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Ontario Geological Survey

Report 215

Geology of the

Kaladar Area

Lennox and Addington and Frontenac Counties

By

J.M. Wolff

1982

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Ministry of
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Hon. Alan W. Pope
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1000-300-81-Thorn

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(back pocket)

Map 2432 (coloured)—Kaladar, Southern Ontario.
Scale 1:31 680.

CONVERSION FACTORS FOR MEASUREMENTS IN ONTARIO GEOLOGICAL SURVEY PUBLICATIONS

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

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

OTHER USEFUL CONVERSION FACTORS

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

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

ABSTRACT

The Kaladar map-area lies about 60 km northwest of the city of Kingston by road and covers approximately 275 km^2.

Bedrock is of Late Precambrian age. The oldest rocks belong to the Hermon Group composed of metavolcanics and metasediments. The metavolcanics are basaltic and of tholeiitic affinity. The metasediments include amphibole-rich gneiss, aluminous schist, clastic siliceous gneiss and paragneiss which are partly volcanogenic but mainly derived from feldspathic and arkosic wackes, and carbonate metasediments defining a miogeosynclinal assemblage.

The Hermon Group is intruded by two compositional types of intrusive rocks: sodic granitic bodies and potassic granitic bodies. The sodic suite includes the Northbrook Batholith and Elzevir Batholith, the latter of which locally contains contaminated mafic (gabbroic) intrusive rocks at its contact with the Hermon Group metavolcanics. The potassic suite is much younger and includes the Addington intrusion. The Sheffield intrusion is grouped with the potassic suite but is highly contorted and gneissic and may in fact represent much older basement.

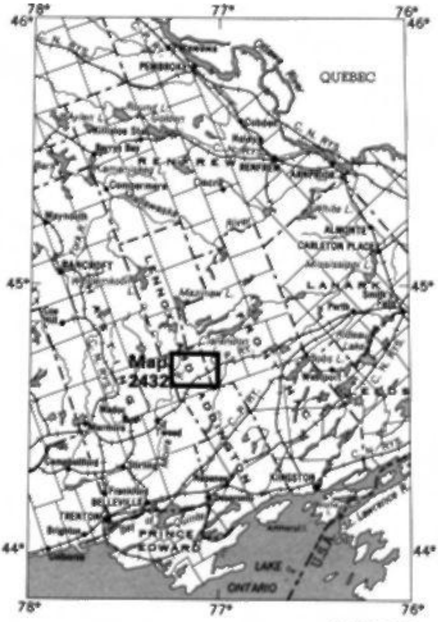
Resting unconformably on the Northbrook Batholith are the Flinton Group clastic metasediments. These comprise a succession containing mafic, carbonate, siliceous, and conglomeratic metasediments representing sedimentary facies change from a relatively low-energy to a higher-energy, depositional environment. Extensive late tectonic pegmatite sheets and dikes intrude the Flinton Group metasediments.

Evidence of at least three periods of deformation is present in the Hermon and Flinton Group rocks which have been folded into a series of antiforms and synforms with north to northeast trending axes. The structural geology of the map-area is complex due to the high ductility and competency contrasts between large bodies of rock.

Metamorphic grade ranges from the high temperature portion of low grade metamorphism (upper greenschist facies) to local zones of medium and high grade metamorphism (amphibolite facies) with some anatectic melting in those areas of higher heat flow and strain. At least two periods of metamorphism are preserved each corresponding with a deformational event. Late-stage, low grade, retrograde alteration is locally developed.

Mineral exploration in the past has concentrated chiefly on gold concentrations located along the Hermon Group—Flinton Group unconformity. Uranium mineralization occurs in migmatitic quartzofeldspathic rocks associated with late tectonic pegmatite sheets and dikes. Molybdenum is associated with the pegmatite dikes along the southern border of the Northbrook Batholith.

Surfical Pleistocene and Recent deposits are most prominent south and west of Flinton and east of Northbrook but generally fill the valleys between northeast-trending ridges.



SMC 14531

Figure 1–Key map showing location of the Kaladar area.

Geology
of the

Kaladar Area

Lennox and Addington and Frontenac Counties

by

J.M. Wolff[1]

INTRODUCTION

The Kaladar map-area lies between Latitudes 44°37'30''N and 44°45'N and Longitudes 77°00'W and 77°15'W and is in the Counties of Frontenac, and Lennox and Addington. The area covers about 275 km^2 and is about 14 km by 20 km. Kaladar is situated about 60 km by road northwest of the city of Kingston.

Although sporadic mineral production had been reported from the 1880s to 1940 this was chiefly limited to gold and minor silver production from the Addington mine, near the village of Flinton. No mineral production has been reported in the map-area from that time to the 1977 field season although sporadic staking has gone on and a number of small occurrences have been found and explored. Notably, concentrations of uranium and base metal sulphides exist in the map-area.

Present Geological Survey

Geological Map 2432 (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 1977. Preliminary Map P.1563 (Wolff 1978) at a scale of 1:15 840 was released in 1978.

The field maps were prepared at the scale of 1:15 840 on base maps produced by the Cartography Section, Surveys and Mapping Branch, Ministry of Natural Resources, from the National Topographic Series, provisional map 31C/11. Field data were plotted on acetate overlays on vertical air photographs

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[1] Geologist, Precambrian Geology Section, Ontario Geological Survey, Toronto. Manuscript approved for publication by Chief Geologist, 21 June, 1978. This report is published with the permission of E.G. Pye, Director, Ontario Geological Survey.

at the same scale as the base maps. The data was primarily collected along pace and compass traverse lines run approximately 400 to 500 m apart and at right-angles to strike. In areas of poor outcrop traverses were run between existing outcrops. Due to the excellent field map (scale 1:15 840) of P.H. Thompson (1972) traversing of the Flinton Group was less extensive but more detailed. Data was also collected from roadcuts in the area.

Acknowledgments

The author was assisted in the field by G. Menard, M. Maharaj, P. Kavanagh and J. McGuire. Mr. Menard as senior assistant carried out independent traverses throughout the field season. The author is grateful to the Geology Department, McMaster University for providing use of a petrographic microscope for part of this study.

During the field season P.H. Thompson of the Geological Survey of Canada, and J.M. Moore of Carleton University visited the author in the field and provided valuable information on the geology of the Flinton Group. Discussions with M. Klugman, Regional Geologist, Eastern Region, and S.B. Lumbers of the Royal Ontario Museum, on the geology of the area proved useful.

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 Highways 41 and 7 transect the map-area north-south and east-west. Secondary roads are well developed north and south of the village of Flinton and less so east of the village of Northbrook. The area around Kaladar is not accessible by road but can be traversed on foot. Lake access is exceptionally poor with the only navigable waterway being Kennebec Lake which penetrates the field area. An abandoned railway bed (formerly belonging to the Canadian Pacific Railways and presently a Bell Canada underground communication line) essentially parallels Highway 7.

Previous Geological Work

The earliest recorded geological observations in the Kaladar area were those of A. Murray (1853), of the Geological Survey of Canada, 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 (1870) did some early work in Kaladar and Kennebec Townships and this was included in a geological map of parts of eastern Ontario.

A work of major significance in the area is that of Miller and Knight (1914) of the Ontario Bureau of Mines. Their study concentrated on the metasediments between Actinolite and Cloyne (the present-day Flinton Group). These workers delineated the following sequence: basal Keewatin volcanic rocks overlain by Grenville sedimentary rocks, Laurentian granite, Hastings sedimentary rocks, post-Hastings granite and other intrusive rocks. Miller and Knight separated the Hastings Series (conglomerate and other sedimentary rocks) from the Grenville Series (crystalline limestone associated with conglomerate, quartzite and granite). The former was correlated with the Timiskaming Series.

M.E. Wilson (1940) of the Geological Survey of Canada published maps of the Madoc and Marmora areas based on field work carried out in 1920-1925. These were the first 1:63 360 (1 inch to 1 mile) map sheets for eastern Ontario. Wilson delineated the Clare River Synform structure and recognized the Hastings Series to lie unconformably over the Grenville Series.

W.D. Harding (1942) mapped Kaladar and Kennebec Townships in 1939 and 1940, at a scale of 1:63 360 (1 inch to 1 mile) and showed the Flinton metaconglomerate units as belonging to the Hastings Series but the Kaladar metaconglomerate and Clare River Synform units as Grenville Series.

In 1950 C.A. Burns of the Geological Survey of Canada mapped the Clare River Synform from Tweed to Kaladar (Ambrose and Burns 1956). Burns divided the metasediments into three groups: the Kaladar Group, the Flinton Group and the Tweed Group. In the present study Burns' Kaladar Group would equate essentially with map-units 3 and 5, the Tweed Group with map-unit 4 and the Flinton Group with map-units 10 and 11. Burns reckoned that stratigraphically each group was separated by a conglomerate unit but that all groups might belong to the Kaladar Group. Burns also produced a detailed cross section of the Clare River Synform structure southwest of the present map-area.

While working on his Ph.D. at Carleton University, P.H. Thompson completed a 1:15 840 map of the Flinton Group from Bishop Corners to Madoc (Thompson 1972). Thompson's study indicated the metamorphic grade of the Flinton Group increases from both Bishop Corners and Madoc toward the midway point between them and that a facies change occurs between these points. The Flinton Group as defined by Moore and Thompson (1972) composes a succession of mafic, carbonate, siliceous and aluminous clastic metasediments in a continuous synform resting unconformably on the Northbrook Batholith and Hermon Group (Lumbers 1964) mafic metavolcanic succession.

A number of less comprehensive studies have been carried out on the Kaladar metaconglomerate (3.5 km north of Kaladar on Highway 41). The first comparative study of this rock unit was by Walton *et al.* (1964). Their studies on this metaconglomerate indicated that the "granitic" pebbles possess a mineral zonation chiefly resulting from the exchange of various cations during progressive metamorphism from the greenschist to middle amphibolite facies of metamorphism. Van de Kamp (1971) undertook an intensive geochemical study of the matrix in this metaconglomerate and concluded it was a metamorphosed mafic sandstone likely formed by the mixing of sediment from nearby granitic gneisses and mafic metavolcanics. Psutka (1976) studied the pebbles in this metaconglomerate and comparing their compositions with the Northbrook Batholith and Addington intrusion suggested both may have contributed material to the pebble population.

Isotopic age determinations have been reported by Silver and Lumbers (1965) on the metavolcanic and sodic and potassic gneisses in the area and by Krogh and Hurley (1968) on the Addington intrusion.

Aeromagnetic Map 95G (GSC 1949) was flown over the map-area in 1949 and an airborne radiometric survey was flown over the map-area in 1976 (GSC 1976).

Two current studies on parts of the map-area at the time of this writing include a finite-strain study on the Flinton Group by S. Tella (Ph.D. student at Queen's University), and a metamorphic and structural geology study of the Clare River Synform and adjoining units by F. Chappel (Ph.D. student at Carleton University).

Topography and Drainage

Relief in the map-area is about 100 m as exemplified by the elevations from the base to the top of the Kaladar Hill near the village of Kaladar. The northern, central and western portions of the map-area are typically between 250 m and 325 m above sea level. The eastern and southeastern portions of the map-area are typified by 35 m high ridges trending northeasterly parallel to the regional foliation-gneissosity. The intervening swamp-filled valleys provide the major drainage pathways.

All waterways drain south or southwest in the map-area. The eastern portion is drained south by the Salmon River (flowing south from Kennebec Lake). The southeastern portion is drained southwesterly while the western portion is drained southerly by the Skootamatta River, both systems feeding the Moira River drainage system. The central and northern parts of the map-area represent the highland area between the Salmon and Moira River systems.

Distribution of rock outcrop is quite variable. Exposures are abundant in the Northbrook and Elzevir Batholiths and the Addington and Sheffield intrusions. These zones locally reach up to 80 percent outcrop. The poorest exposures are found in the carbonate metasediments of the Hermon Group, the mafic intrusive rocks, and the Tudor mafic metavolcanic units (less than 20 percent exposure). The other Hermon Group metasediments and the Flinton Group units are moderately to well exposed (50-80 percent). Carbonate metasediments tend to form the swamp covered valleys.

GENERAL GEOLOGY

Terminology

In order to avoid confusion with 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). 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 is 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 1972). 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.

Geological Summary

The map-area lies within the Central Metasedimentary Belt, subzone IVB, Hastings Basin as defined by Wynne-Edwards (1972), and is composed of Late Precambrian metavolcanics and metasediments of the Grenville Supergroup, and Late Precambrian "granitic" intrusive bodies. Late tectonic pegmatite sheets and dikes cut the supracrustal rocks locally. The general succession of the rocks is given in Table 1, and a comparison of lithologic units in the map-area with those of other workers is given in Table 1a.

TABLE 1 | TABLE OF LITHOLOGIC UNITS FOR THE KALADAR AREA.

CENOZOIC

QUATERNARY

RECENT

Organic swamp and alluvial deposits.

PLEISTOCENE

Outwash deposits, sand, silt, clay and till.

Unconformity

PRECAMBRIAN

LATE PRECAMBRIAN

LATE TECTONIC FELSIC INTRUSIVE ROCKS

Leucocratic granitic dikes; pegmatite dikes; pegmatite sills with inclusions of country rock.

Intrusive Contact

METASEDIMENTS

FLINTON GROUP[a]

CARBONATE METASEDIMENTS (LESSARD FORMATION)

Carbonate-biotite schist; polymictic pebble conglomerate (matrix of plagioclase-hornblende gneiss, pebbles of granitic compositions); calc-silicate (plagioclase-hornblende) gneiss with epidote; epidote-free calc-silicate gneiss; carbonate-bearing quartzofeldspathic sandstone.

CLASTIC SILICEOUS METASEDIMENTS (BISHOP CORNERS FORMATION)

Quartzofeldspathic sandstone, with local quartzofeldspathic conglomerate; quartz-pebble conglomerate; quartzite; biotite-quartz-feldspar schist; quartzofeldspathic sandstone.

Unconformity

INTERMEDIATE TO FELSIC PLUTONIC ROCKS

NORTHBROOK BATHOLITH[b]

Biotite trondhjemite; biotite granodiorite, biotite quartz monzonite; biotite granite; phases with potassic feldspar augens; potassic feldspar segregations; discontinuous hornblende-plagioclase to amphibolite phases; epidote veinlets.

ELZEVIR BATHOLITH[b]

Biotite granodiorite; biotite quartz monzonite; potassic feldspar augen phases.

ADDINGTON AND SHEFFIELD INTRUSIONS[b]

Weakly foliated leucocratic granite; foliated to gneissic biotite granite; interbanded pink granite, grey trondhjemite-granodiorite; foliated to gneissic leucocratic quartz monzonite; foliated to gneissic biotite quartz monzonite; potassic feldspar augen phases.

MAFIC INTRUSIVE ROCKS[b]

Hornblende quartz gabbro, local diorite; hornblende-biotite granodiorite.

Intrusive Contact

METASEDIMENTS AND METAVOLCANICS

HERMON GROUP

AMPHIBOLE-RICH GNEISS AND SCHIST[c,d]

Fine-grained hornblende-plagioclase gneiss; fine-grained plagioclase-hornblende gneiss; medium-grained plagioclase-hornblende paragneiss; hornblende-rich gneiss, usually associated with fine-grained plagioclase-hornblende gneiss; epidote-biotite-feldspar-quartz paragneiss; biotite-chlorite schist; chloritic variety of hornblende-plagioclase and plagioclase-hornblende gneisses and paragneisses; epidote lenses and/or layers; biotitic variety of hornblende-plagioclase and plagioclase-hornblende gneisses; garnetiferous ± muscovite variety of hornblende-plagioclase and plagioclase-hornblende gneisses; hornblende porphyroblastic plagioclase-hornblende gneiss; siderite-bearing plagioclase-hornblende gneiss; calcite-bearing plagioclase-hornblende gneiss.

CARBONATE METASEDIMENTS[c]

Crystalline dolomitic marble, locally up to 20% massive medium-grained lenses and/or layers of quartzite; fragmental dolomitic marble (quartz, quartzite and dolomite fragments and flags); laminated silty marble; phlogopite-bearing marble; diopside-bearing marble; tremolite-bearing marble; serpentine-bearing marble.

CLASTIC SILICEOUS GNEISS[c]

Fine-grained leucocratic quartzofeldspathic gneiss (possibly metavolcanic); layered quartzofeldspathic gneiss with medium-grained muscovite; fine-grained biotite quartzofeldspathic paragneiss; medium-grained biotite quartzofeldspathic paragneiss; medium-grained leucocratic quartzofeldspathic paragneiss; garnetiferous porphyroblastic varieties; muscovitic varieties of medium-grained biotite quartzofeldspathic paragneiss.

ALUMINOUS SCHIST[c]

Quartz-muscovite schist; garnet-quartz-muscovite schist

MAFIC TO INTERMEDIATE METAVOLCANICS (TUDOR FORMATION)[e]

Massive amphibolite; pillowed amphibolite; carbonate-talc-bearing amphibolite; plagioclase-hornblende gneiss; intermediate lapillistone and tuff; amphibolite with acicular hornblende crystals; ultramafic metavolcanics locally containing anthophyllite ± tremolite porphyroblasts; siliceous nodules; carbonate-filled vesicles; carbonate nodules and lenses; thin laminated chert layers; biotitic and chloritic varieties of massive amphibolite.

---

a) Modified after Moore and Thompson (1972).

b) Age correlation between Northbrook and Elzevir Batholiths and Addington and Sheffield intrusions and mafic intrusive rocks is uncertain.

c) No relative age inferred between these units.

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

e) Appear to be the oldest rocks in the map-area.

TABLE 1A—COMPARISON OF LITHOLOGIC UNITS OF VARIOUS WORKERS IN THE KALADAR AREA.

Map-Unit and Lithology (This Report)		Miller and Knight (1914)	Harding (1942)	Ambrose and Burns (1951)	Lumbers (1967)		Moore and Thompson (1972)	
Late Intrusive Rocks	12 Pegmatite and migmatite	Post-Hastings Intrusions	Intrusives	Pegmatite, aplite, felsite				
Intrusive Contact								
Flinton Group	11 Carbonate metasediments 10 Clastic siliceous metasediments	Hastings Sediments	Hastings-Type Sediments	Flinton Group			**Flinton Group**	Lessard Formation
								Bishop Corners Formation
Unconformity								
Intrusive Rocks	9 Northbrook Batholith 8 Elzevir Batholith 7 Addington and Sheffield Intrusions 6 Mafic intrusive rocks	Laurentian Granite	Intrusives	Granitic Gneisses				
Intrusive Contact								
Hermon Group	5 Amphibole-rich gneiss 4 Carbonate metasediments 3 Clastic siliceous gneiss 2 Aluminous schist	Grenville Sediments	Grenville-Type Sediments	Kaladar Group Tweed Group Kaladar Group	**Hermon Group**	Vansickle Formation		
	1 Mafic to intermediate metavolcanics	Keewatin Volcanics	Volcanics	Elzevir Group		Tudor Formation		

The oldest metavolcanics and metasediments in the map-area belong to the Hermon Group, as defined by Lumbers (1969). The major metavolcanic segment of this group is situated near the village of Flinton and is composed of metamorphosed tholeiitic basalts and minor intermediate pyroclastics which have been dated at 1310 ± 15 m.y. using the U-Pb method on zircons (Silver and Lumbers 1965). Minor discontinuous ultramafic segments are found in the mafic volcanic stratigraphy as well. These metavolcanics have been correlated with the Tudor Formation (Lumbers 1969; Moore 1976). The metasedimentary section of the Hermon Group is exposed east of the village of Kaladar in the Kaladar-Dalhousie Trough as defined by Hewitt (1956). It is composed primarily of amphibole-rich gneiss (hornblende, plagioclase and quartz), carbonate metasediments (dolomitic marble), clastic siliceous gneiss (quartz, feldspar and biotite) and minor aluminous schists (quartz and muscovite). The calc-silicate gneisses show sedimentary features of para-amphibolite character, are of a calc-alkaline composition and may represent volcanic ash accumulations. Minor portions of the sequence have features of ortho-amphibolite character and approach tholeiitic compositions. The clastic siliceous gneiss generally has feldspathic to arkosic wacke compositions with the most felsic volcanogenic members displaying rhyolitic compositions (at least in part). The carbonate metasediments contain an intraformational fragmental dolomitic marble with quartz, quartzite and dolomitic fragments and flags. The presence of volcanogenic metasediments, feldspathic to arkosic wacke and much carbonate material suggest that these metasediments are of miogeosynclinal nature (Dietz 1963) and may represent the back arc basin of a eugeosyncline. The basin was tectonically somewhat unstable as the carbonate bank appears to have broken up and slumped locally. The apparent stratigraphic thickness and relative unit thicknesses tend to indicate a shallowing of the basin to the northeast.

The youngest metasediments in the map-area belong to the Flinton Group and rest unconformably on the Northbrook Batholith or are in shear contact with the Hermon Group. In the map-area the Flinton Group is composed of essentially two formations, the Bishop Corners Formation and the Lessard Formation (Thompson 1972). The Bishop Corners Formation is a clastic siliceous succession composed principally of quartzite and quartzofeldspathic sandstone units, both of which contain pebble conglomerate beds, and a biotite-quartz-feldspar schist unit. The Lessard Formation is composed of clastic carbonate metasediments and includes units of polymictic, granitic-pebble conglomerate with a calc-silicate (plagioclase-hornblende) matrix, calc-silicate (plagioclase-hornblende) gneiss, carbonate-bearing quartzofeldspathic sandstone, and carbonate-biotite schist. To the northeast (Bishop Corners) and southwest (Madoc) of the map-area, the Flinton Group is largely composed of pelitic schist and marble. However, within the map-area the Flinton Group is predominantly composed of metamorphosed sandstone and conglomerate of varying bulk compositions. This is interpreted by Thompson (1972) as representing a sedimentary facies change from a relatively low-energy, shallow-water depositional environment in the Madoc and Bishop Corners areas to a higher energy, fluvial deltaic-beach depositional environment in the map-area.

In the map-area two main types of conglomerate exist. The first appears to be the oldest, and is associated with the Hermon Group metasediments. This conglomerate type is intraformational in character being poorly sorted with poorly developed clasts and representing local discontinuous topographic highs. The second is younger and associated with the Flinton Group metasediments. The clasts in the younger conglomerate are well rounded and better sorted, and deformed into flattened ellipsoidal forms. Conglomerates of the second type are much thicker and very continuous, contain pebbles derived from nearby batholiths, and suggest the existence of regional, continuous topographic highs.

Intrusive into the Hermon Group are three prominent plutonic bodies, the Elzevir Batholith, the Addington intrusion and the Northbrook Batholith[1]. The Elzevir Batholith is highly discordant, consisting mainly of biotite granodiorite and biotite quartz monzonite in the map-area, and has been dated by the U-Pb zircon method at 1250 ± 25 m.y. (Silvers and Lumbers 1965). The contaminated mafic intrusive rocks (unit 6) appear to be phases of the Elzevir Batholith formed by the assimilation and reaction of mafic volcanic rocks with intrusive granitic rocks of the batholith. The Addington intrusion is concordant to subconcordant with the regional foliation-gneissosity and is quartz monzonitic to granitic in composition. This intrusion has been dated at 1035 ± 42 m.y. (Krogh and Hurley 1968). The Northbrook Batholith is a composite batholith varying from trondhjemitic to granitic in composition. Although the contact relationship of the Northbrook Batholith with the Hermon Group are often obscured by pegmatite intrusions, the batholithic rocks appear to be intrusive into the Hermon Group at several locations. The Northbrook Batholith is unconformably overlain by the Flinton Group and the Flinton Group conglomerates contain granitic pebbles of similar composition to the Northbrook Batholith intrusive rocks.

The Sheffield intrusion is a highly contorted gneiss. The complexity of its structure suggests that it may represent basement gneiss but this is conjectural because it is not in exposed contact with any rocks in the map-area.

The metamorphic grade in the map-area as indicated by mineral assemblages preserved in the metavolcanics and metasediments ranges from the high-temperature portion of low grade metamorphism to the high-temperature portion of medium grade metamorphism as defined by Winkler (1976). The higher level metamorphic grade tends to be concentrated near the pegmatite units where possibly both the local heat flow and strain may have been higher. In general, in the map-area, the metamorphic grade tends to increase from south to north in the Hermon Group metasediments and from north to southwest in the Flinton Group synform. Locally, anatectic melting has occurred especially within the huge sill-like pegmatite body paralleling Highway 7. The Addington intrusion is not spatially associated with evidence of anatectic melting, although it contains a substantial portion of metasedimentary material. The formation of late-stage minerals such as scapolite, chloritized biotite, talc, and the oxidation of ferrous iron is most prominent in the metasediments of the Hermon Group and is indicative of late-stage alteration by fluids rich in H_2O, CO_2 and Cl. Evidence of two metamorphic periods of regional metamorphism is

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[1] Note that on Map 2432, the numbering of rock-units for the Elzevir and Northbrook Batholiths, the Addington and Sheffield intrusions, and the mafic intrusive rocks does not imply relative ages for these units.

present in the Hermon Group in the Clare River Synform, while the Flinton Group appears to have been subjected to only one regional metamorphic episode.

Structurally, the map-area has been subjected to three episodes of deformation and is folded into a series of synforms and antiforms. The isoclinal Clare River Synform structure predominates in the Hermon Group metasediments and was generated by the second deformation (D2) episode which folded the earlier formed (S1) foliation-gneissosity. The first period of regional metamorphism appears to be associated with the first (D1) deformation event and the second regional metamorphism with the second (D2) deformation. A third (D3) deformation with northwest trending axes gently warps the lineation (L2) associated with the second deformation (D2). The Northbrook Batholith has been deformed in the second (D2) fold episode. The Flinton Group and metavolcanics in the Hermon Group (Tudor Formation) were deformed together by all three periods of deformation. D3 in the Flinton Group has the same orientation as D3 in the Hermon Group metasediments. The D1 and D2 deformation events in the Flinton Group have somewhat different orientations than the Hermon Group metasediments but likely result from similar tectonic events in the map-area. Although similar strain values exist on each flank of the Northbrook Batholith the orientation of the principal strain components differ.

Following the deformation episodes late tectonic pegmatite dikes and sheets intruded the map-area and are associated with local generation of high grade anatectic melts. The pegmatite intrusion was essentially contemporaneous with late-stage faulting which trends southeasterly. The pegmatites are localized along the southern border of the Northbrook Batholith and were probably intruded along a structural break between the Hermon Group metasediments and the Northbrook Batholith. This break in part may locally represent an unconformity between the metasediments of the Hermon and Flinton Groups. Lineaments trending northeasterly and southeasterly are likely contemporaneous with this structural break. Late-stage jointing surfaces form three sets trending N65W, N55E and N10W and locally intersect one another.

Late Precambrian

METASEDIMENTS AND METAVOLCANICS

Hermon Group

MAFIC TO INTERMEDIATE METAVOLCANICS (TUDOR FORMATION)

The mafic to intermediate metavolcanics outcrop immediately around and to the north of the village of Flinton and in the southwest corner of the map-area. On strike and continuous with rocks mapped to the north by Moore (1976) these units are correlative with the Tudor Formation metavolcanics mapped by

TABLE 2—MODAL ANALYSES (VOLUME PERCENT) OF TUDOR METAVOLCANICS IN THE KALADAR AREA.

SAMPLE	M640-1	M801-1	M475-2	M770-2	M661-1	M835-3	M478-2	M800-1	M552-2
Hornblende	92.0	87.0	77.7			63.0	79.3	63.0	
Anthophyllite									93.0
Talc				78.3					5.0
Plagioclase	6.0		7.3	19.3	1.3	23.3	6.3	34.0	
An content	U		U	50-55	S	30-35	S	U	
Biotite					33.7	6.3	9.7		
Calcite[1]				2.3	9.2		1.3		1.3
Quartz		9.0	8.0		47.3				
Scapolite					4.1				
Pyrite, Chalcopyrite, ± Titanite	2.0	4.0	7.0		4.4	7.7	3.3	3.0	0.6
TOTAL	100.0	100.0	100.0	99.9	100.0	100.3	99.9	100.0	99.9

SAMPLES

M640-1	Massive amphibolite (map-unit 1a). 3.6 km W of Northbrook.
M801-1	Massive amphibolite (map-unit 1a). 2.8 km SW of Northbrook.
M475-2	Massive amphibolite (map-unit 1a). 1.6 km SE of Flinton.
M770-2	Altered amphibolite (map-unit 1e). 3.2 km WNW of Northbrook.
M661-1	Altered amphibolite (map-unit 1e). 3.2 km N of Flinton.
M835-3	Gneissic amphibolite (map-unit 1d). 5.2 km SW of Flinton.
M478-2	Gneissic amphibolite (map-unit 1d). 1.6 km ENE of Flinton.
M800-1	Gneissic amphibolite (map-unit 1d). 2.8 km SW of Northbrook.
M552-2	Altered ultramafic metavolcanics (map-unit 1j). 7.6 km WSW of Kaladar.

[1] May be magnesite in part.

U—Untwinned.

S—Sericitized.

Lumbers (1967, 1969) to the west of the map-area and are the oldest rocks in the map-area. Thus the Elzevir Batholith is bordered almost completely by the Tudor Formation.

The metavolcanics in the map-area are composed almost entirely of massive, fine grained, (less than 0.5 mm), equigranular amphibolite (map-unit 1a). In the field these rocks weather dark to medium green and in places contain minor chlorite and biotite. The metavolcanics are intensely deformed, exhibiting two high angle penetrating cleavages which intersect at approximately 35 degrees. In thin section these rocks are seen to be granoblastic and composed mainly of anhedral to subhedral hornblende grains which locally display two S directions inclined 30-35 degrees to one another, indicative of the penetrating cleavages. Anhedral to subhedral quartz and plagioclase (sericitized, untwinned) are the minor phases. The primary opaques are pyrite and associated minor chalcopyrite (Table 2). Highly deformed pillows (Photo 1) were occasionally observed in this unit. Pillow selvages are partially preserved but the pillows have been flattened to such a degree that top determinations are inconclusive. Thinly bedded chert layers are found in unit 1a near the Elzevir Batholith but chert is not widespread in occurrence.

Locally the amphibolite contains carbonate (map-unit 1c), usually less than 10 percent. Where identified the carbonate is calcite and it occurs as small

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Photo 1–Deformed pillows in the Tudor metavolcanics (map-unit 1b) south of Flinton. The top directions are inconclusive. Pencil is 7.5 cm long.

nodules and lenses (2 to 10 cm) which are located along cleavage fractures in the rock but are rare in occurrence. Calcite can also be found filling small pores or relict vesicles. In general the calcite tends to be a secondary space filling. Associated with these carbonate-bearing units is altered amphibolite in which most of the amphibole is altered to talc. The altered amphibolite contains minor carbonate which formed as an alteration product of the amphibole and may be magnesite (Table 2). The altered rocks are generally medium grained (0.5-2.0 mm).

