring locally throughout map-unit 5 are a number of discontinuous units of biotite-hornblende quartzofeldspathic schist, labelled as map-unit 5j. Hornblende and/or biotite constitute between 50 percent and 85 percent of the rock. Quartz and plagioclase (which is heavily sericitized) each are less than 15 percent of the rock. Minor phases include apatite, epidote and pyrite. Hornblende-rich schist often contains talc as well. These schists are usually fine grained (0.1-0.3 mm), however, locally well formed biotite flakes may reach 4 mm and display excellent Newton's rings.

Map-unit 5k is indicative of those units described above which have been sheared and recrystallized forming protomylonite, mylonite and mylonite gneiss. These are located on the western border of the major shear zone running through the village of Mountain Grove. The two samples thin sectioned represent a protomylonite and mylonite. In hand specimen these rocks are highly "stretched". The most resistant minerals to the shear stress have been the quartz, plagioclase, hornblende, and almandine garnet grains. The biotite has freely flowed around the almandine garnet and hornblende grains. The quartz grains have been crushed and in the mylonite sample there is a pronounced bimodal distribution of the grain size of quartz. In the protomylonite, fracturing of these resistant grains is common. Calcite, epidote and pyrite are minor phases in this rock type.

SYNTECTONIC METAMORPHOSED FELSIC TO INTERMEDIATE INTRUSIVE ROCKS

Sheffield and Hinchinbrooke Gneiss Complexes

Map-unit 6 represents two gneiss complexes occurring in the map-area; the Hinchinbrooke Complex and the Sheffield Complex. The Hinchinbrooke Complex outcrops in the southeastern corner of the map-area and lies in fault contact with the rocks of map-unit 1. Inclusions or rafts of map-unit 1 material in map-unit 6a occur near the contact with map-unit 1. This would suggest map-unit 6a may be intrusive into map-unit 1.

Map-unit 6a represents the dominant rock type exposed in the map-area belonging to the Hinchinbrooke Gneiss Complex. This rock is massive to foliated, fine- to medium-grained granoblastic enderbitic granolite (high grade metamorphic terminology after Winkler 1974, 1976). The rock weathers buff to grey with minor green-grey hues and varies from fine grained (0.15 mm) to medium grained (2.5 mm). The mineral phases present are given in Table 6. Plagioclase and quartz form the dominant phases and pyroxene is ubiquitous. The plagioclase is usually sericitized to some degree and varies from andesine to labradorite in composition. The quartz is generally anhedral. Pyroxene is subhedral hypersthene and altered in varying degrees to talc. Hornblende subhedra locally occur. Minor phases tend to be biotite, muscovite and pyrite. This rock type locally contains porphyroblasts of quartz or plagioclase. Near the contact with map-unit 1 rafts of 1a material occur. Map-unit 6b is used to delineate this feature.

The Sheffield Gneiss Complex (Wolff 1978) is located in the southwestern corner of the map-area west of the Salmon River. These outcrops lie on strike and adjacent to the Sheffield gneiss exposure in the Kaladar area (Wolff 1978). The Sheffield gneiss outcrops examined in the present study delineate two major units. The most dominant is map-unit 6c, foliated to massive, medium-grained grey-weathering trondhjemite to granodiorite containing pink-weathering bands of quartz monzonite to granite. This map-unit is often highly contorted and gneissic containing massive pegmatite phases in outcrop. This unit is typical of the 7c map-unit (swirl foliated, interbanded pink granite and grey trondhjemite-granodiorite) described by the author in the Kaladar area. Map-unit 6c is medium grained (0.5-2.0 mm) and is interlocking granoblastic in texture.

Map-unit 6d represents foliated to gneissic, medium-grained trondhjemite to granodiorite gneiss with or without biotite and muscovite. This map-unit occurs chiefly on the eastern margin of the Sheffield complex between McNeil Lakes and Crotch Lake. Map-unit 6d differs from map-unit 6c in that it lacks: 1) quartz monzonite to granite phases; 2) massive pegmatite phases; and 3) the high degree of contortion. The contact between the two units is diffuse. The texture of map-unit 6d is interlocking granoblastic. The grain size varies from 0.5 to 1.0 mm and the unit weathers a pinkish grey.

Similarities between map-units 6d and 6c occur in the mineralogy. Both contain anhedral quartz, heavily sericitized plagioclase, variable amounts of microcline, biotite and muscovite. Opaques were absent in the two samples thin sectioned.

The nature of map-units 6c and 6d suggests that the Sheffield Gneiss Complex could be in part basement to the metasediments of map-units 3, 4 and 5. The pegmatitic contorted banded gneiss (included in map-unit 6c) represents material which reached a higher degree of anatectic partial melting than the more massive homogenous periphery (map-unit 6d). Map-units 6c and 6d differ considerably from the Addington Pluton (map-unit 8, Kaladar area map-units 7a, b, d, e, f) in the mode of occurrence and in mineral assemblages. The Addington Pluton has preserved lit-par-lit contact relationships with the metasediments of map-units 5 and 3, and a very fresh mineralogy (Wolff 1978), whereas

TABLE 6. MODAL ANALYSES OF ENDERBITIC GRANOLITE (MAP-UNIT 6a) FROM THE HINCHINBROOKE GNEISS COMPLEX IN THE LONG LAKE AREA.

Sample	D952-1	D956-2	D963-1	D948-1
Quartz	10	22	33	15
Plagioclase	35 andesine–labradorite	57 andesine–labradorite	40 labradorite–andesine	60 andesine
Pyroxene (Hypersthene)	20	12	20	12 completely altered to talc
Hornblende	30		5	
Biotite		3		5
Muscovite		1		
Pyrite	5	5	2	8
TOTAL	100	98	100	100

SAMPLES
D952-1 3.8 km ESE of Wagarville.
D956-1 3.3 km ESE of Wagarville.
D963-1 2.8 km SE of Wagarville.
D948-1 4.3 km ESE of Wagarville.

the Sheffield Gneiss Complex is more contorted, contains heavily sericitized plagioclase, has partial melting indicators and appears to be in fault contact with the sedimentary "package" consisting of map-units 3, 4 and 5.

Northbrook Batholith

Situated in the far northwest corner of the map-area are outcrops of the Northbrook Batholith (map-unit 7). A large expanse of this body which lies on strike to the west and southwest in the Kaladar area has been described by the author in detail (Wolff 1978).

Figure 6a depicts the distribution of map-unit 7 rocks from the map area in the quartz, plagioclase, K-feldspar plane. Information for this plot is based on 33 slabs stained for K-feldspar. The groupings show clearly that quartz monzonite, granodiorite and trondhjemite compositions of this unit outcrop in the map-area. Minor granite compositions of the Northbrook Batholith were also observed. Aside from the compositional difference, map-units 7a, b, c and d are similar in that they all are shades of grey-white to pinkish white-grey in colour, fine to medium grained, (0.4-1.6 mm), are lineated to weakly foliated and contain biotite.

The texture of these rocks is granoblastic although locally a gneissosity is developed. This map-unit is faulted by southeast trending lineaments, and is cut by southeast-trending, pink-white pegmatite dikes.

Addington Pluton

Map-unit 8, the Addington Pluton, outcrops in the map-area at two localities. The first locality, along the north shore of Kennebec Lake, is an on-strike extension of the Kaladar-Kennebec ridge described by the author in the Kaladar area (Wolff 1978). The second locality is along the north shore of Cranberry Lake and western arm of Horseshoe Lake. This outcrop area is an on-strike extension of the Lingham Lakes ridge described by the author in the Kaladar area (Wolff 1978). The Lingham Lakes ridge terminates south of Dutch Lake in the present map-area.

The Addington Pluton in the map-area exhibits four major rock types, biotite granite (map-unit 8a), leucocratic quartz monzonite (map-unit 8b), biotite quartz monzonite (map-unit 8c) and leucocratic granite (map-unit 8d). All phases are medium grained (0.5-1.5 mm). The granites tend to weather whitish pink to brownish pink, and the quartz monzonites greyish pink to pinkish white-grey, variations being created by the relative amounts of biotite within each rock type. All units contain quartz, plagioclase (andesine) and microcline plus minor orthoclase. The feldspars are very fresh. The minor phases are biotite (locally chloritized), muscovite, epidote and opaques. The texture is granoblastic with a well developed biotite foliation and/or compositional layering defining the gneissosity. Local mortar textures are preserved. Unit 3 and 5 material are often present as thin slices and wedges. Where the pluton is in contact with map-units 3 and 5, lit-par-lit textures are preserved.

Abbotts Hill Intrusion

Map-unit 9 is the Abbotts Hill Intrusion. Outcropping as a prominent ridge with a local relief of 60 m to 75 m, this unit stretches from Abbotts Hill, on the north side of the village of Mountain Grove, southwest to the Salmon River. Just east of the Arden-Tamworth road the unit outcrops in an elliptical pattern enveloped by metasediments of map-units 3 and 5. This unit is in sharp contact with metasediments of units 3, 4 and 5 over much of its strike length and is bounded on the east by the shear zone which passes through the village of Mountain Grove.

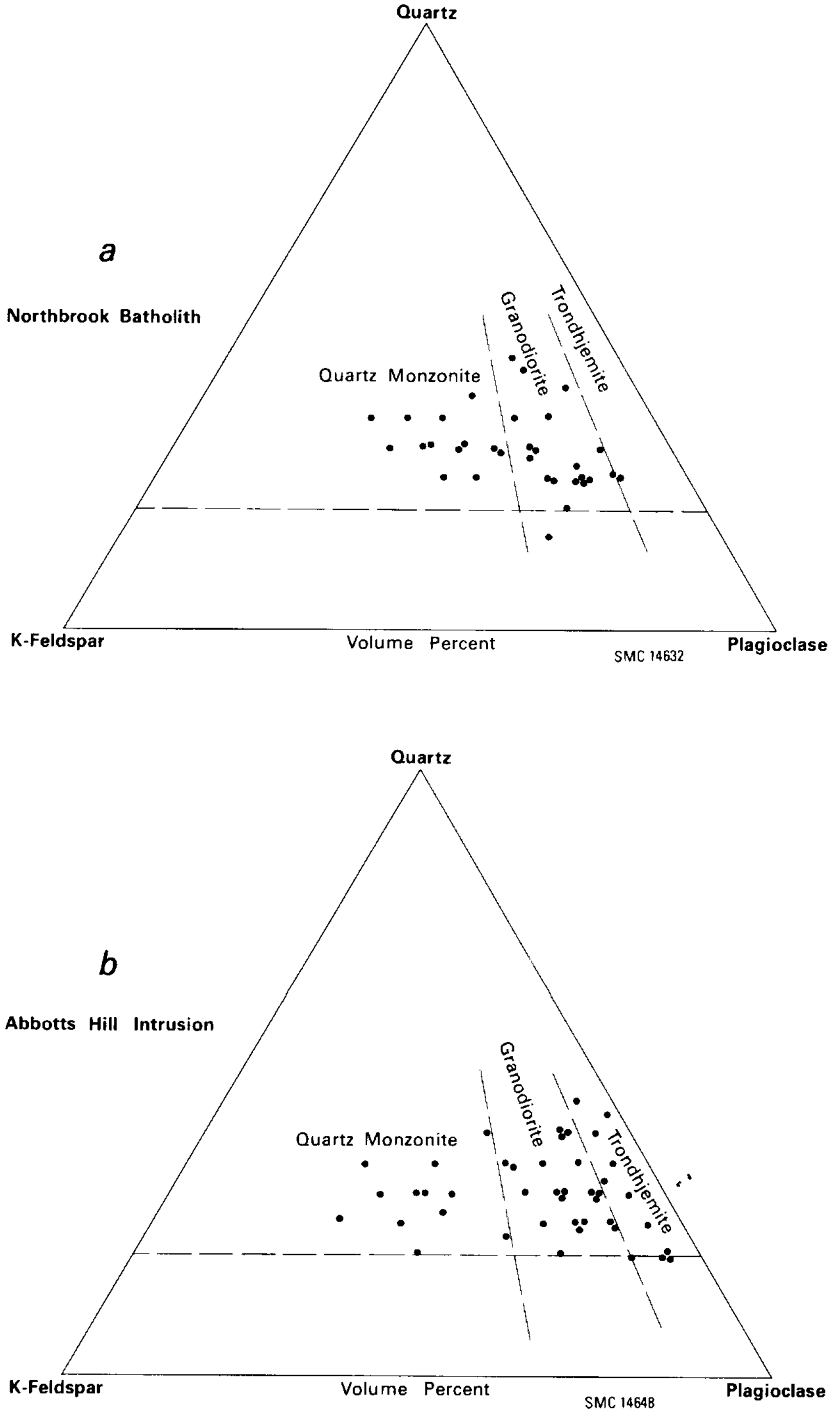


Figure 6—*Compositions of Northbrook Batholith and Abbotts Hill Intrusion in terms of quartz, plagioclase, and K-feldspar.*

Forty-four samples from this intrusion were slabbed and stained for K-feldspar. The results are shown on Figure 6b. Compositions fall in the trondhjemite, granodiorite and quartz monzonite fields. No rocks of granite composition were observed in this unit.

The major subdivisions of map-unit 9 are: map-unit 9a, foliated, medium-grained, biotite trondhjemite, locally containing hornblende; map-unit 9b, foliated, medium-grained, biotite quartz monzonite, locally containing hornblende; and map-unit 9c, foliated, medium-grained, biotite granodiorite with local leucocratic phases containing <5 percent biotite. Rocks of map-unit 9a weather whitish grey with brown-grey flecks, map-unit 9b grey-pink, and map-unit 9c pink-grey. The grain size ranges from 0.5 mm to 3.5 mm. Major mineral phases are quartz, plagioclase (andesine), K-feldspar (orthoclase), and biotite (Table 7). Minor phases include epidote (alteration product after biotite) almandine garnets, allanite, uranothorite and opaques. The feldspars are quite fresh. The texture is granoblastic to interlocking, with garnetiferous varieties exhibiting a poikiloblastic texture. The biotite grains and opaques define a weak foliation. Close examination of hand specimens reveals that the weak biotite foliation is superimposed upon a mosaic of randomly oriented biotite grains. The foliation trends parallel the major shear zone which lies adjacent to this unit. Hence, the weak biotite foliation likely represents the imprint of this shear zone upon a pre-existing massive intrusive texture of the Abbotts Hill Intrusion. The lack of granite compositions, preservation of a massive intrusive texture and a weak late stage shear zone imprint on the rocks of the Abbotts Hill Intrusion segregate this unit from the Northbrook Batholith (map-unit 7).

Variations on the above rock types are represented by map-units 9d, e and f. Map-unit 9d denotes fine-grained aplitic leucocratic quartz monzonite phases or segregations. These are not dikes but irregular masses occurring with any of the above rock types and typically represent only a small fraction (<5 percent) of any outcrop they occur in. Map-unit 9e is used to denote garnetiferous varieties of map-units 9a, b, c and d. Where this map-unit is found, the garnets are invariably almandine poikiloblasts around which the weakly developed biotite foliation has flowed.

TABLE 7. MODAL ANALYSES OF FELSIC TO INTERMEDIATE INTRUSIVE ROCKS OF THE ABBOTTS HILL INTRUSION.

Sample	M474-1	D312-1	M460-1	M459-1
Quartz	60	45	50	45
Plagioclase	18 andesine	30 andesine	25 andesine	30 andesine
K-feldspar	6 orthoclase		15 orthoclase	17 orthoclase
Biotite	8	15	5	5
Almandine Garnet		8		
Epidote	3		1	1
Allanite		<1		
Uranothorite		<1		
Opaques	5	2	3	2
TOTAL	100	100	99	100

SAMPLES
Biotite trondhjemite. Map-unit 9a.
M474-1 2.5 km SW of Small Clear Lake.
D312-1 1.7 km E of Horseshoe Lake.
Biotite quartz monzonite. Map-unit 9b.
M460-1 2.4 km WSW of Small Clear Lake.
Biotite granodiorite. Map-unit 9c.
M459-1 2.3 km WSW of Small Clear Lake.

Map-unit 9f represents shear zone mylonite phases of the above units. These seldom occur in the map-area as the Abbotts Hill intrusion was structurally somewhat buffered from the intense shearing zone stress by unit 5 material. Mylonite phases of unit 9 however, are highly stretched and texturally similar to map-units 2h, 3m, 5k and 11j.

LATE TECTONIC METAMORPHOSED INTRUSIVE ROCKS

Mountain Grove Mafic Intrusion

Map-unit 10 represents the Mountain Grove Mafic Intrusion. This body is situated 1 km southeast of the village of Mountain Grove and extends southwards forming the north shore of Long Lake. The body has a crude "Z" shape, and is sandwiched by intrusive rocks of unit 11, to the east, south and west. The maximum dimension (north-south) of this mafic body is 7 km. On the northern boundary, unit 10 is in contact with unit 2 metavolcanics, and an embayment of unit 4 carbonate metasediments forms the western margin. A number of sphalerite-bearing carbonate wedges are scattered throughout the southern zone of this body, one of which is the Long Lake zinc deposit.

Compositionally, the body varies from gabbro and quartz gabbro to anorthosite, monzonite and syenite. Outcrops of these units tend to be small and massive with locally developed penetrative fractures. Individual outcrops may have more than one phase present. Igneous layering or banding, however, is absent and the different phases have irregular contacts. Locally, intrusive breccias between phases are observed.

Map-unit 10a is the most commonly occurring rock-type of this intrusion and is composed of medium- to coarse-grained gabbro. In hand speciman this rock type has a colour index >30, and weathers dark green to drab olive green. Although typical grain sizes are 1.0-4.0 mm, rocks with 0.5-1.0 mm grains can be found. The plagioclase is subhedral andesine to labradorite. Pyroxene subhedra are usually altered to hornblende, or talc. Few fresh pyroxene grains exist. Biotite, epidote, apatite, hornblende and pyrite form minor phases (Table 8). Texturally, these rocks are interlocking but relict subophitic textures can be found.

The next most common rock-type is map-unit 10b, medium- to coarse-grained anorthositic gabbro and gabbroic anorthosite (colour index 10-30). This rock weathers green to dark green and grain sizes are typically 1.0-5.0 mm. The modal compositions of this rock type are given in Table 8 (because of the coarse grain-size, point counting of thin sections does not always agree with the field classification). The dominant phases include plagioclase (andesine-labradorite), which is seldom saussuritized, pyroxene which is often altered to hornblende, although preserved enstatite grains can be found (sample D802-1). Minor phases are biotite, epidote, and pyrite. This unit primarily displays interlocking textures although some subophitic textures exist.

Map-unit 10c represents medium- to coarse-grained anorthosite. This rock is greyish-greenish-white, with a colour index <10. The sample thin sectioned had 75 percent sericitized plagioclase and 15 percent biotite with 10 percent pyrite. This particular sample, although technically not anorthosite based on point counting, is a plagioclase-rich rock approaching anorthosite composition. The texture is allotriomorphic granular and grain size ranges from 0.5 mm to 1.0 mm.

Map-unit 10d represents medium- to coarse-grained quartz gabbro. In hand specimen this rock weathers similar to gabbro but contains quartz. This rock type is not common.

To differentiate between gabbro, monzonite and syenite, samples from the mafic intrusion were stained for K-feldspar. Results of the K-feldspar testing indicated the presence of monzonite phases within the intrusion. Coded as map-unit 10e, these are typically medium to coarse grained and the K-feldspar seldom weathers pink. These rocks weather a

TABLE 8. MODAL ANALYSES OF ROCKS FROM THE MOUNTAIN GROVE MAFIC INTRUSION (MAP-UNIT 10), LONG LAKE AREA.

Sample	D790-1	D785-1	M1023-1	D802-1	M890-1	D779-1	D805-1	M810-1
Plagioclase	42 seriticized	50 andesine–labradorite	63 andesine	45 labradorite saussauritized	48 andesine	50 andesine	75 labradorite saussauritized	
K-feldspar								20 microcline* 15 orthoclase*
Pyroxene	35 altered to hornblende	40 altered to hornblende and Fe oxide	18 altered to talc	35 enstatite		30 altered to talc	20 diopside	35 altered to hornblende
Hornblende			5		40			
Biotite	10		2	15		10	2	5
Epidote	5				5		2	10
Quartz								10
Apatite		2						
Opaque (Pyrite)	8	8	12	5	7	10	2	5
TOTAL	100	100	100	100	100	100	101	100

*Perthitic.

SAMPLES

Gabbro. Map-unit 10a.
D790-1 0.2 km NE of Little Mud Lake.
D785-1 1.6 km E of Little Mud Lake.

Anorthositic gabbro-gabbroic anorthosite. Map-unit 10b.
M1023-1 0.4 km SE of Little Mud Lake.
D802-1 1.8 km E of Little Mud Lake.
M890-1 1.2 km N of Long Lake.
D779-1 1.5 km SE of Little Mud Lake.

