ISBN 1-4249-0968-6

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Ontario Geological Survey
Open File Report 5554

Geology and Mineral Potential of the Eastern Tomiko Terrane, Grenville Province

2006

Ontario

ONTARIO GEOLOGICAL SURVEY

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by

R.M. Easton

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Abstract

The presence of a thick sequence of metasedimentary gneisses, including quartz arenite and iron formation (hereafter referred to as the Tomiko supracrustal rocks) makes Tomiko terrane unique among the terranes and domains of the northern Central Gneiss Belt of Ontario. Tomiko terrane, however, has undergone only limited mapping since the early 1970s, and little U/Pb geochronological data are available for the terrane. This lack of information has hampered previous efforts to characterize the mineral potential of the terrane, although several workers have previously suggested that Tomiko terrane was a favourable target for Broken Hill-type zinc-lead mineralization. The purpose of this six-week reconnaissance study was to improve our knowledge of the geology of Tomiko terrane, and to determine if it might indeed host Broken Hill-type mineralization. Highlights of this study include

- the discovery of boron-rich (>15% tourmaline) and manganese-rich rocks in association with magnetite-chert iron formation, as well as epidote-rich (>20%) rocks in association with sulphide mineral-bearing rusty gneisses. In addition, some of the feldspathic gneisses in the terrane contain slightly anomalous contents of Be, Nb, Pb, Th, W, and Y.
- iron formation in the northern part of the study area consists of magnetic-chert and ferrosilite gneiss. The ferrosilite gneiss was probably derived from carbonate-facies iron formation by a process of devolatilization and, in this respect, is similar to metamorphosed iron formation that occurs south of the Grenville Front in Labrador.
- the recognition of possible dacitic metavolcanic rocks and sills interlayered with the Tomiko supracrustal rocks, along with amphibolites that may represent sills or flow.
- the identification of a new lobe of the Mulock granite (1244 Ma) that covers at least 25 km^2 in western Lockhart and Garrow townships and the identification of several granite bodies in northern Tomiko terrane that were previously mapped as feldspathic metasedimentary rocks. Thus, the Tomiko supracrustal succession contains fewer metasedimentary rocks than shown on existing maps.
- the recognition of possible Archean “basement” rocks infolded with the Tomiko supracrustal rocks, particularly in northern Tomiko terrane. This basement is likely in structural, not depositional, contact with the Tomiko supracrustal rocks. The Archean rocks are intruded by an orthopyroxene hornblendite body, which may be correlative with similar rocks that are common in Street, Henry and Loughrin townships east of Sudbury and which are 2475 Ma in age.
- the identification of at least 3 metamorphic events affecting the supracrustal rocks in Tomiko terrane, with the intensity of the 2 latest events increasing to the southeast. M2 results in a migmatite front between northern and southern Tomiko terrane, with lower grade rocks to the north. M3 can also be regarded as a regional hydrothermal event, and results in the replacement of blue kyanite and granite leucosome formed during M2 by pale-green kyanite and quartz segregations.
- new geochronology results that confirm previous detrital zircon studies on quartz arenites from the Tomiko terrane have a maximum depositional age of 1687±20 Ma. Leucosome development during M2 metamorphism in migmatitic quartz arenite occurred at 1047±6 Ma.
- new geochronology results that expand the extent of Geon 12 magmatism in the northwestern Grenville Province, including a $1257^{+4}/_{-2}$ Ma age for the Jocko pluton, and a 1250±10 Ma age for grey gneiss interlayered with the Tomiko supracrustal rocks. Known Geon 12 plutons in the study area are characterized by low to moderate magnetic susceptibility readings, suggesting only partial recrystallization during regional metamorphism at circa 1047 Ma. Based on magnetic susceptibility, there are likely several other Geon 12 plutons in the study area.

Regional stratigraphic correlation of the Tomiko supracrustal rocks with other Paleoproterozoic sequences in North America remains problematic, and it is possible that the Tomiko supracrustal rocks represent a unique rock sequence. Stratigraphic correlation with metasedimentary rocks of the Huronian Supergroup, exposed immediately to the north, or with the Frontenac terrane in the Central Metasedimentary Belt is unlikely, based on the detrital zircon age and comparison of Nd/Sm model ages from all 3 sequences.

More compelling, however, is that the Tomiko supracrustal rocks have many lithologic, stratigraphic and geochronologic similarities to Geon 17 rocks of the Mazatzal Orogen exposed in Arizona and New Mexico (Tonto Basin Supergroup and Hondo Group, respectively). For example, the Hondo Group overlies a sequence of older greenstones, and consists of a thin basal unit of quartz pebble conglomerate, over 1 km of quartz arenite, and a capping sequence of muscovite schist and arenite, metarhyolite, phyllite and calc-silicate rocks. A manganese-rich horizon, possibly a paleosol, perhaps lateritic, occurs at the top of the greenstones. Furthermore, some of the muscovite schists in the Hondo Group represented hydrothermally altered felsic volcanic rocks. Rocks of the Hondo Group were deposited between 1700 and 1644 Ma and contain detrital zircons ranging in age from 1850 to 1700 Ma. A key difference is that plutons intruded the Hondo Group between 1680 and 1650 Ma, not at circa 1250 Ma. If this stratigraphic correlation is correct, then the Tomiko supracrustal succession might be host to manganese and volcanogenic massive sulphide (VMS) mineralization.

This study is inconclusive when it comes to the question of the presence of Broken Hill-type mineralization in Tomiko terrane. Nonetheless, the presence of rocks of unusual composition and evidence for widespread hydrothermal activity in the terrane are positive indicators with respect to mineralization.

In addition to current extraction of mica, silica and vermiculite from the area, several areas have potential for kyanite, garnet and graphite exploration.

Geology and Mineral Potential of the Eastern Tomiko Terrane, Grenville Province

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Open File Report 5554
2006

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Introduction

The Broken Hill lead-zinc-silver orebody, located near the border between the states of New South Wales and Southern Australia, has produced over 180 million tonnes of ore from 3 main mines since 1883. Other deposit types present include copper and cobalt associated with iron formation, stratabound tungsten-base metal deposits, and various vein-type deposits (e.g., Stevens, Barnes and Forbes 1990). Easton (2001) provided an overview of Broken Hill geology and discussed the validity of previous suggestions that parts of the Central Gneiss Belt of the Grenville Province (Figure 1) might host Broken Hill-type zinc-lead mineralization. These previous suggestions were based largely on 3 points of comparison, namely 1) the Paleoproterozoic (~1690 Ma) age of the rocks; 2) the high-metamorphic grade of the Broken Hill deposit (granulite facies); and 3) the occurrence of mineralization in a metasedimentary (paragneiss)-dominated sequence (*see* Easton 2001 for details). Determination of more precise target areas for exploration in Ontario has been hampered, in part, by the lack of detailed (less than 1:250 000-scale) mapping within the Central Gneiss Belt. Nonetheless, Easton (2001) identified several potential target areas, the most promising of which was the Tomiko terrane (*see* Figure 1). The purpose of this six-week reconnaissance study was to determine if Tomiko terrane is indeed a favourable host for Broken Hill-type zinc-lead mineralization, to collect samples for geochronology, and to produce an updated compilation map of the terrane (Maps P.2846 and P.2847, back pocket).

Tomiko terrane (*see* Figure 1) is located northeast of North Bay, and is bounded to the west by Highway 11, to the east by the Ottawa River, and to the south by Highway 17. It was defined by Easton (1988), and further distinguished from other Central Gneiss Belt terranes and domains in Easton (1992).

Work focussed on a 2200 km^2 area in eastern Tomiko terrane covered by National Topographic System (NTS) 1:50 000 sheets 31 L/6, 31 L/7, 31 L/10, 31 L/11 and 31 L/14 (Figure 2). The study area is bounded by Universal Transverse Mercator (UTM) co-ordinates 620000E to 675000E and 5130000N and 5192000N, corresponding roughly to 46°18′30″N to 46°52′00″N latitude and 79°26′00″W to 79°44′00″W longitude. The study area encompasses parts or all of Angus, Antoine, Butler, Clarkson, Eddy, French, Garrow, Jocko, Lasalle, Lockhart, Mattawan, McAuslan, Merrick, Mulock, Olrig, Osborne, Parkman, Phelps, Poitras, Widdifield and Wyse townships. Areas specifically targeted for study included quartzite and muscovite-rich rocks in Clarkson and McAuslan townships (*see* Map P.2846), a previously reported marble and sulphide zone in Clarkson Township northwest of Miners Lake (Moore 1976; *see* Map P.2846), and kyanite-bearing rocks near Crocan and Cahill lakes (*see* Map P.2847) in Butler and Olrig townships, respectively.

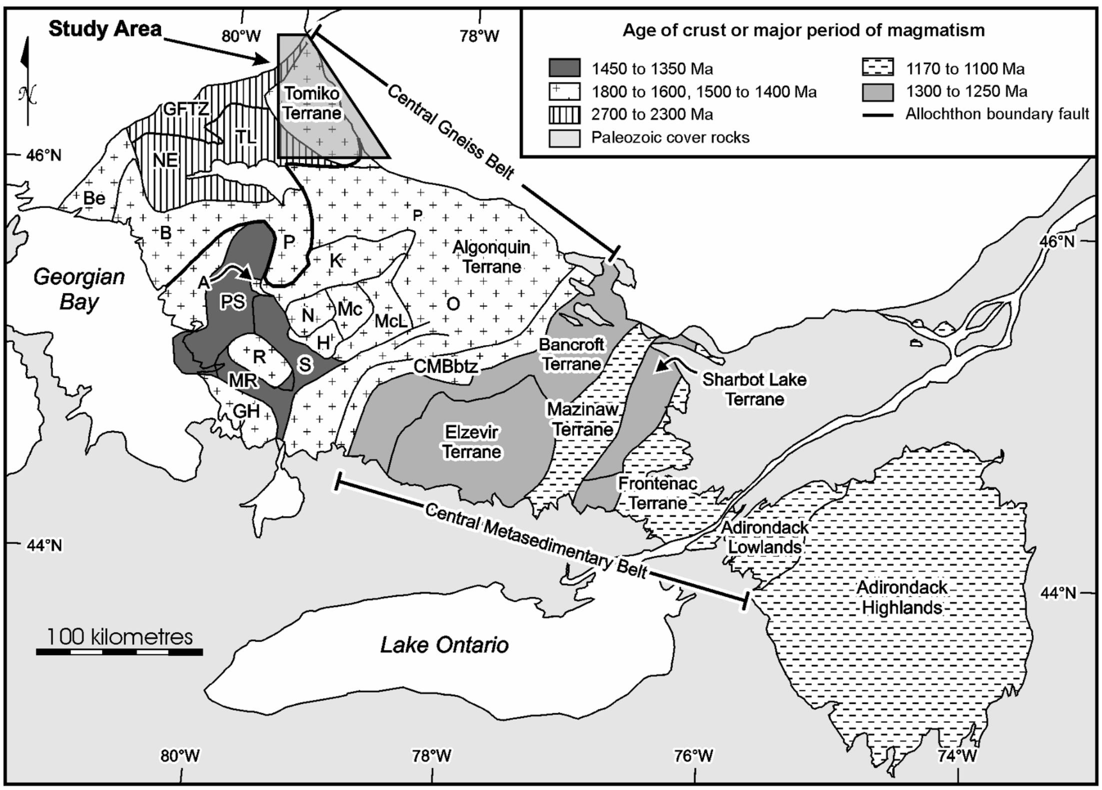
ACCESS

Access to the study area is provided by Highway 63 which links North Bay and Thorne, and Highway 533, which runs north-northwest from Mattawa and connects with Highway 63. The northern half of the map area is also accessible by the McConnell Lake forest access road, as well as a variety of logging roads that branch off from the McConnell Lake road. A forest access road and snowmobile trail through Phelps and Olrig townships links Highways 63 and 533. It, and the logging roads that branch from it, provide access to the southern part of the study area. Access is also provided by a natural gas pipeline north of Highway 63 that follows a northeast direction subparallel to the highway, and a hydroelectric transmission corridor that runs east from Redbridge to north of Mount Antoine. Areas difficult to access include southern Eddy Township, and Butler Township south of Highway 533. The Ottawa River forms the eastern boundary of the study area. The only communities in the study area, are the hamlets of Eldee, Thorne and Wyse, all located on Highway 63 near the bridge that links Ontario and Témiscaming, Quebec. The town of Mattawa is located 1 km east of the southeast corner of the study area.

PHYSIOGRAPHY

Relief in most of the map area is less than 100 m in the central and northern part of the study area, ranging from roughly 300 to 350 m above sea level. Relief is higher in the south, at 200 to 370 m above sea level, and along the Ottawa River, where it ranges from approximately 175 m to over 390 m. The highest elevations occur in northeastern McAuslan Township, where a large area of quartzite ranges from 426 to 480 m above sea level. High hills, up to 430 m high, also occur in the Cahill Lake area. The area underlain by Mattawan domain is characterized by a central plateau about 330 m above sea level, with a topographically rugged margin along the contact with Tomiko terrane. The main highways in the area generally follow topographic lows.

As discussed in greater detail in "Structure", topography in Tomiko terrane is also controlled by at least 4 shear zones, trending 50 to 60°, located approximately 8 to 12 km apart. Physiographic changes across these shear zones include a sudden increase in topography and outcrop abundance on the hanging-wall side of the shear zones, as well as abrupt changes in the direction of major streams and rivers along the trace of the shear zones. In addition, the shear zones are generally marked by topographic lows; it is probably no coincidence that the location of a natural gas pipeline in the area closely parallels the trace of one of these zones.



Abbreviations					
A	Ahmic Domain	GH	Go Home Domain	NE	Nepewassi Domain
B	Britt Domain	H	Huntsville Domain	O	Openongo Domain
Be	Beaverstone Domain (part of Killarney magmatic belt)	K	Kiosk Domain	P	Powassan Domain
CMBbtz	Central Metasedimentary Belt boundary thrust zone	M	Muskoka	PS	Parry Sound Domain
GFTZ	Grenville Front Tectonic Zone	Mc	McCraney Domain	R	Rosseau Domain
		McL	McClintock Domain	S	Seguin Domain
		MR	Moon River Domain	SD	Shawanaga Domain
		N	Novar Domain	TL	Tilden Lake Domain

Figure 1. Tectonic subdivisions of the Grenville Province (*modified from* Easton 1992).

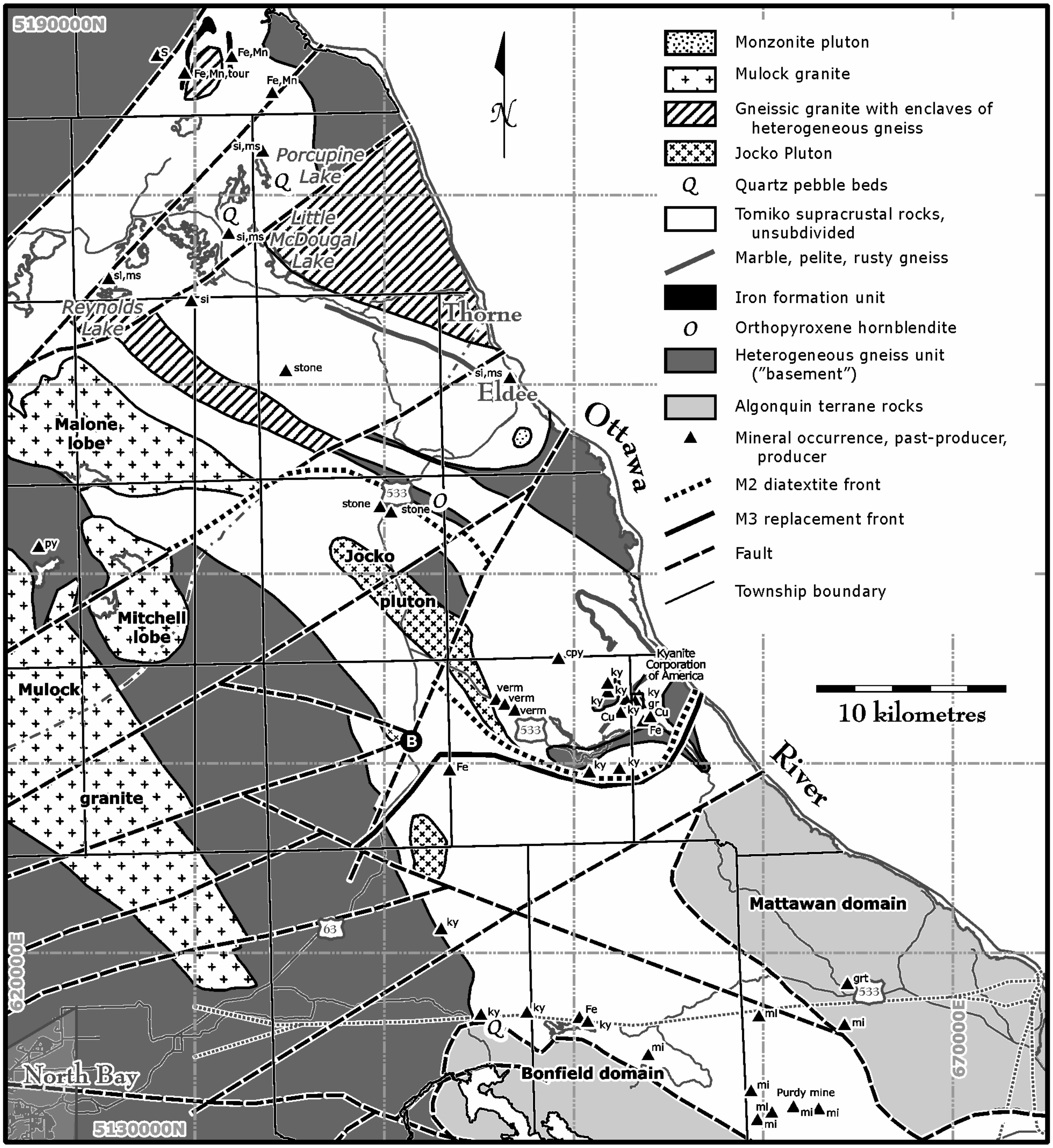


Figure 2. Geologic sketch map of Tomiko terrane, showing location of mineral occurrences, past-producers and producers, including new occurrences reported in this study. Only the distribution of key geological units and structures are shown. Abbreviations: cpy = chalcopyrite, Cu = copper, Fe = iron, gr = graphite, grt = garnet, ky = kyanite, mi = mica, Mn = manganese, ms = muscovite, py = pyrite, S = sulphides, si = silica, tour = tourmaline, verm = vermiculite.

Distribution of outcrop is varied. Exposure throughout the map area is probably on the order of 20%, due to moderate to thick glacial cover over most of the map area; however, as seen on Maps P.2846 and P.2847, drift cover is not evenly distributed within the map area. The most informative bedrock exposures are commonly found along recent logging roads where the overburden has been removed. Such exposures typically are overgrown or buried within a few years after logging. As a consequence, mapping during this project concentrated on areas recently logged, with only limited traversing in the bush to examine weathered and thickly lichen covered outcrops. Also, it should be noted that on Maps P.2846 and P.2847, outcrops that were compiled from maps made more than 20 years ago may no longer be exposed.

PREVIOUS WORK

Reconnaissance mapping by Lumbers (1971a, 1971b, 1971c, 1976) exists for all of Tomiko terrane, along with detailed mapping by Pearson (1959) and Moore (1976) focussing on parts of Butler, Antoine and Olrig townships.

In 1820, Bigsby (1821) described the rocks along the Mattawa River, including the presence of limestones at the east end of Lake Talon. In 1845, Logan (1847) examined the geology along both the Ottawa and the Mattawa rivers. The first comprehensive geological description of the area was by Barlow (1899, 1908), on the geology of the Nipissing and Timiskaming map sheets. Barlow (1908, p.159, 178, 179) reported finding kyanite in some of the gneisses exposed near Snake Creek, on the Quebec side of the Ottawa River, opposite northeastern Mattawan Township. During the period from 1908 to 1942, exploration in the region focussed on Mattawan and Olrig townships, with attention being paid to brucite-bearing marbles and mica-rich pegmatites. This exploration activity lead to mapping of Mattawan and Olrig townships by the Ontario Department of Mines in 1942 and 1943 (Harding 1946).

In the early 1950s, J.W. Hoadley of the Geological Survey of Canada mapped the Timber Lake area, but his map was never published. A copy of his map, however, was included in Pearson’s (1959) PhD thesis, and was used in the compilation of Map P.2847. Pearson’s (1959) thesis focussed on kyanite deposits in the northern Grenville Province in Ontario, and examined deposits in the vicinity of Wahnapitae, near Sudbury, and Crocan Lake, within the study area. In addition to mapping the deposits and studying their mineralogy, Pearson (1959) also obtained major element analyses for some of the gneisses in the study area.

Lumbers (1971a, 1971b, 1971c, 1976) mapped all of the study area at 1:63 360 scale. This work indicated that Tomiko terrane contains Archean rocks overlain by a Paleo- to Mesoproterozoic metasedimentary sequence that contains quartzite, calc-silicate rocks, and locally, magnetite-quartz iron formation.

Moore’s (1976) PhD thesis also had a significant mapping component, and included some major element geochemistry, in addition to its focus on the metamorphic petrology of the metasedimentary gneisses within the area. Moore (1976) also recognized 3 main stratigraphic units in the study area, the Antoine gneiss and the Cahill and Crocan Lake metasedimentary sequences. Moore (1976) also described sulphide-rich horizons within part of the stratigraphy, and provided textural evidence of a two-stage metamorphic evolution in Tomiko terrane.

Only a few geochronology studies have been conducted in Tomiko terrane. Quartzite from a site on Highway 533 near Timber Lake yielded a restricted zircon population dated at 1687±20 Ma, interpreted as a depositional age, with regional metamorphism in the same quartzite occurring at 995 Ma (Krogh 1989). Lumbers et al. (1991) examined the geochemistry of the Mulock granite, focussing on the intrusion in western Tomiko terrane, and published a U/Pb zircon date of $1244^{+4}/_{-3}$ Ma on the body. Davidson and van Breemen (2001) confirmed this age, obtaining an age of $1250^{+10}/_{-6}$ Ma for the Mulock granite from a different sample site. Holmden and Dickin (1995) conducted a regional neodymium isotope survey of Tomiko terrane.

Easton (1992) noted that the rock types and metamorphic history of the area of the Grenville Province between Highway 11 and the Ottawa River, north of the Mattawa fault were distinct from other parts of the Central Gneiss Belt, and proposed the term Tomiko terrane for this area. Rocks in, and adjacent to, the northwest corner of the study area were mapped by the author in 2001, as part of a study of the mafic intrusions in Flett and Angus townships (Easton 2002a).

Exploration activity in the study area is summarized in Appendix 1. For the past 50 years, exploration activity has focussed on industrial minerals, mainly garnet, kyanite, silica and vermiculite.

Geological Data Inventory Folios area available for all townships covered by the study area (Ontario Geological Survey 1984a–f, 1986a–e, 1987, 1988a, 1988b, 1988c, 1989).

PRESENT GEOLOGICAL SURVEY

Field work for the present geological survey (Project 03-009) was conducted by the author over a six-week period during July to September 2003. Mapping focussed on rocks located in Tomiko terrane, rather than on adjoining domains. Able assistance was provided by S. Dean during the field investigations. Preliminary results of this survey were reported in Easton (2003a, 2003b, 2005).

Maps P.2846 and P.2847 (1:50 000 scale) present the results of the geological survey carried out during the course of this project. Geological mapping was conducted using vertical aerial photographs at a scale of 1:20 000, obtained from by the Air Photo Library, Public Information Centre, Ontario Ministry of Natural Resources. Acetate overlays were used to record data that was collected on traverses run by the pace and compass method. Geology was not tied to surveyed lines. Traverses were not spaced at regular intervals, but were designed to include as many of the major outcrop areas as possible, particularly in areas of complex geology and along contacts between major rock units.

Information from mapping was plotted on Ontario Basic Mapping (OBM) 1:20 000 base maps supplied by the Ontario Ministry of Natural Resources, which were digitally combined and simplified. Recent information with respect to roads, buildings, power lines, rock and shoreline features, were added to the resulting base map.

Reference to specific locations (e.g., photographs, samples) in the text are given in (UTM) co-ordinates because of the ability to pinpoint locations more precisely than by using latitude and longitude. The map area is located in UTM Zone 17T and co-ordinates are given using North American Datum 1983 (NAD83).

Six samples were collected from the study area for U/Pb geochronology. Results of these studies are summarized briefly in this report and shown on Maps P.2846 and P.2847. Preliminary geochronology results were reported by Easton and Kamo (2004).

TERMINOLOGY

A number of terms used in this report are outlined below.

Precambrian Time Scale

The Precambrian time scale as subdivided by Easton (1999) is used. This is an updated version of the time scale used for *Geology of Ontario* (Ontario Geological Survey 1992). Precambrian time is divided into 2 eons: the Archean (older than 2500 Ma) and the Proterozoic (between 2500 and 543 Ma). The Proterozoic is divided into 3 eras: Paleoproterozoic (2500 to 1600 Ma), Mesoproterozoic (1600 to 900 Ma) and Neoproterozoic (900 to 543 Ma).

Rock Classification

Terminology for all plutonic rocks in the area follows that of Streckeisen (1976). For metamorphic rocks, mineral prefixes are listed in order of relative abundance, starting with least abundant first. Mineral abbreviations follow Kretz (1983). The following conventions are used regarding descriptive adjectives. A *gneissic granite* is a meta-igneous rock of granitic composition. A *granitic gneiss*, a *granite gneiss*, or a *gneiss of granitic composition* may be either a meta-igneous or a metasedimentary rock. Similarly, a *tonalitic gneiss* or a *tonalite gneiss* is a gneiss of tonalite modal composition, but may be of either meta-igneous or metasedimentary origin. A *gneissic meta-arkose* is a metasedimentary gneiss of overall granitic composition.

The term metamorphic grade is used in the case where bulk-rock composition or other factors prevent a more detailed assignment of metamorphic conditions. Where metamorphic conditions can be outlined more precisely, the metamorphic facies terminology of Turner (1981) is used. In this report, the term quartzite refers to a metamorphic rock derived from a quartz-rich metasedimentary rock, such as a quartz arenite.

A migmatite is a heterogeneous rock composed of 2 or more components, one generally quartzofeldspathic in composition (leucosome or neosome) and the other more mafic in composition (paleosome or mesosome). In the study area, such rocks are commonly layered and, in many instances, are formed by partial melting during high-grade regional metamorphism. Descriptive terminology for these rocks follows Menhert (1971). Other related terms are metatextite—a rock resulting from moderate degrees of partial melting in which leucosome is subordinate to mesosome; and diatextite—a rock resulting from high degrees of partial melting and containing substantial amounts of leucosome.

Foliation, Schistosity, Gneissosity, Cleavage

Foliation is used to describe all types of megascopic structural surfaces of metamorphic origin (Turner and Weiss 1963). Several distinguishable types of foliation include compositional layering and preferred orientation of mineral grains. Gneissosity and schistosity are the most common varieties of foliation in the map area. Gneissosity denotes a layering of metamorphic origin, defined by the alternation of layers, streaks, or lenticles on contrasting mineralogy or texture. The streaks or lenticles may be discontinuous. Schistosity is a planar structure in a metamorphic rock due to abundant, preferentially oriented grains, especially micas. Cleavage denotes a parting in the rock resulting from the parallel growth of micaceous or elongated minerals in fine- to medium-grained rocks.

Layering Thickness Terms

Layering thickness terms used in this report are listed below. These terms apply to bedded, layered and gneissic rocks.

Very thinly layered	<3 cm
Thinly layered	3 to 10 cm
Medium layered	10 to 30 cm
Thickly layered	30 to 100 cm (1 m)
Very thickly layered	1 to 3 m
Extremely thickly layered	>3 m

Geochemical Methods and Terminology

Except where otherwise stated, all chemical analyses that appear in this report were done at the Geoscience Laboratories, Ontario Geological Survey, Sudbury. All chondrite-normalized rare earth element diagrams shown in this report use the chondrite-normalizing values of Sun and McDonough (1989). All geochemical data collected during this study are listed in Appendix 2. Geochemical data from the literature are summarized in Appendix 3. Assay data related to this study are found in Appendix 4. Analytical methods are described in Vander Voet and Riddle (1993). With respect to assay data, the term anomalous is used with reference to background levels determined empirically by this study.

GEOLOGICAL SETTING

The geologic setting of the study area is illustrated in Figure 1. To the northwest are Archean and Paleoproterozoic rocks of the Superior and Southern provinces, to the southwest are Archean and Mesoproterozoic rocks of the Grenville Province. The boundary between the two is marked by a series of faults, known collectively as the Grenville Front (*see* Figure 1).

Tomiko terrane is bounded to the north by the Grenville Front tectonic zone (*see* Figure 1). In this part of the Grenville Province, the northern part of the Grenville Front tectonic zone consists mainly of tectonized Archean metasedimentary rocks belonging to the Red Cedar Lake gneiss, whereas the southern part consists mainly of a variety of Archean heterogeneous gneisses. To the east, Tomiko terrane continues across the Ottawa River into Quebec. It is bounded to the west by Archean rocks of the Tilden Lake domain (*see* Figure 1). To the south, as shown on Map P.2847, it is structurally overlain by the Bonfield and Mattawan domains (*new terms*) of the Algonquin terrane (*see* Figure 1; Table 1). The Allochthon Boundary Thrust marks the boundary between Tomiko and Algonquin terrane, and separates rocks with links to the North American craton from tectonically transported rocks to the south (e.g., Carr et al. 2000). Table 1 summarizes the key features of these domains and terranes. Table 2 summarizes the geologic history of the region and the U/Pb age constraints on this history.

Tomiko terrane can be divided into a western domain dominated by gneisses of Archean and Paleoproterozoic age intruded by the Mulock granite, and an eastern domain dominated by supracrustal rocks of mostly Paleoproterozoic age. Field work focussed on the eastern domain, although rocks of the western Tomiko, Bonfield and Mattawan domains were studied for comparative purposes.

Table 1. Major tectonic subdivisions of the Grenville Province in the vicinity of North Bay.

Terrane	Domain	Major Rock Types	Age
Laurentian margin			
Grenville Front tectonic zone	Eastern segment	Granular and block gneiss of the Red Cedar Lake gneiss, granodiorite gneiss of the Ingall Lake pluton, minor pegmatite (Archean in age). Metamorphosed Sudbury diabase dikes.	Archean with Grenville metamorphic overprint
	Tilden Lake	Heterogeneous mafic to intermediate composition gneisses intruded by younger monzogranite plutons, minor paragneiss, amphibolite. Metamorphosed Sudbury dikes.	Archean gneisses with 1270 to 1235 Ma mafic and felsic metaplutonic rocks
Tomiko	Western	Heterogeneous mafic to intermediate composition gneisses intruded by younger monzogranite plutons (Mulock granite), minor paragneiss, amphibolite. Metamorphosed Sudbury diabase dikes.	Archean to Paleoproterozoic gneisses, cut by 1270 to 1235 Ma mafic and felsic metaplutonic rocks
Tomiko	Eastern	Quartzose and feldspathic metasedimentary rocks with minor calc-silicate gneiss, iron formation, marble and interlayered felsite, dacitic gneisses, and amphibolite (sills, flows and/or volcaniclastic rocks) to mafic sills or volcanic flows, overlying a possible basement complex consisting of heterogeneous mafic to intermediate composition gneisses. Intruded by at least 3 ages of felsic to intermediate metaplutonic rocks. Metamorphosed Sudbury diabase dikes yet to be positively identified.	Paleoproterozoic to Mesoproterozoic. Mulock granite ($1244^{+4}/_{-3}$ Ma) probably cuts the metasedimentary sequence.
South of the Allochthon boundary thrust and the Laurentian margin			
Algonquin	Bonfield	Quartz monzonite to monzogranite plutons, minor amphibolite, marble, granitic pegmatites, meta-anorthosite and related mafic rocks (north of Mattawa fault). Coronitic metagabbro locally present.	Mesoproterozoic 1450 to 1270 Ma (felsic metaplutonic rocks)
	Mattawan	Quartz monzonite plutons, intermediate composition gneisses, pseudoecologite pods and layers associated with meta-anorthosite and related mafic rocks (north of Mattawa fault). Coronitic metagabbro locally present.	Paleoproterozoic to Mesoproterozoic

Table 2. Timing of major geological events and summary of age constraints on the main rock units present in the North Bay to Temagami area. All ages are U/Pb zircon ages.

Event	Age Constraint (in Ma)	Source and/or Comment
Grenville dike swarm	586±4	Kamo, Krogh and Kumarapeli (1995)
Age of youngest "Grenvillian" tectonic activity along the Grenville Front	988±5	Krogh (1994)
Age of M_2 metamorphism	1047±3	this study
Fanny and Fall Lake intrusions	1238±2 and 1235±2, respectively	Easton and Ketchum (2002), Ketchum (2002))
Sudbury dike swarm	1238±4	Emplaced in or along NW-trending faults in the Southern Province, but apparently not deformed by those faults. Deformed and metamorphosed within Grenville Province. Krogh et al. (1987); Dudas, Davidson and Bethune (1994).
Emplacement age of Mulock granite	$1244^{+4}/_{-3}$, $1250^{+10}/_{-6}$	Lumbers et al. (1991); Davidson and van Breemen (2001)
Emplacement age of West Bay and Powassan batholiths	~1235 and 1270±3	Heaman *in* Ketchum and Davidson (2000); Davidson and van Breemen (2001)
Age of sedimentation within central Tomiko terrane	1687±20	Krogh (1989)
Penokean metamorphism and deformation (effects may be minimal in Temagami area)	~1835	Holm et al. (2001)
Emplacement of Nipissing gabbro sills	2219±4 to 2210±4	Corfu and Andrews (1986); Noble and Lightfoot (1992)
Huronian sedimentation	>2220 but <2460	
Huronian felsic volcanism and related metaplutonic rocks	2460±20	Corfu and Easton (2000)
Emplacement of East Bull Lake intrusive suite rocks, including the River Valley intrusion	2475±2	Heaman (University of Alberta, personal communication, 1999), Krogh, Davis and Corfu (1984)
High-grade Archean metamorphism and pegmatite emplacement	2650±4	Krogh (1994); Krogh and Davis (1970)
Emplacement age of Ingall Lake batholith which is cut by Grenville Front	2736±2	Bowins and Heaman (1991)
Emplacement age of Archean metavolcanic rocks in the Temagami greenstone belt	2736±3	Bowins and Heaman (1991)

Superior and Southern Provinces

The Superior Province north of the Grenville Front consists of Neoarchean supracrustal and plutonic rocks of the Temagami greenstone belt (Jackson and Fyon 1991). Although only limited geochronology has been conducted in the Temagami greenstone belt, both U/Pb zircon ages and Ar/Ar hornblende ages in the range of 2730 to 2736 Ma have been obtained (Bowins and Heaman 1991; Smith et al. 1994; *see* Table 1). The southern part of the granite-greenstone belt consists of a large, northeast-trending granodiorite intrusion known as the Ingall Lake batholith (Lumbers 1971a, 1971b, 1978), which is cut in half by the Grenville Front. North of the Grenville Front, the intrusion is massive to foliated, generally exhibiting greenschist-facies mineral assemblages. South of the Grenville Front, the intrusion is gneissic, and generally contains amphibolite-facies mineral assemblages (Lumbers 1978).

Southern Province rocks north of the Grenville Front consist of low-grade (greenschist to sub-greenschist facies) metasedimentary rocks of the Paleoproterozoic Huronian Supergroup and mafic intrusive rocks, with an age of circa 2220 Ma (*see* Table 1), of the Nipissing intrusive suite. Huronian Supergroup rocks in the region consist of both the Coleman (conglomerate-mudstone-wacke) and Firstbrook (mudstone) members of the Gowganda Formation and arkosic quartz arenites of the Lorrain Formation. Both formations belong to the Cobalt Group, the stratigraphically highest of the 4 groups constituting the Huronian Supergroup. The Cobalt Group rests unconformably on Neoarchean supracrustal and plutonic rocks. Gabbroic intrusions of the Nipissing intrusive suite intruded rocks of both the Superior and Southern provinces, generally near the trace of the Archean–Proterozoic unconformity.

Grenville Front Tectonic Zone

The Grenville Front tectonic zone immediately north of the study area consists mainly of Archean rocks that were metamorphosed and deformed during the Grenville Orogeny. In the northern part of the Grenville Front tectonic zone, the main rock units include gneissic granodiorite of the Ingall Lake batholith and heterogeneous, granular gneiss of the Red Cedar Lake gneiss (Lumbers 1978; Easton 1992). Previous workers, such as Lumbers (1978), regarded the Red Cedar Lake gneiss as a metamorphosed and deformed equivalent of Archean metasedimentary rocks within the Pontiac Subprovince of the Superior Province. To the southwest, in the River Valley area, Easton (2000) reported geochemical data from the Red Cedar Lake gneiss that support the interpretation that the gneiss has been derived from Archean metasedimentary rocks. Analysis of regional U/Pb zircon ages led Easton (2000) to suggest that the Red Cedar Lake gneiss was not likely correlative with rocks of the Pontiac Subprovince, but represented a separate metasedimentary sequence. Deformed pegmatite dikes, in the Red Cedar Lake gneiss in the Grenville Front tectonic zone near Highway 11, yield circa 2650 to 2660 Ma zircon ages (Krogh and Davis 1970; Krogh 1994) confirming the Archean age of the Red Cedar Lake gneiss near the study area.

In the southern part of the Grenville Front tectonic zone, including the area shown on Map P.2846, the main rock units are a variety of heterogeneous mafic to intermediate composition gneisses, likely of Archean age (unit 1). These are described in greater detail in a subsequent section of the report.

Grenville Province, Central Gneiss Belt, Tomiko Terrane

The northern part of the study area straddles the boundary between the Grenville Front tectonic zone and the Tomiko terrane (*see* Map P.2846). The Tomiko terrane is one of several lithotectonic domains that comprise the Central Gneiss Belt of the Grenville Province. Easton (1992) separated the Tomiko terrane from other domains in the Sudbury to North Bay area because of the presence of

- An abundance of paragneiss, including quartz arenites and iron formation, within the domain. The quartz arenites contain a restricted zircon population consisting only of Mesoproterozoic zircons (1687±20 Ma, reported in Krogh 1989).
- Archean and Mesoproterozoic Nd/Sm model ages within the domain (e.g., Holmden and Dickin 1995) in contrast to adjacent domains containing mainly Archean Nd/Sm model ages.
- Relatively young (circa 1245 Ma, *see* Table 1) granitoid rocks in the domain.
- Indications of a distinct metamorphic history based on the presence of lower peak metamorphic temperatures and pressures recorded within the domain (Anovitz and Essene 1990).

Mapping by the author in 2001, in the area immediately northwest of the present study area, indicated that the location of the boundary between the Grenville Front tectonic zone and the Tomiko terrane was correctly interpreted in 1992 (Easton 1992, 2002a). In addition, Easton (2002a) noted that the boundary separated rocks of the Red Cedar Lake gneiss (Archean) in the north from a distinct package of rocks, likely of Proterozoic age, in the south (*see* Figures 1 and 2). The bounding shear zone was not observed, however, in large part due to poor exposure (Easton 2002a).

Geology

The tectonostratigraphic sequence present within the study area is summarized in Table 3, which is condensed from the legend on Maps P.2946 and P.2847. Both Table 3 and the map legends incorporate knowledge gained from preliminary U/Pb geochronology and geochemical data collected subsequent to mapping in 2003.

PRECAMBRIAN

Neoarchean

HETEROGENEOUS GNEISSES ("BASEMENT" COMPLEX) (UNITS 1 AND 2)

An extensive area underlain by a unit of heterogeneous gneiss (Photo 1) lies west and north of the main package of supracrustal rocks (*see* Figure 2), as well as being infolded with the supracrustal rocks. In addition, some of the younger granitoid intrusions in eastern Tomiko terrane incorporate screens of these heterogeneous gneisses.

Holmden and Dickin (1995) reported a Nd/Sm model age of 2570 Ma from the heterogeneous gneiss unit near the eastern margin of the Mulock granite, again, suggesting that at least within the area covered by Map P.2846, most of the gneisses are Archean. In addition, an orthopyroxene hornblendite body (unit

Table 3. Table of major rock units in Tomiko terrane. Neodymium–samarium (Nd/Sm) model ages from Holmden and Dickin (1995), other ages from Baer (1980), Lumbers et al. (1991), Krogh (1989) and this study. Italicized units are part of the Tomiko supracrustal rock package. To facilitate comparison with existing maps, the relevant unit codes from those maps are indicated.

Rock Unit	Description	Age or Age Range	Map Unit (Lumbers 1971a, b, c, 1976)
Late diabase dikes (unit 25)	Easterly trend, Grenville swarm	Circa 590 Ma	Unit 11, or 15, or 29
Diatreme-like breccia (unit 24) ♦	Exotic mafic fragments with high magnetic susceptibility in a medium-grained monzonite matrix, forms ovoid body that cuts migmatitic gneisses at a high angle to gneissosity	Minimum age of 1271±4 Ma, includes zircons greater than 1544 Ma in age	Not reported
Late granitic rocks (unit 23)	Feldspar-phyric quartz syenite to quartz monzonite	Between 1250 and 1050 Ma (margins weakly metamorphosed, thus older than ~1040 Ma)	Unit 26d
Diabase dikes (not exposed on Maps P.2846 or P.2847)	Northwesterly trend, Sudbury swarm	Circa 1238 Ma (Krogh et al. 1987)	Unit 11, or 15, or 29
Mulock granite and related rocks (unit 16)	Pink, gneissic monzogranite, feldspar-megacrystic gneissic monzogranite to augen monzogranite gneiss	$1244^{+4}/_{-3}$ and $1250^{+10}/_{-6}$ Ma (U/Pb zircon), Nd/Sm model age of 2360 Ma	Unit 26a or 7c
Jocko pluton and related rocks (unit 15) ♦	Buff or pink, streaky, biotite-hornblende monzonite to monzogranite gneiss	$1257^{+4}/_{-2}$ Ma (U/Pb zircon), >1137±173 Ma (Rb/Sr), <1770 Ma (Nd/Sm model age)	Unit 21a, 21b, or 7c
McDougal pluton and related rocks (unit 14)	Pink, gneissic monzogranite, locally feldspar-megacrystic	Circa 1250 Ma	Not reported
Grey gneiss (unit 13) ♦	Medium-grained, granodiorite gneiss, locally with relict fragments and feldspar megacrysts (possible metavolcanic)	1250±10 Ma (U/Pb zircon), Nd/Sm model ages of 1970 to 2200 Ma	Unit 16 or 17
Felsite (unit 12)	Pink, thin- to medium-layered, fine-grained granitic gneiss (metavolcanic?)	Nd/Sm model age of 1900 Ma, maximum age of unit	Unit 3 or 18
Amphibolite (unit 11)	Dark green, amphibolite and garnet amphibolite, increases in abundance and degree of migmatization to the southeast (possible metavolcanic and/or sills)		Unit 19 and 24 or 5
Quartzite and quartz-muscovite gneiss (unit 10) ♦	Thin- to thick-layered metamorphosed quartz arenite and arenite	1687±20 Ma (U/Pb), Nd/Sm model ages of 1920 to 2340 Ma	Unit 18a, 18c or 4
Feldspathic gneisses (unit 9)	Thin- to medium-layered, muscovite-potassium feldspar-quartz gneiss, weakly to strongly migmatitic, muscovite clots give rock a speckled or spotted appearance	Nd/Sm model ages of 1910 to 2160 Ma, maximum age of unit	Unit 3 or 18 or 17
Pelitic gneisses (units 6 and 8)	Fine-grained, thin-layered, metasiltstone to biotite-kyanite-garnet gneiss, variably migmatitic (may be of hydrothermal origin?)		Unit 18c or 4b or 4
Iron formation and related rocks (unit 7)	Magnetite-chert rock and coarse-grained hornblende gneisses with high (35 to 500) magnetic susceptibility, also rusty-weathering pyrrhotite gneiss		Unit 13 and 19 and 18d
Marble (unit 5)	Massive, grey, medium- to coarse-grained calcite marble		Unit 20 or 6
Calc-silicate gneisses (unit 4)	Grey to grey-green, biotite-rich, medium-layered, quartz-plagioclase gneiss, generally weakly migmatitic		Unit 16, 19 or unit 5
Orthopyroxene hornblendite (unit 3c)	Bronzite megacrysts hosted in a fine-grained, acicular, dark green, amphibole matrix; hosted only in basement complex?	circa 2475 Ma?	Not reported
Heterogeneous gneisses ("basement complex") (units 1, 2 and 3)	Compositionally heterogeneous, thin- to medium-layered, mafic to intermediate (amphibolite, diorite, granodiorite) gneisses, ranging from complexly folded to highly flattened (*see* Photo 1)	In P.2846, mainly Archean, with Nd/Sm model ages >2570 Ma. In P.2847, some Paleoproterozoic Nd/Sm model ages (1830 to 1930 Ma) are present locally.	Units 1 and 2 or 15 and 16

♦ indicates units sampled for U/Pb geochronology as part of this study.

3c) crops out in Jocko Township (*see* "Orthopyroxene Hornblendite"). If the Jocko Township body is the same age as orthopyroxene hornblendite bodies in the Sudbury area, that is, about 2468 Ma (Corfu and Easton 2000), then the heterogeneous gneisses that host the body are older, i.e., Archean.

Two main rock types comprise the heterogeneous gneiss unit. The more common of the 2 types (unit 1) is a grey, biotite-plagioclase gneiss that is generally migmatitic, containing quartz-plagioclase leucosomes that are highly flattened and subparallel to any layering present within the gneiss (unit 1). Quartz content is usually less than 25%. Mafic minerals are biotite and hornblende, or both. The rocks are coarse grained, with a granoblastic texture. Accessory minerals are apatite, iron, titanite and iron oxides. More mafic, as well as amphibolitic, layers and/or pods are present locally within unit 1. The larger and more discrete of these mafic bodies are shown as units 3a, 3b and 3c on the map face.