Micaceous varieties of amphibolites (map-units 1q, 1r) are prominent along the contact with the Elzevir Batholith. The dominant micaceous mineral is biotite but chlorite (map-unit 1r) is found as well. The dominant cleavage in the rocks of this contact zone is essentially parallel to the contact with the Elzevir Batholith, and the micaceous minerals are found within the cleavage planes. The two intersecting cleavages observed elsewhere in the metavolcanics are not found in this zone. In outcrops of amphibolite (1a and 1c) close to the contact with the Elzevir Batholith are contaminated intrusive phases in which biotite, quartz and calcite are the dominant assemblages (Table 2). Plagioclase in these rocks is totally sericitized and scapolite has formed at its expense.

Gneissic amphibolites (map-unit 1d) are not uncommon members of the Tudor Formation in the map-area. These rocks are often interlayered with am-

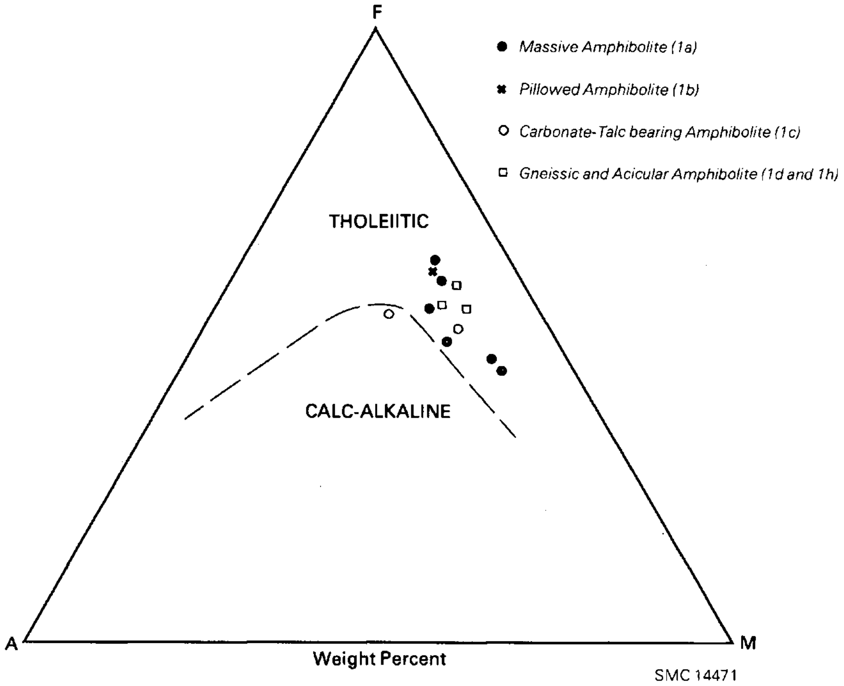

Figure 2–AFM plot (Irvine and Baragar 1971) of the Tudor metavolcanics (map-unit 1), indicating the tholeiitic nature of these rocks.

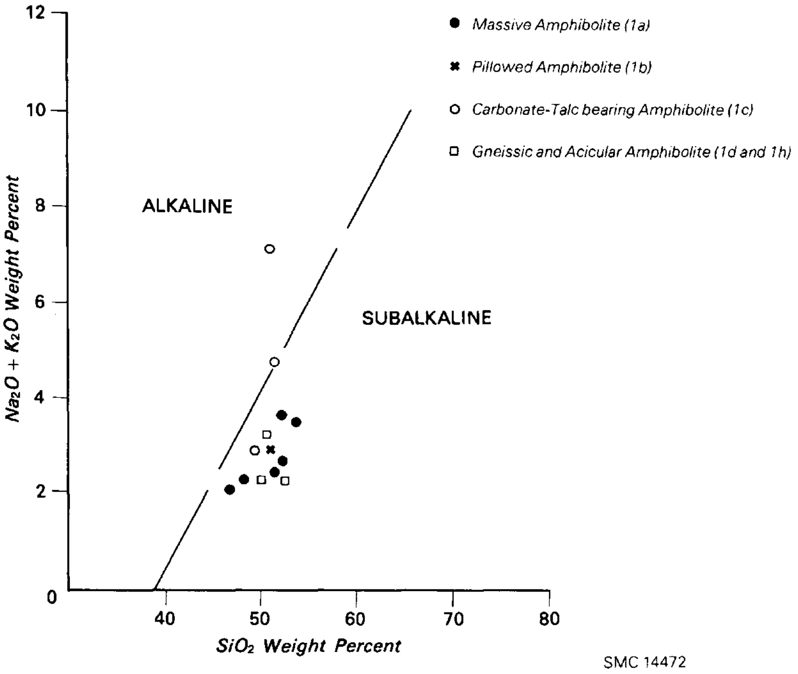

Figure 3–Total alkalies vs. silica plot (Irvine and Baragar 1971) for the Tudor metavolcanics, illustrating the tholeiitic trend.

phibolite (unit 1a) and are generally fine grained (less than 1.0 mm). These rocks have a lower colour index than map-unit 1a and a granoblastic equigranular gneissic texture. The main mineral phases are hornblende, plagioclase (untwinned plus minor oligoclase) and biotite (Table 2). The hornblende and biotite define the gneissosity but biotite tends to cut the hornblende grains. Hornblende grains are mostly poikiloblastic. Spatially this unit is mainly found near the contact with the Flinton Group metasediments. Also this unit locally occurs as discontinuous lenses or slices in the contaminated mafic intrusive rocks (map-unit 6) near the contact with the Flinton Group.

Locally developed is a medium grained (1-5 mm) acicular amphibolite (unit 1h). The acicular grains are hornblende set in a matrix of plagioclase which compositionally is similar to map-unit 1d but lacks the preferred orientation of hornblende grains.

Small slices and wedges of ultramafic rock (map-unit 1j) are of rare occurrence and found at the margins of the Northbrook Batholith near its contact with the Flinton Group and to a lesser extent in the contaminated mafic intrusive rocks (unit 6). These slices parallel the intrusive contacts but are discontinuous along strike. The ultramafic rocks do not cut the metavolcanics and are correlated by the author with the metavolcanics. This rock is medium grained

TABLE 3—CHEMICAL ANALYSES OF TUDOR METAVOLCANICS IN THE KALADAR AREA.

MAJOR ELEMENT OXIDES	WEIGHT PERCENT												
Sample No.	M778-1	M611-1	M613-1	M615-1	M785-1	M695-1	M707-1	M616-1	M709-1	M633-1	M619-1	M620-1	M617-1
SiO_2	44.2	50.2	50.8	50.6	51.3	47.3	49.4	49.1	50.5	50.0	49.5	49.2	48.8
Al_2O_3	13.7	14.5	13.6	13.6	13.8	14.2	13.1	14.9	17.0	17.7	13.8	14.0	14.7
Fe_2O_3	1.90	1.10	1.00	2.00	1.50	1.40	2.30	1.20	3.11	1.00	2.10	2.20	1.80
FeO	9.23	9.23	10.9	12.7	9.81	9.72	12.3	10.6	8.81	5.07	10.6	10.9	12.1
MgO	5.61	9.57	6.61	6.61	8.00	11.4	6.51	8.25	5.38	9.32	8.33	7.80	7.75
CaO	16.2	10.7	8.90	8.32	9.36	11.0	8.97	10.2	7.19	12.9	9.44	9.70	8.78
Na_2O	1.65	2.05	3.29	2.29	3.40	2.06	2.65	2.75	4.48	1.97	2.14	2.70	2.14
K_2O	0.38	0.28	0.08	0.19	0.13	0.16	0.17	0.08	0.14	0.56	0.16	0.21	0.16
H_2O^+	0.45	0.45	0.69	0.54	0.32	0.82	0.68	0.75	0.53	0.85	0.83	0.58	1.04
H_2O^-	0.35	0.27	0.25	0.27	0.46	0.12	0.15	0.19	0.55	0.09	0.17	0.17	0.21
CO_2	2.74	0.26	2.04	0.22	0.20	0.15	0.35	0.38	0.16	0.65	0.38	0.20	0.40
TiO_2	1.85	0.69	1.12	1.83	1.14	0.78	2.13	1.14	1.56	0.22	1.05	1.33	1.32
P_2O_5	0.15	0.07	0.10	0.15	0.10	0.08	0.19	0.10	0.14	0.05	0.10	0.10	0.12
S	0.02		0.02	0.05			0.33	0.01	0.04		0.03	0.07	0.02
MnO	0.18	0.17	0.22	0.22	0.20	0.18	0.25	0.20	0.15	0.12	0.20	0.22	0.20
TOTAL	98.6	99.5	99.6	99.6	99.7	99.4	99.5	99.8	99.7	100.5	98.8	99.4	99.5

TRACE ELEMENTS							PPM						
Ba	50	50	40	40	20	50	30	30	50	80	40	60	30
Co	44	56	46	44	51	49	49	45	36	40	50	51	44
Cr	105	417	138	104	329	480	100	298	70	440	243	74	201
Cu	33	30	49	52	6	140	135	112	88	112	48	50	28
Li	10	9	8	10	8	12	14	8	9	8	11	12	12
Ni	62	94	58	39	90	212	46	85	20	117	69	48	70
Pb	23	16	13	11	11	20	37	11	10	10	18	10	16
Rb	10	10	10	10	10	10	10	10	10	20	10	10	10
Zn	106	60	113	131	90	96	149	115	105	40	120	120	148

SAMPLES
M778-1 Massive amphibolite (map-unit 1a). 2.0 km NW of Flinton.
M611-1 Massive amphibolite (map-unit 1a). 2.3 km WSW of Northbrook.
M613-1 Massive amphibolite (map-unit 1a). 3.2 km WSW of Northbrook.
M615-1 Massive amphibolite (map-unit 1a). 2.9 km SW of Northbrook.
M785-1 Massive amphibolite (map-unit 1a). 1.2 km SE of Flinton.
M695-1 Massive amphibolite (map-unit 1a). 1.2 km NE of Flinton.
M707-1 Pillowed massive amphibolite (map-unit 1b). 1.2 km S of Flinton.
M616-1 Carbonate-talc-bearing amphibolite (map-unit 1c). 3.0 km SW of Northbrook.
M709-1 Carbonate-talc-bearing amphibolite (map-unit 1c). 1.6 km S of Flinton.
M633-1 Carbonate-talc-bearing amphibolite (map-unit 1c). 3.2 km NW of Flinton.
M619-1 Plagioclase-hornblende gneiss (map-unit 1d). 2.6 km SW of Northbrook.
M620-1 Plagioclase-hornblende gneiss (map-unit 1d). 2.7 km SW of Northbrook.
M617-1 Amphibolite with acicular hornblende (map-unit 1h). 3.1 km SW of Northbrook.
Analyses by Geoscience Laboratories, Ontario Geological Survey, Toronto.

(less than 5 mm) containing rosettes of anthophyllite and talc (Table 2). This unit is an altered ultramafic rock, and may represent one of the oldest members of the Tudor Formation in the map-area.

Intermediate metavolcanics of the Tudor formation are rarely found in the map-area. Where they do occur they are interbedded with more mafic members. The intermediate units are composed of medium- and fine-grained equigranular fragments (map-units 1e, 1g) and weather grey to light green. The fragments are composed of quartz, plagioclase and hornblende. These rocks locally contain siliceous nodules (2-5 cm) (map-unit 1k) which are abundant when they occur. Although deformed the nodules or fragments do not appear to be rounded suggesting they are possibly pyroclastic lapilli to bomb-sized ejecta.

Table 3 shows the chemical composition of a sample suite from the metavolcanics in the map-area. Samples for this study were taken across strike from the Elzevir Batholith to the Flinton Group north of Flinton. The analyses have been plotted on several geochemical variation diagrams (Figures 2, 3, 4, 5). Figure 2 is an AFM plot (Irvine and Baragar 1971) which clearly shows the suite to fall in the tholeiitic field. In Figure 3 the (Na_2O + K_2O) vs. SiO_2 plot indicates that all samples but one fall in the subalkaline field (Irvine and Baragar 1971). Figure 4, the SiO_2 vs. FeO/MgO plot (Miyashiro 1974), shows a somewhat wider scatter but the majority of the rocks plot in the tholeiitic field. Figure 5, the FeO vs. FeO/MgO plot (Miyashiro 1974) confirms this distribution as well.

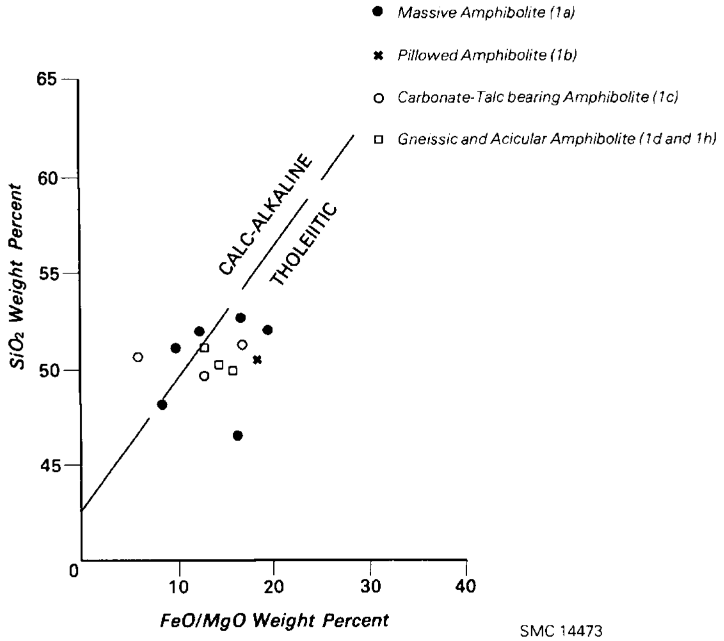

Figure 4–FeO/MgO vs. SiO_2 plot (Miyashiro 1974) for the Tudor metavolcanics displaying the predominantly tholeiitic distribution of this unit.

These plots indicate that the Tudor metavolcanics in the map-area are tholeiitic in composition. The analyses (Table 3) indicate that these metavolcanics contain less than 0.6 percent K_2O. When compared with the data for similiar rocks on strike to the north (Brown *et al.* 1975) the metavolcanics in the map-area closely resemble the tholeiitic members classified as the lower part of the succession. The higher, calc-alkaline portion of the sequence reported to the north (Brown *et al.* 1975) is not present in the map-area.

Although these rocks are metamorphosed there is little evidence of intense alteration. The Fe_2O_3-TiO_2 test for severe alteration of volcanic rocks (Irvine and Baragar 1971) was applied to this suite and showed that no members of the sample population indicated severe alteration. This is borne out in thin section as well since the only alteration found is in the carbonate-bearing amphibolites which locally have much talc forming at the expense of amphibole (tremolite). A sample (M633-1) from this unit shows this chemically as well. This rock falls well into the calc-alkaline field in all plots (Figures 2-5) This is chiefly due to a relative increase in MgO with respect to FeO as well as Na_2O and K_2O with respect to SiO_2. As a group the carbonate-bearing amphibolites have an average Cu concentration of 104 ppm which is two to three times as much as any other group.

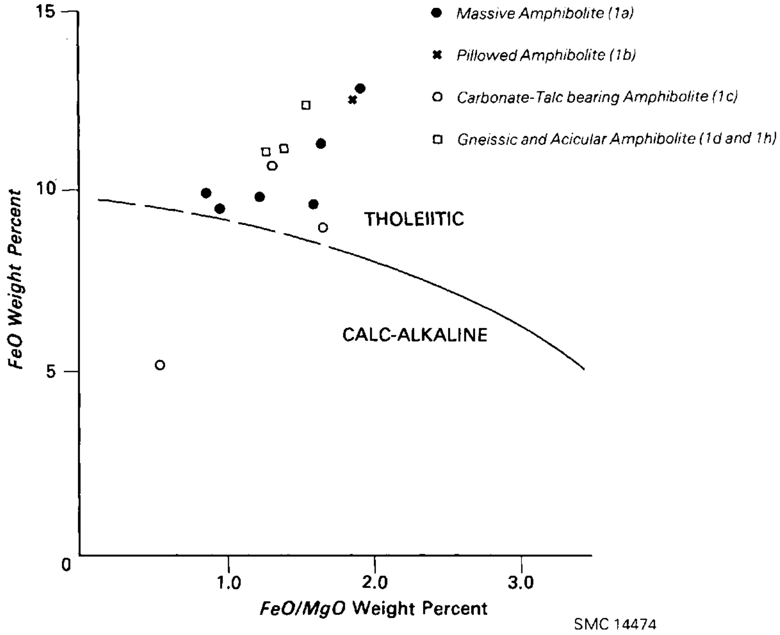

Figure 5–FeO vs. FeO/MgO plot (Miyashiro 1974) for the Tudor metavolcanics showing the tholeiitic composition of these units.

ALUMINOUS SCHIST

Rocks of this unit are not commonly found in the map-area, only occurring south of and parallel to the Flinton Group conglomeratic units which cut Highway 41, 3 km north of the village of Kaladar. The prime alumina bearing mineral is muscovite and the two rock-types found are quartz-muscovite schist (map-unit 2a) and garnet-quartz-muscovite schist (map-unit 2b). The unit is poorly exposed and highly sheared. Map-unit 2a is fine grained (less than 0.5 mm) silver-grey weathering with a well-developed schistosity. The dominant mineral phases are muscovite, quartz and biotite with minor phases of plagioclase (untwinned), orthoclase, epidote, hematite and magnetite (Table 4). The muscovite wraps around anhedral quartz grains which are elongated parallel to the long axis of the muscovite grains. Interfaces between quartz grains show well developed mortar textures with recrystallization of the quartz grains. Biotite is found along the muscovite cleavage traces and is deformed with the muscovite. In hand specimen the muscovite is preferentially weathered relative to the quartz resulting in apparent quartz rich zones which stand out in relief.

The garnet-bearing quartz-muscovite schist is essentially the same rock but contains more plagioclase (highly sericitized) plus almandine garnet poikiloblasts (Table 4). The poikiloblasts of garnet are riddled with quartz inclusions which form parallel trains inclined to the existing schistosity, indicating that the garnets have been rotated. Minor amounts of cordierite, altered to sericite wrapped by the muscovite, are possibly of the same relative age as the garnet poikiloblasts.

TABLE 4—MODAL ANALYSES (VOLUME PERCENT) OF ALUMINOUS SCHISTS IN THE KALADAR AREA.

	M433-2	M434-1
Muscovite	42.3	42.3
Biotite	8.7	4.3
Quartz	37.0	19.3
Plagioclase	2.7	10.2
Orthoclase	3.3	3.0
Almandine garnet		18.0
Epidote	1.3	0.6
Cordierite		0.6
Rutile		1.0
Magnetite + Hematite	4.7	0.6
TOTAL	100.0	99.9

SAMPLES

M433-2	Quartz-muscovite schist (map-unit 2a) 2.8 km N of Kaladar.
M434-1	Garnet-quartz-muscovite schist (map-unit 2b) 1.7 km NW of Kaladar.

CLASTIC SILICEOUS GNEISS

Clastic siliceous gneiss (map-unit 3) outcrops in two main zones in the map-area, 2.5 km north of Kaladar, and between Lingham Lakes and Otter Creek Lakes. Other units are interlayered within amphibole-rich gneiss (map-unit 5). These units show prominent continuous 1 to 2 cm thick layering defined by the zoning of micaceous and quartzofeldspathic compositions (and occasionally magnetite). This compositional layering is continuous along strike for several kilometres and can be traced around minor folds. Evidence for these units being sedimentary in origin include: 1) the repetition of layers across strike; 2) the continuity along strike of mineral zonation; 3) the parallel banding of both micaceous (muscovite and biotite) and non-micaceous (finely disseminated magnetite) minerals; 4) the apparent local facies changes from biotitic siliceous to more quartzofeldspathic compositions along strike; and 5) the continuity of layers about minor folds. The primary bedding (S0) is parallel to and presently defined by the foliation-gneissosity (S1) surfaces. Most microscopic primary metasedimentary structures have been obliterated by recrystallization.

Map-unit 3a is fine-grained (less than 0.5 mm) very white weathering massive leucocratic quartzofeldspathic gneiss. Due to the fine-grained nature it is often difficult to detect any layering except on close examination of the weathered surface which reveals fine laminations (less than 0.5 cm). In hand specimen disseminated magnetite often is found in these laminations. In the field this rock locally resembles unit 7a. The dominant mineral phases present in these units are quartz, plagioclase (andesine, highly sericitized), microcline, orthoclase, muscovite and biotite. Minor phases include almandine garnet, magnetite and rare epidote (Table 5). Texturally these rocks are granoblastic to granoblastic polygonal. The layering is defined by biotite and weakly so by quartz and feldspar. Muscovite grains are usually oriented at high angles to the biotite and contain quartz inclusions as well as some well developed vermiform textures. In sample M101-1 the muscovite forms medium grained (1.0-5.0 mm) poikiloblasts. In these rocks muscovite tends to postdate the biotite, and biotite grains are slightly chloritized. The fine-grained and thinly laminated nature of this unit implies that this rock type may in part be derived from a volcanogenic sediment. Specifically it could represent recrystallized varieties of andesitic (M101-1) and rhyolitic-rhyodacitic (M051-1 and M151-1) tuffs.

Map-unit 3b is fine- to medium-grained (0.2-1.0 mm), well layered, whitish-brown-buff, locally rusty (biotite weathering) quartzofeldspathic gneiss. The main differences between this unit and map-unit 3a are the scale of layering which in this case is 1.0-2.0 cm thick and thus of a bedding scale, the whitish-brown-buff weathering, the somewhat larger (although variable) grain size and the presence of more visible muscovite (1.0 mm or more) throughout the unit. Table 5 indicates the main mineral phases present are quartz, plagioclase (andesine, slightly saussuritized), microcline, muscovite and biotite with minor phases of calcite, chlorite, epidote and magnetite plus zircon. The chlorite is found as an alteration product of biotite. Muscovite is generally less than 1.0 mm in grain size and occurs sympathetically with the biotite usually along the biotite cleavage traces, or as a second type of occurrence, it is found as discrete flakes and/or radiating needles ranging from 1.0 to 1.5 mm in size. This indicates possibly two phases of muscovite generation both which may postdate

TABLE 5—MODAL ANALYSES (VOLUME PERCENT) OF THE CLASTIC SILICEOUS GNEISSES IN THE KALADAR AREA.

	M051-1	M101-1	M151-1	M399-1*	M426-1*	M109-1	M120-2	M404-1	M103-1	M160-1	M021-1	M036-1	M142-1
Quartz	28.4	20.8	36.7	28.7	48.3	23.7	23.8	8.3	42.0	22.0	47.5	52.1	53.1
Plagioclase	22.7	50.4	28.5	29.3	26.0	36.7	47.4	25.0	16.7	33.3	19.9	20.6	20.0
An Content	30-35	S	S	30-35	30-35	S	S	S	S	S	S	30-35	S
Microcline	12.8			23.7	4.7				9.3				3.3
Orthoclase			9.5			2.0					1.6		
Muscovite	6.7	23.4	13.8	2.3	12.3	11.7			14.0	1.0		9.5	20.0
Biotite	25.2	3.3	10.2	9.0	6.7	19.0	24.8	36.0	14.3	31.7	16.1	14.8	3.3
Chlorite				1.0									
Almandine garnet	3.8										10.6	1.0	
Epidote	0.5			1.7	1.0		1.3	14.3	1.0	6.3	3.5	1.0	
Clinozoisite										1.6			
Calcite				4.7				3.3					
Hornblende								12.3					
Magnetite, pyrite		2.0	1.5	1.3	1.6	7.0	2.6	1.0	3.0	4.0	1.0	1.0	
TOTAL	100.1	99.9	100.2	101.7	100.6	100.1	99.3	100.2	100.3	99.9	100.2	100.0	99.7
Biotite/Muscovite	>1	<1	<1	>1	<1	>1	>1	>1	1	>1	>1	>1	<1

SAMPLES

M051-1	Fine-grained leucocratic quartzofeldspathic gneiss (map-unit 3a). 5.7 km ENE of Kaladar.
M101-1	Fine-grained leucocratic quartzofeldspathic gneiss (map-unit 3a). 1.8 km NE of Kaladar.
M151-1	Fine-grained leucocratic quartzofeldspathic gneiss (map-unit 3a). 0.7 km SE of Kaladar.
M399-1	Quartzofeldspathic gneiss with muscovite (map-unit 3b). 2.7 km N of Kaladar.
M426-1	Quartzofeldspathic gneiss with muscovite (map-unit 3b). 4.2 km NE of Kaladar.
M109-1	Fine-grained biotite quartzofeldspathic paragneiss (map-unit 3c). 2.0 km ENE of Kaladar.
M120-2	Fine-grained biotite quartzofeldspathic paragneiss (map-unit 3c). 3.2 km NE of Kaladar.
M404-1	Fine-grained biotite quartzofeldspathic paragneiss (map-unit 3c). 3.4 km NE of Kaladar.
M103-1	Fine-grained biotite quartzofeldspathic paragneiss (map-unit 3c). 1.5 km ENE of Kaladar.
M160-1	Fine-grained biotite quartzofeldspathic paragneiss (map-unit 3c). 0.7 km S of Kaladar.
M021-1	Medium-grained biotite quartzofeldspathic paragneiss with garnet (map-unit 3df). 6.0 km E of Kaladar.
M036-1	Medium-grained leucocratic quartzofeldspathic paragneiss (map-unit 3e). 7.4 km ENE of Kaladar.
M142-1	Medium-grained leucocratic quartzofeldspathic paragneiss (map-unit 3e). 4.5 km ESE of Kaladar.

*Includes minor zircon

S—Sericitized

the biotite grains. In thin section minor discrete zircons less than 0.2 mm are found. Texturally this unit is granoblastic with a preferred orientation or layering defined usually by the biotite grains. Relict mortar textures are preserved in the quartz grains which have been recrystallized internally but retain mortar texture boundaries. Sample M399-1, however, displays a granitic to granoblastic interlocking texture and in outcrop is locally injected by coarse-grained quartz intrusions which parallel the layering; this sample is considered to be a totally recrystallized version of unit 3b.

Map-unit 3c is fine-grained (0.1-0.5 mm) biotite quartzofeldspathic paragneiss. The unit weathers whitish-greyish-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 thicker than 1 cm and thus of bedding scale. This unit shows much repetition across strike on the outcrop scale and contains garnetiferous horizons many of which are discontinuous. Some zones tend to be much richer in quartz and feldspar than in biotite, but biotite is usually 10-35 percent of the rock. This unit is locally folded by minor folds (F2) and contains minor pinch and swell structures averaging approximately 50 cm by 10 cm. Table 5 indicates the modal proportion of mineral phases in this unit which are principally quartz, plagioclase (sericitized), biotite, and in some samples, muscovite. Minor K-feldspar (microcline and orthoclase) epidote and magnetite are generally present. The only exception is sample M404-1 which contains the above major phases plus hornblende and epidote and, as minor phases, calcite and apatite. This particular rock is interlayered with amphibole-rich gneiss (map-unit 5a) and represents a transitional type between the two major unit types. Texturally unit 3a is granoblastic to granoblastic polygonal and exhibits a preferred orientation of the biotite grains. The biotite is often pale in colour and altered to chlorite. Muscovite where it occurs is found to be corroded by quartz but is seldom vermiform and often grades directly into biotite. In this matrix minor spinel and apatite are present. In sample M404-1 a prominent orientation and an obvious second preferred orientation at 30 degrees to the first is defined by the biotite grains. This sample contains anhedral to subhedral hornblende which is highly altered to chlorite. Epidote in this rock is corroded by quartz and is anhedral, often cutting the biotite grains of the dominant preferred orientation. Sample M160-1 contains much epidote as highly fractured poikiloblasts which are altered to magnetite and contain quartz inclusions. Biotite grains have a very prominent preferred orientation and wrap around the epidote grains suggesting that the epidote grains are older than the biotite development.

Map-unit 3d is very similar to map-unit 3c but is generally medium grained (0.5-2.0 mm) and contains little if any muscovite. Locally this unit is garnetiferous (map-unit 3f) and the garnets are more common in these medium-grained units than in map-unit 3c. The sample thin sectioned contains quartz, plagioclase (heavily sericitized), biotite and almandine garnet. Minor epidote, orthoclase and opaques are present (see Table 4). This section displays a granoblastic polygonal texture with large (15-20 mm) poikiloblasts of almandine garnet wrapped by biotite which is the dominant component defining the gneissic layering. The inclusions in the garnet are mostly quartz and opaques with no obvious indication of rotation, although small (less than 0.5 mm) broken garnets occur throughout the thin section. This unit along with 3c occasionally displays quartz rodding in the fold noses of minor (F2) folds.

Map-unit 3e is medium-grained leucocratic quartzofeldspathic paragneiss which weathers a distinctive pink-white. It is more quartz-rich than any of the above units and is moderately well layered on the 1 cm scale. Principal mineral phases in this unit are quartz and plagioclase (andesine, highly sericitized). Minor phases are muscovite, biotite, garnet, epidote and opaque minerals. Texturally, this unit is granoblastic with biotite weakly defining the gneissosity. Muscovite is often ragged and large (1.0 mm) with quartz inclusions. The biotite is chloritized. Small relict poikiloblasts of garnet are highly fractured and altered to epidote. This unit represents a metamorphosed feldspathic wacke while all the previous metasedimentary units are most likely metamorphosed arkosic wacke. The 3e unit is limited in occurrence to the southeasterly region between Lingham Lakes and Otter Creek Lakes and may represent a local facies change.