Anorthosite. Map-unit 10c.
D805-1 1.8 km W of O'Reilly Lake.

Syenite. Map-unit 10g.
M810-1 2.5 km N of Long Lake.

greyish green colour and are not significantly different in habit than the gabbros of map-unit 10a. The K-feldspar present is dominantly orthoclase. Plagioclase present is andesine-labradorite and pyroxene is altered to hornblende. Biotite, epidote and pyrite constitute minor phases. Textures are interlocking to subophitic.

Present in most of the outcrops of the above rocks are fine-grained varieties of the same mineral compositions. These phases are included in map-unit 10f. Usually accompanied by intrusion breccia or fragmentation phases these fine-grained phases are likely self-metamorphosed phases created by later, but essentially contemporaneous intrusions into the mafic body.

Map-unit 10g is composed of syenite phases of the above rock types. These rocks contain both pink weathering and grey weathering K-feldspar. A modal abundance of this rock type is given in Table 8. Dominant phases are microcline, orthoclase and altered pyroxene (altered to hornblende). Epidote, biotite, quartz and pyrite are minor phases. Grains are subhedral and vary in size from 0.7 mm to 4.5 mm. The texture is allotriomorphic granular. Microcline in these syenites is often perthitic and appears to be an exsolution phase rather than a replacement feature.

Map-unit 10h represents the occurrence of porphyroblasts and glomeroporphyroblasts of altered pyroxene and hornblende (after pyroxene) in the above rock types. These

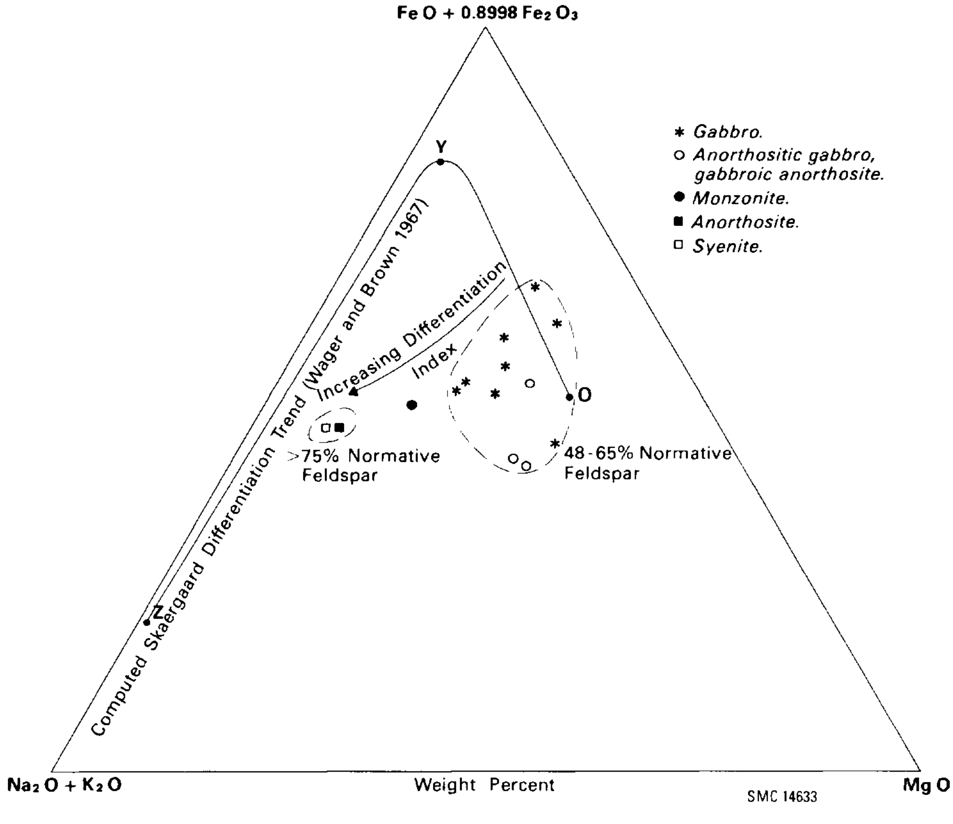


Figure 7—*AFM plot of Mountain Grove Mafic Intrusion.*

porphyroblasts and glomeroporphyroblasts usually give a mottled look to the rock and vary in size from 2.0 mm to 8.0 mm. These represent metamorphosed porphyritic and glomeroporphyritic textures of an igneous origin.

Since the geochemistry of the Mountain Grove Mafic Intrusion had not been previously analysed in detail, the author submitted a sample suite (14 samples) containing gabbro. anorthositic gabbro to gabbroic anorthosite, anorthosite, monzonite and syenite for major and trace element analysis (Table 9). These samples show chemical compositions similar to gabbro and anorthosite samples analysed in nearby mafic intrusions by Miller (1899), Harrison (1944) and Harding (1947). When examined in the AFM plane for basic igneous rocks as used by Wagar and Brown (1967), the suite shows a definite differentiation trend (Figure 7). Gabbro, gabbroic-anorthosite and anorthositic-gabbro samples all group near the "O" apex of the computed "OYZ" differentiation trend of the Skaergaard intrusion (Wager and Brown 1967). Monzonite, syenite and anorthosite samples plot away from this grouping near the "YZ" sector of the Skaergaard computed trend for late stage (more than 88 percent solidification) differentiates. Deviations from the computed trend are not suprising as it is calculated for conditions of low oxygen fugacities at crustal pressures.

Figure 8 depicts the behaviour of the trace elements with respect to the differentiation index. The metals Co, Cu, Zn, Ni and Cr show distinct decreases in abundances with increasing differentiation. All but Zn possess smooth curves. The zinc curve shows a sharp and distinct anomaly at a differentiation index of 40. This increase within a decreasing trend suggests that a zinc influx into the magma occurred part-way through differentiation. In light of the presence of sphalerite-bearing carbonate inclusions within this body, (see "Economic Geology") it seems likely that zinc-bearing carbonate rocks may have been incorporated into the fluid phase of the melt at this point. Such an addition is a favourable explanation because the sphalerite-bearing carbonate material 1) is readily available; 2) contains essentially no other metals (hence preserving the smooth trends of the other metals); and 3) would only increase the Ca and CO_2 budgets of the liquid phase which essentially would not alter the differentiation process with the exception of allowing more anorthite molecule to crystallize in the late stages. Rubidium and barium show smooth increasing trends with continued differentiation within the Mountain Grove Mafic Intrusion, with the exception of Rb depletion in the region of greater than 65 differentiation index.

Buddington (1939) described the Adirondack type of anorthosite as "masses of small to very large areal extent without obviously strongly differentiated characters" in apparent contrast to lithologies of differentiated stratiform sheets or lopoliths. In this regard, the Mountain Grove Mafic Intrusion could be considered as an Adirondack-type of mafic body, as it lacks distinctly differentiated stratiform lithologies. Important differences however, should be mentioned. First, no evidence exists of the intrusion possessing a thick sheet or lens geometry with a domed roof. Second, anorthosite is a minor component of the intrusion while gabbro is the chief constituent. Third, immediately associated igneous rocks lack pyroxene unlike the charnockites of the Adirondack-type. Fourth, the Mountain Grove Mafic Intrusion is very small in areal extent unlike the typical anorthosite plutons in the Grenville Province (Martignole and Schrijver 1970). Lastly, despite the lack of stratiform differentiates, the Mountain Grove Mafic Intrusion contains rock-types which belong to a distinct differentiation series as evidenced by their mineralogy and petrochemistry.

McLean Granitic Pluton and Related Pegmatitic Rocks

Map-unit 11 represents rocks of the McLean Granitic Pluton and related pegmatitic rocks. Approximately circular in shape this pluton is situated in the south central part of the map-area around the hamlet of McLean. The dimensions of the body are approximately 7.5 km north-south and 10 km east-west. This body is definitely intrusive into map-units 1, 2, 3, 4, and 10. Along the northeastern border of the map-area, south of O'Reilly Lake is a body of granitic rock displaying similar intrusive relations. Termed the Leggat Lake granite by Harding (1947), this body is grouped with the McLean Granitic Pluton in this study. The main

TABLE 9. CHEMICAL ANALYSES OF SAMPLES FROM MOUNTAIN GROVE MAFIC INTRUSION (MAP-UNIT 10), LONG LAKE AREA.

MAJOR ELEMENT OXIDES (WEIGHT PERCENT)														
	D720-1	**D714-1**	**D785-1**	**M857-1**	**D802-1**	**D790-1**	**D711-1**	**D779-1**	**M1023-1**	**D823-1**	**D721-1**	**D805-1**	**M833-1**	**M810-1**
SiO_2	41.9	43.7	45.1	47.0	47.6	48.2	48.9	49.8	46.6	48.6	52.8	49.3	50.9	56.0
Al_2O_3	12.6	15.0	15.4	14.9	16.2	16.5	16.3	15.8	18.3	18.8	17.3	24.9	16.0	17.7
Fe_2O_3	7.98	7.21	6.09	4.67	2.97	6.59	4.17	4.84	6.26	3.29	1.09	3.27	6.43	4.13
FeO	10.10	8.99	8.29	8.76	6.60	6.22	7.68	6.53	5.53	5.38	6.37	3.30	4.92	3.69
MgO	6.12	7.11	5.29	6.03	7.60	4.80	4.44	5.36	6.22	6.33	6.09	1.35	3.72	2.48
CaO	9.51	10.00	8.59	8.14	10.3	6.99	7.48	7.83	10.5	8.66	8.48	8.94	5.09	4.87
Na_2O	2.72	2.68	3.78	3.63	3.33	4.34	5.00	3.81	3.34	4.20	3.62	5.06	5.20	5.64
K_2O	0.51	0.38	0.84	1.37	0.91	1.80	1.21	1.17	0.42	0.99	0.78	0.97	2.27	2.70
TiO_2	5.32	2.88	2.71	2.87	1.36	2.32	2.12	2.39	1.81	1.31	1.51	1.33	2.26	1.47
P_2O_5	0.22	0.15	0.83	0.81	0.11	0.67	0.52	0.63	0.12	0.30	0.42	0.10	0.60	0.50
S	0.05	0.38	0.17	0.20	0.20	0.25	0.05	0.14	0.25	0.05	0.12	0.11	0.20	0.21
MnO	0.20	0.17	0.20	0.19	0.20	0.16	0.19	0.19	0.13	0.12	0.15	0.05	0.14	0.15
CO_2	0.29	0.59	0.55	0.54	1.08	0.33	0.32	1.14	0.83	0.31	0.96	0.39	0.38	0.21
H_2O^+	0.50	0.30	0.62	0.67	0.41	0.94	0.57	0.59	0.40	0.55	0.60	0.12	1.76	0.30
H_2O^-	0.56	0.44	0.45	0.29	0.56	0.64	0.57	0.26	0.30	0.59	0.34	0.57	0.44	0.55
TOTAL	98.6	100.0	98.9	100.1	99.4	100.7	99.5	100.5	100.5	99.5	100.6	99.8	100.3	100.6
TRACE ELEMENTS (PPM)														
Ba	270	170	340	470	380	570	400	370	170	300	280	210	800	860
Co	45	65	45	45	35	35	40	35	50	35	30	20	30	20
Cr	8	110	30	95	450	25	25	65	125	95	85	135	15	15
Cu	20	55	45	30	25	25	20	20	35	15	10	20	15	20
Li	8	8	25	9	20	20	25	15	6	20	8	15	15	5
Ni	8	135	25	60	85	20	25	30	70	65	30	35	10	15
Pb	<10	<10	20	<10	<10	<10	<10	<10	<10	<10	10	<10	10	40
Rb	10	<10	10	30	30	30	30	10	10	30	10	20	50	20
Sr	640	650	620	540	640	620	600	620	760	790	701	1100	330	630
Y	40	30	70	50	20	70	60	60	20	30	40	10	80	50
Zn	130	120	150	135	110	125	155	170	80	80	110	45	125	85
Zr	100	40	90	220	40	220	260	190	30	70	30	30	450	190

CIPW NORMATIVE PLAGIOCLASE (MOLECULAR PERCENT)

AB	26.13	24.87	35.41	33.42	26.43	39.66	39.41	35.00	30.13	33.29	32.69	36.75	47.83	50.43
AN	22.12	28.72	23.56	20.83	27.05	20.59	18.84	23.08	34.15	30.01	28.82	42.43	13.95	14.95
TOTAL	48.25	53.59	58.97	54.25	53.48	60.25	58.25	58.08	64.28	63.30	61.51	79.18	61.78	65.38

DIFFERENTIATION INDEX (MOLECULAR)

	29.36	27.19	40.59	41.73	34.31	50.49	50.54	43.08	32.79	42.02	38.55	47.73	61.58	66.34

SAMPLES
Gabbro. Map-unit 10a.
D720-1 0.7 km S of Little Mud Lake.
D714-1 0.8 km SE of Little Mud Lake.
D785-1 1.6 km E of Little Mud Lake.
M857-1 0.8 km S of Bass Lake.
D802-1 1.9 km E of Little Mud Lake.
D790-1 0.2 km NE of Little Mud Lake.
D711-1 1.1 km SSW of Little Mud Lake.
D779-1 2.6 km SE of Little Mud Lake.
Anorthositic gabbro to gabbroic anorthosite. Map-unit 10b.
M1023-1 0.4 km SE of Little Mud Lake.
D823-1 2.3 km SW of O'Reilly Lake.
D721-1 0.6 km S of Little Mud Lake.
Anorthosite. Map-unit 10c.
D805-1 1.8 km W of O'Reilly Lake.
Monzonite. Map-unit 10e.
M833-1 2.5 km SW of O'Reilly Lake.
Syenite. Map-unit 10g.
M810-1 2.5 km N of Long Lake.

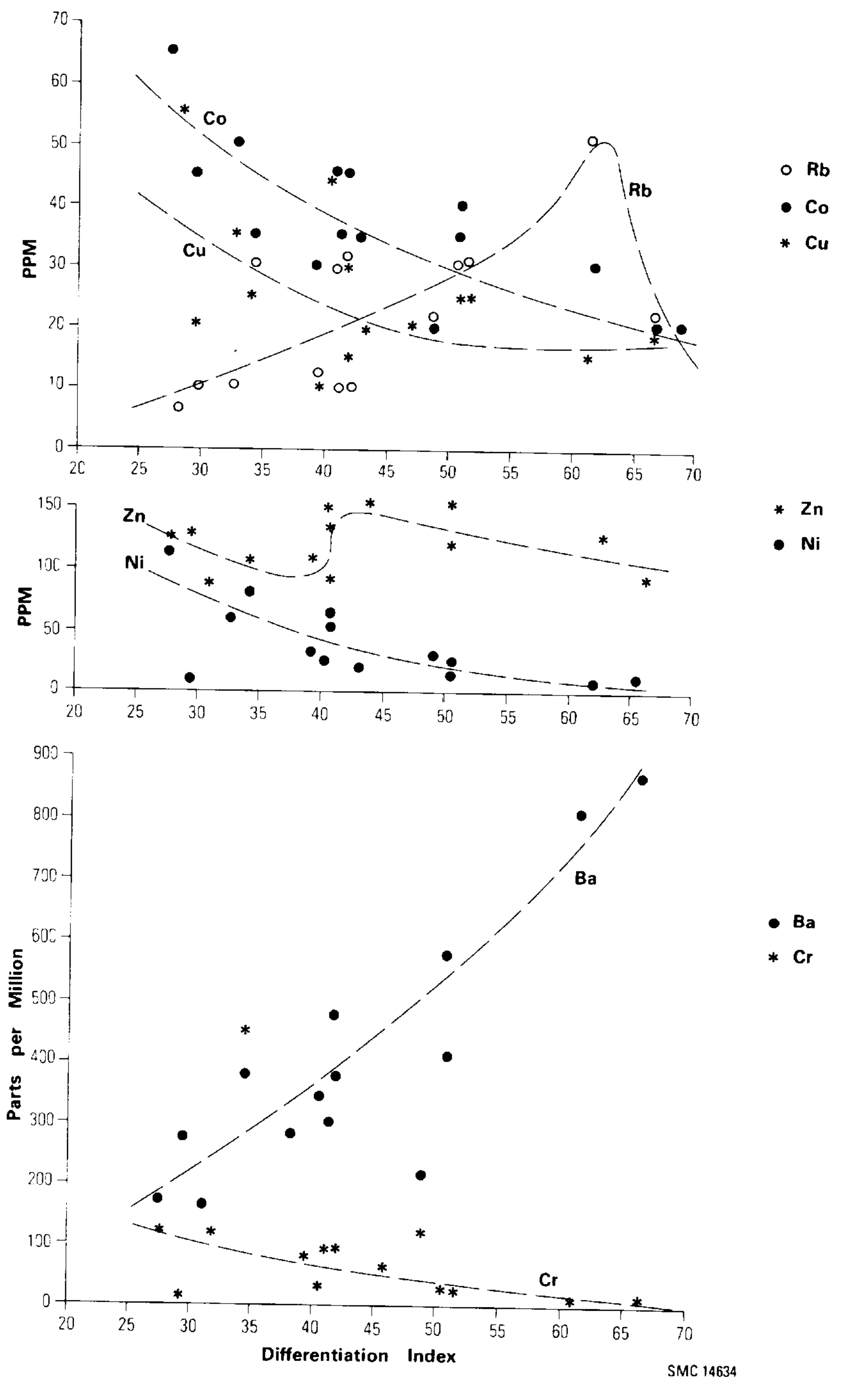


Figure 8—Trace element variation with differentiation index in the Mountain Grove Mafic Intrusion.

bodies of these late stage granites are well exposed and display interesting textures. Late stage pegmatites in the area are considered to be contemporaneous with these granites as they strike towards the body, and within the granite appear as pegmatitic segregations rather than as distinct dikes. A great many of the outcrops in the major shear zone which passes through the village of Mountain Grove are mylonites and mylonite gneisses of unit 11 material.

Modes from 112 samples of the McLean main body and from 12 samples of the Leggat Lake body are given in Figures 9a and b. These were obtained from slabs stained for K-feldspar. The plots clearly show the composition ranges from trondhjemite to granite in the McLean main body, with minor syenite phases. The western part of the body between Small Clear Lake and Bitch Lake displays a definite trondhjemite dominance on this plot. Pegmatitic phases (marked P) have as varied a composition as the main intrusion. The Leggat Lake samples all fall within the quartz monzonite field.

Because of the intimate association of granite and quartz monzonite compositions in this body, on an outcrop basis, and the gradational nature of the contacts between the two compositions, granite and quartz monzonite could not be mapped as separate units. Map-units 11a and 11b contain both rock types but segregate the biotite-poor and biotite-rich phases. Map-unit 11a represents fine- to medium-grained, massive to foliated biotite granite and quartz monzonite (biotite approximately 15 percent). The rock weathers brownish pink and grain sizes are typically 0.5 mm to 2.0 mm. Modes of this unit are given in Table 10. Plagioclase present is typically andesine and the dominant K-feldspar phase is microcline. Biotite, epidote, sphene and opaques are the minor mineral phases. The texture is hypidiomorphic granular. Map-unit 11b is composed of medium- to coarse-grained equigranular massive biotite granite and quartz monzonite (biotite <10 percent). This rock weathers whitish pink and contains visibly less biotite than map-unit 11a. Table 10 lists the mineralogy of both granite and quartz monzonite rock types found in this unit. Plagioclase is andesine to labradorite and K-feldspar is generally microcline, but is accompanied by orthoclase in the granite phases. Perthite is locally found and appears to be an exsolution feature rather than a replacement feature. Minor phases include biotite, muscovite, epidote, sphene, zircon and opaques. The grain size varies from 0.1 mm to 2.0 mm and the texture is hypidiomorphic granular.