Less common is a somewhat more uniform, grey, biotite-plagioclase gneiss of tonalite to granodiorite composition (unit 2) that is well foliated. It locally shows discordant, but highly transposed, contacts with the migmatitic gneiss of unit 1. Rocks of unit 2 are interpreted as discrete intrusions into unit 1, but which have undergone the same subsequent deformational and metamorphic history. Across the study area, unit 2 may include both Neoarchean and Paleoproterozoic intrusive rocks. For example, on Map P.2847, Nd/Sm model ages obtained by Holmden and Dickin (1995) from rocks of unit 2, or parts of unit 1 located adjacent to larger masses of unit 2 rocks, yielded ages of 1830 to 1930 Ma. Further detailed mapping, geochemical and geochronological studies would be necessary to further refine the geological history of map units 1 and 2 and to subdivide the gneisses into their Archean and Paleoproterozoic components.

Parts of the heterogeneous gneiss unit resemble rocks of the Neoarchean Crerar gneiss association in the River Valley area (Easton 2003c). For the most part, rocks of units 1 and 2 correspond to the Antoine gneiss of Moore (1976).

Photo 1. Typical gneisses of the basement complex within Tomiko terrane (UTM NAD83, Zone 17, 651238E, 5162733N). Hammer handle is 30 cm long.

The heterogeneous gneisses may represent basement to the Tomiko supracrustal rocks, although it is not known if this basement is structural or depositional. It is possible that the nature of the basement–cover relationship may vary across the study area. The basement–cover contact may have played both a role in localizing the Geon 12 plutons within the map area and influencing their geochemical differences. For example, the Mulock granite (unit 16), which is hosted solely in rocks of unit 1, yielded an old Nd/Sm model age of 2360 Ma. In contrast, the Jocko pluton (unit 15), which intruded at the contact between units 1 and 9, yields younger Nd/Sm ages ranging from 1770 to 2160 Ma, suggesting less interaction with rocks of unit 1.

Archean to Paleoproterozoic

MAFIC TO ULTRAMAFIC INTRUSIVE ROCKS (UNIT 3)

This unit comprises mafic to ultramafic intrusive rocks of Archean to Paleoproterozoic age found in association with units 1 and 2. Three main types are recognized: amphibolite (unit 3a), mafic gneiss of gabbroic to anorthositic gabbroic composition (unit 3b), and orthopyroxene hornblendite (unit 3c).

Amphibolite (unit 3a)

Dark green to black weathering, fine- to medium-grained amphibolite layers and pods are common within the more intermediate gneisses that constitute the heterogeneous gneisses of unit 1. A few larger, more continuous bodies of amphibolite (unit 3a) occur sporadically throughout the map area, and likely represent parts of larger intrusive bodies.

Mafic Gneiss (unit 3b)

Medium-grained, white and black or white and green weathering, medium- to coarse-grained leucogabbroic to anorthositic gabbro gneisses (unit 3b) also occur as scattered bodies within the heterogeneous gneisses of unit 1. The largest masses of these rocks occur in Flett Township, just west-northwest of the study area (Easton 2002a), and in the vicinity of Net Lake (*see* Map P.2846). Texturally, these rocks resemble deformed members of the East Bull Lake intrusive suite in the River Valley area.

Orthopyroxene Hornblendite (units 3c and 3d)

An orthopyroxene hornblendite body (unit 3c) was located in Jocko Township, near the contact between an area of heterogeneous gneiss and the Tomiko supracrustal rocks. The body appears to be hosted solely in the heterogeneous gneiss unit (unit 1). The rock consists of subrounded, centimetre-size orthopyroxene (bronzite) phenocrysts, ranging from 0.5 to 2 cm in length, hosted in a fine-grained amphibole-plagioclase matrix (Photo 2). A related rock, consisting of fine- to medium-grained hornblendite (unit 3d), but lacking orthopyroxene phenocrysts, is exposed on Highway 63 in Clarkson Township, roughly 500 m west of the orthopyroxene hornblendite body.

The field term, orthopyroxene hornblendite, is based on the dominant mineral phases observed in hand sample for this rock. Easton (2003c) noted that CIPW normative calculations on these rocks suggested that prior to metamorphism, the rocks were olivine gabbronorites or olivine websterites.

Easton (2003c) recognized 2 chemical groups within the orthopyroxene hornblendite bodies exposed east of Sudbury. The first group, characterized by low total REE contents and magnesium contents greater than 20 weight %, occur as isolated bodies not intimately associated with other East Bull Lake intrusive suite rocks. The second group, with higher REE contents and lower magnesium contents (<19.0 weight %) occur at primary intrusive contacts, or as layers, within East Bull Lake suite intrusions. The sample from Jocko Township (unit 3c, sample 03RME-0294, *see* Appendix 2) falls into the first group, having 22.0 weight % MgO and 57.3 ppm total REE. The hornblendite sample from Highway 63 in Jocko Township (unit 3d, sample 03RME-0299, *see* Appendix 2) is chemically similar, with 22.8 weight % MgO and 53.4 ppm total REE. Both bodies are rich in chromium, 2106 and 3498 ppm, respectively, which is a characteristic feature of the orthopyroxene hornblendite bodies found east of Sudbury area (Easton 2003c).

In thin section, samples of the orthopyroxene hornblendite and the hornblendite both contain medium-grained, well-developed amphibole laths. The hornblendite also contains elongated trains of brown biotite laths, oriented parallel to the main foliation in the sample. This contrasts with samples from the Sudbury area, where the hornblendite matrix is typically fine grained, and biotite is absent. The coarser grain size in the study area could be an indication of higher metamorphic grade relative to the Sudbury area. The development of biotite laths may also be related to higher metamorphic grade, perhaps related to the introduction of fluids along foliation planes during metamorphism and deformation.

In the Sudbury area, orthopyroxene hornblendite bodies are commonly spatially associated with rocks of the Paleoproterozoic East Bull Lake intrusive suite (Easton 2003c). To date, the only potential East Bull Lake intrusive suite rocks recognized in the study area are mafic gneisses in Flett and Angus townships (Easton 2002a) and the mafic gneisses southwest of Net Lake (unit 3b, *see* Map P.2846). No mafic gneisses have been observed near the orthopyroxene hornblendite body in Jocko Township; however, in the Sudbury area, some orthopyroxene hornblendite bodies, especially those of the first geochemical group, occur over 1 km distant from the nearest East Bull Lake intrusive suite rocks. If the Tomiko supracrustal rocks are structurally emplaced on the Archean and Paleoproterozoic rocks in Tomiko terrane, then it is quite possible that the East Bull Lake intrusive suite rocks associated with the Jocko Township body could be present beneath the adjacent Tomiko supracrustal rocks.

Photo 2. Orthopyroxene hornblendite (UTM NAD83, Zone 17, 643171E, 5163856N). Hammer handle is 30 cm long.

Paleoproterozoic to Mesoproterozoic

TOMIKO TERRANE

Tomiko Supracrustal Rocks (units 4 to 12)

OVERVIEW

The term "Tomiko supracrustal rocks" is used in this report as an overarching term encompassing a variety of rock types, largely of metasedimentary origin, present in eastern Tomiko terrane. Rocks belonging to this package are highlighted in Table 3, and the stratigraphy of these units is described under "Stratigraphy".

The most common units consist of calc-silicate gneiss (unit 4), quartzite (meta-quartz arenite) and quartz-muscovite gneiss (unit 10), and feldspathic gneiss (unit 9). True quartz arenite is largely confined to the northeastern part of the terrane and consists of 2 types: 1) a massive, locally thick-bedded, variety; and 2) a thin- to medium-bedded variety that locally contains relict cross-bedding. The latter type is more common.

Previous workers (e.g., Lumbers 1971b) have noted the presence of "iron formation" (unit 7) in northeastern Tomiko terrane. This unit is generally poorly exposed. Magnetite-chert rocks appear to be a minor component of this unit. Most of the "iron formation" unit (7) consists of a coarse-grained, dense, pyroxene-rich rock that shows varied magnetic character (magnetic susceptibility generally 10 to 60, locally with bands between 200 and 500). These pyroxene-rich rocks are sandwiched between metapelitic rocks (unit 6) and marble (unit 5). Moore (1976) suggested that the iron formation (unit 7) was correlative with pyrrhotite- and pyrite-bearing feldspathic gneiss (unit 8b) present in the Miners Lake and Timber Lake areas, however, this correlation cannot be directly confirmed.

Two types of feldspathic gneiss are present, one which may be metasedimentary in origin (unit 9), the other which may be igneous (flows or sills)(unit 12). The feldspathic gneiss of metasedimentary origin is commonly migmatitic, regardless of location in the terrane, and contains greater than 5% muscovite. The feldspathic gneiss of igneous origin, referred to as felsite in this report (unit 12), is only migmatitic in the southeast part of the map area, and contains less muscovite and quartz than the metasedimentary type. In thin section, the feldspathic gneiss and the felsite can be readily distinguished from granitoid orthogneiss (unit 14), as the felsite contains more plagioclase, and possesses irregular-shaped grains of all mineral phases. In contrast, the feldspathic gneiss typically contains regular-shaped grains exhibiting 120° grain boundaries, dominated by microcline and perthite. In addition, the granitoid orthogneiss (unit 14) exhibits somewhat elevated magnetic susceptibility values (2 to 15) compared to the feldspathic gneisses (<1, excluding leucosome), especially near the margins of the intrusions.

As well as the felsite unit, a unit of dacitic grey gneiss (unit 13) is present south of Big McDougal Lake. This unit is locally fragmental in character, and may be volcanic in origin, although it most likely represents one or more thick sills. Near Timber Lake, the felsite unit (unit 12) is associated with medium-grained, dark weathering amphibolite and garnet amphibolite bodies (unit 11) that are different in texture and composition from the biotite-epidote-amphibole-bearing rocks typical of the calc-silicate gneisses (unit 4). Again, these amphibolites (unit 11) may represent flows, dikes or sills. In the area dominated by M_3, both the calc-silicate gneisses and the amphibolites are metamorphosed to a medium-grained, garnet amphibolite, and the 2 types of mafic rocks can no longer be distinguished in the field. Amphibolite and calc-silicate gneisses appear to be more abundant south of Highway 63. It has yet to be determined if this is related to a north-to-south facies change in the terrane, or if it simply reflects the fact that these rocks become more resistant to weathering with increased metamorphic grade.

CALC-SILICATE ROCKS (UNIT 4)

Green to green-grey weathering, fine- to medium-grained calc-silicate rocks (unit 4) occur throughout the study area. These rocks have a varied appearance in hand specimen. Mineralogy is highly varied, and includes epidote-muscovite-calcite gneiss, biotite-epidote-hornblende gneiss, and hornblende-plagioclase gneiss. The mafic content of the calc-silicate rocks is usually around 50%, although it can go as high as 90%.

The calc-silicate rocks are most abundant in 2 main horizons in the regional stratigraphy. North of Highway 63 (*see* Map P.2846), they are common at the base of the stratigraphic sequence, near contacts with the heterogeneous gneiss unit (unit 1) or granite gneiss intrusions (unit 14). South of Highway 63 (*see* Map P.2847), they occur higher in the stratigraphy, in association with the kyanite-bearing rocks of unit 8. Thinner layers (<50 m) of calc-silicate gneiss can be found elsewhere in the stratigraphic sequence.

In general, the calc-silicate rocks are medium grained and equigranular. Hornblende is well formed, inclusion free, and is chiefly greenish-brown, although some blue-green grains are observed. Diopside is sometimes found in the core of hornblende grains, suggesting reaction of biotite, quartz and diopside to yield potassium feldspar and hornblende (Moore 1976). Plagioclase is oligoclase to andesine in composition. Calcite is common in most samples. Retrograde chlorite is common, replacing biotite and/or hornblende. Moore (1976) reports the presence of scapolite locally in this unit, in association with late alteration of sulphide minerals.

There may be 2 chemical groupings within the calc-silicate units, a high TiO_2, Fe_2O_3 and/or P_2O_5 group (samples 03RME-0083, A5, and A9, *see* Appendixes 2 and 3) and a second, larger group with no unique chemical features (samples CS, B71-66, B71-99, B71-14, A2, A4, A8 and A15, *see* Appendix 3).

CARBONATE ROCKS (UNIT 5)

Grey weathering, medium- to coarse-grained calcite marble occurs in 2 main parts of the study area: in association with iron formation in Parkman Township, and in Clarkson Township in the area between McConnell Lake road and Miners Lake. Both calcite (unit 5a) and dolomitic marble (unit 5b) have been reported. Rocks of this unit have only been observed in the area covered by Map P.2846, although it is possible that thin marble units may occur in the Timber Lake area (shown on Map P.2847).

The marble unit in Clarkson Township is exposed in a single, small roadside exposure on McConnell Lake road, where it is found in close proximity to a fine-grained, thinly layered, dark grey, siliceous gneiss with some sulphide burns. Maximum thickness of the unit is estimated at 5 m. Immediately to the south are exposures of feldspathic gneiss (unit 9). Immediately to the north are outcrops of thin layered calc-silicate gneiss and feldspathic gneiss (units 4 and 9). Moore (1976) reported several small outcrop exposures of marble and pyrrhotite gneiss in the area between McConnell Lake road and Miners Lake along a logging road; unfortunately, these exposures have been overgrown.

BIOTITE GNEISS (UNIT 6)

Unit 6 consists of a variety of pelitic to semi-pelitic schists to gneisses, which are only exposed in a few parts of the study area (only on Map P.2846), and which are commonly interbedded with the quartz-rich metasedimentary units 9 and 10. In central Clarkson Township, the unit consists of buff- to brown-weathering, fine-grained, thin bedded, metasiltstone (unit 6a) interbedded with quartz arenite of unit 10. In northern Clarkson Township, the unit consists of buff- to grey weathering, medium-grained, homogeneous, medium-layered, biotite gneisses (unit 6b). A brown-weathering, fine-grained, muscovite-rich metasiltstone (unit 6c) occurs in association with iron formation in Parkman Township.

Metapelitic gneiss that occurs structurally below the iron formation unit near Otter Lake in Parkman Township contains thin (<10 cm) tourmaline + garnet-bearing layers, with 15 to 20% tourmaline; these rocks border on being true tourmalinites (unit 8c) (Photo 3). Adjacent layers (beds?) contain no tourmaline or garnet (units 6c and 6a). The garnets show rotated inclusion trails, indicating that they grew during regional metamorphism and deformation (M_1?). The pleochroic green tourmaline grains are euhedral, showing no relict cores, suggesting that they grew during metamorphism (M_1?), probably at the same time as the garnet, rather than being detrital grains. Boron-rich rocks have not been previously reported in association with the iron formation, or from elsewhere in Tomiko terrane.

Chemical analyses are only available from the biotite gneisses (unit 6b, samples 03RME-0094 and 03RME-1002, *see* Appendix 2).

IRON FORMATION (UNIT 7)

Iron formation (unit 7) has only been reported from Parkman Township, in the northern part of the study area just south of the Grenville Front tectonic zone (*see* Map P.2846). This unit is generally poorly exposed. Two types are present.

1. Magnetite-chert rocks (unit 7a) likely derived from oxide-facies iron formation, and
2. Ferrosilite gneiss (unit 7b), likely derived from carbonate-facies iron formation.

Iron formation of the ferrosilite variety is commonly referred to as "amphibole gneiss" in the assessment files (e.g., Giblin 1960) and, in the field, it is difficult to distinguish between amphibole and pyroxene (Photo 4). Most of the iron formation observed in the field by the author was of the ferrosilite type.

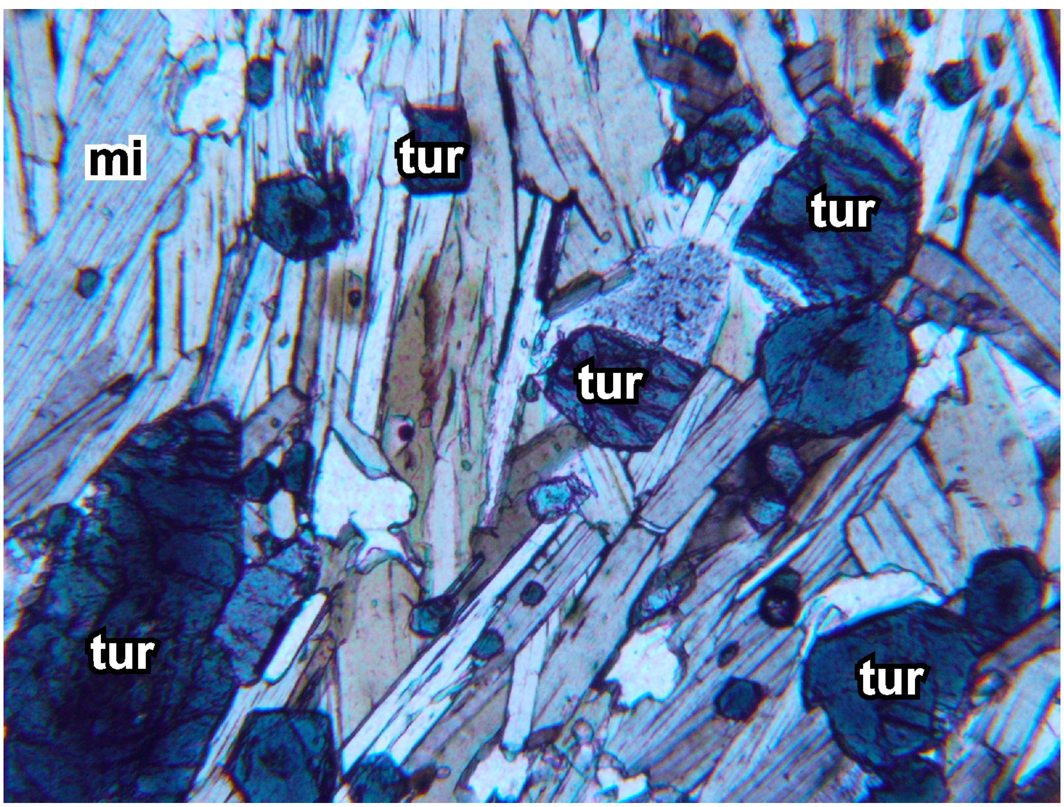


Photo 3. Photomicrograph of thin section of tourmaline-rich pelitic gneiss from the Otter Lake area, Parkman Township (UTM NAD83, Zone 17, 651330E, 5149095N). Tourmaline grains are dark grey, hexagonal grains. Field of view is 2 mm.

The ferrosilite gneiss consists of a coarse-grained, dense rock that shows varied magnetic character (magnetic susceptibility generally 10 to 60, locally with bands between 200 and 500). These rocks are sandwiched between metapelitic rocks (unit 6) and marble (unit 5). Moore (1976) suggested that the iron formation (unit 7) was correlative with pyrrhotite- and pyrite-bearing feldspathic gneiss (unit 8b) present in the Miners Lake and Timber Lake areas, however, this correlation cannot be directly confirmed.

Thin section examination of the ferrosilite gneiss reveals that it consists of thin layers composed of large grains of pyroxene, with some quartz layers. Some layers contain relict garnet grains, possibly spessartine, armoured within large pyroxene grains. None of the primary minerals are fresh, and it is likely that much of the magnetic character of these rocks is probably due to exsolution of iron oxides. Fine opaque dust disseminated throughout the pyroxene grains hindered precise mineral identification by optical means, but subsequent microprobe and X-ray diffraction study has determined that the pyroxene is ferrosilite.

The samples of ferrosilite gneiss analyzed by the author had a range of MnO contents, from 1.25 to 3.75 weight %, averaging 2.8 weight % (samples 03RME-0237 to 03RME-0244, *see* Appendix 4). All of these samples are from the Bishop zone of the iron formation unit. Samples from unit 7, analyzed by Marmont (2000) also contained a high MnO sample (sample PKCO2, *see* Appendix 3). Samples from the Green Lake zone of the iron formation, reported in the assessment files, contain from 4.1 to 7.8 weight % MnO. Insufficient information exists to determine if there is a discrete MnO-rich horizon within the iron formation unit, or if MnO content varies from west to east across the iron formation unit.

The bulk composition of rock sample 03RME-0237 (*see* Appendix 4) is close to the composition of pure, naturally occurring ferrosilite (compare with sample from Deer, Howie and Zussman (1966) listed in Appendix 4), indicating that this rock is nearly monomineralic, consistent with its appearance in thin section. The rock has an Fe/Mg+Fe content of 80%, close to the maximum Fe/Mg+Fe content of 85% reported for naturally occurring pyroxenes (Huebner 1980).

Photo 4. Ferrosilite gneiss near Otter Lake, Parkman Township (UTM NAD83, Zone 17, 629575E, 5186751N). Hammer handle is 30 cm long.

Naturally occurring ferrosilite has received only limited study, mostly on metamorphosed iron formations from Labrador that have been affected by Grenvillian metamorphism (Kranck 1961; Klein 1966; Butler 1969). The Labrador iron formations locally contain manganese and, since they have been metamorphosed under similar conditions to those found in Tomiko terrane, they provide insight into the origin of the iron formation present in Tomiko terrane.

Kranck (1961) and Butler (1969) explain the presence of ferrosilite and related iron-amphiboles, such as grünerite and ferroanthophyllite, to metamorphism of a siderite + ferrodolomite + ankerite protolith. During metamorphism, CO_2 is removed from the protolith, through the general reaction

$$FeCO_3 + SiO_2 \rightarrow FeSiO_3 + CO_2$$
$$\text{siderite + quartz} \rightarrow \text{ferrosilite + vapour}$$

It is possible that intermediary reactions may occur in this process, such as the production of ferroan augite (Butler 1969), but evidence for these reactions is not necessarily preserved in the Tomiko rocks and, regardless, is beyond the scope of this study. As noted by Butler (1969), oxidation of siderite to produce magnetite and pyroxene may also occur locally within the iron formation, but oxidation alone is not sufficient to produce the amount of ferrosilite observed in the rocks.

With respect to Tomiko terrane, the presence of abundant ferrosilite in the iron formation unit, and its spatial association in the field with marbles suggests that the protolith of the unit was most likely carbonate-facies iron formation, composed mainly of siderite and ankerite. During regional metamorphism, devolatilization of CO_2 transformed this rock into a pyroxene ± amphibole gneiss. Siderite-ankerite iron formations generally form in shallow-marine environments, on shallow continental shelves with little adjacent continental relief (Kimberly 1978).

There may be facies variation within iron formation and associated rock units in Tomiko terrane. In Parkman Township in northern Tomiko terrane, the ferrosilite iron formation is associated with magnetite iron formation, thus, both carbonate- and oxide-facies iron formation were likely present. This contrasts with central Tomiko terrane, near Miners Lake for example, where marble occurs with sulphide-rich gneiss (carbonate- and sulphide-facies iron formation?). In the Timber Lake area, carbonate rocks are not present, but abundant calc-silicate rocks and sulphide-rich gneiss could represent metamorphosed carbonate- and silicate-facies iron formation. If these various rock units are indeed representative of the same stratigraphic level (*see* "Stratigraphy"), then this north-to-south facies change could reflect deepening water and/or more anoxic conditions to the south.

In 2 areas, there is a discrepancy between the surface geology and the geophysical trace of the iron formation (*see* Map P.2846). On the northwest side of Green Lake, also in Parkman Township, the iron formation apparently underlies surface exposures of metamorphosed quartz arenite (unit 10). In this area, the presence of iron formation has been noted in drill core, even though surface exposure is poor to non-existent. However, as the quartz arenite is likely interlayered with the iron formation, this difference between surface geology and geophysics is probably insignificant. This is not the case for the second discrepancy, located between Otter Lake and Webb Lake in Parkman Township. Here, the iron formation unit has an east-northeast trend, apparently underlying the granite gneiss (unit 14) exposed on surface. The most likely explanation for this discrepancy is that the granite gneiss is a thin sheet dipping to the south, and is not a large intrusion with depth extent.

Elsewhere in Parkman Township, there is good agreement between surface exposures of iron formation, of both types, and geophysical highs. Much of this geophysical expression likely arises from the magnetite-rich component of the iron formation unit. If so, then it is possible that the potential carbonate-, silicate- and sulphide-facies equivalents of the iron formation unit in the Miners Lake and Timber Lake areas may not have a strong magnetic signature.

COMPOSITIONALLY UNUSUAL ROCKS (UNIT 8)

These rocks are commonly interlayered with other Tomiko supracrustal rocks, but have been broken out as a separate unit on the map in order to highlight their distribution because of the potential economic significance. This is important to bear in mind from a stratigraphic sense, as these units could represent irregularly shaped zones of alteration and/or mineralization rather than being semi-continuous to continuous stratigraphic horizons.

There are 3 main groups of rocks within unit 8:

- kyanite-bearing units (mainly on Map P.2847)
- sulphide-bearing units (on both Maps P.2846 and P.2847)
- tourmaline-bearing units (only on Map P.2846)

The largest expanse of these rocks occurs in the Crocan and Timber lakes area (*see* Map P.2847), where 4 previous interpretations of the geology of these compositionally unusual units have been presented (Hoadley *in* Pearson 1959; Pearson 1959; Lumbers 1971b; Moore 1976). All these maps agree closely in the Crocan Lake area, but differ considerably in some portions, especially east and north of Little Jocko Lake. Part of this discrepancy arises from the fact that only Moore (1976) separated out amphibolite, calc-silicate and older mafic to intermediate gneisses as separate map units, whereas some of the other authors lumped them together as "amphibolite". Part of it arises from limited outcrop exposure. The interpretation shown on Map P.2847 is a combination of new data acquired by the author, combined with the detailed outcrop mapping by Moore (1976).

The general stratigraphic sequence in the Crocan and Timber lakes area, from stratigraphically lowest to highest, is

- heterogeneous gneiss (unit 1)
- a thick sequence of calc-silicate gneiss (unit 4), which locally, may contain quartzose gneiss (unit 9) horizons near its base
- garnet-kyanite gneiss (unit 8a)
- sulphide-bearing gneiss (unit 8b)

Thickness of the individual units is difficult to estimate, in large part because the stratigraphic sequence is complexly folded (*see* Map P.2847). The sequence of calc-silicate (unit 4) and compositionally unusual (units 8a and 8b) gneisses is largely restricted to the vicinity of Timber Lake, even though the lower units in the sequence (units 1 and 9) occur throughout eastern Tomiko terrane. This distribution can be explained in either 2 ways. First, this segment of the Tomiko depositional basin was unique for some reason, and it accumulated a thick succession of carbonate and fine-grained sedimentary rocks, which were subsequently metamorphosed into the gneisses represented by units 4 and 8. This has been the traditional interpretation of these rocks. Alternatively, most of the rocks of unit 4 and 8 were formed as the result of intense regional metasomatic alteration of unknown origin, which was localized in the Timber Lake area. A corollary of this interpretation is that the contacts between rock units in the stratigraphic sequence are not necessarily conformable or follow the law of superposition, and in part reflect the localization of alteration fronts. Insufficient data are available to resolve these 2 possibilities.

Kyanite-bearing Units (unit 8a)

Kyanite-bearing rocks typically contain from 5 to 25% kyanite, but, in the Crocan Lake area, can contain up to 90% kyanite. The kyanite-bearing rocks also contain varied amounts of muscovite, biotite, quartz and almandine garnet. The kyanite-bearing rocks are associated with non-kyanite-bearing biotite-quartz-garnet and muscovite-biotite-quartz-garnet gneiss. This unit corresponds to Moore's (1976) pelitic gneiss unit.

In the Timber Lake area, the rock is medium to coarse grained, with lepidioblastic texture and poikiloblastic garnets, up to 1 cm in diameter (Photo 5). Muscovite, where present, is strained and bent around minor folds and crenulation in the rock. Kyanite can form porphyroblasts up to 5 cm in length, although 1 cm is more common. Accessory minerals are apatite, tourmaline, graphite, iron oxides and zircon. Moore (1976) reports some exposures of this unit in the Miners Lake area, but notes that garnets there are much smaller, typically less than 5 mm in diameter, but that they have rotated inclusion trails, a feature not shown in rocks of this unit south of Highway 63.

As discussed in greater detail under "Metamorphism", kyanite occurs in 2 varieties: blue and pale green. Each variety developed during a specific metamorphic event by different chemical reactions. Green kyanite developed during M_3, and replaces earlier formed blue kyanite. North of Highway 533, kyanite is dominantly blue, and is the result of M_2 metamorphism. South of Highway 533, kyanite is dominantly pale green, and the results of M_3 metamorphism.

Several samples of kyanite-bearing rocks from north of Highway 533 have been chemically analyzed as part of this study (samples 03RME-0235, 03RME-0336, 03RME-0337, *see* Appendix 2) and by Pearson (1959) (samples A1, A10, A12, *see* Appendix 3). An important question with respect to mineral exploration and stratigraphic analysis in the study area is whether the kyanite-bearing rocks are metamorphosed mudstones, or are they the metamorphosed equivalent of a hydrothermally altered rock sequence.

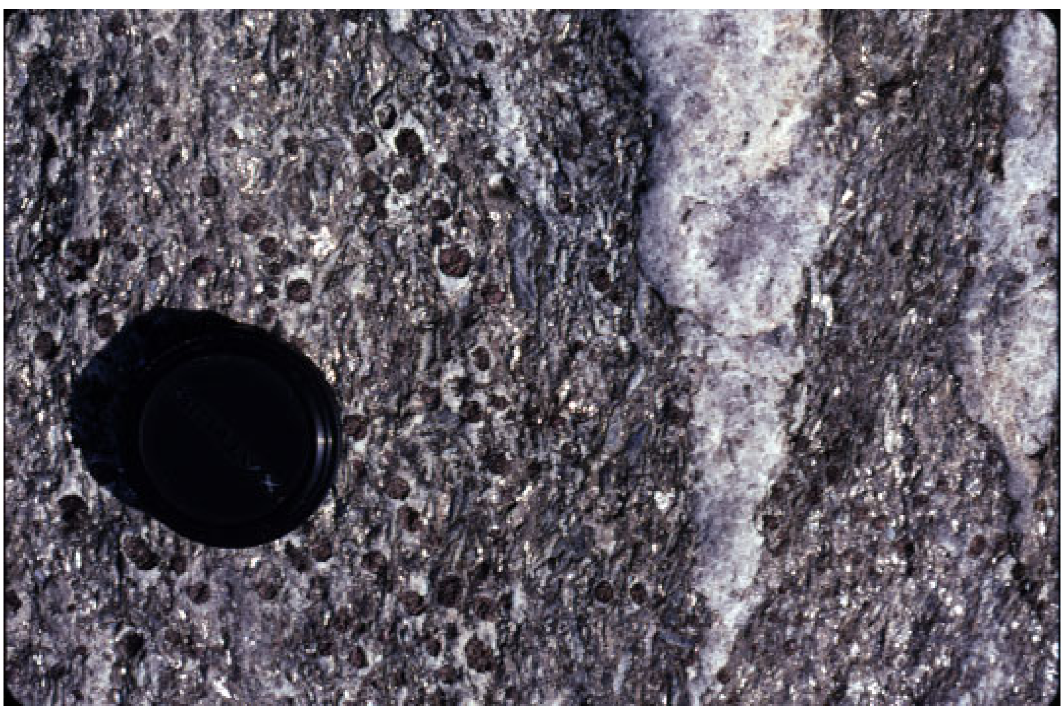


Photo 5. Garnet-kyanite gneiss north of Timber Lake, Butler Township (UTM NAD83, Zone 17, 650978E, 5149659N). Lens cap is 6.5 cm in diameter.

Table 4. Summary of chemical index of alteration (CIA) values for the Tomiko supracrustal rocks.

Unit	CIA	Mg Number	Comment
Unit 4 calc silicate	50.3 to 63.2	30.1 to 67.3	Mg number generally <50
Unit 6 biotite gneiss	57.5 to 60.4	28.2 to 54.9	
Unit 7b iron formation	196	19.5	
Unit 8a kyanite-bearing	83.5 to 86.0	34 to 40	higher than other metasedimentary units
Unit 9 metasedimentary gneisses	60.3 to 62.0	16.1 to 28.4	
Unit 10 muscovite quartzite	66.1 to 71.8	9.6 to 20.5	
Unit 10 quartzite	69.6 to 78.0	8.5 to 35.2	
Unit 11a amphibolite	33.8 to 56.7	38 to 79	may include some rocks with calc-silicate protoliths, based on CIA values <50
Unit 11b garnet amphibolite	54.9 to 61.1	44.4 to 60.5	
Unit 12 felsite	61.3 to 64.3	14.6 to 25.9	igneous signature?
Unit 13 grey gneiss	55.9 to 57.6	13.4 to 21.4	igneous signature?

Chemical index of alteration (CIA) calculations for samples of the kyanite-bearing rocks highlight their chemically unusual character. Kyanite-bearing units show a limited range of CIA values and Mg numbers between 83.5 and 86 and 34 to 40, respectively (*see* Appendix 2). For reference, unweathered igneous and sedimentary rocks typically have CIA values of 50 to 60. Sedimentary rocks derived from deeply weathered terrains will have CIA values between 90 and 100. CIA values for all chemically analyzed samples from the area are listed in Appendixes 2 and 3, and are summarized in Table 4.

The fact that the CIA values for the kyanite-bearing units is higher than that for metasedimentary rocks from Tomiko terrane (*see* Table 4) can be interpreted in 2 ways. First, it could indicate that the kyanite-bearing units were derived from a protolith containing much higher clay contents than the other units. This seems unlikely, however, as the CIA values are much higher than those observed for any of the muscovite-rich or pelitic units present in either units 6, 9 or 10 (*see* Table 4), which likely had moderate to high clay contents. Second, the high CIA values could reflect alteration of the kyanite-bearing rocks at some point in their history, either by the addition of alumina or the loss of alkalis, or both. An increase in relative alumina content is suggested simply by the high (>20.5 weight %) content of Al_2O_3 in these rocks. For comparison, a rock composed wholly of potassium feldspar, albite, or illite, would only have an Al_2O_3 content of 18 to 20.5 weight % for a silica content of roughly 56 to 66 weight %. Although a rock composed totally of anorthite or kaolinite could contain much higher Al_2O_3 contents, the SiO_2 content would be much lower (<45 weight %). All but one of the kyanite-bearing samples from the study area have SiO_2 contents of 60 to 65 weight %, Al_2O_3 contents of >20.5 weight % and K_2O contents of 3.7 to 5.1 weight %, but extremely low CaO and Na_2O contents, suggesting the addition of silica, alumina, and possibly potassium to the original protolith for these rocks. The association of these rocks with sulphide-rich gneisses, some of which are epidote rich, also suggests that these rocks have been extensively altered.

Sulphide-bearing Units (units 8b and 8d)

Sulphide-bearing units, consisting mainly of pyrrhotite gneiss, occur in 3 localities. One is in an east-trending belt near Miners Lake, the second is in a fold south of Timber Lake, and the third is in the large fold north of Timber Lake. The author only examined the last area in detail. The Miners Lake locality is well described by Moore (1976), but is now largely overgrown. The locality south of Timber Lake is also described by Moore (1976). The sulphide-bearing rocks crop out poorly, as they weather easily (Photo 6). They are most commonly exposed along lakeshores and in cleared areas in low ground. This unit corresponds to the pyrite gneiss unit of Pearson (1959) and the pyrrhotite gneiss unit of Moore (1976).

A key difference between the sulphide-bearing gneisses in the Miners Lake area versus those in the vicinity of Timber Lake is that the gneisses in the Timber Lake area are closely associated with kyanite-bearing gneisses, and appear to occur as discontinuous zones located in the core of wide belts of kyanite-bearing gneiss. This distribution suggests that, at least in the Timber Lake area, there may be a genetic linkage between the development of both the kyanite-bearing and sulphide-bearing gneisses.

In most exposures, the sulphide-bearing rocks consist of a quartz-microcline gneiss containing anywhere from 2 to 10% pyrrhotite and pyrite. Moore (1976) reports that small amounts of calcite are common in the unit and, in the Miners Lake area, it is spatially associated with calcite marble horizons (unit 5). Plagioclase is oligoclase in composition. Moore (1976) reports that the mafic silicate minerals are magnesium rich, and that they consist of biotite, tremolite, diopside and chlorite. This is reflected in the chemistry of the sample collected by the author from north of Timber Lake (sample 03RME-0233, *see* Appendix 2, 11.68 weight % MgO). Accessory minerals include apatite, tourmaline, titanite and chalcopyrite.

At the locality north of Timber Lake that was sampled by the author, the sulphide-bearing gneiss differs from samples described by Moore (1976) in that, in addition to pyrrhotite, pyrite, quartz, and feldspar, the rock contains over 20% epidote, and could be termed an epidosite (Photo 7). This is also readily seen in the chemistry of the sample (03RME-0233, *see* Appendix 2), which contains 16.5 weight % CaO, but only minor CO_2 (3.3 weight %). The abundance of epidote in this sample is reflected by the high CaO and MgO content of the rock.

Tourmaline-bearing Units (unit 8c)

As mentioned previously, metapelitic gneiss that occurs structurally below the iron formation unit near Otter Lake in Parkman Township contains thin (<10 cm) tourmaline + garnet-bearing layers, with 15% to 20% tourmaline; these rocks border on being true tourmalinites (unit 8c). Adjacent layers (beds?) contain no tourmaline or garnet (units 6c and 6a). Tourmaline was only visible in thin section, not in hand sample, consequently, it is possible that more beds and/or layers of this rock type may exist within the study area.

Photo 6. Sulphide-rich gneiss from northwest shore of Crocan Lake (UTM NAD83, Zone 17, 652921E, 5153528N). Hammer handle is 30 cm long.

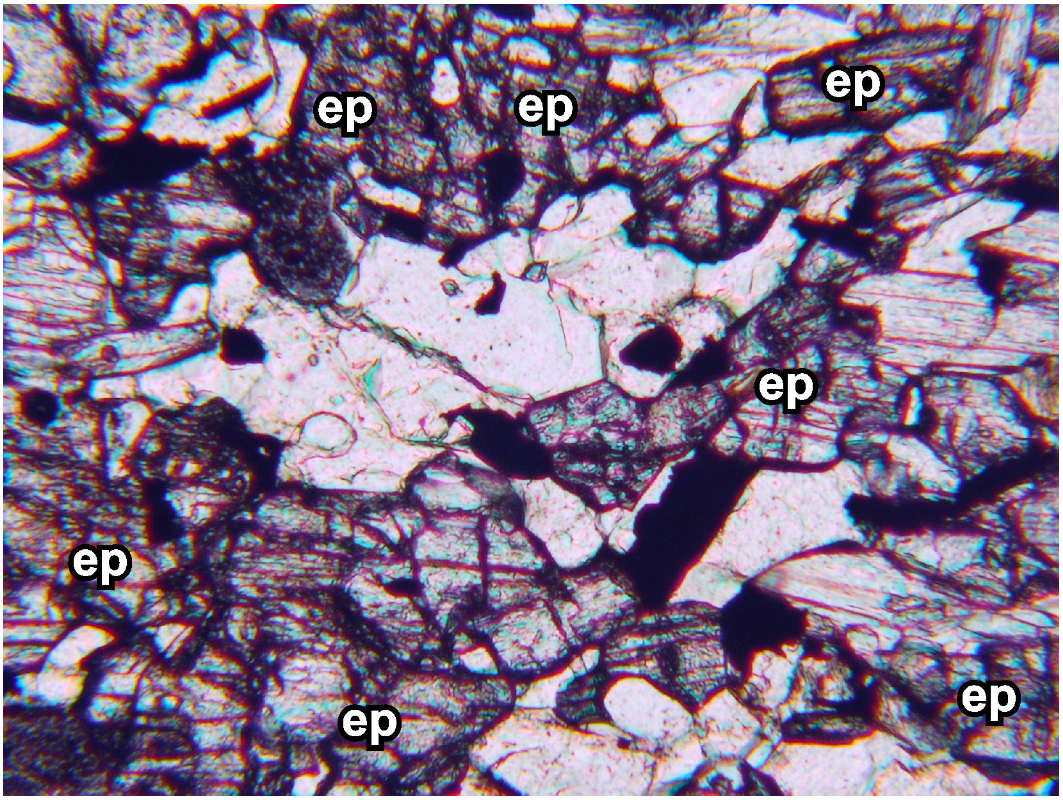


Photo 7. Photomicrograph of sulphide-rich gneiss from northwest shore of Crocan Lake showing abundance of epidote grains in the sample (UTM NAD83, Zone 17, 652921E, 5153528N). Epidote grains are the high relief, greyish coloured, fractured crystals. Field of view is 2 mm.

Photo 8. Cross-bedding in metamorphosed quartz arenite (unit 10) from Clarkson Township (UTM NAD83, Zone 17, 640355E, 5169483N). Hammer handle is 30 cm long.

QUARTZOSE METASEDIMENTARY ROCKS (UNITS 9 AND 10)

Quartzose metasedimentary rocks are divided into 2 broad classes on Maps P.2846 and P.2847:

1. Feldspathic and micaceous sedimentary rocks (unit 9)
2. Quartzose sedimentary rocks (unit 10)

The main discriminant between the 2 classes is mica content, with rocks of unit 9 generally being more muscovite rich, as well as generally possessing small to moderate amounts of granitic leucosome. Rocks of unit 10 are clean, quartz arenites, commonly showing preserved sedimentary features such as cross-bedding (Photo 8). It is not clear if these 2 classes reflect a primary sedimentological difference, or if the difference in muscovite and leucosome content is primarily due to regional alteration of a more homogeneous sedimentary sequence that results in mica-rich (more altered) and mica-poor (less altered) rocks. Rocks of both classes may be interlayered on the scale of individual outcrops; consequently, the division between the 2 classes, at least on a regional map scale, is somewhat arbitrary. Distinction between the 2 broad classes of sedimentary rocks can be done fairly easily north of Highway 63 (*see* Map P.2846). South of Highway 63, where metamorphic grade is higher, almost all quartzose gneisses in the area are assigned to unit 9 (*see* Map P.2847).

Unit 9

There are 3 main subdivisions of unit 9, which correspond broadly to the 3 main metamorphic domains present in the study area. Unit 9a consists of layered (bedded?), potassium feldspar-muscovite-quartz gneiss, commonly containing minor (<5%), scattered pods of granitic leucosome (Photo 9a). Muscovite is commonly present as large grains, giving a spotted appearance to outcrop surfaces. Unit 9b contains substantially more leucosome (10 to 30%); these rocks are metatextites (Photo 9b). Unit 9c consists of diatextites, with leucosome contents of greater than 30%. Locally, leucosome in rocks of unit 9b and 9c is highly flattened due to intense deformation along major fault structures, these areas are designated as unit 9d. Extremely rich mica bands (>30% mica, generally a coloured muscovite), up to several metres in width, occur locally within areas underlain by rocks of unit 9a and 10, particularly in McAuslan and Wyse townships, and are designated as unit 9e. These mica-rich units show a variety of colours (red, green, black) depending on whether or not they are hematite stained (red), partly chloritized (green), or are biotite rich (black). It is unclear if these mica-rich bands represent original mudstone or siltstone horizons in the original metasedimentary sequence, or if they are the results of intense alteration along deformation zone or specific sedimentary horizons. Unit 9f consists of gneissic metaconglomerate units present in the Cahill Lake area (Photo 10), first described by Moore (1976).

Geochemical data from rocks of units 9 and 10 do not shed much light on the origin of these rocks. As might be expected, rocks of unit 10 have much higher quartz contents (>88 weight %) than rocks of unit 9, and there is little disputing that these rocks were deposited as quartz arenites. CIA values for rocks of unit 10 (*see* Table 4) are moderate, indicating that the source region for these quartz arenites was not intensely weathered. CIA values for rocks of unit 9 are generally lower than those for unit 10, which is unexpected, given the high mica content of these samples, which is reflected also in their K_2O and Na_2O contents. One explanation for this could be that the original protolith of unit 9 was slightly calcareous. Subsequent loss of CO_2 during metamorphism would result in lower CIA values. Evidence for this is seen in the fact that samples with the highest CaO contents (>1.0 weight %) have the lowest CIA values (<62). It is also possible that partial melting of rocks of unit 9 was not an entirely isochemical process on an outcrop scale and, thus, any whole rock sample collected from this unit will not reflect the true character of the protolith.

Photo 9. a) Upper photograph shows typical medium-layered feldspathic gneiss of the metasedimentary gneiss package in the area where M_1 is dominant (UTM NAD83, Zone 17, 640207E, 5169958N). b) Lower photograph shows typical "juicy" migmatitic gneiss (metatextite) derived from the same medium-layered feldspathic gneiss as shown in the upper photograph, but from the area where M_2 is dominant (UTM NAD83, Zone 17, 651170E, 5149455N). Hammer handle is 30 cm long.

Unit 10

The chemical index of alteration (CIA) also provides a mechanism of examining how deeply weathered the source terrain may be for a particular sedimentary unit. Quartzites from the study area generally have CIA values ranging from 69.6 to 78.0, indicating that the source region was not deeply weathered (*see* Table 4). An exception is sample 03RME-0071, an extremely clean quartz arenite from the Porcupine Lake quarry in Wyse Township, which has a CIA of 97.7. It is likely that this value is unreliable, because the CaO, Na_2O, and K_2O contents of this sample were below or at the detection limit. The moderate CIA values in the Tomiko quartz arenites (unit 10) contrasts with values of 85 to 95 reported from Lorrain Formation quartzites of the Huronian Supergroup. The latter values have been interpreted to reflect either deep weathering in the source region, or regional alkali alteration after sedimentation.

A sample of quartz arenite was collected from the Porcupine Lake quarry in order to determine the age of the quartzose metasedimentary rocks in northeastern Tomiko terrane, as well as to compare with the data obtained by Krogh (1989). Krogh (1989) dated a higher grade, migmatitic quartz arenite sample obtained along Highway 533, and obtained a detrital age of 1687±20 Ma, based on roughly 15 grains. Krogh (1989) did not report any Archean detrital grains from his sample; consequently, the interpretation of this age as a depositional age has been questioned.