Figure 6 displays the petrographic analyses of map-unit 3 in terms of the

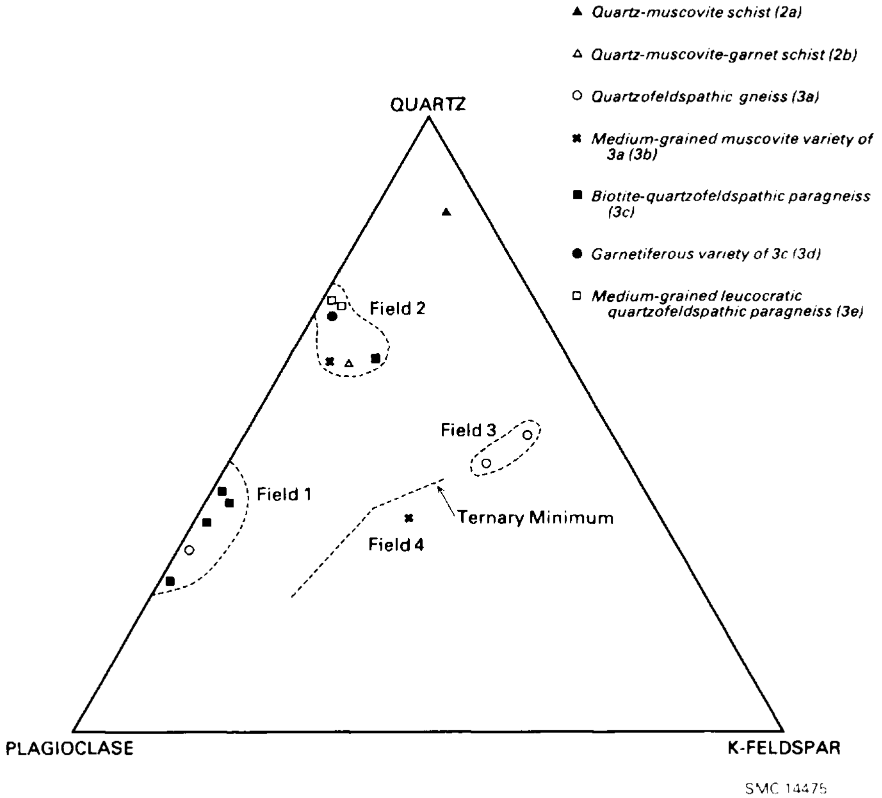

Figure 6–Distribution of the clastic siliceous gneisses and aluminous schists in terms of modal quartz, plagioclase and K-feldspar recalculated to 100 percent. The ternary minimum from 4 to 10 Kbar (Luth *et al.* 1964) is shown.

volume percent of quartz, plagioclase and potassic feldspar recalculated to 100 percent. The modes of map-units 2a and 2b have also been plotted for comparison and the trend of the ternary minimum of the granite system from 4 to 10 kbars (Luth *et al.* 1964) has been included. The behaviour of the rocks in this system is interesting. Field 1 is essentially only map-unit 3c which contains biotite greater than 18 percent and a biotite-muscovite ratio much greater than 1. The exception to this is M103-1 which has a biotite/muscovite ratio of approximately 1 and higher quartz thus falling in field 2. Field 2 is composed of rocks which have more than 8 percent muscovite in their modes and a biotite/

TABLE 6—CHEMICAL ANALYSES[1] OF CLASTIC SILICEOUS GNEISSES OF THE KALADAR AREA.

MAJOR ELEMENT OXIDES	WEIGHT PERCENT				
Sample No.	M102-1	M213-1	M527-1	A	B
SiO_2	73.7	71.6	72.0	68.45	73.5
Al_2O_3	13.3	13.3	14.5	12.05	12.7
Fe_2O_3	3.52	3.79	1.48	2.72	0.9
FeO	0.33	1.58	0.75	2.03	1.2
MgO	0.40	0.63	0.72	2.96	0.8
CaO	0.64	1.21	0.51	0.50	1.1
Na_2O	4.92	3.54	4.84	4.87	3.3
K_2O	2.01	2.81	2.76	1.81	3.0
H_2O^+	0.31	0.59	0.72	2.30	
H_2O^-	0.16	0.15	0.15	0.77	
CO_2	0.22	0.24	0.16	0.08	
TiO_2	0.38	0.61	0.47	0.74	0.14
P_2O_5	0.08	0.16	0.11	0.06	
S	0.01	0.01	0.01		
MnO	0.02	0.06	0.04	0.05	
TOTAL	100.0	100.3	99.2		
TRACE ELEMENTS	PPM				
Ba	340	460	760		
Co	<5	6	8		
Cr	7	6	13		
Cu	5	<5	6		
Li	16	10	40		
Ni	<5	<5	<5		
Pb	<10	<10	<10		
Rb	50	60	70		
Zn	41	70	42		

SAMPLES

M102-1 Fine-grained leucocratic quartzofeldspathic gneiss (map-unit 3a). 1.6 km NE of Kaladar

M213-1 Well layered quartzofeldspathic gneiss with muscovite (map-unit 3b). 6.9 km NE of Kaladar.

M527-1 Well layered quartzofeldspathic gneiss with muscovite (map-unit 3b). 2.0 km NW of Kaladar.

A—Greywacke (Rosler and Lang 1972, p. 297).

B—Rhyolite (Condie 1976, p. 406).

[1] Analyses by Geoscience Laboratories, Ontario Geological Survey, Toronto.

muscovite ratio of less than 1. The exception is M021-1, a garnet-bearing biotite quartzofeldspathic paragneiss in which the biotite/muscovite ratio is somewhat anomalous due to the incorporation of alumina in the garnet phase. Rocks poor in K-feldspar can be separated into two fields: field 2 containing those rocks which are quartz-rich and possessing alumina-rich minerals (muscovite and garnet), and field 1 containing those rocks which are quartz-poor and richer in mafic minerals (biotite). One exception is M101-1 a rock containing much plagioclase (50.4 percent) but little biotite (3.3 percent). The position of this rock on the diagram is typically weighted by its feldspar content as are M051-1 and M151-1 (both in field 3). All three of these are expected to have volcanogenic origins. The two samples of map-unit 2, both quartz- and muscovite-rich fall in or near the field 2 portion of the diagram. The only sample falling near the ternary minimum is M399-1, a partially migmatized and totally recrystallized variety of map-unit 3b having a granitic composition.

The chemical analyses of the clastic siliceous gneisses (map-units 3a and 3b) are given in Table 6. When compared with the most siliceous greywackes (Rosler and Lang 1972; Condie 1976) these rocks are much lower in MgO content. Except for Fe content these gneisses compare more closely with average compositions of rhyolites. It is suggested then, that, at least in part, the siliceous members of this unit (3a especially) were derived from felsic volcanic rocks.

Near Lingham Lakes coarse-grained pink quartz monzonite (map-unit 7d) intrudes the clastic siliceous gneisses passively along the gneissosity.

CARBONATE METASEDIMENTS

Carbonate metasediments outcrop at the hamlet of Elm Tree and extend south and west of this location, south of Otter Creek Lakes and north of Lingham Lakes, enclosing the clastic siliceous gneisses (map-unit 3) situated between the two lake systems. A thin band of carbonate metasediments also passes through the village of Kaladar, extending along the northern margin of a long swamp which trends southwesterly from the west end of Kennebec Lake. These rocks are best exposed where farm land has been cleared, but otherwise are sparsely exposed.

The dominant carbonate metasediment in the map-area is medium grained (1.0-1.5 mm) crystalline dolomitic marble. This unit is very clean, weathers snow-white to greyish-blue and locally contains massive medium-grained (0.5-1.0 mm) discontinuous layers or lenses of quartzite. These quartzitic units are typically 10 to 20 cm thick and weather a distinct white. Map-units 4d, 4e, 4f and 4g are pholgopite-, diopside-, tremolite- and serpentine-bearing varieties of 4a. Phlogopite is rare and usually fine grained (less than 0.5 mm), but diopside usually forms well developed green elongate crystals up to 3 cm long. Tremolite is typically found in radiating groups with individual crystals reaching 5 cm in length. Serpentine is usually found in pale green waxy bundles 2-3 cm long. Minor amounts of apatite, tourmaline (especially an orange variety) and graphite are locally developed.

Table 7 lists the modal abundances of four different marbles, a clean variety of 4a (sample G036-1), a quartzitic variety of map-unit 4a (G052-1), a diop-

TABLE 7—MODAL ANALYSES (VOLUME PERCENT) OF THE CARBONATE METASEDIMENTS IN THE KALADAR AREA.

	G036-1	M040-1	M040-3	G052-1
Dolomite	98.0	10.9	1.9	42.3
Calcite		75.8	78.7	
Quartz				25.3
Plagioclase		3.8	1.9	7.3(S)
Microcline				14.0
Biotite				7.7
Muscovite				1.0
Phlogopite	1.6			
Diopside		7.3		
Tremolite			14.8	
Tourmaline				1.7
Apatite	0.4			
Opaque		2.0	3.0	0.6
TOTAL	100.0	99.8	100.3	99.9

SAMPLES
G036-1 Dolomitic marble (map-unit 4a). 9.8 km NE of Kaladar.
M040-1 Diopsidic marble (map-unit 4e). 10.4 km NE of Kaladar.
M040-3 Tremolitic marble (map-unit 4f). 10.4 km NE of Kaladar.
G052-1 Quartzitic layer in dolomitic marble (map-unit 4a). 8.3 km NE of Kaladar.
S—Sericitized.

sidic variety 4e (M040-1) and a tremolitic variety 4f (M040-3). With the exception of the quartzitic marble (G052-1) the dominant mineral phases are dolomite and calcite, and the minor phases are diopside, tremolite, phlogopite, untwinned plagioclase, apatite, and opaques. The samples containing pyroxene or amphibole invariably contain 2-3 percent opaques (Fe sulphides) and possess more calcite than dolomite. This may indicate that these units actually represent zones where the dolomite has been de-dolomitized upon recrystallization allowing tremolite, diopside or serpentine to form. Texturally these rocks are interlocking granoblastic to idiotopic with idioblasts to subidioblasts of the above Fe-Mg silicate minor phases.

Sample G052-1, the quartzitic dolomitic marble, shows the typical composition of the quartzitic material. The major phases in the quartzitic layers are quartz, plagioclase (highly sericitized), K-feldspar (microcline), and biotite, while the minor phases are muscovite, tourmaline, apatite and opaques. From the composition of the quartzitic material in this sample the parent material may have been an arkosic wacke, similar to that forming the clastic siliceous gneiss (map-unit 3). Texturally, this rock is granoblastic with a gneissosity defined by the quartzose layers.

A unit of prime interest is the fragmental dolomitic marble (map-unit 4b) containing quartz, quartzite and dolomite fragments and clasts. This unit is poorly exposed but can be found on the north side of the old Canadian Pacific crossing at the Elm Tree Road. The unit is discontinuous along strike in the map-area but appears sporadically throughout the marble units near Donahue Creek and Lingham Lakes. The dolomitic fragments or clasts are typically 10 cm long and possess uneven surfaces and are plate or flag-like in character. These flags are aligned parallel to the regional foliation-gneissosity but themselves show few signs of deformation. Minor quartz and quartzite clasts are more pebble-like and deformed with the regional foliation-gneissosity and are often ubiquitous within the quartzitic matrix. These flags and clasts rest in a dolomitic marble and quartzite pebble matrix (map-unit 4a). The fragmental unit varies in thickness but is typically 1-2 m thick at any given location and may occur several times within a given section. The discontinuous and flaggy nature of this unit strongly suggests that this unit is an intraformational breccia, likely formed from local breakup and slumping of the carbonate bank.

Map-unit 4c is composed of a fine grained silty marble which is essentially unmappable as it is poorly exposed. This unit is indicative, however, of the coexisting clastic sedimentation which accompanied carbonate deposition in the area.

Coarse-grained quartz monzonitic intrusive rocks passively cut these rocks in the vicinity of Lingham Lakes but are not continuous along strike.

AMPHIBOLE-RICH GNEISS AND SCHIST

Amphibole-rich gneiss and schist outcrop primarily north and south of Highway 7 in the map-area and are quite well exposed. Compositional layering

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Photo 2–Boudin neck in amphibole-rich gneiss (map-unit 5) southwest of Kennebec Lake. The boudin neck contains medium-grained calcite, chlorite and locally hematite.

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 change quickly across strike. In general, these units are thickest and contain the least amount of clastic siliceous gneiss south of Highway 7 and east of Highway 41. North of Highway 7 more clastic siliceous gneiss was observed and the units change more quickly across strike. To the northeast the stratigraphic thickness of the amphibole-rich gneiss decreases and on the southwest shore of Kennebec Lake, units 5a, 5b and 3c are interlayered systematically on the scale of an outcrop. Locally, the amphibole-rich gneiss is boudinaged, producing boudins up to 1 m long and 0.2 m wide on the exposed surface. These boudins exhibit chlorite, calcite and hematite secondary mineralization in the boudin necks (Photo 2). Amphibole-rich gneiss is also found as thin but continuous units in the clastic siliceous gneiss section between Otter Creek Lakes and Lingham Lakes. The amphibole-rich gneiss is composed of two main mappable types: hornblende-plagioclase gneiss and plagioclase-hornblende gneiss. Figure 7 shows that in the modal quartz–total feldspar–hornblende plane these units can be separated. The mineral quartz is included as locally these rocks may contain layers of recrystallized quartz. Aside from these two basic types, hornblende-rich gneiss

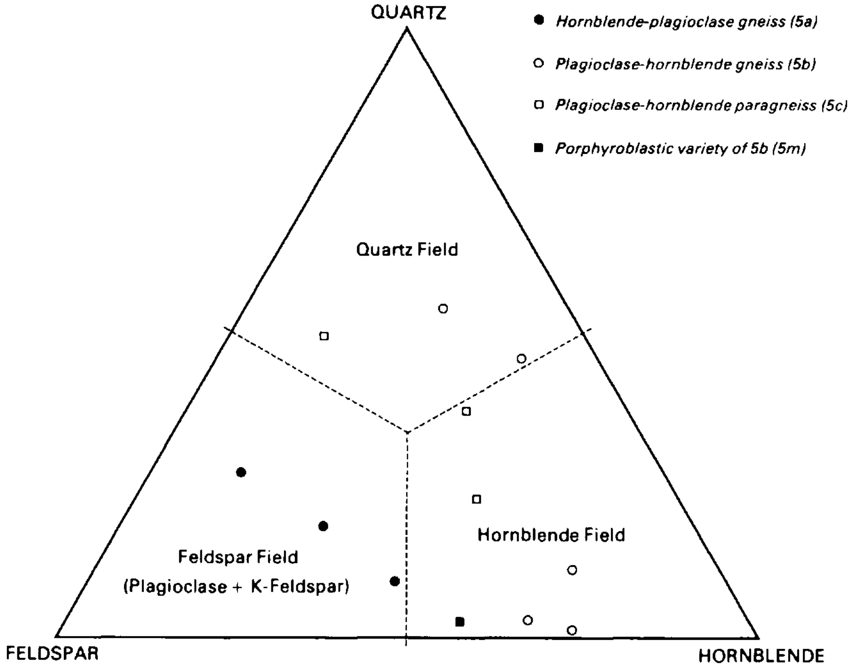

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Figure 7–Distribution of the amphibole-rich gneisses in terms of modal quartz, hornblende and total feldspar recalculated to 100 percent. Divisions between the fields are at equal ratio positions for any two end members.

TABLE 8—MODAL ANALYSES (VOLUME PERCENT) OF THE AMPHIBOLE-RICH GNEISSES IN THE KALADAR AREA.

	M214-2	M267-1	M239-2	M151-2	G126-1	M442-1	M064-1	M085-1	M131-1	M084-1	M015-1	M017-2	M009-2	M033-2	M045-1
Plagioclase	33.0	23.0	45.0	30.7	25.3	19.4	9.5	14.3	21.7	20.7	25.7	20.0	29.1	39.0	
An Content	8-12	8-12	S, U	55-60	45-50	45-50	U		U	U			55-60	U	
Orthoclase		21.0									0.3			1.0	
Microcline													2.0		
Nepheline															24.0
Quartz	6.3	20.0	15.7	3.3		10.2	36.5	43.7	34.3	27.2	20.7	33.7	39.4	3.3	
Hornblende	31.3	9.0	24.6	64.3	72.0	60.9	33.5	21.7			41.3	33.7	11.5	50.0	
Tremolite															62.3
Biotite	12.3	14.7	2.7			1.4		3.7	0.3	26.6	1.7		11.8		
Chlorite									33.7	20.3					
Almandine garnet									6.7			3.7			
Epidote	1.0	10.7					6.5	15.3	trace	4.6	0.6		trace	0.6	
Clinozoisite		1.3					4.0								1.3
Calcite	2.7		6.0				9.5		1.3					4.7	
Apatite									0.6						
Talc	3.0														
Scapolite									7.7						
Sphene													2.3		4.3
Magnetite		1.3		1.7	2.7	7.6	0.5	1.0	2.0	1.0		2.7	4.3		
Hematite															5.0
Pyrite±chalcopyrite	10.3		6.0											1.3	3.0
TOTAL	99.9	100.0	100.0	100.0	100.0	99.5	99.5	100.3	100.0	100.3	99.9	100.1	100.4	99.9	99.9

SAMPLES

M214-2	Fine-grained hornblende-plagioclase gneiss (map-unit 5a). 6.9 km NE of Kaladar.
M267-1	Fine-grained hornblende-plagioclase gneiss (map-unit 5a). 3.3 km NE of Kaladar.
M239-2	Fine-grained hornblende-plagioclase gneiss (map-unit 5a). 2.7 km SW of Kaladar.
M151-2	Fine-grained plagioclase-hornblende gneiss (map-unit 5b). 0.7 km SE of Kaladar.
G126-1	Fine-grained plagioclase-hornblende gneiss (map-unit 5b). 3.8 km NE of Kaladar.
M442-1	Fine-grained plagioclase-hornblende gneiss (map-unit 5b). 3.8 km N of Kaladar.
M064-1	Fine-grained plagioclase-hornblende gneiss (map-unit 5b). 7.0 km NE of Kaladar.
M085-1	Fine-grained plagioclase-hornblende gneiss (map-unit 5b). 3.6 km NE of Kaladar.
M131-1	Chloritic variety of map-unit 5a. 6.2 km ENE of Kaladar.
M084-1	Biotite-chlorite schist (map-unit 5f). 3.8 km NE of Kaladar.
M015-1	Medium-grained plagioclase-hornblende paragneiss (map-unit 5c). 8.4 km ENE of Kaladar.
M017-2	Medium-grained plagioclase-hornblende paragneiss (map-unit 5c). 6.6 km E of Kaladar.
M009-2	Medium-grained plagioclase-hornblende paragneiss (map-unit 5c). 9.7 km ENE of Kaladar.
M033-2	Hornblende porphyroblastic 5b. 5.8 km ENE of Kaladar.
M045-1	Contaminated phase of 5a. 10.0 km NE of Kaladar.

U—Untwinned.
S—Sericitized.

and chloritic schist are also found in the map-area and are included in this group. The remaining subdivisions are essentially local variations of the above types.

Map-unit 5a is composed of fine-grained (less than 0.5 mm) hornblende-plagioclase gneiss. which weathers greenish grey because plagioclase is more dominant. The modal compositions of this unit are given in Table 8. The major phases are plagioclase (albite-oligoclase), hornblende and quartz. Minor phases are biotite, epidote, calcite, talc, clinozoisite and magnetite and pyrite. Sample M267-1 also contains orthoclase and much epidote. This rock is rather unique in that it represents a contamination phase of map-unit 5a occurring at the contact of these rocks and the Addington intrusion (map-unit 7a). Map-unit 5a is gneissic with individual grains of plagioclase, hornblende and quartz displaying a granoblastic texture. The compositional layering defines the gneissosity and is composed of plagioclase and quartz layers and hornblende-rich layers. Where biotite is present in these rocks the plates are aligned parallel to the gneissosity. The other minor phases tend to be anhedral and randomly oriented. Talc when it occurs is acicular in thin section and may represent a late stage alteration of chlorite. Hornblende is porphyroblastic in places and weakly wrapped by the biotite fabric. These samples all fall in the feldspar sector of Figure 7.

Grouped in map-unit 5b are fine-grained (less than 0.5 mm) plagioclase-hornblende gneisses. This unit weathers predominantly greyish green with local apple green concentrations (epidote). These rocks (see Table 8) contain hornblende and plagioclase (andesine and labradorite) as the major mineral phases. The minor phases are biotite, epidote, clinozoisite, calcite and magnetite. Quartz in general is a minor phase but can reach large proportions locally. Specific examples are M064-1 and M085-1. These samples both plot in the quartz sector of Figure 7 while the other samples of this unit plot well within the hornblende field. These two samples contain much recrystallized quartz, in fact M064-1 has a quartzite layer constituting one-third of the thin-section and in the field thin quartzite layers were locally observed. Both samples are not only quartz-rich but contain discrete epidote layers (map-unit 5h), and may represent the prograde metamorphism of chlorite, calcite and quartz to epidote and amphibole. Texturally, these units are gneissic with the compositional layering being defined by hornblende-rich and plagioclase-rich zones. The grains themselves are granoblastic. In the most siliceous specimen M064-1 the quartzite layer displays a recrystallized mortar texture and hornblende grains juxtaposed at this boundary are vermiform with siliceous intergrowths.

Map-unit 5c is medium-grained (0.5-1.5 mm) plagioclase-hornblende paragneiss. Most of the minerals are medium grained, although the minor phases are usually smaller. This unit weathers greyish green and often displays a "salt and pepper" colouring. Modal compositions for this unit (Table 8) indicate the major phases to be plagioclase (labradorite), hornblende and quartz. The minor phases are K-feldspar, biotite, almandine garnet, epidote, sphene and magnetite. Spatially the majority of these units are interbedded with clastic siliceous gneisses (map-unit 3) between Lingham Lakes and Otter Creek Lakes, hence the dominance of quartz grains in this unit is not suprising. This unit falls mainly in the hornblende field in Figure 7 but near the quartz field with one falling within that field. Texturally, this unit is gneissic with granoblastic quartz and plagioclase grains plus hornblende grains deforming the compositional layering gneissosity. Hornblende and garnet grains are commonly poikiloblastic with inclusions of quartz. Biotite grains tend to cut and partially enclose hornblende grains suggesting they are a younger metamorphic event than the hornblende.

Map-unit 5d is hornblende-rich gneiss. This unit weathers dark green-brown and is medium grained (0.5-5.0 mm). The rock commonly contains 80 percent hornblende and little plagioclase. This unit is only mappable over short distances and commonly associated with unit 5b. Locally developed is a fine-grained (less than 0.5 mm) epidote-biotite-feldspar-quartz paragneiss (map-unit 5e), which occurs as thin bands and sometimes mappable units within other amphibole-rich gneisses. This unit weathers a streaky grey-green-brown. The maximum amounts of biotite and epidote in hand specimen are 25 and 15 percent. The biotite typically defines the foliation gneissosity and the epidote occurs in thin (less than 1 cm) laminations parallel to the gneissosity. Quartz and feldspar are the dominant phases and occur in essentially equal proportions.

Two sparsely occurring variations of map-units 5a and 5b are a biotitic variety which contains 5 to 15 percent biotite, and a garnetiferous variety which contains medium-grained (0.5-2.0 mm) poikiloblasts of almandine garnet with minor amounts of muscovite.

The amphibole-rich gneisses also include chlorite-bearing assemblages. The most prominent of these is a biotite-chlorite schist (map-unit 5f). A highly sheared, schistose unit which is highly eroded, this rock weathers a greenish rusty red. The dominant mineral phases are chlorite, biotite, quartz and plagioclase (untwinned), while epidote and magnetite form minor phases (Table 8, M084-1). This rock is fine grained (less than 0.5 mm). The chlorite grains are poikiloblastic and wrapped by fresh biotite grains indicating the biotite postdates the chlorite formation.

Map-units 5a, 5b and 5c are locally chloritic containing 5 to 15 percent chlorite. The modal abundance of a chloritic variety of map-unit 5a is shown in Table 8 (M131-1). In this particular sample the dominant phases are plagioclase (untwinned), quartz and chlorite with almandine garnet, biotite, calcite, epidote, scapolite and magnetite forming the minor phases. This rock contains no hornblende but in thin section it can be seen that the chlorite has formed from hornblende with the formation of epidote. The chloritic variety of map-unit 5a appears a metamorphic product formed in a K-poor, CO_2-rich environment. Texturally, this rock is granoblastic with a remnant gneissic layering.

Map-unit 5k is mappable and continuous over much of the strike length of the amphibole-rich gneisss. This unit is quite resistant to weathering and thus forms topographic highs with respect to the other units. This rock type contains medium grained (0.5-2.0 mm) hornblende grains which create a knobby dark green weathering surface. Compositionally, it is essentially a variation of 5b as it plots in the hornblende field in Figure 7. The dominant mineral phases in this rock are plagioclase (untwinned) and hornblende, and the minor constituents are calcite, quartz, orthoclase, epidote and pyrite (Table 8, M033-2). Although hand specimens of this rock suggest a porphyroblastic texture is predominant, thin sections show the texture is gneissic composed of alternating layers of granoblastic hornblende and plagioclase grains. The porphyroblastic look is a weathering feature only.

A small amount of amphibole-rich gneiss is found locally in the carbonate metasediments. These occurrences are conformable with the local gneissosity in the carbonate units and highly altered. One sample from this type of occurrence was thin sectioned and found to contain a highly altered mineral assemblage (Table 8, M045-1) containing tremolite and nepheline as major phases and sphene, clinozoisite, chalcopyrite and hematite as minor phases. This rock

TABLE 9—CHEMICAL ANALYSES OF AMPHIBOLE-RICH GNEISS IN THE KALADAR AREA.

MAJOR ELEMENT OXIDES	WEIGHT PERCENT								
Sample No.	M090-1	M202-1	M225-1	M089-1	M207-1	M222-1	M212-1	M214-1	M084-2
SiO_2	57.7	53.8	49.2	56.4	60.3	51.4	47.7	48.9	55.6
Al_2O_3	16.1	15.6	16.5	16.0	15.7	15.7	16.3	13.0	16.5
Fe_2O_3	4.39	6.20	4.38	6.24	5.95	6.85	4.35	7.80	4.47
FeO	4.07	2.33	7.31	2.91	2.16	4.82	8.06	8.73	3.99
MgO	3.55	4.86	7.71	3.62	2.34	7.02	6.73	5.05	5.27
CaO	4.90	6.68	7.29	7.26	7.70	7.19	10.2	7.98	3.47
Na_2O	4.34	3.47	3.97	3.63	3.03	4.38	2.63	1.98	3.69
K_2O	1.88	2.58	0.08	0.42	0.46	0.07	0.28	0.93	2.31
H_2O^+	0.31	0.34	1.14	0.41	0.35	0.58	0.35	0.67	1.51
H_2O^-	0.42	0.31	0.25	0.38	0.29	0.29	0.33	0.24	0.57
CO_2	0.30	0.88	0.18	0.50	0.22	0.20	0.28	0.32	0.40
TiO_2	1.32	1.09	1.40	1.04	0.94	1.24	1.41	2.78	1.36
P_2O_5	0.39	0.36	0.19	0.25	0.24	0.23	0.27	0.45	0.38
S	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
MnO	0.10	0.12	0.18	0.13	0.14	0.16	0.23	0.24	0.10
TOTAL	99.8	98.6	99.8	99.2	99.8	100.1	99.1	99.1	99.6
TRACE ELEMENTS	PPM								
Ba	620	780	40	180	130	40	60	350	600
Co	25	28	44	28	17	44	45	44	28
Cr	102	221	440	203	72	440	276	44	130
Cu	6	6	6	6	126	6	8	96	74
Li	16	28	18	10	8	18	15	22	22
Ni	49	76	154	86	56	154	122	23	61
Pb	11	10	10	15	10	10	11	25	10
Rb	40	50	10	10	10	10	10	20	40
Zn	113	104	124	99	82	124	150	280	148

SAMPLES

M090-1	Hornblende-plagioclase gneiss (map-unit 5a). 2.6 km E of Kaladar.
M202-1	Hornblende-plagioclase gneiss (map-unit 5a). 8.3 km NE of Kaladar.
M225-1	Hornblende-plagioclase gneiss (map-unit 5a). 11.6 km NE of Kaladar.
M089-1	Plagioclase-hornblende gneiss (map-unit 5b). 3.1 km E of Kaladar.
M207-1	Plagioclase-hornblende gneiss (map-unit 5b). 7.6 km NE of Kaladar.
M222-1	Plagioclase-hornblende gneiss (map-unit 5b). 11.4 km NE of Kaladar.
M212-1	Hornblende-rich gneiss (map-unit 5d). 6.8 km NE of Kaladar.
M214-1	Hornblende-rich gneiss (map-unit 5d). 7.1 km NE of Kaladar.
M084-2	Biotite-chlorite schist (map-unit 5f). 3.8 km NE of Kaladar.

Analyses by Geoscience Laboratories, Ontario Geological Survey, Toronto.

is medium grained (0.5-1.2 mm) and gneissic in texture and contains orbicular hematite grains.

The carbonate minerals siderite and calcite are also found in concentrations of 5 to 10 percent in the amphibole-rich gneiss units. Map codes 5n and 5p are qualifiers to distinguish these occurrences which in themselves are not mappable but usually occur in unit 5b.

To further examine the nature of these amphibole-rich gneisses nine samples were chemically analysed (Table 9). Samples analysed were limited to the 5a, 5b and 5d map-units and one from the 5f map-unit. The quartz-bearing phases were not analysed as they are likely hybrid varieties which would screen chemical investigation into the possible provenance of the amphibole-rich gneiss. To determine the provenance of these rocks the average composition of units 5a, 5b and 5f combined (hornblende-plagioclase gneiss, plagioclase-hornblende gneiss and biotite-chlorite schist) and the average composition of unit 5d (hornblende-rich gneiss) are compared with averages of para-amphibolite, ortho-amphibolite, granite gneiss and greywacke in the literature (Table 10). Examination of this table reveals the average composition of map-units 5a, 5b and 5f compares most closely with those average values of para-amphibolite from the Haliburton-Madoc area (van de Kamp 1968) and the Green Bed, Scotland (van de Kamp 1970). The only element of major dispute is iron of which ferric is higher and ferrous is lower in the samples from this study. The average of map-unit 5d compares very closely with the average composition of ortho-amphibolite from the Haliburton-Madoc area (van de Kamp 1968) with the exception of ferric iron which tends to be higher in samples from this study.

TABLE 10—COMPARISON OF AVERAGE CHEMICAL COMPOSITIONS OF AMPHIBOLE-RICH GNEISSES WITH "AVERAGE" ROCK-TYPES FROM THE LITERATURE.

	WEIGHT PERCENT							
	1	2	3	4	5	6	7	8
SiO_2	54.8	49.29	53.29	48.3	48.21	58.29	66.75	69.70
Al_2O_3	16.0	14.97	13.85	14.65	14.98	11.18	13.54	14.97
Fe_2O_3	5.49	2.28	3.46	6.08	3.57	2.88	1.60	1.67
FeO	3.94	8.06	8.46	8.89	8.95	4.00	3.54	1.11
MgO	4.91	5.94	6.51	5.89	6.82	5.53	2.15	1.05
CaO	6.35	9.51	6.38	9.09	9.23	9.25	2.54	2.61
Na_2O	3.79	3.50	2.39	4.61	3.49	1.83	2.93	4.17
K_2O	1.11	1.32	1.13	0.61	0.40	2.92	1.99	3.64
TiO_2	1.20	1.35	1.15	1.20	1.15	0.83	0.63	0.84
P_2O_5	0.30	0.21	0.11	0.30	0.11	0.26	0.16	0.10
MnO	0.13	0.13	0.18	0.13	0.18	0.11	0.12	0.08
CO_2	0.38	1.83	0.76	0.38	0.76	0.98	1.24	0.26

1 Average of seven samples from this study (map-units 5a, 5b, 5f) Table 9.
2 Average para-amphibolite, Haliburton-Madoc area (van de Kamp 1968)
3 Average Green Bed, Scotland (van de Kamp 1970).
4 Average of two samples from this study (map-unit 5d) Table 9.
5 Average ortho-amphibolite, Haliburton-Madoc area (van de Kamp 1968).
6 Average of 26 analyses of Kaladar Conglomerate matrix (van de Kamp 1971).
7 Average of 61 greywackes, Pettijohn (1963, Table 7, Analysis A).
8 Average of six granitic gneisses (Wynne-Edwards 1967, p. 266).