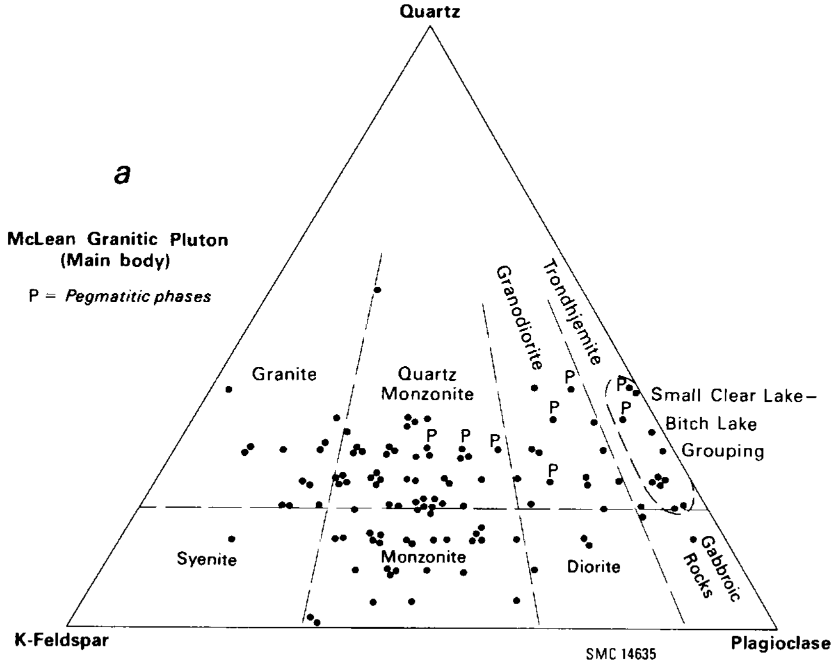
Map-unit 11c is fine- to medium-grained, massive to foliated, biotite granodiorite. The rock weathers pinkish to whitish grey. Grain sizes are typically 0.2 mm to 2.5 mm. Modes for this rock type are included in Table 10. Plagioclase is usually andesine but oligoclase can be found. K-feldspar is usually microcline. The minor phases are biotite, muscovite, epidote and opaques. The texture is hypidiomorphic granular.

Map-unit 11d is fine- to medium-grained, massive to foliated, biotite trondhjemite. Weathering whitish grey, this unit varies in grain size from 0.5 mm to 2.0 mm. Plagioclase is typically andesine, and biotite, muscovite and opaques are minor phases. The texture is hypidiomorphic granular.

Map-unit 11e represents fine grained leucocratic granite. This unit weathers white-pink and has a low colour index. The modes of this rock type are given in Table 10. Plagioclase is sericitized but probably andesine, and microcline is the K-feldspar phase present. Biotite is minor, and muscovite is the main mica found. Rutile and opaques are accessory. The texture is hypidiomorphic granular.

Locally occurring in the McLean Granitic Pluton main body are syenite phases (map-unit 11f). These are massive to foliated and medium grained. Modes of two syenite samples are included in Table 10. Plagioclase is andesine but is locally altered to sericite. The K-feldspar phases are orthoclase and microcline. Minor phases are biotite, epidote, sphene, hornblende, quartz, and opaques. The texture is hypidiomorphic granular. The chief difference between syenites of map-unit 11 and map-unit 10 is the abundance of mafic minerals. Map-unit 11 syenite typically contains 25 percent mafic minerals while map-unit 10 syenite contains 50 percent mafic minerals.

Map-unit 11g represents porphyritic varieties of the above map-units, but chiefly this



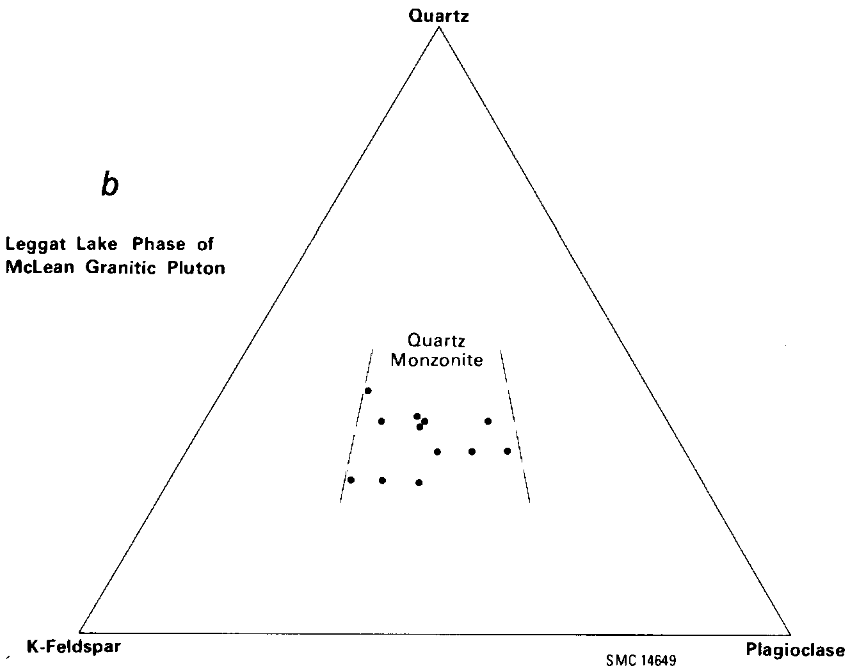


Figure 9—*Composition of McLean Granitic Pluton in terms of quartz, plagioclase, and K-feldspar.*

TABLE 10. MODAL ANALYSES OF FELSIC INTRUSIVE ROCKS OF McLEAN GRANITIC PLUTON (MAP-UNIT 11), LONG LAKE AREA.

Sample	**M773-1**	**D661-1**	**D477-1**	**D1026-1**	**M769-1**	**M534-1**	**D626-1**	**D522-1**	**D541-1**	**D897-1**	**D590-1**
Quartz	10	35	36	25	43	52	40	50	46	5	5
Plagioclase	35	18	20	15	25	20	35	40	15	20	21
Orthoclase			36	15*						45	
Microcline	30	20		25*	20	15	10		20		50
Biotite	15	15	5	7	5	5	5		5	10	1
Muscovite			1	5				5	10		
Epidote	7	10	1	2		3	5	5			15
Sphene		2			3					10	
Rutile									1		
Zircon					1						
Hornblende										5	
Opaque	3	2	1	6	3	5	5		3	5	7
TOTAL	100	102	100	100	100	100	100	100	100	100	99

*Perthitic

SAMPLES

Quartz monzonite. Map-unit 11a.
- M773-1 1.2 km SSE of Scanlin Lake.
- D661-1 3.0 km WSW of McLean.

Granite. Map-unit 11b.
- D477-1 1.6 km NNW of Scanlin Lake.
- D1026-1 Island near S shore of Long Lake.

Quartz monzonite. Map-unit 11b.
- M769-1 1.5 km NW of McLean.
- M534-1 1.0 km NE of Small Clear Lake.

Granodiorite. Map-unit 11c.
- D626-1 1.8 km NE of Scanlin Lake.
- D522-1 1.5 km N of Small Clear Lake.

Granite. Map-unit 11e.
- D541-1 0.1 km W of Scanlin Lake.

Syenite. Map-unit 11f.
- D897-1 0.25 km S of Long Lake.
- D590-1 0.7 km NW of Scanlin Lake.

texture is limited to map-units 11a and b. Phenocrysts are either quartz or feldspar, and usually microcline is the chief feldspar phenocryst. The size of phenocrysts vary but the typical range is 2.0 mm to 6.0 mm. Map-unit 11h is used to code these rock types containing visible muscovite, usually >10 percent.

The western margin of the McLean Granitic Pluton is highly sheared as it is situated in the major shear zone which runs through the village of Mountain Grove. Map-unit 11j represents shear zone granite and granodiorite phases including protomylonite, mylonite and mylonite gneiss with or without porphyroclasts and usually containing epidote. Protomylonite types typically contain a bimodal grain size distribution of quartz, and have a fine-grained (<0.2 mm) mortar texture matrix, with larger (2.5 mm) resistant grains of quartz, plagioclase (andesine) and K-feldspar (orthoclase). The rock has a foliation defined by biotite grains and contains 10-50 percent matrix. The mylonite to mylonite gneiss samples contain 50-90 percent matrix. Usually, the quartz is bimodal as above, but a much higher proportion of it is fine grained (as the matrix proportion increases). Micas also tend to be of a high concentration in these rocks as well (10-15 percent compared to 10 percent in the protomylonite). Mylonite gneiss samples show a definite alignment of the quartz and feldspar grains and an extremely well developed foliation gneissosity. The mineralogy of these rocks is dependent upon the original rock type, hence most of the sheared phases of map-unit 11 are quite felsic.

The pegmatite dikes and irregular masses found throughout the map-area are considered to be phases of the McLean Granitic Pluton (mentioned above). Map-unit 11k represents pink granitic pegmatite dikes and irregular masses locally containing tourmaline, biotite and muscovite, while map-unit 11m represents white granitic pegmatite dikes and irregular masses locally containing muscovite, biotite and almandine garnet. Dikes of the above material vary in width from 0.2 m to 0.8 m but locally 5.0 m wide dikes occur. Perhaps the most prominent dikes occur in the carbonate metasediments south of the village of Arden. The high (6 m to 8 m) relief of these dikes is due to the large contrast in resistance to erosion between the granite and carbonate material. Irregular masses vary in shape but seldom exceed 0.5 km in maximum dimension.

Prominent along the western margin of the McLean Granitic Pluton are scattered inclusions, xenoliths and slices of undifferentiated metasediments and metavolcanics of map-units 2 and 3 and lesser amounts of map-units 1 and 4. Map unit 11n denotes the presence of these inclusions. In zones where the concentration of these are high a weak "ghost stratigraphy" can be seen, but this is usually discontinuous. Where the included material is less than 0.5 m thick a well defined but discontinuous gneissosity is locally developed.

Mafic Intrusive Rocks

Map-unit 12 represents undifferentiated mafic diabase dikes. These are poorly exposed in the map-area, and only two localities were found during the mapping season. The sample contained 45 percent highly sericitized but euhedral plagioclase laths (0.2 mm), 5 percent chlorite and a very fine grained undifferentiated ground mass. These dikes cut pegmatite phases assigned to map-unit 11. Typical widths of these dikes are 0.2 m to 0.5 m. The texture of the dikes is intersertal.

Cenozoic

QUATERNARY

Pleistocene and Recent

Most of the Cenozoic sediments in the map-area were deposited during the Pleistocene epoch in glacial and post-glacial lakes. The majority of these deposits are outwash deposits of sand, silt, clay and till. Perhaps the most striking Pleistocene deposit in the map-area is a narrow band of glacial, glaciofluvial and glaciolacustrine deposits which occupy the major shear zone which passes through the village of Mountain Grove. Henderson (1973) described these deposits as "ice-contact stratified drift; sand, gravel, minor till in eskers, kames, kame moraines; topography generally hummocky, but may be locally subdued by wave action". This glaciofluvial system was traced by Henderson (1973) northeastward through Snow Road Station, Palmerston Township, Frontenac County, giving it a total strike-length of some 80 km in the Precambrian Canadian Shield. From the nature of this Pleistocene deposit as it occurs in the present map-area, it appears that the major shear zone may itself extend for such a distance because the glacial rivers have employed the shear zone as a natural low relief pathway. Personal communication with N.R. Gadd (Geological Survey of Canada) during the field season revealed that these deposits may be inter-lobate as well. The above mentioned deposits are actively worked by local sand and gravel operators, (see "Economic Geology"). Pleistocene deposits in the remainder of the map-area include ground moraines composed of sandy till (Henderson 1973). Glacial striae are not commonly found in the map-area but three striae shown by Henderson (1973) in the map-area indicate a general movement of the last ice sheet in a southwest direction north of Long Lake and a south-southwest direction at the western tip of Bull Lake.

The Recent deposits in the map-area are organic swamp and alluvial deposits. The majority of the swamps are located either in fault zones or in low areas which parallel the foliation gneissosity of the bedrock. The first type of swamps are generally limited to the Sheffield and Hinchinbrooke Gneiss Complexes, the McLean Granitic Pluton, the Northbrook Batholith and the Mountain Grove Mafic Intrusion. These swamps are usually dendritic in shape occurring where one or more faults and/or lineaments intersect one another, and are often water filled. The second type of swamp is usually narrow and long, paralleling the regional structural fabric, and typically associated with the major water systems, like the Salmon River and Long Lake. The Recent alluvial deposits are associated with these swamps and waterways and include minor stream sediments and minor deltaic deposits.

METAMORPHISM

The rocks in the map-area have undergone regional metamorphism during the Late Precambrian. Mineral assemblages vary with the large number of rock chemistries present and the grade of metamorphism and subsequent alteration.

In general the map-area can be divided into three metamorphic zones: A) the metasediments of map-units 3, 4 and 5 which outcrop west of the major shear zone passing through the village of Mountain Grove; B) the metavolcanics of map-unit 2, and the Mountain Grove Mafic Intrusion and the McLean Granitic Pluton, all of which outcrop east of the shear zone passing through the village of Mountain Grove; and C) the gneisses of map-units 1 and 6a, b outcropping south and east of the McLean Granitic Pluton and the Mountain Grove Mafic Intrusion, near the hamlet of Wagarville.

The best rocks for metamorphic mineral indicators in the map-area are the metasediments and metavolcanics, and the granolites and granoblastites. Unfortunately the clastic siliceous metasediments are aluminum-poor, hence the aluminosilicate indicator assemblages cannot be employed. The McLean Granitic Pluton is only weakly metamorphosed (alteration of plagioclase) but the Mountain Grove Mafic Intrusion shows heavily altered pyroxene grains and some feldspar alteration.

Zone A contains the following metamorphic mineral assemblages.

Clastic siliceous gneisses, map-unit 3:
quartz + plagioclase + muscovite + biotite (1);
quartz + plagioclase + muscovite + biotite + almandine (2).

Carbonate metasediments, map-unit 4:
calcite + dolomite + diopside + tremolite + quartz (3).

Amphibole-rich gneisses, map-unit 5:
plagioclase (oligoclase-andesine) + hornblende + quartz + epidote (4);
plagioclase (oligoclase-andesine) + hornblende + quartz + calcite + epidote + biotite (5).

The above mineral assemblages indicate that rocks of this metamorphic zone lie in the low temperature (500-550°C) field of medium grade metamorphism (Figure 10) as given by Winkler (1976). Assemblage 1 places this zone above the "muscovite-chlorite out" isoreaction-grad, but below the "muscovite + quartz to K-spar + sillimanite" isoreaction-grad.

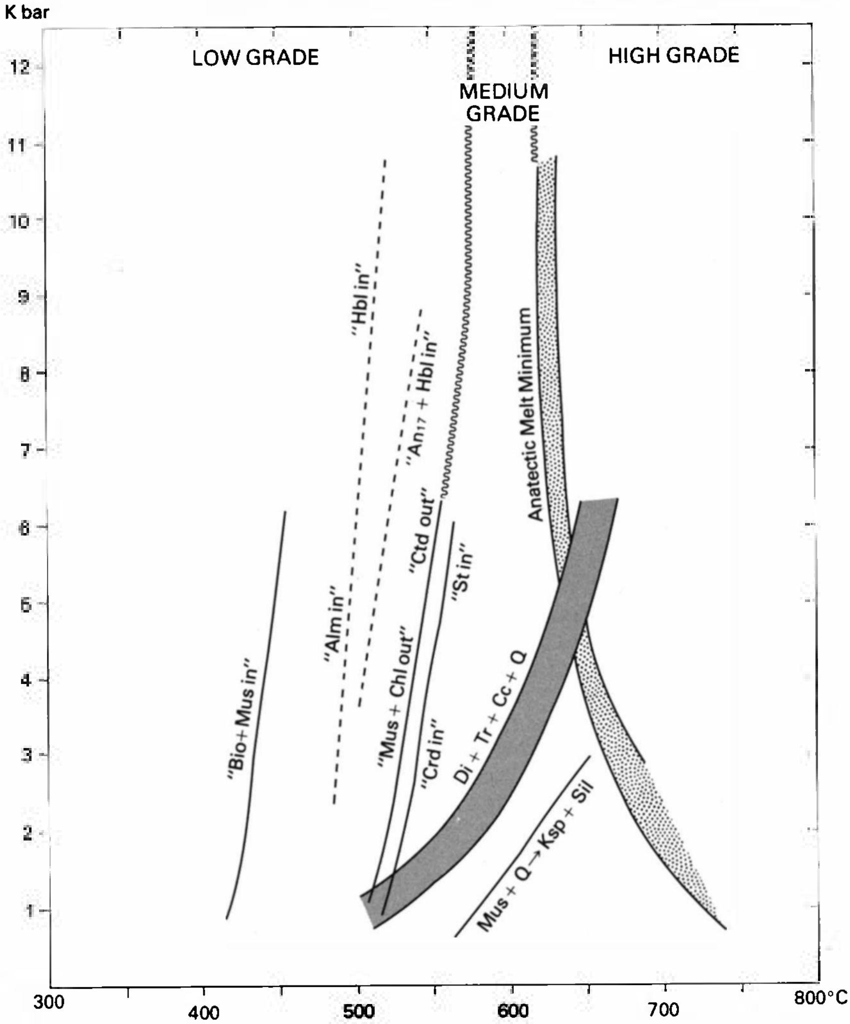


Figure 10—*Metamorphic pressure-temperature composite, indicating pertinent metamorphic zones and isograds in the Long Lake area. Bio = biotite, Mus = muscovite, Alm = almandine, Hbl = hornblende, An = plagioclase, Chl = chlorite, Ctd = chloritoid, Crd = cordierite, St = staurolite, Di = diopside, Tr = tremolite, Cc = calcite, Q = quartz, Ksp = K-feldspar, Sil = sillimanite.*

Assemblage 2 places these rocks above the "almandine in" isoreaction-grad. Assemblage 3 is important as it puts a constraint of 2-4 Kbar on the pressure. Assemblages 4 and 5 are important as the plagioclase composition positions these rocks above the "An_{17} + hornblende" isoreaction-grad.

Zone B contains rocks which display little in the way of diagnostic metamorphic mineral assemblages. The mafic metavolcanics (map-unit 2) contain plagioclase (andesine)-hornblende assemblages which due to the lack of oligoclase suggest somewhat higher temperatures than zone A above as the abundance of the anorthite molecule has increased (Wenk and Kellar 1969). The very nature of the Mountain Grove Mafic Intrusion and the McLean Granitic Pluton suggests that zone B represents a lower level in the crust than zone A. Thus metamorphic zone B is within the zone of medium grade metamorphism at a temperature range of 550°C-600°C and pressures of 3-4 Kbar (Figure 10).

Zone C contains metamorphic mineral assemblages which are definitely diagnostic of the hypersthene zone of regional metamorphism as defined by Winkler (1976). Typical mineral assemblages which are apparently stable in this zone are as follows.

Mafic to felsic gneiss and related anatectite, map-unit 1:

plagioclase (labradorite) + hornblende + hypersthene (6);

plagioclase (andesine) + quartz + almandine + hornblende + pyroxene (orthopyroxene + clinopyroxene) (7);

calcite + dolomite + tremolite + diopside + quartz (8).

Hinchinbrooke Gneiss Complex, map-unit 6a, b:
plagioclase (andesine-labradorite) + quartz + hypersthene + hornblende + biotite + muscovite (9);

Assemblages 6, 7, 8 and 9 are typical of granolites and granoblastites. Clearly, these are high grade assemblages, although P and T regimes would be very dependent on P_{H2O} and P_{CO2} conditions (Winkler 1976). To accomodate the carbonate assemblage (8) however, minimum P and T would be 5 Kbar and 650°C (Figure 10).

The boundary between metamorphic zones A and B is rather important as it represents the metamorphic break between the Hastings Basin and Frontenac Axis segments (IVb and IVc respectively) of the Central Metasedimentary Belt defined by Wynne-Edwards (1972). The metamorphic grade increases to the south and east in the Westport map-area described by Wynne-Edwards (1967). According to Wynne-Edwards (1964) the rocks of the Tichborne area (which adjoins the present map-area on the east) are metamorphosed to the granulite and upper amphibolite facies.

STRUCTURAL GEOLOGY

Regional Setting

The map-area lies within the Central Metasedimentary Belt as defined by Wynne-Edwards (1972) and specifically straddles the IVb and IVc segments. The contrast in structural geology between the two segments allows the map-area to be divided into two structural zones, Zone A and Zone B. Zone A contains the rocks of the IVb segment (Wynne-Edwards 1972) of the Central Metasedimentary Belt as it is part of the Kaladar-Dalhousie Trough (Hewitt 1956) containing the northeast extension of the Clare River Synform as described by Ambrose and Burns (1956), Schwerdtner *et al.* (1977) and Wolff (1978). Zone A is composed of all the lithologies situated west of the major shear zone which passes through the village of Mountain Grove. Zone B contains the rocks of the IVc segment (Wynne-Edwards 1972) of the Central Metasedimentary Belt, frontier portion of the Frontenac Axis. In contrast to the structure of Zone A, Zone B is composed of several dome-shaped late stage intrusions (map-units 10 and 11) and surrounding metavolcanics, metasediments and anatectites, (map-units 1 and 2 primarily).