Geochronology on the Porcupine Lake sample was conducted at the Jack Satterly Geochronology Laboratory at the University of Toronto (Easton and Kamo 2004). Preliminary results from 6 single zircon grains yielded 4 Archean grains with $^{207}Pb/^{206}Pb$ ages of 2813, 2795, 2766 and 2658±2 Ma. In addition, 2 Paleoproterozoic grains were recovered, yielding $^{207}Pb/^{206}Pb$ ages of 1873±5 Ma and 1686±4 Ma. The latter age is nearly identical to the age of 1687±20 Ma obtained by Krogh (1989). The previous age was also confirmed by dating of a leucosome pod from the same outcrop sampled by Krogh (1989). Inherited zircons

Photo 10. Migmatitic, gneissic metaconglomerate (unit 9f) from the Cahill Lake area (UTM NAD83, Zone 17, 647442E, 5136610N). Hammer handle is 30 cm long.

from this pod yielded an upper intercept age of 1716±62 Ma, indistinguishable within error from the age obtained by Krogh (1989). Both the data obtained by Krogh (1989) and this study place a maximum depositional age on the quartzose metasedimentary rocks in Tomiko terrane of roughly 1686±4 Ma.

Two rutile grains from the Porcupine Lake sample yielded an average $^{207}Pb/^{206}Pb$ age of 957±4 Ma, which likely dates cooling through the blocking temperature of rutile after the peak of Grenville metamorphism. Corfu and Easton (2000) obtained ages of circa 973 Ma from rutile along the Grenville Front near Sudbury, with apatite grains from the same area yielding ages of circa 959 Ma. The slightly younger ages of rutile from Tomiko terrane may be related to the fact that the Tomiko samples are located some 30 km south of the Grenville Front, and perhaps cooled more slowly than did the samples dated by Corfu and Easton (2000) at the Grenville Front itself.

MAFIC METAVOLCANIC OR METAPLUTONIC ROCKS (UNIT 11)

Rocks of unit 11 occur mainly in the southern part of the study area (*see* Map P.2847). Unit 11 can be divided into amphibolite (unit 11a) and garnet amphibolite (unit 11b)(Photo 11). Where contact relationships and layering can be observed in the host rocks (generally metasedimentary gneisses of unit 9b and 9c), the mafic rocks appear to be stratiform. Width of individual units can vary from tens of centimetres to tens of metres, and grain size can be either fine- or medium-grained. Consequently, it is not known if these metamorphosed igneous rocks are of volcanic (flows, tuffs) or plutonic (sills) origin. In the Timber Lake area, some rocks of unit 11 are intimately interlayered with felsite gneiss of unit 12 (Photo 12), which may suggest that at least some parts of unit 11 are volcanic in origin.

In the area subjected to M_3 metamorphism, it is also possible that some of the rocks designated as unit 11 may be highly metamorphosed calc-silicate gneisses (equivalents of unit 4). This is suggested by geochemical data from some of the samples (samples 03RME-0097 and 03RME-0272, *see* Appendix 2), which exhibit abnormal CIA values.

In the Cahill Lake area, some amphibolite and garnet amphibolite outcrops contain the assemblage hornblende-kyanite. Those that do are indicated as unit 11k on Map P.2847. This assemblage was first reported by Moore (1976), but was also observed in the field by the author. Kyanite crystals are either white or pale blue, and up to 2 cm long. In thin section, the kyanite grains are altered around their edges to a fibrous mineral, which is, in turn, surrounded by plagioclase, biotite and hornblende. The kyanite may also be completely replaced by plagioclase. The remainder of the rock is coarse grained, with 120° triple junctions, garnet poikiloblasts up to 3 cm in diameter occurring in some samples. Geochemistry from a sample of unit 11k, reported by Moore (1976), is not notably different from other unit 11 samples (sample Hb-Ky, *see* Appendix 3).

Several rocks from unit 11 were chemically analyzed (samples 03RME-0202, 03RME-0204, 03RME-0271, 03RME-0272 and 03RME-0279, *see* Appendix 2; samples B71-28 and Hb-Ky, *see* Appendix 3). At least 3 main chemical groupings are present, independent of whether or not the unit is garnet bearing.

Even though samples 03RME-0202 and 03RME-0204 were located within centimetres of one another, separated by a layer of felsite, they are chemically distinct. Sample 03RME-0204 is broadly similar in composition to the felsite samples from the same outcrop (03RME-0201 and 03RME-0203, *see* Appendix 2), exhibiting a calc-alkalic character, and with REE patterns similar to that of continental basalts and/or crustally derived rhyolites, based on their compositions. In contrast, sample 03RME-0202 has many of the chemical features associated with dikes of the Sudbury diabase dike swarm, most notably high TiO_2 (2.68 weight %), P_2O_5 (1.03 weight %), Ba (1423 ppm) and Zr (193 ppm). MgO (4.22 weight %) is lower than in most other mafic rocks from the area.

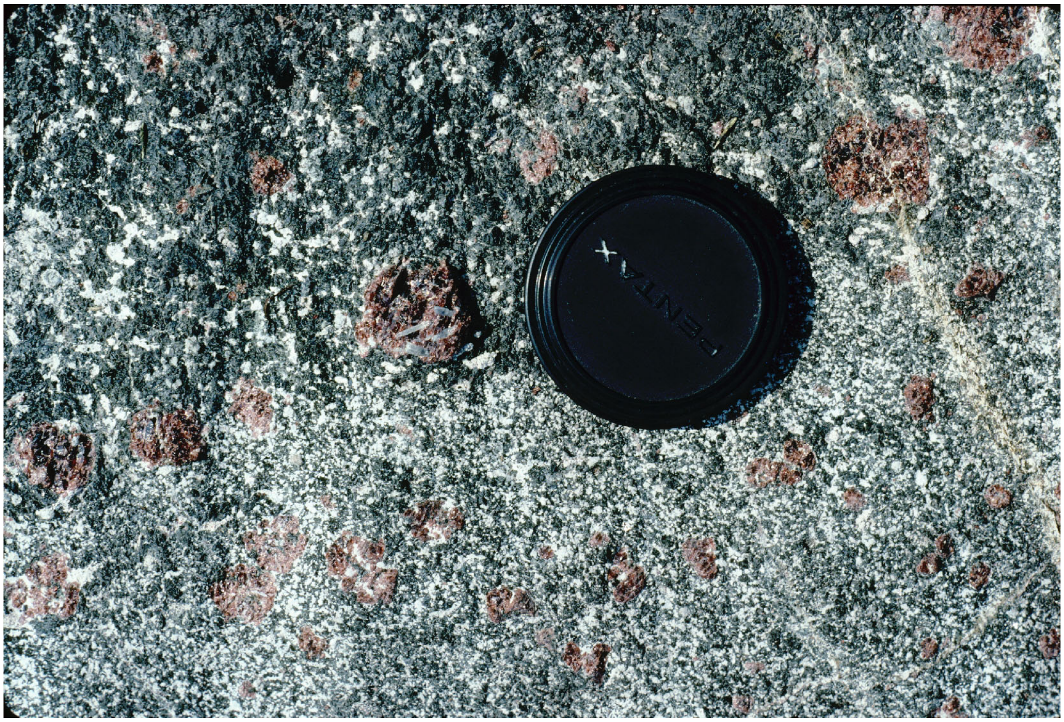


Photo 11. Garnet amphibolite, unit 11b, Phelps Township (UTM NAD83, Zone 17, 646643E, 5136683N). Lath-like crystals in large garnet to left of lens cap are kyanite. Hammer handle is 30 cm long.

Photo 12. Interlayered amphibolite (left, unit 11) and felsite (right, unit 12) on Highway 533, Butler Township (UTM NAD83, Zone 17, 646796E, 5152658N). Hammer handle is 30 cm long.

Although having considerably different garnet contents, samples 03RME-0271 and 03RME-0272 have many chemical similarities. Both are low-potassium tholeiites with calc-alkalic affinities, flat rare earth patterns (10× chondrite) with weak positive Eu anomalies, low total REE contents (36.2 and 26.7 ppm, respectively) and moderate to high MgO contents (9.03 and 17.73 weight %, respectively). The primary chemical difference between the 2 samples is in Al_2O_3 and MgO content, with the garnet-bearing sample (03RME-0271) having higher Al_2O_3 and lower MgO. Samples B71-28 and Hb-Ky (*see* Appendix 3) are probably also part of this chemical group. Both of these samples are garnet bearing, and also have higher Al_2O_3 contents than sample 03RME-0272. Thus, garnet content may reflect Al_2O_3, not Fe_2O_3, content in the rock.

Sample 03RME-0279 has some similarities with samples 03RME-0271 and 03RME-0272, but has higher light REE and total REE contents, and higher TiO_2. Unlike sample 03RME-0202, it lacks the high Ba and Zr contents typical of the Sudbury diabase dike swarm. It is somewhat similar chemically to sample 03RME-0270, a retrogressed eclogite (unit 20).

This wide variation in chemistry between these mafic rock units that look very similar in the field indicates that a variety of mafic units of different ages are present in southeastern Tomiko terrane, and that considerably more geochemistry and geochronology on these mafic rocks is needed to unravel the history of these units.

INTERMEDIATE TO FELSIC METAVOLCANIC OR METAPLUTONIC ROCKS (UNIT 12)

Unit 12 consists of fine-grained, pink felsites that could be felsic flows or intrusions. In contrast to the intermediate and felsic metaplutonic rocks of units 13 to 17, rocks of unit 12 are clearly interlayered with the Tomiko supracrustal rocks, specifically units 9 and 11. It is difficult to tell if these rocks were deposited simultaneously with the adjacent metasedimentary rocks, or if they represent sills that were emplaced subsequently into the metasedimentary succession.

Assignment of these felsites to the Tomiko supracrustal package is based on the fact that they are interlayered with rocks of units 9 and 11. Unlike the other Tomiko supracrustal rocks, however, some felsites of unit 12 show moderate magnetic susceptibility readings (*see* Appendix 5). This observation, in conjunction with the fact that there are some geochemical similarities between rocks of unit 12 and the intermediate to felsic metaplutonic rocks of units 13 to 17 (high field strength and rare earth element contents, *see* samples 03RME-0201 and 03RME-0203, *see* Appendix 2), suggests that they could be co-genetic with rocks of units 13 to 17.

Mesoproterozoic

INTERMEDIATE TO FELSIC INTRUSIVE ROCKS (UNITS 13 TO 17)

Overview

A variety of intermediate to felsic intrusive rocks (unit 13 to 17) intrude the Tomiko supracrustal rocks. All may be Geon 12 in age, although ages have been obtained for only 2 of the suites. There are some geochemical and textural differences between the 4 rock units distinguished on the map of the study area, however, it is possible that all 4 rock units are related to the same major magmatic event. Table 5 summarizes the textural, isotopic and geochemical features of all the intrusive rocks in Tomiko terrane.

Table 5. Characteristics of the felsic intrusive rocks in Tomiko terrane. Neodymium data *from* Holmden and Dickin (1995).

Unit	Rock Type	Textures	Key Chemical Features	Chemical Affinity	Nd Model Age (Ma)	Age (U/Pb, Ma)
Grey gneiss (unit 13)	Quartz monzonite to monzogranite, fine grained, grey weathering	Equigranular, pyroclastic?	Minor Eu anomaly	A-type, subalkalic, within-plate granite field	1820, 1910, 1970, 2200	1250±10[1]
Gneissic granite suite (unit 14)	Monzogranite	Equigranular, locally potassium feldspar laths	Th >25 ppm, minor Eu anomaly, low HREE	A-type, subalkalic, volcanic-arc granite field	No data	Not dated
Jocko suite (unit 15)	Monzogranite, green or red coloured	Medium grained, protomylonitic	Low CaO, Rb, Sr, Ba, Cs, high Na_2O, total REE	A-type, subalkalic, within-plate granite field	1770, 1940, 2160	$1257^{+4}/_{-2}$[1]
Mulock suite (unit 16)	Monzogranite and quartz monzonite, fluorite present	Augen, equigranular, aplite		A-type, subalkalic, straddles volcanic-arc to within-plate granite fields	2360	$1244^{+4}/_{-3}$[2], $1250^{+10}/_{-6}$[3]
Bonfield suite (unit 17)	Quartz monzonite to monzogranite	Medium grained, locally potassium feldspar laths		No data	No data	Not dated
Late intrusions (unit 23)	Monzogranite	Coarse grained, large potassium feldspar laths	High SiO_2	A-type, subalkalic, within-plate granite field	No data	Not dated, edges metamorphosed and deformed, suggesting older than ~1040±4 Ma

Chemical affinity: Within-plate granite field and volcanic-arc granite field refers to location on Pearce, Harris and Tindle (1984) diagrams.
Geochronology sources: [1] Easton and Kamo (2004), Kamo (2005); [2] Lumbers et al. (1991); [3] Davidson and van Breemen (2001).

The earliest rocks, at least in terms of relative age (unit 14), consists of medium-grained, locally potassium feldspar phyric, gneissic granite and granodiorite that is most abundant in the area north of Highway 63. Next in relative age is a volumetrically smaller suite of penetratively deformed, buff to pink weathering, hornblendite monzonite to monzogranite (unit 15), typified by the Jocko Lake pluton, that is most common in the areas affected by M_2 and M_3. The youngest granitic rocks, apart from the single pluton represented by unit 23, is a volumetrically larger suite of variably deformed, commonly potassium feldspar megacrystic or porphyroblastic, monzogranite to syenogranite (unit 16) and is typified by the Mulock granite. This suite is most abundant in the western Tomiko terrane. Rocks of unit 13, although possibly extrusive, share many of the same compositional, isotopic and geochemical features as the felsic intrusive rocks (units 14 to 17) in Tomiko terrane (*see* Table 5).

Grey Gneiss (unit 13)

Grey, granodioritic, gneiss (unit 13) is interlayered with, and folded with, quartzose metasedimentary rocks (units 9 and 10) of the Tomiko supracrustal package in the northern part of the study area (*see* Map P.2846). Two main varieties are present, the most common of which are rocks of unit 13a, which consists of the fine- to medium-grained, grey, tonalite to granodiorite gneiss. Incorporated within outcrop areas of unit 13a is a fragmental variety (Photo 13), which was originally interpreted as possibly volcanic in origin (unit 13b). Also present is a unit containing flattened plagioclase feldspar megacrysts (unit 13c), which is most likely of intrusive origin (Photo 14). Rocks of unit 13, thus, represent sills and or volcanic horizons interlayered with the Tomiko supracrustal sequence. When first mapped in 2003, the author interpreted this unit as a possibly older synsedimentary igneous unit (Easton 2003a). Subsequent geochemical and geochronological study has revealed this unit to by of A-type character, and of similar age, to the other more felsic intrusive rocks found within Tomiko terrane (*see* Table 5). Thus, the unit is now interpreted to be entirely intrusive in origin.

Rocks of unit 13 are largely restricted to the Jocko River area (*see* Map P.2846), although a thin unit (13d) exposed along Highway 533 in the Timber Lake may be related. This horizon consists of a biotite-plagioclase gneiss, which was originally thought to be sedimentary in origin, but which is similar geochemically (sample 03RME-0206, Appendix 2) to samples of units 13a and 13b (samples 03RME-0016 and 03RME-0017, respectively, Appendix 2).

Photo 13. Grey gneiss (unit 13b), derived either from a fragmental volcanic rock or extreme tectonism of a feldspar megacrystic granitoid (UTM NAD83, Zone 17, 639995E, 5171075N). Hammer handle is 30 cm long.

Photo 14. Grey gneiss (unit 13c), with flattened feldspar megacrystics (UTM NAD83, Zone 17, 639717E, 5171580N). Hammer handle is 30 cm long.

McDougal Pluton and Associated Intrusions (unit 14)

Gneissic granites (unit 14) were observed only in the northern portion of the map area (covered by Map P.2846), mainly in the area north of Highway 63. The largest belt of these rocks occurs in the area between Big McDougal Lake and the Ottawa River, but they also core the iron formation unit exposed in Parkman Township and crop out south of Reynolds Lake.

Most outcrops consist of medium-grained, pink, foliated to gneissic monzogranite. Some outcrops and parts of outcrop contain small (up to 2 cm long) potassium feldspar laths with diffuse grain boundaries. For the most part, the bodies of this unit are homogeneous, however, more heterogeneous zones containing gneissic granodiorite or partly assimilated xenoliths of amphibolite or gneissic rocks are present, particularly near the edges of some of the bodies.

Many features of these granite intrusions are similar to those observed in some of the equigranular gneissic granite phases of the Mulock granite (unit 16). Rocks of unit 14 are distinguished on Map P.2846 from unit 16, in large part because they have higher Th and K_2O contents as compared to other granites in the study area (>25 ppm Th, >4.5 weight % K_2O, *see* Appendix 2). This higher Th and K_2O content is reflected in the fact that these bodies can be observed on the radiometric survey that covers the study area. It is not known if the higher Th and K_2O content is related to the lower metamorphic grade or the greater abundance of metasedimentary rocks in this part of the study area, or both. In addition to the higher Th and K_2O content, rocks of unit 14 have slightly lower heavy rare earth elements contents (less than 10× chondrite) and no to minor positive Eu anomalies, compared to the other granite units (greater than 10× chondrite, large positive Eu anomalies).

Jocko Pluton and Associated Intrusions (unit 15)

The Jocko pluton, also called the Timber Lake pluton by Baer (1980), is an elongate intrusion approximately 15 km long and up to 1.5 km wide, located mainly in Jocko Township. The body is well exposed on both Highways 63 and 533. The term Jocko pluton is preferred over Timber Lake pluton because the intrusion does not occur at Timber Lake, and because the name could be confused with other granitic rocks exposed at Timber Lake. Some small intrusive bodies located to the west and south of the main Jocko pluton are also considered to be related to the Jocko pluton and, consequently, are also designated as unit 15 on Maps P.2846 and P.2847.

The Jocko pluton contains a well-developed foliation that trends northwesterly, parallel with the long axis of the pluton, and dips 50° to the southwest. Where least deformed and recrystallized, the Jocko pluton is a medium- to fine-grained, pink, leucocratic monzogranite. Mafic minerals consist of platy aggregates of biotite and minor hornblende, which are evenly distributed and define the foliation in the body. More commonly, the rock has been recrystallized, taking on a pale green colour on fresh surfaces. Recrystallization makes it difficult to distinguish between potassium and plagioclase feldspar, making rock nomenclature in the field difficult. Chemically, however, the greenish phase also classifies as a monzogranite on a quartz–alkali feldspar–plagioclase diagram.

In thin section, the rock is equigranular, with grains exhibiting 120° triple junctions. The recrystallized rock consists of feldspar (60 to 70%), quartz (20 to 40%), with minor biotite, hornblende and epidote. Within both the pink and green phases of the body, localized shear zones with a width of a centimetre to decametre are common. These shear zones crenulate the main foliation in the granite. Large parts of the body are deeply weathered, especially in areas underlain by the greenish phase of the pluton.

Geochemically, the Jocko pluton differs from the other felsic intrusions in having lower abundances of CaO, Rb, Sr, Ba and Cs, but the highest total REE content of all the sampled intrusions. It is also possible that the Na_2O content of the pluton is slightly elevated compared to other felsic intrusions in the area. The differences in alkali content in the Jocko pluton relative to other Geon 12 plutons in the study area could reflect alteration of the body, which would be consistent with its distinctive colour and deep weathering. The timing of this alteration is not known, however, it could be late Grenvillian, as Baer (1980) obtained a Rb/Sr age of 994±157 Ma from recrystallized phases of the pluton, compared to a Rb/Sr age of 1137±173 Ma from the pink phase of the pluton. Interpretation of either Rb/Sr age is suspect, given the evidence for alkali mobility. Both Rb/Sr ages are younger than the $1257^{+4}/_{-2}$ Ma U/Pb zircon age obtained on a green phase of the intrusion (Easton and Kamo 2004).

Mulock Granite (unit 16)

The Mulock granite (unit 16) is situated mostly in western Tomiko terrane, adjacent to the western boundary of the study area; however, during the course of this study, a new lobe of the Mulock granite that covers at least 25 km^2, was identified in western Lockhart and Garrow townships. This lobe has been termed the Malone lobe (Easton 2003a), as it is centred on Malone Lake (*see* Map P.2846). The main body of the intrusion has been studied in detail by Lumbers et al. (1991).

According to Lumbers et al. (1991), the typical granite of the main lobe of the intrusion is a pink augen gneiss, with coarse-grained recrystallized alkali feldspar augen surrounded by a fine groundmass of quartz, feldspar and mafic minerals (Photo 15). Equigranular gneissic granite, containing only a few or no alkali feldspar augen, occurs throughout the intrusion. The equigranular gneissic granite commonly shows diffuse boundaries with the host augen gneissic granite, and can contain xenoliths of augen gneissic granite. The equigranular gneissic granite both cuts and is cut by aplite dikes. Mafic minerals

Photo 15. Photograph of typical augen gneiss of the Mulock granite (UTM NAD83, Zone 17, 651330E, 5149095N). Hammer handle is 30 cm long.

Table 6. Petrographic groupings of the Mulock granite (*modified from* Lumbers et al. 1991).

Group	Texture	Ferromagnesium Minerals	Colour Index (average)	Plagioclase Composition (average)	Chemical Equivalent
Ferrohastingsite-biotite	Augen	Ferrohastingsite, biotite	14.4	8	Subalkalic metaluminous
Biotite	Augen	Biotite	14.7	11	Subalkalic metaluminous
Leucocratic	Augen and equigranular	Biotite	5.7	7	Subalkalic metaluminous, peraluminous, peralkaline
Aplite	Fine-grained	Biotite	3.0	7	Subalkalic peraluminous, peralkaline

consist of biotite, ferrohastingsite, titanite and magnetite. Fluorite and monazite are also common accessory minerals. Lumbers et al. (1991) divided the granitic rocks into 4 petrographic groups based on text, ferromagnesium mineral contents and colour index, as summarized in Table 6. All mineral phases have been partly or wholly recrystallized during regional metamorphism.

The geology and mineralogy of the Malone lobe is similar to that described for the main body (Lumbers et al. 1991). Pink augen gneiss is the most common phase, although equigranular gneissic granite is also present, as are aplite dikes.

The geochemistry of the Mulock granite has been well described by Lumbers et al. (1991). Samples of the Malone lobe of the Mulock granite, collected as part of this study, fall in the range of the Mulock granite defined by Lumbers et al. (1991) (*see* Appendixes 2 and 3). Compositionally, on a quartz–alkali feldspar–plagioclase diagram, most of the Mulock samples classify as monzogranites, along with a few quartz monzonites. The suite of rocks sampled by Lumbers et al. (1991) is mainly metaluminous to marginally peraluminous, with a few peralkaline samples. The suite itself is subalkalic, not calc-alkalic. All of the major and trace element characteristics indicate that the suite is A-type. As a reminder, anorogenic or A-type granites are characterized by high SiO_2, Fe/Mg, Ga/Al, high field strength elements such as Nb, Yb and the REE (except Eu) and by low CaO and MgO (e.g., Anderson 1983). Lumbers et al. (1991) noted high Zn content (23 to 202 ppm) in their samples, however, these contents are within the range typical of A-type granites.

Lumbers et al. (1991) concluded that the Mulock granite likely crystallized under relatively low pressures (<2 kilobars) from a high-temperature, fluorine-enriched magma. They also concluded that magma generation occurred at lower crustal levels by anatexis of tonalitic to granodioritic or felsic granulite source rocks, which had previously undergone melt depletion. The ε_{Nd} value of –11.1 obtained by Holmden and Dicken (1995) from a sample of the Mulock granite is consistent with significant involvement of older crust in the generation of the Mulock magma. The Tomiko supracrustal rocks were not a potential source rock, given their aluminous character and the abundance of Proterozoic detrital zircons. Mafic magmatism in the area at Geon 12 (e.g., Flett Township mafic intrusion, Sudbury diabase dike swarm) may have helped contribute to melting of the lower crust to generate the granites.

Bonfield Pluton (unit 17)

The Bonfield monzonite to monzogranite (unit 17) crops out in the southern part of the study area (*see* Map P.2847). Contacts with migmatitic Tomiko supracrustal rocks (units 9b and 9c) are either intrusive or faulted. Locally, south of Cahill Lake, rafts of Tomiko supracrustal rocks occur in the northern margin of the Bonfield pluton. In the Purdy Lake area, rafts of mafic gneiss, are abundant in the Bonfield pluton, and this area is a loci for emplacement of extremely coarse-grained granite pegmatite veins (unit 22), which were exploited for their mica content in the 1930s and 1940s (Harding 1946).

Although relatively homogeneous in the western part of the map area, in the east, south of Highway 533, the Bonfield pluton is more heterogeneous, and shows a greater compositional range. In the west, the pluton consists mainly of fine- to medium-grained, pink or grey weathering, equigranular gneissic quartz monzonite to monzogranite (unit 17a). In contrast, in the east, the gneissic quartz monzonite to gneissic monzogranite is interlayered with fine- to medium-grained, pink or grey weathering, equigranular gneissic tonalite to gneissic granodiorite (unit 17d), which commonly exhibits a strong, highly flattened fabric (unit 17c). Mafic enclaves and schlieren (unit 17e) are also commonly locally. In addition, there is one area of a block tectonic breccia (unit 17f). Lumbers (1971c) noted that the Bonfield pluton was more homogeneous toward its core, and that it contained more inclusions and had a more intense fabric near its margins. Lumbers (1976) shows a complex pattern of interference folding is present in the eastern part of the Bonfield pluton, and it is possible that the eastern part of intrusion represents part of the marginal phase of the intrusion.

In thin section, monzonitic and monzogranitic rocks of the Bonfield pluton have a diagnostic mafic mineral assemblage of biotite, garnet and hornblende, which is usually found in small aggregates. Moore (1976) noted that this mafic mineral assemblage is not found in the granitic rocks present in Tomiko terrane.

Lumbers (1971c) correlated the Bonfield pluton with the Geon 12 Powassan pluton. This interpretation is consistent with observations made during this study, which indicate that the intrusion is younger than the Tomiko supracrustal rocks, and the fact that the Bonfield pluton shows the varied magnetic susceptibility response characteristic of other Geon 12 intrusions in the map area.

MATTAWAN DOMAIN (UNITS 18 TO 22)

Overview

Rocks of this domain are found mainly in Mattawan Township (*see* Map P.2847), from which the name of the domain was derived. Mattawan domain was not a focus of this study, consequently, only limited mapping was conducted in this domain. Mattawan domain is distinguished from Tomiko terrane by the following features:

1. Change in dominant structural trends, from dominantly northwest in Tomiko terrane to north and east-northeast in Mattawan domain. In addition, structures are generally steeper (80 to 90°) in Mattawan domain compared to Tomiko terrane (60 to 70°).
2. Change in character of the major gneiss units in both areas, from well-layered, mafic to intermediate heterogeneous gneiss (unit 1) typical of Tomiko terrane to a more diffusely layered, intermediate to felsic, typically garnet-bearing gneiss (unit 18).
3. Presence of retrograded eclogite in Mattawan domain.
4. Presence of larger masses of metagabbroic rocks interlayered with the gneisses of Mattawan domain.
5. Absence of Tomiko supracrustal rocks from Mattawan domain.
6. Change in granitoid composition from dominantly A-type granitoids in Tomiko terrane to volcanic-arc granitoids in Mattawan domain.
7. Based on limited data, rocks from Mattawan domain have younger Nd model ages (<1700 Ma: Holmden and Dickin 1995), suggesting less interaction with older crustal rocks.

On the basis of the low-resolution aeromagnetic data for the area, there is not a noticeable magnetic difference between Tomiko terrane and Mattawan domain, other than the aforementioned change in structural grain. Potassium, uranium and thorium are uniformly high over Mattawan domain, and this higher total gamma-ray signature may be diagnostic of Mattawan domain.

The lack of a distinct magnetic (or gravity) signature associated with Mattawan domain could indicate that Mattawan domain is a relatively thin structural sliver that was emplaced over Tomiko terrane, and which has now largely been eroded away. This is best observed in southern Antoine Township, where structural trends in Tomiko terrane appear to project beneath rocks of Mattawan domain (*see* Map P.2847), and where it is difficult in the field to separate the gneissic packages characteristic of Tomiko terrane and Mattawan domain.

The contact between the Bonfield pluton and the Mattawan domain is apparently not exposed in the study area, but is likely a fault. Contact relationships between Mattawan domain and Tomiko terrane are largely obscured by glacial cover; thus, the contact shown on Map P.2847 is an approximation, especially at its northern end. Based on comparison with better exposed areas elsewhere in the Ontario Grenville Province, the contact is most likely a ductile shear zone, which was initiated between 1090 and 1070 Ma, prior to peak metamorphism in the area. The contact between Tomiko terrane and Mattawan domain has been correlated with the Allochthon Boundary Thrust, which forms the boundary between parautochthonous rocks to the north and west (Tomiko terrane) from allochthonous rocks (Algonquin terrane, including Mattawan domain) to the south and east (Ketchum and Davidson 2000; Carr et al. 2000). A characteristic feature of the Allochthon Boundary Thrust is the presence of pods of retrograded eclogite in its immediate hanging wall (Ketchum and Davidson 2000), a feature which is found within the study area (*see* outcrops of unit 20, Map P.2847).

In the study area, the trace of the Allochthon Boundary Thrust has been modified by younger northeast-trending normal faults, with differential vertical movement on these normal faults exposing different structural levels within Mattawan domain. Map unit contacts and structural grain in the core of Mattawan domain appear to be transposed into parallelism along the western contact of the domain (change from east-northeast trends to a north-northwest trend), suggesting that earlier fabrics are present in the core of the domain, and that these earlier fabrics have been overprinted by the fabric directly related to the Allochthon Boundary Thrust.

Lumbers (1976) showed considerably more lithologic variation within Mattawan domain than is shown on Map P.2847, particularly within the intermediate to felsic gneisses designated as unit 18. The more simplified lithologic structure on Map P.2847 is due to the difficulty in assessing the degree of intra-outcrop variability resulting from heterogeneity in the unit and/or changes in intensity of deformation versus interlayering of several discrete mappable units. This difficulty is compounded in the areas underlain by intermediate to felsic gneisses and by the limited outcrop exposure in the study area. As such, the differences between Map P.2847 and Lumbers (1976) are best viewed as the result of the application of different methodologies to mapping high-grade gneiss terranes, and not any fundamental difference with respect to the geology of the area.

Heterogeneous, Intermediate to Felsic Gneiss (unit 18)

Unit 18 consists of mainly leucocratic, intermediate to felsic, diffusely layered, compositionally heterogeneous gneiss. These rocks range compositionally from tonalite to granodiorite, and are commonly fine grained. Protolith of these gneisses is difficult to determine, but they are likely derived from metamorphic rocks that have been variably injected by younger granitoid phases, and subsequently metamorphosed and deformed. Consequently, some outcrop areas appear to be somewhat more homogeneous and of igneous character, whereas other parts of this unit are lithologically and texturally heterogeneous. This is reflected in Lumbers' (1976) map of the area, where he tried to separate out the more igneous looking components (his units 11a, 11b and 11c) from the more metamorphic components (his units 2a, 2b and 3a). Mafic inclusions within these gneisses commonly have diffuse contacts, are migmatitic, and are partly assimilated into the surrounding host material. This is in contrast to the heterogeneous gneisses of unit 1, where contacts with incorporated mafic material and mafic layers is generally sharp.

Mafic Intrusive Rocks (unit 19)

There are 3 main subdivisions of the mafic intrusive rocks found within Mattawan domain:

1. gneissic metagabbro (unit 19a).
2. gneissic anorthositic gabbro and gabbroic anorthosite (unit 19b).
3. mafic gneiss, commonly garnet-bearing (unit 19c).

It is not known if the 3 mafic units are similar in age, or whether each subunit differs in age and origin.

Unit 19a consists of dark weathering, medium-grained, gneissic metagabbro, and forms several large bodies within Mattawan domain, 2 of which are located proximal to the Ottawa River (*see* Map P.2847). These rocks could represent more mafic equivalents of the plagioclase-rich gabbroic rocks of unit 19b, or they could be the result of a separate mafic intrusive event. Moore (1976) describes corona textures from this unit, with the assemblage diopside-garnet-biotite rimming original olivine and hypersthene. It is possible that this unit is equivalent to the 1160 Ma coronitic gabbros commonly found in the hanging wall of the Allochthon Boundary Thrust (Ketchum and Davidson 2000).

Unit 19b consists of gneissic anorthositic gabbro and gabbroic anorthosite, with minor gneissic leucogabbro. A large mass of these rocks occurs in Calvin Township, just south of the community of Mattawa, and it is possible that the exposures in the study area are related to this larger intrusive body to the south. Texturally, these rocks are similar to the gneissic anorthositic gabbro (unit 3b) of the East Bull Lake intrusive suite, although it is likely that the rocks of unit 19b are considerably younger and are genetically unrelated to the East Bull Lake intrusive suite.

A sample of unit 19b was chemically analyzed (sample 03RME-0258, *see* Appendix 2). The sample had low, but above detection limit values for platinum and palladium (5 ppm and 4.5 ppm, respectively), suggesting that this unit might have potential for hosting Ni-Cu-PGE mineralization.

Unit 19c consists of dark weathering, fine- to medium-grained, mafic gneiss, commonly bearing garnet. Some parts of unit 19c may simply represented highly tectonized equivalents of units 19a and/or 19b, particularly where these units are found in close proximity. Other parts of unit 19c may represent highly retrograded equivalents of unit 20. It is also likely that parts of unit 19c represent mafic dikes injected into the granitoid gneisses of Mattawan domain. Because these rocks are fine-grained, and contain garnet and pyroxene, Lumbers (1976) mapped some of these rocks as calc-silicate gneisses.

Mafic Intrusive Rocks (Retrograded Eclogite Facies Rocks) (unit 20)

Unit 20 consists of green-red weathering, garnet-pyroxene gneiss, derived from retrograded eclogite facies mafic rocks. These rocks are best exposed on Highway 533, as well as immediately west of the highway, near the junction of the forest access road that heads west into Olrig and Phelps townships. These rocks have been the subject of considerable exploration activity over the past decade for their garnet potential, given the abundance (30 to 45%) and uniform grain size of garnet in this unit (*see* Appendix 1).

Unit 20 crops out as discrete masses and ridges of mafic rocks (unit 20a), as well as large screens hosted within fine- to medium-grained intermediate to felsic gneisses of unit 18 (unit 20b). Compared to other mafic rocks in the study area, rocks of unit 20 have moderate magnetic susceptibility values (1 to 10 SI units), likely due to the exsolution of iron oxide during the retrograde reaction from eclogite to amphibolite facies.

A sample of unit 20 was chemically analyzed (sample 03RME-0270, *see* Appendix 2). The rock is ultramafic, but has low Cr and Ni contents, moderate REE contents (125.7 ppm total REE) and high TiO_2 (3.0 weight %). It has a relatively flat REE pattern (~30× chondrite for light REE, ~15× chondrite for heavy REE), with no Eu anomaly. On trace element discrimination plots, the rock classifies as a high-iron tholeiite.

Felsic Intrusive Rocks (unit 21)

Unit 21 consists of fine- to medium-grained, gneissic monzonite to gneissic monzogranite. In both hand and thin section, the mafic assemblage of biotite-garnet-hornblende is observed in these rocks, usually present in small aggregates. At least 3 main intrusions of this unit are found in Mattawan Township (*see* Map P.2847). These bodies are generally homogeneous in their core, however, along their margins, screens and rafts of mafic and intermediate gneiss are common.

Only one sample of unit 21 was chemically analyzed as part of this study (sample 03RME-0259, *see* Appendix 2). It contains significantly higher Al_2O_3 (>20 weight %) than other granitoid rocks from the study area, low Zr and Y contents, extremely low total REE contents (46.8 ppm), and a positive Eu anomaly, most likely related to accumulation of plagioclase. It classifies as a volcanic-arc granite on a Y+Nb versus Rb diagram (Pearce, Harris and Tindle 1984). It is also highly peraluminous. In addition to these chemical differences, 2 samples collected by Holmden and Dickin (1995) from this unit yielded Nd model ages of 1700 and 1620 Ma, much lower than ages obtained from the intrusive rocks within Tomiko terrane. These model ages place a maximum age on this intrusion of circa 1650 Ma.

Felsic Intrusive Rocks (unit 22)

Unit 22 consists of coarse-grained to extremely coarse-grained granite pegmatite veins present in the southernmost part of the study area (*see* Map P.2847). These veins are spatially associated with the contact between the Bonfield pluton and the Tomiko supracrustal rocks, however, because some of these veins occur solely within Tomiko supracrustal rocks, they have been broken out as a separate unit, rather than as a phase of the Bonfield pluton.

A potassium feldspar from the Purdy Mine was chemically analyzed (sample 03RME-0314, *see* Appendix 2) to see if these pegmatites had potential for hosting rare element mineralization. Cesium is low (1 ppm), K/Ba ratio is less than 550, and Rb is low at 239 ppm. These elements, along with other key ratios, all indicate that the Purdy Lake pegmatite fall in the Type 1b (barren) pegmatite type of Gordiyenko (1971) and, thus, have no rare metal potential.

Mesoproterozoic to Neoproterozoic

LATE FELSIC INTRUSIVE ROCKS (UNIT 23)

Rocks of unit 23 occur as a single, stock-like pluton, roughly 600 m in diameter, that is located due east of the Hamlet of Eldee and which forms a regional topographic high, standing up to 125 m higher than the surrounding landscape. A communication tower is located at the highest point on the stock. The stock has an undeformed core, but does exhibit a foliation along its margins. The contact between the stock and its country rocks is not exposed.

In the core of the stock, the rock is a medium- to coarse-grained, white to pink weathering, pink hornblende granite to syenite, with well-formed feldspar laths. Heading outward from the core, biotite in the rock becomes chloritized, the feldspar laths take on a glassy appearance, and both the weathered and fresh surfaces become redder. At the margins, a well-developed foliation is present, and the rock itself is fine to medium grained, and lacks the feldspar laths present in the core of the stock.

In thin section, the rock consists of large perthite laths in an interstitial matrix of quartz and andesine. Biotite occurs both as larger laths and as small grains associated with iron oxides. The small grains may be related to breakdown of the oxides during regional metamorphism. Apart from the development of secondary biotite, the rock is not obviously metamorphosed.

Lumbers (1971b) termed the rock a quartz monzonite, which corresponds to a monzogranite using Streckeisen (1976). Geochemically, on a quartz–alkali feldspar–plagioclase diagram, the rock classifies as a monzogranite (sample 03RME-0140, *see* Appendix 2) with an overall A-type granite affinity. The sample is not alkalic. On a Y+Nb versus Rb diagram (Pearce, Harris and Tindle 1984), it plots in the within-plate granite field. It differs somewhat from the Mulock granite in its content of high field strength elements, being higher in Ta, Nb, Hf, Y and U, and lower in Ba and Sr, but this may simply reflect the more fractionated nature of the rock, as reflected in its silica content (76.8 weight %). The stock-like form of the body, its generally undeformed character, and its moderate magnetic susceptibility at its core (average 20), suggests that this stock is slightly younger than other intrusions in the area. The fact that the margins of the body are deformed, indicate however, that it was subjected, at least in part, to Grenvillian deformation and metamorphism.

LATE INTRUSIVE ROCKS

Breccia Dike (unit 24a)

A weakly metamorphosed breccia is exposed along Highway 63 in French Township (Photo 16). It is hosted in diatextite derived from quartz-muscovite rocks of the Tomiko supracrustal rocks. The breccia body is roughly 10 m wide and 20 m long, and consists of exotic, fine-grained, variably epidotized, mafic fragments with magnetic susceptibility between 0.5 and 2. The fragments are hosted in a medium-grained, granodioritic matrix consisting of a mixture of feldspar and quartz xenocrysts, small mafic fragments and biotite granodiorite with a magnetic susceptibility between 30 and 100. In places, the breccia resembles an intrusion breccia, but it may also resemble a diatreme. The breccia is in an area excluded from staking because of a nearby Ministry of Natural Resources fish hatchery. In thin section, the breccia matrix consists of large alkali feldspar laths in a fine-grained, equigranular matrix of quartz, plagioclase, green-brown biotite and titanite. The rock is not obviously metamorphosed, although the equigranular nature of the fine-grained parts of the rock could reflect metamorphic recrystallization.

A sample of the breccia matrix was collected for geochemistry (sample 03RME-0112, *see* Appendix 2). The matrix is intermediate in composition, and is not alkalic. On a quartz–alkali feldspar–plagioclase diagram the matrix classifies as a granodiorite. The rare earth element pattern for the matrix is almost identical to that of sample of unit 23 (sample 03RME-0140, *see* Appendix 2), suggesting an A-type granite affinity. The lower silica content of the matrix (65.9 weight %) compared to sample 03RME-0140 (76.8 weight %) could in part reflect contamination by the mafic fragments present in the breccia. On a Y+Nb versus Rb diagram (Pearce, Harris and Tindle 1984), the matrix sample plots in the volcanic-arc granite field, near the boundary with the within-plate granite field. Samples of the A-type Mulock granite, however, plot in both fields on the Y+Nb versus Rb, thus this diagram does not exclude samples 03RME-0112 and 03RME-0140 from being related.

A sample of the breccia was studied for geochronology at the Jack Satterly Geochronology Laboratory at the University of Toronto (Kamo 2005). Preliminary results from 3 single zircon grains showed a small amount of scatter and Pb loss, but the grains plot on, or close to, a reference line from 1280 to 1040 Ma. The least discordant datum had a $^{206}Pb/^{238}U$ age of 1271±4 Ma, which can be regarded as a minimum estimate of the age of the breccia. The data for the least discordant datum are slightly reversely discordant (–1%), likely due to the large uncertainty in the $^{207}Pb/^{204}Pb$ correction and, therefore, it has an artificially young $^{207}Pb/^{206}Pb$ age. A fourth grain contains an inherited component and has a $^{207}Pb/^{206}Pb$ age of 1544±6.8 Ma (3.8% discordant). A line calculated through this datum and anchored at 1280 Ma gives an approximate upper intercept age for the inherited component of 1740±32 Ma, which is only accurate if it is mantled by 1280 Ma zircon. The age of the inherited component is consistent with derivation from Tomiko supracrustal rocks.

The origin of this rock is unclear. It is dike-like in form and is not a typical intrusion breccia. On the other hand, geochemically, it is similar to other felsic intrusive rocks in the area, in particular, unit 23. The geochronology results, although equivocal, would indicate that the granodioritic matrix to the sample is Geon 12 in age. Field relationships indicate that the breccia is younger than leucosome development in the

Photo 16. Diatreme-like breccia exposed on Highway 63 (UTM NAD83, Zone 17, 641228E, 5150937N). Hammer handle is 30 cm long.

adjacent host metasedimentary host rocks, suggesting that migmatization either occurred prior to circa 1270 Ma, or that it occurred at 1040 Ma, but that the breccia body did not undergo partial melting at that time. Regardless, the non-alkalic geochemical signature of the breccia would seem to indicate that it is not related to any of the Neoproterozoic alkalic and carbonatitic intrusions present in and around Lake Nipissing.

Lamprophyre Dikes (unit 24b)

Rocks of this unit have not been observed by the author, but have been reported by Marmont (2002), who identified 2 lamprophyre dikes in Parkman Township (*see* Map P.2846).

GRENVILLE DIABASE SWARM DIKES (UNIT 25)

Two west-northwest-trending diabase dikes are observed on the regional aeromagnetic maps (Ontario Geological Survey 1991a, 1991b) in Butler and French townships. The dikes extend for a strike-length of over 20 km, but do not crop out (Lumbers 1971c). These dikes are assigned to the Grenville dike swarm on the basis of their lateral continuity, which suggests that they postdate the Grenville Orogeny. The Grenville dike swarm has an age of 586±4 Ma (Kamo, Krogh and Kumarapeli 1995).

A 15 cm wide, vertical dike with well-developed chill margins that cuts gneissic granite in Parkman Township (station 03RME-0119, UTM 630419E, 5186891N) is tentatively assigned to the Grenville dike swarm, in part because of its high magnetic susceptibility (average 89.5). In contrast, Sudbury diabase dikes in the Grenville Province near Sudbury generally have low to moderate magnetic susceptibility (0.9 to 30), with moderate magnetic susceptibility only observed in the largest (>50 m wide) and least metamorphosed dikes (Easton 2002b).

PHANEROZOIC

Cenozoic

QUATERNARY

Geology

The Quaternary geology of the area has been described by Gartner (1980). In areas where bedrock exposures dominate, surficial deposits consist of a thin veneer of till. The northern and central parts of the area are covered by a variety of glaciofluvial deposits. A large hummocky moraine and kame deposit, the McConnell Lake Moraine, occurs along the boundary between McAuslan and Wyse townships. Swamp and organic deposits are also common throughout the study area.

The study area was occupied by the Labrador sector of the Laurentide Ice sheet during the Wisconsin Episode of the Pleistocene Epoch (Barnett 1992). In general, the ice sheet advanced south to southwest across the study area. On the basis of glacial striae orientations in the Timiskaming region, it has been proposed that 3 different stages of ice flow affected the Timiskaming region (Veillette 1986). Only 2 of these ice flow directions are observed in the study area. The older of these, oriented south-southwest (180 to 220°) is related to the early stages of deglaciation, subsequently changing direction to the southeast (130 to 170°) and shaping the present landscape (Veillette 1986).

The main carriers of glacial debris were the 2 oldest ice flows (Veillette 1986) and, as a consequence, most of the surficial deposits in the study area are thought to have been deposited primarily during the latter part of the Wisconsin Episode (Reid 2002). Advance of glacial ice across the area first deposited a discontinuous veneer of undifferentiated, sandy to silty till, with a general lack of carbonate, over bedrock (Gartner 1980). The till is poorly sorted, unstratified, and has a sandy to silty matrix and a high content of pebbles, cobbles and boulders that are mostly locally derived (Reid 2002).