Comparison of these average values with that of the Kaladar metaconglomerate shows a distinct difference as this rock type is considered to have been immature clastic sediments derived from granitic gneisses and mafic igneous rocks (van de Kamp 1971). Comparison with the average of 61 greywackes (Pettijohn 1963) reveals strikingly different values thus precluding this possible compositional source. For comparative purposes the average values of six granitic gneisses (Wynne-Edwards 1967) are included, and not suprisingly are dissimiliar with respect to the amphibole-rich gneisses. Comparison of the average Ba values also reveals this distinction. The average Ba value for map-units 5a, 5b and 5f from this study is 341 ppm compared to 346 ppm for para-amphibolites (van de Kamp 1968) and unit 5d has a mean Ba of 205 ppm which compares favourably with 173 ppm for the ortho-amphibolites from the Haliburton-Madoc area (van de Kamp 1968).

In light of the similiarity of these chemical compositions with ortho- and para-amphibolites, these rocks, for comparison, have been plotted on the AFM volcanic rock classification diagram of Irvine and Baragar (1971) and are presented in Figure 8. These rocks fall within the calc-alkaline field with the exception of the hornblende-rich gneiss (map-unit 5d) which is tholeiitic. It should be mentioned that when tested for alteration using the Fe_2O_3-TiO_2 relationship each rock required Fe_2O_3 adjustment. Although this does not affect the AFM plot it does point out that these rocks have undergone substantial oxida-

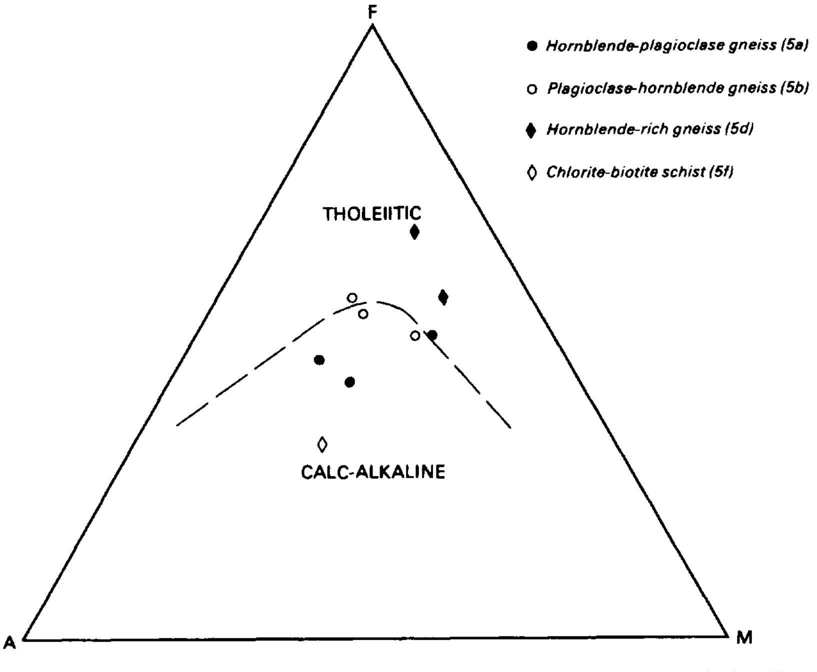

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Figure 8–AFM plot (Irvine and Baragar 1971) for the amphibole-rich gneisses revealing the calc-alkaline affinities of this unit.

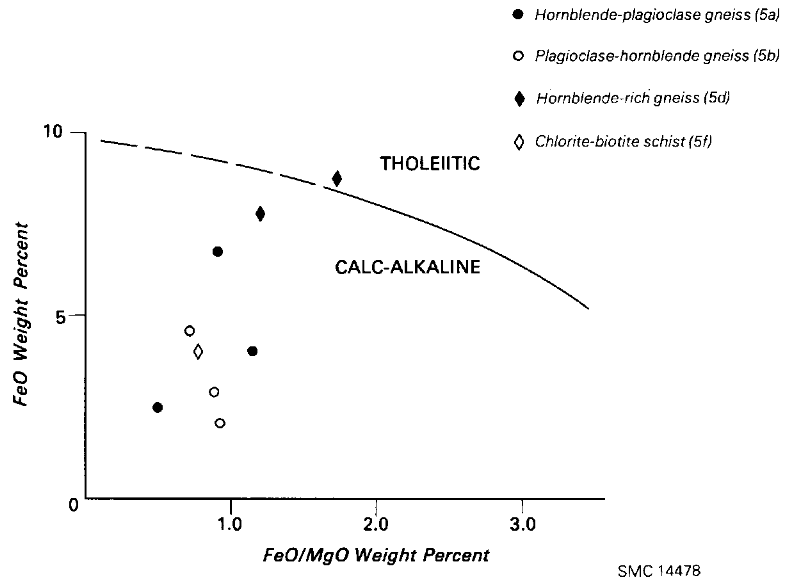

Figure 9–FeO vs. FeO/MgO plot (Miyashiro 1974) for the amphibole-rich gneisses displaying the calc-alkaline nature of the hornblende-plagioclase and plagioclase-hornblende members (para-amphibolite) and the more tholeiitic nature of the hornblende-rich gneisses (ortho-amphibolites).

tion thus explaining the higher Fe_2O_3 values with respect to other average values (see Table 10). The FeO vs. FeO/MgO plot (Miyashiro 1974) presented in Figure 9 also verifies the calc-alkaline nature of these amphibole-rich gneisses. Note that the hornblende-rich gneiss (map-unit 5d) plots closest to the tholeiitic border.

The amphibole-rich gneisses possibly represent a sedimentary sequence in which volcanic ash deposition was concurrent with siliceous clastic deposition of feldspathic wacke and arkosic wacke. Possible rhyolitic tuff lenses are also found in these units. The stratigraphic section appears to thin towards the northeast and individual units become much thinner suggesting that in this direction units may have been more distal from the clastic or pyroclastic source. The sedimentary pile is locally interrupted by ortho-amphibolites which appear to be conformable with the layering. These amphibolites are mainly of calc-alkaline composition and similarities of these compositions with those of the higher levels of the Tudor metavolcanics in Barrie and Anglesea Townships (Moore 1976) suggest the same volcanic source may have been responsible for both the Tudor metavolcanic sequence and the amphibole-rich gneiss in this map-area.

MAFIC INTRUSIVE ROCKS

South of Flinton a mafic body is in contact with the metavolcanic pile (unit 1). This body is poorly exposed and compositionally ranges from quartz gabbro to diorite (Figure 10) with minor grandodiorite zones. The rock weathers green and white and is fine grained to medium grained (0.2-4.0 mm). The intrusion is not homogeneous but includes incorporated segments of mafic metavolcanics (map-unit 1a) and locally ultramafic metavolcanics (map-unit 1j). This body is cut by discordant to locally subconcordant dikes of hornblende granodiorite (map-unit 6b). This unit is probably an offshoot of the Elzevir Batholith which has become richer in mafic minerals upon intrusion into the mafic metavolcanics. This body is not clearly intrusive into the Tudor metavolcanics and may represent a contamination phase of the Elzevir Batholith formed by the assimilation and reaction of mafic volcanic rocks and granitic magma. Brown *et al.* (1975) consider parts of this unit to represent possible ocean floor material, however, the author considers it to be more akin to the contaminated mafic intrusive rocks described by Lumbers (1968) at the western border at the Weslemkoon Batholith, Cashel Township.

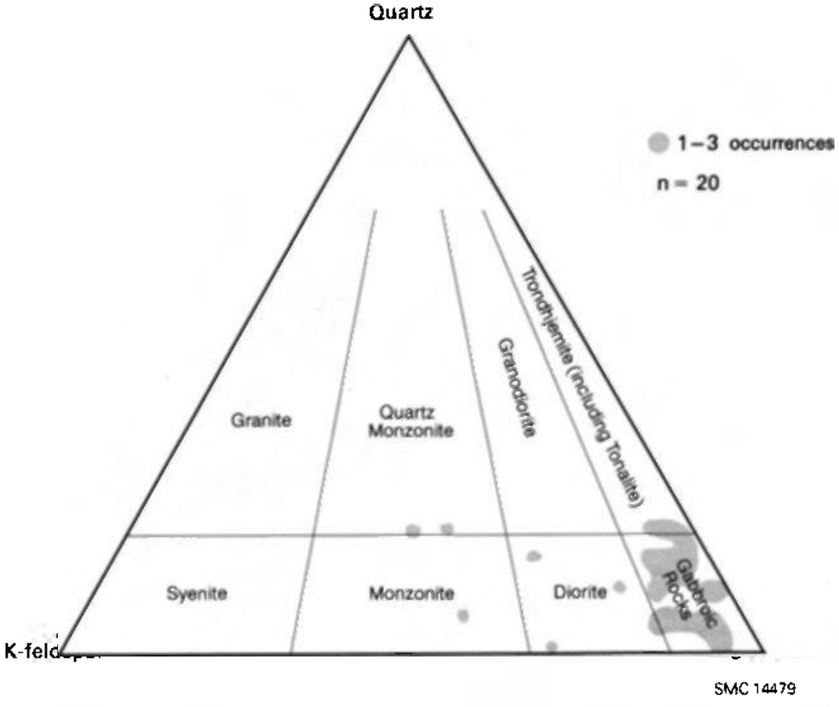

Figure 10–Contoured distribution of the modal compositions of 20 stained samples from the mafic intrusive rocks in terms of quartz, plagioclase, and K-feldspar recalculated to 100 percent.

The inhomogeneity and high degree of structural reworking has caused a variability in the textures and mineralogy of this unit. Locally the unit possesses typical textures and mineral assemblages of hornblende-bearing quartz gabbro, but rocks which are transitional between hornblende-bearing quartz gabbro and hornblende-bearing quartz diorite also are found. Table 11 illustrates the modal compositions of four thin-sectioned samples from this unit. The hornblende quartz gabbro (map-unit 6a) contains very calcic, well twinned plagioclase (An_{70-100}) and more than 10 percent quartz. The plagioclase is usually sericitized and saussuritized. The matrix of samples M729-1 and M477-2 contains untwinned plagioclase. Both samples have large porphyroblasts (2.0-7.0 mm) of well twinned calcic plagioclase, set in a matrix which is primarily granoblastic with a weakly developed preferred orientation. Sample G874-1 is typical of quartz gabbro with a hypidiomorphic granular, medium-grained (0.4-2.0 mm) texture. The biotite in all three samples is psuedomorphic after hornblende and the hornblende locally appears to be psuedomorphic after pyroxene (augite). Epidote, calcite and opaques are minor constituents.

Sample G862-1 represents a hornblende-biotite granodiorite (map-unit 6b). These occur as discordant to subconcordant dikes and contain quartz, plagioclase (untwinned), microcline and biotite as essential phases. Muscovite and calcite also are present in this rock. This rock is fine grained with a granoblastic interlocking texture and hornblende has been completely altered to biotite.

TABLE 11—MODAL ANALYSES (VOLUME PERCENT) OF MAFIC INTRUSIVE ROCKS IN THE KALADAR AREA.

	M729-1	M477-2	G874-1	G862-1
Quartz	11.0	13.0	11.0	35.1
Plagioclase	37.7[1]	25.0[2]	50.7	36.3
An Content	90-100	70-80	85-95	U
Microcline			14.7	9.6
Orthoclase	17.3			
Biotite[3]	15.6	22.0	16.7	7.00
Hornblende	13.3	38.3	5.0	
Muscovite				8.4
Epidote		1.7	<1.0	
Calcite	4.7		1.6	1.7
Opaque	1.0		<4.0	
TOTAL	100.6	100.0	99.7	100.1

SAMPLES
M729-1 Quartz gabbro (map-unit 6a) 2.9 km S of Flinton.
M729-1 Quartz gabbro (map-unit 6a) 4.2 km SW of Flinton.
G874-1 Quartz gabbro (map-unit 6a) 4.9 km SW of Flinton.
G862-1 Hornblende-biotite granodiorite (map-unit 6b) 6.2 km SW of Flinton.

[1] Includes untwinned plagioclase in matrix.

[2] Includes sericitized plagioclase and untwinned plagioclase in matrix.

[3] Pseudomorphic after hornblende

U-Untwinned

Addington and Sheffield Intrusions

The Addington and Sheffield intrusions are grouped together as both have similiar rock compositions. The Addington intrusion is a band of foliated to gneissic biotite granite and quartz monzonite which outcrops as a prominent northeast-trending ridge essentially paralleling Highway 7 in the map-area. The ridge is approximately 1 km wide with a local relief of 65 m. Situated on the northern fringe of the village of Kaladar it is locally known as the Kaladar Hill or Kaladar granite. A thinner parallel ridge of the same material occurs 0.25 km south of the main ridge between the village of Kaladar and the western end of Kennebec Lake. A third ridge of the same size is located on the southern shore of Lingham Lakes. The Sheffield intrusion is located in the southeast corner of the map-area and is composed of swirl foliated and banded to gneissic, pink granite and grey trondhjemite to granodiorite. The Sheffield intrusion is highly transected by northeast- and southeast-trending faults and lineaments.

The Addington intrusion is composed of three major units and two minor

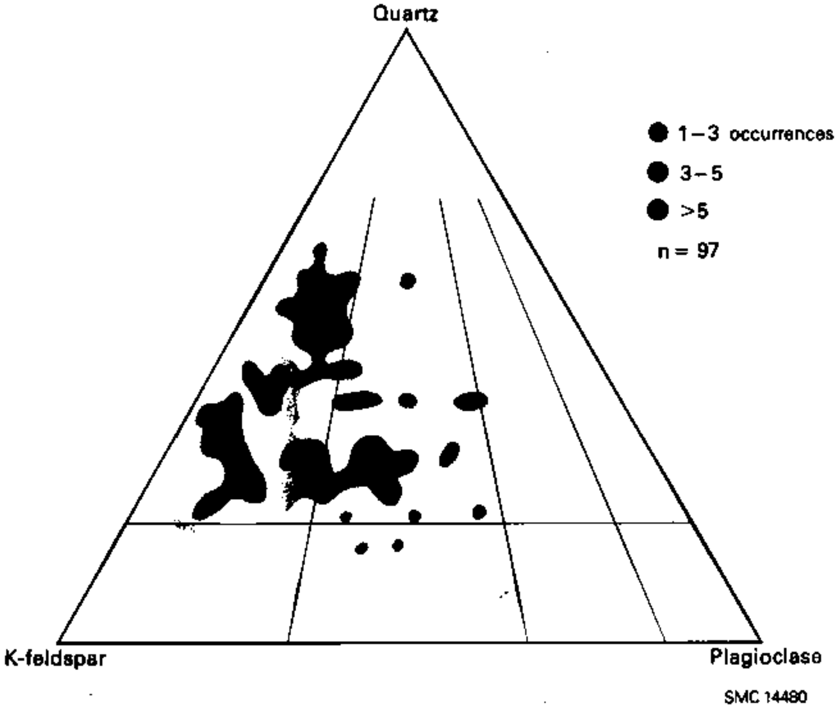

Figure 11–Contoured distribution of the modal compositions of 97 stained samples from the Addington intrusion in terms of quartz, plagioclase and K-feldspar recalculated to 100 percent. For rock classification, see Figure 10.

units. The distribution of 97 stained samples from this intrusion indicates that the bulk composition is quartz monzonitic to granitic (Figure 11).

The Kaladar Hill ridge is mainly composed of map-units 7a, 7b, 7e and lesser amounts of 7d and 7f. The modal compositions of these map-units are given in Table 12 (M241-1, M246-1, M244-1). Map-unit 7a is weakly foliated, leucocratic pink granite which is medium grained (0.3-1.0 mm) and weathers whitish pink. Map-unit 7b is foliated to gneissic, medium-grained (0.3-1.0 mm) pink biotite granite which weathers brownish pink. Map-unit 7d is medium grained (0.2-1.0 mm), foliated to gneissic, leucocratic quartz monzonite and weathers pinkish white-grey. All three units contain quartz, fresh plagioclase (andesine) and microcline, plus minor orthoclase. Map-units 7a and 7d are poor in biotite while map-unit 7b contains up to 25 percent biotite, which in the sample thin sectioned was completely chloritized. Epidote, clinozoisite and opaques are common minor phases. Units 7a and 7b are granoblastic in texture, whereas 7d possesses a mortar texture containing both crushed and recrystallized quartz grains. Map unit 7e is medium grained (0.5-1.0 mm) foliated to gneissic biotite quartz monzonite (biotite less than 25 percent) which weathers brownish, pinkish white-grey. Locally developed in the above units are potassic feldspar augens which are medium grained (less than 2.0 mm) and wrapped by the biotite layers of the foliation-gneissosity. Map-units 7a, b, d and e are very continuous along strike and locally contain thin slices of map-unit 3c (fine-grained biotitic quartzofeldspathic paragneiss) and thin quartz-rich zones both of which are continuous to discontinuous and parallel to the developed foliation-gneissosity. Locally this unit is cut by southeast-trending faults and southeast-trending pink-white pegmatite dikes (map-unit 12b).

The Kaladar to Kennebec Lake ridge is mainly composed of leucocratic pink granite, foliated pink biotite granite and foliated biotite quartz monzonite (map-units 7a, 7b and 7e). Map-units 7a and 7b in this ridge possess mineral assemblages similar to those mentioned above (Table 12, M274-1, M274-3) and have granoblastic and mortar textures with crushed and totally recrystallized quartz grains. Map unit 7e (Table 12, M276-1) contains quartz, plagioclase (andesine), orthoclase and biotite, plus minor amounts of epidote, almandine garnet and calcite. The carbonate occurs in porphyroblasts of radiating acicular grains incorporated from neighbouring carbonate metasediments upon intrusion. The texture of this rock is granoblastic to gneissic. All the rocks in this ridge show chloritization of the biotite. Muscovite in these samples interleaved with biotite locally exhibits acicular forms but is also vermiform. These two muscovite habits suggest two different generations of muscovite. Locally map-units 3c and 5a outcrop discontinuously within this ridge.

The Lingham Lakes ridge is entirely composed of foliated pink biotite granite (map-unit 7b). Similar to the other thin-sectioned samples of this unit, it is composed of quartz, plagioclase (andesine) and microcline and chloritized biotite in a granoblastic interlocking gneissic texture. This ridge contains thin discontinuous slices of medium-grained biotite quartzofeldspathic gneiss and fine-grained hornblende-plagioclase gneiss (map-units 3d and 5a) in lit-par-lit relationships with the granitic intrusive rocks.

The intrusive nature of the Addington intrusion is indicated by the lit-par-lit contact relationships it has with the Hermon Group, the continuous to discontinuous thin slices of the Hermon Group contained within it, and the pecu-

TABLE 12—MODAL ANALYSES (VOLUME PERCENT) OF THE ADDINGTON AND SHEFFIELD INTRUSIONS IN THE KALADAR AREA.

	M241-1	M246-1	M244-1	M274-1	M274-3	M276-1	M001-2	M002-1	M008-2
Quartz	60.0	45.8	46.2	62.7	39.7	56.3	25.7	38.8	38.3
Plagioclase	15.7	15.3	18.4	11.0	22.7	15.7	22.0	18.9	31.8
An Content	30-35	30-35	30-35	U	30-35	30-35	30-35	30-35	S
K-feldspar	16.7	31.2	24.6	13.7	21.3	6.0	39.6	28.5	20.5
	M, O	M, O	M, O	M	M, O	O	M	M	M
Biotite		0.7	0.5	5.0	3.3	19.0	8.7	10.8	4.0
Muscovite	1.0	4.7		7.0	6.0				3.4
Chlorite	1.7	2.3	9.5		3.0				
Epidote	3.3	1.0	0.5			0.5			
Clinozoisite	1.0				1.0				
Spinel				1.0					
Opaque	3.0		0.7	1.0	3.0		3.7	2.9	2.1
Calcite						2.0			
Almandine Garnet						5.0			
TOTAL	100.4	100.0	99.9	100.4	100.0	100.0	99.7	99.9	100.1

SAMPLES

M241-1	Leucocratic quartz monzonite (map-unit 7d). Addington intrusion, Kaladar Hill. 2.6 km SW of Kaladar.
M246-1	Leucocratic pink granite (map-unit 7a). Addington intrusion, Kaladar Hill. 2.4 km WSW of Kaladar.
M244-1	Pink biotite granite (map-unit 7b). Addington intrusion, Kaladar Hill. 2.9 km SW of Kaladar.
M274-1	Leucocratic pink granite (map-unit 7a). Addington intrusion, Kaladar to Kennebec Lake ridge. 6.1 km NE of Kaladar.
M274-3	Pink biotite granite (map-unit 7b). Addington intrusion, Kaladar to Kennebec Lake ridge. 6.1 km NE of Kaladar.
M276-1	Biotite quartz monzonite (map-unit 7e). Addington intrusion, Kaladar to Kennebec Lake ridge. 6.0 km NE of Kaladar.
M001-2	Pink biotite granite (map-unit 7b). Addington intrusion, Lingham Lakes ridge. 8.5 km E of Kaladar.
M002-1	Pink biotite granite (map-unit 7b). Addington intrusion. 8.6 km E of Kaladar.
M008-2	Interbanded pink granite and grey trondhjemite to granodiorite (map-unit 7c). Sheffield intrusion. 9.4 km E of Kaladar.

U—Untwinned.
S—Sericitized.
O—Orthoclase.
M—Microcline.

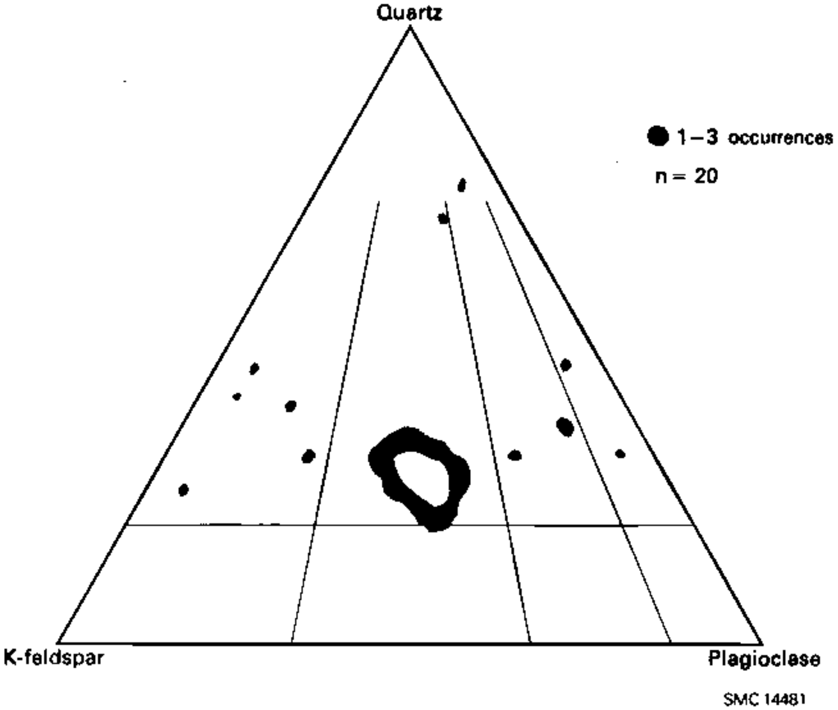

Figure 12–Contoured distribution of the modal compositions of 20 stained samples from the Sheffield intrusion in terms of quartz, plagioclase and K-feldspar recalculated to 100 percent. For rock classification, see Figure 10.

liar existence in a typical "granitic" mineralogy of vermiform muscovite and carbonate porphyroblasts. This unit is interpreted as having intruded the Hermon Group in a lit-par-lit manner with complete granitization commonly developed, yet locally juxtaposed with preserved sedimentary units. The Addington intrusion is not considered to be part of the basement in this study and may likely even postdate the Northbrook Batholith event.

The Sheffield intrusion is quite distinctive in the field from the Addington intrusion. It is composed entirely of map-unit 7c, swirl foliated, banded to gneissic, pink granite to quartz monzonite and grey trondhjemite to granodiorite (Figure 12). This unit displays well developed but highly contorted banding-gneissosity (swirl foliation). Banding is the preferred term for this rock as the planar nature of gneissosity is seldom observed. The banding predominantly comprises alternating pink and grey bands (granite-quartz monzonite and trondhjemite-granodiorite). Mineralogically, the one sample thin sectioned (see Table 12, M008-2) is similar to the samples of the Addington intrusion but the plagioclase is severely sericitized and the biotite is not chloritized. This rock is medium grained (0.5-1.0 mm) and interlocking granoblastic in texture. The highly contorted banding and heavily altered plagioclase grains suggest that the Sheffield intrusion is older than the Addington intrusion, and possibly may represent a basement gneiss in the map-area.

Elzevir Batholith

The Elzevir Batholith outcrops in the western portion of the map-area. This intrusion is the most massive of any in the map-area and is chiefly granodioritic to quartz monzonitic in composition (Figure 13). These rocks weather light grey and are distinguished from the Northbrook Batholith by the general absence of a biotite lineation. Locally, a nearly horizontal lineation is weakly developed and has a seemingly random orientation. However, when examined closely these orientations delineate circular zones. These are interpreted by the author as being due to internal deformation within the batholith created by multistage intrusion. Along the eastern border of the batholith weakly developed lineations are omni-directional indicating the semi-plastic state of the batholith upon intrusion into the Hermon Group. The contact with the Tudor metavolcanics (map-unit 1) is very irregular and inclusions and xenoliths of Tudor material are not uncommon.

The rocks of the batholith are medium grained (0.5-2.0 mm) and the modal compositions of three thin-sectioned samples are presented in Table 13. Both rock types are quite similar in composition except for the feldspar proportions and the presence of more microcline than orthoclase in the quartz monzonite.

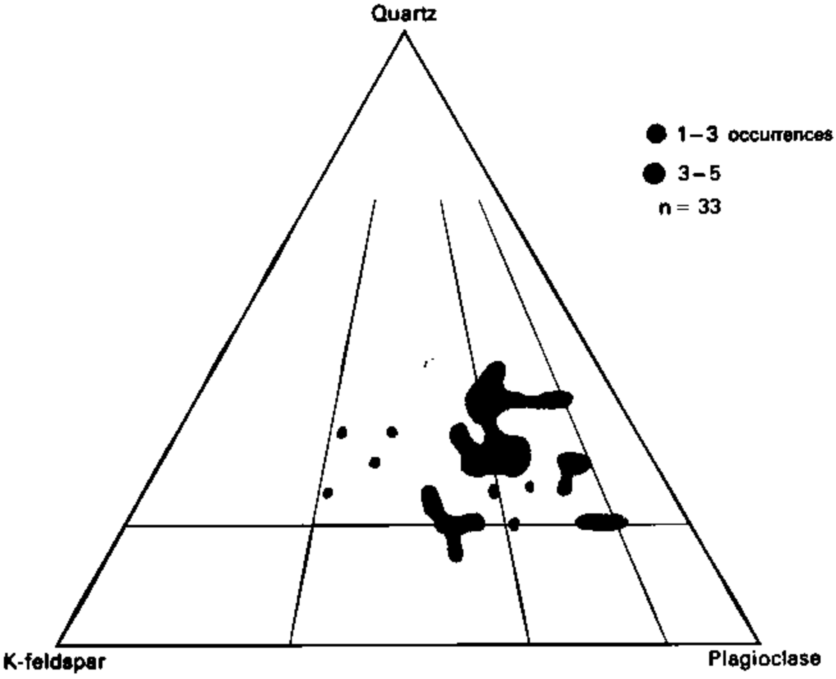

Figure 13–Contoured distribution of the modal compositions of 33 stained samples from the Elzevir Batholith in terms of quartz, plagioclase, and K-feldspar recalculated to 100 percent. For rock classification, see Figure 10.

TABLE 13—MODAL COMPOSITION (VOLUME PERCENT) OF THE ELZEVIR BATHOLITH IN THE KALADAR AREA.

	M666-1	M686-1	M757-1
Quartz	39.0	40.0	48.7
Plagioclase	39.0	31.3	18.7
	U, S	U, S	U, S
Orthoclase ± Microcline	6.7	2.0	6.0
Biotite	8.3	14.0	21.3
Muscovite	3.3	12.3	2.7
Chlorite	1.0		
Epidote	1.0		1.0
Sphene	1.0		1.0
Calcite	1.0	1.0	1.3
Opaque	1.0		
TOTAL	100.3	100.6	99.7

SAMPLES

M666-1 Biotite granodiorite (map-unit 8a), 4.2 km WSW of Northbrook.

M686-1 Biotite granodiorite (map-unit 8a), 2.5 km N of Flinton.

M757-1 Biotite quartz monzonite (map-unit 8b), 6.9 km SW of Flinton.

U—Untwinned

S—Sericitized.

The dominant mafic mineral phase in both rock types is biotite, and the minor mineral phases are muscovite, chlorite, epidote, sphene, calcite and opaques. The biotite is chloritized, and muscovite occurs in two modes: 1) interleaved with biotite, and 2) discrete acicular and vermiform flakes. Sphene occurs as euhedral to subhedral rhombs and wedges. Texturally, these rocks are generally granoblastic interlocking with minor zones of granoblastic gneissic texture (located in the lineated zones mentioned above). The occurrence of sphene and calcite in rocks of these compositions is attributed to the introduction of Ti and Ca upon intrusion of the body into the Tudor metavolcanics.

Northbrook Batholith

The Northbrook Batholith is a large composite batholith which covers approximately 80 km^2 or almost one-third of the map-area. Rocks of the batholith are well exposed from the southwest border of the map-area to the northeast corner. To the southwest, the batholith narrows and continues beyond the map-area for a short distance. To the northeast, the batholith continues out of the map-area for a considerable distance and increases in width. This body is structurally very massive, weakly lineated with a locally developed discontinuous gneissosity. The batholith contains many northeast- and east-trending lineaments which truncate and cut one another. Faults with obvious offsets tend to have southeasterly trends. Some southeast trending pink-white pegmatite dikes (map-unit 12b) cut the batholith along its southern margin. The body is intrusive into the Hermon Group as evidenced by thin linear slice-like inclusions of map-unit 1h along its western margin. The southern contact with the

Hermon Group is poorly exposed and often obliterated by pegmatite intrusions (map-unit 12). The Northbrook Batholith and the Hermon Group form the basement upon which the Flinton Group was deposited.

The composite nature of this batholith is illustrated in Figure 14. This figure represents the distribution of 149 samples from the entire batholith in the map-area in terms of quartz, potassic feldspar and plagioclase recalculated to 100 percent. Although the most densely populated zones are the granodiorite and quartz monzonite fields, substantial numbers of samples fall in both the trondhjemite and granite fields.