Zone A

Structural zone A is composed of northeast-trending structures which are on strike with the Clare River Synform closure to the southwest of the map-area and northeast of Tweed (Ambrose and Burns 1956, Schwerdtner *et al.* 1977). Although no primary bedding (S0) is preserved in this zone the well developed foliation-gneissosity (S1) is extremely continuous appearing quite often to be parallel to the original layering. Figure 11a illustrates the distribution of 203 poles to the S1 foliation-gneissosity from the amphibole-rich gneisses (map-unit 5) in this zone. The distribution of this data is densely grouped indicating the general homoclinal orientation of these units which trend N50E and dip 10-50S. The Addington Pluton foliation-gneissosity orientations also fall within this zone when plotted on the stereonet indicating it has been deformed at the same time. The S1 foliation-gneissosity is locally folded into isoclinal and locally asymetrical minor "Z" folds (F2), with well developed quartz and/or hornblende rodding in the fold noses. Thirty-four of these quartz/hornblende rodding lineations (L2) are plotted on Figure 11a and show shallow plunges (10°) to the southwest (236°). The girdle to these poles of the S1 foliation gneissosity is shown and the pole to this girdle is located very close to the maximum of the L2 lineations indicating they are lineations within the F2 axial plane. A certain degree of infolding within this structural zone occurs. The deviant clusters on Figure 11 define a minor synform within map-unit 5. This synform is an open style fold (dihedral angle of 110°), and plunges shallowly southwest but closes northeast of the map-area. An F2 fold, this feature is located north of Highway 7 and the fold axis essentially follows the Salmon River northeastwards from the mouth of Kennebec Lake.

The carbonate metasediments (map-unit 4) within this structural zone are generally structurally conformable with the other metasedimentary units but display a larger number of local minor antiforms and synforms and commonly horizontal attitudes. Figure 11b illustrates the distribution of 107 poles to foliation within this unit indicating they are part of a second (D2) deformation event. The pole to the girdle defined by the poles to the foliations coincides with the lineation maximum from Figure 11a. When viewed in the third dimension in the field these minor folds within the carbonate metasediments often display horizontal fold noses and steep limbs which quickly degenerate into adjacent folds of the same description. Such structural behaviour indicates these carbonate rocks were very ductile during deformation and the resultant fold structures are a reflection of the competancy contrast between these units and amphibole-rich gneisses and clastic siliceous gneisses (map-units 5 and 3) which border them.

The amphibole-rich gneisses typically display boudinage features and the clastic siliceous gneisses contain pinch and swell structures (see "General Geology").

The Clare River Synform structure is not easy to detect in the map area. Only minor folds of the "Z" geometry are found and a lack of lithological symmetry disguises the structure. Ambrose and Burns (1956) defined the axis of this structure to lie within the carbonate metasediments (map-unit 4) but did not delineate its projection to any great length within the current map-area. The carbonate metasediment unit and adjacent supracrustal rocks (map-units 3 and 5) appear to be a very continuous section extending some 95 km from the closure near Madoc to Carleton Place where they disappear under the Paleozoic cover (Reinhardt 1964) (although subsequent investigation may reveal at least a partial truncation of this structure northeast of the present map-area by the northeastern extension of the major shear zone which passes through Mountain Grove). The carbonate metasediments still possess a central (fold axis) position with respect to the stratigraphy in this structural zone, and the structural behaviour of this unit may be indicative of fold axis type stresses. The general homoclinal orientation of the units within this zone indicates that the Clare

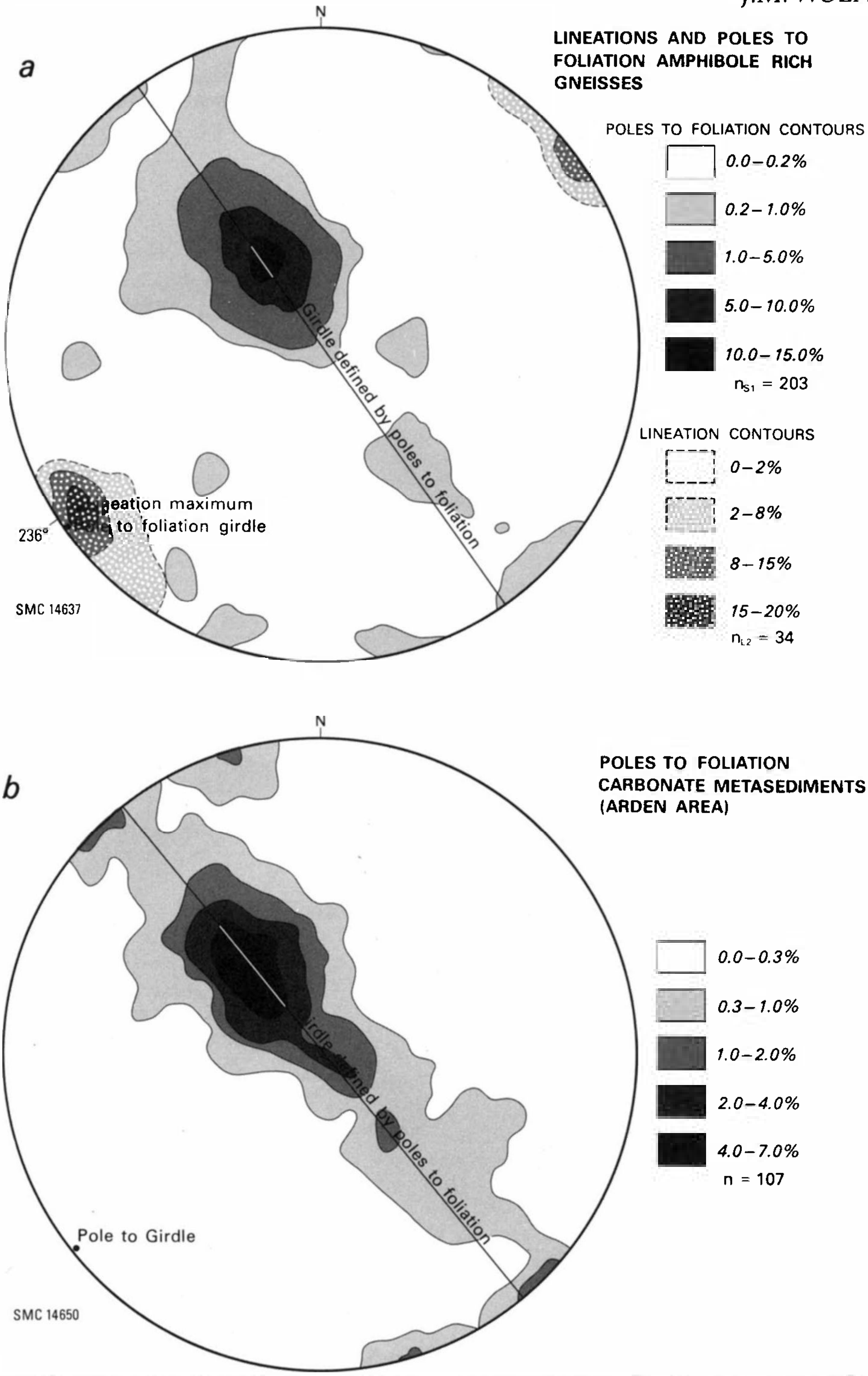
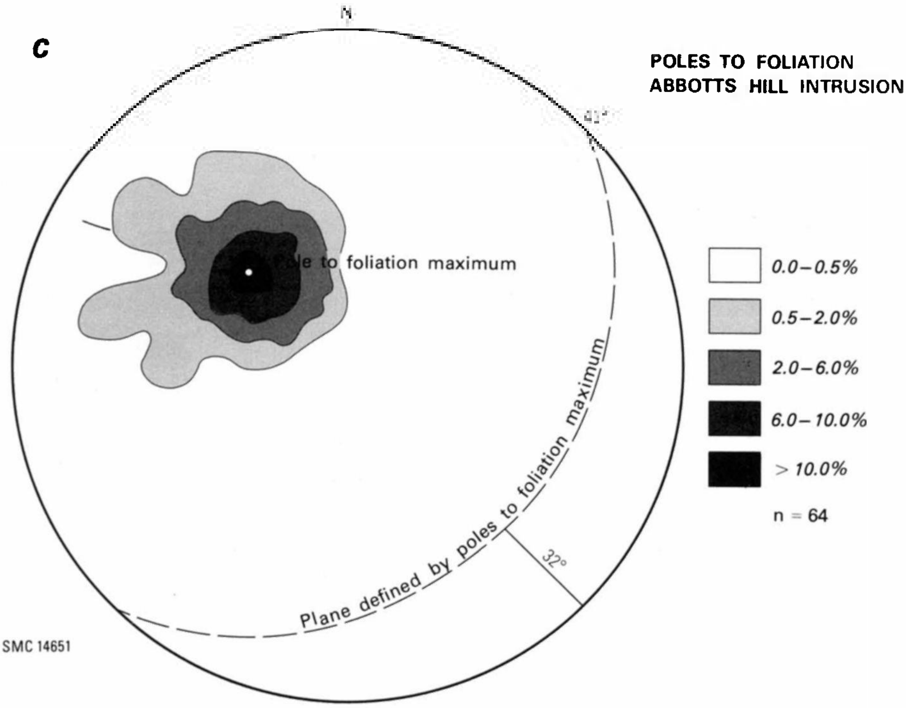


Figure 11—*Contoured stereograms for lineations, poles to foliation, and joints.* ***a.****Amphibole-rich gneisses.* ***b.****Carbonate metasediments.*



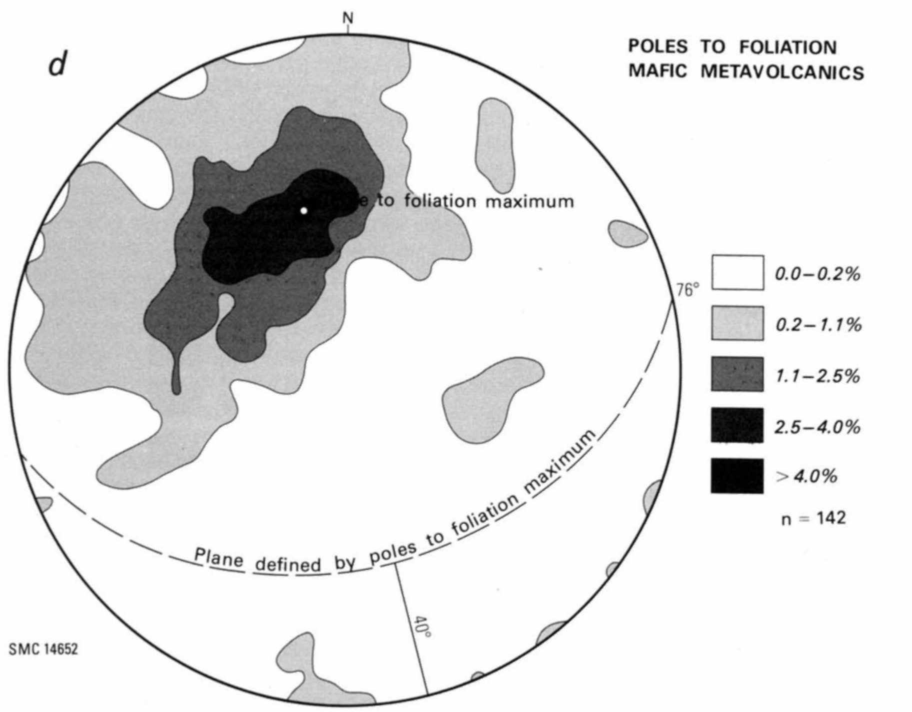
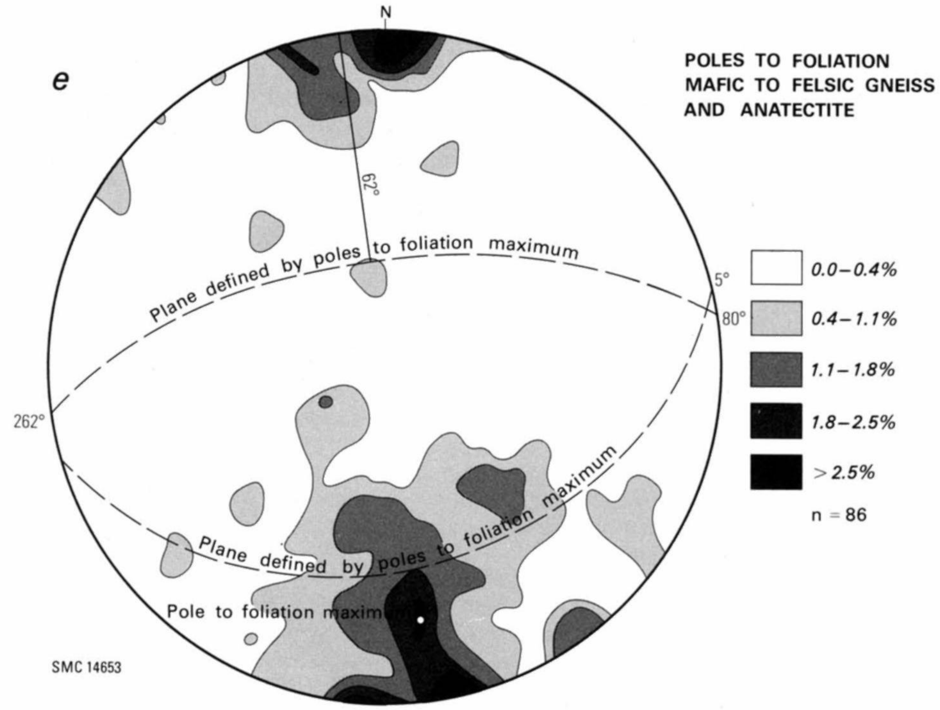


Figure 11—*Continued.* ***c.****Abbotts Hill Intrusion.* ***d.****Mafic metavolcanics.*



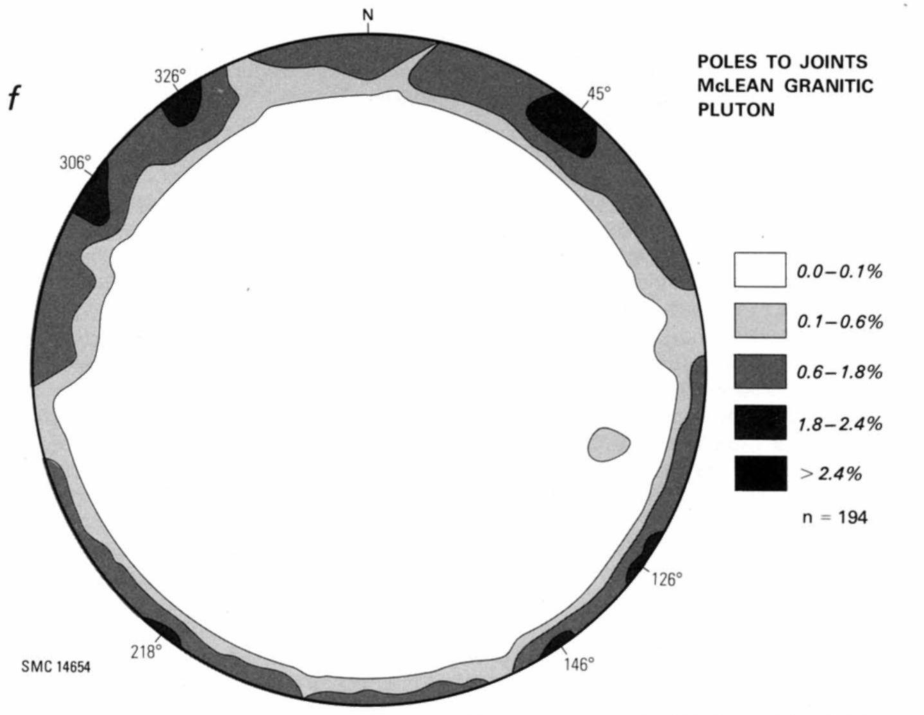


Figure 11—*Continued.* ***e.*** *Mafic to felsic gneiss and anatectite.* ***f.*** *McLean Granitic Pluton.*

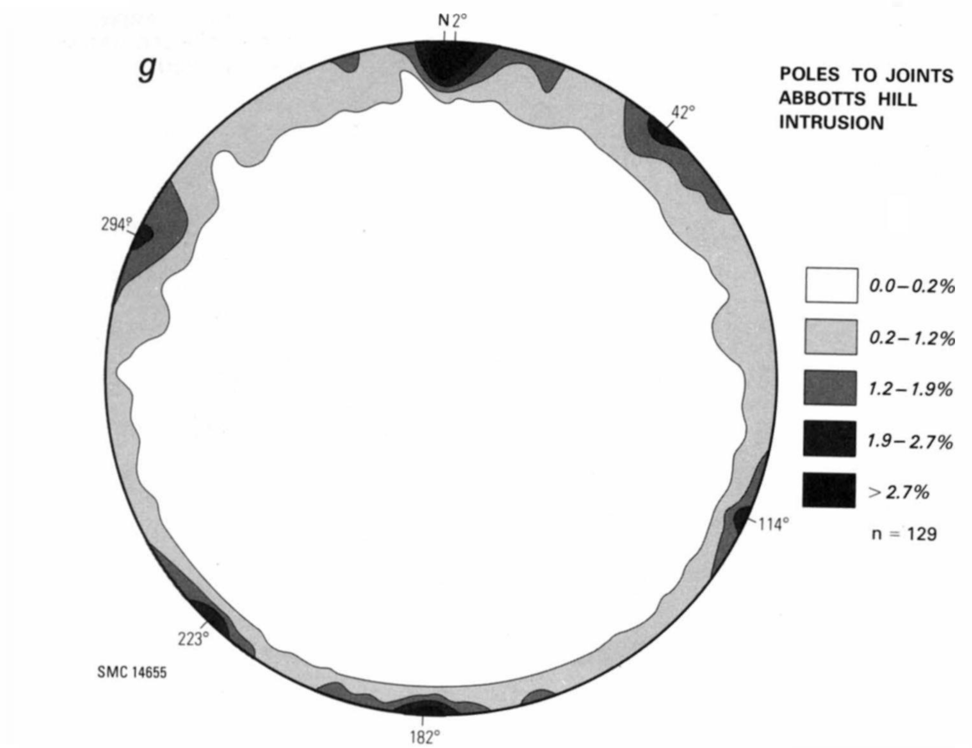


Figure 11—*Continued.* ***g.****Abbotts Hill Intrusion (joints).*

River Synform in the map area is isoclinal and plunges gently southwest. The only evidence of the folded nature of these units in the map-area is the F2 folds. This is in agreement with Venkitasubramanyan (1969) and Wolff (1978) both of whom considered the Clare River Synform closure to be a D2 structure.

The existence of foliation-gneissosity (S1) parallel to the original bedding or compositional layering, the absence of axial planar foliation, the existence of few minor folds and lineations (L2) parallel to major fold axes, suggest that structural zone A in the map-area has been subjected to flow-folding as described by Wynne-Edwards (1963). The minor Salmon River synform present in map-unit 5 (described above) is a likely example of a flow fold structure, and that the Clare River Synform is itself part of the flow folding phenomenon.

Occurring along the eastern margin of structural zone A is the Abbotts Hill Intrusion. This map-unit (9) contains a very monotonous weakly defined foliation. Sixty-four poles to this foliation are presented in Figure 11c and define a median plane striking N45E and dipping 32S. This orientation parallels that of the major shear zone which passes through the village of Mountain Grove and is immediately adjacent to this unit. It would appear that the shear zone has superimposed this weak biotite foliation upon the original randomly oriented biotite configuration of the Abbotts Hill Intrusion. To the southwest near Lyman Lake in the map-area the intrusion appears to contain an elliptical shaped dome structure. This structure is strikingly obvious on aerial photographs of the area and has been mentioned by Harding (1942). The present author considers this structure not to be a true domal intrusion because upon close examination it is a highly segmented linear body. The domal appearance of this body is highly accentuated by the behaviour of the surrounding metasediments (maps units 3 and 5). The interior of the intrusion contains a consistent foliation trending NE with consistent easterly dips. The structure thus lacks any dip symmetry indicative of a domal structure. The structure does close very tightly at its southwest limit where a great deal of brittle fracturing has occurred indicative of the post-intrusion timing of the deformation responsible for the pseudo-domal nature of this body. The structure has undergone exfoliation weathering on a grand scale such that aerial photo examination suggests the existence of an intrusive domal structure.