During deglaciation, the receding ice front deposited several east-northeast-trending moraines across northeastern Ontario and northwestern Quebec, including the McConnell Lake Moraine. As the ice front receded to the north, meltwaters deposited outwash sand and gravel throughout the map area. The most extensive deposits of outwash sand are found in McAuslan, LaSalle and Garrow townships.

During deglaciation, a large glacial lake formed in the area of the current Lake Nipissing basin. The early history of this lake is recorded by raised beaches and sand terraces preserved at elevations of 215 to 380 m above seal level (Lumbers 1971c). Although Boissonneau (1968) suggested that the southern half of the study area may have been temporarily inundated by glacial Lake Nipissing, Gartner (1980) noted that the only record of this event is found in a small deposit of lacustrine silt in Field Township, outside of the study area. Glacial Lake Nipissing drained along the Mattawa Valley to the Ottawa Valley.

Weathering of Bedrock

Lumbers (1971c) was the first to report the presence of highly weathered bedrock outcrops in the central part of the study area. Exposures of such weathered outcrops are particularly abundant in the area of the junction between highways 63 and 533. Lumbers (1971c) noted that the weathering was older than the development of glacial Lake Nipissing, and suggested that the weathering could be preglacial, because many of the weathered outcrops occur in low drift covered hills on both north- and south-facing slopes. The preservation of these outcrops was attributed by Lumbers (1971c) to the mantling of the outcrops by thick drift during the initial stages of glaciation.

Easton (2003a) noted that weathering was particularly intense in the area around the Jocko pluton. Not only were the Jocko pluton and related satellite intrusions highly friable, locally developing thick saprolite mantles, but that vermiculite occurrences in the area, developed in weathered zones in amphibolite and calc-silicate gneiss interlayered with felsite of the metasedimentary sequence, all occurred within 1 km of the eastern margin of the Jocko pluton. He attributed this spatial relationship to indicate fluid movement and alteration in the country rocks during pluton emplacement. This pre-conditioning then left these rocks more susceptible to intense weathering sometime after the Grenville Orogeny.

Modern Alluvium Survey Results

Most of the study area was covered by a modern alluvium sampling survey of the Mattawa–Cobalt corridor conducted by the Ontario Geological Survey (Allen 2001; Reid 2002), to which the reader is referred for details. The purpose of this section is to relate specific observations made during that study to the bedrock geology of the area, especially with respect to metamorphic and sulphide minerals such as garnet, kyanite, chalcopyrite and pyrite. Most of these minerals are classified as metamorphic/magmatic massive sulphide indicator minerals (MMSIM®[1]), which Reid (2002) examined as a group. In the analysis below, the individual minerals are examined separately.

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[1] MMSIM is a registered trademark of Overburden Drilling Management Limited, Nepean Ontario

Table 7. Summary of modern alluvium results of Reid (2002) in the study area in terms of metamorphic and sulphide minerals. UTM co-ordinates for all samples are provided in Reid (2002).

Sample	Location	Minerals	Comment
01JRSG-007	South end, Spring Lake	~1500 grains pyrite	Related to iron formation to the north?
01JRMA-014*	West-central Phelps Township	10 sodic Cr-diopside grains	In migmatitic gneiss terrain, kimberlite?
01JRMA-029*	Northern Phelps Township	20 gold grains, all reshaped	Near major NW-trending fault
01JRMA-112	Western Mulock Township, south of Valin Lake	22 grains chalcopyrite, ~20 grains pyrite	Sulphides in Archean basement rocks?
01JRMA-241*	Eddy–Butler townships boundary	22 grains chalcopyrite, ~2000 grains pyrite, 85% kyanite	May reflect unknown, buried occurrence of kyanite and sulphide-bearing rocks, 1 km due east of Eddy Lake chalcopyrite occurrence
01JRMA-042*	South of Timber Lake, near Crooked Lake	15% kyanite	Probably reflects derivation from kyanite occurrence at Crocan Lake
01JRMA-078*	Near Phelps–Olrig township boundary	60% kyanite	Probably reflects derivation from local kyanite occurrences, known occurrences 1 km to west and 1 km to east of sample site
01JRMA-013*	Southern Olrig Township	50% kyanite	South of 01JRMA-078. May reflect derivation from same source
01JRMA-077*	Central Olrig Township, northeast of Perron Lake	80% kyanite, ~300 grains pyrite	In kyanite-bearing belt, may reflect derivation from unknown occurrence
01JRMA-106*	Olrig Township, south of Perron Lake	75% kyanite	In kyanite-bearing belt, may reflect derivation from unknown occurrence
01JRMA-120*	Southern Olrig Township	50% kyanite	In kyanite-bearing belt, may reflect derivation from unknown occurrence
Many samples	Southern part of study area	Mn-epidote, kyanite, Cr-diopside	Diagnostic of area affected by M_3 metamorphism
01JRMA-098*	Just outside study area, by La Salle Lakes, Lasalle Township	17 gold grains, all reshaped	Distant transport?
01JRMA-236*	Just outside study area, west of Sucker Lake, Lasalle Township	7 grains chalcopyrite, ~450 grains pyrite, 15% staurolite	South of 01JRMA-236. Sulphides from Archean basement rocks?
01JRMA-126*	Highway 63, Jocko River	1 gahnite grain, 51 KIM chromite grains	Within 1 to 2 km of known Cr-bearing hornblendite bodies
01JRMA-115	Ottawa River, Mattawan Township	90% kyanite	Probably reflects derivation from kyanite occurrences in Crocan Lake area
01JRMA-134*	Ottawa River, Parkman Township	30 gold grains, mostly reshaped	171 total KIM grains, distant transport?
01JRMA-135*	Ottawa River, Parkman Township	32 gold grains, mostly reshaped	151 total KIM grains, distant transport?

Abbreviations: KIM = kimberlite indicator mineral. **Note:** Asterisk indicates sample site shown on Maps P.2846 or P.2847.

Results are summarized in Table 7. In addition, the samples listed in Table 7 are shown on Maps P.2846 and P.2847. Samples located near the Ottawa River are more difficult to interpret, or to tie to local sources, as they may have undergone greater transport distances than other samples. Other samples, such as 01JRMA-0078 occur in areas of known kyanite occurrences, and likely reflect derivation from local sources, as summarized in Table 7. It is possible that this is also the case for samples 01JRMA-077, 01JRMA-106, and 01JRMA-120, but they could also reflect an unknown kyanite source located somewhere to the northeast in the area between Parks and Sand lakes, which is difficult to access. This could be a southward continuation of the kyanite-bearing rocks exposed in the Francis Lake to Dillow Lakes area.

Most of the samples recording high kyanite contents occur south of the M_3 metamorphic front. In part, this could be an effect of the dominant glacial transport directions from the north and northeast; however, it could also be due to the fact that kyanite in the rocks affected by the M_3 event is more easily liberated. If the latter, then the modern alluvium survey sample results could be biased in terms of identifying M_3 metamorphic kyanite relative to M_2 metamorphic kyanite occurrences. This could be significant, as M_2 kyanite is of greater economic interest. This question could be easily addressed, as M_2 kyanite is blue, and M_3 kyanite is pale green; unfortunately, kyanite colour was not reported for the modern alluvium samples.

Manganese-epidote is found in many of the kyanite-bearing samples (e.g., 01JRMA-077, 01JRMA-078, 01JRMA-106), which is probably derived from calc-silicate units associated with the kyanite-bearing rocks. Mn-epidote is most abundant in the area subjected to M_3 metamorphism.

Sample 01JRMA-241, south of Little Jocko Lake on the Butler–Eddy townships boundary, is significant, as it may indicate a continuation of the kyanite- and sulphide-bearing rocks typical of the Timber Lake–Crocan Lake further to the north, and of greater thickness, than is indicated on previous geological maps in the area.

As noted by Reid (2002), chromian diopside (Cr-diopside) grains are the dominant kimberlite-indicator mineral in the Grenville Province south of Highway 63. Because Cr-diopside is very susceptible to weathering (Reid 2002), the widespread distribution and abundance of Cr-diopside grains in this area suggest that the grains are likely derived locally from rocks that formed during either of the M_2 or M_3 metamorphic events in this part of the study area, rather than from kimberlitic magmas. Diopside is a common mineral species in calc-silicate rocks in this part of the study area (Moore 1976), but no compositional data exist for diopside in these rocks. The single exception to the above is sample 01JRMA-014, located in an area underlain by migmatitic Tomiko supracrustal rocks north of Highway 63. As noted by Reid (2002), it contains Cr-diopside grains that are more sodic than from any of the other sampled sites in the study area and, thus, it could indicate a nearby kimberlitic source.

The zinc spinel, gahnite ($ZnAl_2O_4$), is commonly used as an indicator mineral for base metal mineralization. All gahnite grains recovered that were chemically analyzed by Reid (2002) are zinc enriched and MgO depleted—chemical features of gahnite grains formed with rare element pegmatites or peraluminous granites. Only 7 samples from the study area contained gahnite grains. Two samples along the Ottawa River may not reflect local derivation and, thus, are difficult to interpret. Two sample sites near Mattawa likely reflect derivation from pegmatite found in Bonfield domain. Only 2 samples occur in the area underlain by the Tomiko supracrustal rocks. One is near Big McDougal Lake (01JRMA-097), and could be related to a nearby granite gneiss intrusion (unit 14). The other occurs near Highway 63 on the Jocko River, on the north flank of the Jocko pluton (unit 15), and could be related to this intrusion. No gahnite grains occur in the samples rich in pyrite and chalcopyrite grains found in proximity to the sulphide-bearing (unit 12) Tomiko supracrustal rocks (e.g., sample 01JRMA-241). There is no indication that any of the gahnite occurrences in the study area are related to metamorphosed volcanogenic massive sulphide occurrences, contrary to the conclusion reached by Reid (2002, p.66).

Sample 01JRMA-112 occurs in Mulock Township, south of Valin Lake, and may reflect minor sulphide occurrences in poorly exposed Archean heterogeneous gneisses in the area, similar to those shown by Lumbers (1971b) northwest of Moose Lake in Stewart Township.

Sample site 01JRMA-126, which contains a high proportion of chromite grains (Reid 2002) is located within 1 to 2 km of hornblendite samples (03RME-0294 and 03RME-0299), which both contain over 2200 ppm Cr; consequently, the chromite grains may be locally derived, and of non-kimberlitic origin.

STRATIGRAPHY

Moore (1976) outlined a stratigraphic sequence in southeastern Tomiko terrane (Figure 3). This study confirms many aspects of this earlier work, most notably the identification of metaconglomerate in the Cahill Lake area, and the correlation of the supracrustal rocks between the Timber Lake and Cahill Lake area. Moore (1976) proposed that the Antoine gneiss overlies the metasedimentary sequence; however, this unit actually consists of several rock types, including parts of the “basement” complex, as well as plagioclase-rich gneisses interlayered with the supracrustal rocks. Thus, the Antoine gneiss has a more complex stratigraphic relationship with the supracrustal rocks than envisaged by Moore (1976).

Stratigraphic analysis is most easily accomplished in northeastern Tomiko terrane, where M_1 dominates, but becomes increasingly difficult to the southeast as metamorphic grade and fold complexity increases. North of Highway 63, cross-bedding and grading, particularly in the quartz arenite units, provides some control on facing direction. Figure 3 shows some of the regional variation that is present in Tomiko terrane, and is based on stratigraphic sections from Parkman and Clarkson townships and Timber Lake. In addition, Figure 3 shows a revised interpretation of the stratigraphic column proposed by Moore (1976) for the Timber and Cahill Lake areas.

Important features to note in Figure 3 are as follows:

1. Quartz arenite occurs both near the base and the top of the succession. The lower quartz arenite units are thin to medium bedded, are interlayered with calc-silicate rocks, and appear to be no more than a few hundred metres thick. In contrast, the upper quartz arenite units are medium to thick bedded, locally contain quartz pebble and cobble horizons, and may be over 500 m thick. The upper quartz arenite unit appears to thin to the south, but this may reflect preservation, rather than a true facies change.

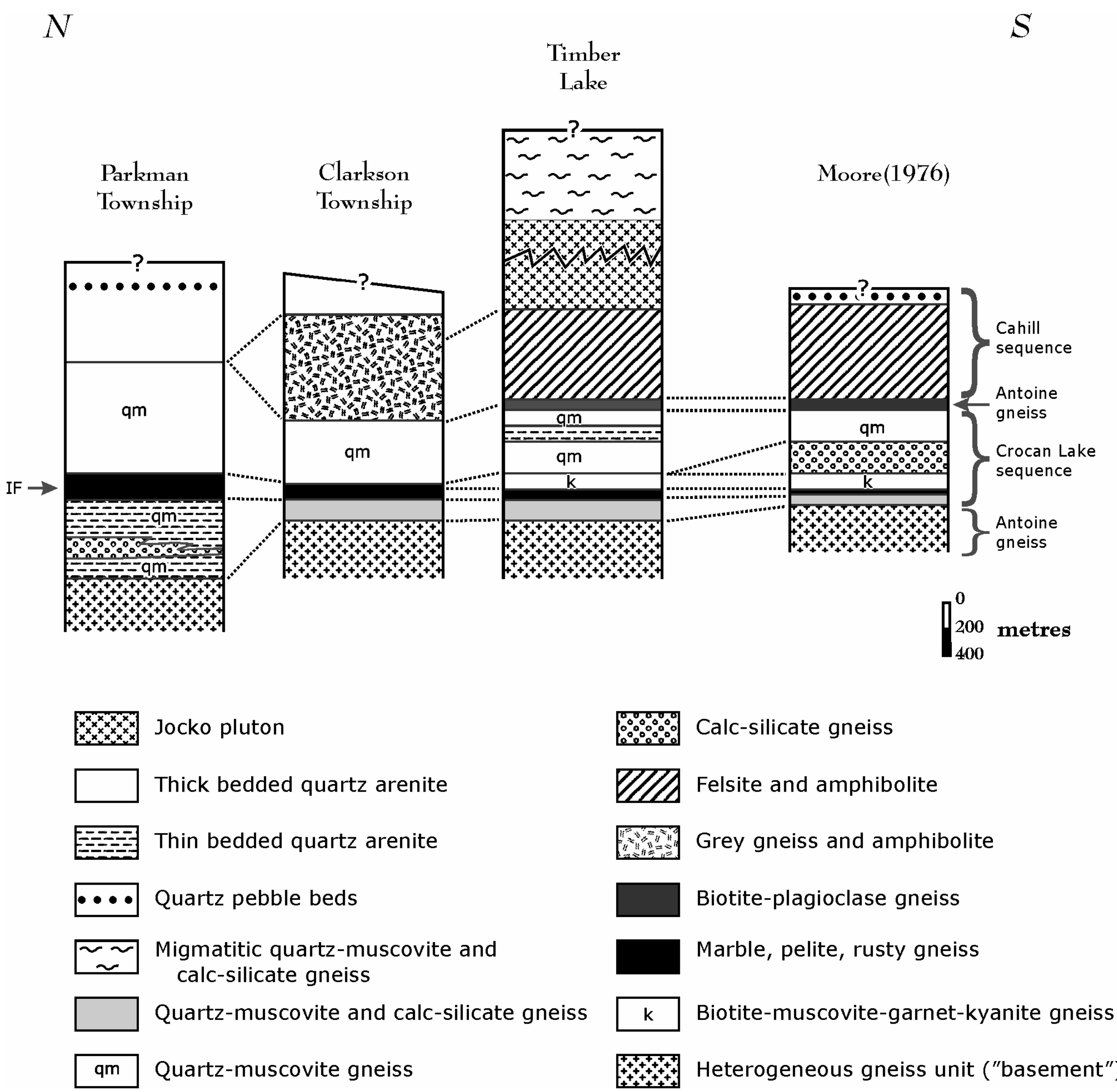

Figure 3. Stratigraphic sections from north to south across Tomiko terrane. A revised interpretation of the section of Moore (1976) is shown on the right-hand side of the diagram, linking the Timber Lake and Cahill Lake areas.

2. Possible metavolcanic rocks and related sills first appear north of the Pipeline shear zone, and are mainly dacitic. In the Timber Lake area, possible metavolcanic and related intrusive rocks are bimodal, consisting of felsite and amphibolite, and appear to be of greater thickness.
3. Although calc-silicate rocks occur at several places in the succession, they appear to be most common near the base. Generally, a thin unit of quartz-muscovite rock or quartz arenite is present immediately adjacent to the contact with rocks of the heterogeneous gneiss unit.
4. The sequence of marble, iron formation, sulphide-rich schist and metapelite (units 5 to 8) appears to represent a marker horizon, at least north of Highway 63, and appears to be restricted to the lower part of the section. In Figure 3, it is assumed that the sulphide-rich gneisses and biotite-garnet-kyanite rocks (unit 8) in the Timber Lake area are equivalent to this horizon, an assumption that is generally consistent with the overall stratigraphic section near Timber Lake. If this assumption is incorrect, then linkage between the stratigraphy north of Highway 63 and in the Timber Lake area is problematic.

   As discussed in "Iron Formation (unit 7)", if the marble, iron formation and sulphide-rich gneisses indeed form a single stratigraphic unit, then a north-to-south facies change might be present within this unit. From carbonate- and oxide-facies iron formation in the north, to sulphide- and carbonate-facies in the centre, and finally to sulphide- and silicate-facies in the Timber Lake area. This facies change could be indicative of deepening water and/or anoxic conditions to the south.
5. In all 3 areas, rocks of the heterogeneous gneiss unit appear to underlie the supracrustal rocks. The contact between the supracrustal rocks and the heterogeneous gneiss unit has not been observed in the field, but there is no evidence such as the presence of conglomerates or weathering of the underlying gneisses to indicate that it is an unconformity.

STRUCTURE

As illustrated in Figure 4, eastern Tomiko terrane is cut by at least 4 shear zones, trending 50 to 60°, located roughly 8 to 12 km apart. For the purpose of clarity, minor offsets of the shear zones by faults related to the Ottawa–Timiskaming graben are not shown in Figure 4. A variety of physiographic and geological changes occur across these shear zones as illustrated in Figure 4. Physiographic changes include a sudden increase in topography and outcrop abundance on the hanging-wall side of the shear zones, as well as abrupt changes in the direction of major streams and rivers along the trace of the shear zones. In addition, the shear zones are generally marked by topographic lows; it is probably no coincidence that the location of a natural gas pipeline in the area closely parallels the trace of one of these zones. Where exposed, the shear zones consist of porphyroclastic or straight gneisses, or both.

Geological changes across the shear zones are indicated in Figure 4, and include changes in metamorphism (*see* "Metamorphism"), fold interference style, and orientation of major geological units (e.g., Jocko pluton, *see* Figure 4). The shear zones parallel the orientation of the Grenville Front, and appear to affect all major Precambrian rock units in the terrane. It is likely that these are Grenville Front parallel thrust faults that have exhumed progressively deeper structural levels to the south. If so, then the shear zones likely formed between 1040 and 990 Ma, during the development of the Grenville Front tectonic zone (Carr et al. 2000).

Due to thick drift, it has not been possible to ascertain if the contact between possible basement rocks and the metasedimentary gneiss package—characteristic of Tomiko terrane along Opimika Creek—is an unconformity, or if it is a shear zone that parallels Opimika Creek (*see* Figure 4).

Some of the north-northwest-trending and northeast-trending faults shown on Map P.2847 appear offset from the 590 Ma Grenville Swarm dikes. If these dikes are truly offset, as opposed to simply showing some *en échelon* emplacement pattern, then some faulting is younger than these dikes, and is most likely related to movement along the Ottawa–Timiskaming graben system in the Neoproterozoic and/or the Jurassic.

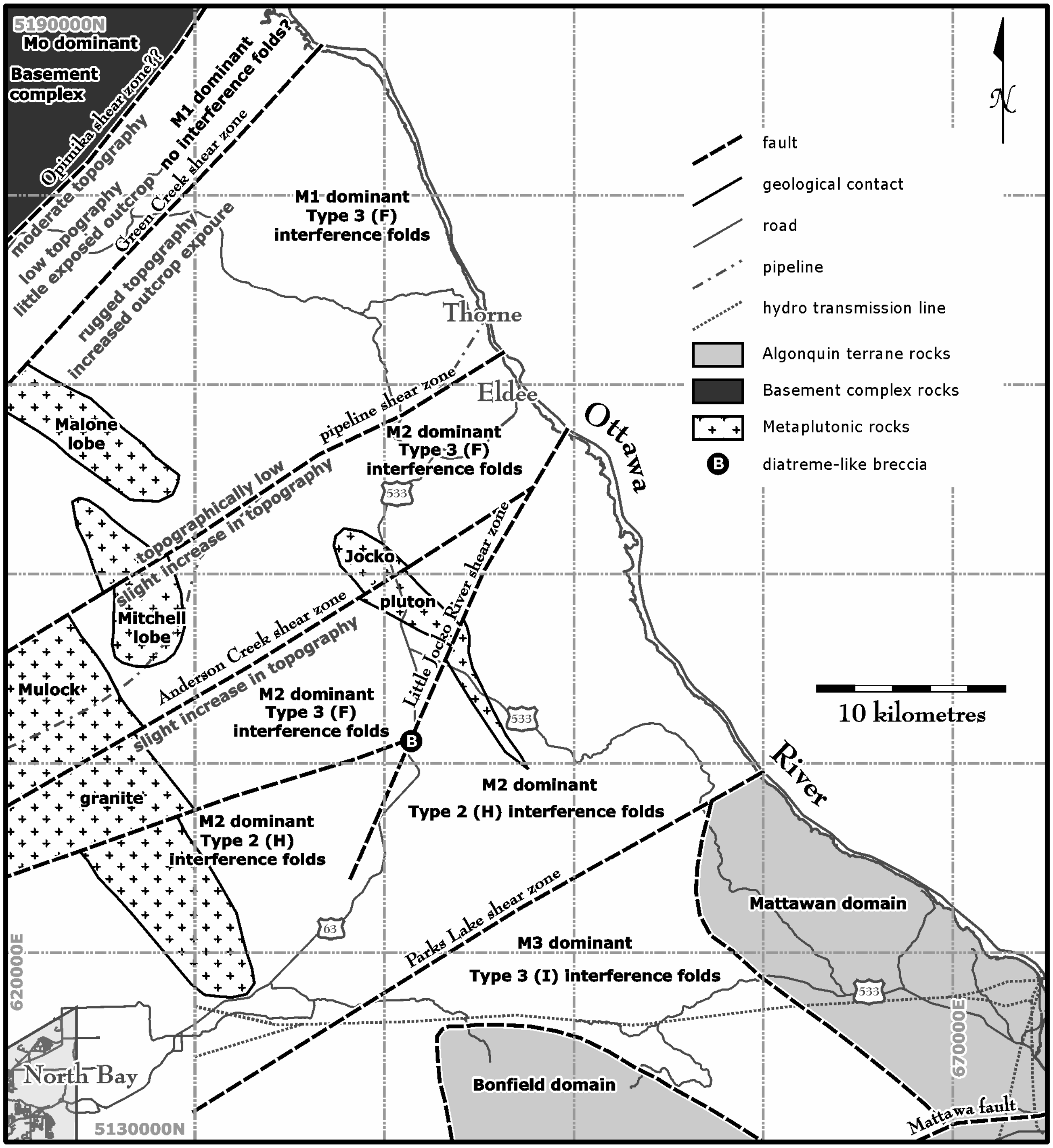

Figure 4. Sketch map showing location of major shear zones in eastern Tomiko terrane, as well as the geological and physiographic changes across the zones. Slight offsets of the shear zones by Ottawa graben faults are not shown for clarity. Pluton contacts simplified from Figure 2. Fold interference types from Ramsay and Huber (1987, p. 484).

METAMORPHISM

Both the intensity and spatial distribution of several metamorphic events play a critical role both in the appearance of the major rock units within the Tomiko terrane (compare Photos 9a and 9b) and the ability to perform stratigraphic analysis. In brief, the best preserved and least deformed rocks are located northeast of Highway 63.

At least 4 regional metamorphic events are present in the area, as summarized in Table 8. M_0 is restricted to the heterogeneous gneisses that may represent basement to the terrane, and apart from the fact that partial melting occurred, there are no constraints on the pressure–temperature (*P–T*) conditions of this event. M_1 is best preserved in the northeastern part of Tomiko terrane, and consists of early-formed kyanite or sillimanite that has been largely replaced by white mica that was formed during M_2. Early formed leucosome in rocks of the metasedimentary sequence may also have developed during M_1.

M_2 is manifested by the widespread development of abundant (25 to 40% of the rock) partial melt pods and layers in quartzofeldspathic gneisses of the metasedimentary sequence (*see* Photo 9b), and late melt (~10%) within amphibolite that is interlayered with the metasedimentary sequences. It is also likely that the muscovite-biotite-garnet-kyanite gneisses in the Timber Lake area developed during M_2.

M_3 is represented by the replacement of granitic melt pods formed during M_2 by pale green kyanite and quartz assemblages (Photo 17). Other effects of M_3 are the replacement of early formed blue kyanite by pale green kyanite; breakdown of muscovite to form kyanite and potassium feldspar; and the development of kyanite within garnet amphibolite interlayered with the metasedimentary gneisses. Furthermore, Moore (1976) observed that the muscovite-out reaction had occurred in samples collected south of Highway 533, although he could not locate the isograd precisely. It is possible that the muscovite-out isograd may coincide closely with the change in kyanite composition.

M_3 may be as much a metasomatic replacement event as a regional metamorphic episode. It is also possible that M_2 and M_3 might represent a continuous event, as both events are fluid rich, and the intensity of both events increase to the southeast. It is possible that M_2 and M_3 are related to the emplacement of the Bonfield and Mattawan domains atop Tomiko terrane and the initiation of the Allochthon Boundary Thrust. As shown in Figure 4, different fold interference styles are also associated with each of M_1, M_2 and M_3.

Gresens (1971) described kyanite-quartz segregations from New Mexico that are hosted in a Precambrian metavolcanic and metasedimentary sequence lithologically similar to that preserved in the southeastern Tomiko terrane. Gresens (1971) suggested that the segregations formed by metasomatic reaction between the metarhyolite host rocks and acidic fluids transported along shear zones, with the primary reaction being

$$\text{potassium feldspar} + H^+ = \text{kyanite} + \text{quartz} + H_2O + K^+$$

with a secondary reaction

$$\text{kyanite} + \text{quartz} + H_2O + K^+ = \text{muscovite} + H^+$$

occurring as a result of increasing potassium in the fluid with increased leaching. As long as the initial fluid was highly acidic (i.e., ~5% HCl), fluid volumes necessary for the process were reasonable. Gresens (1971) likened this fluid to a high temperature equivalent of an acidic hydrothermal fluid. The process suggested by Gresens (1971) is a likely explanation for the development of the segregations in Tomiko terrane, and may also explain the origin of the kyanite rocks in the Timber Lake area (*see* discussion in "Kyanite"). The presence of acidic fluids late in the geological evolution of Tomiko terrane has implications for mineralization, as discussed later under "Mineral Potential".

Table 8. Summary of major metamorphic events present in Tomiko terrane.

Event	Rock Unit	Description and Estimated *P-T* Conditions	Where Dominant and Inferred Age	Comment
M_3	Muscovitic and quartzitic gneisses, calc-silicate and mafic gneisses	Replacement of M_2 leucosome by kyanite-quartz (*see* Photo 17), development of kyanite in some garnet amphibolite units. Bathozone 6. >640°C and >7 kbar.	South and west of Highway 533. Between 1047 and 995 Ma?	M_2 muscovite locally breaks down forming kyanite-potassium feldspar, related to metasomatic fluids?
M_2	Muscovitic and quartzitic gneisses, calc-silicate and mafic gneisses	Development of abundant (>25% in metasedimentary gneisses, *see* Photo 9b) granitic leucosome and muscovite. Bathozone 5 or 6, <640°C but >5 kbar. Moore (1976) estimated >8.5 kbar and ~725°C. Anovitz and Essene (1990) estimated 8.6–9.3 kbar and >600°C.	Southeast of Highway 63, south and west of Highway 533. Dated at 1047±3 Ma (Kamo 2005).	Leucosome is commonly pod-like
M_1	Muscovitic and quartzitic gneisses (*see* Photo 9a)	Development of kyanite or sillimanite in metasedimentary gneisses. Unknown, but likely 600–700°C and >5 kbar. Anovitz and Essene (1990) estimated >6.6 kbar and <760°C.	Northeast of Highway 63. Between 1250 and 1685 Ma?	Poorly preserved, as early formed minerals are partly or wholly replaced by white mica, minor partial melting locally, early leucosome is thin (<3 cm thick), layer parallel?
M_0	Heterogeneous gneisses (structural or depositional basement)	Migmatization of ortho- and paragneisses. Unknown, other than that temperatures were high enough for partial melting to occur.	Restricted to exposures of basement in terrane. Archean or Paleoproterozoic.	

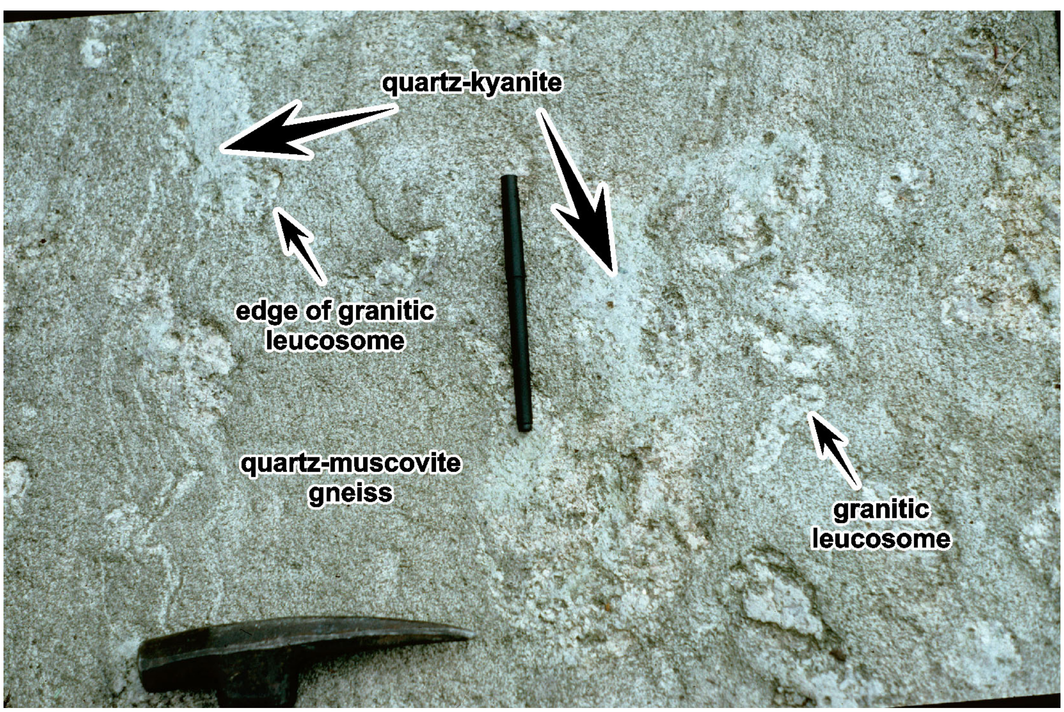

Photo 17. Photograph showing partial replacement of a pod of granitic leucosome formed during M_2 in a quartzose gneiss by pale green kyanite and quartz formed during M_3. Outcrop on a logging road south of Timber Lake (UTM NAD83, Zone 17, 651330E, 5149095N). Pen is 13.5 cm long.

Timing of Metamorphism

A sample from a granitic leucosome from metasedimentary gneiss of unit 9b, from the same outcrop that Krogh (1989) analyzed for detrital zircons, was submitted for geochronology to the Jack Satterly Geochronology Laboratory at the University of Toronto (Kamo 2005). This granite leucosome presumably formed during M_2 regional metamorphism. Data for 4 single zircon analyses were obtained (Kamo 2005). Three of these give overlapping data that have a weighted mean $^{206}Pb/^{238}U$ age of 1040.6±1.6 Ma (MSWD=1.8) and a weighted mean $^{207}Pb/^{206}Pb$ age of 1047.3±3.4 Ma (MSWD=0.4). Thorium–uranium ratios are extremely low, which is typical for zircons crystallizing under metamorphic facies conditions. These 2 ages define the best minimum and maximum ages, respectively, for this pegmatite. Given that the 2 most precise data appear to have lost some lead (0.8% for both), the best estimate of the age is the weighted mean $^{207}Pb/^{206}Pb$ age (Kamo 2005). A fourth datum point gives distinctly older data and the zircon most probably contained an older core component, rather than being a discrete older grain, given its extensive discordance. A line that is calculated through all 4 points has an upper intercept age of 1716±62 Ma and a lower intercept age of 1034±5 Ma (76% probability of fit) (Kamo 2005). The lower intercept age is considered the least dependable age for the pegmatite because it may be biased toward a younger age by the smallest amount of lead loss in the crystals that formed in the pegmatite. The upper intercept age is similar to the 1687±20 Ma age Krogh (1989) reported from detrital grains from this same outcrop.

Geophysics

MAGNETIC SUSCEPTIBILITY DATA

Magnetic susceptibility measurements collected during this study are listed in Appendix 5, and summarized in Table 9. Measurements were collected using an Explorium® KT-9 magnetic susceptibility meter. Magnetic susceptibility is defined as the degree to which a substance can be magnetized and, in this case, is expressed as the ratio of the intensity of magnetization (*k*) to the ratio of the Earth's magnetic field to magnetic field induced by the susceptibility meter. The measurements (*k*) are expressed as 10^{-3} times the SI unit for susceptibility and are dimensionless. The minimum value that can be recorded by the meter is 0.01×10^{-3} SI units; the largest value is 999×10^{-3} SI units.

In general, observations from the study area are similar to those reported by Easton (2002a) from rock units in Angus and Flett townships, adjacent to the study area. Strongly recrystallized or gneissic rocks all exhibit relatively low and consistent measurements on the order of 0.01 to 0.9, with mafic rocks lying at the higher end of this range. The low magnetic character of all of these rocks, despite the wide variation in bulk rock composition, probably reflects the destruction of most primary magnetic minerals during regional metamorphism.

In contrast, the Mesoproterozoic felsic intrusive rocks show a considerable range of readings that can not be directly linked to any particular feature in the rock such as compositional layering or the presence of inclusions. Some outcrops or parts of outcrops are nonmagnetic in character (<0.9), but other parts regularly yield higher values, anywhere from 2 to 70. All of the intermediate to felsic intrusions that show this highly varied magnetic character have A-type geochemical signatures, and those intrusions that have been dated are all Geon 12 in age. There is some correlation with deformation, for example, the finer grained and more deformed phases of the Mulock granite regularly yield low values (<0.9), where better preserved, megacrystic parts of the body yield higher values (>5). Similarly, the late monzogranite intrusion south of Eldee has an average value of 20.7 at its core, but only 0.09 at its deformed margin.

Table 9. Summary of magnetic susceptibility characteristics of map units from the study area.

Map Unit	Magnetic Susceptibility (typical values per outcrop) ($\times 10^{-3}$ SI)	Interpretation
Heterogeneous gneiss (basement complex, units 1 and 2)	0.1 to 1.1	Magnetic minerals destroyed during metamorphism.
Orthopyroxene hornblendite (unit 3c)	7 to 16 and 0.43 to 0.57	Magnetic minerals variably destroyed during metamorphism.
Amphibolite (Tomiko terrane and Mattawan domain)	0.45 to 1.6	Magnetic minerals destroyed during metamorphism.
Tomiko supracrustal rocks (quartzites, feldspathic gneisses, felsite, calc-silicate gneisses)	0.6 to 1.2	Magnetic minerals destroyed during metamorphism.
Tomiko supracrustal rocks (iron formation)	5 to 234, average 15 to 30 for ferrosilite iron formation	Magnetic minerals mainly intact.
Amphibolite (Tomiko terrane)	0.45 to 1.6	Magnetic minerals destroyed during metamorphism.
Grey gneiss (unit 13) 1250±10 Ma	0.82 to 18.10, average 5 to 10	Magnetic minerals variably destroyed during metamorphism.
Granitic gneiss (unit 14)	1.2 to 15.5 and 0.10 to 0.8	Magnetic minerals variably destroyed during metamorphism and regional deformation.
Jocko pluton (unit 15) $1257^{+4}/_{-2}$ Ma	0.1 to 0.4 (green phase)	Magnetic minerals destroyed during metamorphism or metasomatism.
Mulock granite (unit 16) $1244^{+4}/_{-3}$ Ma	2 to 70 (least deformed), 0.10 to 0.20 (deformed)	Magnetic minerals variably destroyed during metamorphism and regional deformation.
Late monzonite intrusion (unit 22)	13 to 24 (by tower), 1.6 to 5.0 (typical), 0.05 to 0.21 (deformed)	Magnetic minerals mainly intact in core of body. Magnetic minerals destroyed by metamorphism and deformation along the margins of the body.
Breccia body (unit 24)	10 to 98 (matrix), 0.4 to 3.5 (mafic fragments)	Magnetic minerals mainly intact in the matrix. Magnetic minerals in fragments destroyed during metamorphism.

The only exception is the Jocko pluton, which has so far yielded only low values (<0.4). The Jocko pluton, however, is generally greenish coloured, and is highly friable, and it is possible that the low magnetic signature of this body reflects the combined effects of hydrothermal alteration and regional metamorphism. This correspondence between geochemical affinity and age suggests that the primary magnetic signature of the Geon 12 plutons was only partly reset during regional metamorphism, with the most intense recrystallization and loss of magnetic character occurring in areas of higher deformation and/or fluid flow. If this interpretation is correct, then it may provide a field method for distinguishing Geon 12 plutons from older intrusive rocks in the area, that is, Geon 12 plutons would be expected to yield a range of magnetic susceptibility readings, from 0.5 to 70.

Easton (2002a) noted the some gneissic granites in Flett and Angus townships showed a similar wide range in magnetic susceptibility readings. Consequently, it is possible that some of the rocks mapped as unit 6 on Map P.3452 (Easton 2002a) are Geon 12 intrusions.

There is no noticeable difference in magnetic susceptibility characteristics between amphibolites and felsic intrusive rocks from Tomiko terrane and those found in Mattawan and Bonfield domains.

AEROMAGNETIC DATA

The study area is covered by low resolution (1 km grid) aeromagnetic data (Ontario Geological Survey 1991a, 1991b; Geological Survey of Canada–Ontario Department of Mines 1965a, 1965b, 1965c, 1965d). Consequently, it is difficult to relate the aeromagnetic data to the geology. In part, this may reflect the lack of magnetic contrast between many of the major rock units, as seen in the magnetic susceptibility data. The aeromagnetic data indicates the presence of 2 subparallel, west-northwest-trending dikes in Butler and French townships, which can be traced for over 20 km along strike, but which have limited surface outcrop expression. The continuity of these dikes suggests that they belong to the Grenville diabase dike swarm, emplaced at circa 590 Ma (Kamo, Krogh and Kumarapeli 1995).

The vertical gradient aeromagnetic data (Ontario Geological Survey 1991b) shows a closer correspondence with geology. Areas underlain by either the Archean heterogeneous gneisses or the Mulock granite are characterized by broad, uniform patterns, whereas areas underlain by the Tomiko supracrustal rocks show more varied patterns and a wide range in magnetic intensity.

There is no clear difference in pattern between rocks of the Tomiko terrane and the Mattawan and Bonfield domains. This is consistent with the magnetic susceptibility data, which also did not indicate any significant differences between these terranes and domains.

GRAVITY DATA

The study area is covered by low resolution (1 to 2 km grid) gravity data (Gupta and Wadge 1980; Ontario Geological Survey 1991c). There are no significant anomalies in the study area, although there is a small gravity high over the iron formation unit in Parkman Township (Gupta and Wadge 1980). There is a general southeast decrease in Bouguer gravity values across the area, from –45 milligals near the Grenville Front tectonic zone to –70 milligals near Mattawa.

RADIOMETRIC DATA

The study area is covered by a low resolution (2 km grid) gamma-ray spectrometric survey (Ontario Geological Survey 1978a–g). Despite the low resolution of the survey, and the abundance of Quaternary cover in parts of the map area, some of the anomalies observed in the radiometric data can be directly related to specific geological features, as described below.

Potassium, Uranium and Thorium Highs

Intense potassium highs are located over a large area of bedrock exposure in Clarkson Township, associated with exposure of quartz arenites and feldspathic gneisses of the Tomiko supracrustal rocks. An intense potassium high is located over the late monzonite body located south of Eldee, which is well exposed and has moderate to high potassium and uranium contents (sample 03RME-0140, *see* Appendix 2). Uranium and thorium highs coincide with all of these potassium highs, but are more diffuse and cover broader areas. A broad, potassium–uranium–thorium high in French and Butler townships, trends east from Balsam Creek, west of Highway 63, to Timber Lake, and may be associated with an outcrop belt of highly migmatized (M_2) quartzites and feldspathic gneisses. There appears to be a decrease in potassium, uranium and thorium south of the M_3 metamorphic boundary, however, it is unclear if this reflects a change in bedrock concentrations, or variations in drift cover. Potassium, uranium and thorium are uniformly high over both the Bonfield and Mattawan domains, and this higher total gamma-ray signature appears to be a feature of these 2 domains. A moderate potassium high is located over the Malone lobe of the Mulock batholith.

Potassium, Uranium and Thorium Lows

Intense lows in all 3 elements are associated with areas underlain by rocks of the Archean basement complex (units 1 and 2). This includes an area of the basement complex exposed east and southeast of Timber Lake. The association between the basement complex and low radio-element values is consistent with the fact that these rocks are of mafic to intermediate composition, and have been subjected to high-grade metamorphism in the Archean, which would have resulted in the removal of heat-producing elements such as potassium, uranium and thorium. Mapping of the contact between the Archean gneisses and the Tomiko supracrustal rocks might be possible with high-resolution radiometric data.

Thorium Highs

An area of granite gneiss in Wyse Township located north of Big McDougal Lake is associated with a moderate to intense U/Th high. These granite gneisses have high thorium contents (>25 ppm, samples 03RME-0004 and 03RME-0040, *see* Appendix 2) compared to other granite units in the area (<15 ppm). The southern boundary of this high is somewhat subdued, likely due to thick drift. This area also corresponds to an area of elevated uranium contents recorded in lake sediments (Hornbrook and Friske 1989).

Uranium/Thorium Highs

For the most part, there is no clear association between the regional radiometric pattern and areas of thicker Quaternary cover. An exception to this observation might occur in McAuslan Township, where high U/Th ratios occur over an area underlain by a large outwash plain. The cause of this area of anomalous ratios is unknown.

Discussion and Synthesis

REGIONAL CORRELATION

An important question with respect to addressing the mineral potential of the Tomiko supracrustal rock package is whether or not it developed *in situ*, or if it is correlative with other neighbouring metasedimentary sequences present in the Canadian Shield? Prior to discussing the *in-situ* possibility, potential correlation with rocks of the Huronian Supergroup, the Frontenac terrane, the Baraboo interval, and the Mazatzal Orogen terrane are discussed below.

Are the Tomiko Supracrustal Rocks Correlative with the Paleoproterozoic Cobalt Group of the Huronian Supergroup?

The proximity (~20 km) of the supracrustal rocks of Tomiko terrane to exposed rocks of the Cobalt Group located immediately adjacent to the Grenville Front, as well as broad similarities in rock types, makes correlation with the Huronian Supergroup compelling. In such a correlation, the quartzose feldspathic gneisses would correspond to the Lorrain Formation; the metasiltstones, metapelites and some of the calc-silicate lenses would correspond to the Gordon Lake Formation; and the cleaner quartz arenites would represent the Bar River Formation. The iron formation present in Parkman Township might correspond to the middle member of the Gordon Lake Formation, which has a regional aeromagnetic expression (Card 1976).

The main argument against this correlation is that it does not fit with the available isotopic data. Neodymium–samarium model ages for the supracrustal rocks (Holmden and Dickin 1995) are all less than 2340 Ma, typically averaging 2000 Ma, whereas one would expect Huronian Supergroup rocks to yield Archean Nd/Sm model ages. There is little difference in Nd/Sm model ages for quartzose gneisses on either side of the migmatite front north and south of Highway 63 (Holmden and Dickin 1995), making it unlikely that metamorphism has greatly affected the Nd/Sm results. Although Krogh (1989) did not find Archean detrital grains within the quartzite sample he studied along Highway 533; Easton and Kamo (2004) found a few Archean detrital grains in the sample they studied. Both studies, however, found an abundance of Geon 16 grains, which effectively exclude correlation with the much older (>2210 Ma) Huronian Supergroup.

Are the Tomiko Supracrustal Rocks Correlative with Mesoproterozoic Metasedimentary Rocks of the Frontenac Terrane, Central Metasedimentary Belt?

It has been suggested that rocks of the Parry Sound terrane represent tectonically transported rocks derived from the Central Metasedimentary Belt. Thus, it is necessary to consider that the Tomiko supracrustal rocks might represent a tectonically transported sliver of Frontenac terrane rocks, which is the only sequence in the Central Metasedimentary Belt containing extensive amounts of quartz arenite (Carr et al. 2000). This correlation is considered unlikely, for the following reasons:

- the Tomiko metasedimentary gneiss package is cut by the Mulock granite, suggesting that the package existed prior to about 1250 Ma, some 90 million years before Frontenac terrane started interacting with Laurentia (Carr et al. 2000). In addition, plutonic rocks that are about 1250 Ma in age are not characteristic of Frontenac terrane;
- Nd/Sm model ages for the Tomiko supracrustal rock package are 400 to 500 million years older than ages from metasedimentary gneisses from the Frontenac terrane;
- none of the plutons in Tomiko terrane are characteristic of the Frontenac suite plutons of Frontenac terrane; and
- the presence of possible metavolcanic rocks, and abundant amphibolite associated with the quartz arenites of Tomiko terrane, is uncharacteristic of Frontenac terrane.