Map-unit 9a, biotite trondhjemite (Table 14, G529-1, M472-1) is the phase with the lowest potassic feldspar content in the batholith. The rock weathers grey-white, is medium grained (1.0-1.2 mm) and texturally is granoblastic. The principal mineral phases are quartz, plagioclase (andesine, sericitized) and biotite; the minor phases are microcline, muscovite, epidote, sphene and opaques. The epidote grains often have allanite cores and muscovite tends to occur either as discrete flakes or within the biotite cleavage.

Map-unit 9b is biotite granodiorite. The unit does not weather as white as the biotite trondhjemite and upon close examination usually contains more pink feldspar, although map-units 9a and 9b can often look alike in the unstained hand specimen. This unit is medium grained (0.5-1.8 mm). The dominant minerals are quartz, plagioclase (bytownite, saussuritized) and biotite with minor microcline, hornblende, epidote and sphene (Table 14, G576-1). This rock has an interlocking granoblastic texture with hornblende grains wrapped by biotite flakes which have euhedral sphene wedges in their cleavage. The epidote grains tend to have allanite cores.

TABLE 14—MODAL COMPOSITIONS (VOLUME PERCENT) OF THE NORTHBROOK BATHOLITH IN THE KALADAR AREA.

	G529-1	M472-1	G576-1	M383-1	M327-1	M550-1
Quartz	35.3	39.9	32.2	33.7	48.3	56.3
Plagioclase	44.3	39.5	44.2	26.6	14.1	15.3
An content	S	30-35	75-80, Sa	30-35, S	30-35, Sa	S
Microcline	3.3	1.3	4.3	15.0	29.0	24.4
Muscovite	5.3				3.3	2.0
Biotite	10.3	14.2	10.7	16.6	5.0	1.0
Hornblende			4.4	0.6		
Epidote	1.0	5.7	3.4	3.7	0.5	<0.5
Sphene	0.5		1.0	1.6	0.5	
Opaque	1.0			2.0		<0.5
TOTAL	100.0	99.6	100.2	99.8	100.2	100.0

SAMPLES

G529-1	Biotite trondhjemite (map-unit 9a). 1.1 km SE of Northbrook.
M472-1	Biotite trondhjemite (map-unit 9a) 2.6 km SE of Flinton.
G576-1	Biotite granodiorite (map-unit 9b). 3.9 km SE of Northbrook.
M383-1	Biotite quartz monzonite (map-unit 9c) 3.4 km SE of Northbrook
M327-1	Biotite granite (map-unit 9d). 11.2 km E of Northbrook.
M550-1	Potassic feldspar segregations (map-unit 9f). 6.8 km S of Flinton

S—Sericitized
Sa—Saussuritized

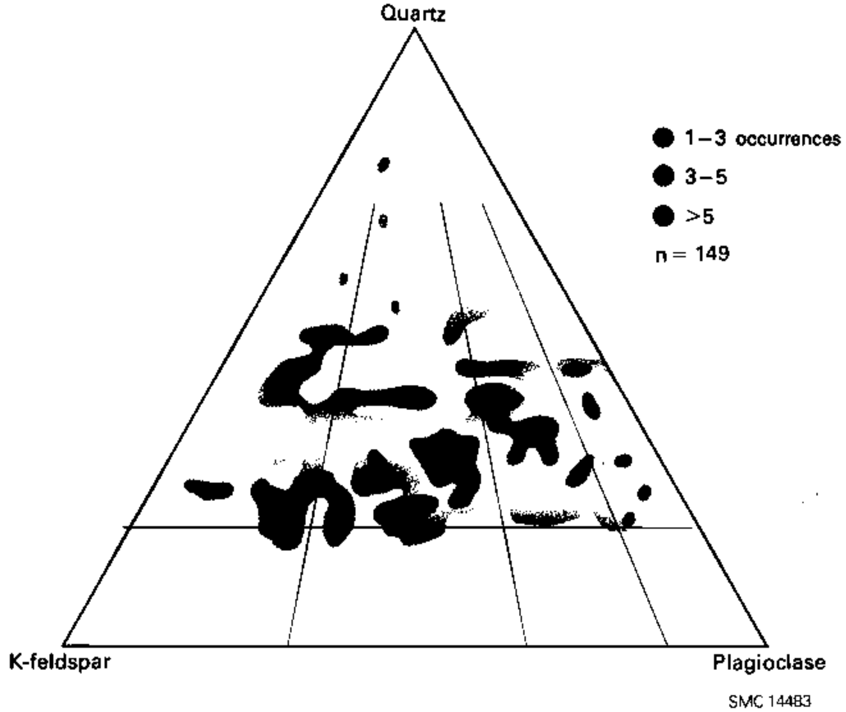

Figure 14–Contoured distribution of the modal compositions of 149 stained samples from the Northbrook Batholith in terms of quartz, plagioclase and K-feldspar recalculated to 100 percent. For rock classification, see Figure 10.

Map-unit 9c is biotite quartz monzonite which weathers a distinctive pinkish white-grey and is medium grained (0.5-1.2 mm). The dominant minerals (Table 14, M383-1) are quartz, plagioclase (andesine), microcline and biotite. Hornblende, epidote, allanite, sphene and opaques comprise the minor phases. The epidote tends to be an alteration product of biotite and hornblende while sphene and allanite are subhedral to euhedral grains. This particular sample is from a foliated to gneissic zone and displays a recrystallized mortar texture of the quartz grains suggesting the locally developed gneissosity may be tectonic in origin.

Map-unit 9d is biotite granite, a pink weathering rock which is medium grained (0.4-1.6 mm) containing quartz, plagioclase (andesine, saussuritized) and microcline as major phases (Table 14, M327-1). The minor phases are biotite, muscovite, epidote and sphene. Sample M327-1 has a granoblastic texture with the quartz forming crude discontinuous layers. The quartz appears to be totally recrystallized in this sample.

Map-unit 9f is fine grained (less than 0.5 mm) potassic feldspar segregations which consist of white weathering aplite. These aplites are discontinuous and parallel to the local lineation and gneissosity (if present). The boundaries with the country rock are indistinct and gradational. The principal mineral phases in one sample thin sectioned (Table 14, M550-1) are quartz, plagioclase (sericitized) and microcline with minor amounts of muscovite, biotite, epidote and opaques. The rock has a granoblastic interlocking texture and is quartz monzonitic in composition.

Map-unit 9g represents discontinuous hornblende-plagioclase to amphibolite phases within the Northbrook Batholith. Although these units have sharp contacts with the rocks of the batholith they are usually parallel to the developed lineation and gneissosity (if present). Typically these units are less than 1 m wide and discontinuous on an outcrop scale, but can be up to 3 m wide and traced for up to 0.5 km. East of Highway 41 these units are hornblende-plagioclase gneiss but west of the highway amphibolite is predominant. These units are interpreted as being remnant xenoliths of the Hermon Group mafic metavolcanics and calc-silicate gneiss which have not been totally assimilated into the Northbrook Batholith.

The more K-feldspar rich units locally contain K-feldspar augens (map-unit 9c). These are typically medium grained (less than 5 mm). Map-unit 9h indicates the presence of epidote-rich veinlets which are locally abundant in the batholith. The western portion of the batholith in the map-area contains more sphene and hornblende than do the northern or eastern portions. This is interpreted by the author as a result of the Northbrook Batholith intruding the mafic volcanic pile (map-unit 1) along the western border and picking up sufficient amounts of Ca, Mg, Ti, and Fe to form these minerals.

METASEDIMENTS

Flinton Group

The Flinton Group is a formally defined (Moore and Thompson 1972), largely metaclastic succession which lies unconformably on all the preceeding units. In the map-area this group is largely confined to two narrow synformal structures which strike N15E and transect the lithologies of the western map-area near the village of Flinton. The easternmost synform is continuous in the map-area but the westernmost is discontinuous and is not present south of Flinton. In addition to these two zones the Kaladar metaconglomerate 3.5 km north of Kaladar is included by the author in the Flinton Group because it lies unconformably on the Northbrook Batholith. In the map-area the Flinton Group can be subdivided into two major rock units: clastic siliceous metasediments and carbonate metasediments.

CLASTIC SILICEOUS METASEDIMENTS

The rocks of this unit are essentially equivalent to the Bishop Corners Formation as defined and mapped by Thompson (1972). It is considered to be the basal unit in the Flinton Group near the village of Flinton.

TABLE 15—MODAL ANALYSES (VOLUME PERCENT) OF THE CLASTIC SILICEOUS METASEDIMENTS OF THE FLINTON GROUP IN THE KALADAR AREA.

	M469-2	M451-6	M500-2	M479-2	M481-2
Quartz	53.7	75.0	83.3	79.1	64.0
Plagioclase	5.7	7.3	2.0		12.3
An Content	S	30-35	S		
Microcline			1.6	1.0	
Orthoclase		7.0			
Muscovite	16.7	1.0	9.0	16.9	16.0
Biotite	9.0	2.7	4.0		12.3
Almandine garnet		5.7			
Calcite	7.3				
Epidote	6.0	1.0			7.0
Zircon		1.0			
Opaque	1.3		<1.0	1.5	1.0
TOTAL	99.7	99.7	99.9	100.5	100.3

SAMPLES

M469-2	Quartzofeldspathic sandstone (map-unit 10a), 2.1 km SE of Flinton.
M451-6	Matrix of quartz-pebble conglomerate (map-unit 10b) 5.0 km NE of Kaladar
M500-2	Matrix of quartz-pebble conglomerate (map-unit 10b) 2.8 km NW of Kaladar
M479-2	Matrix of quartz-pebble conglomerate (map-unit 10b) 3.0 km SW of Northbrook.
M481-2	Biotite-quartz-feldspar schist (map-unit 10d), 2.6 km SW of Northbrook.

S—Sericitized

Map-unit 10a is a quartzofeldspathic sandstone with local quartzofeldspathic conglomerate units. This rock contains quartz, plagioclase, mica and potassic feldspar as the main minerals with tourmaline, carbonate, oxide and apatite as accessories, (Thompson 1972). A sample thin sectioned in this study reveals quartz, muscovite, biotite, plagioclase (untwinned), calcite, and epidote (Table 15, M469-2), and minor opaques. Texturally, this rock is granoblastic with a weakly defined foliation which appears to be relict bedding planes. The rock weathers a buff-pinkish white with a distinctive differential ribbing parallel to strike of feldspar rich and poor zones. The sandstone is medium grained (0.5-2.0 mm) as is the matrix of the metaconglomerate phases. The clasts in the metaconglomerate are pebble size (5-15 mm). Compositionally the pebbles are mainly white quartzite with more minor amounts of vein quartz and trace amounts of black quartz. Preferential weathering causes the pebbles in this conglomerate to stand out in relief with respect to the matrix. This unit is well exposed and stratigraphically separates the quartz-pebble metaconglomerate (map-unit 10b) from the carbonate metasediments (map-unit 11).

Map-unit 10b is quartz-pebble metaconglomerate which locally contains an aluminous micaceous matrix and lenses of quartzite. This unit is well exposed and continuous along strike in the synformal structures east of Flinton and is well exposed in the southernmost margin of the Kaladar metaconglomerate 3.5 km north of Kaladar. This unit weathers a distinct white to shiny grey and depending on the matrix composition may be smooth or have outstanding pebbles. The matrix in general composes 40 percent of the rock by volume and is either quartzofeldspathic (containing quartz, plagioclase and K-feldspar with minor amounts of muscovite, biotite and garnet with or without apatite and tourmaline) or micaceous (composed of muscovite, biotite and hematite with lesser amounts of quartz, feldspar, carbonate, epidote, apatite and tourmaline). The matrix is fine grained to medium grained (0.3-1.0 mm). The clasts are always pebble size (5-15 cm most commonly) and rounded but deformed with flattened ellipsoidal shapes. Thompson (1972) reported that 50-67 percent of the pebble population is composed of grey to white quartzite, 25 percent of vein quartz, 10 percent of black quartzite and rare granitic clasts. Two samples of the matrix of this unit where it outcrops north of Kaladar were thin sectioned. The modal compositions are presented in Table 15 (M451-6, M500-2). Quartz, plagioclase (andesine to sericitized), and potassic feldspar (orthoclase and microcline) compose the bulk of the rock. Minor phases tend to be muscovite, biotite, garnet, epidote, zircon and opaques. The samples both display classic mortar textures; crushed quartz as well as recrystallized crushed quartz are both present. Garnets are poikiloblastic and biotite grains are partially chloritized. Sample M451-6 was taken from a migmatized screen of uraniferous quartz-pebble metaconglomerate (see "Economic Geology"). One sample of the matrix from this unit east of Flinton was also thin sectioned and found to be very similar in modal compositions to those discussed above but containing more muscovite and less feldspar (Table 15, M479-2).

Map-unit 10c is massive, grey to white weathering quartzite. This unit is medium grained (0.6-1.5 mm) and outcrops northeast of Flinton and on strike with the 10b unit north of Kaladar (mentioned above). This unit occurs as continuous to discontinuous layers or lenses parallel to strike. Quartz is the obvious major phase with minor hematite, mica, feldspar, epidote and tourmaline comprising a total of approximately 10 percent. Thompson (1972) reported that locally trough crossbedding is present in this unit. A poorly exposed unit similar to map-unit 10c is map-unit 10e, a quartzofeldspathic sandstone. Weathering a buff-pinkish-white colour this unit is also medium grained (0.6-1.5 mm) but contains more feldspar than the above unit.

Map-unit 10d is a biotite-quartz-feldspar schist with hornblende and garnet as accessory phases. In the map-area this unit weathers dark black and outcrops along the unconformable contact with the Hermon Group mafic metavolcanics (Tudor Formation, map-unit 1). This contact is often sheared and the biotite schist is poorly exposed and very thin (less than 20 m thick). The major phases are biotite, chlorite, plagioclase (oligoclase), garnet, quartz and Fe oxides. Tourmaline and apatite are minor accessories. Near the contact with map-unit 1 this unit contains hornblende which along with garnet forms medium-grained (1-2 mm) poikiloblasts in an otherwise fine-grained (less than 0.5 mm) schistose rock. Staurolite is locally developed in hornblende-free zones within this unit (Thompson 1972). Where this unit is in contact with the quartzite units of 10c above, it contains little feldspar and more muscovite (Table 15, M481-2).

CARBONATE METASEDIMENTS

Map-unit 11 is composed of those rocks which Thompson (1972) mapped as the Lessard Formation. Although overlying the Bishop Corners Formation in the study area of Thompson, in the present map-area members of this unit lie unconformably on the Northbrook Batholith 3.5 km north of Kaladar.

Map-unit 11a is carbonate-biotite schist. This unit weathers a distinctive brown mixed with pinkish tones, and is generally medium grained (0.5-1.0 mm). Spatially this unit occupies the central portions of the synformal structures east of Flinton. The dominant minerals are biotite, carbonate (ferroan calcite and ferroan dolomite, Thompson 1972), plagioclase and quartz. Minor phases are apatite, tourmaline, zircon and pyrite. Thompson (1972) reported this unit to vary in composition from more siliceous phases near the base (with minor quartzite and granitic pebbles) to more carbonate-rich compositions up section. These latter compositions also contain microcline and actinolitic amphibole.

Map-unit 11b is polymictic pebble metaconglomerate which has a matrix of plagioclase-hornblende gneiss, calcite and potassic feldspar, and pebbles which are largely granitic in composition. This unit weathers dark green with pale grey to pink clasts. Within the map-area this unit outcrops in one main zone situated 3.5 km north of Kaladar and the rocks in this location have often been referred to as the Kaladar metaconglomerate and have been examined by many workers, including more recently studies by Walton *et al.* (1964), van de Kamp (1971) and Psutka (1976). Thompson (1972) reported an occurrence of this rock type in the Flinton structure southwest of this map-area.

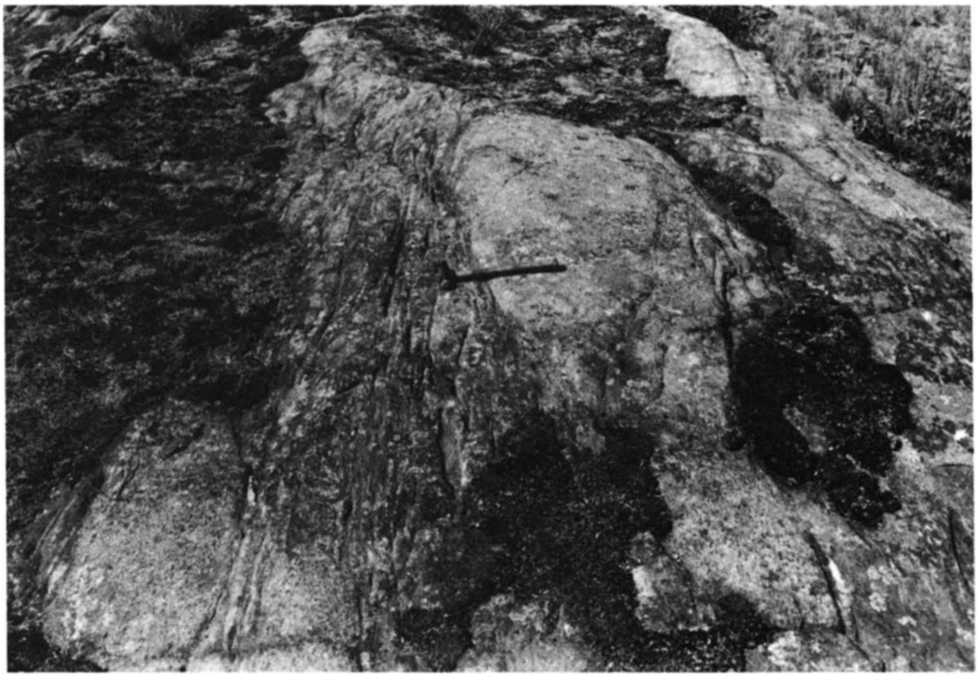

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Photo 3–Basal conglomerate at unconformity between the Northbrook granodiorite (right) and polymictic conglomerate (left). The large blocks are lineated biotite granodiorite completely surrounded by polymictic conglomerate matrix. Hammer handle is 0.3 m long.

OGS 10 341

Photo 4–Typical polymictic conglomerate 3.5 km north of Kaladar. Pebbles are stretched parallel to the foliation gneissosity. Hammer handle is 0.2 m long.

In the map-area this unit rests unconformably on the Northbrook Batholith. Photo 3 shows the nature of this contact which is interpreted by the author as a basal conglomerate. The large blocks are up to 1 m in the longest dimension but many of 0.5 m and less are found in this zone. The blocks are completely surrounded by matrix although this can be locally difficult to trace in the zone of larger blocks close to the contact. The matrix tends to contain many pebbles and cobbles in this zone and the clasts at the contact are biotite granodiorite in composition, which is the same material as the Northbrook Batholith at this locality. It would appear that the larger blocks have not moved far but may represent large fractured debris which has since been deformed essentially in situ to its present form. Away from the contact into the metaconglomerate, the size of the clasts quickly drops to pebble size and the amount of granodioritic material becomes less.

Away from the unconformity the matrix is fine grained to medium grained (0.2-1.0 mm) and gneissic with alternating mafic and felsic layers of granoblastic grains defining the compositional layering. Where the quartz content is high, mortar textures are preserved and the quartz is recrystallized. The pebbles are generally 5 to 15 cm in size and rounded but have been deformed into flattened ellipsoidal forms. Photo 4 depicts the typical character of this unit in outcrop. The modal compositions of the matrix are variable due to the extreme layer to layer differences thus impeding representative sampling. The results of the previously mentioned workers provide the following compositional range (based only on point counted samples): quartz 15-40 percent, hornblende 10-40 percent, plagioclase (oligoclase to andesine) 2-30 percent, K-feldspar 3-30 percent, epidote 3-30 percent, and biotite 3-30 percent; the minor phases include diopside trace-10 percent, calcite < 4 percent, chlorite < 3 percent, sphene < 2 percent and opaques, zircon, apatite, tourmaline and garnet all less than 1 percent. One thin sectioned sample of this matrix was examined in this study (Table 16, M444-1). The clasts are primarily composed of granodiorite, aplite and quartz monzonite with very minor amounts of vein quartz, quartzite and pyroxenite.

The provenance of this deposit is of major interest. Van de Kamp (1971) in comparing the geochemistry of 26 samples of the metaconglomerate matrix showed, from the average composition of these rocks and other sedimentary rocks (see Table 10) as well as elemental variation patterns, that the parent material for the matrix was neither para-amphibolite nor ortho-amphibolite but likely a mixture of local granitic gneisses and basic metavolcanics forming an immature mafic sandstone. The source of the pebbles is another matter.

TABLE 16—MODAL ANALYSES (VOLUME PERCENT) OF THE CARBONATE METASEDIMENTS OF THE FLINTON GROUP IN THE KALADAR AREA.

	M444-1	M474-2	M476-2
Quartz	19.7	39.0	71.0
Plagioclase	28.0	6.7	5.6
An Content	U, S	30-35, Sa	U
Orthoclase	2.7		
Microcline		10.3	
Hornblende	40.0		
Epidote	9.0	6.3	1.0
Biotite		10.3	4.3
Muscovite		17.0	12.7
Calcite		10.0	5.0
Sphene	1.3		
Opaque		1.0	1.0
TOTAL	100.7	100.6	99.6

SAMPLES

M444-1	Matrix of polymictic conglomerate (map-unit 11b) (Kaladar Conglomerate). 4.4 km N of Kaladar.
M474-2	Carbonate-bearing quartzofeldspathic sandstone (map-unit 11e). 2.0 km SE of Flinton.
M476-2	Carbonate-bearing quartzofeldspathic sandstone (map-unit 11e). 1.9 km SE of Flinton.

U—Untwinned.
S—Sericitized.
Sa—Saussuritized.

Thompson (1972) suggested the Northbrook Batholith and the Addington intrusion could be likely contributors and Psutka (1976) verified this by demonstrating that the Northbrook Batholith alone does not contain quartz monzonitic and granitic compositions. However, in light of the composite nature of the Northbrook Batholith revealed in this study it is possible to obtain all the pebble compositions (except minor pyroxenite) from the Northbrook Batholith alone. Thus the provenance of the Kaladar metaconglomerate is likely the Northbrook Batholith (map-unit 9) plus contributions from the mafic metavolcanics of the Hermon Group (map-unit 1). The Kaladar metaconglomerate is crosscut by pink-white pegmatite dikes trending southeast (map-unit 12b).

Map-unit 11c is calc-silicate (plagioclase-hornblende) gneiss with epidote. This unit occurs at the junction of the southern boundary of the map-area and the Flinton Group. It is a mappable unit to the south (Thompson 1972), but poorly developed in the map-area. A fine grained to medium grained unit (0.3-1.0 mm), it possesses a distinctive green and pink striped colouration reflecting the compositional layering. The principal minerals are quartz, microcline, plagioclase, epidote, amphibole, diopside and calcite. Minor phases are sphene, apatite and oxides plus minor scapolite after plagioclase. Pebbles locally occur in this unit south of the map-area and the unit is considered to be the stratigraphic equivalent of map-unit 11e but at a higher metamorphic grade (Thompson 1972).

Map-unit 11d is an epidote-free variety of map-unit 11c and occurs in the same portion of the map-area. This unit is the high grade equivalent of the carbonate-biotite schist (map-unit 11a) (Thompson 1972) and is fine grained (less than 0.5 mm) containing diopside, actinolite, quartz, microcline, calcite and sphene, with accessory amounts of zircon, apatite and pyrrhotite. The unit weathers brown-green and the compositional layering is discontinuously developed.

Map-unit 11e is carbonate-bearing quartzofeldspathic sandstone. This unit is mainly exposed in the western synformal structure northeast of Flinton. This unit weathers grey-brown buff and is medium grained (0.5-2.0 mm) with a sandy texture. Locally quartzite pebbles (5-10 cm) can be found. Two samples from this unit were thin sectioned and modal compositions (Table 16) reveal the dominant phases are quartz, plagioclase, microcline, muscovite, biotite, calcite and epidote. Thompson (1972) reported that when dolomite occurs in this rock epidote and actinolite may be present, but both carbonates are ferroan. Minor phases are iron oxide, tourmaline, zircon and apatite.

LATE TECTONIC FELSIC INTRUSIVE ROCKS

The late tectonic felsic intrusive rocks are composed of three main rock types including coarse grained leucocratic granitic dikes (map-unit 12a), pink to white pegmatite dikes (map-unit 12b) and pink to white pegmatite sills with inclusions of country rock (map-unit 12c). This last unit is by far the most striking of the three. Spatially confined to the southeastern border of the Northbrook Batholith, this unit is continuous across the map-area. Composed of coarse-grained pink-white pegmatite, it intruded parallel to the developed foliation gneissosity and locally warped and bulged the country rocks on its flanks.

Screens and blocks of country rock are assimilated in this unit and often reach volumes of 0.5 m^3 (Photo 5). This unit itself is not folded and stratigraphically essentially separates the bulk of the Hermon Group from the Flinton Group south of the Northbrook Batholith indicating it may have intruded along a regional structural break.

The majority of the pink-white pegmatite dikes (map-unit 12b) strike at high angles to the pegmatite sill (map-unit 12c) and are concentrated to the north and south of this body cutting into the Northbrook Batholith and Kaladar Hill ridge of the Addington intrusion. The pegmatite dikes are typically 0.3 to 0.8 m in width although near the coarse grained leucocratic granitic dikes these widths substantially increase to 1 m, with local widths up to 5 m. Both map-units 12a and 12b appear to be of the same age. The pegmatite is often very leucocratic but in places contains large flakes (3.0-10.0 cm) of biotite, muscovite, phlogopite and concentrations of garnet, molybdenum and uranium (see "Economic Geology"), depending upon the composition of the assimilated material.

Map-unit 12a is poorly developed and occurs near the southern boundary of the Northbrook Batholith. It comprises coarse grained pink-white leucocratic granitic dikes which are not deformed. Not observed in contact with map-units 12b or 12c, it may be slightly older as it is compositionally similar to the Addington intrusion and may be related to this intrusive event.

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Photo 5–Block of assimilated country rock in massive white pegmatite sill (map-unit 12c). Hammer handle is 0.2 m long. 4 km north of Kaladar.

Cenozoic

QUATERNARY

Pleistocene and Recent

The bulk of the Cenozoic sediments in the map-area were deposited during the Pleistocene epoch in glacial and post-glacial lakes. Most of these deposits are outwash deposits of sand, silt, clay and till. The largest Pleistocene deposit is a prominent sand plain which extends from the southwest corner of the map-area to the village of Flinton and eastwards to Highway 41. Another well developed sand plain is situated at the village of Northbrook and extends eastwards for approximately 3 km. Although chiefly composed of sand these plains locally contain concentrations of silt and clay. The depth of sand is likely quite shallow as bedrock frequently outcrops in these areas. Smaller sand, silt and clay deposits dot the map-area and usually have bedrock outcropping. The glacial deposits are quite dispersed in occurrence and tend to be local concentrations which have been worked for their gravel potential (see "Economic Geology").

A number of glacial erosion features are preserved in the map-area, especially along the Skootamatta River and Little Skootamatta Creek. Bedrock exposures along these waterways locally display chattermarks and potholes. Potholes are typically 35 cm in diameter and up to 1 m deep. No glacial striae were noted in the map-area.

The Recent deposits in the map-area are composed of organic swamps and alluvial deposits. The majority of the swamps are located in two types of settings, either occupying faults zones or in low-lying areas parallel to the regional foliation-gneissosity. The first type is generally limited to the intrusive rocks and is common in the Northbrook Batholith and Sheffield 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 very long (up to 10 km) but usually less than 1 km across and parallel to the regional structural fabric. These swamps are most prominent over the Hermon Group metasediments and contain prominent lake systems, including Kennebec Lake, Otter Creek Lakes and Lingham Lakes. Between the lakes in any given linear swamp is densely vegetated spruce and/or cedar vegetation with a muskeg base. The Recent alluvial deposits are associated with these swamps and include minor stream sediments and deltaic deposits, the latter being developed at the west end of Kennebec Lake.

METAMORPHISM

Metamorphism in the map-area is quite variable due to the large number of different bulk rock compositions, the variable stress-strain patterns and the injection of granitic material throughout the stratigraphy. The field of metamorphic petrology has also undergone great changes in the last ten years and terminology and concepts previously used are seldom implemented today. The present study uses the terminology of Winkler (1976) and the key terms have been defined at the beginning of this report.

Metamorphism in the map-area is best observed in the metavolcanic and metasedimentary sequences. The Hermon Group metasediments south of the Northbrook Batholith, and the Flinton Group metasediments and Hermon Group metavolcanics near the village of Flinton have been grouped into zones A and B respectively for the purpose of examining the metamorphism in the map-area. The Northbrook Batholith does not appear to be metamorphosed; the occurrence of sphene near its western margin does not appear to have formed from the anatectic melt of biotite and plagioclase plus quartz as suggested by Busch (1966, 1970), as no hornblende is produced and biotite, plagioclase and quartz remain stable phases. The Elzevir Batholith may be slightly metamorphosed as it locally appears recrystallized, however, this has been reported to decrease towards its core (Thompson 1972). The contaminated mafic intrusive rocks (map-unit 6) are also metamorphosed as actinolitic amphibole locally occurs within them.

ZONE A

Metamorphic zone A includes all the rocks south of the Northbrook Batholith in the map-area including the Clare River Synform structure. The metamorphic mineral assemblages in these lithologies are as follows.

Clastic Siliceous Gneiss (map-unit 3).

Quartz + plagioclase + muscovite + biotite + chlorite.
Quartz + plagioclase + muscovite + biotite + almandine + epidote.
Quartz + plagioclase + muscovite + biotite + almandine.
Quartz + plagioclase + muscovite + biotite + epidote.

Amphibole-Rich Gneiss (map-unit 5).

Plagioclase (oligoclase-andesine) + hornblende + biotite + quartz + calcite + epidote + sphene + garnet + (scapolite + apatite).
Plagioclase (oligoclase-andesine) + hornblende + quartz + calcite + epidote.
Plagioclase (oligoclase-andesine) + biotite + quartz + chlorite + epidote + calcite.
Plagioclase (oligoclase-andesine) + hornblende + quartz + epidote.
Plagioclase (oligoclase-andesine) + hornblende.

Carbonate Metasediments (map-unit 4).

Calcite + dolomite + diopside + tremolite + quartz.

Aluminous Schist (map-unit 2) and Quartzofeldspathic Sandstone (map-unit 11e).

Quartz + muscovite + biotite + garnet + cordierite.
Quartz + muscovite + biotite + sillimanite + garnet (Sethuraman 1970).
Quartz + muscovite + biotite + staurolite + garnet + orthoclase (Psutka 1976).