Zone B

Structural zone B is composed of domal late stage intrusions (map-units 10 and 11), and surrounding supracrustal rocks (map-units 1 and 2), similar to that structural pattern of the Frontenac Axis as described by Wynne-Edwards (1967, 1972). Although no primary bedding (S0) is preserved within the supracrustal rocks of this zone, the well developed foliation-gneissosity (S1) is extremely continuous appearing quite often to be parallel to the original layering. Figures 11d and e illustrate the distribution of poles to foliation in the supracrustal rocks within this zone. Figure 11d indicates the mafic metavolcanics of map-unit 2 define a median plane striking N76E and dipping 40S. Figure 11e indicates the mafic to felsic gneisses and anatectites define a median plane striking N82E and dipping 62N. These represent, respectively, the limbs of a synform which closes to the southwest (Small Clear Lake, Bitch Lake area of the map-area) and plunges shallowly (05°) along an azimuth of N80E. As can be seen from the accompanying geologic map (back pocket) the synform covers much of the areal extent of structural zone B and the limbs are up to 7 km apart locally. This structure is an F2 fold, and possibly synchronous with the D2 event forming the Clare River Synform. The domal intrusions occupy the inter-limb zone near the fold axial trace. The fold itself is crossed by a metamorphic isograd, hence the north limb is representative of the high temperature part of medium grade metamorphism, while the south limb is indicative of the regional hypersthene high grade zone (see "Metamorphism").

The Mountain Grove Mafic Intrusion (map-unit 10) is structurally undeformed, but contains highly deformed inclusions of carbonate material (map-unit 4). An example of such an inclusion is the Long Lake zinc mine described in some detail in the "Economic Geology" section. These carbonate inclusions are generally arranged such that their long axis parallels the boundary of the intrusion.

The McLean Granitic Pluton is also structurally undeformed but contains local dominant inclusions of supracrustal (map-units 2 and 3) material near its western boundary. These inclusions locally exhibit a discontinuous ghost stratigraphy (see "General Geology").

Both the Mountain Grove Mafic Intrusion and the McLean Granitic Pluton are intrusive into the surrounding supracrustal rocks. It is not obvious, however, whether the supracrustal rocks have been deformed around the more resistant intrusive rocks or whether the intrusive rocks were post-tectonic or late stage syntectonic and intruded a fully to partially formed synformal structure. Certainly, the latter explanation would accommodate the absence of complete wrap-around structures and the preservation of original igneous textures within the intrusive rocks.

Faults and Dikes

The most prominent faulting feature in the map-area is the major shear zone which passes through the village of Mountain Grove. This feature is topographically obvious as it forms a sinuous valley covered with Pleistocene deposits (see "General Geology"). Geologically it is indeed a major feature as it separates two distinct lithologic and structural zones. The shear zone itself is typically 0.5 km to 1.0 km wide and may have a total strike length of 80 km (see "General Geology"). Lithologies within the shear zone are protomylonite, mylonite and mylonite gneiss varieties of the adjoining map-units (Photos 7 and 8) and are described under their parent units ("General Geology"). The fault trends N45E with moderate dips 30-50S. Movement on the fault is difficult to discern, as no slickensides were found, however the easternmost block appears to be a lower level assemblage.

Numerous lineaments can be traced on air photographs of the map-area, a number of which can be ascribed to faulting and fracturing. Due to insufficient stratigraphic and structural control only a few of these can be assigned movements. The more prominent lineaments along which fault movements may or may not have occurred are indicated on Map 2449 (back pocket).

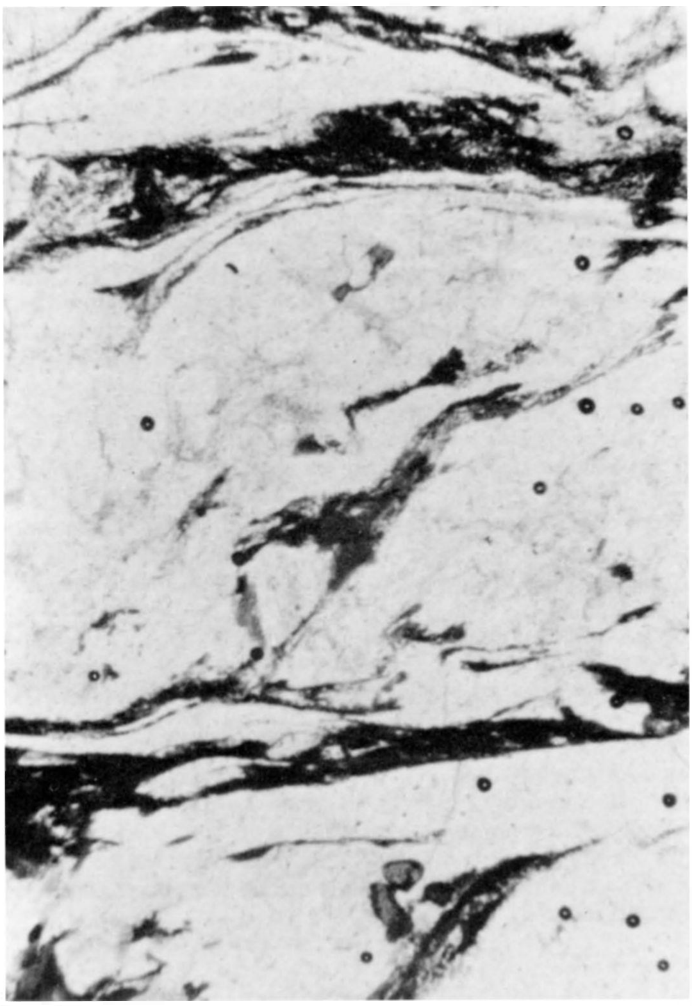


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***Photo 7**—Photomicrograph (crossed nicols, field of view 5 mm) of a protomylonite from the major shear zone. The opaque material forming the matrix is biotite, and the light-coloured material is quartz and plagioclase.*

Joints or fractures abound especially in structural zone B. Joint data from 194 measured joints in the McLean Granitic Pluton are shown on Figure 11f. These joints define three major sets: 1) trending N45E-S38W; 2) trending S34E-N14W, and S54E-N54W; and 3) a north-south set. Sets 1 and 2 are essentially orthogonal to one another and set 3 is about 45° to both sets 1 and 2. Joints in structural zone A are chiefly found in map-unit 9. Figure 11g illustrates that joints in this zone form three distinct sets very similar to those in structural zone B, suggesting jointing was contemporaneous in both structural zones. These joint distributions are similar to those found in the Kaladar area (Wolff 1978), except that the three sets in that study were 120° apart (i.e. the orthogonal set was not present).

The most abundant dikes are the pegmatite dikes of map-units 11k and 11m. These most often are found to parallel the second joint set and are usually more abundant near the McLean granitic pluton where they become diffuse pegmatitic segregations. Irregular

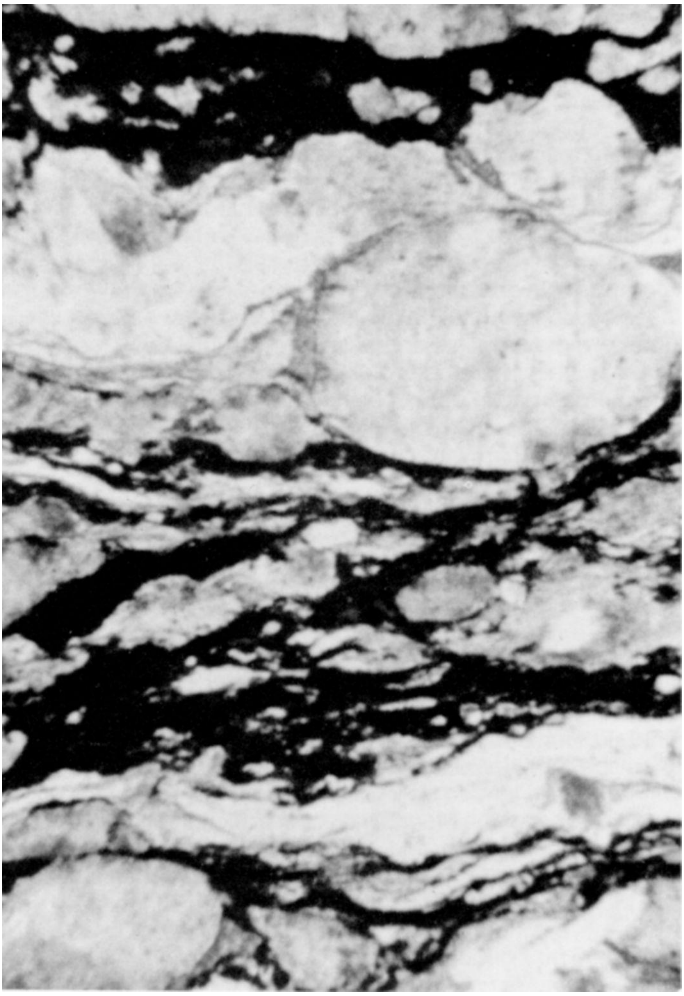

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***Photo 8**—Photomicrograph (crossed nicols, field of view 5 mm) of mylonite gneiss from the major shear zone. The dark material is biotite and along with ribbons of recrystalized quartz and fragments of feldspar forms the matrix. Augens or porphyroclasts are generally quartz.*

pegmatite masses tend to follow the first joint set. Aplites in both map-units 9 and 11 tend to be omnidirectional and discontinuous.

AEROMAGNETIC DATA

Comparison of Map 2449 (back pocket) and the available aeromagnetic survey (GSC 1970) indicates a reasonable correlation between aeromagnetic contour patterns and rock-type. The aeromagnetic pattern can be divided into three gross types: 1) wide contour spacing and low flux (3000-4000 gammas); 2) dense contour spacing and low flux (2000-4000 gammas); and 3) dense spacing and high flux (3000-5500 gammas).

The first pattern is typical of the metasedimentary areas and massive granitic intrusions, including map-units 3, 4, 5, 6, 7, 8, 9 and 11. These rock-types all lack magnetic minerals and are essentially indistinguishable from one another in the aeromagnetic survey.

The second pattern is typical of the metavolcanic and mafic to felsic gneiss and anatectite terrains, map-units 1 and 2. These produce a much denser pattern and somewhat higher values as more mafic minerals (magnetite and pyrrhotite) exist in these rocks. Upon close examination this aeromagnetic pattern can be followed around the western boundary of the McLean Granitic Pluton, outlining its synformal nature.

The third, most striking, pattern delineates the Mountain Grove Mafic Intrusion, and is caused by the higher content of magnetic minerals. The "Z" shaped outline of this body amongst granitic and metavolcanic rocks is well defined. Although individual carbonate metasedimentary inclusions cannot be differentiated at the scale of the aeromagnetic map, the large carbonate metasediment embayment into this body east of Carnahan Lake shows up as a prominent aeromagnetic depression.

In general the aeromagnetic data does not reflect any of the faulting in the map-area.

ECONOMIC GEOLOGY

The Long Lake area contains a variety of metallic and non-metallic mineral deposits but the only significant producer on record in the area is the Long Lake zinc mine just west of the hamlet of Long Lake. Minor surface workings for feldspar and hornblende were active from 1936 to 1942. In 1978 mineral production was limited to sand and gravel which are used locally for construction purposes.

Metallic mineralization consists mainly of zinc, lead, copper, nickel and iron, plus small scatterings of molybdenum, cobalt and gold and very little uranium and radioactive material. The known zinc deposits tend to be limited to carbonate metasediment inclusions along the south and west borders of the Mountain Grove Mafic Intrusion. Occurrences of copper, nickel, cobalt and iron and gold tend to be limited to the Mountain Grove Mafic Intrusion, and/or the mafic to intermediate metavolcanics. Molybdenum is limited to the late stage granitic intrusion (McLean Granitic Pluton) and usually with associated granitic pegmatites. Uranium and radioactive mineralization is found in a pegmatitic unit thought to be associated with the McLean Granitic Pluton as well, but occurring on strike with the uranium mineralization in the Kaladar area (Wolff 1978). It is of interest to note that the metallic mineralization in the Long Lake area is confined to those rocks to the east of the major shear zone which form the Frontenac Axis (segment IVc of the Central Metasedimentary Belt defined by Wynne-Edwards 1972).

Non-metallic mineralization consists mainly of feldspar and hornblende which are both associated with the coarse-grained phases of the Mountain Grove Mafic Intrusion.

Prospecting and Mining Activity

Recorded data on mineralization in the area dates back to the turn of the century when L. Benn of Long Lake discovered zinc on the current Long Lake zinc mine location. Benn was able to produce 100 tons of zinc ore from a small open pit operation while the latest working of this deposit produced 9,467 tons from underground workings (Lynx-Canada Explorations Limited and Canadian Reynolds Metals Company Limited, 1973-1974). Scattered test pits, trenches and geological studies in the immediate vicinity since the original discovery have revealed no other economic zinc deposits.

Exploration for molybdenite was active in the period 1915-1917, and yielded two short-lived pits producing less than 1500 pounds combined of marginal grade ore (0.6 percent MoS_2 maximum). The late 1930s saw the quarrying of feldspar and hornblende for building products and surface trenching for copper, nickel and gold. The period 1956-1959 was active with drilling for copper, nickel and zinc. Exploration and diamond drilling in the metavolcanics yielded only trace amounts of these metals but results from the Mountain Grove Mafic Intrusion (Sharbot Lake Mines Limited) outlined a sulphide-bearing zone 228 m long, and 46 m wide to a maximum depth of 312 m with low Ni, Cu, and Co concentrations (0.3 percent maximum). Unsuccessful attempts to discover radioactive mineralization also took place in this period.

Recent exploration in the area has included surface geochemistry and diamond drilling for Zn-Pb sulphides in carbonate units by Lynx-Canada Explorations Canada Limited (1973) (8, 9,and 10 on map), and the airborne gamma-ray spectrometry survey by the Federal and Provincial Governments (GSC 1976).

Metallic Mineralization

ZINC

The zinc mineralization is associated with carbonate metasediments where they occur as large inclusions or xenoliths within the Mountain Grove Mafic Intrusion, or in carbonate units occurring very near the border contact of the mafic intrusion. The author believes the ore to be stratabound as described by Stanton (1972) with subsequent reconcentration during deformation-metamorphism (discussed in more detail below). This suggests that the deposits would contain highly concentrated, restricted volumes of ore grade material confined mainly to the carbonate rocks. Zones which lack the high degree of metamorphism and deformation will contain less restricted volumes of substantially lower concentrations of sulphides, but are more representative of the original stratabound material.

Description of Deposits

CORVAL CORPORATION LIMITED [1957] (4)
LOT 2, CONCESSION V, AND WEST 1/2, LOT 2, CONCESSION VI, OLDEN TOWNSHIP

Situated directly south of and adjacent to the Long Lake zinc deposit this parcel of land was given meticulous examination for Zn-Pb mineralization by the Corval Corporation Limited in 1957. The study involved detailed (1:2400) mapping of the property. Although the surface geology is similar to the Long Lake zinc deposit, no substantial sulphide mineralization was discovered. Examination of this parcel by the author revealed that a substantially smaller amount of carbonate metasediment outcrops on this parcel of land and, perhaps more significantly, the 4ak unit (very coarse-grained calcite marble) was not found. Most of the outcrops are composed of gabbro, anorthositic gabbro, and monzonite of the Mountain Grove Mafic Intrusion. Corval Corporation Limited's interest in the property has lapsed.

W.H. DOUGLAS (5)
NORTHEAST 1/4, LOT 3, CONCESSION V, OLDEN TOWNSHIP

In 1972 W.H. Douglas drilled two holes in massive gabbro and monzonite of the Mountain Grove Mafic Intrusion (map-unit 10) directly north and adjacent to the Long Lake zinc deposit. At depth the work revealed continuous mafic intrusive lithologies cut by pink pegmatite of the McLean Granitic Pluton and neither sulphide mineralization nor carbonate metasediments were encountered. The holes plunged 45° south towards the Long Lake zinc deposit and were 30 m and 36 m in length (Assessment Files Research Office, Ontario Geological Survey, Toronto).

HAWLEY OCCURRENCE (6)
NORTHWEST 1/4, LOT 4, CONCESSION III, OLDEN TOWNSHIP

The Hawley occurrence consists of sphalerite and pyrite within map-units 4a,b,k which are the same carbonate units as at the Long Lake zinc deposit. The carbonate zone is intruded by both the Mountain Grove Mafic Intrusion, and the pegmatite phases of the McLean Granitic Pluton. Two small (0.25 m maximum dimension) concentrations of massive sphalerite and pyrite were found near an abandoned shack in a unit of medium- to coarse-grained calcite marble at the base of a small knoll west of the Hawley farmhouse. An assayed (Geoscience Laboratories, Ontario Geological Survey, Toronto) grab sample taken by the author yielded Zn 48.3 percent, Pb 0.55 percent and Cu 198 ppm. In 1972-1973 Lynx-Canada Explorations Limited did a soil geochemistry survey of this occurrence which showed background Zn values of 200 ppm and a few isolated scattered anomalous values higher than this threshold (Assessment Files Research Office, Ontario Geological Survey, Toronto).

LYNX-CANADA EXPLORATIONS LIMITED [1973] (8)
SOUTHWEST 1/4, LOT 10, CONCESSION III, OLDEN TOWNSHIP

In a 1973 soil geochemistry survey, Lynx-Canada Explorations Limited located a few scattered Zn anomalies in carbonate metasediments of map-unit 4ak, very coarse grained calcite marble. Background values were typically 200 ppm Zn and anomalous spots higher than this threshold. This survey work has not been submitted for assessment credit and Lynx-Canada Explorations Limited's interest in the ground lapsed.

LYNX-CANADA EXPLORATIONS LIMITED AND CANADIAN REYNOLDS METALS COMPANY LIMITED (LONG LAKE ZINC MINE) (9)
LOT 3, CONCESSION V AND LOT 3, CONCESSION VI, OLDEN TOWNSHIP

History and Recent Development of the Deposit

The Long Lake zinc mine was first discovered in 1896 by L. Benn on the farm of Howard Ritchie. The first operation produced 100 tons of zinc ore from a small pit. From 1897 to 1925 James Richardson and Sons carried out exploration, development and mining on the property and produced 3442 tons of Zn valued at $41,500. The operation involved trenching and pitting, five shafts 60 to 125 feet deep plus drifting and cross-cutting. The property was optioned in 1914-1915 and dewatered by the Long Lake Zinc Company. Surface exploration and 1000 feet of diamond drilling yielded little and the option was dropped. In 1947 Rochette Gold Mines leased the property. Under this organization a new headframe was erected, the No. 2 shaft retimbered, an overhead ore tramway constructed, milling equipment installed and 24 surface diamond drill holes sunk. During this period 1674 tons of ore were milled, half from surface dumps and the remainder from underground workings. In 1950 the company reorganized as Consolidated Rochette Mines Limited, and 7066 feet of underground diamond drilling was completed. Operations ceased in 1952. In 1966 Mid South Explorations Limited optioned the property and carried out surface exploration.

In 1970 Dr. W. D. Beaton of Montreal proposed the Kingston Project to Lynx-Canada Explorations Limited, to test the Long Lake zinc deposit for deeper extensions of known near-surface sphalerite, galena, chalcopyrite, pyrrhotite and silver mineralization. The same year Lynx-Canada Explorations Limited purchased the mining rights and leased the surface rights and were joined in partnership by Canadian Reynolds Metals Company Limited (Lynx-Canada 45 percent, Canadian Reynolds 55 percent). Lynx-Canada mapped the property and conducted magnetometer, induced polarization, resistivity, self potential, gravimetric and soil geochemistry surveys of the property.