Are the Tomiko Supracrustal Rocks Correlative with Mesoproterozoic Rocks of the Shawanaga Domain, Central Gneiss Belt?

The Shawanaga domain along Georgian Bay consists of a large nappe formed of the metasupracrustal Sand Bay and metaplutonic Ojibway gneiss associations (Culshaw et al. 2004). The entire domain has been metamorphosed to upper amphibolite facies, at greater than 700°C and 10 to 12 kilobar. Deformation and high-grade polyphase metamorphism took place between about 1090 and 1050 Ma (Culshaw et al. 2004). Unlike the Parry Sound and Britt domains, there are no crosscutting mafic dikes in the Shawanaga domain, but there are pods of retrogressed mafic eclogites of uncertain age and 1170 to 1150 Ma coronitic metagabbros (Culshaw et al. 2004).

The layered rocks of the Sand Bay gneiss association include felsic supracrustal orthogneiss, amphibolite and metasedimentary rocks (Culshaw et al. 2004). Sand Bay metasedimentary rocks include quartzite, calc-silicate and semipelite. The semipelitic Dillon schist is a prominent marker unit that outlines the fold structure of the domain. Early Paleoproterozoic to circa 1400 Ma ages have been recorded from detrital zircons in a Sand Bay gneiss association quartzite (Culshaw et al. 2004). The Dillon schist, has yielded zircon grains ranging from 1900±23 Ma to 1362±35 Ma, giving a maximum depositional age for the Sand Bay gneiss association protoliths of circa 1360 Ma (Culshaw et al. 2004).

The felsic supracrustal orthogneisses are the most voluminous member. These are mostly pink, leucocratic, medium- to fine-grained equigranular migmatitic rocks interpreted as metarhyolites. Grey, more plagioclase-rich intervals are also common.

A geochemical study of the Sand Bay amphibolites and felsic orthogneisses suggested their protoliths were bimodal volcanic rocks. The major and trace element geochemistry of the Sand Bay amphibolites resembles modern continental tholeiites, showing no significant metamorphic disruption of diagnostic trace elements, for example, the high field strength elements. The Sand Bay amphibolites have a prominent negative Nb anomaly suggesting involvement of subduction-modified mantle in their genesis. High Th/La in the Sand Bay amphibolites compared to modern mid-ocean ridge basalts (MORB) indicate the possibility of minor crustal contamination. Sand Bay felsic orthogneisses have negative Eu, Ti and Nb anomalies compatible with a continental crustal or arc origin. The igneous protoliths may have originated in a continental environment undergoing active extension, perhaps a continental rift or continental arc-rift (back-arc or intra-arc) setting (Culshaw et al. 2004).

The Ojibway gneiss association is a 1466±11 Ma orthogneiss body of granodioritic-tonalitic composition with arc-type granitoid geochemistry (Culshaw et al. 2004). The sheet-like Shawanaga pluton lies along the lower boundary of the Shawanaga domain. It is a circa 1460 Ma body of megacrystic garnet-amphibole-bearing granodiorite-granite (Culshaw et al. 2004).

Although there are some broad lithological similarities between rocks of the Tomiko terrane and the Sand Bay gneiss association, the differences in age of the supracrustal units (<1360 Ma for Sand Bay gneiss, circa 1685 for Tomiko terrane), intrusive phases (Geon 14 for Ojibway gneiss association, Geon 12 for intrusive units in Tomiko terrane), and the fact that Shawanaga domain lies in the hanging wall of the Allochthon Boundary Thrust, whereas the Tomiko terrane lies within the footwall, would appear to preclude a correlation between the 2 supracrustal sequences. It may be that the lithological similarities between the Tomiko supracrustal rocks and the Sand Bay gneiss association may simply reflect a similar depositional and tectonic setting on the outboard margin of Laurentia.

Are the Tomiko Supracrustal Rocks Correlative with Paleoproterozoic Quartz Arenites of the Baraboo Interval?

The Baraboo and 6 other correlative red quartz arenites in the southern Lake Superior region (i.e., Wisconsin) were deposited between 1710 and 1630 Ma. Some of the quartz arenite sequences were affected by regional deformation and metamorphism at about 1630 Ma, as well as by a 1465 Ma potassium metasomatic event (Medaris et al. 2003). Some of the Baraboo quartz arenites were deposited on intermediate to felsic volcanic rocks and related high-level plutons that were emplaced at about 1765 Ma. Some of the quartz arenites are overlain by banded iron formation and black shale. The Baraboo and related quartz arenites may also be correlative with quartz arenites in the Athabasca and Thelon basins (Medaris et al. 2003), indicating widespread sedimentation across much of North America in the late Paleoproterozoic. Key features of the Baraboo and related quartz arenites, as well as the Athabasca basin quartz arenites, include the local presence of well-developed paleosols, a high-degree of supermaturity of the quartz arenites, and chemical index of alteration (CIA) values of 95 to 99. These 3 features have been interpreted to indicate that profound chemical weathering occurred across much of North America between 1750 and 1630 Ma (e.g., Medaris et al. 2003). The depositional environment has been interpreted to be in a fluviatile to shallow marine setting, possibly in a passive margin setting (Medaris et al. 2003 and references therein).

Correlation of the Tomiko quartz arenites and muscovite-rich rocks with the Baraboo and related quartz arenites is compelling. The Tomiko quartz arenites appear to be mature to supermature in character, and are associated with intermediate to felsic orthogneisses (metamorphosed volcanic and plutonic rocks?) and minor amounts of iron formation. One can argue that the kyanite-bearing and muscovite-rich gneisses in Tomiko terrane represent a combination of metamorphosed paleosols and potassium metasomatized quartz-rich sedimentary rocks, respectively. Indeed, Watts, Griffis and McOuat and Ontario Geological Survey (2002) suggested independently that metasomatism was probably instrumental in creating some of the more muscovite-rich rocks in the terrane. The U/Pb zircon age of 1687±20 Ma (Krogh 1989) is consistent with this correlation. Holmden and Dickin (1995) also suggested correlation of the Tomiko supracrustal rocks with the Baraboo quartz arenites, but on the basis of isotopic and tectonic arguments.

Are the Tomiko Supracrustal Rocks Correlative with Paleoproterozoic Rocks of the Mazatzal Orogen?

Rocks of the Mazatzal Orogen crop out in Arizona and New Mexico, where they constitute the Tonto Basin Supergroup and the Hondo Group, respectively. Both the Tonto Basin Supergroup and the Hondo Group consist mainly of quartz arenite with minor shale, siltstone and calc-silicate rocks, associated with felsic metavolcanic rocks (Robertson et al. 1993). Rocks of the Tonto Basin Supergroup were deposited between 1720 and 1700 Ma and rocks of the Hondo Group were deposited between 1700 and 1644 Ma (Robertson et al. 1993). Quartz arenites from the Hondo Group contain detrital zircons ranging in age from 1850 to 1700 Ma. The metasedimentary and metavolcanic rocks are thought to have been deposited outboard of the slightly older (1790 to 1710 Ma) Yavapai Orogen. It is worth noting that the combination of rapid sedimentation of shelf-type siliciclastic rocks in conjunction with felsic volcanism, as seen in the Mazatzal Orogen, has no direct analogue in the Phanerozoic.

The Hondo Group overlies a sequence of older greenstones, and consists of a thin basal unit of quartz pebble conglomerate, thicker than 1 km of quartz arenite that is capped by a sequence of muscovite schist and arenite, metarhyolite, phyllite and calc-silicate rocks (Robertson et al. 1993). A manganese-rich horizon, thought to be a possible paleosol, perhaps lateritic, occurs at the top of the greenstone sequence. Gresens (1971) suggested that some of the muscovite schists in the Hondo Group represented hydrothermally altered felsic volcanic rocks. The Tonto Basin Supergroup stratigraphy in Arizona is similar to that of the Hondo Group, but contains more felsic volcanic units, as well as some basalt horizons (Robertson et al. 1993). The Mazatzal supracrustal rocks are intruded by plutonic rocks of 1680 to 1650 Ma, similar in age to rocks of the Labrador batholith in the eastern Grenville Province in Labrador. The Mazatzal Orogen is also cut by Geon 14 plutons. The rock types, stratigraphy, thickness, alteration history and age of the Tonto Basin Supergroup and the Hondo Group is similar to that observed in the Tomiko supracrustal rocks, and provides a more compelling correlation than with the Baraboo quartz arenite, even though the Mazatzal rocks in New Mexico are now some 3500 km distant.

Williams et al. (2003) have suggested 2 peaks of rhyolite volcanism and quartzite sedimentation in the supracrustal sequences in the southwest United States, including the Hondo Group, one at circa 1695 Ma and the other at circa 1660 Ma. Williams et al. (2003) suggested that these sequences were deposited in syntectonic basins, related to local orogenic pulses. Furthermore, Southwick (2004) has suggested that the Baraboo quartzites are equivalents to the southwestern United States rhyolite-quartzite sequences. If Southwick is correct, then the Tomiko terrane rocks are correlative with both the Baraboo and Mazatzal quartzite sequences.

If correlation with the Mazatzal Orogen is valid, then it has the following implications.

1. Since the Tomiko supracrustal rocks are now in contact with likely Archean gneisses, rather than Paleoproterozoic metavolcanic rocks, it is likely that the Tomiko supracrustal rocks were

thrust northward onto Laurentia, and that the heterogeneous gneiss unit represents structural, not depositional, basement to the supracrustal rocks.

2. The iron formation unit in northern Tomiko terrane may be equivalent to the manganese-rich unit at the base of the Tonto Basin Supergroup and the Hondo Group, and may have served as the décollement surface along which northward-directed thrusting occurred.
3. The supracrustal rocks are likely dominated by Paleoproterozoic detritus that has no direct link to Laurentia. Deposition of the Tomiko supracrustal rocks likely occurred between 1700 and 1650 Ma.
4. Similar styles of mineralization and alteration may be present in the Tomiko supracrustal rocks and the Mazatzal supracrustal rocks. The implications of this are explored further in "Mineral Potential".

In summary, it is conceivable that the Tomiko supracrustal rocks represent a sliver of the Mazatzal Orogen, which, at one time, must have stretched from Arizona to Labrador.

An *In-Situ* Origin for the Tomiko Supracrustal Rocks?

A final possibility is simply that the Tomiko supracrustal rocks represent a unique package of rocks deposited during the Paleoproterozoic in what is now the North Bay area, and that it is not correlative with any other orogenic belt or sedimentary basin in the Canadian Shield. As such, the terrane would possess a unique environment with respect to mineralization, making it difficult to identify potential exploration commodities or targets on a comparative basis. In this discussion, it is worth bearing in mind that an equally large area of Tomiko supracrustal rocks also occurs east of the Ottawa River in Quebec.

Precise regional correlation is made difficult by 2 main unknown factors. First, are the Tomiko supracrustal rocks close to being in place (e.g., is there a basement–cover relationship with unit 1), or have they been transported from elsewhere onto the basement complex represented by unit 1? If the latter, then the origin of the Tomiko supracrustal rocks may never be resolved.

Second, still open for interpretation is the age of deposition of the Tomiko supracrustal rocks. The age of deposition is bracketed between 1687 Ma, the age of the youngest detrital zircon grains recovered from the quartz arenites within the Tomiko terrane, and circa 1250 Ma, the age of the many intermediate to felsic intrusive rocks present in Tomiko terrane. Two end member possibilities present themselves:

- Sedimentation (and volcanism?) occurred close to 1687 Ma, with subsequent plutonism (and M_1 metamorphism?) taking place during Geon 12.
- Alternatively, sedimentation (and volcanism?) occurred during Geon 12, in conjunction with emplacement of some of the earlier intrusive units (e.g., units 13 and 14), with some of the amphibolites and felsites of units 11 and 12 related to this intrusive activity. This would require that the sediments were derived from a Geon 16 source region, with no exposure to any sediments derived from the abundance of Geon 14 and Geon 13 rocks being emplaced into the southern margin of Laurentia during the Mesoproterozoic. This might be unlikely, but is not impossible.

In either scenario, M_2 and M_3 metamorphism occur at circa 1047 Ma, well after sedimentation and plutonism. The first possibility, that of Geon 16 deposition, allows for potential correlation with either the Baraboo or Mazatzal sequences. In contrast, Geon 12 deposition would represent an environment unique to Tomiko terrane.

SIGNIFICANCE OF GEON 12 MAGMATISM IN THE NORTHERN GRENVILLE PROVINCE OF ONTARIO

An unanticipated result of this study was the discovery of several more Geon 12 plutons within Tomiko terrane. Since 2000, there has been increasing evidence for the importance of a major bimodal magmatic event during Geon 12 in the northern part of the Ontario Grenville Province, particularly in the area between Highway 11 and the Ottawa River (e.g., Easton 2002a, Easton and Ketchum 2002). Table 10 and Figure 5 summarize the distribution of Geon 12 intrusions in the northern Ontario Grenville Province.

Geon 12 mafic magmatism in the northwestern Grenville Province is dominated by the Sudbury diabase dike swarm. Fahrig (1987) and Ernst and Buchan (2001) both related the Sudbury diabase dike swarm to the presence of a large mantle plume, possibly with an associated spreading centre, located southeast of Sudbury (*see* Figure 5). A difficulty with this model is the absence of any evidence within the Grenville Province for the presence of such a spreading centre during Geon 12 (e.g., younger sedimentary sequences, unusual fault patterns, deep crustal intrusions, etc.) even taking into account the effects of Grenville metamorphism and deformation. If such rocks were present, they would have to be buried beneath allochthonous rocks present within the Central Gneiss Belt. Furthermore, it is difficult to resolve a model involving continental rifting and formation of even a small ocean basin with the evidence for compressional tectonics within the Central Gneiss Belt of the Grenville Orogen in late Geon 12 and early Geon 11 time.

An alternative tectonic setting for the Sudbury dike swarm and the Flett Township mafic intrusions is an extensional rift (i.e., back-arc) basin in a continental-arc setting, similar to that in which the Columbia River Basalt Group was emplaced (Easton 2002a). Such an environment is more consistent with the inferred tectonic development of the southern Central Gneiss Belt, which envisages the presence of a continental-arc regime between 1480 and 1300 Ma (e.g., Carr et al. 2000). It is also consistent with the timing of mafic and felsic magmatism in the North Bay region (*see* Figure 5; *see* Table 1) between 1270 to 1225 Ma, which occurs subsequent to shutdown of the major period of arc magmatism. The apparent concentration of magmatism of Geon 12 age in the Tomiko terrane (*see* Figure 5) may indicate that the centre of this magmatic activity was centred somewhere in the vicinity of Mattawa. It is also likely that rocks of Geon 12 age may be more common in the northeastern Central Gneiss Belt in Ontario and western Quebec than has been previously recognized.

It is likely that the felsic plutons observed in the northwestern Grenville Province are the consequence of crustal melting related to mafic underplating associated with the mafic magmatism that generated the Sudbury diabase dike swarm. Such a model is consistent with the A-type chemistry from the Geon 12 felsic plutons in the area. In addition, Nd/Sm isotopic data from these plutons (Holmden and Dickin 1995) indicate significant amounts of crustal contamination in the Geon 12 plutons present in Tomiko terrane, again, consistent derivation by crustal melting. The greater abundance of Geon 12 plutons as one goes from west to east, from Sudbury to Mattawa, might suggest that the source of the mantle upwelling was centred somewhere in the Mattawa area, as indicated in Figure 5.

It is also possible to invoke a model involving a combination of back-arc spreading and an upwelling mantle plume for the Geon 12 magmatic activity in the Tomiko terrane (Easton 2002a). Such a model would result in the generation of mafic and felsic magmas in the lower crust, but would not necessarily lead to development of a spreading centre or a failed continental rift. Opplinger, Murphy and Brimhall (1997) have suggested such a model for the Columbia River Basalt Group. This model also relates the development of Carlin-type gold deposits in the region to the period of back-arc extension that occurs prior to the main period of plume associated flood basalt volcanism. If this model is in any way applicable to the Tomiko terrane, then alteration zones associated with large fracture systems located near

Geon 12 granitic plutons such as the Mulock granite batholith would be the favoured target in any gold exploration program. Given the proximity of the Geon 12 mafic magmatism to the Grenville Front, gold might also be expected along large fracture systems cutting Archean and Paleoproterozoic rocks in the adjacent Temagami greenstone belt and Cobalt plate.

Table 10. Summary of Geon 12 magmatism in the northwestern Grenville Province.

Name	Age (in Ma)	Source
Mafic Intrusions		
Sudbury diabase dike swarm	1238±4	Krogh et al. (1987)
Fleet Township intrusions	1238±2, 1235±2	Easton and Ketchum (2002); Easton (2002a)
Mercer anorthosite	1222±2	Prevec (1993)
St. Charles anorthosite	1206±36	Prevec (1993)
Felsic Intrusions (known)		
Breccia dike matrix	circa 1271	This study
Grey gneiss, Clarkson Township	1250±10	This study
Jocko pluton	1257 +4/–2	This study
Mulock granite	1244 +4/–3, 1250 +10/–6	Lumbers et al. (1991); Davidson and van Breemen (2001)
Powassan pluton	1270±3	Davidson and van Breemen (2001)
Red Pine Chute gneiss (Villedieu pluton, Quebec)	1247±47	Currie and van Breemen (1996)
West Bay pluton	circa 1235	Heaman *in* Davidson and van Breemen (2001)
Felsic Intrusions (probable)		
Bonfield pluton		This study, magnetic susceptibility
Eldee pluton		This study, geochemistry, magnetic susceptibility
McDougal pluton		This study, geochemistry, magnetic susceptibility

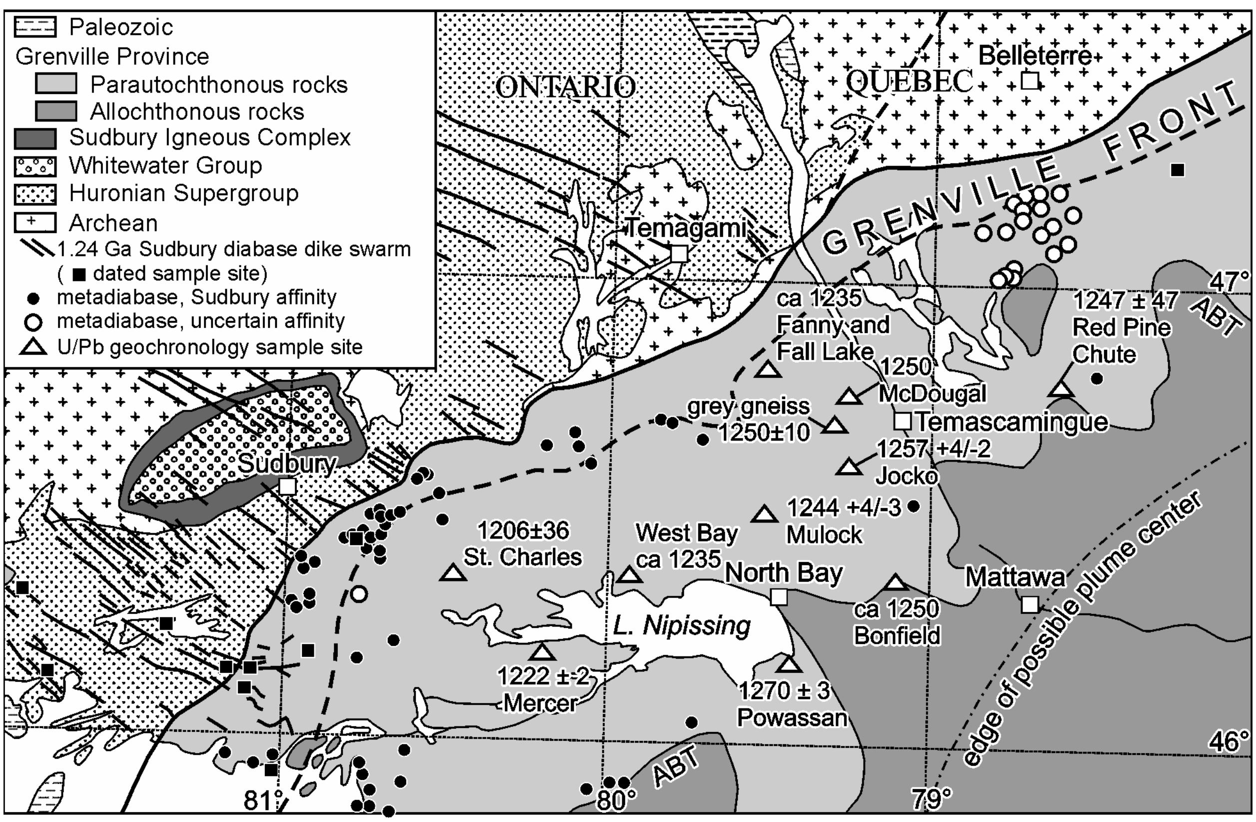

Figure 5. Map showing the distribution of Geon 12 rocks in the northwestern Grenville Province. Data shown in figure are listed in Table 10. Also shown is the location of the possible plume centre that may have been responsible for magmatism in the region at about 1270 to 1230 Ma. Figure *modified from* Ketchum and Davidson (2000).

Mineral Potential

REGIONAL METASOMATISM AND ITS EFFECT ON ROCK TYPES, STRATIGRAPHY AND MINERAL POTENTIAL

Previous workers (Hewitt 1952; Pearson 1959; Moore 1976; Vos, Smith and Stevenato 1981) have considered the biotite-garnet-kyanite gneisses in the Timber Lake area of eastern Tomiko terrane to be formed by metamorphism of pelitic rocks. Metapelitic rocks, however, are relatively uncommon in northeast Tomiko terrane; thus, their abundance and concentration in the Timber Lake area is difficult to explain stratigraphically. The similarity of the Tomiko supracrustal rock package to rocks in northern New Mexico described by Gresens (1971), however, suggests that consideration be given to the involvement of a hydrothermal or metasomatic process for the formation of the biotite-garnet-kyanite gneisses, most likely during M_2. Given the clear field evidence for the formation of kyanite during M_3 by replacement of granitic leucosome, possibly by hot, acidic fluids, a hydrothermal origin for biotite-garnet-kyanite gneisses in the Timber Lake area is less preposterous than it might otherwise seem.

Within the Hondo Group in New Mexico, Gresens (1971) described the development of muscovite-rich zones both in feldspathic metasedimentary rocks and metarhyolite related to fluids channelled along shear zones, as well as the local development of pegmatite pods where fluid flow was more intense. Several aspects of Tomiko terrane geology fit with Gresens' (1971) observations, notably the development of both muscovite-rich zones and coarse granitic sweats within the feldspathic gneisses, which are derived from rocks of similar bulk composition to those studied by Gresens (1971). In addition, in some parts of the study area, thin-bedded quartz arenite can be observed grading into quartz-muscovite rocks, and then into more muscovite and feldspar-rich gneiss. One explanation for this gradation is that it is related to increasing metasomatism of an original sequence of thin- to medium-bedded quartz arenite. Preliminary geochemical data suggest slight enrichment in the quartz-muscovite rocks of Be, Nb, W, Y, and Zr, in addition to Ba, Pb, Sr, Rb, and Th relative to the contents of these elements present in quartz arenite, metapelitic and calc-silicate units in the terrane. The enrichment in these elements are most easily explained by a metasomatic or hydrothermal process. Although the enrichments detected so far are minor, the fact that the several elements appear to be coupled with one another, and were observed in samples collected for rock unit characterization rather than assay, is significant.

Furthermore, the development of other unusual rock types in the Timber Lake area, for example the pyrrhotite gneiss unit, the development of sulphide-rich zones within the biotite-garnet-kyanite gneiss, the formation of kyanite-rich (>60 % kyanite) lenses and the almost complete replacement of biotite-garnet-kyanite gneiss by graphite along the biotite-garnet-kyanite gneiss contact, can all be related to a hydrothermal replacement process. In thin section, garnet within the biotite-garnet-kyanite unit is not zoned and lacks inclusion trails or inclusions of prograde metamorphic minerals such as staurolite, and there is no other evidence in thin section for an earlier metamorphic history in these rocks. This textural evidence suggests that the biotite-garnet-kyanite gneiss originated from a rock that formed after M_1. On the basis of the data collected so far, a hydrothermal model best explains these observations, although it is quite possible that hydrothermal alteration may have been concentrated within a zone or zones that had a metapelitic precursor. If a hydrothermal or metasomatic origin is correct, than it is likely that the distribution of the biotite-garnet-kyanite gneiss units and the pyrrhotite gneiss unit is not stratigraphically controlled, but may instead reflect the location of old shear zones or channelways.

BROKEN HILL-TYPE MINERALIZATION

Key Elements of the Geology of the Broken Hill Deposit

The Broken Hill lead-zinc-silver orebody is hosted by the Paleoproterozoic Willyama Supergroup and is located near the boundary between the states of New South Wales and Southern Australia (Figure 6). The Paleoproterozoic rocks are unconformably overlain by Neoproterozoic (Adelaidean) sedimentary and minor volcanic rocks. The Willyama Supergroup comprises lower amphibolite to hornblende granulite facies metamorphic rocks with minor post-metamorphic intrusions, and was deformed at least 3 times during the Olarian Orogeny (circa 1600 Ma) and again during the Delamerian Orogeny (circa 500 Ma) (Stevens, Gibson and Page 2000).

Siliciclastic metasedimentary and migmatitic rocks form the majority of the rocks in the Willyama Supergroup (Figure 7). Also present are substantial bodies of quartzofeldspathic gneiss, large and small pegmatite bodies, mafic gneisses (amphibolite and mafic granulite) and minor calc-silicate rocks, banded iron formations and quartz-gahnite, garnet-quartzite and garnetite “lode” rocks.

The Broken Hill lead-zinc-silver orebody, which has produced over 180 million tonnes of ore from 3 main mines since 1883, occurs near the top of the Broken Hill Group (*see* Figure 7). Many smaller orebodies of similar composition occur throughout the Broken Hill district, and all but a few are hosted in the Broken Hill Group (*see* Figure 7). In addition to the lead-zinc-silver Broken Hill-type deposits, several other deposit types are present, including copper and cobalt associated with iron formations, stratabound tungsten-base metal deposits, and various vein-type deposits (e.g., Stevens, Barnes and Forbes 1990).

Figure 7 outlines the main stratigraphic units of the Willyama Supergroup, along with the present age constraints on the succession (most are sensitive high-resolution ion microprobe (SHRIMP) U/Pb ages on zircon). Mineralization is restricted to the Broken Hill Group, particularly rocks of the Freyers metasediments proximal to the Hores gneiss. Basement to the Willyama Supergroup has yet to be recognized. The age range of the Willyama Supergroup is 1700 to 1680 Ma, this is younger than the previously suggested age of circa 1800 Ma. The key elements of Broken Hill geology, summarized from Stevens, Burton and Leyh (1998) and Stevens, Gibson and Page (2000) are outlined below in point form.

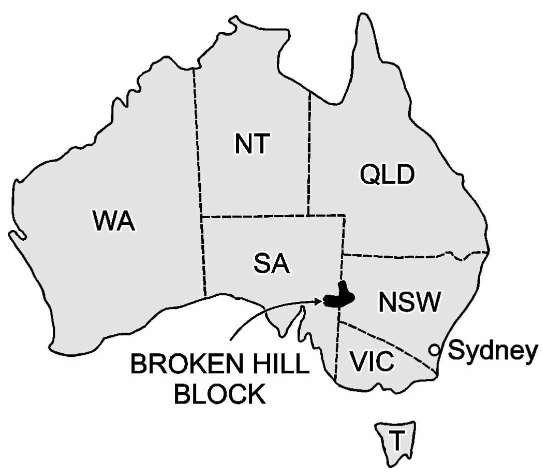

Figure 6. Sketch map of Australia showing the location of the Broken Hill deposit. Abbreviations: NSW = New South Wales, NT = Northern Territory, QLD = Queensland, SA = Southern Australia, T = Tasmania, VIC = Victoria, WA = Western Australia.

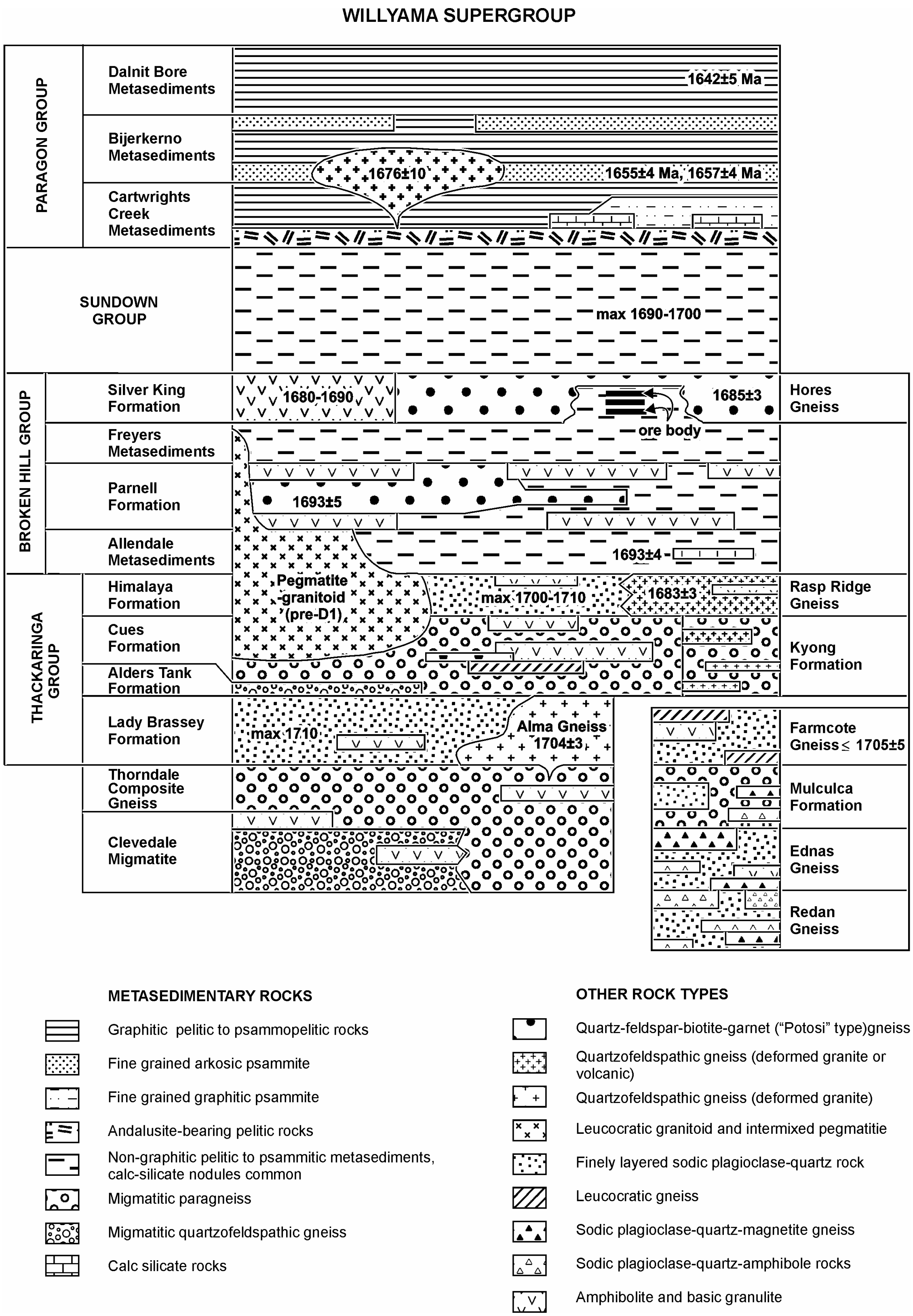

Figure 7. Stratigraphy, geochronology and simplified rock relationships within the Willyama Supergroup (*modified from* Stevens, Burton and Leyh (1998) and Stevens, Gibson and Page (2000)).

DEPOSITIONAL ENVIRONMENT

- extensional, likely at a continent margin
- volcanic-starved, with some bimodal, tholeiitic volcanic rocks
- distal (no conglomerates); thin "volcanic units" (some of which may be sills)
- general fining upward of the sedimentary sequence
- rapid deposition (maximum 30 to 40 million years)
- variety of chemical sediments in the Broken Hill Group (various iron formation facies, tourmalinites (boron-rich rocks), manganese-rich rocks, calc-silicate rocks, evaporitic rocks). Some of the compositionally unusual rocks are probably the result of primary deposition or diagenetic processes (e.g., evaporitic, sabkha or playa lake environments?), whereas others may be the result of alteration- and mineralization-related processes.

MINERALIZATION

- associated with early pegmatite development in Broken Hill Group
- some control by Hores gneiss (felsic metavolcanic), possibly as a cap rock (in conjunction with overlying graphitic pelites of the Sundown Group)
- general association with part of succession containing amphibolites, felsic metavolcanic rocks, aluminous and psammitic metasediments and chemical sediments
- pre-metamorphic
- one major orebody, many minor deposits
- ore mineralogy within the uppermost oxide zone of the deposit is complex, containing a variety of minerals such as coronadite, chlorargyrite, cerussite, malachite, azurite, anglesite, native copper, marmatite and rhodonite (e.g., van der Heyden and Edgecombe 1990). In contrast, the unweathered ore mineralogy consists of galena, sphalerite, chalcopyrite, arsenopyrite and loellingite, generally hosted in a quartz-garnet-gahnite rock (e.g., van der Heyden and Edgecombe 1990). Zinc-rich and lead-rich zones are present within the main deposit.
- the main and minor orebodies in the Broken Hill block do not have strong or distinctive aeromagnetic signatures, possibly reflecting the fact that sphalerite is not a good conductor, interference from iron formation horizons throughout sequence, and that even the high-resolution surveys are still coarser than the thickness of corresponding geological units.

POST-ORE HISTORY

- high-temperature, low- to moderate-pressure (~5 to 7 kilobar) metamorphism occurred less than 50 million years after deposition
- no recognized heat source (i.e., plutons) for metamorphism, low- to moderate-pressure and rapid onset of metamorphism constrains ability to invoke crustal thickening as a driving force for metamorphism
- higher grade rocks are generally those lowest in stratigraphy (achieved partial melting), this suggests heating from bottom up (a pattern not likely superimposed after younger orogenesis?)
- deformation (folding and thrusting) may have occurred prior to peak metamorphic conditions. One scenario is the development of a fold and thrust belt, which was then subjected to intense heating.

OTHER POINTS

- metasedimentary rocks in the Broken Hill Group are sillimanite rich (does this indicate that the protolith was extremely rich in alumina or strongly altered?)
- geochemical data consist mostly of major element chemistry on possible mafic and felsic volcanic rocks; there is only, limited major element geochemistry on sedimentary rocks. Rare earth element data on the volcanic and sedimentary rocks would assist in determining tectonic setting and provenance, respectively.
- stratigraphy appears to work in the belt

Discussion

Clearly, there are some similarities between the Tomiko supracrustal rocks and the Willyama Supergroup in the Broken Hill area. These include the presence of a psammitic sequence with amphibolite layers (Cahill Lake sequence of Moore (1976) = lower Freyers metasediments) overlain by a sequence of calc-silicate gneiss, pyrrhotite gneiss, pelitic gneiss and amphibolite (Crocan Lake sequence of Moore (1976) = upper Freyers metasediments or Sundown Group). Migmatitic rocks occur in the south part of Tomiko terrane. Rocks with unusual mineralogy (e.g., boron or manganese rich) are present locally, at least in north Tomiko terrane. Notable differences are the apparent abundance of fairly mature quartz arenite within the succession (unlike the turbidite-dominated Willyama Supergroup), and the dominance of kyanite rather than sillimanite. Overall, the differences probably outweigh the similarities, and would lead to the conclusion that the Tomiko terrane may not be a favourable host for Broken Hill-type mineralization.

The geochronology between the Broken Hill area and Tomiko terrane is somewhat similar. Deposition of the Broken Hill Group and the orebody was deposited within a 10 million year interval around 1685 Ma (Page, Stevens and Gibson 2005), with deposition of the entire Willyama Supergroup occurring between 1705 and 1655 Ma (Page, Stevens and Gibson 2005). This is similar to the ages of the youngest detrital zircons found in the Tomiko supracrustal rocks. The timing of the subsequent deformational history at Broken Hill and in Tomiko terrane differ considerably. D_2 and D_3 deformation and high-grade metamorphism at Broken Hill occurred between 1600 and 1590 Ma (Page, Stevens and Gibson 2005), whereas, in Tomiko terrane, major deformation and metamorphism occurred circa 1047 Ma. If the Broken Hill orebody is indeed syngenetic, as has been suggested by several authors (e.g., Stevens, Barnes and Forbes 1990; Page, Stevens and Gibson 2005), then the fact that deformation and metamorphism occurred at different times in the 2 areas may not be significant with respect to exploration for Broken Hill-style mineralization.

If it turns out that the correlation with the Baraboo and related quartz arenites is correct, then the inferred depositional setting of a fluviatile to shallow marine setting on a passive margin would be inconsistent with the extensional setting envisioned by many workers for the Broken Hill district (Stevens, Burton and Leyh 1998; Stevens, Gibson and Page 2000). Massive sulphide mineralization has not been reported in association with the Baraboo and related quartz arenite units.

Alternatively, it is possible that the critical elements responsible for mineralization are not controlled by rock type or stratigraphy. Rather, they may depend on the presence of a rapidly deposited, Geon 16 metasedimentary sequence associated with felsic or bimodal volcanism; and which has evidence for significant local fluid flow and the presence of rocks of unusual composition (e.g., boron, manganese, and/or tungsten rich). If this is the case, then the Tomiko terrane may very well be an excellent host for Broken Hill-type or other types of sulphide mineralization. It is also possible that this may be a unique Paleoproterozoic environment that has no direct analogue in the Phanerozoic.

In terms of fluid flow regimes, this study has identified the presence of at least 3 major fluid flow events: 1) a pre-M_1 event in northern Tomiko terrane that formed the tourmalinites and manganese- and iron-rich rocks; 2) a pre-M_2 event in the Timber Lake area that may have formed the biotite-garnet-kyanite gneisses; and 3) a M_3 event, which resulted in the replacement of biotite-garnet-kyanite rocks in the Timber Lake area by graphite, and the development of quartz-kyanite segregations replacing M_2 leucosome between Timber Lake and Cahill Lake. Certainly, the widespread evidence in Tomiko terrane for extensive fluid flow at several times in its history is a favourable indicator for mineralization.

Recommendations for Exploration

Although the potential for Broken Hill-type mineralization in Tomiko terrane may be equivocal, nonetheless, some recommendations can be made with respect for exploration.

Primary target areas are

1. northern Tomiko terrane, both in association with the iron formation unit in Parkman Township
2. in the area around McDougal Lake, where Reid (2002) reported gahnite in the regional modern alluvium survey, as far south as the Miners Lake area
3. in the Little Jocko Lake to Timber Lake area, where there is extensive evidence of alteration, sulphide minerals, and local geochemical anomalies

It should be borne in mind that both areas 1 and 2 are extensively drift covered.

Use of airborne magnetic surveys to identify target areas might not be productive, for the same reasons these methods did not work well in the Broken Hill block; namely, sphalerite is not a good conductor, there may be interference from iron formation horizons, and that even high-resolution surveys are still coarser than the thickness of corresponding geological units.

IRON

The first recorded work in the area was in 1959, when a Mr. Hardie drilled 3 holes near Opimika Creek to test for iron ore. Several periods of drilling in the Otter Lake–Green Lake area of Parkman Township, referred to hereafter as the Parkman iron property, followed over the next 13 years, as outlined in Table 11. Drilling was based on geological mapping and ground fluxgate magnetometer surveys performed by Ventures Limited in 1960 and by Iron City Mines Limited between 1965 and 1972 (Iron City Mines 1973). In addition, a ground radiometric survey was performed by Iron City Mines Limited in 1970. Most assays appear to have been reported in the assessment files, but almost all are only for total iron, acid soluble iron and manganese. Assays of the Green Lake zone, performed at the Ontario Department of Mines, ranged from 9.1 to 36.7%, with an approximate average of 21.1% soluble iron. Analyses of the Cook zone showed an average of 13.3% soluble iron. Average manganese content in the Green Lake zone was 4.1% on the north limb, with a high of 7.8%.

C. Marmont and R. Thomas visited the Cook and Webb zones of the Parkman iron property in 1998, and the pyrrhotite occurrence in Clarkson Township studied by Selco Limited. They collected rock samples, and obtained high manganese values from the Webb Lake zone, where no previous analytical data had been reported (Marmont 2000).

An aeromagnetic, very low frequency electromagnetic (VLF-EM) survey was completed over the Parkman iron property in March 2003 (Hearst 2003). The survey outlines the extent and folding of iron formation on the property.

Table 11. Summary of diamond drilling for iron ore, Parkman Township, Jocko River map area.

Zone	Company	Year	Number of Holes	Total (feet)	Total (metres)
Cook, west Limb and nose	Hardie	1959	3	88.5	27
	Ventures Limited	1960	6	1658	505.4
	Iron City Mines	1966	8	3839	1170.1
	Hardie?	1966	3	306	93.3
Cook, east limb	Iron City	1970	1		
		1971	5	1344	409.7
Bishop	Iron City	1966	2	961	292.9
Little Webb Lake	Iron City	1966	1		
		1972	6	2436	742.5
Green Lake	Iron City	1966	1		
		1969	7	5685	1732.8

Table 12. Summary of diamond drilling for other purposes, Jocko River map area.

Area	Company	Year	Number of Holes	Total (feet)	Total (metres)
Parkman Township, testing dolomite marble	Iron City Mines	1973	12	1507	459
Parkman Township, silica?	C. Mortimer	1980	5	537	163.7
Clarkson Township	Selco Limited	1981	2	452	137.8
McAuslan Township	Selco Limited	1981	2	479	146

Seven assay samples collected from the amphibole-rich phase of the iron formation near Otter Lake all contain low contents of siderophile elements (<2 ppm Cu, <45 ppm Co, <45 ppm Ni, <3 ppm Sc, <22 ppm V), confirming that the amphibole-rich phase is not derived from a metamorphosed ultramafic intrusion (samples 03RME-0237 to -0244, *see* Appendix 4).

The presence of boron- and manganese-rich rocks associated with the iron formation unit has not been previously recognized, and may indicate that the unit results from hydrothermal alteration, rather than from direct precipitation of iron in a marine environment. This unit deserves further exploration for elements such as gold, manganese, tungsten and zinc.

BASE METALS

In 1981, Selco Limited optioned and staked claims in McAuslan and Clarkson townships, with the intention of exploring for sedimentary-exhalative (SEDEX)-type base metal mineralization. Selco Limited cut a small grid in each township, performed ground magnetometer and horizontal loop electromagnetic (HLEM) surveys followed by diamond drilling. They intersected thin units of pyrrhotite and graphite gneiss, but reported no base metal mineralization.

Disseminated, semi-massive and massive concentrations of pyrrhotite are reported in the assessment files from the Parkman iron property, but only 7 samples were tested for nickel or other elements. Hole 1966 V-2 contained 0.1% Pb, likely in silicate iron formation. Other diamond drilling in the vicinity of the Parkman iron property is summarized in Table 12.

A regional lake sediment survey was completed in 1989. Only 4 samples are relevant to the Parkman iron property (*see* “Iron”): Emerald Lake, Green Lake, Little Webb Lake and a small lake near the mouth of Opimika Creek. Emerald Lake has anomalous Cd, Cu, Ni and Pb values; Green Lake has anomalous Cu values; and the lake near Opimika Creek has anomalous Cu and Au values.

BUILDING STONE

Between 1993 and 1995, R. Komarechka examined the monzonite body east of Eldee for its building stone potential. The polished rock has a mahogany colour, with some schiller. Unfortunately, the body is of limited areal extent, with the least deformed and most easily quarried exposures located beneath a communication tower located atop the hill formed by the intrusion.

Potassium feldspar megacrystic to augen granite of the Malone lobe of the Mulock granite might make an attractive pink stone. Areas of exposed rock exhibiting moderate relief and containing widely spaced joints are easily accessed along the logging road that extends north of Malone Lake. In addition, Marmont (1992) identified an area of good potential in the Mulock granite in Stewart Township (UTM 615500E to 619000E, 515800N to 5161200N), due west of the study area. The rock is a minimally jointed, potassium megacrystic, gneissic granite. A colour photograph of a polished slab of the Mulock granite from Stewart Township is included in Marmont (1992, p.19).

DIAMONDS

Abundant kimberlite indicator minerals (KIM), consisting of pyrope garnet, chrome diopside, chromite and picroilmenite (magnesioilmenite), were first identified in Parkman Township in 1998 (Marmont 2000), highlighted by a sample from Green Creek containing a KIM count of 6619 grains (RNT-028), including the presence of subcalcic pyrope garnets (G10). This work preceded a modern alluvium survey of the area by the Ontario Geological Survey (Reid 2002). Additional exploration work has been conducted in the Green Lake area between 2000 and 2005 by several companies and individuals, as summarized in Appendix 1. This work has focussed on identifying the source of the observed KIM anomalies.

An aeromagnetic VLF-EM survey was completed over the Parkman iron property in March 2003 (Hearst 2003). In addition to outlining the extent of iron formation on the property, the survey detected 28 magnetic features possibly representing kimberlite pipes.

FELDSPAR

Although not a focus of this study, feldspar properties in the vicinity of the Purdy Mine in Mattawan and southeastern Olrig townships were examined briefly by the author. These properties produced mica (muscovite), hosted in pegmatite dikes, in the period 1941 to 1944, as documented in detail in Harding (1946). The mica was mined because of its favourable dielectric properties (Harding 1946).