Examination of these mineral assemblages reveals a number of interesting mineral groupings. The clastic siliceous gneiss shows that the formation of almandine garnet may have occurred by two different reactions depending upon the presence or absence of epidote (Winkler 1976, p.215):

a) chlorite + biotite + quartz → almandine + biotite + H_2O
b) chlorite + muscovite + epidote → almandine + biotite + H_2O

These garnets predate the foliation-gneissosity. Chlorite where it occurs is mostly a late stage alteration product formed from biotite, and epidote tends to occur in those clastic siliceous gneiss units which are in contact with amphibole-rich gneiss units. Biotite and muscovite are often interleaved and muscovite flakes are intergrown with quartz, producing a vermiform texture. These assemblages indicate that these rocks belong to the high temperature (400-500°C) part of low grade metamorphism situated above the "biotite + muscovite in" isoreaction-grad, locally above the "almandine in" isoreaction-grad but also locally below the "muscovite-chlorite out" isoreaction-grad (Figure 15).

The amphibole-rich gneiss assemblages indicate that two types of epidote assemblages exist, one which has calcite present and the other with calcite absent. In the assemblages where calcite is absent the epidote is an alteration phase of the hornblende. The chlorite phases have no hornblende present and the biotite-free phases have more than 50 percent hornblende present. Where both biotite and hornblende occur together the biotite tends to postdate the hornblende and almandine garnet appears to have formed from the reaction (Winkler 1976, p.215):

chlorite + biotite + quartz → almandine + biotite + H_2O

The plagioclase present is typically oligoclase to andesine which would indicate these assemblages lie above the isoreaction-grad "An_{17} + hornblende in" (Figure 15). It should be mentioned that in those phases where epidote is present in hornblende-plagioclase-quartz gneiss the An content is higher than in those paragneisses where epidote is absent (Wenk and Kellar 1969). Thus the positioning of these rocks with the above assemblage of plagioclase and hornblende on Figure 15 is conservative. Those assemblages containing chlorite are also stable in this P-T field. Locally, scapolite is present and is accompanied by apatite. The formation of scapolite in such rocks indicates the existence of alteration fluids rich in Cl, CO_2, and H_2O (Shaw 1960). Alteration is also present in the oxidation of ferrous iron and the local but rare formation of talc in these units.

The carbonate rocks especially those which show dedolomitization and the presence of diopside and tremolite are indicative of medium grade metamorphism (see Figure 15).

The aluminous schists and quartzofeldspathic sandstone units possess mineral assemblages which suggest a higher temperature regime than that established above. This part of zone A is one of much stress and strain (shearing) which locally increases the metamorphic grade as well. The coexistence of cordierite, almandine garnet, biotite, muscovite and quartz in a rock which nearby has staurolite present suggests that the following reaction may have been possible (Winkler 1976, p.224), assuming that muscovite and quartz did not already coexist:

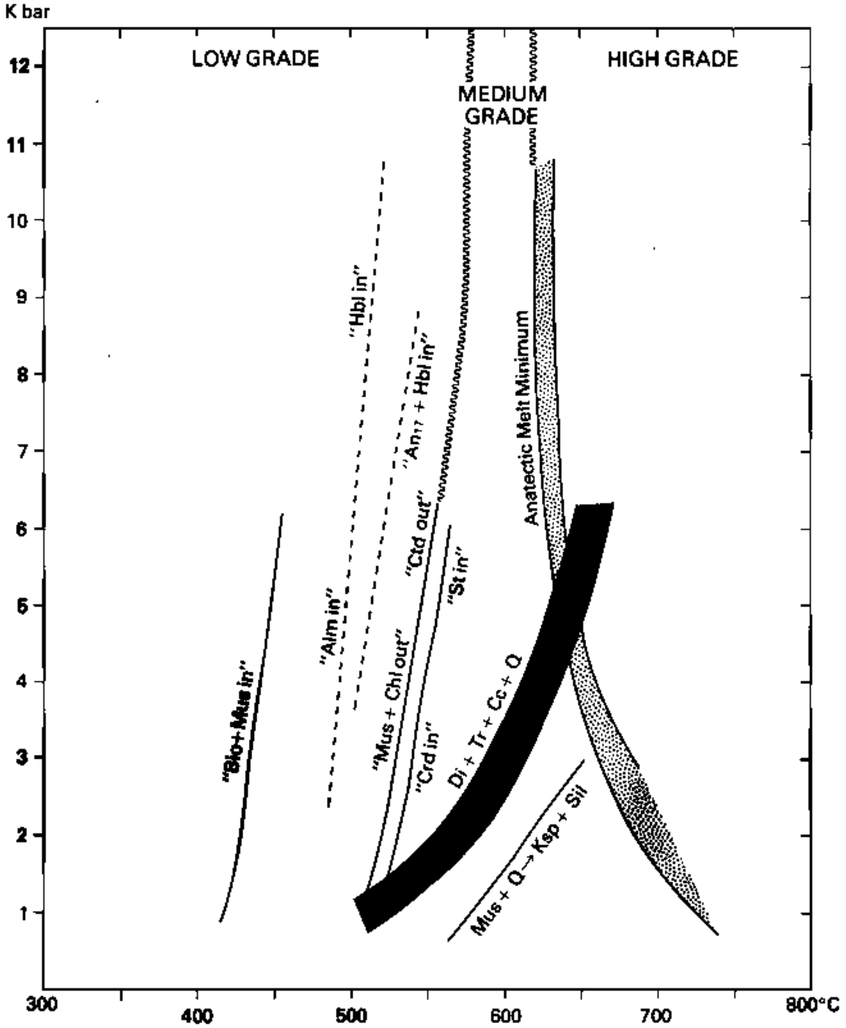

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Figure 15–The pressure-temperature domain (from Winkler 1976, p.238, 242) for the isoreaction grads present in the Kaladar area, indicating metamorphism in the Herman Group metasediments ranges from the high temperature portion of low grade metamorphism to the lower limit of anatectic melting or high grade metamorphism. Bio = biotite, Mus = muscovite, Alm = almandine garnet, Hbl = hornblende, An = plagioclase composition, Chl = chlorite, Ctd = chloritoid, Crd = cordierite, St = staurolite, Di = diopside, Tr = tremolite, Cc = calcite, Q = quartz, Ksp = K-feldspar and Sil = sillimanite.

staurolite + biotite + quartz → cordierite + garnet + muscovite + H_2O.

This reaction typifies the higher temperature part of medium grade metamorphism (Figure 15). The coexistence of sillimanite, almandine garnet and quartz plus biotite in this part of zone A also indicates this to be a high temperature portion of medium grade metamorphism. Walton *et al.* (1964) in their study of mineral zonation in the pebbles of the Kaladar metaconglomerate distinguished a number of reactions accounting for the minerals present in the pebbles. The reactions indicate that Na, K and Ca cations were mobile during the progressive increase in metamorphism from low grade (greenschist facies) to medium grade (almandine amphibolite facies). Also located in this part of zone A are a number of migmatitic pegmatites (map-unit 12c), indicative of partial melting. These features together with the above mineral assemblages indicate the rocks near the Northbrook Batholith are of a higher metamorphic grade than the other units in zone A.

Pressures do not appear to be easily discernable in this metamorphic zone. All mineral phases tend to be explained by thermal and bulk composition differences and can therefore be considered essentially isobaric and likely between 3 and 5 Kbar in order to accomodate the presence of diopside, tremolite, calcite and quartz in the carbonate rocks.

Intrusive into these units is the Addington intrusion which displays the following mineral assemblages.

Quartz + plagioclase (andesine) + K-feldspar + biotite + chlorite + muscovite ± epidote.

Quartz + plagioclase (andesine) + K-feldspar + biotite + chlorite ± epidote ± (garnet + calcite).

These rocks indicate the coexistence of several metastable phases: 1) muscovite in the presence of K-feldspar, quartz and plagioclase without an alumino-silicate (Al_2SiO_5) component, and 2) chlorite in the presence of the first assemblage. Muscovite often occurs in two separate forms: 1) as large ragged vermiform plates replaced by quartz, and 2) as discrete smaller well-formed flakes. This would indicate that muscovite started to break down but the reaction did not go to completion and later on a second generation of muscovite formed. This implies that the metasedimentary component in the "granitic" intrusion was small and/or dry as the muscovite did not break down completely, hence anatectic melting was thwarted probably due to the lack of H_2O. Thus the highest metamorphic grade in these rocks may have been just on the border of high grade metamorphism below the anatectic melt minimum (Figure 15). These rocks have been subjected to a second lower grade metamorphism as indicated by the coexistence of muscovite and biotite (which is invariably altered to chlorite) belonging to the high-temperature portion of low grade metamorphism (Figure 15). The existence of almandine garnet and calcite represents the metamorphism of rocks of a slightly different bulk composition (more CaO rich) and probably higher in CO_2 pressure.

ZONE B

Comprising the Flinton Group and adjacent Tudor metavolcanics, Zone B has been studied in great detail with special emphasis on the metamorphic mineral zones and isograds in these rocks (Thompson 1973). Thompson's work indicates that the metamorphic grade in these rocks varies from the lowermost amphibolite facies (chloritoid, staurolite, dolomite, quartz) north and east of Flinton to upper middle amphibolite facies (sillimanite, muscovite, diopside, microcline) in the southwest corner of the present map-area and resulted from one period of regional metamorphism. Thompson's lowermost amphibolite facies corresponds to the low grade – medium grade transition zone characterized by "chloritoid out" and "staurolite in" (Figure 15). His upper middle amphibolite facies corresponds to the high temperature part of medium grade metamorphism, "muscovite + quartz → K-feldspar + sillimanite", i.e. "sillimanite in" (Figure 15).

Due to the lack of pelitic assemblages in the Flinton Group, Thompson (1973) used mineral zonation in the carbonate-biotite schist (map-unit 11a) and in the carbonate-bearing quartzofeldspathic sandstone (map-unit 11e) as metamorphic grade indicators. Mineral assemblages present in the carbonate-biotite schist defining four different metamorphic zones (in order of increasing grade) are:

quartz + plagioclase + calcite +
  biotite + ferroan dolomite (zone 1)
  biotite + actinolite (zone 2)
  biotite (1 percent) + actinolite + microcline + sphene (1 percent) (zone 3)
  biotite (1 percent) + actinolite + microcline + sphene (1 percent) + diopside (zone 4).

In the carbonate-bearing quartzofeldspathic sandstone the mineral assemblages found are:

quartz + plagioclase + calcite +
  biotite + phengite (muscovite) + Fe-Ti oxide + sphene + ferroan dolomite ± epidote (zone 1)
  biotite + phengite (muscovite) + Fe-Ti oxide + epidote + sphene + microcline (zone 2)
  microcline + epidote + hornblende + sphene ± biotite ± Fe-Ti oxide (zone 3)
  microcline + epidote + hornblende + diopside ± sphene (zone 4).

All specimens from each unit have accessory tourmaline, zircon and apatite. Thompson was further able to reduce these to three major mineral zones; zone 2 above could be incorporated into zone 1 as it results from a difference in bulk composition. The three zones in order of increasing grade are Zone I (typified by the biotite-calcite pair), Zone II (typified by the Ca-amphibole-microcline pair) and Zone III (typified by the diopside-microcline pair). Zone I was divided into three subzones in the following manner: Zone Ia — ferroan dolomite stable, Zone Ib — ferroan dolomite unstable, epidote and biotite stable, and Zone Ic — ferroan dolomite unstable, actinolite and calcite stable. For the positioning of these isograds with respect to the map-area refer to Thompson (1973, p.71). Zone III contains much pegmatite southwest of the map-area, and this unit is very similar to map-unit 12c in the map-area and structurally occurs in a similar position.

The metavolcanics present in this metamorphic zone (map-unit 1) tend to be in the high temperature part of low grade metamorphism with hornblende and plagioclase-biotite stable, thus lying above the isoreaction-grad "hornblende in" (Figure 15). Chlorite is locally present but weakly developed. Late-stage talc alteration is not uncommon in this metamorphic zone.

GEOCHRONOLOGY

A number of geochronological studies have been carried out in the Grenville Province, two of which are applicable to the map-area. Silver and Lumbers (1965) provided U-Pb ages on zircons from both metavolcanic and metaplutonic rocks in the immediate vicinity of the map-area. The metavolcanics dated include rhyolite of the Tudor Formation and the metaplutonic rocks include the high rank metamorphic terrain in the Haliburton-Hastings Lowlands (potassic granite group, Lumbers 1964) and the low to intermediate rank metamorphic terrain between Madoc and Bancroft (sodic granite group, Lumbers 1964). The Tudor Formation yielded a U-Pb zircon age of 1310 ± 15 m.y., while the sodic granite group yielded an age of 1250 ± 25 m.y. and the potassic granite group an age of 1125 ± 25 m.y. The sample from the sodic granite group was collected from the Elzevir Batholith. The Northbrook Batholith is considered to belong to this group as well, while the Addington intrusion is considered to belong to the potassic granite group (Lumbers 1964).

Krogh and Hurley (1968) published a Rb-Sr isochron on the Kaladar "granite" from the Kaladar Hill ridge of the Addington intrusion. The isochron age for this body is 1035 ± 60 m.y. with an initial $^{87}Sr/^{86}Sr$ ratio of 0.711 ± 0.002.

These ages agree very well with the geology in the map-area. The Hermon Group metavolcanics are the oldest rocks, and the Elzevir and Northbrook Batholiths intrude them. The Flinton Group resting unconformably on the Northbrook Batholith is interpreted to be younger than 1250 ± 25 m.y. (Moore and Thompson 1972) and predates the Addington intrusion (1035 ± 42 m.y). No isotopic dating has been carried out on the Northbrook Batholith to date. The intrusive nature of the Addington body is supported by the high initial $^{87}Sr/^{86}Sr$ ratio. This value falls well above both the "main path" $^{87}Sr/^{86}Sr$ mantle differentiation curve of Jahn and Nyquist (1976) and the hypothetical upper mantle linear growth curve of Moorbath (1976), but falls close to the "continental crust" growth curve of Faure and Powell (1972, p.45). This indicates that the likely source for the Addington intrusion is remelted continental crust and from the field evidence likely included some Hermon Group metasediments assimilated in situ. The age, source material and field relationships of the Addington intrusion strongly suggest that this body is not the basement in the map-area.

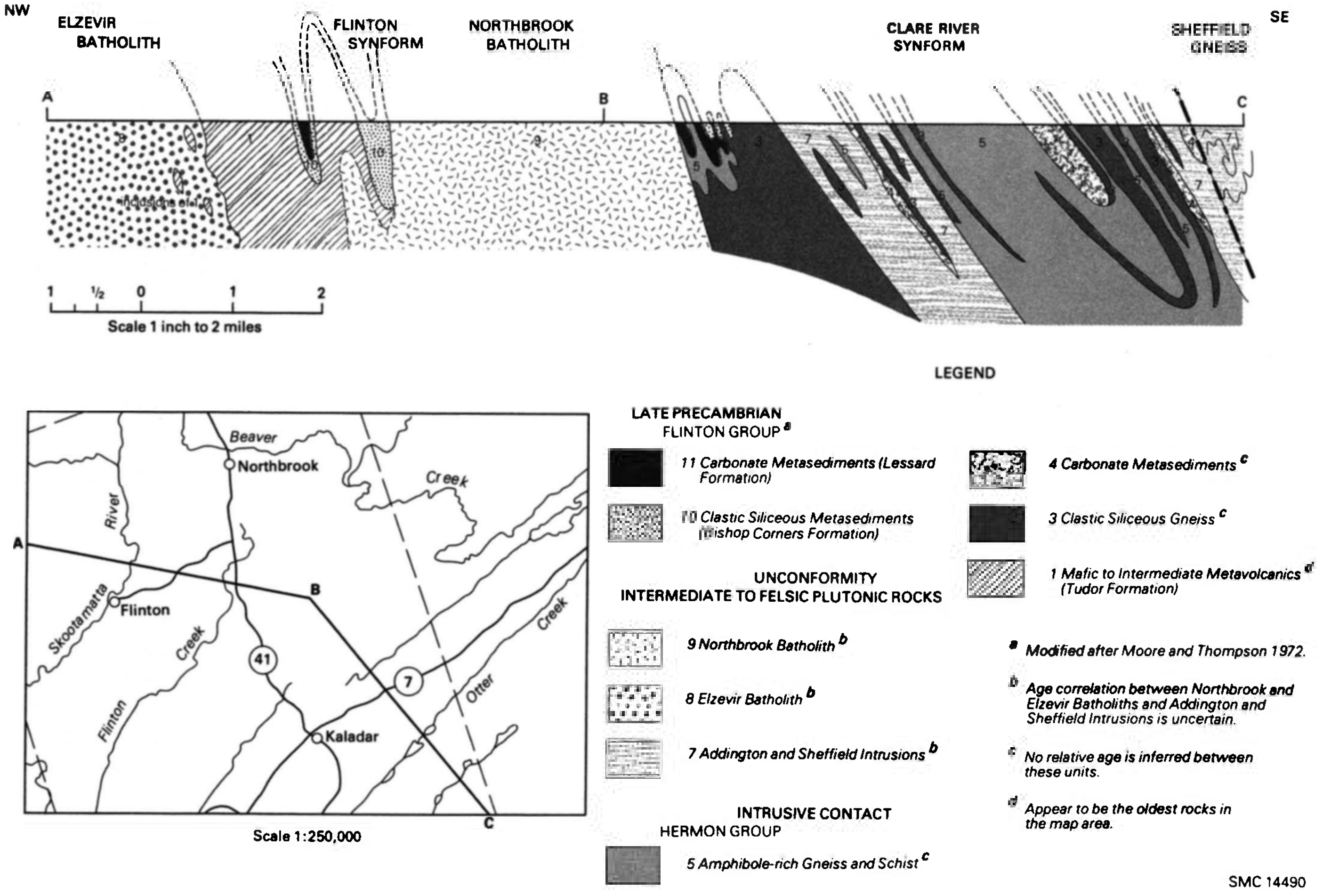
STRUCTURAL GEOLOGY

Regional Setting

The map-area lies within the Central Metasedimentary Belt as defined by Wynne-Edwards (1972) and specifically is within the IVB segment in the eastern Hastings Basin. 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) and Schwerdtner *et al.* (1977). The map-area can be divided into four different major structural zones: Zone A containing the Hermon Group and Addington and Sheffield intrusions situated south of the Northbrook Batholith; Zone B composed of the Northbrook Batholith itself; Zone C including the Tudor metavolcanics north of the village of Flinton and the Flinton Group metasediments; and Zone D composed of the Elzevir Batholith, contaminated mafic intrusive rocks and Tudor metavolcanics in the southwestern corner of the map-area. The structural geology of each of these zones is strikingly distinct but related. A structural cross-section through the four zones is given in Figure 16.

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 compositional layering. Figure 17 illustrates the distribution of 663 poles to the S1 foliation-gneissosity from the Hermon Group in this zone. The distribution of this data is densely grouped indicating the homoclinal nature of the orientation of these units which trend N50E and dip 30-50 degrees. The Addington intrusion 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 asymmetrical minor "Z" folds (F2) (Photos 6 and 7); quartz-rodding is well developed in the fold noses. Twenty-one of these quartz-rodding lineations (L2) are plotted on Figure 17 and show shallow plunges predominantly to the southwest (S34W) with plunges less than 20 degrees. Some of these lineations plunge shallowly to the northeast. The girdle to the poles of the S1 foliation-gneissosity is shown and the pole to this girdle is located very close to the maximum of the L2 lineation indicating they are lineations within the F2 axial plane. Evidence of a third deformation (D3) is suggested by the bimodal plunge directions of the L2 lineation.



LEGEND

LATE PRECAMBRIAN
FLINTON GROUP [a]

■ 11 Carbonate Metasediments (Lessard Formation)

▨ 10 Clastic Siliceous Metasediments (Bishop Corners Formation)

UNCONFORMITY
INTERMEDIATE TO FELSIC PLUTONIC ROCKS

▨ 9 Northbrook Batholith [b]

▨ 8 Elzevir Batholith [b]

▨ 7 Addington and Sheffield Intrusions [b]

INTRUSIVE CONTACT
HERMON GROUP

▨ 5 Amphibole-rich Gneiss and Schist [c]

▨ 4 Carbonate Metasediments [c]

■ 3 Clastic Siliceous Gneiss [c]

▨ 1 Mafic to Intermediate Metavolcanics [d] (Tudor Formation)

[a] Modified after Moore and Thompson 1972.

[b] Age correlation between Northbrook and Elzevir Batholiths and Addington and Sheffield Intrusions is uncertain.

[c] No relative age is inferred between these units.

[d] Appear to be the oldest rocks in the map area.

SMC 14490

Figure 16–Structural cross-section of the Kaladar area.

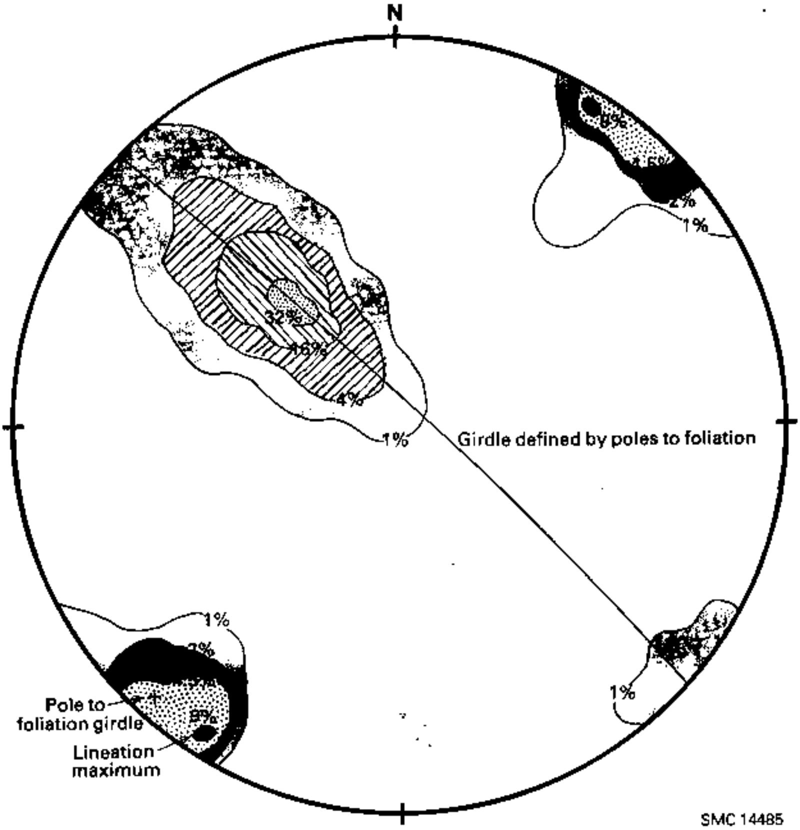
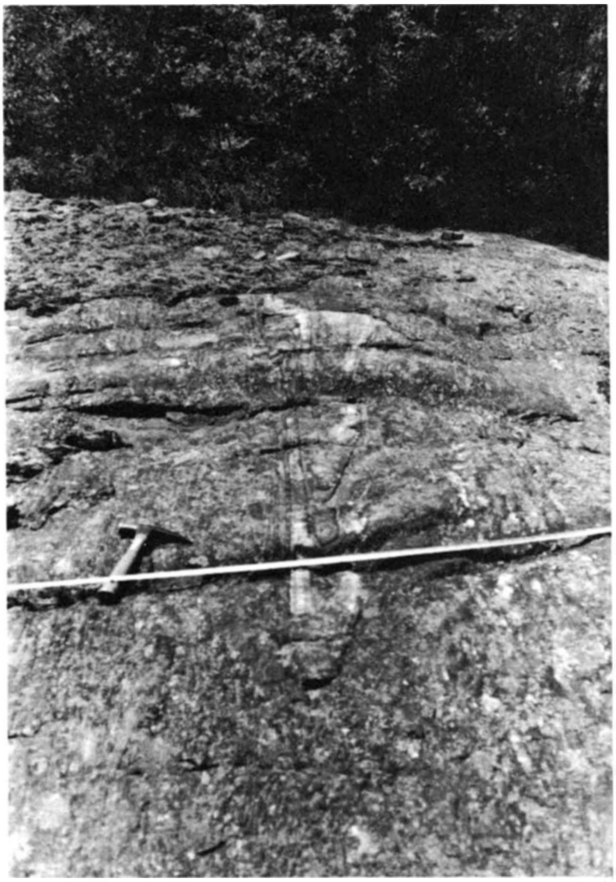


Figure 17–Contoured diagram of 663 poles to foliation-gneissosity (girdle) and 21 lineations, structural zone A (map-area southeast of Northbrook Batholith). Stereographic projection, lower hemisphere. Contours at 1, 4, 17, and 32 percent for foliations and 1, 2, 4.5 and 9 percent for lineations.

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 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 in detail its projection within this map-area. Certainly, the carbonate metasediments (marble) and adjacent supracrustal rocks (map-units 3 and 5) are 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). The carbonate metasediments situated between Otter Creek Lakes and Lingham Lakes possess a central (fold axis) position with respect to the stratigraphy in the map-area collinear with the axis delineated to the southwest by Ambrose and Burns (1956). The homoclinal orientation of the units indicates that the Clare 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 minor folds. This is in agreement with Venkitasubramanyan (1969) who demonstrated that there were two phases of deformation in the area east of Madoc and that the Clare River Synform closure was a second phase 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 undergone flow-folding as described by



OGS 10 343

Photo 6–Isoclinal F2 minor fold in clastic siliceous gneiss of the Hermon Group metasediments. The fold plunges shallowly southwest. The photo is taken looking down plunge. Hammer handle is 0.3 m long. North of Lingham Lakes.

OGS 10 344

Photo 7–Asymmetrical F2 minor fold in clastic siliceous gneiss of the Hermon Group metasediments. The fold plunge is shallowly to the right. Lens cap is 5 cm in diameter. North of Lingham Lakes.

Wynne-Edwards (1963). This style of folding and the injection of abundant granitic material (map-unit 7) within this structural zone make the degree of infolding difficult to ascertain.

The carbonate metasediments (map-unit 4) within this zone are generally structurally conformable with the other metasedimentary units but locally exhibit minor antiforms and synforms and locally horizontal attitudes. These carbonate rock types were very ductile during deformation and the resultant structures are a reflection of the competancy contrast between these units and the amphibole-rich and clastic siliceous gneisses (map-units 3 and 5).

Near the contact with the Flinton Group and the Northbrook Batholith (3.5 km north of Kaladar) a minor antiformal structure is developed and the Flinton Group appears to be locally infolded with the Hermon Group.

This structural zone is also typified by abundant boundinage and pinch and swell structures. Well developed boudins with well formed boudin necks are not uncommon (see Photo 2) in amphibole-rich gneiss (map-unit 5), while pinch and swell structures are found in clastic siliceous gneiss (map-unit 3) (see "General Geology").

ZONE B

The Northbrook Batholith is structurally quite homogeneous, containing a prominent nearly horizontal lineation and a weakly developed foliation-gneissosity. The batholith in the map-area can be structurally examined in three sectors: the sector west of Highway 41, the central sector east of Highway 41 and west of the Kaladar-Kennebec Township line, and the sector east of the Kaladar-Kennebec Townships line. Figure 18 shows the distribution of 305 lineation measurements from the western and eastern sectors. The western sector has a mean lineation azimuth of S44W while the eastern sector has a mean lineation azimuth of S57W. Both sectors have very shallow plunges (0-8 degrees) and in many places plunge northeasterly as well. Not shown is a stereonet plot of 179 lineations from the central sector. When these are plotted they superimpose over the total distribution of the western and eastern sectors indicating the systematic and gradual change in lineation azimuths in the Northbrook Batholith from west to east. In comparison with Figure 17 it can be seen that

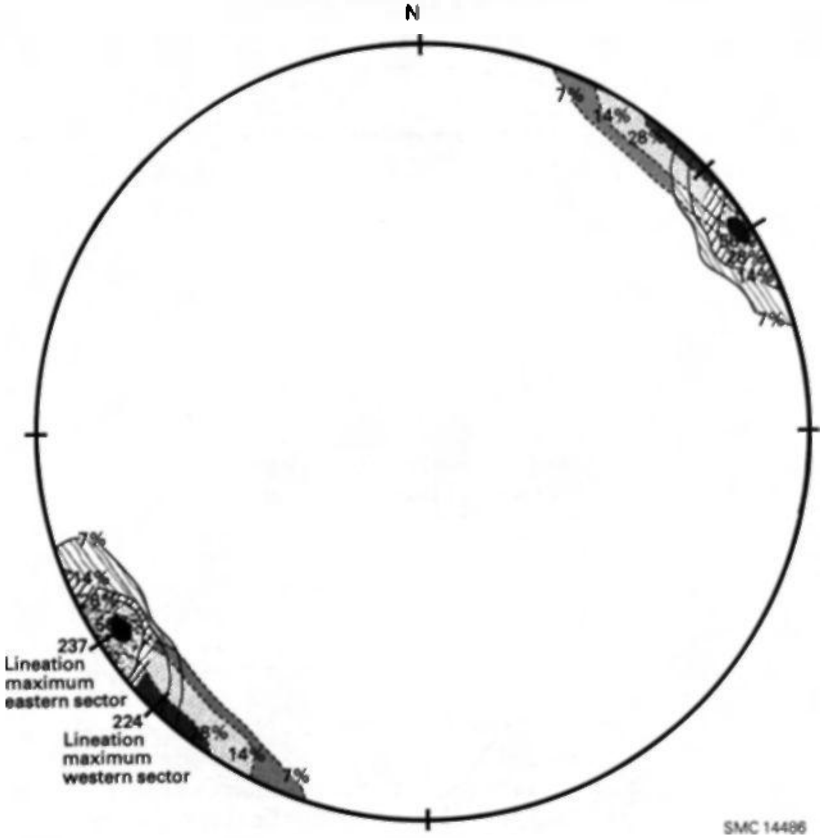


Figure 18–Contoured diagram of 163 lineations (eastern sector), and 142 lineations (western sector) structural zone B (Northbrook Batholith). Stereographic projection, lower hemisphere. Contours at 7, 14, 28 and 56 percent for eastern sector and 7, 14 and 28 percent for western sector.

lineations from both structural zones A and B overlap, implying that the lineations within the Northbrook Batholith are L2 lineations. Thus both structural zones A and B were deformed by the same deformation event D2. Ambrose and Burns (1956) considered the western sector of the Northbrook Batholith to be an antiformal structure.

A small number of foliation-gneissosity surfaces are developed and when plotted fall within the S1 field on Figure 17. The author does not consider the foliation-gneissosity in the Northbrook Batholith to be of the S1 generation but S2 because they are not folded. Thus the foliation-gneissosity in the Northbrook Batholith is likely axial planar.