The best responses from the geophysical surveys for delineating the ore bodies were received from the induced polarization work (Figure 12). These results clearly delineate five anomalous zones. Zone 3 was not only the largest of these but was adjacent to old workings and the extension of these at depth. The suggested depth to the centre of assumed spherical bodies from this zone was 150 feet which, given the body dimensions previously known on the property, suggested upper limits of 50 to 100 feet below the present ground level. Zone 1 appeared to have possible economic concentrations but was not worked after drilling the anomaly. Zones 2, 4 and 5 could be accounted for by clay-rich trenches or disseminated sulphides within the mafic intrusive body near the contact of the carbonate zone. Magnetometer surveys were useful in defining the contacts of the mafic intrusion with the carbonate metasediments (Figure 13). Principal contacts were defined by outlining a 2000 gamma contrast in line profiles, and were accurate to within 50 feet. Minor difficulties in defining the contact were reported to have occurred on the southern portions of lines 4W and 8E where mafic intrusive inliers occur. Zinc, lead and mercury respon-

OGS 10 354

Photo 9—*Panoramic view of the Long Lake zinc mine, looking southwest. The building on the left is the core shack, in the center is the separator facility, and on the right is the mine dump. A projection of the "ore zone" to surface would run generally east-west under the mine ramp and separator towards the cluster of trees middle-left in this view.*

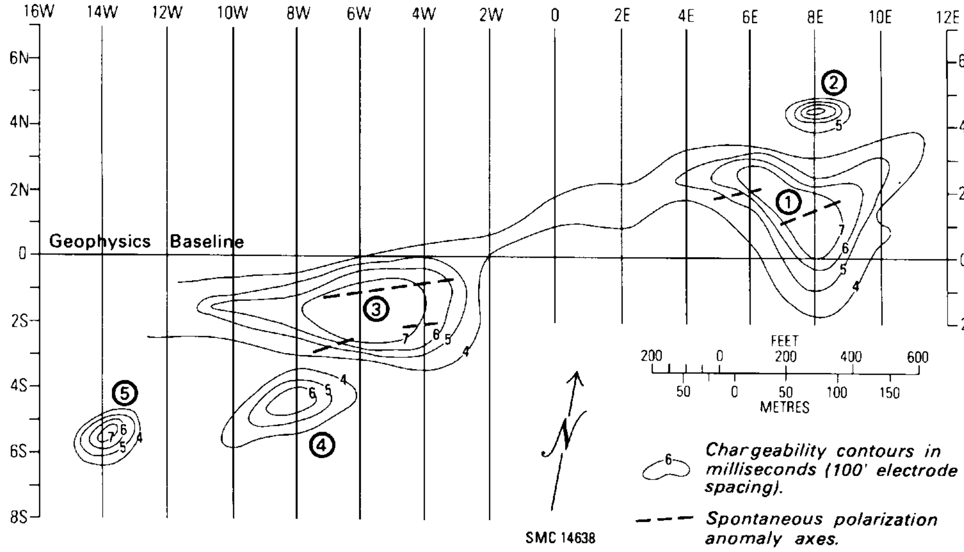


***Figure 12**—Induced and spontaneous polarization survey of the Long Lake zinc deposit. Compiled from data provided by Lynx-Canada Explorations Limited.*

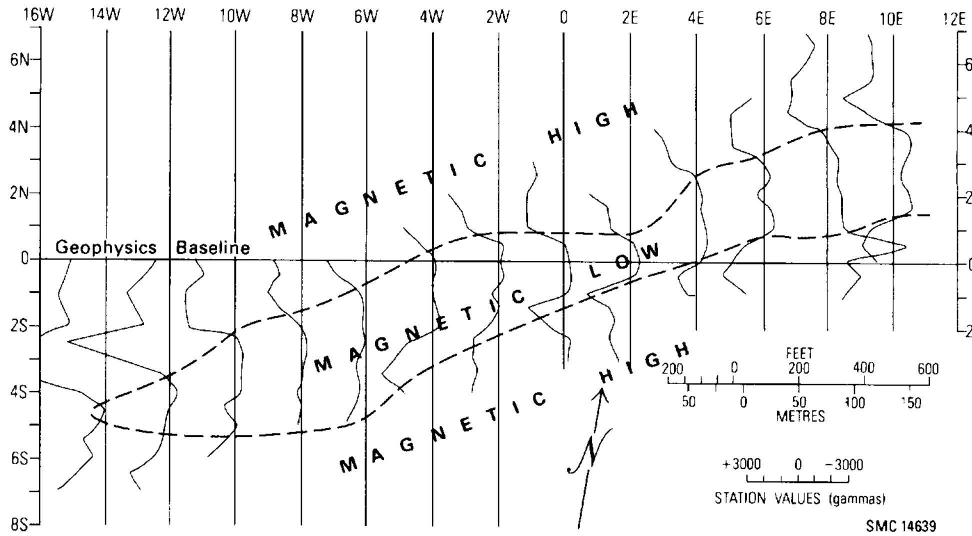


***Figure 13**—Vertical magnetic intensity survey of Long Lake zinc deposit. Compiled from data provided by Lynx-Canada Explorations Limited.*

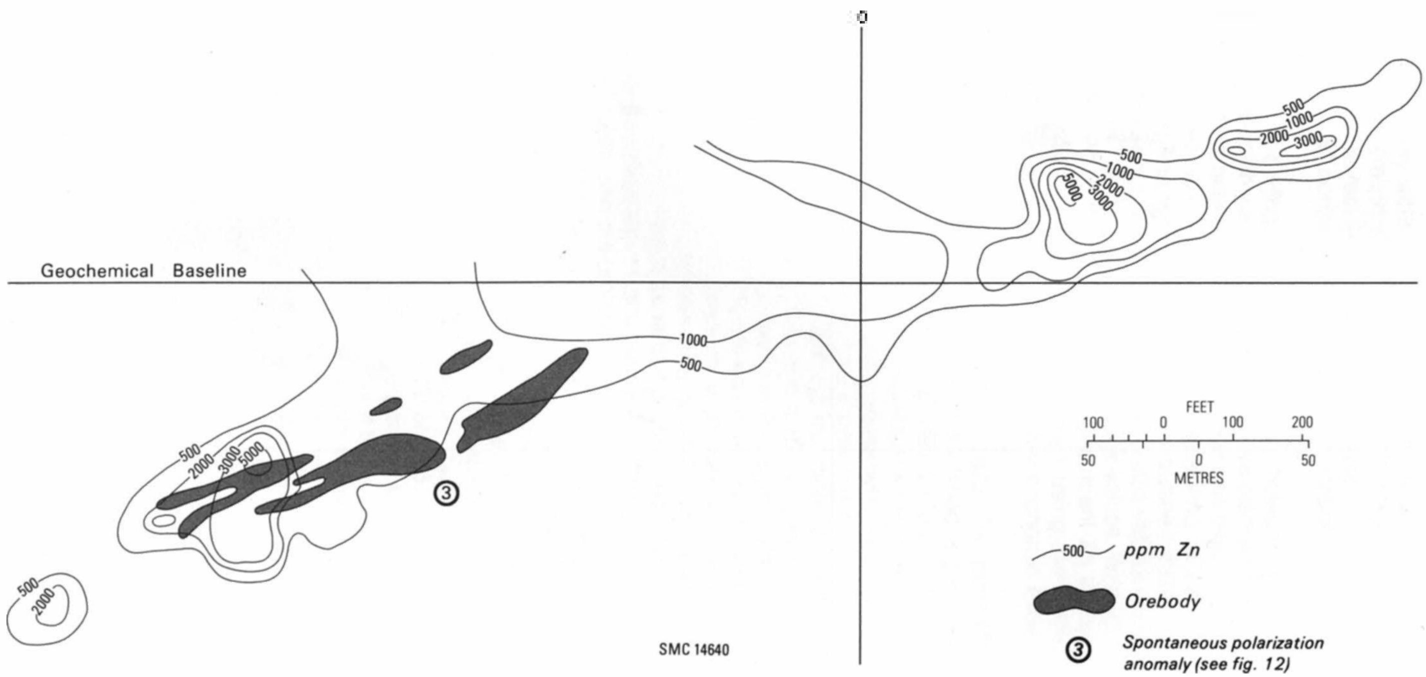


Figure 14—*Zinc soil geochemical survey of Long Lake zinc deposit. Compiled from data provided by Lynx-Canada Explorations Limited.*

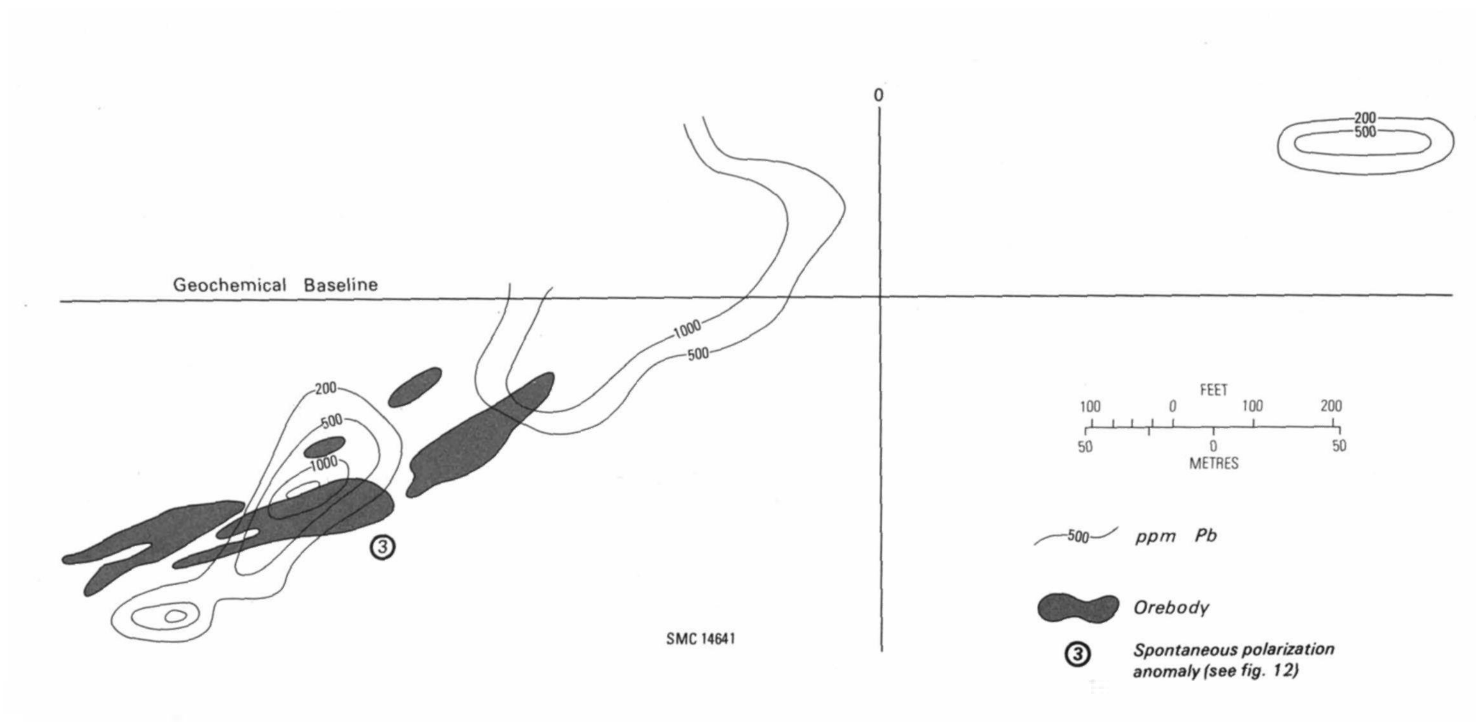


***Figure 15**—Lead soil geochemical survey of Long Lake zinc deposit. Compiled from data provided by Lynx-Canada Explorations Limited.*

ses from soil geochemistry were used to locally define zones of mineralization. Figures 14 and 15 show soil geochemistry patterns for Zn and Pb respectively. The "B" soil horizon provided the most reliable results as the "A" soil horizon seemed contaminated by previous workings (3 times "B" horizon values). Both metals gave excellent anomalies over the ore zones.

The initial diamond drilling program entailed 25 holes totalling 6000 feet and delineated several lenses which warranted a more intensive diamond drilling program in 1970-1971. The drilling pattern, oriented about an east-west axis over the above anomalies from Zone 3, consisted of two sets of 33 holes, each intersecting its partner across the axis at depth. This phase of drilling totalled 18,542 feet and outlined the ore bodies of Zone 3 in detail. Reserve figures vary slightly but the most optimistic values indicated 84,750 tons of ore grading 21.6 percent Zn with minor lead and silver values. With 25 percent dilution the reserves totalled 106,000 tons of ore grading 17.3 percent Zn at that time. Subsequent drilling immediately eastward in the vicinity of Zone 1 using the same drilling pattern involved 68 holes totalling 16,538 feet and did not show economic extension of the body at this level.

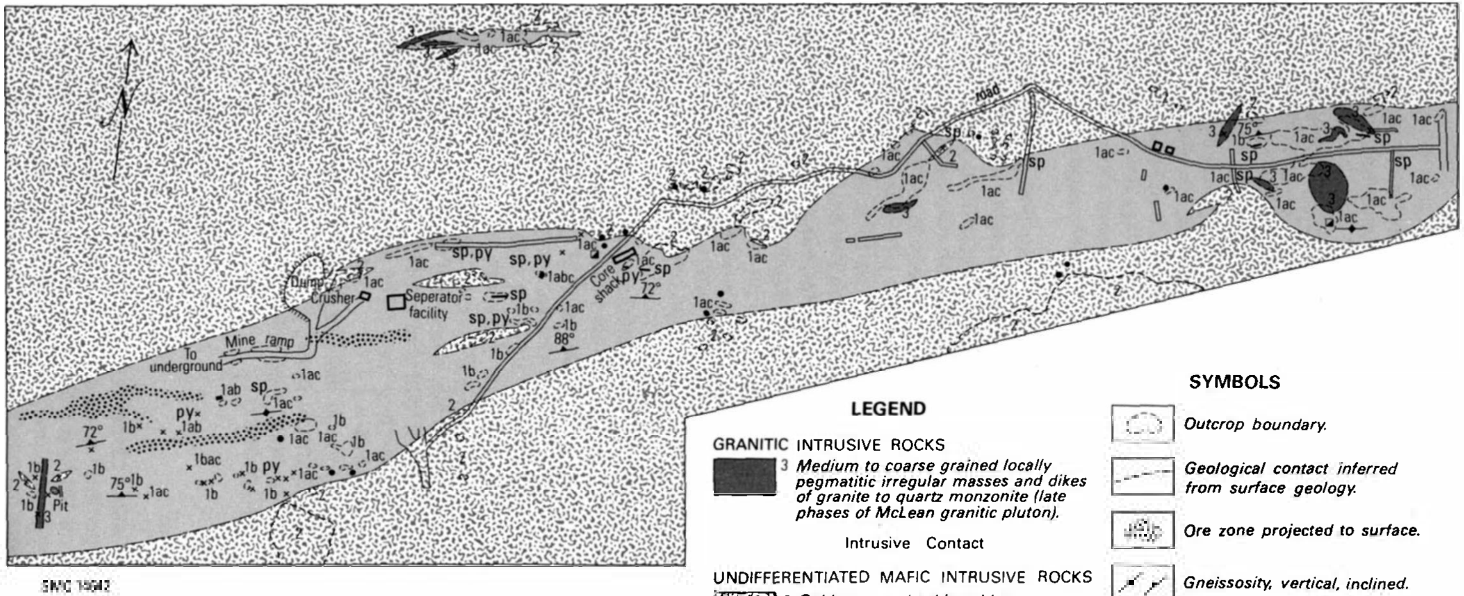
The official mine opening took place June 27, 1973. The plant (Photo 9) included a workshop, core-shack with office space, a compressor shed, a generator house, a crusher ramp and crusher, conveyor belts, wash house, heavy media separating plant, ore and waste stockpiles and settling pond for mine drainage water which was used in the plant. Mining was carried out using trackless mining equipment. Access to underground workings was gained from an adit which employed a previous open pit. Below ground, a two-drill jumbo was used and three load-haul-dump machines carried the ore to the surface where it was directly dumped into a grizzly and a 15 by 30 inch jaw crusher. Ore was extracted by first driving a 10-foot by 8-foot ramp at 20 percent grade in waste and turning off at right angles to sill out the ore lens. The ore was mined in 15 stopes with an average stope width of 12 feet at the face. Crusher products were screened for fines (less than 3/16 inch) and sent to the ore pile. Material between 3/16 and 1-1/2 inches was washed and sent to the heavy media separator. The Wemco separator which used a ferro silicon (s.g. 3) media allowed only 1 percent average loss of zinc because of the clean break between the gangue (calcite and calc-silicates) and ore (sphalerite).

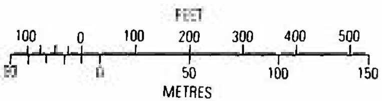
The average ore grade was 12 percent and was beneficiated to 20 percent for shipment; local 40 percent ore grades increased the beneficiated grade to as much as 25-30 percent. Ore concentrate was sent to the Balmat-Edwards mill of St. Joe Minerals Corporation near Gouverneur, New York, by truck. The rate of production was typically 200-350 tons per day allowing 120-200 tons per day of concentrate to be shipped. A total of 5.5 day shifts per week were worked during peak operation. The maximum depth reached was 115 feet. From March 1973 to February 1974 a total of 9,467 tons of Zn valued at $1,227,000 was extracted. Pre-production development expenses amounted to $203,000 and capital outlay for plant and equipment was $264,000 for a total cost of $467,000, not including exploration expenses. Operating costs for the month of May 1973 amounted to $0.056 per pound of zinc. The mine closed in December 1974.

The author visited the mine in 1978. Although inactive, the property has not been abandoned. The buildings of the plant, core-shack, conveyor belts, crushing equipment and separator were intact. The mine workings were filled with water and all entrances and pits and trenches were appropriately fenced or sealed.

Geological Nature and Genesis of the Deposit

The Long Lake zinc deposit is situated within carbonate metasediments (map-unit 4) (unit 1 on Figure 16) of Late Precambrian age, and surrounded by mafic intrusive rocks of the Mountain Grove Mafic Intrusion (map-unit 10) (unit 2 on Figure 16) also of the same age. Irregular masses and dikes of granitic pegmatite (map-unit 11) (unit 3 on Figure 16) intrude the above two lithologies. The carbonate metasediments are calcite-rich and have three





LEGEND

GRANITIC INTRUSIVE ROCKS

3 *Medium to coarse grained locally pegmatitic irregular masses and dikes of granite to quartz monzonite (late phases of McLean granitic pluton).*

Intrusive Contact

UNDIFFERENTIATED MAFIC INTRUSIVE ROCKS

2 *Gabbro, anorthositic gabbro, monzonite and syenite, usually medium to coarse grained but locally fined grained. (Mountain Grove mafic intrusion).* Intrusive Contact

CARBONATE METASEDIMENTS

1a *Medium to coarse grained granoblastic calcite marble locally containing minor quartz and calc silicates (usually pyroxene).*

1b *Fine to medium grained granoblastic laminated calcite marble with 0.5 to 2.0 cm thick layers locally containing minor quartz and calc silicates (usually pyroxene).*

1c *Coarse grained (2 to 7 cm) calcite marble, rhombs of calcite.*

SYMBOLS

- *Outcrop boundary.*
- *Geological contact inferred from surface geology.*
- *Ore zone projected to surface.*
- *Gneissosity, vertical, inclined.*
- *Trench.*
- *Shaft.*
- *Diamond drill hole.*
- *Mineral seam.*
- py — *Pyrite.*
- sp — *Sphalerite.*

Figure 16—Surface geology of Long Lake zinc deposit. Adapted from company plans.

modes of occurrence: 1) medium to coarse grained granoblastic calcite marble (map-unit 4a) (1a on Figure 16); 2) fine-grained to medium-grained granoblastic laminated calcite marble with continuous well defined 0.5 to 2 cm thick layers (map-unit 4b) (1b on Figure 16); and 3) very coarse grained (2-7.5 cm) varieties of the first unit (map-unit 4k) (unit 1c on Figure 16). Each type is found in continuous units which grade into each other over short distances (20 m). Quartz is an uncommon mineral associated with the carbonate, and on the weathered surface small disseminated pyroxene (diopside) grains may be found. The band of carbonate metasediments has a total strike length of about 1 km and a total width at the surface of 180 m. This narrow band of marble strikes N40-60E with generally steep but variable dips. Underground, large vugs in the carbonate unit are found. These have well developed growths of quartz and locally diopside, but no sulphide mineralization has developed in vugs of this type.

The surrounding mafic intrusive rocks vary in composition including medium to coarse grained varieties of gabbro, anorthositic gabbro, monzonite, and syenite. Local fine grained varieties are less common. One rock type grades into another over short distances (1 m) and with diffuse irregular boundaries. There are locally 2-7 cm feldspar laths in these units. Pyroxene is usually poorly preserved in these rocks and hornblende and feldspar are the dominant minerals with accessory magnetite. Orientations in this unit are similar to the carbonate units, N40-N60E, but moderate in dip (30°-60°N).

The granitic rocks which intrude both the carbonate and mafic rocks are associated with the McLean Granitic Pluton (unit 11) and are found throughout the entire area. Compositionally these are typically granite to quartz monzonite and usually coarse grained, although aplitic dikes were observed.

The geology of the mineralized zones is slightly different. On the surface disseminated sphalerite, galena and pyrite occur in definite horizons within the laminated carbonate unit. This particular rock type was thin sectioned by the author and assayed by the Geoscience Laboratories, Ontario Geological Survey, Toronto. Assayed values were Zn 21 percent, Pb 3.3 percent, S 17.3 percent, Ag 103 ppm, and Cu 54 ppm. The gangue consisted of carbonate with minor calc-silicate material. In this sample the sulphides appear stratabound and contemporaneous with the carbonate mineralization, although carbonate and sulphides are slightly recrystallized. Below ground the orebodies are lensoidal in shape and separated from one another. The ore is either massive coarse-grained sphalerite or disseminated sphalerite, galena, pyrite, pyrrhotite, ± chalcopyrite. The massive coarse-grained ore type is usually dark brown to black and may include as much as 16 percent iron in the $Zn_xFe_{1-x}S$ molecule. Grain size varies from 2 cm to 7 cm and usually the only other sulphide minerals are minor, recrystallized pyrite and pyrrhotite. A sample of this massive ore type was assayed (Geoscience Laboratories) yielding Zn 52.0 percent, Fe 6.5 percent, S 29.9 percent, Cu 108 ppm and Pb 11 ppm.