Host rocks to the pegmatite dikes consist of either pink, granitic gneiss or dark-green to dark-grey, amphibolite, which may or may not be garnet bearing. The mica-bearing pegmatite dikes on the Purdy Mine property, occur in a belt about 120 m wide and at least 500 m long, that trends northeast. At least 6 muscovite-bearing pegmatite dikes were trenched or mined on the Purdy property. The size of the individual dikes is 2.5 to 3.5 m wide, and less than 120 m long. In addition to the first discovery site, mica was extracted from 3 main pits: pit numbers 1, 2 and 3, respectively (Harding 1946).

A sample of feldspar was collected from pit number 3 on the old Purdy Mine property, as indicated by Harding (1946, p.37) to test for possible rare metal potential (sample 03RME-0314, *see* Appendix 2). Cesium was only 1.25 ppm in the sample; lithium was not analyzed. K/Ba ratio is less than 45, and Rb is 239 ppm. These elements, along with other key ratios, suggest that the pegmatites in Bonfield domain fall in the Type 1b (barren) pegmatite type of Gordiyenko (1971) and, thus, have no rare metal potential.

GARNET

The best prospects within the region are associated with mafic gneisses (pseudoeclogite) present in the Mattawan domain in Mattawan Township, as these contain garnet of uniform size and quality, with minimal inclusions. Garnet is locally abundant anywhere in Tomiko terrane where either M_2 or M_3 are the dominant metamorphic events. Garnet is most common in metapelitic or interlayered amphibolite bands in the metasedimentary sequence. In Tomiko terrane, garnet production is more likely to occur as a by-product of either kyanite or mica extraction.

KYANITE

The economic potential of kyanite occurrences in the Timber and Crocan lakes area has been studied since 1951 (Hewitt 1952; Pearson 1959; Moore 1976; Vos, Smith and Stevenato 1981; R.M. Blais and Associates, Ltd. 1998), culminating in extraction of a test sample from the Kyanite Corporation of America property in 1998 (R.M. Blais and Associates, Ltd. 1998). The property is currently idle, but remains the best target for kyanite within Tomiko terrane. Northeast of Highway 63, kyanite, although present, is not abundant and has been partly replaced by muscovite. South of Highway 533, as noted in "Metamorphism", blue kyanite occurs in metapelitic gneiss (M_2) and was variably replaced by green kyanite during M_3. As a consequence, kyanite occurrences south of Highway 533 contain at least 2 varieties of kyanite, of different colour, habit, inclusions, and associated host minerals; all factors that will complicate mineral extraction and processing and, thus, the economic viability of any kyanite prospect. If exploring for kyanite south of Highway 533, the best targets are located on the hydroelectric line near Cahill Lake, where almost complete replacement of blue kyanite by green kyanite has occurred.

GRAPHITE

Pearson (1959) described the presence of graphite at the contact of garnet-kyanite gneiss and surrounding mafic and metasedimentary gneisses in the Crocan Lake area. Massive graphite is locally exposed at this contact at the Kyanite Corporation of America mill site, and consists of massive, coarse flake graphite in a lens up to 1.5 m wide and at least 5 m long. Pearson (1959) suggested that the graphite replaced the pre-existing rocks. Evidence for replacement is observed locally, as parts of the graphite occurrence contains clots of bright red weathering hematite and goethite that is likely derived from alteration of primary garnet as well as remnant kyanite grains. Although the volume of graphite may not be sufficient to sustain a mining operation, given the coarseness of the flake and the massive character of the graphite, it could be an important by-product of the kyanite mining operation.

MUSCOVITE

Watts, Griffis and McOuat and Ontario Geological Survey (2002) evaluated muscovite occurrences in Tomiko terrane, specifically the Reynolds Lake properties of McLaren's Bay Mica (Wayne Borer) and Mote (Garmak Investments), and the Porcupine Lake, Threetails Lake and Thorne Brilliant Stone quarries. All of these sites are located northeast of Highway 63 and are situated in the less metamorphosed part of the terrane which remains the best area for muscovite exploration. Beneficiation tests were conducted on samples from the 2 Reynolds Lake properties. These samples had fewer inclusions and were coarser grained than samples from other parts of the Grenville Province in Ontario, but had higher iron content, which may preclude the use of this muscovite in the plastics and paint industry (Watts, Griffis and McOuat and Ontario Geological Survey 2002). Muscovite from the Kyanite

Corporation of America occurrence at Crocan Lake was also examined and, although it possesses lower iron content, was less abundant (<20%) than at the other Tomiko occurrences (30 to 80%) (Watts, Griffis and McOuat and Ontario Geological Survey 2002).

Coarse muscovite was previously extracted from granite pegmatite veins associated with amphibolite and garnet amphibolite enclaves within the Bonfield pluton in the Bonfield domain in south Olrig and southwest Mattawan townships. Most of the production came from the Purdy Mine (Harding 1946).

SILICA

Exploration for quartz arenites for silica extraction (Photo 18) should focus on the area northeast of Highway 63, which is where most past-producers are located. Quartz arenites in this area generally contain few accessory minerals, such as feldspar, and are weakly to non-migmatitic. The area east and south of Tower Lake in Garrow Township has excellent potential, but has not been explored recently. South and east of Highway 63, the quartz arenite units are migmatitic and, thus, contain abundant feldspar and mica, making silica extraction more complicated.

Photo 18. Silica test quarry at Porcupine Lake, June 2003.

VERMICULITE

Discovered in 1957, during the construction of what is now Highway 533, several vermiculite occurrences northwest of Timber Lake have received extensive exploration interest (e.g., Millar vermiculite in Vos, Smith and Stevenato 1981). Currently, Enviro Industrial Technologies (Canada) Inc. is building a mill on the west end of the former Millar property for the purposes of producing vermiculite concentrate. The deposits are associated with weathered zones developed in amphibolite and calc-silicate gneiss that are interlayered with felsite of the metasedimentary sequence. All the occurrences are located within 1 km of the eastern margin of the Jocko pluton. The Jocko pluton and related plutonic bodies are highly friable, locally developing thick saprolite mantles. Since these zones of intense weathering are largely restricted to this one rock unit, the close proximity of the vermiculite occurrences to the pluton may be related, possibly to fluid movement during pluton emplacement. If so, exploration for vermiculite should focus on the margins of the Jocko pluton and compositionally similar plutons in the area.

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Appendix 1

Summary of Mineral Exploration Work in the Jocko River and Songris Map Areas

Townships

Antoine, Butler, Clarkson, Eddy, French (no files), Garrow (no files), Jocko, Lasalle (no files), Lockhart (no files), Mattawan, McAuslan, Merrick (no files), Mulock (no files), Olrig (no files), Osborne (no files), Parkman, Phelps, Poitras, Stewart (no files), Widdifield (no files), Wyse

as of February 28, 2006

Abbreviations

EM = electromagnetic survey
g/t = grams per tonne
IP = induced polarization survey
KIM = kimberlite indicator minerals
VLF-EM = very low frequency electromagnetic survey

Appendix 1. Summary of mineral exploration work in the Jocko River and Songris map areas.

Antoine Township.

Company or Individual	Location	Year of Work	Commodity	Work	Best Results	Comments	RGO File Number or Other Reference
Marum Resources Inc., survey by Aerodat Inc.	Antoine Township, east to Ottawa River and into Quebec	1996	diamonds	total field aeromagnetic survey		8–1:20 000 sheets, over 70% of survey area is in Quebec	Antoine SP-001; 2.17302, W9770.158, W9770.159
Graham Smith	South of Highway 533 near Timber Lake area	1996–1997	kyanite, garnet, mica	prospecting			Antoine SP-002; 2.17540, W9770.00474
Graham Smith	South of Highway 533 near Timber Lake area	1997–1998	kyanite, garnet, mica	prospecting			Antoine SP-003; 2.18925, W9870.00521
R.M. Blais & Associates Ltd. for Kyanite Mining Corp.	Crocan Lake occurrence, ~79°00′W, 46°31′N	1998	kyanite, garnet, mica	prospecting	estimated 50 000 000 tonnes of ore	geological map	Antoine SP-004; 2.18925, W9870.00574
Golwynne Chemical Corp.	Crocan Lake occurrence, ~79°00′W, 46°31′N	1952–1954	kyanite, garnet, mica	diamond drilling			Antoine SP-005
Cononaco Mines Ltd.	Crocan Lake occurrence, ~79°00′W, 46°31′N	1969–1972	kyanite, garnet, mica	trenching		1952 – 574m, 1953 – 326 m, 1954 – 65 m	Antoine SP-006
Arrowhead Silica Corp.	Crocan Lake occurrence, ~79°00′W, 46°31′N	1973–1974	kyanite, garnet, mica	diamond drilling		1972 – 310 m, 1973 – 785 m	Antoine SP-007, 2.1171
Kyanite Mining Corp.	Crocan Lake occurrence, ~79°00′W, 46°31′N	1975–1976	kyanite, garnet, mica	diamond drilling		1975 - 789m; 1976 – 1042m	Antoine SP-008
Kyanite Mining Corp.	Crocan Lake occurrence, ~79°00′W, 46°31′N	1992	kyanite, garnet, mica	mostly environmental		being proposed for a kyanite extraction and milling industry	Antoine SP-009
Kyanite Mining Corp.	Crocan Lake occurrence, ~79°00′W, 46°31′N	1993	kyanite, garnet, mica	stripping/ drilling, loading/ blasting			Antoine SP-010
Graham Smith	South of Highway 533 near Timber Lake area	1995	kyanite, garnet, mica	prospecting			Antoine SP-011

Appendix 1. continued.

Butler Township.

Company or Individual	Location	Year of Work	Commodity	Work	Best Results	Comments	RGO File Number or Other Reference
J.J. Kenmey-(Goldwynne Chem. Corp.) -(Arrowhead Silica)	Crocan Lake occurrence, ~79°00′W, 46°31′N	1952	kyanite, garnet, mica	diamond drilling			Butler SP-017
D.W. Sullivan	Crocan Lake occurrence, ~79°00′W, 46°31′N	1952–1954	kyanite, garnet, mica	diamond drilling		50 000 000 tons of ore	Butler SP-002
D.W. Sullivan	Crocan Lake occurrence, ~79°00′W, 46°31′N	1954	kyanite, garnet, mica	prospecting			Butler SP-018
Northern Kyanite Mines Ltd.	Crocan Lake occurrence, ~79°00′W, 46°31′N	1954–1958	kyanite	prospecting		File includes a copy of 27p. Canada Mines Branch Report IR 58-165 by Wyman & Stone	Butler SP-001
Cononaco Mines Ltd.	Crocan Lake occurrence, ~79°00′W, 46°31′N	1969	kyanite, garnet, mica	trenching			Butler SP-004
Morris MacWilliam		1970–1972	kyanite, garnet, mica	stripping			Butler SP-003
Joseph Roy	West of Timber Lake off Highway 533	1971	kyanite, garnet, mica	trenching			Butler SP-005
N.R. Ruttan		1976	kyanite, garnet, mica	trenching, mechanical land clearing			Butler SP-006
Kyanite Mining Corp.	Crocan Lake occurrence, ~79°00′W, 46°31′N	1976	kyanite, garnet, mica	diamond drilling			Butler SP-007
R.J. Meikle for Kyanite Mining Corp.	Crocan Lake occurrence, ~79°00′W, 46°31′N	2003	kyanite, garnet, mica	ground IP survey		Need geology or drilling to distinguish sulphide from other conductors	Butler SP-025, 2.26765, W0370.01897
Kyanite Mining Corp.	Crocan Lake occurrence, ~79°00′W, 46°31′N	2004	kyanite, garnet, mica	stripping, assays following up group IP survey results		Site 4 exposes sulphide-rich quartz arenite, high Ni assays from 218 to 1750 ppm, Cu 180 to 232 ppm	Butler SP-029. 2.30760, W0570.01688
Doug Rogers	Highway 63 to Indian Lake turn-off (follow trail south of highway 2.75 km, flagged trail leads north)	1984	amethyst	blasting and drilling			Butler SP-008
L. Snodden	French and Butler township line near Reynolds Lake	1985–1986	amethyst	prospecting, trenching		"Not enough quantity for profitable extraction"	Butler SP-009
G. Kealey, A. Howden	French and Butler township line near Reynolds Lake	1995	amethyst	prospecting,			Butler SP-010

Appendix 1. continued.

Butler Township, continued.

Company or Individual	Location	Year of Work	Commodity	Work	Best Results	Comments	RGO File Number or Other Reference
G. Kealey, A. Howden	French and Butler township line near Reynolds Lake	1996	amethyst	trenching			Butler SP-011, W9870.00005
G. Kealey, A. Howden	French and Butler township line near Reynolds Lake	1997	amethyst	trenching			Butler SP-012, 2.18403, W9870.00062
G. Kealey	French and Butler township line near Reynolds Lake	2000	amethyst	re-establishing claim boundaries			Butler SP-016, 2.20833, W0170.00006
Millar Properties	6.1 km east of Highway 63 on north side of Highway 533	1958	vermiculite	diamond drilling			Butler SP-019
Richland Mines Inc.	North side of Highway 533	1997	vermiculite	prospecting			Butler SP-013, 2.18750, W9870.00517, W9870.00518
Wilfred C. Symonds		1999–2000	vermiculite	stripping and trenching	85% vermiculite and 15% amphibolite in the concentrate	Continuous zone of vermiculite was encountered for 300 feet	Butler SP-015, 2.19981, W9970.00328
Enviro Industrial Technologies	Off Highway 533	2002	vermiculite	diamond drilling			Butler SP-020, 2.22580, W0170.31250
Pierre Menard		1998	kyanite, garnet, mica	prospecting, stripping			Butler SP-014, 2.18670, W9870.00514
G. Shouinard, D. Lashbrook	Sparks–Tremblay Lake area	2003	kyanite, garnet, mica	prospecting			Butler SP-021, 2.26506, W0370.01665
G. Shouinard, D. Lashbrook	Sparks–Tremblay Lake area	2003	kyanite, garnet, mica	prospecting, stripping			Butler SP-022, 2.26504, W0370.01663
G. Shouinard, D. Lashbrook	Eddy–Sparks Lake area	2003	kyanite, garnet, mica	prospecting			Butler SP-023, 2.26505, W0370.01664
G. Shouinard, D. Lashbrook	Eddy–Sparks Lake area	2003	kyanite, garnet, mica	prospecting		A1 zone 648349E, 5154650N; A2 zone 648460E, 5154000N to 648275E, 5154700N; A3 zone 649124E, 5154444N	Butler SP-024, 2.26509, W0370.01618
G. Shouinard, D. Lashbrook	Eddy–Sparks Lake area	2004	kyanite, garnet, mica	prospecting, trenching			Butler SP-026, 2.27887, W0470.00946
G. Shouinard, D. Lashbrook	Sparks–Tremblay Lake area	2004	kyanite, garnet, mica	prospecting			Butler SP-027, 2.28649, W0470.01662
G. Shouinard, D. Lashbrook	Sparks–Tremblay Lake area	2004	kyanite, garnet, mica	prospecting			Butler SP-028, 2.28650, W0470.01663

Appendix 1. continued.

Clarkson Township.

Company or Individual	Location	Year of Work	Commodity	Work	Best Results	Comments	RGO File Number or Other Reference
J. Knox		1964	calcite, mica	diamond drilling			Clarkson SP-001
Joseph Haberer		1970		manual labour, drilling and blasting		1 trench 7 feet wide, 8 feet long and 6 feet deep	Clarkson SP-002
Selco Mining Corp.		1981	calcite, mica, quartz, garnet	diamond drilling			Clarkson SP-003
G. Shouinard, D. Lashbrook		2004	quartz, muscovite	diamond drilling			Clarkson SP-004 2.28913, W0470.01918

Eddy Township.

Company or Individual	Location	Year of Work	Commodity	Work	Best Results	Comments	RGO File Number or Other Reference
G. Shouinard, D. Lashbrook		2004	kyanite, garnet, muscovite	prospecting			Eddy SP-001, 2.27930, W0470.00978
G. Shouinard, D. Lashbrook		2004	kyanite, garnet, muscovite	prospecting			Eddy SP-002, 2.27929, W0470.00977
G. Shouinard, D. Lashbrook		2004	kyanite, garnet, muscovite	prospecting			Eddy SP-003, 2.27927, W0470.00975
G. Shouinard, D. Lashbrook		2004	kyanite, garnet, muscovite	prospecting		Sample of quartz-muscovite gneiss at 651590E, 5157376N	Eddy SP-004, 2.27850, W0470.00909

Jocko Township.

Company or Individual	Location	Year of Work	Commodity	Work	Best Results	Comments	RGO File Number or Other Reference
Mote, Maxwell Kitchener		1971-1976	unknown	trenching, stripping, mechanical drilling			Jocko SP-001
G. Mote	Test area centred on 640585E, 5163025N	2004	stone (flagstone)	bulk sampling		Text area centred on 640585E, 5163025N	Jocko SP-002, 2.30346, W0570.01297

Location in UTM co-ordinates, NAD83.

Appendix 1. continued.

Mattawan Township.

Company or Individual	Location	Year of Work	Commodity	Work	Best Results	Comments	RGO File Number or Other Reference
G. Shouinard, R. Montreuil	West of Highway 533, ~20 km northwest of Mattawa	1996	garnet, Ni-Cu-PGE	trenching			Mattawan SP-001, 2.17145, W9770.0009 to 00101
G. Shouinard, R. Montreuil	West of Highway 533, ~20 km northwest of Mattawa	1997	garnet, Ni-Cu-PGE	prospecting, stripping	5.62% TiO_2		Mattawan SP-002, 2.18477, W9870.00064 to 00067
G. Shouinard, R. Montreuil	West of Highway 533, ~20 km northwest of Mattawa	1997	garnet, Ni-Cu-PGE	prospecting			Mattawan SP-003, 2.18452, W9870.00258
G. Shouinard, R. Montreuil	West of Highway 533, ~20 km northwest of Mattawa	1997	garnet, Ni-Cu-PGE	prospecting			Mattawan SP-004, 2.18454, W9870.00256
G. Shouinard, R. Montreuil	West of Highway 533, ~20 km northwest of Mattawa	1998	garnet, Ni-Cu-PGE	stripping			Mattawan SP-005, 2.18453, W9870.00257
G. Shouinard, R. Montreuil	West of Highway 533, ~20 km northwest of Mattawa	1998	garnet, Ni-Cu-PGE	prospecting, sampling, stripping			Mattawan SP-007, 2.19370, W9970.00081 to 00086
G. Shouinard, R. Montreuil	"Spring Creek", west of Highway 533, ~20 km northwest of Mattawa	1999	garnet, Ni-Cu-PGE	prospecting	Garnet content 30–50%		Mattawan-SP-009, 2.19369, W9970.00076 to 00080
G. Shouinard	West of Highway 533, ~20 km northwest of Mattawa	2000	garnet, PGE	ground geophysical survey, linecutting			Mattawan SP-020, 2.20707, W0070.00224
G. Shouinard, R. Montreuil	West of Highway 533, ~20 km northwest of Mattawa	2001	garnet	prospecting		Bangs Lake grid	Mattawan SP-022, W0170.00066
G. Shouinard and Barton Mines	West of Highway 533, ~20 km northwest of Mattawa	2001	garnet	linecutting and ground VLF-EM		Discovery Hill area	Mattawan SP-0023, 2.23266, W0270.00539
Imperial Minerals Corp.	West of Highway 533, ~20 km northwest of Mattawa	2000	garnet	geology, sampling		Written report	Mattawan SP-0010, 2.19765, W9970.00302
Imperial Minerals Corp., G. Shouinard	West of Highway 533, ~20 km northwest of Mattawa	2000	garnet	geotechnical ground geophysical survey, mapping		See Mattawan SP-0010 for more complete report	Mattawan SP-019, 2.20593, W0070.00185
Carl T. Bischoff	South of Kearney Lake	1977	pegmatite, mica	trenching			Mattawan SP-013
Jean-Marc Hanveaux	Southwest shore of Kearney Lake	1988	potassium feldspar	prospecting, trenching, sampling			Mattawan SP-016, W8907.00097 to 00099, W8807.00147 to 00149

Appendix 1. continued.

Mattawan Township - continued.

Company or Individual	Location	Year of Work	Commodity	Work	Best Results	Comments	RGO File Number or Other Reference
Angus John McDonnell	Old mica mines south of Kearney Lake	1998	pegmatite, mica	road upkeep			Mattawan SP-006, 2.18558, W9870.00328
Angus John MacDonnell	By Mattawan-Olrig line, Lot 1, Concession 3	2002	pegmatite, mica	blasting, adding new flagging			Mattawan SP-0024, 2.23695
E.A. Rose	Lot 34, Conc. 5, 3.5 miles NW of Mattawa on Hwy 533, then S for ~0.25 mile to a bailey bridge. Project E of bridge	1998	potassium feldspar	prospecting		Whole rock chemistry on feldspars	Mattawan SP-008, OP97-014, 97-019
Hudson Bay Exploration & Development Company Ltd.	Lot 13, Concessions 9 and 10	1986	gold	diamond drilling		Exploration based on report in OGS MP 128 on 0.41 g/t Au from sulphide unit at Crocan Lake	Mattawan SP-014; MP 128 (Owsiacki 1986)
Hudson Bay Exploration & Development Company Ltd.	1650 acres straddling Hwy 533; 18 km NW of Mattawa	1985–1987	gold	overburden sampling, assaying, drilling		Written summary report	Mattawan SP-015, 2.10741
High G Minerals Corp.	East of Highway 533, ~15 km northwest of Mattawa	1999	garnet	drilling, prospecting		Report and maps, 28 short holes	Mattawan SP-0011, 2.19906, OP99-331
Robert Komarechka	East of Highway 533, ~15 km northwest of Mattawa	1994	garnet	prospecting		Written report	Mattawan SP-017, OP93-685, OP94-302
Robert Komarechka	East of Highway 533, ~15 km northwest of Mattawa	1996	garnet	mineral beneficiation, some assays & prospecting			Mattawan SP-018, 2.16603, 2.16604, W9670.00103, W9670.00104
Robert Komarechka	Tower Lake grid, Lot 1, 2, Concessions 10 and 11	2000	garnet	geotechnical, linecutting, ground magnetic survey		Magnetometer survey outlined 2 highs that likely represent mafic intrusions (gabbro)	Mattawan SP-0012, 2.20235, W0070.00064
Robert Komarechka	East of Highway 533, ~15 km northwest of Mattawa	2000	garnet	geotechnical and ground geophysical survey			Mattawan SP-021, 2.20766, W0070.00246
Robert Komarechka for Barton Mines Ltd.	Highway 533, ~15 km northwest of Mattawa	2002	garnet	prospecting, geological mapping		Summary report on Bangs Lake, Discovery Hill and Tower Lake grids of Shouinard and Komarechka claims	Mattawan SP-0025, 2.25006, W0370.00252
Robert Komarechka for BMCTBG Canada Ltd.	Highway 533, ~15 km northwest of Mattawa	2004	garnet	prospecting, stripping, trenching, geological mapping		61-page report on Bangs Lake, Discovery Hill and Tower Lake grids	Mattawan SP-0026, 2.29550, W0570.00531

Appendix 1. continued.

McAuslan Township.

Company or Individual	Location	Year of Work	Commodity	Work	Best Results	Comments	RGO File Number or Other Reference
Germain Chevrier		1965–1967	pyrite, garnet, chalcocite	assay, core logs			McAuslan SP-006
Iron City Mines Ltd.		1966	garnet, magnetite	diamond drilling			McAuslan SP-014
Northland Stone Company Ltd	N side of Reynolds Lake	1966	mica, quartz	blasting (vertical drill holes at 3 foot intervals)			McAuslan SP-005
McLaren Bay Mica Stone Quarries	N side of Reynolds Lake	2005	mica, quartz	chemistry on samples of 3 rock types		Samples of red, green and black micaceous rocks, work done by SRS Lakefield Research	McAuslan SP-015, 2.29686, W0570.00668
Germain Chevrier, Sam Stargrat		1971		trenching, stripping			McAuslan SP-008
Gary M. Mote		1974–1976		trenching, stripping			McAuslan SP-007
Joseph Haberer	Pine Lake silica occurrence	1977	quartz, mica	trenching, stripping			McAuslan SP-009
Joseph Haberer	Pine Lake silica occurrence	1981	quartz, mica	trenching, stripping			McAuslan SP-010
Joseph Haberer	Pine Lake silica occurrence	1982	quartz, mica	trenching, stripping			McAuslan SP-011
William A. Hogg	Pine Lake silica occurrence	1990	quartz, mica	geochemical sampling, geological mapping		Written report, chemical analyses	McAuslan SP-012
John Pilger	McConnell Lake area	1992	amblygonite lepidolite	reconnaissance geology			McAuslan SP-013
D. Hardie	Halfmoon Lake	1996–1997		ground VLF and scintillometer survey			McAuslan SP-001, 2.17304 W9770.00160
D. Hardie	Halfmoon Lake and NW of Otter Lake	1995		linecutting, ground VLF survey			McAuslan SP-002
John Pilger	Along McConnell Lake Road, ~29 km	1995–1996	quartz, mica	geological mapping, line cutting			McAuslan SP-003, 2.16924 W9670.00158
Fluxor Inc.	Along McConnell Lake Road ~20 km to a bush trail	1999	quartz	line cutting, sampling, geochem, prospecting			McAuslan SP-004, 2.19647 W9940.00259

Appendix 1. continued.

Parkman Township.

Company or Individual	Location	Year of Work	Commodity	Work	Best Results	Comments	RGO File Number or Other Reference
M.A. Hanna Company		1957 1963	iron	sampling, assays	66.17% Fe, 4.45% SiO_2		Parkman SP-001
Hardie Iron Prospect	Opimika Creek	1959	iron	diamond drill hole logs			Parkman SP-002
Ventures Ltd. (Iron City, Cessland Corp., Hardie Iron, Terrell Iron)		1966	iron	geology report, ground magnetic survey, diamond drill hole logs, geological maps		Includes geology map by P.E. Giblin	Parkman SP-003, 63.1072
Iron City Mines Ltd.	Otter Lake to Green Lake	1966–1967, 1969–1973	iron	ground magnetic survey, ground radiometric survey, diamond drill hole logs, geological maps	Total of roughly 4967 m of diamond drilling for iron on Cook, Bishop, Webb Lake and Green Lake zones	Amalgamation of several different files and reports	Parkman SP-004
A. Hopkins	Otter Lake area	1977	iron	trenching			Parkman SP-005
C.H. Mortimer	Green Lake area	1980	quartzite?	trenching, diamond drill hole logs			Parkman SP-006
C. Marmont and R. Thomas	Otter Lake to Green Lake	2000	iron, sedex, diamonds	prospecting, whole-rock geochemistry, modern alluvium sampling for KIMs		OPAP99-204 and OPAP99-205	Parkman SP-007, W0070.00138
C. Marmont and R. Thomas	Otter Lake to Green Lake	2001	diamonds	microprobe analyses of KIM grains			Parkman SP-008, 2.22522, W0170.31186
C. Marmont and R. Thomas	Green Lake	2002	diamonds	microprobe analyses of KIM grains			Parkman SP-008, 2.24062, W0270.01319
C. Marmont	Otter Lake to Green Lake area, includes parts of McAuslan and Wyse townships	2002	diamonds	pebble analysis of modern alluvium and till, petrography and geochemistry of lamprophyre dikes			Parkman SP-010, 2.24697, W0270.01933
C. Marmont and Grenville Gold Corporation	Otter Lake to Green Lake area, includes parts of McAuslan and Wyse townships	2002	diamonds	KIM analyses, air photo interpretation, till sampling, surficial geology mapping			Parkman SP-011, 2.24388, W0270.01617

Appendix 1. continued.

Parkman Township - continued.

Company or Individual	Location	Year of Work	Commodity	Work	Best Results	Comments	RGO File Number or Other Reference
G. Harron	McLaren Bay	2003	diamonds	KIM analyses, soil geochemistry		Report by V.N. Rampton	Parkman SP-012, 2.26436, W0370.01596
G. Harron	Ottertail Creek	2003	diamonds	KIM analyses, soil geochemistry		Report by C.F. Gleeson	Parkman SP-013, 2.26451, W0370.01613
Grenville Gold Corporation	Otter Lake to Green Lake area	2003	iron, diamonds	airborne magnetic and VLF-EM survey		Terraquest geophysical contractor, includes report by Hearst	Parkman SP-014, 2.25342, W0370.00568
C. Marmont and Grenville Gold Corporation	Green Lake area	2003	diamonds	ground magnetic survey, KIM analyses			Parkman SP-015, 2.26882, W0370.02008
C. Marmont	Little Webb Lake area	2004	iron, diamonds	diamond drill hole logs	2 holes, total of 195.4 m		Parkman SP-016, 2.27491, W0470.00560
C. Marmont	Green Lake area	2004	iron, diamonds	diamond drill hole logs	3 holes, total of 322.4 m		Parkman SP-017, 2.27633, W0470.00699
C. Marmont	Otter Lake to Green Lake area, includes parts of McAuslan and Wyse townships	2004	diamonds	KIM analyses, modern alluvium sampling		R.J. Dillman report	Parkman SP-018, 2.28918, W0470.00194
C. Marmont	Green Lake area	2004	diamonds	soil geochemistry			Parkman SP-019, 2.29103, W0570.00099
C. Marmont	Green Creek and Big Webb Lake areas, B10 ~634420E, 5185390N, B11A-4 ~634770E, 5185775N, B18A ~631660E, 5186575N	2004	base metals	diamond drilling		5 of 8 holes lost in overburden	Parkman SP-020, 2.29649, W0570.00628

Location in UTM co-ordinates, NAD83.

Appendix 1. continued.

Phelps Township.

Company or Individual	Location	Year of Work	Commodity	Work	Best Results	Comments	RGO File Number or Other Reference
Tracy Gordon Roy		2002	garnet	prospecting			Phelps SP-001, 2.23119, W0270.00413
Tracy Gordon Roy		2002	garnet	stripping and Trenching			Phelps SP-002, 2.24910, W0370.00167

Poitras Township.

Company or Individual	Location	Year of Work	Commodity	Work	Best Results	Comments	RGO File Number or Other Reference
Douglas Gauvreau		1970		trenching, stripping			Poitras SP-002,
Robert Komarechka	1 km S of Eldee by the CBC tower, & east of Highway 533, 15 km NW of Mattawa	1995	garnet	prospecting, sampling		OPAP final report, also contains assay & chemistry on eclogitic rocks	Poitras SP-001, OP95-269
Robert Komarechka	1 km S of Eldee by the CBC tower	1995	monzonite-syenite	prospecting, linecutting, geology, ground magnetic		Written report	Poitras SP-003, 2.16163 W9570.00065, W9570.00066, W9570.00081, W9570.00082, W9570.00067
Robert Komarechka	1 km S of Eldee by the CBC tower	1995	monzonite	geology, ground magnetic, final report			Poitras SP-004, OP94-302, OP93-685

Wyse Township.

Company or Individual	Location	Year of Work	Commodity	Work	Best Results	Comments	RGO File Number or Other Reference
Joseph Haberer		1969–1972	quartz	trenching, drilling, blasting			Wyse SP-001
Joseph Haberer		1981	quartz	assays, geology			Wyse SP-002
Joseph Haberer	Porcupine Lake Rd.	2000	quartz	stripping			Wyse SP-003, 2.20378, W0070.00117

Appendix 2

Listing of Geochemical Data on Rock Units in the Study Area Collected as Part of this Study

Abbreviations

NA = not analyzed
NC = not calculated
NR = not reported
less than (<) symbol indicates element was below the detection limit in the sample
greater than (>) symbol indicates element was above instrument calibration limit

Method Abbreviations

FA = fire assay
ICP-AES = inductively coupled plasma atomic emission spectroscopy
ICP-MS = inductively coupled plasma mass spectroscopy
XRF = X-ray fluorescence on pressed pellets

Appendix 2. Listing of geochemical data on rock units in the study area collected as part of this study.

Sample Name	Source	UTM Co-ordinates		Township	Rock Type	Map Code	SiO_2	TiO_2	Al_2O_3	Fe_2O_3
Method		Zone 17	NAD83				XRF	XRF	XRF	XRF
Units		(m)	(m)				wt.%	wt.%	wt.%	wt.%
Detection Limit		Easting	Northing				***0.01***	***0.01***	***0.01***	***0.01***
03RME-0294	this study	643171	5163856	Clarkson	Orthopyroxene hornblendite	3c	50.34	0.32	7.13	9.22
03RME-0299	this study	642455	5166055	Clarkson	Hornblendite	3d	49.85	0.30	6.55	9.20
03RME-0083	this study	629045	5173865	Garrow	Calc-silicate gneiss	4	47.82	3.15	16.13	14.46
03RME-0094	this study	639464	5170871	Clarkson	Biotite gneiss	6b	64.73	0.57	16.07	4.58
03RME-1002	this study	639075	5173960	Clarkson	Biotite gneiss	6b	73.27	0.37	11.13	4.58
03RME-0206	this study	647046	5152257	Butler	Plagioclase gneiss	13d	63.42	0.89	15.60	6.87
03RME-0237	this study	629500	5186591	Parkman	Ferrosilite iron formation	7b	43.75	0.07	1.43	46.76
03RME-0235	this study	653167	5186591	Butler	Garnet-kyanite gneiss	8a	62.09	0.80	22.13	7.74
03RME-0336	this study	651455	5148810	Butler	Garnet-kyanite gneiss	8a	60.89	0.90	21.86	8.93
03RME-0337	this study	651485	5148762	Butler	Garnet-kyanite gneiss	8a	64.76	0.67	20.65	6.76
03RME-0233	this study	652921	5153528	Butler	Pyrrhotite gneiss	8d	55.42	0.21	6.14	4.83
03RME-0006	this study	631863	5177971	McAuslan	Quartz-muscovite gneiss	10a	87.96	0.09	7.35	0.51
03RME-0071	this study	633600	5182600	Wyse	Orthoquartzite	10b	95.35	0.12	4.23	0.71
03RME-0072	this study	633628	5182560	Wyse	Muscovite schist	9e	75.57	0.42	13.30	2.79
03RME-0092	this study	638685	5174092	Clarkson	Quartz-muscovite gneiss	9a	73.34	0.30	15.01	0.95
03RME-0093	this study	638230	5170292	Clarkson	Quartz-muscovite gneiss	9a	73.96	0.24	14.09	1.03
03RME-0095	this study	639464	5170871	Clarkson	Quartz-muscovite gneiss	9a	76.77	0.27	12.67	0.96
03RME-1000	this study	639150	5173970	Clarkson	Quartzite	10a	95.54	0.06	2.98	0.38
03RME-1001	this study	639150	5173970	Clarkson	Quartzite	9e	76.00	0.41	13.55	2.53
03RME-1003	this study	639150	5173970	Clarkson	Quartzite	10a	93.33	0.09	4.27	0.80
03RME-0210	this study	647884	5151936	Butler	Quartz-muscovite gneiss	9b	74.53	0.45	14.30	2.96
01RME-0150	Easton 2002a	610792	5185535	Flett	Quartzose gneiss	10a	82.04	0.17	10.86	1.14
03RME-0124	this study	645296	5166878	Poitras	Feldspathic gneiss	9a	69.47	0.45	14.10	4.62
03RME-0270	this study	663814	5138465	Mattawan	Garnet amphibolite	20a	43.57	3.02	16.47	18.80
03RME-0097	this study	642452	5160054	Clarkson	Amphibolite	11a	49.50	0.41	9.47	9.12
03RME-0202	this study	646796	5152658	Butler	Amphibolite	11a	49.31	2.68	15.10	13.65
03RME-0204	this study	646856	5152654	Butler	Amphibolite	11a	51.76	0.62	15.97	9.45
03RME-0271	this study	659071	5138500	Mattawan	Garnet amphibolite	11b	46.40	0.94	17.66	11.70
03RME-0272	this study	654124	5138385	Olrig	Amphibolite	11a	48.16	0.36	7.40	9.46
03RME-0279	this study	653899	5138485	Olrig	Garnet amphibolite	11b	45.20	2.02	16.44	15.80
03RME-0258	this study	657705	5144604	Olrig	Metagabbro	19b	48.95	0.52	15.20	9.66
03RME-0201	this study	646517	5152725	Butler	Felsite	12	76.31	0.32	13.98	1.76
03RME-0203	this study	646856	5152654	Butler	Felsite	12	70.39	0.72	15.05	4.30
03RME-0016	this study	640133	5170683	Clarkson	Grey gneiss	13a	65.25	0.91	14.27	6.48
03RME-0017	this study	639995	5171075	Clarkson	Grey gneiss	13a	63.40	0.92	14.36	8.20
03RME-0122	this study	645638	5167283	Poitras	Granodiorite gneiss	13a	67.46	0.50	14.27	5.53
03RME-0004	this study	639418	5174360	Clarkson	Gneissic granite	14a	72.27	0.28	14.09	1.81
03RME-0040	this study	635520	5176422	Wyse	Gneissic granite	14a	73.09	0.21	14.31	1.29
03RME-0104	this study	640700	5159444	Jocko	Granite gneiss	15a	71.00	0.35	13.37	3.69
03RME-0280	this study	653020	5139015	Olrig	Granite gneiss	15b	75.05	0.42	12.43	3.25
03RME-0165	this study	626127	5164223	Garrow	Gneissic granite	16	73.84	0.25	13.59	1.97
03RME-0172	this study	624637	5167680	Garrow	Gneissic granite	16	76.50	0.29	12.62	1.99
03RME-0140	this study	647462	5167020	Poitras	Syenite	23	76.81	0.17	11.77	1.75
03RME-0259	this study	658288	5143621	Olrig	Quartz monzonite	21a	70.23	0.09	20.24	0.59
03RME-0314	this study	661499	5131900	Mattawan	Potassium feldspar	22	65.55	<0.01	19.00	0.03
03RME-0112	this study	641228	5150937	French	Breccia matrix	24a	65.91	0.56	15.20	5.66

Appendix 2. continued.

Sample Name	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5	CO_2	S	LOI	Total	CIA	Mg #
Method	XRF	XRF	XRF	XRF	XRF	XRF	XRF	XRF	XRF			
Units	wt.%	wt.%	wt.%	wt.%	wt.%	wt.%	wt.%	wt.%	wt.%	wt.%		
Detection Limit	***0.01***	***0.01***	***0.01***	***0.01***	***0.01***	***0.01***	***0.03***	***0.01***	***0.05***			
03RME-0294	0.15	22.00	8.48	0.33	0.06	0.11	0.06	<0.01	1.61	99.75	44.7	82.5
03RME-0299	0.13	22.79	7.67	0.64	1.68	0.16	0.13	<0.01	1.83	100.80	39.9	83.1
03RME-0083	0.20	4.01	4.69	4.36	2.27	1.80	0.08	<0.01	1.03	99.92	58.9	35.5
03RME-0094	0.09	2.56	2.62	4.04	3.99	0.17	0.10	<0.01	1.02	100.44	60.4	52.5
03RME-1002	0.02	2.81	2.47	3.41	1.53	0.10	0.10	<0.01	0.75	100.44	60.4	54.9
03RME-0206	0.17	1.36	3.34	4.88	3.37	0.33	0.07	<0.01	0.64	100.87	57.5	28.2
03RME-0237	3.71	5.73	0.90	0.02	0.03	0.13	1.65	<0.01	<0.05	102.53	195.9	19.5
03RME-0235	0.06	2.48	0.19	0.08	4.11	0.03	0.15	<0.01	1.54	101.25	84.0	38.8
03RME-0336	0.07	2.64	0.34	0.15	4.20	0.04	0.36	<0.01	1.43	101.45	83.5	36.9
03RME-0337	0.05	2.27	0.20	0.13	3.73	0.03	0.20	<0.01	1.46	100.71	84.3	39.9
03RME-0233	0.12	11.68	16.20	0.72	2.52	0.07	3.30	1.83	2.29	100.20	27.6	82.7
03RME-0006	<0.01	0.14	<0.01	0.14	1.98	0.02	0.03	<0.01	1.21	99.40	77.9	35.2
03RME-0071	<0.01	<0.01	<0.01	<0.01	0.10	0.02	<0.03	<0.01	0.28	100.81	97.7	0.0
03RME-0072	0.01	0.15	1.00	0.36	3.90	0.70	0.04	<0.01	2.03	100.23	71.8	9.6
03RME-0092	0.02	0.19	1.64	4.54	3.07	0.16	0.05	<0.01	0.79	100.01	62.0	28.4
03RME-0093	0.02	0.10	0.91	4.01	4.22	0.04	0.07	<0.01	0.69	99.31	60.8	16.1
03RME-0095	0.02	0.11	1.04	5.13	2.24	0.05	0.06	<0.01	0.32	99.58	60.3	18.5
03RME-1000	<0.01	0.07	0.14	0.18	0.80	0.02	0.09	<0.01	0.53	100.70	74.3	26.7
03RME-1001	0.09	0.46	0.05	0.10	4.82	0.05	0.05	<0.01	2.14	100.20	73.4	26.5
03RME-1003	0.00	0.15	0.29	0.34	0.96	0.02	0.12	<0.01	0.78	101.03	74.4	27.1
03RME-0210	0.10	0.28	0.70	1.52	5.15	0.02	0.04	<0.01	1.39	101.40	66.1	15.8
01RME-0150	<0.01	0.50	0.15	0.39	3.95	0.03	0.10	<0.01	1.48	100.71	71.2	46.5
03RME-0124	0.09	0.19	1.42	4.32	5.50	0.06	0.13	<0.01	0.45	100.67	55.9	7.5
03RME-0270	0.18	6.82	7.50	2.97	1.26	0.43	0.04	0.10	0.13	101.15	58.5	41.8
03RME-0097	0.14	14.75	11.68	1.16	1.11	0.19	0.09	<0.01	1.11	98.64	40.6	76.2
03RME-0202	0.21	4.22	7.31	3.75	1.80	1.03	0.19	0.01	0.55	99.61	54.4	38.0
03RME-0204	0.12	7.24	7.17	3.78	1.36	0.03	0.11	<0.01	1.36	98.86	56.7	60.3
03RME-0271	0.17	9.03	9.93	3.34	0.42	0.06	0.11	<0.01	0.79	100.44	56.5	60.5
03RME-0272	0.17	17.73	13.78	0.85	0.41	0.03	0.54	<0.01	1.48	99.83	33.8	78.8
03RME-0279	0.22	6.36	10.12	2.63	1.11	0.27	0.35	<0.01	1.15	101.32	54.9	44.4
03RME-0258	0.17	9.90	12.73	2.27	0.89	0.09	0.16	<0.01	0.88	101.26	49.1	67.0
03RME-0201	0.03	0.31	0.68	1.89	5.40	0.03	0.20	<0.01	0.41	101.12	64.3	25.9
03RME-0203	0.04	0.37	1.27	3.71	4.58	0.10	0.07	<0.01	0.71	101.24	61.3	14.6
03RME-0016	0.10	0.89	2.46	3.98	4.89	0.24	0.07	0.02	0.57	100.04	55.9	21.4
03RME-0017	0.15	0.64	2.44	4.17	4.43	0.20	0.48	0.01	0.95	99.86	57.6	13.4
03RME-0122	0.11	0.18	1.52	4.17	5.73	0.05	0.49	<0.01	0.90	100.42	56.6	6.1
03RME-0004	0.02	0.40	1.05	3.23	6.15	0.10	0.07	<0.01	0.53	99.93	57.6	30.4
03RME-0040	0.02	0.25	1.30	4.58	4.45	0.06	0.05	0.01	0.41	99.97	58.2	27.7
03RME-0104	0.08	0.14	0.85	4.24	5.76	0.03	0.06	<0.01	0.39	99.90	55.3	7.0
03RME-0280	0.04	0.21	0.51	2.96	5.65	0.06	0.04	<0.01	0.36	100.94	57.8	11.3
03RME-0165	0.03	0.26	0.66	3.57	5.95	0.03	0.06	<0.01	0.59	100.74	57.3	20.7
03RME-0172	0.04	0.30	1.26	3.98	3.77	0.08	0.04	<0.01	0.47	101.30	58.5	23.0
03RME-0140	0.03	0.06	0.23	3.47	5.39	0.01	0.22	<0.01	0.58	100.27	57.0	6.4
03RME-0259	0.01	0.14	0.94	3.37	4.04	0.01	0.03	<0.01	0.33	99.99	70.9	32.0
03RME-0314	<0.01	0.07	0.05	1.83	14.02	<0.01	0.05	<0.01	0.45	101.00	54.5	82.2
03RME-0112	0.09	2.12	3.89	3.23	2.74	0.09	0.08	<0.01	0.84	100.33	60.8	42.6

Appendix 2. continued.