ZONE C

The structural patterns found in the Flinton Group and the Tudor metavolcanics north of Flinton appear to be quite similar. Figure 19 shows the distribu-

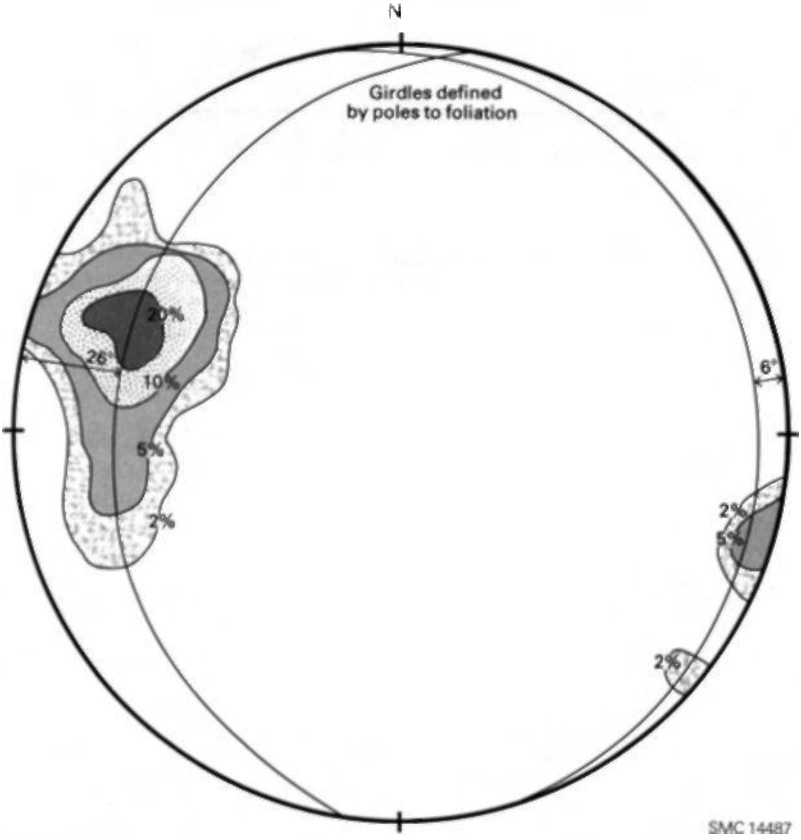
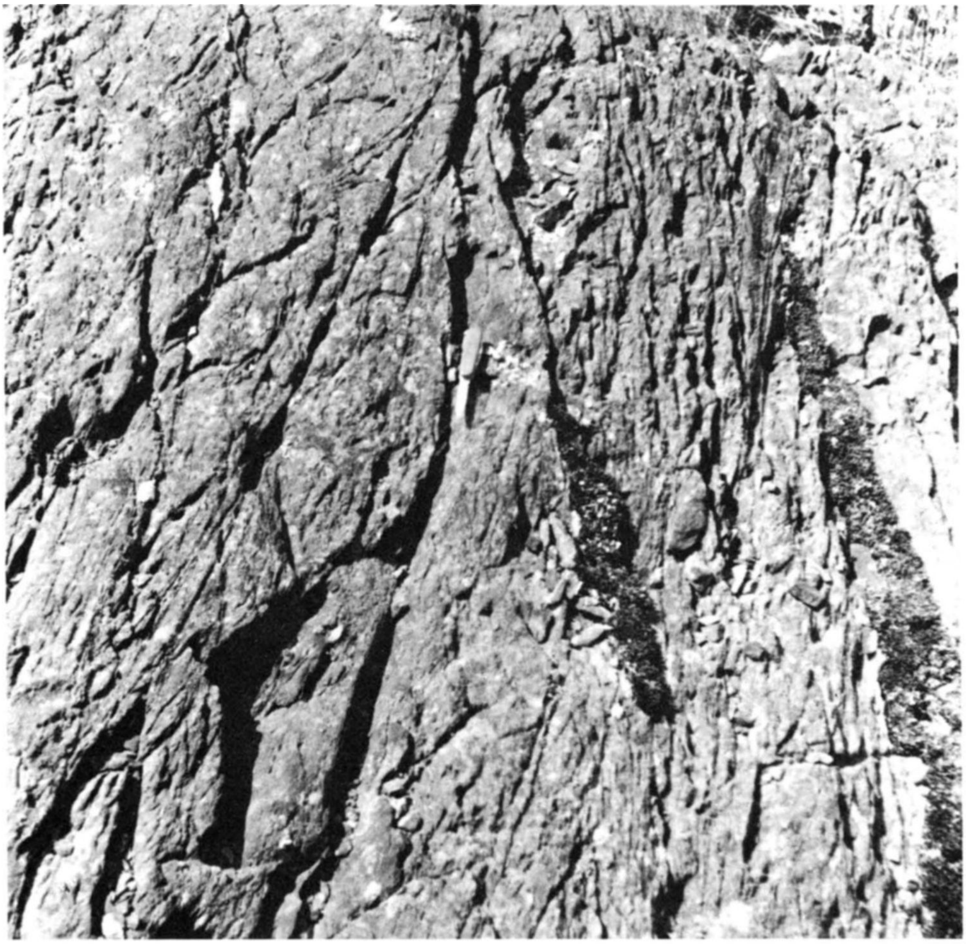


Figure 19–Contoured diagram of 102 poles to foliation, structural zone C (area west of Northbrook Batholith and east of Elzevir Batholith). Stereographic projection lower hemisphere. Contours at 2, 5, 10 and 20 percent.

tion of poles to foliation-cleavage surfaces within the Tudor metavolcanics in the map-area. Although primarily defining a set of planes oriented N10E with steep dips (65-75 degrees east) a less dominant set of planes oriented at N20E with high dips (75-85 degrees west) intersects the dominant set with an apical angle of approximately 30 degrees as defined by the girdles to these data (Photo 8). In comparison with the detailed structural analysis of the Flinton Group in the map-area (Thompson 1972, p.66) these would correspond to S1 surfaces formed by the D1 deformation event.

The Flinton Group occupies two northerly trending synforms. Thompson's study reveals that within the Flinton Group, bedding (S0) can be traced around F1 folds and the dominant foliation (S1) is parallel to the F1 axial planes and trend N45E with high to moderate dips. The developed mineral lineation (L1) is the intersection of the S0 and S1 surfaces and trends both N50E and S45W



OGS 10 345

Photo 8–Intersecting folication-cleavage surfaces in the Tudor metavolcanics north of Flinton. Apical angle is approximately 30 degrees. Jacknife is 12.5 cm long.

but the plunge is very high (65-85 degrees) (Thompson 1972, p.66). The D2 structures are less well developed and consist mainly of the intersection of the S1 and S2 surfaces producing mineral lineations developed on the S1 surfaces, and the development of small scale asymmetrical folds (apical angle of 30-60 degrees). The S2 surfaces have less spread and are oriented more easterly (N65E) with high dips (greater than 55°) and the L2 lineations are oriented at N45E and S45W with variable plunges (25-90 degrees) (Thompson 1972, p.73). In the map area there is little evidence for the D3 deformation in the Flinton Group except where there is a major change in the trend of S1 (Thompson 1972). The D3 event is the same as that in structural zone A with a northwest-trending axis.

ZONE D

Structural zone D contains structural patterns of a varied nature. The metavolcanics and contaminated mafic intrusive body south of Flinton depict an

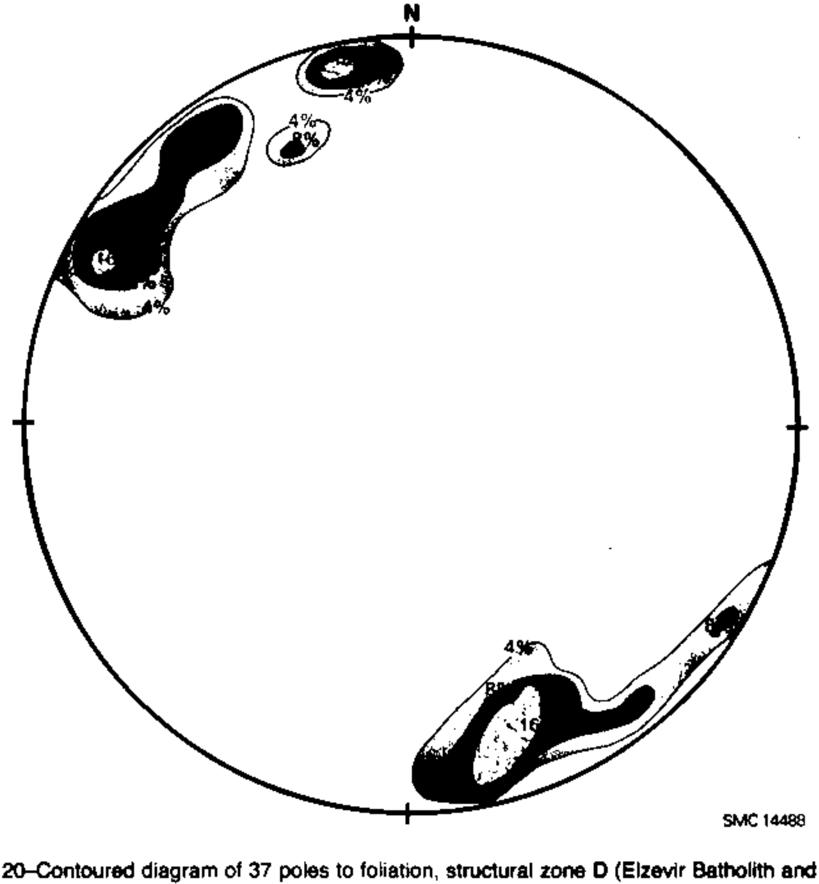


Figure 20–Contoured diagram of 37 poles to foliation, structural zone D (Elzevir Batholith and area to south). Stereographic projection, lower hemisphere. Contours at 4, 8 and 17 percent.

interesting structure. Figure 20 and the data on Map 2432 (back pocket) indicate the metavolcanics define a synformal structure with the north limb just south of Flinton trending N30E and the south limb in the southwest corner of the map-area trending west. Both limbs dip steeply (65-80 degrees) and close southwestward. The contaminated mafic intrusion contains lineations which are essentially parallel to the axial trace of this structure. These are similar to L2 lineations in zone C, hence this may be an F2 fold. This structure swings northerly into the Tudor metavolcanics in structural zone C and is at a very high angle to the bedding S0 and F1 axial planar foliation (S1) in the Flinton Group synformal structure. This indicates that the structural relationships between zones C and D are somewhat ambiguous and may reflect the relative competance contrast between the contaminated mafic intrusive rocks and mafic metavolcanics with respect to that of the Flinton Group.

The Elzevir Batholith is in general quite structureless but does contain lineations within its body. These tend to define circular perimeters and may be internal intrusive deformation features (see "General Geology").

STRAIN

Several metaconglomerate units in the map-area have preserved some good indicators of strain in structural zones A and C. Illustrated in Figure 21, the orientation of the principal strain components with respect to the pebble elongation and the foliation plane reveals that λ_3 was oriented the same in both zones but λ_1 and λ_2 are different, producing pebble elongations which are very near parallel to the dip in structural zone C and essentially parallel to strike in zone A (but can be inclined up to 25° from the strike line). This dichotomy in strain orientation is manifested quite well on the regional scale, with Zone A being part of the Clare River Synform Structure trending northeast for large distances beyond the map-area. Zone C represents a different stress field which is a result of the intrusion of the Elzevir Batholith and suggesting Zone C postdates the Zone A deformation.

In measuring finite strain, the author used the method of Flinn (1956) which expresses the amount of strain as a function of the diameter of a sphere

TABLE 17—STRAIN PARAMETERS (AFTER FLINN 1956) FOR STRUCTURAL ZONES A AND C IN THE KALADAR AREA.

	Zone A[2]		Zone C[3]
Orientation[1]	Granodiorite Pebbles	Quartzite Pebbles	Quartzite Pebbles
L	2.87d	3.82d	0.9d
M	1.03d	0.93d	3.6d
N	0.33d	0.27d	0.29d

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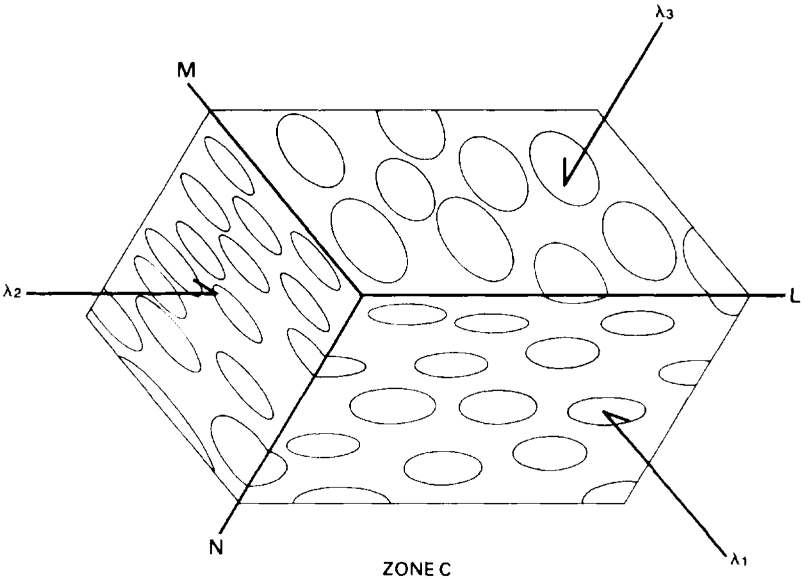
[1] L M plane is plane of foliation.

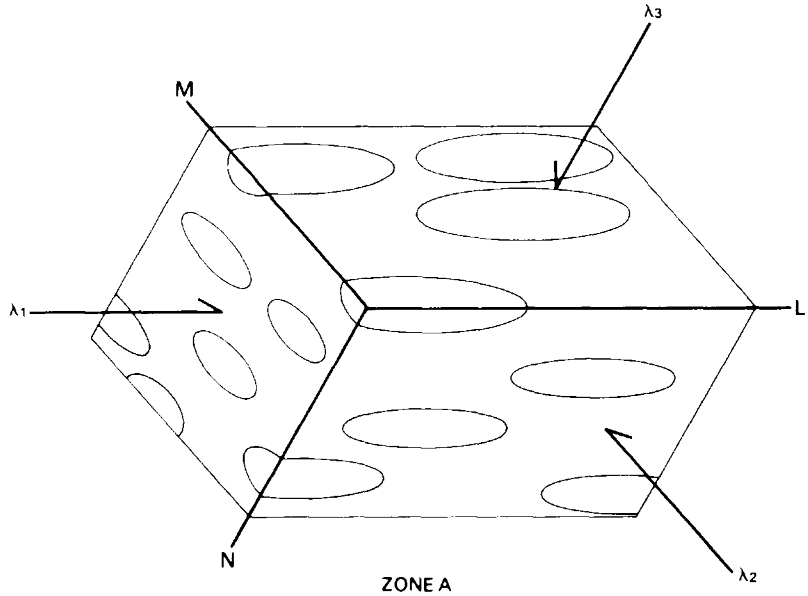
[2] Original data from Walton *et al.* (1964), parameters calculated by author.

[3] Data and parameters from Thompson (1972).



ZONE C

Foliation parallels LM plane



ZONE A

SMC 14489

Figure 21–A schematic representation of principal strain components preserved in pebble conglomerates from structural zones A and C indicating the different orientations of λ_1 and λ_2 with respect to the foliation plane.

with the same volume as the pebble ellipsoid. This method was used by Thompson (1972) to determine the three-dimensional strain in the Flinton Group quartz-pebble metaconglomerate and these data have been used here for structural zone C strain indicators. For structural zone A the average pebble dimensions of 8.6:3.1:1.0 for "granitic" (granodiorite) pebbles and 13.8:3.4:1.0 for quartzite pebbles in the Kaladar metaconglomerate (Walton *et al.* 1964) have been used. The resultant strain values are given in Table 17 and indicate the quartzite pebbles to be more strained than the granodiorite pebbles and the maximum strain in both structural zones is approximately the same (350 percent elongation, or 30 percent shortening orthogonal to this direction).

FAULTING AND DIKING

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 lineaments can be assigned definite movements. The more prominent lineaments along which fault movements may or may not have occurred are indicated on Map 2432 (back pocket). Lineaments tend to be of four major orientations: NNE trending, NE trending, ENE trending and ESE to SE trending.

Faulting tends to be confined to one dominant orientation running ESE. These faults are limited in number and usually continuous for 1 to 2 km. The offset is depicted in the geology and contains both sinistral and dextral movements. Many of the lineaments which possess ESE and SE trends are probably faults of this same generation but as no apparent offset is discernable they have been mapped as lineaments.

The emplacement of late tectonic pegmatites along the southern margin of the Northbrook Batholith may represent an old fault or at least a structural break between structural zones A and B. A major and continuous boundary between two rock bodies of extremely differing competencies, this break may have been opened in the late stages of tectonism (perhaps during D3) and provided an access route for lower level pegmatites to reach the surface.

Joints or fractures abound especially in structural zone B and form three sets oriented at S65E, N45E and N10W. These joints are approximately at 120 degrees to each other and do not appear to differ in age. Joints also occur in structural zone A and most often are of the S50-65E orientation.

The most abundant dikes are pegmatite (map-unit 12b). The orientation of these dikes is S50-65E. These are essentially parallel to the prominent fault set and the one set of fractures and may represent faults/fractures which due to their proximity to map-unit 12c and/or sufficient depth became filled with pegmatite.

Minor aplites in the Northbrook Batholith and granodiorite dikes in the contaminated mafic intrusive rocks are omnidirectional and discontinuous.

Although not indicated on the map the contact between the Tudor metavolcanics (map-unit 1) and the Flinton Group is quite commonly a shear zone containing sulphide mineralization. The zone usually contains schistose varieties of map-units 1a and 10d. Associated with this zone are transecting quartz veins which tend to be auriferous in the Flinton Group and arsenic-bearing in the metavolcanics (see "Economic Geology").

AEROMAGNETIC DATA

Comparison of Map 2432 (back pocket) and the available aeromagnetic survey (GSC 1949) indicates a reasonable correlation between aeromagnetic contour patterns and rock type. The Hermon Group volcanic rocks (map-units 1 and 5) stand out as the contour spacing is much smaller and the magnetic intensity is much higher than in other rock types in the map-area. The typical magnetic values for the Hermon Group are 800-1500 gammas, and values greater than 1000 gammas are common. These readings result from the generally higher amounts of magnetic minerals in these rocks (mostly magnetite and minor pyrrhotite).

The metasedimentary units of both the Hermon and Flinton Groups (map-units 2, 3, 4, 10, and 11) are virtually indistinguishable from the granitic intrusive rocks in the map-area as these units lack magnetic minerals and are compositionally not very different.

The intrusive bodies (map-units 6, 7, 8, 9, and 12) are quite easily distinguished from the volcanic units. The intrusive rocks generally have values of 1100 ± 60 gammas and a wide contour spacing. One well defined structure is the Elzevir Batholith. The contact of this body with the Tudor metavolcanics is extremely well delineated. Also the Kaladar Hill and Kaladar-Kennebec Lake ridges of the Addington intrusion are distinctly defined bodies and the metasedimentary units of the Hermon Group separating these ridges give a relative magnetic depression.

In general the aeromagnetic data do not reflect any of the faulting, however, the similarity of some aeromagnetic contours and regional lineaments within the Northbrook Batholith is of note.

ECONOMIC GEOLOGY

The Kaladar area contains a variety of metallic and non-metallic mineral deposits but the only significant producer on record in the area was the Addington gold mine near the village of Flinton. Minor surface workings for actinolite, quartz, feldspar and mica were active between the late 1800s and 1940. In 1977 mineral production was limited to sand and gravel used locally for construction purposes.

Metallic mineralization consists mainly of gold, molybdenum, iron and copper with trace amounts of silver, nickel, zinc and arsenic. The known gold deposits tend to be limited in occurrence to the contact between the mafic metavolcanics and the Flinton Group metasediments. Molybdenum mineralization is limited to white pegmatite dikes (map-unit 12b) which trend approximately S45E and are adjacent to, or near the borders of, the Northbrook Batholith. Copper tends to occur as chalcopyrite in the mafic to intermediate metavolcanics and also in some mafic-rich members of the amphibole-rich gneisses. The iron- and arsenic-bearing sulphides are also found in these gneisses. The trace amounts of silver, nickel and zinc occur in small rusty gossan zones within the clastic siliceous metasediments of the Hermon Group, however, minor silver was recovered in the past with gold from workings along the mafic metavolcanics and Flinton Group contact zone.

Radioactive mineralization is limited to uranium and rare earth element concentrations which occur where white pegmatite (units 12b and 12c) has intruded and locally migmatized quartzite-pebble metaconglomerate units (map-unit 10b), but minor concentrations exist in foliated to gneissic leucocratic quartz monzonite (map-unit 7d) and pink pegmatites.

Non-metallic mineralization consists mainly of feldspar, quartz, mica and actinolite. The feldspar, quartz and mica occurrences are all associated with the late pegmatite dikes (map-unit 12). Actinolite is associated with the ultramafic rocks, and are spatially limited to the southwest corner of the map-area (not shown on map).

Prospecting and Mining Activity

Recorded data on mineralization in the area dates back to the late 1800s in the works of Murray (1852) and Vennor (1870) who both mapped for the Geological Survey of Canada. Active prospecting in these early years was limited to scattered pits and trenches primarily for the extraction of actinolite in the western portion of Kaladar Township. The actinolite was transported to Kaladar by wagon. The first mine in the area was the former Golden Fleece gold mine (presently called the Addington mine, a past producer located on lots 24 and 25, concession VI, Kaladar Township), which opened in 1881 and was worked sporadically until it was closed in 1940. Other exploration in this period led to small surface developments of gold, chalcopyrite, arsenopyrite, pyrite, molybdenum, quartz, feldspar and mica. Activity in the area is reported to have been very limited during the Second World War.

Renewed interest in the area was sparked in 1952 when some old pits in a zone of base metal sulphide mineralization were examined by the New Jersey Zinc Exploration Company (Canada) Limited in the metasediments and gneisses of the Hermon Group (south of the present map area). In the early 1960s two holes were drilled by K. Sullivan on the contact of the mafic metavolcanics and Flinton Group metasediments, but yielded no gold. Activity in this area resumed in the 1970s. Several parcels of land were staked in the metaconglomerate units north of Kaladar adjacent to Highway 41. Of the two holes drilled on these claims by T. Michie, one intersected trace amounts of gold and the other some pyrite mineralization. In 1975 Glenshire Mines Limited carried out extensive exploration work on the prospects examined by New Jersey Zinc Exploration Company (Canada) Limited in 1952 and discovered uranium as well as minor copper, silver, nickel and zinc mineralization.

In 1977 staking was very active in the map-area primarily due to promising results of the joint Federal-Provincial Uranium Reconnaissance Program (GSC 1976). Hudson Bay Exploration and Development Company Limited staked three parcels of land comprising 34 claims, 15 claims and 8 claims (number 5 on map), while Canadian Occidental Petroleum Limited staked one parcel of land containing 30 claims (number 1 on map). Hudson Bay Exploration carried out a ground radiometric survey on portions of the Addington intrusion with relative radiometric highs, and Canadian Occidental staked areas underlain by carbonate metasediments. No work by these two companies has been submitted for assessment on these claims to date.

Metallic Mineralization

GOLD

The gold mineralization is associated with the mafic metavolcanics (map-units 1a, 1d) in contact with the metaconglomerate units of the Flinton Group (usually unit 10b). The gold occurs as disseminations within small quartz stringers and veins, penetrating both the metavolcanic and metaconglomerate units. The most auriferous zones tend to be confined to those quartz-filled fractures in the conglomerates and associated schists while arsenopyrite mineralization dominates the veins in the metavolcanics. This would suggest that the gold was disseminated in the quartzite pebble conglomerate units and has been locally concentrated in later fractures filled with hydrothermal quartz and associated with shear zones at the unconformity between the Hermon Group mafic metavolcanics and the Flinton Group, thus making this concentration of gold mineralization epigenetic. Trace gold mineralization also exists in "granitic" rocks on lot 15, concession VII, Kaladar Township (Assessment Files Research Office, Ontario Geological Survey, Toronto).

Description of Deposits

COMINCO LIMITED (ADDINGTON MINE) (2)[1]
WEST HALF, LOTS 24 AND 25, CONCESSION VI, KALADAR TOWNSHIP

The Addington mine deposit was first discovered in 1881 by the Golden Fleece Mining Company, and is often referred to as the Golden Fleece deposit. Little work was carried out until 1887 when two shallow shafts were sunk and a 10-ton stamp mill erected by the Adelaide Mining Company of Baltimore, Maryland. The mine was operated from 1907 to 1915 by the A.B.P. Mining Company under option from the above owner. From 1915 to 1922 the Cobalt-Frontenac Mining Company Limited deepened one of the original shafts to 60 feet and the inclined shaft (N63E azimuth) to 100 feet with a level at this depth from which a winze was sunk another 66 feet. A total of 350 feet of drifting and 402 feet of crosscutting was completed. Up to the end of 1919 the total produc-

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[1] Number refers to property and deposit list on Map 2432 (back pocket).

tion of the mine was about $10,000 from the 10-ton stamp mill (Harding 1942; Source Mineral Deposit Files, Ontario Geological Survey, Toronto). In 1922 a cyanide plant was added to the mill equipment and total production for that year (Source Mineral Deposit Files, Ontario Geological Survey, Toronto) was 50 ounces of gold and 26 ounces of silver worth $1056. The mine at this time was not profitable to operate. In 1927 some development work was carried out at the 100 foot level disclosing three veins having average widths of 20 feet, 30 feet and 12 to 15 feet. In 1928 the property was purchased by Rich Rock Gold Mines a company controlled by the Cobalt-Frontenac Mining Company Limited. In 1932 the property was sampled by C.N. Thompson and pumped out to the 100 foot level. Some mining was carried out and part of the mill reopened. The property was obtained under option in 1935 by the Canadian Mining and Smelting Company of Canada Limited who commenced work on the property. At that time the main workings of the plant consisted of an inclined shaft 100 feet deep, a winze from the 100-foot level to the 200-foot level, and a raise from the 200-foot level to the 100-foot level. No horizontal work had been done below the 100-foot level. Addington Mines Limited (a subsidiary of the Consolidated Mining and Smelting Company of Canada Limited) took over the property in 1936. Underground development carried out over two years included deepening the inclined shaft to 535 feet and sinking a winze 273 feet below the 500-foot level with levels at 625 feet and 700 feet. Work was mainly confined to the 300-foot, 400-foot, 500-foot and 700-foot levels and totalled 3033 feet of cross cutting and 7096 feet of drifting. Eight surface and sixty-eight underground diamond drill holes totalling 8856 feet yielded an estimated reserve of 256,000 tons of ore averaging $5.60 per ton[1] with 103,000 tons "probable ore" as of June 1939 (Source Mineral Deposit Files, Ontario Geological Survey, Toronto).

In 1940 the mill was removed from the site and the mine has been inactive since that time. Today, the property is held by Cominco Limited and the main shaft is sealed with concrete, all buildings have been removed and much of the surface site is overgrown by bushland.

A surface geological sketch map and plan of the underground workings of the Addington mine are provided in Harding (1942). The geology of the deposit was described by Harding (1942, p.71-72) as follows:

> The mineralized gold-bearing ore zone is situated at the contact between a large area of volcanics and a belt of conglomerate (Hastings series). These rocks are highly folded. The beds strike a few degrees east of north and dip about 70°E. The vein zone consists of altered lavas and sediments cut by veins and stringers of quartz, the strikes and dips of which conform to those of the host rocks. The zone has a maximum width of 35 feet. It has been exposed intermittently on the surface by means of pits and trenches for a distance of more than 3,000 feet.
>
> Minerals identified in the vein and in the mine dump include quartz, ankerite, calcite, tourmaline, pyrite, chalcopyrite, pyrrhotite, arsenopyrite, and scheelite. The arsenopyrite is most abundant in the northern part of the mine, where the vein lies mostly in lavas.
>
> Mineralization appears to have taken place according to a definite sequence. Tourmaline was deposited abundantly in the early fractures. Additional fracturing and the reopening of the tourmaline veins was followed by the main period of quartz-vein formation. The introduction of sulphides and gold took place toward the end of the mineralization period.

The above information is the accumulation of information from many re-

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[1] In 1935-1936 the price of gold fluctuated between $33 and $36 Canadian per ounce, so $5.60 per ton represents grades in the range 0.15 to 0.17 ounces of gold per ton.

ports including Corkill (1907, 1908, 1913), Sutherland *et al.* (1916, 1917, 1919, 1920, 1921, 1922, 1923), Sinclair *et al.* (1933, 1936, 1937, 1938, 1939), Tower *et al.* (1941), Tremblay (1942), and Harding (1942).

EWING OCCURRENCE (3)
WEST HALF LOT 20, CONCESSION IV, KALADAR TOWNSHIP

In the southeast corner of the west-half of the lot 20, concession IV, gold mineralization was reported (Harding 1942) in quartz stringers within a 10-foot wide sulphide-bearing shear zone near the contact of the mafic metavolcanics (map-unit 1a) and the Flinton Group quartzite-pebble conglomerate (map-unit 10b). The occurrence was worked from 1935 to 1937 by J. Ewing who did a limited amount of trenching. Chip samples taken by Harding (1942) assayed 0.07 ounces of gold per ton.

T.C. MICHIE (6)
SOUTHWEST QUARTER, LOT 15, CONCESSION VII, KALADAR TOWNSHIP

In 1972 a diamond drill hole 124.5 feet in length on a bearing of N15W at a dip of 80 degrees intersected a medium to fine grained “granitic” rock with a banded texture. A 1 foot section from the 118 foot level assayed trace amounts of gold. The core log description from this hole is limited in geological detail (Assessment Files Research Office, Ontario Geological Survey, Toronto). The property was still held by T.C. Michie at the time of the survey.

STONE OCCURRENCE (7)
WEST HALF LOT 23, CONCESSION V, KALADAR TOWNSHIP

Near the northeast corner of the west half of the lot 23, concession V, visible gold mineralization was found in 1939 by W. Lessard (Harding 1942) occurring in quartz stringers at the contact of the mafic metavolcanics (map-unit 1a) and the Flinton Group quartzite-pebble conglomerate (map-unit 10b). Accessory sulphides are mainly pyrite, pyrrhotite and arsenopyrite. The ground was open for staking at the time of this survey.

MOLYBDENUM

Seven occurrences of molybdenum mineralization have been identified in the map-area and are located on the east half of lot 9, concession IV, Kaladar Township; the west half of lot 12, concession III, Kaladar Township (Harding 1942); the east half of lot 13, concession II, Kaladar Township (Harding 1942); the east half of lot 14, concession V, Kaladar Township; the west half of lot 17, concession IX, Kaladar Township; the east half of lot 17, concession X, Kaladar Township; and the west half of lot 15, concession I, Kennebec Township (Harding 1942). Invariably the mineralization is in the form of molybdenite and occurs in white crosscutting pegmatite dikes (map-unit 12b). These dikes range from 0.5 m to 3 m in width and occur near the borders of the Northbrook Batholith. The molybdenite occurs as massive to scattered flakes, and the mineralization is not continuous along the strike length of these dikes. The best showing (east half of lot 14, concession V, Kaladar Township) has molybdenite concentrations over a strike length of 5 m. The molybdenum occurrences do not appear to be controlled by the composition of the country rocks cut by the dikes and are considered by the author to be a syngenetic mineralization indigeneous to the penetrating pegmatite fluids. No exploration work has been recorded on these occurrences.