The disseminated ore type is medium to coarse grained and contains sphalerite, pyrite, galena, pyrrhotite ± chalcopyrite with a calcite, chlorite ± calc-silicate gangue. These lenses often contain pyrite-rich zones near the contact with the carbonate unit. A sample of this material assayed (Geoscience Laboratories) Zn 33.4 percent, Fe 6.8 percent, S 12.3 percent, Pb 2240 ppm, Cu 104 ppm and Ag 22 ppm. The gangue consisted of calcite and minor quartz and pyroxene. The contact of the carbonate with both ore types often includes calc-silicate minerals, the most common being dark green pyroxene (diopside); less common are chondrodite and grossularite. Minor amounts of galena ± molybdenite are found. Rarely, marcasite occurs with preserved delicate colloform overgrowths of sphalerite and pyrite. Hematite is a common supergene accessory throughout the carbonates.

The ore extracted from 1973 to 1974 occurred in three main zones (A, B and C zones), as depicted in Figure 17 from the mined out stopes. The A zone was the richest with ore grades reaching 40 percent or more. The B zone was the most voluminous with typical ore grades of 23 percent. The C zone was of smaller volume than the others and a little lower in grades. The B ore zone had a strike length of about 100 m, a maximum width of 4-5 m and extended about 30 m vertically. A section through the width of the main (B) zone (Figure 18) shows the typical stratigraphy of the deposit. The section extends from the north side of the deposit at the top and dips approximately 45 degrees through the ore zone to the south side. The section shows the occurrence of alternating zones of medium- to coarse-grained calcite marbles (unit 1a, Figure 16), fine- to medium-grained laminated calcite marbles (unit 1b, Figure 16), and very coarse grained varieties (unit 1c, Figure 16) in the top 21 m of the section. (Widths of the zones and depths to the ore zone from the surface vary along strike because the bodies plunge northeast). Minor aplitic and mafic intrusive rocks cut the section near the top (units 2 and 3, Figure 16). The abundance of sulphide minerals increases steadily toward the ore zone on the hanging wall. The carbonates on the hanging wall and footwall are very similar (1a units) both containing chlorite and disseminated pyrite and pyrrhotite. The very coarse grained marbles (unit 1c) tend to be barren of sulphide material (even when occurring between massive sulphide zones). Sulphide mineral concentrations drop off quickly away from the footwall. The disseminated sulphide zones occur not only adjacent to massive sulphide zones but between lenses, along strike, as well.

The genesis of this deposit has been discussed by Uglow (1916) and Alcock (1930), both of whom had little drillhole data and only surface pits with minor cross-cutting from which to obtain information. Uglow's examination of the deposit concluded it was originally Mississippi Valley-type, and was remobilized by metamorphism, while Alcock reckoned it was formed by "solutions at high temperature from the intrusive granite under conditions of contact metamorphism". In light of the new information disclosed by the large amount of recent development of this deposit and the two differing genetic theories currently existing in the literature, the following genetic concept is proposed by the author.

Evidence from the underground geology combined with surface geology from the mine and stratigraphically similar carbonate units in the immediate vicinity suggest to the present author that the Long Lake deposit is most likely a stratabound-mesothermal Pb-Zn deposit. The disseminated nature of the sulphide mineralization in foliation planes (relict bedding) within carbonate units between ore zones both along and across strike, and the occurrence of disseminated sulphide mineralization totally removed from ore zones suggest these are stratabound sulphides (as described by Stanton 1972). The pyritiferous bor-

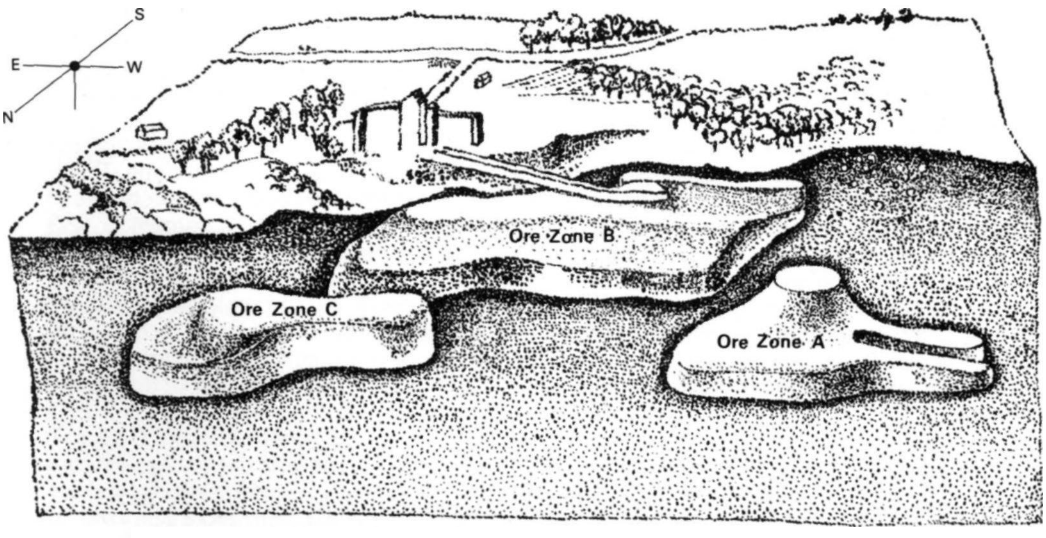


***Figure 17**—Three-dimensional sketch of Long Lake zinc orebody.*

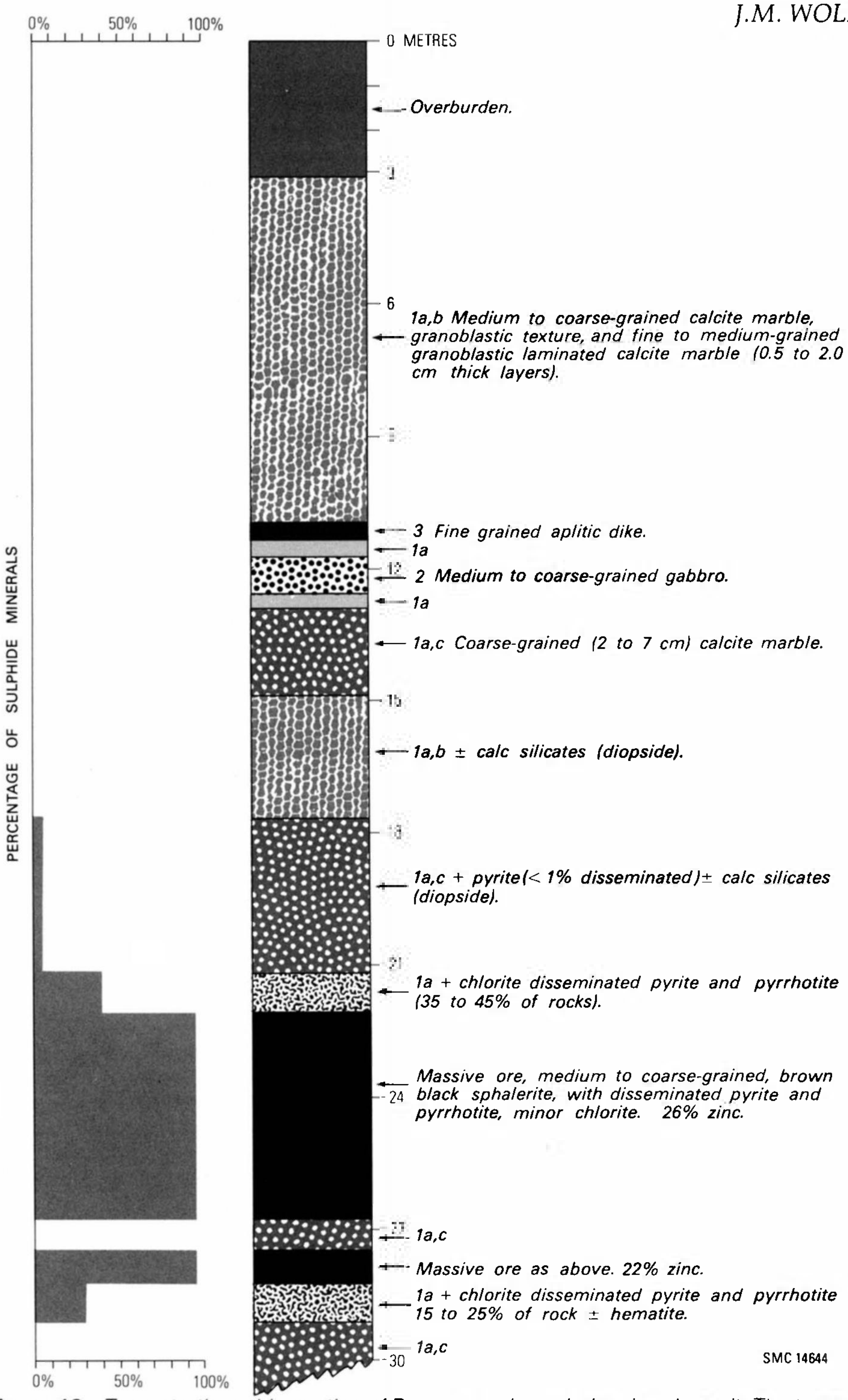


Figure 18—Type stratigraphic section of B ore zone, Long Lake zinc deposit. The top of the section is to the north, and the section dips approximately 45 degrees south.

ders adjacent to the massive sphalerite zones are also typical of stratabound Zn-Pb occurrences. The linear nature of individual massive ore seams and the en echelon fold geometry of the deposit suggest an original lithology control subsequently complicated by deformation. The competancy contrast provided by the varying carbonate rock types present (including the abundance of disseminated sulphides as a competancy component) allowed cavities to form during deformation. The chemical potential contrast thereby created, together with metamorphism, allowed the cavities in and immediately adjacent to sulphide rich zones to be filled with sphalerite, pyrite and pyrrhotite. Cavities created away from sulphide rich zones, or isolated from these zones by permeability screens became vugs lined with quartz and calc-silicate minerals. Subsequent metamorphism caused recrystallization which produced the coarse-grained sphalerite and calcite zones.

Preserved cavities are the result of the structural deformation and no evidence of a pre-existing Karst-type topography is seen. No fracture or vein sulphide mineralization exists and the barren nature of the surrounding mafic intrusive rocks with respect to sphalerite and massive sulphides on surface and in drill cores precludes a hydrothermal or intrusive origin. The felsic intrusive rocks are very late stage cutting all lithologies and are barren of sulphides. No contact metamorphic aureole exists and the geothermal gradient was likely produced by regional metamorphism.

Sources of information used above include: Uglow (1916), Alcock, (1930), Harding (1947), Thomson (1957), Shklanka (1969), Lynx-Canada Explorations–Canadian Reynolds Metals (1973), Northern Miner (1973), Canadian Mining Journal (1973) and Brown (1976).

LYNX-CANADA EXPLORATIONS LIMITED (SMITH OCCURRENCE) (10)
WEST 1/2 LOT 8, CONCESSION II, OLDEN TOWNSHIP

The Smith occurrence was originally described by Harding (1947), as disseminated sphalerite and pyrite in narrow bands parallel to the bedding in white crystalline limestone, which have been intruded by dikes and irregular masses of granite. Three pits were sunk at this location but terminated at shallow depth. In 1973 Lynx-Canada Explorations Limited drilled four holes in a similar zone but away from the pits described above. The holes ranged from 60 to 75 m in length and revealed a zone of 1 percent Zn over about 30 m (D.J. Villard, Resource Geologist, Ontario Ministry of Natural Resources, Huntsville, personal communication, 1978).

MID SOUTH EXPLORATIONS LIMITED (13)
NORTHWEST 1/4, LOT 3, CONCESSION V, OLDEN TOWNSHIP

Under the direction of W.H. Douglas as president, Mid South Explorations Limited sunk two diamond drill holes in massive gabbro and monzonite of the Mountain Grove Mafic Intrusion north of the Long Lake zinc deposit. The holes plunged west for distances of 36 m and 68 m. Each hole revealed a continuous section of mafic intrusive rocks (map-unit 10) which were locally cut by pegmatites of the McLean Granitic Pluton. Each hole was barren of sulphide mineralization (Assessment Files Research Office, Ontario Geological Survey, Toronto).

NICKEL, COPPER AND IRON SULPHIDE MINERALIZATION

The nickel, copper and iron sulphide concentrations in the Long Lake map-area are limited to the mafic to intermediate metavolcanics (map-unit 2) and to the Mountain Grove Mafic Intrusion (map-unit 10). Regardless of rock type the sulphides occur as either scattered disseminations or as massive seams. On the surface these can be quickly detected by prominent gossan zones. The sulphide mineral assemblages always contain pyrite and varying amounts of pyrrhotite and chalcopyrite. To date none of these concentrations have been economically recoverable and only one deposit has had extensive exploration work carried out (Sharbot Lake Mines Limited).

Description of Deposits

CARNAHAN LAKE OCCURRENCE (1)
SOUTHEAST 1/4, Lot 11, CONCESSION II, OLDEN TOWNSHIP

Located in a gossan zone on the western shore of Carnahan Lake, in metavolcanics (map-unit 2), a drillhole by Cremac Surveys Company Limited, in 1959, intersected what appeared to be promising sulphide mineralization. Two sulphide-rich zones, one 21 m in core length and the second 4 m in core length, were intersected at the 27 m and the 64.5 m levels. The first zone contained 2-5 percent disseminated pyrrhotite with minor pyrite ± chalcopyrite and two subzones less than 1 m long of 5-10 percent disseminated pyrrhotite with minor pyrite ± chalcopyrite. The second zone contained 5-10 percent pyrite ± pyrrhotite. Detailed assays of these zones disclosed less promising results. A total of 5 m yielded 0.04 percent Ni and 3.5 m yielded 0.05 percent copper (Assessment Files Research Office, Ontario Geological Survey, Toronto). Gneiss consisting of quartz, feldspar, biotite and garnet was intersected at depth in this hole.

N. CLARK (2)
SOUTHEAST 1/4, LOT 10, CONCESSION X, KENNEBEC TOWNSHIP

In 1959 three diamond drill holes were sunk in unit 2 metavolcanics by N. Clark on his farm in Kennebec Township south of Kellar Lake. The holes were 81 m, 68 m and 77 m in length. Assays from these holes show greater than 1 percent Fe, 0.15 percent Ni and trace amounts of copper, titanium and manganese (Assessment Files Research Office, Ontario Geological Survey, Toronto). Although collared in metavolcanics the hole is reported by Clark to have intersected gabbro and quartzite at depth.

CORVAL CORPORATION LIMITED [1957] (3)
LOT 7, CONCESSION VI, AND WEST 1/2, LOT 7, CONCESSION VII, OLDEN TOWNSHIP

In 1957 Corval Corporation Limited conducted a geological survey and soil geochemical study of seven contiguous claims, six of which are in the Long Lake map-area south of O'-Reilly Lake. The results of this study revealed no copper mineralization (Assessment Files Research Office). This ground included the MacDonnell molybdenum occurrence (see below).

HUGHES OCCURRENCE (7)
NORTHEAST 1/4, LOT 9, CONCESSION IX, KENNEBEC TOWNSHIP

In the late 1940s Amos Hughes opened a pit in massive sulphides on his property (N. Clark, local resident, personal communication, 1978). Measuring 2.5 m long, 0.5 m wide and 1 m deep the pit exposed massive pyrite. A sample taken by the author from the location and assayed by Geoscience Laboratories, Ontario Geological Survey, yielded 37.8 percent Fe, 0.39 percent Zn, 0.35 percent Cu, 32.6 percent S and trace Pb. The pit is located in metavolcanics very near the major shear zone in an area of protomylonite and mylonite gneiss.

W.M. MCKNIGHT [1947] (12)
WEST 1/2, LOT 10, CONCESSION IV, OLDEN TOWNSHIP

Located 30 m east of the old Long Lake road southeast of Little Mud Lake, this occurrence is reported to contain trace nickel and gold (Harding 1947). The showing is in a pit 3 m deep in a rusty gossan zone, which is part of a metasedimentary inclusion near the border of the Mountain Grove Mafic Intrusion. These metasediments are quartz-rich and not carbonate-bearing.

H.G. QUINN AND S.R. MCEWEN [1957] (15)
LOT 8, CONCESSION VI, OLDEN TOWNSHIP

Three shallow diamond drill holes were sunk by H.G. Quinn and S.R. McEwen into sulphide-bearing rocks of map-units 10 and 11 on this property southwest of O'Reilly Lake during the summers of 1956 and 1957. The first hole was 15 m in length and sunk in sulphide bearing gabbro which assayed only trace Ni, Cu, and other metals (Assessment Files Research Office, Ontario Geological Survey, Toronto). The second and third holes were drilled into granitic rocks and yielded pyrite in the core. Each of these holes were 12.5 m in length and no samples from these were assayed.

RAYMOND OCCURRENCE (16)
LOT 10, CONCESSION VI, OLDEN TOWNSHIP

A small showing of pyrite near the contact of the metavolcanics and Mountain Grove Mafic Intrusion in a zone containing granitic intrusive rocks (unit 11) and minor metasediments south of Bass Lake was reported by Harding (1947) to have assayed trace amounts of nickel.

SHARBOT LAKE MINES LIMITED [1956] (17)
LOT 10, CONCESSION VI, SOUTHWEST 1/4, LOT 10, CONCESSION V, AND SOUTHWEST 1/4, LOT 11, CONCESSION V, OLDEN TOWNSHIP

Located just west of O'Reilly Lake the occurrence in lot 10, concession VI, is situated in massive medium- to coarse-grained gabbro and anorthositic gabbro (map-unit 10). In 1956 stripping and trenching were undertaken and a geophysical survey is reported to have been completed. At that time a grab sample is said to have assayed 1 percent nickel, 0.75 percent copper and 0.1 percent cobalt. In 1957, 13,000 feet of diamond drilling in 17 holes delineated a sulphide-rich zone 228 m long, 46 m wide and a maximum of 312 m deep. One hole assayed 0.3 percent nickel, 0.3 percent copper and 0.14 percent cobalt in a section 5.5 m long. None of this work has been submitted for assessment and the property appears abandoned.

Both of the other locations are located in the Mountain Grove Mafic Intrusion. Each was drilled to the 30 m level and indicated disseminated sulphide concentrations. The sulphide mineralization was primarily pyrite and only trace nickel and copper values were found. This work was performed in 1957 (Assessment Files Research Office, Ontario Geological Survey, Toronto).

MOLYBDENUM

Few molybdenum occurrences exist is the Long Lake map-area. Those to be found are concentrated in the granite and granite-pegmatite phases of the McLean Granitic Pluton. Occurrences observed by the field party during the 1978 field season were of a mineralogic interest only, but two promising deposits were worked in the early 1900s.

Description of Deposits

MACDONNELL OCCURRENCE (11)
NORTHWEST 1/4, LOT 7, CONCESSION VI, OLDEN TOWNSHIP

In 1915 G.M. MacDonnell opened a 4 m by 2 m pit in a molybdenum-bearing carbonate inclusion surrounded by granite and granitic pegmatite. A 108 kg shipment of this material assayed 0.4 percent molybdenite. This deposit has no apparent extension and has been exhausted. References to this deposit may be found in Eardley-Wilmot (1925) and Harding (1947).

SMITH OCCURRENCE (18)
LOT 6, CONCESSION VI, OLDEN TOWNSHIP

In 1916 a pit 6 m by 1 m by 2 m was opened in a molybdenite-bearing hornblendic lens within granitic rock. A 450 kg shipment of this ore was sent to the Mines Branch, Ottawa in 1917 and contained 0.27 percent molybdenite. A later 68 kg shipment assayed 0.6 percent molybdenite. This deposit has no apparent extension and has been exhausted. References to this deposit can be found in Eardley-Wilmot (1925) and Harding (1947).

URANIUM AND RARE EARTH MINERALIZATION

Uranium and rare earth mineralization is generally lacking in the Long Lake map-area. One occurrence of uranium oxide staining was encountered by the field party during the 1978 field season. This showing is located north of Kennebec Lake and is on strike with uraniferous pegmatites described by Wolff (1978). Total field scintillation was only marginally above background. The joint Federal-Provincial Uranium Reconnaissance Program (GSC 1976) revealed a small anomaly near this locality.

Non-Metallic Mineralization

FELDSPAR AND HORNBLENDE

Feldspar and hornblende occur in a deposit of anorthositic gabbro of map-unit 10 southeast of the village of Mountain Grove, in lot 11, concession III, Olden Township. This quarry was sporadically active from 1936 to 1942 and the material was used for roofing and stucco purposes by Building Products Limited of Montreal (Harding 1947).