Sample Name	Cr	Ni	Co	Sc	V	Cu	Pb	Zn	Sn	W	As	Mo	Au	Pt	Pd
Method	XRF	ICP-AES	ICP-AES	ICP-AES	ICP-AES	ICP-AES	XRF	ICP-AES	XRF	ICP-AES	XRF	ICP-AES	FA	FA	FA
Units	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppb	ppb	ppb
Detection Limit	***4***	***3***	***1***	***0.3***	***0.6***	***3***	***5***	***2***	***5***	***2***	***1***	***8***	***6.0***	***1.0***	***2.0***
03RME-0294	2106	545	64	24	54	<3	<5	68	<5	<3	<1	<8	<6.0	<1.0	<2.0
03RME-0299	3498	805	76	20	21	11	6	70	<5	<3	<1	<8	<6.0	<1.0	<2.0
03RME-0083	<4	19	14	17	54	89	26	189	<5	<2	<1	<8	<6.0	<1.0	<2.0
03RME-0094	17	17	12	10	82	<3	11	61	<5	3	<1	<8	<6.0	<1.0	<2.0
03RME-1002	69	24	15	11	77	<3	15	57	<5	3	<1	<8	<6.0	<1.0	<2.0
03RME-0206	13	8	8	12	414	<3	14	105	<5	4	<1	<8	<6.0	<1.0	<2.0
03RME-0237	35	41	43	2	23	<3	<5	91	<5	<3	<1	<8	<6.0	<1.0	<2.0
03RME-0235	128	34	22	5	19	8	<5	59	6	<3	<1	<8	<6.0	<1.0	<2.0
03RME-0336	129	36	21	5	32	<3	<5	91	<5	<3	<1	<8	<6.0	<1.0	<2.0
03RME-0337	114	28	21	7	36	<3	<5	80	<5	<3	<1	<8	<6.0	<1.0	<2.0
03RME-0233	52	25	13	4	56	9	20	35	<5	3	7	<8	<6.0	<1.0	<2.0
03RME-0006	<4	<3	<1	1	6	<3	6	13	<5	<2	<1	<8	<6.0	<1.0	<2.0
03RME-0071	17	<3	<1	7	1	<3	<5	3	<5	<2	2	<8	<6.0	<1.0	<2.0
03RME-0072	27	15	3	5	28	<3	8	8	<5	<2	2	<8	<6.0	<1.0	<2.0
03RME-0092	<4	<3	<1	5	9	<3	23	20	<5	5	2	<8	<6.0	<1.0	<2.0
03RME-0093	<4	<3	<1	4	7	<3	10	24	<5	<2	<1	<8	<6.0	<1.0	<2.0
03RME-0095	<4	<3	<1	4	7	<3	10	14	<5	4	<1	<8	<6.0	<1.0	<2.0
03RME-1000	8	<3	<1	1	4	<3	<5	7	<5	<2	<1	<8	<6.0	<1.0	<2.0
03RME-1001	10	6	3	2	13	<3	9	39	<5	3	<1	<8	<6.0	<1.0	<2.0
03RME-1003	5	4	1	1	6	<3	6	16	<5	<3	<1	<8	<6.0	<1.0	<2.0
03RME-0210	10	5	4	4	116	<3	24	67	<5	<3	<1	<8	<6.0	<1.0	<2.0
01RME-0150	16	<5	<5	1	25	<5	<5	21	<5	<35	<2	<8	<5.0	<8.0	<8.0
03RME-0124	21	5	2	4	102	5	22	144	<5	6	<1	<8	<6.0	<1.0	<2.0
03RME-0270	106	85	52	19	329	43	<5	157	<5	<3	<1	<8	<6.0	<1.0	<2.0
03RME-0097	1570	355	55	37	159	127	8	72	<5	<2	<1	<8	<6.0	6.7	9.6
03RME-0202	40	37	28	19	640	26	11	147	<5	<3	<1	<8	<6.0	<1.0	<2.0
03RME-0204	76	125	51	17	518	<3	9	78	<5	3	<1	<8	<6.0	<1.0	<2.0
03RME-0271	59	163	60	20	362	<3	<5	86	<5	<3	<1	<8	13.0	<1.0	<2.0
03RME-0272	1774	230	68	50	106	30	<5	99	<5	<3	<1	<8	<6.0	11.2	20.8
03RME-0279	91	59	48	34	371	11	7	128	<5	<3	<1	<8	<6.0	<1.0	<2.0
03RME-0258	450	88	48	35	346	38	6	68	<5	<3	<1	<8	<6.0	5.3	4.5
03RME-0201	24	3	3	4	166	<3	25	40	<5	<3	1	<8	<6.0	<1.0	<2.0
03RME-0203	45	10	5	5	255	<3	13	37	<5	10	<1	<8	<6.0	<1.0	<2.0
03RME-0016	<4	9	5	9	20	3	21	120	<5	<2	<1	<8	<6.0	<1.0	<2.0
03RME-0017	<4	10	3	12	13	4	20	154	<5	<2	<1	<8	<6.0	<1.0	<2.0
03RME-0122	<4	4	1	4	67	<3	20	172	<5	<3	<1	<8	<6.0	<1.0	<2.0
03RME-0004	<4	4	2	3	17	7	26	52	<5	<2	2	<8	<6.0	<1.0	<2.0
03RME-0040	15	3	2	3	14	18	23	22	<5	<2	2	<8	<6.0	<1.0	<2.0
03RME-0104	<4	5	<1	3	<1	<3	16	143	<5	<2	<1	<8	7.1	<1.0	<2.0
03RME-0280	6	4	3	4	131	7	26	88	<5	<3	1	<8	<6.0	<1.0	<2.0
03RME-0165	18	<3	2	5	82	<3	19	45	<5	11	<1	<8	<6.0	<1.0	<2.0
03RME-0172	22	<3	2	5	164	<3	15	34	<5	5	<1	<8	<6.0	<1.0	<2.0
03RME-0140	4	<3	2	1	30	<3	20	53	<5	7	<1	<8	<6.0	<1.0	<2.0
03RME-0259	5	<3	2	1	164	3	22	6	<5	3	<1	<8	6.7	<1.0	<2.0
03RME-0314	14	5	2	<1	319	<3	110	-2	<5	<3	7	<8	<6.0	<1.0	<2.0
03RME-0112	57	33	15	9	73	65	18	111	<5	4	<1	<8	<6.0	<1.0	2.0

Appendix 2. continued.

Sample Name	Rb	Rb	Cs	Ba	Sr	Sr	Sr	Ga	Ta	Nb	Nb	Hf	Zr	Zr	Y
Method	XRF	ICP-MS	ICP-MS	XRF	XRF	ICP-AES	ICP-MS	XRF	ICP-MS	XRF	ICP-MS	ICP-MS	ICP-MS	XRF	XRF
Units	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
Detection Limit	***2***	***0.05***	***0.007***	***20***	***2***	***0.7***	***0.5***	***2***	***0.2***	***2***	***0.2***	***0.1***	***4***	***3***	***1***
03RME-0294	<2	1	0.01	<20	55	53.7	59.4	9	0.20	<2	3.5	1.30	51	44	12
03RME-0299	70	70	8.98	203	21	21.1	21.3	7	<0.20	<2	2.3	1.00	37	33	7
03RME-0083	66	71	3.99	2360	472	432.0	497.0	25	1.57	22	28.3	9.80	445	405	60
03RME-0094	113	143	3.18	1250	327	318.0	403.0	16	0.92	9	12.3	4.60	183	177	31
03RME-1002	35	44	2.24	424	397	382	488.0	11	0.48	4	5.6	3.20	107	133	14
03RME-0206	83	92	1.95	1178	422	469	469.0	19	0.62	10	12.0	5.30	217	186	32
03RME-0237	<2	1	0.25	35	27	22.8	22.7	3	<0.20	<2	1.6	1.00	48	43	36
03RME-0235	178	38	2.14	387	44	18.6	22.0	29	0.97	18	19.6	8.10	293	257	39
03RME-0336	188	49	2.82	410	58	32.2	40.4	29	0.98	17	19.0	6.60	250	217	34
03RME-0337	162	90	2.91	369	45	35.7	44.0	29	0.89	16	18.7	9.30	344	287	38
03RME-0233	66	63	2.43	447	64	56.0	60.5	8	0.44	5	6.1	4.30	170	180	19
03RME-0006	64	48	1.09	256	19	18.8	24.2	7	0.31	<2.0	2.5	3.40	149	118	5
03RME-0071	3	3	0.60	<20	25	27.4	32.2	5	0.55	4	5.8	2.80	106	83	8
03RME-0072	99	98	2.61	565	94	89.7	101.0	17	0.99	10	13.0	6.90	279	240	22
03RME-0092	90	73	1.73	482	269	265.0	326.0	10	1.00	11	14.4	7.00	281	240	21
03RME-0093	136	107	1.86	644	146	149.0	182.0	12	1.08	13	16.7	5.90	212	183	35
03RME-0095	61	45	1.08	787	248	245.0	312.0	8	0.85	9	12.8	5.20	214	182	19
03RME-1000	26	20	0.53	65	12	12.9	14.6	4	0.29	<2.0	2.0	2.00	76	59	5
03RME-1001	80	111	2.54	827	30	21.1	24.9	13	0.77	9	10.9	5.50	219	175	18
03RME-1003	29	23	0.72	178	30	33.4	38.4	3	0.31	<2.0	2.8	1.80	68	55	9
03RME-0210	139	150	2.54	1480	112	116.0	131.0	17	0.92	15	18.4	6.60	265	230	28
01RME-0150		161	3.54	522			27.0	27	0.36	4		1.82	72		2
03RME-0124	132	150	2.27	1036	100	102.0	118.0	28	2.97	51	56.9	17.00	701	648	63
03RME-0270	32	32	0.72	727	369	329.0	364	24	0.51	7	8.7	3.10	122	166	35
03RME-0097	22	25	1.15	426	163	168.0	163	12	0.27	3	3.4	1.20	41	41	12
03RME-0202	28	30	0.89	1423	711	640.0	702	23	0.79	12	14.7	3.00	130	193	27
03RME-0204	45	50	1.59	322	549	518.0	567	14	0.32	3	4.8	2.20	85	87	14
03RME-0271	5	6	0.12	198	376	362.0	395	19	<0.20	<2	15.0	1.30	48	52	14
03RME-0272	6	5	0.05	75	105	106.0	105	8	<0.20	<2	0.8	0.70	22	24	8
03RME-0279	10	10	0.11	202	410	371.0	408	23	0.27	2	4.3	2.90	112	127	32
03RME-0258	16	15	0.16	233	366	346.0	371	15	<0.20	<2	1.2	0.80	28	31	10
03RME-0201	143	150	2.39	1431	169	166.0	201.0	14	0.88	13	16.0	6.90	266	214	26
03RME-0203	87	97	0.62	1789	264	255.0	293.0	15	0.66	15	18.0	11.00	471	391	32
03RME-0016	130	161	2.92	1210	230	230.0	272.0	23	2.22	33	37.6	11.70	491	463	45
03RME-0017	101	132	2.92	1580	234	234.0	305.0	26	2.35	42	46.3	14.60	668	605	55
03RME-0122	132	146	2.80	815	68	67.2	77.0	30	3.28	59	64.0	23.30	1070	970	67
03RME-0004	207	261	2.59	1140	252	252.0	304.0	17	0.48	7	9.3	7.50	302	243	7
03RME-0040	137	183	1.09	909	308	308.0	401.0	20	1.17	11	14.2	5.70	210	172	12
03RME-0104	98	125	0.95	507	49	49.0	61.8	29	2.18	46	51.6	16.70	787	686	49
03RME-0280	117	129	0.43	1054	130	131.0	146.0	23	0.85	17	22.0	16.50	680	586	62
03RME-0165	140	150	0.75	719	82	82.4	97.0	18	1.08	24	27.0	7.80	303	244	25
03RME-0172	76	92	0.49	814	166	164.0	168.0	17	0.86	15	19.0	5.80	226	209	21
03RME-0140	130	150	1.98	341	30	29.6	37.0	25	2.13	31	34.0	9.90	356	290	39
03RME-0259	64	77	0.20	1002	160	164.0	191.0	19	<0.20	<2	1.0	2.20	56	2	2
03RME-0314	239	>150	1.25	2860	330	319.0	412.0	16	<0.20	<2	0.3	<0.10	<4	6	3
03RME-0112	76	100	1.92	975	342	342.0	439.0	23	1.38	22	27.0	15.30	644	596	33

Appendix 2. continued.

Sample Name	**Y**	**Th**	**Th**	**U**	**Be**	**La**	**Ce**	**Pr**	**Nd**	**Sm**	**Eu**	**Gd**	**Tb**
Method	ICP-MS	XRF	ICP-MS	ICP-MS	ICP-AES	ICP-MS	ICP-MS	ICP-MS	ICP-MS	ICP-MS	ICP-MS	ICP-MS	ICP-MS
Units	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
Detection Limit	***0.02***	***4***	***0.1***	***0.007***	***0.1***	***0.02***	***0.07***	***0.006***	***0.03***	***0.01***	***0.005***	***0.009***	***0.003***
03RME-0294	12.4	<4	1.9	0.70	0.8	7.90	20.70	2.83	13.00	2.99	0.91	2.81	0.42
03RME-0299	7.0	<4	1.4	0.38	0.7	9.38	21.00	2.80	11.70	2.45	0.55	2.11	0.27
03RME-0083	64.7	<4	3.2	0.88	2.3	77.46	167.69	23.37	103.53	19.79	5.98	16.56	2.29
03RME-0094	35.4	11	12.8	3.00	1.7	53.26	93.40	12.24	44.26	7.50	1.64	5.92	0.94
03RME-1002	17.4	5	6.4	1.06	0.5	25.94	49.67	6.24	23.73	4.29	1.04	3.66	0.51
03RME-0206	35.2	5	7.1	1.10	1.5	35.90	79.90	9.96	40.50	8.12	2.22	7.22	1.07
03RME-0237	33.8	<4	1.1	0.40	1.9	11.30	19.80	2.37	10.90	2.49	0.72	3.70	0.60
03RME-0235		22	19	2.96	0.2	53.30	114.00	13.60	49.80	8.90	0.95	6.54	0.84
03RME-0336	20	18	16	2.39	0.2	46.40	98.10	11.60	42.00	7.62	1.06	5.44	0.67
03RME-0337	25	19	21	3.22	<0.1	64.60	137.00	15.90	57.90	10.10	1.32	6.84	0.88
03RME-0233	19	6	5	2.61	0.7	18.30	38.20	4.92	18.80	3.92	0.88	3.74	0.59
03RME-0006	5.1	<4	4	0.69	0.8	12.45	18.22	2.99	10.60	1.73	0.36	1.24	0.18
03RME-0071	10.4	6	9	0.63	0.4	20.93	44.06	4.72	16.73	2.96	0.42	2.11	0.31
03RME-0072	25.1	9	13	2.73	2.0	37.26	67.19	8.48	32.12	6.47	1.21	5.68	0.83
03RME-0092	25.8	10	13	1.83	2.3	76.68	130.71	16.59	60.75	9.56	1.96	6.92	0.90
03RME-0093	43.9	9	12	2.16	2.3	58.65	113.40	13.08	49.21	8.48	1.47	6.85	1.12
03RME-0095	24.7	7	9	0.67	1.5	45.31	89.52	10.25	37.52	6.06	1.38	4.60	0.69
03RME-1000	6.9	<4	4	0.47	0.2	11.44	26.87	2.71	9.92	1.69	0.34	1.31	0.19
03RME-1001	10.4	8	8	1.47	1.0	16.19	32.33	4.24	16.26	2.84	0.79	2.15	0.34
03RME-1003	10.6	<4	4	0.91	0.4	18.71	36.59	4.30	15.26	2.51	0.61	1.94	0.30
03RME-0210	31.0	13	16	2.77	1.8	67.40	121.00	15.30	54.20	8.88	1.65	6.31	0.88
01RME-0150			4	0.52	<3.0	3.92	7.02	0.95	3.28	0.53	0.11	0.39	0.06
03RME-0124	71.0	9	13	4.06	3.9	80.70	168.00	22.00	85.50	16.40	2.72	14.20	2.18
03RME-0270	36	<4	1	0.42	0.8	16.30	39.30	5.96	28.60	7.08	2.56	8.04	1.24
03RME-0097	12	<4	2	0.42	1.3	12.74	28.89	3.99	17.52	3.91	1.05	3.47	0.47
03RME-0202	28	<4	2	0.43	1.0	48.50	104.00	14.20	60.00	11.10	3.86	9.23	1.15
03RME-0204	15	<4	3	0.43	0.4	9.25	18.90	2.10	10.60	2.37	0.88	2.58	0.42
03RME-0271	16	<4	0	0.30	0.3	3.95	9.46	1.43	7.53	2.12	0.99	2.88	0.48
03RME-0272	9	<4	0	0.10	0.3	3.16	7.79	1.19	5.95	1.74	0.51	1.79	0.29
03RME-0279	33	<4	1	0.19	0.8	11.90	29.40	4.46	21.40	5.78	2.09	6.56	1.03
03RME-0258	11	<4	0	0.13	0.4	5.15	11.80	1.71	8.17	2.07	0.81	2.34	0.37
03RME-0201	30.0	12	14	2.08	1.4	50.30	94.90	12.30	44.80	7.25	1.43	5.60	0.81
03RME-0203	36.0	12	14	1.59	0.8	51.50	99.40	11.80	42.40	7.15	1.72	5.49	0.82
03RME-0016	53.4	9	12	3.76	3.1	69.84	140.84	18.06	70.84	13.33	2.44	10.74	1.59
03RME-0017	65.6	7	10	2.29	2.5	73.48	148.07	19.76	80.17	15.61	3.50	12.86	1.98
03RME-0122	71.0	10	14	3.87	3.9	85.40	172.00	23.00	90.00	16.80	3.03	14.40	2.18
03RME-0004	9.5	26	28	2.39	1.2	81.01	147.82	16.35	60.52	6.60	0.87	3.45	0.40
03RME-0040	15.0	28	30	3.70	2.3	35.37	74.11	7.59	25.17	4.05	0.66	2.67	0.42
03RME-0104	60.2	7	12	1.42	2.0	159.12	302.20	39.35	149.33	23.20	2.16	15.78	2.18
03RME-0280	68.0	8	12	1.46	1.6	86.10	185.00	22.20	86.80	17.20	1.77	15.30	2.34
03RME-0165	28.0	13	16	0.95	1.8	85.70	172.00	20.20	68.90	10.50	0.97	7.06	1.00
03RME-0172	24.0	8	11	0.84	2.3	66.40	124.00	14.40	47.00	6.67	1.53	5.18	0.74
03RME-0140	41.0	13	14	2.24	2.8	98.00	179.00	22.70	79.40	12.40	1.38	9.42	1.34
03RME-0259	2.0	<4	4	0.35	1.0	14.20	21.00	2.05	6.41	0.77	0.53	0.59	0.07
03RME-0314	1.0	<4	<0.06	0.11	0.4	0.19	0.25	0.04	0.19	0.09	0.70	0.07	0.02
03RME-0112	42.1	<4	10	2.10	2.0	76.18	149.51	18.09	68.09	11.41	1.90	9.15	1.29

Appendix 2. continued.

Sample Name	Dy	Ho	Er	Tm	Yb	Lu	Total REE	Zr/Y
Method	ICP-MS	ICP-MS	ICP-MS	ICP-MS	ICP-MS	ICP-MS		
Units	ppm	ppm	ppm	ppm	ppm	ppm	ppm	
Detection Limit	***0.008***	***0.003***	***0.008***	***0.003***	***0.01***	***0.003***		
03RME-0294	2.36	0.48	1.37	0.18	1.19	0.18	57.3	4.1
03RME-0299	1.34	0.26	0.73	0.11	0.64	0.11	53.4	5.3
03RME-0083	12.43	2.41	6.23	0.85	5.14	0.78	444.5	7.4
03RME-0094	5.59	1.14	3.43	0.54	3.52	0.55	233.9	5.9
03RME-1002	2.83	0.59	1.71	0.25	1.70	0.26	122.4	7.6
03RME-0206	6.22	1.20	3.59	0.54	3.43	0.53	200.4	6.8
03RME-0237	4.02	0.93	2.92	0.40	2.20	0.34	62.7	1.3
03RME-0235	3.99	0.77	2.33	0.37	2.51	0.42	258.3	7.5
03RME-0336	3.40	0.74	2.27	0.36	2.48	0.42	222.6	7.4
03RME-0337	4.35	0.89	2.70	0.46	3.07	0.49	306.5	9.1
03RME-0233	3.28	0.66	2.00	0.29	1.93	0.28	97.8	8.9
03RME-0006	0.93	0.18	0.51	0.08	0.59	0.10	50.2	23.6
03RME-0071	1.63	0.34	1.03	0.15	1.03	0.15	96.6	10.4
03RME-0072	4.16	0.82	2.26	0.36	2.31	0.36	169.5	10.9
03RME-0092	4.64	0.88	2.40	0.37	2.38	0.40	315.1	11.4
03RME-0093	6.66	1.44	4.34	0.71	4.54	0.74	270.7	5.2
03RME-0095	3.99	0.82	2.32	0.37	2.28	0.38	205.5	9.6
03RME-1000	1.12	0.24	0.68	0.10	0.72	0.11	57.4	11.8
03RME-1001	1.87	0.40	1.11	0.17	1.07	0.18	79.9	9.7
03RME-1003	1.73	0.34	0.90	0.17	1.00	0.16	84.5	6.1
03RME-0210	5.06	1.07	3.41	0.57	4.22	0.70	290.7	9.5
01RME-0150	0.30	0.06	0.17	0.03	0.24	0.04	17.1	40.9
03RME-0124	12.70	2.52	7.43	1.13	7.20	1.14	423.8	11.1
03RME-0270	7.01	1.40	3.88	0.54	3.23	0.51	125.7	3.4
03RME-0097	2.31	0.44	1.19	0.17	1.03	0.16	77.3	3.4
03RME-0202	5.88	1.08	2.78	0.37	2.34	0.34	264.8	4.6
03RME-0204	2.60	0.53	1.66	0.25	1.51	0.23	53.9	5.7
03RME-0271	2.90	0.60	1.76	0.25	1.58	0.25	36.2	3.0
03RME-0272	1.80	0.36	1.02	0.15	0.86	0.13	26.7	2.6
03RME-0279	6.12	1.27	3.65	0.52	3.21	0.51	97.9	3.4
03RME-0258	2.12	0.44	1.32	0.18	1.07	0.18	37.7	2.5
03RME-0201	4.82	0.98	3.08	0.48	3.19	0.53	230.5	10.2
03RME-0203	5.19	1.23	4.53	0.78	5.33	0.88	238.2	14.7
03RME-0016	8.84	1.82	5.14	0.77	4.77	0.73	349.7	10.9
03RME-0017	11.09	2.21	6.37	0.94	6.01	0.95	383.0	12.1
03RME-0122	12.40	2.53	7.37	1.17	7.81	1.32	439.4	16.0
03RME-0004	1.76	0.30	0.82	0.12	0.74	0.13	320.9	43.1
03RME-0040	2.29	0.44	1.28	0.19	1.28	0.19	155.7	17.5
03RME-0104	11.67	2.31	5.98	0.91	5.65	0.91	720.8	16.1
03RME-0280	13.60	2.56	6.99	1.05	6.82	1.09	448.8	11.0
03RME-0165	5.46	1.07	3.03	0.43	2.80	0.45	379.6	12.1
03RME-0172	4.14	0.85	2.53	0.41	2.62	0.43	276.9	10.8
03RME-0140	7.35	1.44	4.21	0.64	4.04	0.66	422.0	9.1
03RME-0259	0.41	0.07	0.29	0.04	0.34	0.07	46.8	28.0
03RME-0314	0.18	0.05	0.20	0.03	0.26	0.04	2.3	NC
03RME-0112	7.38	1.55	4.20	0.64	4.03	0.64	354.1	19.5

Appendix 3

Listing of Geochemical Data on Rock Units in the Study Area Compiled from the Literature

Abbreviations

NA = not analyzed
NC = not calculated
NR = not reported
less than (<) symbol indicates element was below the detection limit in the sample
greater than (>) symbol indicates element was above instrument calibration limit

Appendix 3. Listing of geochemical data on rock units in the study area compiled from the literature.

Sample Name	Source	Township	Rock Type	Map Code	SiO_2	TiO_2	Al_2O_2	Fe_2O_3	FeO
Units					wt. %	wt. %	wt. %	wt. %	wt. %
B71-45	Moore 1976	Olrig	Antoine gneiss	1	66.45	0.68	16.09	0.93	4.15
CS	Moore 1976	NR	Calc-silicate gneiss	4	69.18	0.39	10.12	3.11	2.48
B71-66	Moore 1976	Olrig	Calc-silicate gneiss	4	61.07	0.77	16.95	3.01	2.91
B71-99	Moore 1976	NR	Calc-silicate gneiss	4	61.88	0.56	13.93	5.36	1.45
B71-14	Moore 1976	Butler	Calc-silicate gneiss	4	55.39	0.63	16.69	1.87	6.88
A14	Pearson 1959	Butler	Calc-silicate gneiss	4	48.87	0.70	11.80	5.49	6.12
A2	Pearson 1959	Butler	Calc-silicate gneiss	4	49.62	0.79	14.30	4.61	4.84
A4	Pearson 1959	Butler	Calc-silicate gneiss	4	60.61	0.53	14.70	3.13	4.30
A9	Pearson 1959	Butler	Calc-silicate gneiss	4	48.15	1.21	14.90	6.08	4.80
A15	Pearson 1959	Butler	Calc-silicate gneiss	4	53.66	0.72	14.60	5.60	4.48
A5	Pearson 1959	Butler	Calc-silicate gneiss	4	52.83	2.19	14.30	2.95	9.56
A8	Pearson 1959	Butler	Calc-silicate gneiss	4	54.17	0.73	17.30	7.20	3.40
CMR03	Marmont 2000	Parkman	Silicate iron formation	7b	NA	0.017	0.57	NA	6.57
CMR06	Marmont 2000	Parkman	Iron formation	7a	NA	<0.01	0.23	NA	>19.30
PKC02	Marmont 2000	Parkman	Calc-silicate gneiss	7b	NA	0.35	2.38	NA	5.88
PKW01	Marmont 2000	Parkman	Iron formation	7a	NA	0.05	1.00	NA	>19.30
PKW02	Marmont 2000	Parkman	Silicate iron formation	7b	NA	<0.01	0.17	NA	4.81
PKW03	Marmont 2000	Parkman	Skarn rock	4	NA	<0.01	0.21	NA	4.52
PKW005	Marmont 2000	Parkman	Pyroxene rock	4	NA	<0.01	0.23	NA	7.55
PKW007	Marmont 2000	Parkman	Skarn rock	4	NA	0.017	0.23	NA	>19.30
PKW008	Marmont 2000	Parkman	Iron formation	7a	NA	0.017	0.32	NA	>19.30
A10	Pearson 1959	Butler	Kyanite gneiss	8a	60.41	0.47	23.20	0.24	6.24
A12	Pearson 1959	Butler	Kyanite gneiss	8a	60.62	0.55	22.70	1.96	4.40
A1	Pearson 1959	Butler	Kyanite gneiss	8a	70.78	0.37	14.70	0.64	3.44
A19	Pearson 1959	Butler	Pyrite gneiss	8b	55.17	0.36	23.00	1.61	0.36
A20	Pearson 1959	Butler	Pyrite gneiss	8b	72.34	0.27	12.20	0.96	0.84
A27	Pearson 1959	Butler	Pyrite gneiss	8b	78.96	0.42	8.50	1.73	0.36
B71-10	Moore 1976	Butler	Psammite	9b	78.03	0.25	13.75	0.91	0.84
B71-51	Moore 1976	Butler	Psammite	10a	82.09	0.63	10.90	3.17	1.54
Red	McAuslan SP-015	McAuslan	Quartz-muscovite gneiss	9e	81.20	0.16	10.60	1.34	NA
Green	McAuslan SP-015	McAuslan	Quartz-muscovite gneiss	9e	83.20	0.29	9.51	1.77	NA
Black	McAuslan SP-015	McAuslan	Quartz-muscovite gneiss	9e	68.40	0.33	16.70	4.50	NA
B71-28	Moore 1976	Butler	Amphibolite	11	52.74	0.98	17.65	1.54	7.63
Hb-Ky	Moore 1976	Olrig	Amphibolite	11	47.50	1.06	17.99	0.95	8.97
B71-2	Moore 1976	Butler	Granite gneiss	15a	72.28	0.39	13.75	0.19	3.39
B71-4	Moore 1976	Butler	Granite gneiss	15b	69.70	0.50	15.31	0.17	4.52

Appendix 3. continued.

Sample Name	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5	CO_2	S	LOI	Total	CIA	Mg #
Units	wt. %	wt. %	wt. %	wt. %	wt. %	wt. %	wt. %	wt. %	wt. %	wt. %		
B71-45	0.11	0.55	2.16	3.31	5.04	0.18	NA	NA	NA	99.65	60.5	16.4
CS	0.09	2.98	9.59	0.24	0.17	0.03	NA	NA	NA	98.38	50.3	50.2
B71-66	0.12	2.72	3.28	3.55	3.02	0.22	NA	NA	NA	97.62	63.2	46.3
B71-99	0.12	2.38	13.19	0.48	0.11	0.16	NA	NA	NA	99.62	50.3	40.3
B71-14	0.19	5.73	8.69	2.25	1.22	0.17	NA	NA	NA	99.71	57.9	54.4
A14	0.24	8.90	10.80	2.35	0.48	0.00	0.71	NA	NA	95.75	47.7	58.9
A2	0.13	10.40	7.70	3.92	1.65	0.00	0.08	NA	NA	97.96	52.0	67.3
A4	0.08	4.00	5.30	3.19	1.95	0.00	0.14	NA	NA	97.79	58.8	50.0
A9	0.23	10.90	8.12	2.98	1.67	0.00	0.11	NA	NA	99.04	54.1	65.4
A15	0.12	4.51	9.10	3.30	1.12	0.00	0.05	NA	NA	97.21	52.0	45.8
A5	0.18	5.30	7.15	3.14	1.25	0.00	0.18	NA	NA	98.85	55.7	43.6
A8	0.16	2.39	6.30	3.90	1.90	0.00	0.11	NA	NA	97.45	59.1	30.1
CMR03	0.36	0.52	0.73	NA	0.48	0.09	NA	1.19	NA	9.34	32.0	11.2
CMR06	0.05	0.34	0.10	NA	0.01	0.04	NA	<0.01	NA	0.77	67.3	NC
PKC02	2.01	0.25	2.20	NA	0.78	0.11	NA	0.24	NA	13.96	44.4	6.4
PKW01	0.22	0.32	0.11	NA	0.36	0.15	NA	0.36	NA	2.22	68.0	NC
PKW02	0.22	0.23	0.27	NA	<0.01	0.03	NA	0.10	NA	5.73	38.6	7.2
PKW03	0.46	0.31	1.05	NA	<0.01	0.04	NA	0.15	NA	6.59	16.7	9.9
PKW005	0.13	0.08	0.11	NA	0.06	0.07	NA	0.12	NA	8.23	57.5	1.6
PKW007	0.15	0.09	0.04	NA	0.96	0.03	NA	0.11	NA	1.52	18.7	NC
PKW008	0.15	0.11	0.06	NA	0.01	0.03	NA	0.01	NA	0.70	82.1	NC
A10	<0.01	1.90	0.20	0.36	4.60	0.00	1.32	NA	NA	97.62	85.8	34.4
A12	<0.01	1.62	0.20	1.78	5.08	0.00	1.10	NA	NA	98.91	79.2	31.9
A1	<0.01	4.10	0.20	0.35	4.81	0.00	0.43	NA	NA	99.39	74.9	64.5
A19	NA	3.20	0.82	1.49	11.80	0.00	0.56	NA	NA	97.81	62.9	75.9
A20	NA	2.19	1.22	1.04	5.20	0.00	1.66	NA	NA	96.26	67.8	69.6
A27	NA	1.77	1.39	2.06	3.76	0.00	0.41	NA	NA	98.95	55.6	62.2
B71-10	0.03	0.24	0.04	0.45	5.51	0.03	NA	NA	NA	100.08	69.6	20.5
B71-51	0.03	0.23	0.17	0.41	2.50	0.08	NA	NA	NA	101.75	78.0	8.5
Red	0.10	0.20	0.03	0.13	3.27	0.03	NA	NA	1.64	98.70	75.6	22.8
Green	0.01	0.28	0.04	0.13	2.95	0.03	NA	NA	1.51	99.72	75.3	23.9
Black	0.05	0.80	0.66	0.24	5.35	0.04	NA	NA	2.65	99.72	72.8	26.0
B71-28	0.14	6.38	8.33	2.47	0.46	0.10	NA	NA	NA	98.42	61.1	55.8
Hb-Ky	0.14	8.13	9.64	2.28	0.53	0.19	NA	NA	NA	97.38	59.1	59.6
B71-2	0.09	0.09	0.72	1.11	5.27	0.04	NA	NA	NA	97.32	65.9	4.3
B71-4	0.12	0.12	1.09	4.66	4.84	0.08	NA	NA	NA	101.11	59.1	4.4

Appendix 3. continued.

Sample Name	Source	Township	Rock Type	Map Code	SiO_2	TiO_2	Al_2O_3	Fe_2O_3
Units					wt. %	wt. %	wt. %	wt. %
Mulock granite *								
MA1	Lumbers et al. 1991	NR	granite	16	67.98	0.51	15.24	0.96
MA2	Lumbers et al. 1991	NR	granite	16	69.03	0.51	15.16	3.60
MA3	Lumbers et al. 1991	NR	granite	16	68.20	0.54	14.85	3.87
MA4	Lumbers et al. 1991	NR	granite	16	68.66	0.45	15.48	2.98
MA5	Lumbers et al. 1991	NR	granite	16	68.24	0.62	14.27	4.00
MA6	Lumbers et al. 1991	NR	granite	16	66.87	0.76	14.46	4.90
MA7	Lumbers et al. 1991	NR	granite	16	69.04	0.46	14.25	3.80
MI1	Lumbers et al. 1991	NR	granite	16	69.94	0.62	13.99	4.38
MI2	Lumbers et al. 1991	NR	granite	16	69.74	0.60	14.12	4.07
MS1	Lumbers et al. 1991	NR	granite	16	69.17	0.77	13.78	4.01
MS2	Lumbers et al. 1991	NR	granite	16	68.28	0.73	13.65	4.64
MS3	Lumbers et al. 1991	NR	granite	16	69.56	0.72	14.00	3.55
MS4	Lumbers et al. 1991	NR	granite	16	68.69	0.82	13.23	5.28
MS5	Lumbers et al. 1991	NR	granite	16	69.27	0.73	13.98	4.80
MS6	Lumbers et al. 1991	NR	granite	16	68.56	0.86	13.44	5.25
MS7	Lumbers et al. 1991	NR	granite	16	71.54	0.41	13.99	2.70
MS8	Lumbers et al. 1991	NR	granite	16	73.13	0.31	12.76	2.86
MS9	Lumbers et al. 1991	NR	granite	16	68.63	0.67	13.98	4.14
MS10	Lumbers et al. 1991	NR	granite	16	70.61	0.55	13.76	3.83
MS11	Lumbers et al. 1991	NR	granite	16	69.96	0.61	14.03	4.34
MS12	Lumbers et al. 1991	NR	granite	16	70.02	0.57	13.99	3.10
PA1	Lumbers et al. 1991	NR	granite	16	68.62	0.50	14.30	4.55
PA2	Lumbers et al. 1991	NR	granite	16	64.69	0.92	14.72	5.74
PA3	Lumbers et al. 1991	NR	granite	16	69.04	0.49	15.29	3.31
PI1	Lumbers et al. 1991	NR	granite	16	71.32	0.25	13.99	2.92
PI2	Lumbers et al. 1991	NR	granite	16	67.96	0.57	14.00	4.33
PI3	Lumbers et al. 1991	NR	granite	16	70.55	0.44	14.30	3.48
PS1	Lumbers et al. 1991	NR	granite	16	74.14	0.39	12.30	2.85
PS2	Lumbers et al. 1991	NR	granite	16	74.37	0.18	12.78	1.64
PS3	Lumbers et al. 1991	NR	granite	16	75.04	0.23	12.94	1.99
PS4	Lumbers et al. 1991	NR	granite	16	73.75	0.32	13.41	2.48
PS5	Lumbers et al. 1991	NR	granite	16	73.87	0.21	13.53	1.35
PS6	Lumbers et al. 1991	NR	granite	16	75.03	0.34	12.89	2.15
PS7	Lumbers et al. 1991	NR	granite	16	75.34	0.16	13.02	1.39
PS8	Lumbers et al. 1991	NR	granite	16	69.07	0.70	14.77	4.13
PS9	Lumbers et al. 1991	NR	granite	16	74.46	0.18	12.90	1.90
PAA1	Lumbers et al. 1991	NR	granite	16	70.53	0.49	12.94	4.88
PAA2	Lumbers et al. 1991	NR	granite	16	67.77	0.50	14.37	4.32
PAS1	Lumbers et al. 1991	NR	granite	16	76.55	0.09	12.25	1.48
PAS2	Lumbers et al. 1991	NR	granite	16	72.00	0.36	12.44	3.61
PAS3	Lumbers et al. 1991	NR	granite	16	74.98	0.12	12.55	1.75
A1	Lumbers et al. 1991	NR	aplite	16	76.41	0.01	12.99	0.14
A2	Lumbers et al. 1991	NR	aplite	16	75.40	0.06	12.84	0.86
C1	Lumbers et al. 1991	NR	contaminated granite	16	68.25	0.24	15.81	2.03
C2	Lumbers et al. 1991	NR	contaminated granite	16	67.15	0.26	16.13	2.23

* FeO not reported for Mulock granite (unit 16) samples

Appendix 3. continued.

Sample Name	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5	CO_2	S	LOI	Total	CIA	Mg #
Units	wt.%	wt. %	wt. %	wt. %	wt. %	wt. %	wt. %	wt. %	wt. %	wt. %		
Mulock granite												
MA1	0.04	0.78	0.66	4.71	6.06	0.05	NA	NA	0.55	97.54	57.1	61.7
MA2	0.06	0.33	1.30	4.67	5.06	0.06	NA	NA	0.39	100.17	57.9	15.4
MA3	0.06	0.40	1.26	4.30	5.21	0.12	NA	NA	0.38	99.19	58.0	17.0
MA4	0.04	0.44	0.80	5.57	5.01	0.11	NA	NA	0.36	99.90	57.6	22.6
MA5	0.07	0.65	1.26	4.45	4.80	0.12	NA	NA	0.51	98.99	57.6	24.3
MA6	0.08	0.81	1.86	4.55	4.84	0.17	NA	NA	0.38	99.68	56.2	24.7
MA7	0.05	0.45	1.03	5.03	5.05	0.07	NA	NA	0.45	99.68	56.2	19.0
MI1	0.06	0.33	1.09	4.12	5.14	0.08	NA	NA	0.37	100.12	57.5	13.0
MI2	0.07	0.50	1.29	4.77	4.68	0.10	NA	NA	0.19	100.13	56.8	19.6
MS1	0.08	0.95	1.58	4.37	4.59	0.23	NA	NA	0.57	100.10	56.7	31.9
MS2	0.08	0.69	1.57	3.86	4.89	0.14	NA	NA	0.43	98.96	56.9	22.8
MS3	0.08	0.66	1.63	4.55	4.44	0.10	NA	NA	0.29	99.58	56.9	26.9
MS4	0.08	0.85	1.75	3.93	4.47	0.19	NA	NA	0.20	99.49	56.6	24.2
MS5	0.07	0.68	1.69	4.14	4.35	0.18	NA	NA	0.24	100.13	57.9	21.9
MS6	0.08	0.81	1.90	4.03	4.32	0.22	NA	NA	0.65	100.12	56.7	23.4
MS7	0.05	0.27	0.90	4.41	5.05	0.03	NA	NA	0.55	99.90	57.5	16.5
MS8	0.04	0.18	0.67	4.48	4.70	0.01	NA	NA	0.19	99.33	56.4	11.1
MS9	0.08	0.80	1.68	4.00	4.59	0.15	NA	NA	0.19	98.91	57.6	27.7
MS10	0.06	0.49	0.94	5.13	4.18	0.09	NA	NA	0.20	99.84	57.3	20.2
MS11	0.07	0.53	1.27	4.33	4.79	0.10	NA	NA	0.09	100.12	57.5	19.5
MS12	0.03	0.67	1.87	3.21	5.37	0.20	NA	NA	1.19	100.22	57.2	30.0
PA1	0.04	0.60	0.32	4.53	5.21	0.04	NA	NA	0.49	99.20	58.7	20.7
PA2	0.08	0.83	2.50	4.69	4.55	0.26	NA	NA	1.17	100.15	55.6	22.3
PA3	0.07	0.53	1.08	4.09	5.70	0.09	NA	NA	0.47	100.16	58.4	24.1
PI1	0.02	0.17	0.33	4.81	5.60	0.01	NA	NA	0.28	99.70	56.6	10.3
PI2	0.07	0.95	1.27	4.07	5.03	0.13	NA	NA	0.70	99.08	57.4	30.3
PI3	0.06	0.33	1.15	4.41	4.85	0.05	NA	NA	0.53	100.15	57.9	15.8
PS1	0.04	0.49	0.34	3.91	4.74	0.15	NA	NA	0.66	100.01	57.8	25.4
PS2	0.01	0.06	0.14	3.66	5.90	0.07	NA	NA	0.29	99.10	56.9	6.8
PS3	0.03	0.18	0.42	4.32	4.66	0.09	NA	NA	0.29	100.19	57.9	15.2
PS4	0.03	0.24	0.53	3.99	5.05	0.04	NA	NA	0.27	100.11	58.4	16.1
PS5	0.02	0.17	0.43	4.44	5.22	0.05	NA	NA	0.37	99.66	57.3	20.0
PS6	0.02	0.23	0.50	3.68	5.19	0.12	NA	NA	0.09	100.24	57.9	17.5
PS7	0.00	0.11	0.65	3.68	5.47	0.02	NA	NA	0.30	100.14	57.1	13.5
PS8	0.06	0.69	1.55	4.21	4.54	0.11	NA	NA	0.29	100.12	58.9	24.9
PS9	0.02	0.09	0.43	4.23	5.02	0.10	NA	NA	0.28	99.61	57.1	8.6
PAA1	0.08	<0.10	0.69	4.53	5.16	0.01	NA	NA	0.35	99.66	55.5	4.3
PAA2	0.08	0.43	1.09	5.65	5.18	0.05	NA	NA	0.36	99.80	54.7	16.5
PAS1	0.02	<0.10	0.28	4.71	4.30	0.03	NA	NA	0.48	100.19	56.9	NC
PAS2	0.03	0.32	0.26	4.19	5.22	0.03	NA	NA	0.47	98.93	56.3	14.9
PAS3	0.02	<0.10	0.14	4.87	4.77	0.09	NA	NA	0.25	99.54	56.2	NC
A1	<0.01	<0.10	0.03	5.76	4.50	0.09	NA	NA	0.17	100.10	55.8	NC
A2	0.01	<0.10	0.33	4.06	5.32	0.07	NA	NA	0.19	99.14	56.9	NC
C1	0.02	1.10	1.76	4.63	5.74	0.10	NA	NA	0.80	100.48	56.6	51.8
C2	0.03	1.33	1.77	3.92	5.58	0.10	NA	NA	1.10	99.60	58.9	54.2

Appendix 4

Listing of Assay Data on Rock Units in the Study Area Collected as Part of this Study

Abbreviations
NA = not analyzed
NC = not calculated
NR = not reported
less than (<) symbol indicates element was below the detection limit in the sample
greater than (>) symbol indicates element was above instrument calibration limit

Method Abbreviations
FA = fire assay
ICP-AES = inductively coupled plasma atomic emission spectroscopy
XRF = X-ray fluorescence on pressed pellets

Appendix 4. Listing of assay data on rock units in the study area collected as part of this study.

Sample Name	UTM Co-ordinates		Township	Rock Type	Source	SiO_2	TiO_2	Al_2O_3	Fe_2O_3
Method	Zone 17	NAD83				XRF	XRF	XRF	XRF
Units	(m)	(m)				wt. %	wt. %	wt. %	wt. %
Detection Limit	Easting	Northing				***0.01***	***0.01***	***0.01***	***0.01***
Iron formation (unit 7)									
13.3, p.105	NR	NR	NR	ferrosilite	Deer, Howie and Zussman 1966	45.95	0.10	0.90	46.60
03RME-0237	629500	5186591	Parkman	ferrosilite iron formation	this study	45.18	0.07	1.49	45.87
03RME-0238	631110	5199120	Parkman	ferrosilite iron formation	this study	52.97	0.18	4.80	32.79
03RME-0239	631110	5199120	Parkman	ferrosilite iron formation	this study	59.28	0.23	5.53	27.59
03RME-0240	631110	5199120	Parkman	ferrosilite iron formation	this study	46.68	0.12	2.44	45.40
03RME-0241	631931	5197720	Parkman	ferrosilite iron formation	this study	48.10	0.03	0.64	44.46
03RME-0243	631931	5197720	Parkman	ferrosilite iron formation	this study	36.92	0.03	0.47	55.81
03RME-0244	631931	5197720	Parkman	ferrosilite iron formation	this study	36.94	0.04	0.71	55.00
Sulphide-rich gneiss (unit 8b, 8d)									
03RME-0233	652921	5153528	Butler	pyrrhotite gneiss	this study	63.25	0.33	8.77	5.75
03RME-0234	652921	5153528	Butler	soil derived from pyrrhotite gneiss	this study	65.65	0.36	10.14	6.43
Kyanite-rich gneiss (unit 8a)									
03RME-0371	653421	5153455	Butler	rusty garnet-kyanite gneiss	this study	NA	NA	NA	NA
03RME-0372	653421	5153455	Butler	rusty garnet-kyanite gneiss	this study	NA	NA	NA	NA

Sample Name	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5	LOI	Total *	Mg #	Cr	Ni	Co	Sc
Method	XRF	XRF	XRF	XRF	XRF	XRF	XRF			XRF	ICP-AES	ICP-AES	ICP-AES
Units	wt. %	wt. %	wt. %	wt. %	wt. %	wt. %	wt. %	wt. %		ppm	ppm	ppm	ppm
Detection Limit	***0.01***	***0.01***	***0.01***	***0.01***	***0.01***	***0.01***	***0.05***			***4.0***	***1.0***	***0.8***	***0.2***
Iron formation (unit 7)													
13.3, p.105	5.02	3.49	1.43	NA	NA	NA	0.65	104.14	12.9	NR	NR	NR	NR
03RME-0237	3.75	5.64	0.88	0.02	0.01	0.11	<0.05	103.02	19.6	26	40	46	2
03RME-0238	1.25	6.54	0.67	0.62	0.82	0.06	<0.05	100.70	28.3	39	35	42	3
03RME-0239	1.69	4.28	0.48	0.40	0.41	0.04	<0.05	99.93	23.5	49	29	29	3
03RME-0240	2.77	4.55	0.58	0.02	0.02	0.09	<0.05	102.67	16.6	46	39	29	2
03RME-0241	3.92	4.60	0.60	0.02	0.01	0.09	<0.05	102.47	17.0	29	37	23	1
03RME-0243	3.13	6.80	0.19	0.12	0.04	0.10	<0.05	103.61	19.4	26	43	38	2
03RME-0244	3.37	6.73	0.19	0.08	0.02	0.11	<0.05	103.19	19.5	25	43	35	2
Sulphide-rich gneiss (unit 8b, 8d)													
03RME-0233	0.05	6.39	6.46	0.96	3.67	0.10	4.48	100.21	68.8	72	18	9	6
03RME-0234	0.04	4.70	3.99	1.32	3.93	0.12	3.86	100.54	59.2	104	27	11	7
Kyanite-rich gneiss (unit 8a)													
03RME-0371	NA	NA	NA	NA	NA	NA	NA	NC	NC	135	34	13	13
03RME-0372	NA	NA	NA	NA	NA	NA	NA	NC	NC	96	24	6	10

* Sum, not analytical total, high total reflects high Fe_2O_3 content.