SULPHIDE MINERALIZATION

Widely distributed throughout the map-area are a number of occurrences of pyrite, chalcopyrite, pyrrhotite, arsenopyrite and minor galena and sphalerite. The sulphides occur in four different modes: 1) stratiform sulphide bands in clastic siliceous gneiss and amphibole-rich gneiss and schist (map-units 3 and 5) in the Hermon Group; 2) disseminated blebs in the mafic metavolcanics (map-unit 1); 3) disseminated to locally massive concentrations in contact shear zones between the mafic metavolcanics (map-unit 1) and the younger Flinton Group metasediments (map-units 10 and 11); and 4) a localized massive concentration in the Elzevir Batholith (map-unit 8).

The stratiform sulphides occur as fine disseminations and as massive veinlets, stringers and seams of sulphide mineralization composed mostly of pyrite, pyrrhotite, chalcopyrite and sphalerite in gneisses in the map-area. These sulphide zones do not constitute ore grade material themselves but may if they occur in conjunction with faulting, shearing, formational contacts or other such structures. In the map-area stratiform sulphide mineralization is found in the Clare River Synform structure, in the following units: 1) fine-grained hornblende-plagioclase gneiss (5a); 2) hornblende-rich gneiss (5d); and 3) medium-grained biotite quartzofeldspathic paragneiss (3d). Minor work on this type of mineralization in the map-area has been carried out at two localities. Trenching at an occurrence of disseminated to massive chalcopyrite and pyrite was carried out on the west half of lot 11, concession II, Kennebec Township before 1940, and trenching plus two diamond drill holes at an occurrence of chalcopyrite, pyrite, pyrrhotite and minor sphalerite was performed by Glenshire Mines Limited (property 4 on map) in 1975. The stratiform sulphide concentrations are likely syngenetic in origin as the disseminated sulphide mineralization parallels the gneissosity planes which are coincident with the original bedding surfaces. Gammon's study (1966) of a similar deposit in Norway indicates deposition may have taken place in a near-shore deltaic environment with favourable conditions for sulphide deposition. Metamorphism totally recrystallized the sulphides thus obliterating any trace of their original organic origin or texture. Local mineral concentrations may have been achieved through post-deposition deformation.

Disseminated blebs of chalcopyrite in the mafic metavolcanics (map-unit 1) usually are found in the carbonate-bearing amphibolite. Occurrences of chalcopyrite observed during the present survey in the field were estimated to contain less than 1 percent chalcopyrite and grab samples of these occurrences taken by the field party assayed 0.01 percent Cu, 0.01 percent Ni and 0.01 percent Zn (Geoscience Laboratories, Ontario Geological Survey). The author considers these sulphide occurrences to be syngenetic.

The presence of sulphide mineralization in shear zones which are in the contact zone with the mafic metavolcanics (map-unit 1) and the Flinton Group metasediments (map-units 10 and 11), have been briefly mentioned in the discussion on gold mineralization (locations 2, 3 and 7 on map). This type of occurrence usually contains pyrite, chalcopyrite, pyrrhotite and arsenopyrite, and small amounts of galena and sphalerite are present locally. Two 170-foot diamond drill holes near this contact were sunk on properties (8 on map) held by K.M. Sullivan in 1962 (east half of lot 23, concession V, Kaladar Township), and in 1963 (west half of lot 20, concession IV, Kaladar Township). Both holes encountered pyrrhotite and pyrite mineralization in "greenstone schists" (Assessment Files Research Office, Ontario Geological Survey, Toronto). This mineralization is similar to that in the surface-exposed shear zones mentioned above. The shear zone mineralization is likely an epigenetic enrichment of the sulphides from within the mafic metavolcanics near the shear zone.

A small but massive occurrence of arsenopyrite was located by the field party in the west half of lot 25, concession III, Kaladar Township. The sulphide occurs as a massive concentration within granodiorite of the Elzevir Batholith and has been blasted in the past, but the mineralized zone appears to have been approximately 3 m in diameter. This occurrence is localized on the surface possessing no apparent vertical or lateral extension.

A small occurrence of pyrite in "streaks" has been reported from the 350-351 foot section of a 400-foot diamond drill hole sunk on the property held by T.C. Michie (lot 15, concession VII, Kaladar Township). The mineralized zone is found within rocks described as hornblende, quartz and epidote-bearing metasediments, although the core log lacks detail in description (Assessment Files Research Office, Ontario Geological Survey, Toronto).

Description of Property

GLENSHIRE MINES LIMITED (4)
LOT 5, CONCESSION IX, KALADAR TOWNSHIP

The first reported data on this property indicates it was examined in 1952 by the New Jersey Zinc Exploration Company (Canada) Limited. At that time old pits dug in zones of pyrite, pyrrhotite, chalcopyrite and sphalerite were exposed by H. Dowhaluk. In 1974 the showing was acquired as part of twelve claims staked by H. Bregman and S. Mourin of Toronto. A very low frequency electromagnetic survey carried out in February and March 1975 delineated five conductive zones. The property was purchased in March 1975 by Glenshire

Mines Limited of Toronto. In the summer of 1975 a 5 m trench was opened in the east part of claim 414238. An assayed grab sample from the showing is reported by the company to have yielded 2.88 percent copper and 0.17 percent zinc (Assessment Files Research Office, Ontario Geological Survey, Toronto).

Detailed geological mapping of the claim group was carried out in 1975 at the scale of 1 inch to 200 feet, and a geochemical soil survey of the four easternmost claims was executed. Results of this survey yielded no anomalies (Assessment Files Research Office, Ontario Geological Survey, Toronto).

Six diamond drill holes were also sunk on the Glenshire Mines Limited property in 1975, two of which are in the map-area (Assessment Files Research Office, Ontario Geological Survey, Toronto). The southernmost hole was sunk 105 feet and intersected a 34-foot sulphide zone at the 38-foot level and a 12-foot sulphide zone at the 81-foot level. Sulphide mineralization in these zones was mainly limited to pyrite and pyrrhotite with minor sphalerite. The northernmost hole on lot 5, concession IX was sunk 111 feet and encountered alternating horizons of pegmatite and quartzite throughout its length. The pegmatite units contained uranium mineralization described below and some of the quartzite units contained disseminated pyrite and pyrrhotite (Assessment Files Research Office, Ontario Geological Survey, Toronto).

SILVER

Silver mineralization is generally quite sparse but occurs in two different geologic settings. It occurs locally with gold in quartz stringers and veins at the Addington mine (mentioned above) which produced 26 ounces of silver in 1922. It also occurs in a sulphide zone within an impure quartzite in the southeast quarter of lot 5, concession IX, Kaladar Township (Glenshire Mines Limited). Silver assayed 0.02 ounces per ton and 0.06 ounce per ton in the 85- to 93.5-foot section of the sulphide zone (pyrite and pyrrhotite) of the southernmost drill hole mentioned above (Assessment Files, Research Office, Ontario Geological Survey, Toronto).

Radioactive Mineralization

Uranium mineralization occurs in a number of localities and in similar geologic environments. The main concentrations of uranium are associated with pegmatites. One mode of uranium concentration in the map-area is typified by an occurrence located on the west-half of lot 17, concession XI, Kaladar Township. White pegmatite dikes (map-unit 12b) cut and locally migmatized and assimilated screens of quartz-pebble conglomerate and quartzite of the Flinton Group (map-unit 10b). In this type of occurrence the pegmatite often contains phlogopite and zircon which may occur in either the pegmatite or the assimilated metasedimentary screens. Molybdenite was also found at this occurrence in the white pegmatite. Uraniferous oxide weathering is locally present. A grab sample from this locality taken by the author gave total field (U + K + Th) counts of 50 times background. This sample assayed 2.8 pounds U_3O_8 per ton, and 0.02 percent Mo (Geoscience Laboratories, Ontario Geological Survey). No work has been recorded on this occurrence.

Another example of this same type of radioactive mineralization is found along strike of this occurrence on the west half of lot 17, concession IX, Kaladar Township. This showing gave a total field (U + K + Th) count of 8 times background.

The second type of uranium occurrence is typified by drill hole number 5 (northernmost hole) of Glenshire Mines Limited (property 4 on map). Assayed samples from this hole have reported U_3O_8 concentrations ranging from 0.010 percent to 0.021 percent (0.2 to 0.4 pounds per ton) (Assessment Files Research Office, Ontario Geological Survey, Toronto). The mineralized zones are within rocks which have been reported to be pink pegmatite but are often medium- to coarse-grained quartz monzonite (map-unit 7d) and which locally intrude the metasediments in a lit-par-lit fashion. Locally these intrusive units are reported to contain uraninite, uranophane and garnet. In the uraniferous zones the felsic intrusive sills were reported to be in contact with impure quartzite units which the author interprets as a leucocratic quartzofeldspathic paragneiss (map-unit 3e) and possibly minor amounts of biotite quartzofeldspathic paragneiss (map-unit 3d).

The fact that these two types of uranium concentration occurrences are in immediate contact with assimilated quartzitic metasediments suggests to the author that the uranium was originally in the sediments and has been hydrothermally reconcentrated in the pegmatites upon intrusion and metatexis of the metasediments. The uranium mineralization is probably epigenetic. Where pegmatites are in contact with other rock types in the map-area uraniferous mineralization does not occur.

Non-Metallic Mineralization

MICA

Mica, mainly muscovite was at one time extracted from a trench on lot 17, concession II, Kennebec Township. The muscovite occurs in a pegmatite dike (map-unit 12b). The dike is about 1.5 m wide, has been trenched for approximately 20 m and is 3 to 5 m deep. Muscovite plates up to 5 cm in diameter have been reported from this trench (Harding 1942).

QUARTZ AND FELDSPAR

Quartz and feldspar have been quarried in the past in a small way. An occurrence of massive white bull quartz on the east half of lot 11, concession V, Kaladar Township appears to be a local large quartz-rich pegmatite (map-unit 12) intrusive into clastic siliceous gneiss (map-unit 3). A feldspar occurrence on the west half of lot 15, concession VII, Kaladar Township, is part of map-unit 12 as well and is massive potash-rich pink pegmatite. These workings were surface operations in existence before 1940.

ACTINOLITE

Actinolite was also mined in a small way and was described by Harding (1942, p.72) as follows:

> Massive actinolite is exposed on the northeast part of lot 13, concession II, Kaladar Township. The actinolite occurs as a band about 50 feet wide situated at the contact between granite gneiss and conglomerate (Hastings type). This deposit was operated years ago by A.M. Chisholm. The actinolite was transported by team to Kaladar station for shipment. Only a limited amount of actinolite was shipped. This operation was suspended about the beginning of the present century, and there has been no production since.

SAND AND GRAVEL

Local pits of sand and gravel have been worked throughout the area. Most of these are situated off Highway 41 and around the village of Flinton. These supplies are extracted for local construction purposes and those along the highway were exploited for the rebuilding of Highway 41. The individual pits are small and of scattered distribution.

Suggestions for Future Exploration

The present study of the Kaladar 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. Major conclusions with regard to the mineral potential of the area are presented below.

METALLIC MINERALS

The occurrence of gold, base metals, sulphides and associated minor silver mineralization in the contact zone of the mafic metavolcanics (map-unit 1) and the younger Flinton Group metasediments (map-unit 10b especially) indicates that this contact is important with respect to mineralization of this type, both within and immediately adjacent to the map-area. The Cominco Limited deposit (Addington mine) is of particular interest as a potential gold producer. The tonnage and concentration of this deposit are not trivial and the ore is relatively close to the surface. Also, the deposit is situated very close to a Provincial highway which gives good access. Although the deposit is uneconomic at gold prices at the time of writing ($U.S. 130-180 per ounce), a rise in the price of gold could reverse this situation. Further engineering studies to determine the exact size and position of the ore zones would be essential for deciding the gold price at which production would be viable.

Molybdenum mineralization is invariably found in the late white pegmatite dikes which cut the Northbrook Batholith and various metasediments near the batholith's borders. Since the Northbrook is a large complex regional batholith, the author would expect more molybdenum to be found in similar associations both within and adjacent to the batholith east of the map-area and possibly to the north.

Stratiform sulphide mineralization containing minor chalcopyrite, pyrite, pyrrhotite and sphalerite is confined to the rocks of the Hermon Group in the Clare River Synform. Although of small concentration in the map-area, these sulphide units are on strike with zones of iron sulphide concentrations which were once worked near Sulphide, Ontario, for sulphur used in the production of sulphuric, nitric, and hydrochloric acids (Fraleck 1907); no base metal values are recorded for these operations.

Minor copper mineralization is disseminated in the mafic metavolcanics (map-unit 1) especially in the carbonate-bearing phases. The possibility that concentrations of this type may occur in the volcanic rocks should be kept in mind and may be significant not only in the map-area but to the immediate north where these units continue (Moore 1976).

RADIOACTIVE MINERALIZATION

Uranium mineralization tends to be controlled by white-pink pegmatite dikes (map-unit 12) which have intruded and assimilated quartz-rich metasediments (map-units 10 and 3d). This association is worth considering especially in the examination of rocks near the mineralized zones and on strike to the north and east of these zones which displayed interesting uranium anomalies on the joint Federal-Provincial uranium reconnaissance (airborne gamma-ray spectrometric maps) (GSC 1976).

NON-METALLIC MINERAL RESOURCES

Many of the rocks of the area are potential sources of building and ornamental stone, and although this resource has not been exploited to date it possibly constitutes an important mineral resource in the area. The wide variety of metamorphosed sedimentary rock types and the several igneous rock types have a wide range of interesting colours and textures that may prove marketable in the urban centres. These rocks are not only well exposed but lie very near major highways leading to these urban centres.

With the exception of the local sand and gravel pits the other occurrences of non-metallic minerals appear to be of minor economic potential.

ROCKS AND MINERALS FOR THE COLLECTOR

Like much of the Grenville Province the map-area hosts a variety of rocks and minerals of interest to the mineral collector. The pegmatite dikes (map-unit 12) locally contain garnet, molybdenite, muscovite, biotite, phlogopite, zircon and tourmaline, especially where the dikes cut metasediments.

Some of the metasediments contain good crystals of hornblende, diopside, tourmaline and garnet. The amphibole-rich gneisses (map-unit 5) locally contain good garnet and hornblende crystals, and the garnetiferous units of the clastic siliceous metasediments (map-unit 3) locally contain numerous large garnet poikiloblasts. The marble units contain some well developed but small diopside crystals and locally orange tourmaline crystals occur south of Elm Tree, on the east half of lot 9, concession II, Kennebec Township.

Well developed rosettes of actinolite can be collected in the ultramafic rocks (map-unit 1j) in the west half of lot 11, concession II, Kaladar Township. Also, some excellent samples of polymictic conglomerate (map-unit 11b), quartzite-pebble conglomerate (map-unit 10b) and garnet-quartz-muscovite schist (map-unit 2b) can be collected very easily from road cuts on Highway 41, 2.5 km north of Kaladar.

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1972: The Grenville Province; p.264-334 *in* Variations in Tectonic Styles in Canada, Geological Association Canada Special Paper 11, ed. R.A. Price and R.J.W. Douglas.

INDEX

Ministry of
Natural
Resources
Ontario

Ontario Geological Survey
Map 2432
Kaladar

LEGEND

PHANEROZOIC
CENOZOIC[a]
QUATERNARY
RECENT
Organic swamp and alluvial deposits.

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

UNCONFORMITY

PRECAMBRIAN[b]
LATE PRECAMBRIAN
LATE TECTONIC FELSIC INTRUSIVE ROCKS

12
- 12a Leucocratic granitic dikes.
- 12b Pegmatite dikes.
- 12c Pegmatite sills.

INTRUSIVE CONTACT

METASEDIMENTS
FLINTON GROUP[c]
CARBONATE METASEDIMENTS (LESSARD FORMATION)

11
- 11a Carbonate-biotite schist.
- 11b Polymictic pebble conglomerate (matrix plagioclase-hornblende gneiss, pebbles of granitic compositions).
- 11c Calc-silicate (plagioclase-hornblende) gneiss with epidote.
- 11d Epidote free variety of 11c.
- 11e Carbonate-bearing quartzofeldspathic sandstone.

CLASTIC SILICEOUS METASEDIMENTS (BISHOP CORNERS FORMATION)

10
- 10a Quartzofeldspathic sandstone and quartzofeldspathic conglomerate.
- 10b Quartz-pebble conglomerate (± aluminous matrix), local quartzite lenses.
- 10c Quartzite.
- 10d Biotite quartz feldspar schist ± hornblende ± garnet.
- 10e Quartzofeldspathic sandstone.

UNCONFORMITY

INTERMEDIATE TO FELSIC PLUTONIC ROCKS
NORTHBROOK BATHOLITH[d]

9
- 9a Biotite trondhjemite.
- 9b Biotite granodiorite.
- 9c Biotite quartz monzonite.
- 9d Biotite granite.
- 9e Potassic feldspar augens.
- 9f Potassic feldspar segregations.
- 9g Discontinuous hornblende-plagioclase to amphibolite phases.
- 9h Epidote veinlets.

ELZEVIR BATHOLITH[d]

8
- 8a Biotite granodiorite.
- 8b Biotite quartz monzonite.
- 8c Potassic feldspar augens.

ADDINGTON AND SHEFFIELD INTRUSIONS[d]

7
- 7a Weakly foliated leucocratic pink granite.
- 7b Foliated to gneissic pink biotite granite (biotite< 25%).
- 7c Swirl foliated; interbanded pink granite, grey trondhjemite-granodiorite.
- 7d Foliated to gneissic leucocratic quartz monozonite.
- 7e Foliated to gneissic biotite quartz monozonite (biotite< 25%).
- 7f Potassic feldspar augens.

MAFIC INTRUSIVE ROCKS[d]

6
- 6a Hornblende quartz gabbro, diorite.
- 6b Hornblende-biotite granodiorite.

INTRUSIVE CONTACT

METASEDIMENTS AND METAVOLCANICS
HERMON GROUP
AMPHIBOLE-RICH GNEISS AND SCHIST[e,f]

5
- 5a Fine-grained hornblende-plagioclase gneiss.
- 5b Fine-grained plagioclase-hornblende gneiss.
- 5c Medium-grained plagioclase-hornblende paragneiss.
- 5d Hornblende-rich gneiss.[g]
- 5e Epidote-biotite-feldspar-quartz paragneiss.
- 5f Biotite-chlorite schist.
- 5g Chloritic 5a, b & c.
- 5h Epidote lenses and/or layers.
- 5j Biotitic 5a or b.
- 5k Garnetiferous ± muscovite 5a or b.
- 5m Hornblende porphyroblastic 5b.
- 5n Siderite-bearing 5b.
- 5p Calcite-bearing 5b.

CARBONATE METASEDIMENTS[e]

4
- 4a Crystalline dolomitic marble; locally up to 20% massive medium-grained lenses and/or layers of quartzite.
- 4b Fragmental dolomitic marble (quartz, quartzite, and dolomite fragments and flags).
- 4c Laminated silty marble.
- 4d Phlogopite-bearing marble.
- 4e Diopside-bearing marble.
- 4f Tremolite-bearing marble.
- 4g Serpentine-bearing marble.

CLASTIC SILICEOUS GNEISS[e]

3
- 3a Fine grained leucocratic quartzofeldspathic gneiss (possibly metavolcanic).
- 3b Layered quartzofeldspathic gneiss with medium grained muscovite.
- 3c Fine-grained biotite quartzofeldspathic paragneiss.
- 3d Medium-grained biotite quartzofeldspathic paragneiss.
- 3e Medium-grained leucocratic quartzofeldspathic paragneiss.
- 3f Garnetiferous porphyroblastic.
- 3g Muscovitic 3d (1-5%).

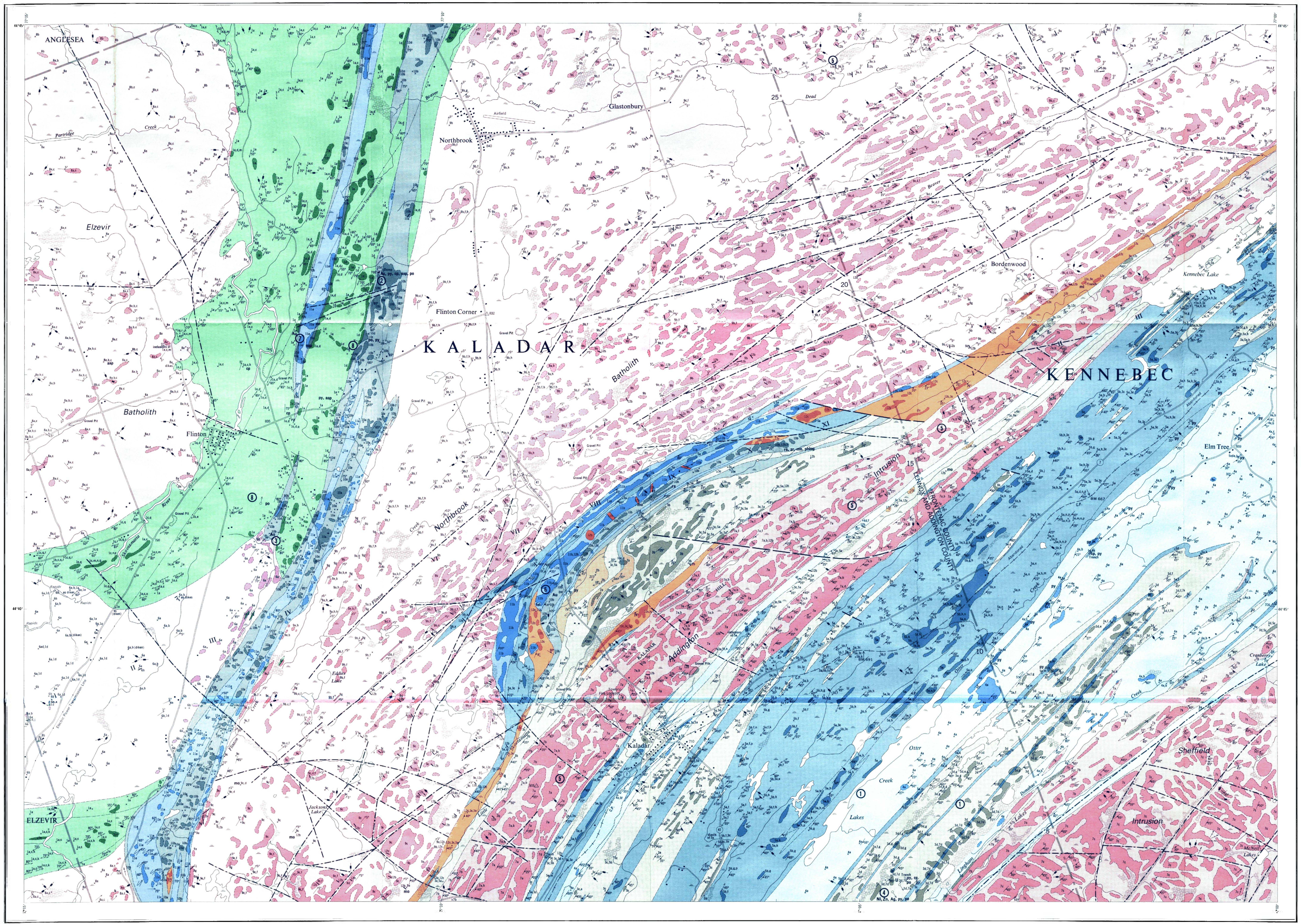
ALUMINOUS SCHIST[e]

2
- 2a Quartz-muscovite schist.
- 2b Garnet-quartz muscovitic schist.

MAFIC TO INTERMEDIATE META-VOLCANICS[h] (TUDOR FORMATION)

1
- 1a Massive amphibolite ± chlorite, biotite.
- 1b Pillowed amphibolite.
- 1c Carbonate-talc bearing amphibolite.
- 1d Plagioclase-hornblende gneiss.
- 1e Intermediate lapillistone.
- 1g Intermediate tuff.
- 1h Amphibolite with acicular hornblende crystals.
- 1j Ultramafic metavolcanics, locally containing anthophyllite ± tremolite porphyroblasts.
- 1k Siliceous nodules.
- 1m Carbonate-filled vesicules.
- 1n Carbonate nodules and lenses.
- 1p Thin laminated chert layers.
- 1q Biotitic 1a.
- 1r Chloritic 1a.

Ag	*Silver.*
asp	*Arsenopyrite.*
Au	*Gold.*
cp	*Chalcopyrite.*
fel	*Feldspar.*
mi	*Mica.*
mo	*Molybdenite.*
Ni	*Nickel.*
phlog	*Phlogopite.*
po	*Pyrrhotite.*
py	*Pyrite.*
q	*Quartz.*
ra	*Radioactive minerals.*
U	*Uranium.*
Zn	*Zinc.*
zr	*Zircon.*



Published 1981

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

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

[c] *Modified after J. M. Moore and P. H. Thompson, 1972: The Flinton Group, Grenville Province, Eastern Ontario, Canada; 24th Int. Geol. Congress, Montreal, Sect. 1, P. 221-229.*

[d] *Age correlation between Northbrook and Elzevir Batholiths and Addington and Sheffield intrusions and mafic intrusive rocks is uncertain.*

[e] *No relative age inferred between these units.*

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

[g] *Usually associated with 5b.*

[h] *Appear to be the oldest rocks in the map area.*

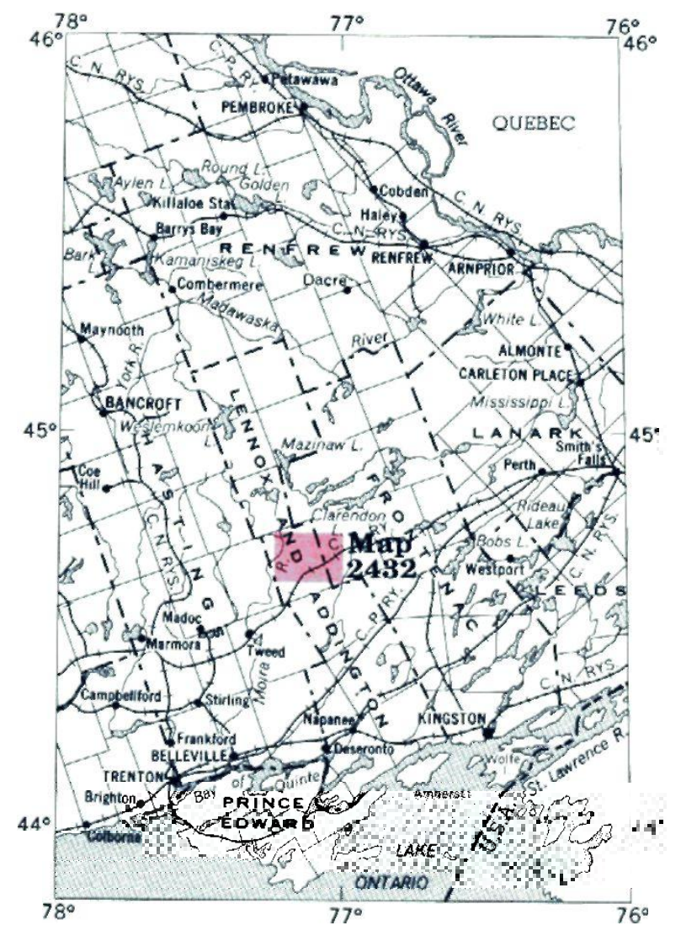
Ontario Geological Survey
Map 2432

KALADAR

SOUTHERN ONTARIO

Scale 1:31,680 or 1 Inch to ½ Mile

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



Scale 1 inch to 50 miles
N.T.S. Reference 31C/11

SYMBOLS

- *Small bedrock outcrop.*
- *Area of bedrock outcrop.*
- *Bedding, top unknown; (inclined, vertical).*
- *Schistosity; (horizontal, inclined, vertical).*
- *Gneissosity, (horizontal, inclined, vertical).*
- *Foliation; (horizontal, inclined, vertical).*
- *Banding; (horizontal, inclined, vertical).*
- *Lineation with plunge.*
- *Geological boundary, observed.*
- *Geological boundary, position interpreted.*
- *Fault; (observed, assumed). Spot indicates down throw side, arrows indicate horizontal movement.*
- *Lineament.*
- *Jointing; (horizontal, inclined, vertical).*
- *Drag folds with plunge.*
- *Drill hole; (vertical, inclined).*
- 700′ *Shaft; depth in feet.*
- 709 *Altitude in feet above mean sea level.*
- BM 667 *Bench mark in feet.*
- *Swamp.*
- *Inundated land.*
- *Motor road. Provincial highway number encircled where applicable.*
- *Other road.*
- *Trail, portage, winter road.*
- *County boundary; approximate position only.*
- *Township boundary, surveyed; approximate position only.*
- ① *Location of mining property or mineral deposit; approximate position only.*

PROPERTIES, MINERAL DEPOSITS

1. *Canadian Occidental Petroleum Ltd.*
2. *Cominco Ltd. (Addington mine).*
3. *Ewing occurrence.*
4. *Glenshire Mines Ltd.*
5. *Hudson Bay Exploration and Development Co. Ltd.*
6. *Michie, T.C.*
7. *Stone occurrence.*
8. *Sullivan occurrence.*

Information current to 31 December, 1977.

Only former properties on ground now open for staking are shown where exploration information is available. For further information see report.

SOURCES OF INFORMATION

Geology by J. M. Wolff and assistants, Ontario Geological Survey, 1977.
Geology is not tied to surveyed lines.

Thompson, P.H., 1972: Stratigraphy, structure and metamorphism of the Flinton Group in the Bishop Corners-Madoc Area, Grenville Province, Eastern Ontario; Carleton University, Unpublished Ph. D. Thesis, Ottawa. Assessment Files Research Office, Ontario Geological Survey, Toronto.

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Hewitt, D. F., 1964: Geological Notes for Maps Nos. 2053 and 2054; Ontario Department of Mines, Geological Circular No. 12.
Preliminary map (OGS), P1563, Kaladar Area, scale 1 inch to ¼ mile, issued 1978.

Cartography by J. D. Holweg and assistants, Surveys and Mapping Branch, 1979.

Basemap from National Topographic System sheet 31c/11, with additional information by J. M. Wolff.

Magnetic declination in the area was approximately 9° 30″ West in 1977.

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.
1981: Kaladar; Ontario Geological Survey Map 2432, Precambrian Geology Series, scale 1 inch to ½ mile, geology 1977.