SAND AND GRAVEL

Local pits of sand and gravel have been worked throughout the area. Most of these are located over the northeast trending shear zone which passes through Mountain Grove. Individual pits are continuously worked. Currently active operators include the Gray Brothers, Mountain Grove, G. Marden, and the See Brothers of Arden.

Suggestions for Future Exploration

The present study of the Long Lake area has shown that the known mineralization can be related to the known stratigraphy and the complex plutonic and deformational history of the area and provides some basic data for the planning and execution of future exploration work. Conclusions with regard to the mineral potential of the area are presented below.

METALLIC MINERAL RESOURCES

Zinc and associated minor lead mineralization as typified by the Long Lake zinc deposit are perhaps the most obvious potential metallic mineral resource for the Long Lake area. The present level of understanding of the nature of this deposit and the surface geology of the carbonate metasediments in the immediate vicinity can be used to delineate some definite exploration targets. At the mine site itself the "en echelon" geometry of the ore lenses suggests that more ore may exist down plunge. Further detailed diamond drilling would be required to determine this and extraction feasibility would be dependent upon the ability to adapt the present stopes and ramps to a deeper level mining operation. Carbonate metasedimentary units in the immediate vicinity especially those containing units 4a, b and k adjacent to the Mountain Grove Mafic Intrusion, should be considered as potential exploration targets for Pb-Zn deposits similar to the Long Lake deposit. Some of these have been examined in varying detail, as described earlier, and any of these could be examined further. Of particular interest are the carbonate metasediments outcropping in the northwest 1/4, lot 4, concession III, the west 1/2, lots 5 and 6, concession III, the east 1/2, lot 3, concession III, and the west 1/2, lot 8 concession II, of Olden Township. Investigation for this type of deposit should include detailed mapping, detailed vertical magnetic, induced polarization and self polarization surveys plus zinc, lead and mercury soil geochemistry surveys. Assayed samples from these areas included trace amounts of Zn. A detailed geological and soil geochemistry study for Zn, Pb and Hg may prove beneficial for further evaluation of the degree of Zn and Pb mineralization at these locations.

The deposits of Ni and Cu located in the Long Lake map-area to date have been low grade but appear to be associated with the Mountain Grove Mafic Intrusion. The possibility of low grade disseminated deposits may warrant investigation.

Small quantities of molybdenum have been extracted from apparently localized deposits, south of O'Reilly Lake, and associated with the McLean Granitic Pluton. No indication of more extensive mineralization of this type was observed by the field party although small occurrences were located.

A minor indication of uranium mineralization is confined to one area in the map-area, but is perhaps significant because it is part of a pegmatite zone which stretches for several miles southwest and northeast of the map-area. To the southwest, uraniferous zones were found in this zone (Wolff 1978). In all likelihood uraniferous zones in this pegmatite body exist to the northeast of the map area.

NON-METALLIC MINERAL RESOURCES

Rock types in the area are potential sources of building and ornamental stone and industrial minerals but this potential has been largely untested. Rocks of the Mountain Grove Mafic Intrusion and the MacLean Granitic Pluton are both potentially interesting candidates. The striking colours and textures of these rocks might provide attractive building and ornamental stone. These rocks are not only well exposed but located very near a major highway.

Rocks and Minerals for the Collector

Like much of the Grenville Province the map-area hosts a variety of rocks and minerals for the interested mineral collector. The carbonate metasediments contain not only large rhombs of calcite but well formed calc-silicates including euhedral tremolite needles, black and brown scapolite and green, orange and brown diopside. Carbonate samples from the Long Lake zinc deposit often host pyrite and massive sphalerite and less commonly galena, pyrrhotite and chalcopyrite. Large tourmaline and feldspar crystals can be obtained from the late stage granite-pegmatite dikes and good textural samples of gabbro, porphyritic granite, protomylonite and mylonite gneiss can be obtained.

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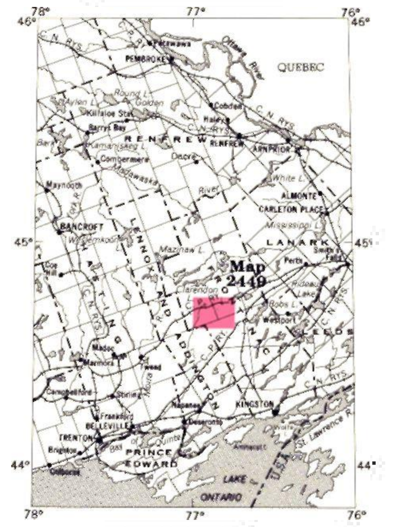
INDEX

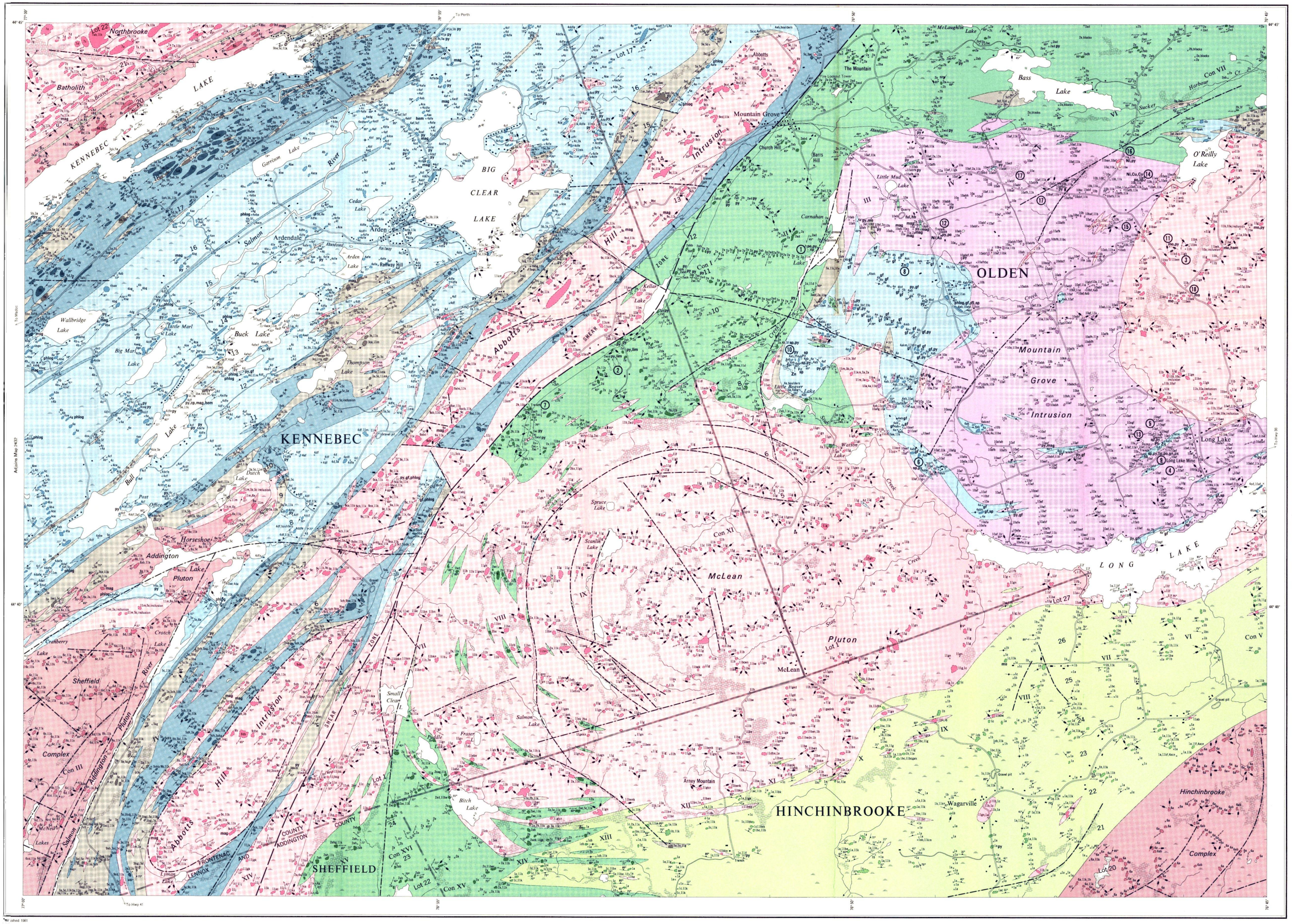
Ministry of Natural Resources
Ontario

Ontario Geological Survey
Map 2449
Long Lake



Scale, 1 inch to 50 miles

N.T.S. Reference 31 C/10



SYMBOLS

- Small bedrock outcrop.
- Area of bedrock outcrop.
- Schistosity; (horizontal, inclined, vertical).
- Gneissosity, (horizontal, inclined, vertical).
- Foliation; (horizontal, inclined, vertical).
- Lineation with plunge.
- Geological boundary, observed.
- Geological boundary, position interpreted.
- Fault; (observed, assumed). Spot indicates down throw side, arrows indicate horizontal movement.
- Lineament.
- Jointing; (horizontal, inclined, vertical).
- Drill hole; (vertical, inclined).
- Inundated land.
- Swamp
- Motor road. Provincial highway number encircled where applicable.
- Other road.
- Trail, portage, winter road.
- Building.
- County boundary; approximate position only.
- Township boundary, surveyed; approximate position only.
- ④ Location of mining property or mineral deposit.

PROPERTIES, MINERAL DEPOSITS

1. Carnahan Lake occurrence.
2. Clark N.
3. Corval Corp. Ltd. [1957].
4. Corval Corp. Ltd. [1957].
5. Douglas W. H.
6. Hawley occurrence.
7. Hughes occurrence.
8. Lynx Canada Explorations Ltd. [1973].
9. Lynx Canada Explorations Ltd. and Canadian Reynolds Metals Co. Ltd. (Long Lake mine).
10. Lynx Canada Explorations Ltd. (Smith occurrence).
11. MacDonnell occurrence.
12. McKnight W. M. [1947].
13. Mid South Explorations Ltd.
14. O'Reilly Lake prospect (Sharbot Lake Mines Ltd.).
15. Quinn H. G. and McEwen S. R. [1957].
16. Raymond occurrence.
17. Sharbot Lake Mines Ltd. [1957]
18. Smith occurrence.

Information current to December 31st, 1979. Former properties on ground now open for staking are only shown if exploration data is available. A date in square brackets indicates last year of exploration activity. For further information see report.

SOURCES OF INFORMATION

Geology by J. M. Wolff, D. A. Smith and assistants, Geological Branch, 1978.

Geology is not tied to surveyed lines.

Assessment Files Research Office, Ontario Geological Survey, Toronto.

Aeromagnetic Map 8380G, Geological Survey of Canada.

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Cartography by D. J. Laroche and assistants, Surveys and Mapping Branch, 1980.

Base map derived from National Topographic System sheet 31C/10, with additional information by J. M. Wolff.

Magnetic declination in the area was approximately 10° 16' west in 1978.

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

Wolff, J. M. and Smith, D. A.:
1981: Long Lake; Ontario Geological Survey Map 2449, Precambrian Geology Series, scale 1 inch to ½ mile. Geology 1978.

ished 1981

Ontario Geological Survey

Map 2449

LONG LAKE

SOUTHERN ONTARIO

Scale 1:31,680 or 1 Inch to ½ Mile

Chains 80 60 40 20 0 1 2 Miles
Metres 1000 3 Kilometres
Feet 1000 0 5,000 10,000 Feet

LEGEND

PHANEROZOIC

CENOZOIC[a]

QUATERNARY

RECENT

Organic swamp and alluvial deposits.

PLEISTOCENE

Outwash and interlobate deposits, sand, silt, clay and till.

UNCONFORMITY

PRECAMBRIAN[b]

LATE PRECAMBRIAN

LATE TECTONIC METAMORPHOSED INTRUSIVE ROCKS

MAFIC INTRUSIVE ROCKS

12 *Mafic (diabase) dikes.*

INTRUSIVE CONTACT

McLEAN GRANITIC PLUTON AND RELATED PEGMATITIC ROCKS

- 11a *Fine to medium grained, massive to foliated, biotite granite, quartz monzonite (biotite ≈ 15%).*
- 11b *Medium to coarse grained, massive biotite granite, quartz monzonite (biotite < 10%).*
- 11c *Biotite granodiorite.*
- 11d *Biotite trondhjemite.*
- 11e *Leucocratic granite.*
- 11f *Syenite.*
- 11g *Porphyritic (quartz or feldspar phenocrysts) varieties of 11a, b.*
- 11h *Muscovite bearing.*
- 11j *Shear zone granite and granodiorite phases including protomylonite, mylonite and mylonite gneiss ± porphyroclasts usually containing epidote.*
- 11k *Pink granitic pegmatite, locally containing tourmaline, biotite, muscovite.*
- 11m *White granitic pegmatite, locally containing muscovite, biotite, garnet.*
- 11n *Unsubdivided metasedimentary and metavolcanic inclusions (mainly assimilated material from units 2 and 3 but locally unit 1 material).*

INTRUSIVE CONTACT

MOUNTAIN GROVE MAFIC INTRUSION

- 10a *Gabbro (colour index > 30).*
- 10b *Anorthositic gabbro, gabbroic anorthosite (colour index 10-30).*
- 10c *Anorthosite (colour index < 10).*
- 10d *Quartz gabbro.*
- 10e *Monzonite phase.*
- 10f *Fine grained varieties of 10a, b, c, d.*
- 10g *Syenite phases of above rock types.*
- 10h *Porpyroblastic and glomeroporphyroblastic phases.*

FAULT AND/OR INTRUSIVE CONTACT

SYNTECTONIC METAMORPHOSED FELSIC TO INTERMEDIATE INTRUSIVE ROCKS

ABBOTTS HILL INTRUSION[c]

- 9a *Biotite trondhjemite.*
- 9b *Biotite quartz monzonite.*
- 9c *Biotite granodiorite (local leucocratic phases < 5% biotite).*
- 9d *Aplitic leucocratic quartz monzonite.*
- 9e *Garnetiferous varieties of 9a, b, c, d.*
- 9f *Shear zone mylonite phases of above units ± porphyroclasts.*

ADDINGTON PLUTON[c]

- 8a *Biotite granite (biotite < 25%).*
- 8b *Leucocratic quartz monzonite.*
- 8c *Biotite quartz monzonite (biotite < 25%).*
- 8d *Leucocratic pink granite.*

NORTHBROOK BATHOLITH[c]

- 7a *Biotite trondhjemite.*
- 7b *Biotite granodiorite.*
- 7c *Biotite quartz monzonite.*
- 7d *Biotite granite.*

FAULT AND/OR INTRUSIVE CONTACT

HINCHINBROOKE GNEISS COMPLEX[d]

- 6a *Massive to foliated, fine to medium grained granoblastic enderbitic granolite with local porphyroblasts of quartz or plagioclase.*
- 6b *Inclusions of 1a material.*

SHEFFIELD GNEISS COMPLEX

- 6c *Foliated to massive, medium grained trondhjemite, granodiorite, containing quartz monzonite, granite phases (locally highly contorted and massive pegmatite phases).*
- 6d *Foliated to gneissic, medium grained trondhjemite, granodiorite gneiss.*

FAULT AND/OR INTRUSIVE CONTACT

METASEDIMENTS AND METAVOLCANICS

AMPHIBOLE-RICH GNEISSES AND SCHISTS[e, f, g]

- 5a *Hornblende-plagioclase gneiss.*
- 5b *Plagioclase-hornblende gneiss.*
- 5c *Quartz-plagioclase-hornblende gneiss.*
- 5d *Foliated subidioblastic fine grained to medium grained plagioclase-hornblende gneiss (80% hornblende).*
- 5e *K-feldspar-hornblende gneiss.*
- 5f *Amphibolite (possibly metagabbro).*
- 5g *Calcite porphyroblasts (in units 5a, b).*
- 5h *Almandine garnet porphyroblasts (in units 5a, b, c).*
- 5j *Biotite-hornblende quartzofeldspathic schist.*
- 5k *Shear zone phases of above units including, protomylonite, mylonite and mylonite gneiss, porphyroclasts.*

CARBONATE METASEDIMENTS[e, f, g]

- 4a *Medium to coarse grained calcite marble.*
- 4b *Fine to medium grained laminated calcite marble (with 0.5 to 2 cm thick layers).*
- 4c *Dolomite marble.*
- 4d *Dolomite-calcite marble.*
- 4e *Calc-silicate assemblages containing tremolite, scapolite, diopside, talc, apatite.*
- 4f *Fragmental dolomite-calcite marble containing flags of quartzite, quartz and calc-silicate (unit 4e material).*
- 4g *Quartzite with quartzofeldspathic blocks, broken beds and flags.*
- 4h *Chert beds (< 5 cm thick).*
- 4j *Mafic hornblende-rich segmented layers.*
- 4k *Coarse grained (> 2 cm) varieties of 4a, c, d.*
- 4m *Amorphous calcite marble.*
- 4n *Calcite-talc schist.*

CLASTIC SILICEOUS GNEISSES AND SCHISTS[e, f, g]

- 3a *Biotite-quartzofeldspathic paragneiss (biotite 10-35%).*
- 3b *Biotite-hornblende-plagioclase-quartz-rich paragneiss.*
- 3c *Epidote-biotite-K-feldspar-plagioclase-quartz paragneiss.*
- 3d *Leucocratic biotite-magnetite-muscovite-quartzofeldspathic gneiss.*
- 3e *Epidote-calcite-hornblende-biotite-plagioclase-quartz paragneiss.*
- 3f *Pyritic varieties of 3a, c, rusty quartzofeldspathic paragneiss.*
- 3g *Garnetiferous porphyroblastic varieties of unit 3a, c.*
- 3h *Muscovite-bearing varieties of unit 3a, c.*
- 3j *Medium grained quartzofeldspathic layers (< 5 cm thick).*
- 3k *Muscovite-quartzofeldspathic schist ± garnet.*
- 3m *Shear zone phases of above units including protomylonite, mylonite and mylonite gneiss.*

MAFIC TO INTERMEDIATE METAVOLCANICS[e, f, g]

- 2a *Quartz-orthoclase-epidote-plagioclase-hornblende amphibolite and amphibolite gneiss, gneissic varieties usually have up to 20% biotite (colour index > 35).*
- 2b *Epidote-plagioclase-hornblende amphibolite containing porphyroblasts and glomeroporphyroblasts of hornblende (colour index > 35).*
- 2c *Biotite-hornblende quartzofeldspathic meta-ash tuff (colour index 15-30).*
- 2d *Carbonate-bearing phases of 2a, (containing up to 15% fine-grained calcite idioblasts).*
- 2e *Massive phases of 2a containing medium grained xenoblastic crystals of saussuritized andesine in a fine grained subidioblastic epidote-plagioclase-hornblende groundmass.*
- 2f *Garnetiferous phases of unit 2a.*
- 2g *Intercalated beds of fine grained recrystallized chert (1 to 10 cm thick).*
- 2h *Shear zone phases of above units including protomylonite, mylonite and mylonite gneiss porphyroclasts, locally containing K-feldspar.*

MAFIC TO FELSIC GNEISS AND RELATED ANATECTITE[e, f, g]

- 1a *Pyroxene-bearing amphibolite and hornblende-plagioclase gneiss; locally containing minor intercalated carbonate metasediments (unit 4), (probably high grade metamorphic equivalent of unit 2).*
- 1b *Hornblende-biotite granodiorite, trondhjemite anatectite (possibly high grade metamorphic equivalents of units 2 and 3).*
- 1c *Contact metamorphic and assimilated phases of unit 1a adjacent to unit 11 (McLean Granitic Intrusion).*

cp	*Chalcopyrite*
Co	*Cobalt*
Cu	*Copper*
fel	*Feldspar*
gn	*Galena*
Au	*Gold*
gf	*Graphite*
hem	*Hematite*
hb	*Hornblende*
Pb	*Lead*
lim	*Limonite*
mag	*Magnetite*
mo	*Molybdenite*
Ni	*Nickel*
phlog	*Phlogopite*
py	*Pyrite*
px	*Pyroxene*
po	*Pyrrhotite*
sp	*Sphalerite*
U	*Uranium*
Zn	*Zinc*

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

[b] *Bedrock geology. Outcrops and inferred extensions of each rock map unit are shown respectively in deep and light tones of the same colour.*

[c] *No relative age difference is implied between the Abbotts Hill intrusion, Addington Pluton and Northbrook Batholith.*

[d] *High grade metamorphic terminology is after Winkler (1976).*

[e] *No relative age is implied between these units.*

[f] *The metamorphic convention is used in naming these rocks with the least plentiful mineral placed first.*

[g] *Metamorphic textural terminology is after Spry [illegible]*