Appendix 4. continued.

Sample Name	V	Cu	Pb	Zn	Sn	W	Mo	As	Au	Pt	Pd	Be	Sr
Method	ICP-AES	ICP-AES	XRF	ICP-AES	XRF	ICP-AES	ICP-AES	XRF	FA	FA	FA	ICP-AES	ICP-AES
Units	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppb	ppb	ppb	ppm	ppm
Detection Limit	***0.6***	***2.0***	***5.0***	***4.0***	***5.0***	***40.0***	***8.0***	***1.0***	***6.0***	***1.0***	***2.0***	***0.1***	***0.5***
Iron formation (unit 7)													
13.3, p.105	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
03RME-0237	8	<2	<5	94	<5	<40	<8	<1	<6	<1	<2	1.9	20
03RME-0238	21	<2	<5	64	<5	<40	<8	1	<6	<1	<2	2.0	30
03RME-0239	21	<2	<5	58	<5	<40	<8	<1	<6	<1	<2	1.0	21
03RME-0240	10	<2	<5	79	<5	<40	<8	<1	<6	<1	<2	1.3	18
03RME-0241	2	<2	<5	54	<5	<40	<8	<1	<6	<1	<2	1.5	14
03RME-0243	3	<2	<5	75	<5	<40	<8	1	<6	<1	<2	1.6	5
03RME-0244	3	<2	<5	73	<5	<40	<8	<1	<6	<1	<2	1.8	6
Sulphide-rich gneiss (unit 8b, 8d)													
03RME-0233	70	29	19	71	7	<40	<8	5	<6	<1	<2	0.8	73
03RME-0234	76	25	20	93	7	<40	<8	6	139.0	1.4	<2	0.9	114
Kyanite-rich gneiss (unit 8a)													
03RME-0371	193	41	61	364	<5	<40	<8	4	<6	<1	<2	0.3	45
03RME-0372	192	59	21	174	<5	<40	14	1	<6	1.6	<2	0.3	17

Appendix 5

Magnetic Susceptibility Measurements from Rocks in the Study Area

Abbreviations
AMP = amphibolite
DIA = diabase
DIO = diorite
FEL = felsite
GAB = gabbro and/or metagabbro
GNE = gneiss
IFO = iron formation
MAF = mafic rock
OTH = other
sed = sedimentary
SYE = syenite
ULT = ultramafic rock
volc = volcanic

avg = average
pop = number of readings
rdg = reading
S.D. = standard deviation

Appendix 5. Magnetic susceptibility measurements from rocks in the study area.

Station	Township	Easting	Northing	Rock Type	Rdg 1	Rdg 2	Rdg 3	Rdg 4	Rdg 5	Rdg 6	Rdg 7	Rdg 8	Rdg 9	Rdg 10	Avg	Pop (n)	S.D.	Comments
03RME-0001a	Clarkson	639110	5173952	GNE	0.11	0.42	0.45								0.33	3	0.19	quartzite, biotite-rich layer
03RME-0001b	Clarkson	639110	5173952	GNE	0.04	0.14	0.04	0.06	0.10	0.08	0.07	0.07	0.07	0.13	0.08	10	0.03	quartzite, muscovite-rich layer
03RME-0001c	Clarkson	639110	5173952	GNE	0.17	0.05	0.06	0.05	0.12	0.08	0.09	0.09	0.20	0.06	0.10	10	0.05	quartzite, muscovite-rich layer
03RME-0001d	Clarkson	639110	5173952	GNE	0.05	0.23	0.09	0.04	0.00	0.13	0.08	0.14	0.04	0.03	0.08	10	0.07	quartzite, muscovite-rich layer
03RME-0001e	Clarkson	639110	5173952	GNE	0.00	0.00									0.00	2	0.00	quartzite
03RME-0001f	Clarkson	639110	5173952	GNE	0.17	0.18									0.18	2	0.01	quartzite, muscovite-rich layer
03RME-0002	Clarkson	639150	5173970	GNE	0.29	0.33	0.17	0.28	0.17	0.19	0.20	0.18	0.17	0.18	0.22	10	0.06	biotite gneiss
03RME-0003	Clarkson	639075	5173960	GNE	0.13	0.33	0.09	0.07	0.14	0.30	0.04	0.24	0.02	0.11	0.15	10	0.11	quartzite
03RME-0004a	Clarkson	639418	5174360	GNE	0.19	0.11	0.14	1.19	1.54	2.54	0.07	1.24	4.36	1.32	1.27	10	1.35	granite gneiss
03RME-0004b	Clarkson	639418	5174360	GNE	3.10	7.13	3.91	15.50	0.17	1.30	1.40	2.45	0.73	2.75	3.84	10	4.55	granite gneiss
03RME-0005a	Clarkson	640319	5174456	GNE	1.09	2.15	1.96	0.80	1.46	3.05	2.24	0.97	2.29	2.42	1.84	10	0.73	granite gneiss
03RME-0005b	Clarkson	640319	5174456	GNE	0.08	0.25	0.28	0.02	0.11	0.08	0.06	0.05	0.05	0.02	0.10	10	0.09	granite gneiss
03RME-0005c	Clarkson	640372	5174453	GNE	0.53	0.82	0.13	0.00	0.05	0.02	0.07	0.05	0.06	0.01	0.17	10	0.28	granite gneiss
03RME-0006	Clarkson	631863	5177971	GNE	0.02	0.04	0.02	0.03	0.00	0.00	0.01	0.02	0.01	0.00	0.02	10	0.01	mica-rich quartzite
03RME-0016a	Clarkson	640133	5170683	GNE	2.04	12.80	0.51	0.42	18.10	14.20	9.32	13.20	13.50	12.20	9.63	10	6.35	grey gneiss
03RME-0016b	Clarkson	640133	5170683	GNE	14.30	3.72	1.36	1.04	1.11	0.82	8.05	4.67	14.40	0.32	4.98	10	5.47	grey gneiss
03RME-0016c	Clarkson	640133	5170683	AMP	1.76	1.67	1.95	1.79	2.33	3.26	3.17	2.56	2.36	1.96	2.28	10	0.57	
03RME-0017	Clarkson	639995	5171075	GNE	4.76	3.56	3.27	2.10	3.52	0.99	1.46	2.22	2.32	2.12	2.63	10	1.13	grey gneiss, geochronology sample site
03RME-0019	Clarkson	639670	5171873	GNE	0.45	0.41	0.50	0.51	0.29	0.32	0.40	0.57	0.60	0.44	0.45	10	0.10	grey gneiss
03RME-0024a	Clarkson	639699	5172938	GNE	0.12	0.21	0.18	0.15	0.13	0.22	0.15	0.33	0.18	1.54	0.32	10	0.43	metapelite
03RME-0024b	Clarkson	639699	5172938	LIM	0.03	0.04	0.11	0.06	0.02	0.01	0.02	0.02	0.01	0.02	0.03	10	0.03	calcite marble
03RME-0047	Osborne	623499	5172363	GNE	0.41	0.46	0.44	0.51	0.54	0.57	0.36	0.34	0.34		0.44	9	0.09	altered calc-silicate gneiss
03RME-0048	Osborne	623480	5172611	GNE	0.38	0.74	0.62	0.50	0.27						0.50	5	0.19	calc-silicate gneiss
				GNE														
03RME-0049a	Lasalle	621439	5175923	GNE	0.03	0.03	0.03	0.01	0.07						0.03	5	0.02	quartzite
03RME-0049b	Lasalle	621439	5175923	GNE	0.14	0.05	0.02	0.04	0.04	0.07					0.06	6	0.04	mica-rich quartzite

Appendix 5. continued.

Station	Township	Easting	Northing	Rock Type	Rdg 1	Rdg 2	Rdg 3	Rdg 4	Rdg 5	Rdg 6	Rdg 7	Rdg 8	Rdg 9	Rdg 10	Avg	Pop (n)	S.D.	Comments
03RME-0068a	Parkman	631520	5189873	GNE	0.00	0.37	0.37	0.18							0.23	4	0.18	quartz-muscovite gneiss
03RME-0068b	Parkman	631520	5189873	GNE	0.17	0.18	0.16	0.19	0.19	0.15	0.17				0.17	7	0.01	quartzite
03RME-0068c	Parkman	631520	5189873	GNE	0.17	0.52	0.42	0.18							0.32		0.18	pelitic gneiss
03RME-0069	Parkman	631370	5190829	GNE	0.12	0.06	0.09	0.09	0.11	0.09	0.12				0.10	7	0.02	quartz-muscovite gneiss
03RME-0071	Wyse	633628	5182560	GNE	0.02	0.07	0.12	0.00	0.01	0.23	0.03	0.03	0.00	0.03	0.05	10	0.07	quartzite
03RME-0072a	Wyse	633514	5182455	GNE	0.04	0.04	0.38	0.11	0.08	0.05	0.05	0.30	0.34	0.04	0.14	10	0.14	quartzite, bedded, geochronology site
03RME-0072b	Wyse	633514	5182455	GNE	0.43	0.27	0.70	1.92	2.33						1.13	5	0.93	muscovite-rich bed
03RME-0072c	Wyse	633514	5182455	IFO	27.60	13.80	13.30	9.95	7.84						14.50	5	7.72	magnetite layer
03RME-0081	Garrow	629504	5174203	GNE	0.01	0.05	0.02	0.15	0.02	0.00	0.95	0.03	0.03	0.04	0.13	10	0.29	quartz-muscovite gneiss
03RME-0083	Garrow	629405	5173865	GNE	0.34	0.53	0.40	0.44	0.49	0.53	0.43	0.40	0.47	0.49	0.45	10	0.06	calc-silicate gneiss
03RME-0085a	Garrow	629134	5173747	GNE	0.41	0.25	0.21	0.24	0.26						0.27	5	0.08	calc-silicate gneiss
03RME-0085b	Garrow	629134	5173747	GNE	0.04	0.07	0.05	0.09	0.06						0.06	5	0.02	quartz-muscovite gneiss
03RME-0087	Garrow	629082	5173685	GNE	0.72	0.68	0.54	0.31	0.32	0.27	0.33	0.38	0.32	0.21	0.41	10	0.18	calc-silicate gneiss
03RME-0089a	Garrow	631421	5173618	GNE	0.04	0.02	0.01	0.02							0.02	4	0.01	quartz-muscovite gneiss, bedded
03RME-0089b	Garrow	631421	5173618	GNE	0.03	0.02	0.01	0.03	0.04						0.02	5	0.02	quartz-muscovite gneiss, migmatitic
03RME-0089c	Garrow	631421	5173618	GNE	0.10	0.00	0.00	0.00	0.02	0.02	0.03				0.02	7	0.04	quartzite
03RME-0094	Clarkson	639464	5170871	GNE	0.23	0.21	0.20	0.20	0.20	0.20	0.18	0.20	0.19	0.22	0.20	10	0.01	bi gneiss
03RME-0095	Clarkson	639464	5170871	GNE	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.01	0.00	0.00	10	0.00	quartz-muscovite gneiss
03RME-0096	Poitras	643325	5166110	GNE	0.32	0.33	0.32	0.24	0.19	0.30	0.19	0.20	0.25	0.34	0.27	10	0.06	quartz-muscovite gneiss
03RME-0097	Clarkson	642452	5166054	AMP	0.43	0.49	0.42	0.34	0.37	0.46	0.52	0.48	0.50	0.37	0.44	10	0.06	
03RME-0098	Clarkson	642550	5166150	GNE	0.11	1.55	5.02	0.10	0.14	0.25	2.33	1.08	4.33	0.28	1.52	10	1.83	heterogeneous gneiss
03RME-0099	Clarkson	642115	5165501	GNE	0.18	0.19	0.08	0.06	0.06	0.03	0.14	0.07	0.20	0.14	0.12	10	0.06	quartz-muscovite gneiss

Appendix 5. continued.

Station	Township	Easting	Northing	Rock Type	Rdg 1	Rdg 2	Rdg 3	Rdg 4	Rdg 5	Rdg 6	Rdg 7	Rdg 8	Rdg 9	Rdg 10	Avg	Pop (n)	S.D.	Comments
03RME-0100a	Jocko	641450	5164875	GNE	0.05	0.04	0.09	0.05	0.08	0.06	0.06	0.04	0.05	0.15	0.07	10	0.03	quartz-muscovite gneiss
03RME-0100b	Jocko	641450	5164875	GNE	0.46	0.57	0.47	0.35	0.55	0.58	0.35	0.60	0.55	0.61	0.51	10	0.10	calc-silicate gneiss
03RME-0100c	Jocko	641450	5164875	GNE	0.59	5.34	0.64	0.91	0.61	0.15	4.54	0.04	1.66	6.49	2.10	10	2.40	heterogeneous gneiss
03RME-0101	Jocko	641267	5164824	GNE	0.45	4.00	0.34	0.57	0.50	0.78	0.47	3.67	0.77	1.66	1.32	10	1.38	heterogeneous gneiss, basement type
03RME-0102a	Clarkson	642025	5165100	GNE	4.97	8.39	11.90	3.36	9.58	7.16	5.97	12.50			7.98	7	3.24	grey gneiss
03RME-0102b	Clarkson	642025	5165100	GNE	0.60	0.25	0.22								0.36	3	0.21	migmatitic quartz-muscovite gneiss
03RME-0104	Jocko	640700	5159444	GNE	0.19	0.25	0.29	0.20	0.23	0.18	0.14	0.16	0.26	0.16	0.21	10	0.05	Jocko pluton, monzonite gneiss, greenish, geochronology sample site
03RME-0106a	Jocko	640075	5163325	GNE	1.62	1.71	9.20	120.00	90.70	73.10	68.00	4.84	1.28	1.49	37.19	10	45.80	garnet amphibolite
03RME-0106b	Jocko	640075	5163325	GNE	0.58	0.22	0.23	0.23	0.23	0.24	0.16	0.18	1.60	0.70	0.44	10	0.45	migmatitic quartz-muscovite gneiss
03RME-0107	French	641706	5153981	GNE	0.83	0.92	0.50	0.79	0.65	0.35	0.57	1.26	0.67	0.42	0.70	10	0.27	migmatitic mafic gneiss
03RME-0111a	French	641308	5151128	GNE	0.04	0.05	0.22	0.05	0.04	0.03	0.03	0.04	0.06	0.05	0.06	10	0.06	granitic veins
03RME-0111b	French	641308	5151128	GNE	0.08	0.08	0.06	0.02	0.44	2.05	0.67	1.75	0.17	0.23	0.56	10	0.74	quartz-muscovite gneiss
03RME-0112a	French	641228	5150937	OTH	0.20	2.67	30.50	10.90	0.49	0.45	0.70	12.50	36.50	0.78	9.57	10	13.46	breccia body
03RME-0112b	French	641228	5150937	OTH	62.50	92.30	50.40	49.00	10.50	5.37	29.60	53.50	98.00	56.30	50.75	10	30.30	matrix to breccia
03RME-0112c	French	641228	5150937	OTH	0.52	1.34	3.55	2.01	0.92	0.43	0.52	1.91	0.73	1.00	1.29	10	0.97	mafic fragments in breccia
03RME-0114a	Parkman	631221	5186139	GNE	8.07	7.90	7.78	6.81	11.00	7.67	8.63	7.18	8.91	8.90	8.29	10	1.18	granite gneiss
03RME-0114b	Parkman	631221	5186139	GNE	96.60	19.30	24.00	1.75	7.58	0.89					25.02	6	36.29	pegmatite pods in granite gneiss
03RME-0115	Parkman	631116	5186418	GNE	7.53	12.50	8.16	8.80	9.61	12.00	21.20	20.90	9.19	21.30	13.12	10	5.74	granite gneiss
03RME-0117	Parkman	630318	5186720	GNE	0.15	0.15	0.13	0.11	0.11	0.11	0.12	0.13	0.16	0.12	0.13	10	0.02	granite gneiss
03RME-0119	Parkman	630419	5186891	GNE	0.09	0.11	0.08	0.17	0.21	0.08	0.07	0.07	0.07	0.08	0.10	10	0.05	quartz-muscovite gneiss
03RME-0119	Parkman	630419	5186891	DIA	82.80	97.70	135.00	52.60	155.00	80.60	91.30	78.10	39.00	82.80	89.49	10	34.39	Grenville swarm dike?
03RME-0120	Parkman	630381	5186981	GNE	0.11	0.08	0.07	0.08	0.06	0.08	0.09	0.08	0.08	0.08	0.08	10	0.01	granite gneiss
03RME-0122	Poitras	645638	5167283	GNE	1.17	8.01	7.09	5.74	13.40	8.37	6.42	4.83	2.74	12.50	7.03	10	3.84	monzogranite gneiss

Appendix 5. continued.

Station	Township	Easting	Northing	Rock Type	Rdg 1	Rdg 2	Rdg 3	Rdg 4	Rdg 5	Rdg 6	Rdg 7	Rdg 8	Rdg 9	Rdg 10	Avg	Pop (n)	S.D.	Comments
03RME-0124	Poitras	645296	5166878	GNE	0.35	0.17	0.37	0.28	0.31	0.34	0.25	0.22	0.26	0.19	0.27	10	0.07	granodiorite gneiss
03RME-0131	Eddy	643924	5165030	GNE	0.41	0.41	0.37	0.52	0.59	1.28	2.27	7.92	5.76	4.85	2.44	10	2.75	grey gneiss
03RME-0133a	Eddy	655575	5164703	GNE	7.64	2.35	5.56	14.70	5.87	1.49	2.06	17.70	5.13	5.46	6.80	10	5.37	grey gneiss
03RME-0133b	Eddy	655575	5164703	GNE	9.76										9.76	1		grey gneiss
03RME-0136a	Eddy	651238	5162733	GNE	0.37	0.43	0.09	0.26	0.12	0.27	0.62	0.20	0.84	0.57	0.38	10	0.24	heterogeneous gneiss, basement type
03RME-0136b	Eddy	651238	5162733	GNE	0.22	0.20	0.18	0.22	0.21	0.19	0.22	0.22	0.21	0.22	0.21	10	0.01	heterogeneous gneiss, basement type, granodiorite
03RME-0139a	Poitras	647461	5167078	SYE	23.90	17.10	12.60	24.20	20.20	23.80	23.70	21.50	21.20	18.90	20.71	10	3.71	by tower
03RME-0139b	Poitras	647461	5167078	SYE	4.04	5.06	3.66	1.59	3.07	1.65	1.61	2.39	1.90	3.96	2.89	10	1.24	by chemistry sample site
03RME-0139c	Poitras	647461	5167078	SYE	0.05	0.07	0.05	0.05	0.07	0.08	0.06	0.09	0.13	0.21	0.09	10	0.05	downhill from sample site, more deformed
03RME-0142	Jocko	638810	5163570	AMP	0.82	0.74	0.86	1.00	0.70	1.06	0.79	0.93	0.76	0.79	0.85	10	0.12	
03RME-0143	Jocko	635119	5162432	GNE	0.06	0.09	0.08	0.06	0.07	0.07	0.08	0.05	0.05	0.05	0.07	10	0.01	migmatitic quartz-muscovite gneiss
03RME-0145	Lockhart	633471	5161725	GAB	0.54	0.50	0.58	0.61	0.45	0.59	0.59	0.36	0.87	0.67	0.58	10	0.14	gneissic
03RME-0147a	Lockhart	633148	5161536	GNE	20.60	19.00	28.40	27.30							23.83	4	4.71	granitoid gneiss, Jocko type, red coloured
03RME-0147b	Lockhart	633148	5161536	GNE	0.12	0.09	0.03	0.09	0.10	0.11					0.09	5	0.03	granitoid gneiss, Jocko type, greenish
03RME-0148	Lockhart	631651	5162061	GNE	0.06	0.03	0.07	0.11	0.05	3.23	0.21	0.22	0.24	0.24	0.45	10	0.98	granitoid gneiss, Jocko type, greenish
03RME-0149	Lockhart	631360	5162036	GNE	0.30	0.28	0.27	0.29	0.23	0.26	2.54	0.26	0.23	0.28	0.49	10	0.72	granitoid gneiss, Jocko type, 2.54 value from mafic enclave
03RME-0150	Lockhart	631104	5162084	GNE	64.10	71.80	68.90	61.60	38.60	44.60	44.00	39.40	61.60	42.70	53.73	10	13.00	granitoid gneiss
03RME-0151	Lockhart	630912	5162208	GNE	30.10	29.90	28.90	28.80	30.00	31.60	25.90	30.30	28.80		29.37	10	1.58	heterogeneous gneiss, basement type
03RME-0156	Lockhart	629564	5161680	GNE	0.66	0.46	0.23	0.54	0.23	0.26	0.20	0.23	0.23	0.20	0.32	10	0.17	porphyroclastic gneiss
03RME-0157	Lockhart	627503	5162827	GNE	0.16	0.08	0.17	0.19	0.12	0.18	0.14	0.17	0.30	0.20	0.17	10	0.06	flattened migmatitic quartz-muscovite gneiss

Appendix 5. continued.

Station	Township	Easting	Northing	Rock Type	Rdg 1	Rdg 2	Rdg 3	Rdg 4	Rdg 5	Rdg 6	Rdg 7	Rdg 8	Rdg 9	Rdg 10	Avg	Pop (n)	S.D.	Comments
03RME-0158	Lockhart	627191	5163030	GNE	2.76	2.60	2.13	2.27	5.13	2.67	1.65	5.35	0.77	0.27	2.56	10	1.63	granite gneiss
03RME-0158	Lockhart	627191	5163030	GNE	0.69	0.78	1.02	0.55	0.91	0.58	0.67	0.72	0.71	1.17	0.78	10	0.20	calc-silicate gneiss
03RME-0160	Lockhart	626992	5163559	GNE	0.98	0.20	0.18	0.97	0.95	1.34	1.55	4.39	2.65	2.49	1.57	10	1.29	migmatitic quartz-muscovite gneiss
03RME-0162	Lockhart	626638	5164038	GNE	0.83	0.89	0.64	0.90	0.64	0.52	1.06	1.06	0.95	1.14	0.86	10	0.21	granite gneiss
03RME-0163	Lockhart	626374	5164127	GNE	0.17	0.16	0.50	0.71	0.22	0.23	0.26	0.22	0.22	0.24	0.29	10	0.17	heterogeneous gneiss, basement type
03RME-0165	Lockhart	626127	5164223	GNE	2.70	2.25	2.99	2.41	8.58	6.03	3.13	3.89	0.30	1.89	3.42	10	2.33	megacrystic granite gneiss, Mulock
03RME-0167	Lockhart	626350	5165654	GNE	0.18	0.19	0.10	0.10	0.17	0.12	0.10	0.12	0.18	0.13	0.14	10	0.04	megacrystic granite gneiss, Mulock
03RME-0168a	Lockhart	626360	5165795	GNE	0.09	0.06	0.08	0.10	0.55	3.98	1.65	1.94	0.36	0.12	0.89	10	1.28	fine grained granite gneiss, Mulock
03RME-0168b	Lockhart	626360	5165795	GNE	6.92	2.11	70.60	6.22	2.80	46.80	20.00	3.35	1.69	5.86	16.64	10	23.46	megacrystic granite gneiss, Mulock
03RME-0172	Lockhart	624637	5167680	GNE	12.60	4.70	11.20	12.70	10.60	9.09	9.38	4.46	2.79	1.13	7.87	10	4.23	megacrystic granite gneiss, Mulock
03RME-0173	Lockhart	624158	5167912	GNE	11.00	7.69	10.30	7.47	8.59	10.50	5.39	11.20	13.70	15.70	10.15	10	3.05	megacrystic granite gneiss, Mulock
03RME-0175	Osborne	623661	5168004	GNE	0.07	0.12	0.19	0.08	0.30	2.82	0.52	0.08	3.11	1.44	0.87	10	1.18	deformed megacrystic granite, Mulock
03RME-0178	Lockhart	628002	5160455	GNE	31.20	25.40	30.00	25.10	22.40	25.30	21.10	8.64	25.70	29.10	24.39	10	6.39	megacrystic granite gneiss, Mulock
03RME-0179a	Lockhart	627033	5159808	GNE	19.30	20.70	9.68	5.79	10.50	3.42	5.66	2.80	1.94	5.19	8.50	10	6.65	megacrystic granite gneiss, Mulock
03RME-0179b	Lockhart	627033	5159808	GNE	11.60	10.70	8.16	7.37	7.15	7.22	5.49	2.85	7.29	8.09	7.59	10	2.44	megacrystic granite gneiss, Mulock
03RME-0183	Stewart	623855	5159649	GNE	71.40	72.50	62.00	68.20	87.00	79.30	56.60	64.80	53.10	38.90	65.38	10	13.73	megacrystic granite gneiss, Mulock
03RME-0184	Stewart	623063	5159174	GNE	5.26	9.58	6.90	7.28	3.96	14.00	8.79	11.20	8.76	13.80	8.95	10	3.33	megacrystic granite gneiss, Mulock
03RME-0185	Stewart	622697	5157758	GNE	0.41	0.61	0.50	0.53	0.75	0.27	0.55	1.07	0.51		0.58	9	0.23	heterogeneous gneiss, basement type
03RME-0188	Lockhart	631888	5162430	GNE	0.15	0.24	0.43	0.09	1.37	0.13	0.14	0.74	0.12	0.84	0.43	10	0.43	migmatitic quartz-muscovite gneiss
03RME-0192	Lockhart	632416	5159802	GNE	1.06	0.88	1.10	6.92	0.43	0.75	0.55	11.10	8.93	2.03	3.38	10	4.02	migmatitic granite gneiss

Appendix 5. continued.

Station	Township	Easting	Northing	Rock Type	Rdg 1	Rdg 2	Rdg 3	Rdg 4	Rdg 5	Rdg 6	Rdg 7	Rdg 8	Rdg 9	Rdg 10	Avg	Pop (n)	S.D.	Comments
03RME-0195	Butler	643978	5154902	GNE	0.33	0.41	0.34	0.33	0.44	0.35	0.37	0.38	0.22	0.43	0.36	10	0.06	greenish phase, Jocko pluton
03RME-0197	Butler	644701	5154219	GNE	0.00	0.12	0.13	0.11	0.14	0.20	0.14	0.14	0.14	0.13	0.13	10	0.05	granite phase, Jocko pluton
03RME-0198	Butler	645627	5153427	AMP	0.48	0.56	0.77	0.62	0.67	0.57	0.80	0.71	0.65	0.55	0.64	10	0.10	
03RME-0201	Butler	646517	5152725	FEL	0.05	0.16	0.08	0.05	0.07	0.11	0.09	0.12	0.10	0.09	0.09	10	0.03	quartz-muscovite gneiss, sed or volc?
03RME-0202	Butler	646796	5152658	AMP	0.98	0.84	1.08	0.68	0.91	0.65	0.90	1.06	0.90		0.89	9	0.15	
03RME-0203a	Butler	646856	5152654	FEL	7.68	3.63	5.64	8.30	14.90						8.03	5	4.26	layer 1
03RME-0203b	Butler	646856	5152654	FEL	3.27	7.75	19.30	7.78	8.64						9.35	5	5.95	layer 2
03RME-0204	Butler	646856	5152654	MAF	0.59	0.69	0.73	0.56	0.51						0.62	5	0.09	interlayered with 03RME-0203
03RME-0206	Butler	647046	5152257	GNE	8.09	9.33	11.30	9.76	13.50	13.80	9.26	9.64	8.92	9.12	10.27	10	1.96	fine grained, biotite-plagioclase gneiss
03RME-0208	Butler	647319	5152274	GNE	0.63	12.40	0.70	14.00	16.60	0.69	0.65	0.33	0.38	0.51	4.69	10	6.73	granitoid gneiss
03RME-0209a	Butler	647579	5152092	GNE	40.30	1.91	2.82	1.89							11.73		19.05	40.3 on vein, rest near vein
03RME-0209b	Butler	647579	5152092	GNE	0.04	0.08	0.01	0.13	0.01	0.03					0.05		0.05	migmatitic quartz-muscovite gneiss
03RME-0210	Butler	647884	5151936	GNE	0.09	0.07	0.09	0.05	0.07	0.44	0.06	0.07	0.09	0.07	0.11	10	0.12	migmatitic quartz-muscovite gneiss
03RME-0211a	Butler	648304	5151526	GNE			0.59	0.43	0.16	0.19	0.95	0.08	0.05	0.10	0.32	8	0.32	migmatitic quartz-muscovite gneiss
03RME-0211b	Butler	648304	5151526	GNE	16.30	3.87									10.09	2	8.79	vein in gneiss
03RME-0211c	Butler	648304	5151526	AMP	0.55	0.44	0.49	0.43	0.48	0.46	0.51	0.60	0.51	0.47	0.49	10	0.05	amphibolite
03RME-0213a	Butler	648631	5150980	GNE	14.40	27.10	15.90								19.13	3	6.94	migmatitic quartz-muscovite gneiss, leucosome-poor
03RME-0213b	Butler	648631	5150980	GNE	0.51	6.32	0.50	0.42	0.51	0.44	0.48				1.31	7	2.21	migmatitic quartz-muscovite gneiss
03RME-0214	Butler	649225	5150809	GNE	7.61	3.80	5.39	1.33	14.10	7.42	9.36	0.91	10.70	0.81	6.14	10	4.51	migmatitic quartz-muscovite gneiss
03RME-0216	Antoine	653338	5151917	GNE	21.80	19.50	20.90	1.37	6.95	8.38	13.00	15.50	2.82	5.32	11.55	10	7.62	granite gneiss

Appendix 5. continued.

Station	Township	Easting	Northing	Rock Type	Rdg 1	Rdg 2	Rdg 3	Rdg 4	Rdg 5	Rdg 6	Rdg 7	Rdg 8	Rdg 9	Rdg 10	Avg	Pop (n)	S.D.	Comments
03RME-0217a	Antoine	656555	5150127	AMP		0.52	0.64	0.54	61.00	2.73	0.56	0.81	0.60	0.70	7.57	9	20.05	heterogeneous gneiss, basement type?
03RME-0217b	Antoine	656555	5150127	AMP	136.00											1		quartz-plagioclase sweat
03RME-0218	Antoine	656585	5150040	GNE	0.53	1.71	0.10	0.22	2.00	1.13	1.59	0.78	4.41	8.80	2.13	10	2.65	heterogeneous gneiss, basement type?
03RME-0219	Antoine	656639	5149888	GNE	0.00	0.02	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.02	0.00	10	0.01	quartz-muscovite gneiss
03RME-0222a	Antoine	657347	5148836	GNE	0.56	0.19	0.25	0.21	0.28	0.40	0.37	0.26	0.28	0.14	0.29	10	0.12	heterogeneous gneiss, basement type?
03RME-0222b	Antoine	657347	5148836	AMP	0.56	0.53	0.78	1.26	0.95	1.41	0.49	0.70	0.00	1.89	0.86	10	0.54	heterogeneous gneiss, basement type?
03RME-0237a	Parkman	629500	5186591	IFC	117.00	234.00	3.28	12.30	8.04	6.95	2.82	153.00	223.00		84.49	9	98.5	ferrosilite iron formation
03RME-0237b	Parkman	629500	5186591	AMP	5.87	5.11	3.21								4.73	3	1.37	garnet amphibolite
03RME-0237c	Parkman	629500	5186591	AMP	21.70	60.80	14.20	5.25							25.49	4	24.48	garnet amphibolite, layered
03RME-0237d	Parkman	629500	5186591	AMP	15.70	33.00	7.41	4.96							15.27	4	12.68	garnet amphibolite
03RME-0237e	Parkman	629500	5186591	AMP	5.82	23.20	2.70	21.40							13.28	4	10.52	amphibolite
03RME-0237f	Parkman	629500	5186591	IFC	5.49	7.00	7.38	13.70	12.70	16.70	23.10	41.70	20.50	11.80	16.01	10	10.70	ferrosilite iron formation
03RME-0246a	Parkman	629530	5186734	GNE	0.84	0.21	0.20	0.18	0.67	0.67	0.25	0.19	0.36	0.25	0.38	10	0.25	biotite-garnet gneiss
03RME-0246b	Parkman	629575	5186751	IFC	555.00	513.00	150.00	332.00	424.00	339.00	398.00	480.00	374.00	369.00	393.40	10	113.4	ferrosilite iron formation
03RME-0246c	Parkman	629575	5186751	IFC	126.00	153.00	219.00	32.50	115.00	35.50	168.00				121.29	7	68.36	ferrosilite iron formation, near veins
03RME-0257a	Poitras	646953	5168632	MAF	0.39	0.58	0.58	0.68	0.55	0.48	0.73	0.50	0.66	0.58	0.57	10	0.10	weathered mafic dike
03RME-0257b	Poitras	646953	5168632	GNE	0.41	0.33	0.71	1.87	2.76	0.67	2.58	0.65	1.10	0.98	1.21	10	0.89	calc-silicate
03RME-0257c	Poitras	646953	5168632	GNE	0.03	0.04	0.05	0.02	0.07	0.11	0.04	0.01			0.05	8	0.03	layered quartzite
03RME-0258	Olrig	657705	5144604	GAB	0.54	0.45	0.17	0.38	0.44	0.45	0.57	0.49	0.47	0.49	0.41	10	0.21	leucogabbro
03RME-0259	Olrig	658288	5143621	GNE	1.65	1.56	1.15	1.88	2.23	2.62	1.10	1.75	1.17	1.44	1.66	10	0.49	quartz monzonite gneiss
03RME-0260	Mattawan	659249	5143311	GNE	0.07	0.13	0.10	0.08	66.60	19.20	77.90	0.17	0.10	0.14	16.45	10	30.12	pink layered, monzonite gneiss
03RME-0260	Mattawan	659249	5143311	GNE	40.30	1.31	0.95	0.75	0.75	2.10	72.00	156.00	105.00	40.10	41.93	10	53.96	grey, thin layered gneiss
03RME-0261	Mattawan	659784	5143103	GNE	0.78	0.77	0.41	0.14	0.40	1.46	12.40	11.90	6.46	8.32	4.30	10	5.00	quartz monzonite gneiss
03RME-0262a	Mattawan	660449	5142342	GNE	2.89	1.13	0.49	0.35	0.45	0.54	0.50	0.59	0.68	5.64	1.33	10	1.69	garnet quartz monzonite gneiss
03RME-0262b	Mattawan	660449	5142342	GAB	0.86	0.89	1.23	1.26	1.10						1.07	5	0.19	coronitic metagabbro pod

Appendix 5. continued.

Station	Township	Easting	Northing	Rock Type	Rdg 1	Rdg 2	Rdg 3	Rdg 4	Rdg 5	Rdg 6	Rdg 7	Rdg 8	Rdg 9	Rdg 10	Avg	Pop (n)	S.D.	Comments
03RME-0263a	Mattawan	661277	5141486	GNE	1.21	1.56	1.44	1.50	3.47	2.45	0.68	0.63	2.42	1.57	1.69	10	0.87	grey, thin layered gneiss
03RME-0263b	Mattawan	661277	5141486	AMP	3.91	2.08	0.73	0.60	0.74	0.72	1.79	1.14	1.41	2.36	1.55	10	1.04	amphibolite
03RME-0264	Mattawan	661311	5141439	GNE	1.08	0.60	1.02	0.96	1.02	0.98	2.56	1.12	0.92	1.13	1.14	10	0.52	mafic to intermediate gneiss
03RME-0265	Mattawan	662498	5140294	GNE	0.28	0.27	0.31	0.30	0.27	0.09	0.20	0.24	0.29	0.24	0.25	10	0.06	layered granodiorite gneiss
03RME-0266	Mattawan	662669	5139995	GAB	3.99	2.43	5.60	2.22	1.45	2.06	1.52	2.22	3.28	1.77	2.65	10	1.30	anorthositic gabbro
03RME-0267	Mattawan	663530	5139250	GNE	0.31	0.44	0.34	0.42	0.44	0.42					0.40	6	0.06	grey intermediate gneiss
03RME-0268a	Mattawan	663662	5139055	GNE	2.63	1.44	10.70	13.20	0.25	0.47	8.36	6.91	6.93	4.22	5.51	10	4.44	quartz monzonite gneiss
03RME-0268b	Mattawan	663662	5139055	GNE	2.59	5.62	8.07	7.08	7.41	7.88	1.17	2.54	11.40	11.40	6.52	10	3.55	quartz monzonite gneiss
03RME-0269	Mattawan	663700	5138600	OTH	2.79	2.72	2.22	1.64	1.60	2.32	3.04	3.30	2.31	3.58	2.55	10	0.66	pseudoecologite
03RME-0271	Mattawan	659071	5138500	AMP	0.62	0.43	0.54	0.40	0.49	0.42	0.54	0.53	0.65	0.76	0.54	10	0.11	garnet amphibolite
03RME-0272	Mattawan	654124	5138385	AMP	0.45	0.52	0.60	1.62	0.69	0.51	1.12	1.07	0.69	0.45	0.77	10	0.38	amphibolite
03RME-0274	Mattawan	654598	5137370	GNE	18.20	21.70	24.00	16.00	18.10	19.70	20.40	23.60	21.10	11.60	19.44	10	3.71	granitoid gneiss
03RME-0275	Mattawan			GNE	0.02	0.01	0.11	0.00	0.01	0.00	0.01	0.00	0.11	0.04	0.03	10	0.04	granitic gneiss
03RME-0277	Mattawan	660747	5138730	GNE	4.85	5.90	14.70	13.90	6.18	2.86	2.92	6.27	1.11	1.86	6.06	10	4.71	migmatitic granite gneiss
03RME-0278	Mattawan	661148	5138688	GNE	3.29	2.73	7.72	3.19	1.96	4.31	2.44	2.38	2.03	6.74	3.68	10	2.01	migmatitic granite gneiss
03RME-0279	Olrig	653899	5138485	GNE	1.63	0.89	0.52	8.72	7.61	2.44	4.96	11.10	1.88	11.40	5.12	10	4.26	migmatitic gneiss and amphibolite
03RME-0280	Olrig	653036	5138991	GNE	3.18	1.23	6.90	2.03	1.62	2.66	1.84	2.85	3.03	5.34	3.07	10	1.77	migmatitic granite gneiss
03RME-0281	Olrig	644858	5142232	GNE	0.73	0.75	0.67	0.60	0.62	0.46	0.61	0.65	0.66	0.63	0.64	10	0.08	garnet amphibolite
03RME-0282	French	642704	5145826	GNE	0.18	0.13	0.21	0.14	0.15	0.19	0.19	0.19	0.15	0.20	0.17	10	0.03	granitoid gneiss, Jocko type
03RME-0283	French	642010	5146462	GNE	0.12	0.16	0.17	0.18	0.12	0.17	0.15	0.18	0.10	0.13	0.15	10	0.03	granitoid gneiss, Jocko type

Appendix 5. continued.

Station	Township	Easting	Northing	Rock Type	Rdg 1	Rdg 2	Rdg 3	Rdg 4	Rdg 5	Rdg 6	Rdg 7	Rdg 8	Rdg 9	Rdg 10	Avg	Pop (n)	S.D.	Comments
03RME-0284a	French	639732	5146783	GNE	20.20	21.20	21.70	15.00	18.20	4.47	0.26	0.31	0.16	0.17	10.17	10	9.84	migmatitic gneiss, north part of outcrop, quartz-muscovite unit?
03RME-0284b	French	639732	5146783	GNE	0.26	0.20	0.05	0.09	0.02	0.46	0.10	0.16	0.10	0.15	0.16	10	0.13	heterogeneous gneiss, basement type?
03RME-0285	Phelps	639940	5145711	GNE	0.18	0.21	0.17	0.18	0.18	0.26	0.24	0.27	0.32	0.25	0.23	10	0.05	granitoid gneiss, Jocko type
03RME-0286	Phelps	639980	5145534	GNE	0.03	0.10	0.17	0.17	0.10	0.23	0.05	0.19	0.06	0.06	0.12	10	0.07	granitoid gneiss, Jocko type
03RME-0287a	Phelps	639837	5144263	GNE	0.77	0.75	0.27	0.75	0.27	0.28	0.47	0.77	0.22	1.45	0.60	10	0.38	granitoid gneiss (Mulock?), main part of outcrop
03RME-0287b	Phelps	639837	5144263	GNE	0.22	0.15	0.17	0.20	0.14	0.17	0.72	0.13	0.14	0.14	0.22	10	0.18	migmatitic granitoid gneiss, north part of outcrop
03RME-0292	Phelps	643440	5164000	GNE	1.60	2.72	2.44	2.12	2.35	2.56	3.22	0.93	1.23	3.39	2.26	10	0.80	medium grained granodiorite gneiss
03RME-0294	Jocko	643171	5163856	ULT	0.49	0.44	0.44	0.44	0.52	0.57	0.52	0.53	0.43	0.54	0.49	10	0.05	orthopyroxene hornblendite
03RME-0299	Clarkson	642452	5166054	ULT	13.00	9.76	11.40	9.36	11.30	7.16	11.60	15.80	11.40	12.80	11.36	10	2.33	ultramafic, altered orthopyroxene hornblendite
03RME-0300	Phelps			GNE	0.52	0.28	0.50	0.49	0.43	0.43	0.41	0.28	0.50	0.34	0.42	10	0.09	granite gneiss, Mulock?
03RME-0301a	Phelps	643231	5135737	GNE	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.01	0.01	0.01	0.01	10	0.01	migmatitic granite gneiss, south part of outcrop
03RME-0301b	Phelps	643231	5135737	GNE	0.00	0.04	2.39	1.02	0.00	2.91	5.15	0.01	0.00	0.00	1.15	10	1.78	migmatitic granite gneiss, middle of outcrop
03RME-0301c	Phelps	643231	5135737	GNE	0.50	0.13	0.56	0.63	0.15	0.08	0.71	0.34	0.60	0.41	0.41	10	0.23	heterogeneous migmatitic gneiss
03RME-0302	Phelps	644352	5136464	GNE	0.00	0.06	0.00	0.01	0.49	0.10	0.12	0.01	0.13		0.10	9	0.15	migmatitic granite gneiss
03RME-0303	Phelps	646625	5136653	AMP	2.69	3.22	1.56	1.45	2.63	1.02	4.35	6.73	0.27	0.73	2.47	10	1.95	migmatitic mafic gneiss to amphibolite
03RME-0304	Phelps	646643	5136683	AMP	0.49	0.49	0.47	0.51	0.47	0.47	0.31	0.45	0.62	0.37	0.47	10	0.08	garnet amphibolite
03RME-0306a	Phelps	647442	5136610	GNE	0.58	1.61	2.77	2.03							1.75	4	0.91	migmatitic conglomerate, dark clasts
03RME-0306b	Phelps	647442	5136610	GNE	0.21	0.23	0.21	0.18	0.12	0.37					0.22	6	0.08	migmatitic conglomerate, matrix
03RME-0307	Phelps	647499	5136609	GNE	0.43	0.05	0.07	0.04	0.08	0.10	0.06	0.05	0.09	0.07	0.10	10	0.12	migmatitic conglomerate

Appendix 5. continued.

Station	Township	Easting	Northing	Rock Type	Rdg 1	Rdg 2	Rdg 3	Rdg 4	Rdg 5	Rdg 6	Rdg 7	Rdg 8	Rdg 9	Rdg 10	Avg	Pop (n)	S.D.	Comments
03RME-0313a	Mattawan	660865	5132926	GNE	0.52	0.43	0.25	0.40	0.71	0.90	0.23	0.42	0.28	0.35	0.45	10	0.21	typical intermediate layered gneiss
03RME-0313b	Mattawan	660865	5132926	GNE	0.47	0.41	0.08	0.51	0.58	0.35	0.23				0.38	7	0.17	rusty zone in gneiss
03RME-0313c	Mattawan	660865	5132926	GNE	1.53	0.57	0.88	2.81							1.45	4	0.99	rusty part of small outcrop
03RME-0315a	Mattawan	661418	5131623	AMP	0.57	0.67	0.65	0.63	0.78	0.62	0.65	0.91	1.06	0.59	0.71	10	0.16	amphibolite
03RME-0315b	Mattawan	661418	5131623	GNE	0.90	3.91	1.00	1.54	1.63	0.96					1.66	6	1.15	garnetite zones in amphibolite
03RME-0317	Mattawan	667696	5136164	GNE	14.30	19.50	19.60	18.70	18.40	17.10	17.20	13.90	10.80	12.10	16.16	10	3.17	granodiorite gneiss
03RME-0318a	Mattawan	668289	5135554	GNE	5.16	7.53	2.41	3.59	7.61	2.17	4.93	2.84	4.46	2.52	4.32	10	2.01	monzogranite gneiss
03RME-0318b	Mattawan	668190	5135245	GNE	1.14	1.43	1.61	1.07	1.21	1.47	1.26	1.01	1.26	1.26	1.27	10	0.19	migmatitic granodiorite gneiss
03RME-0319a	Mattawan	668170	5135017	AMP	51.70	53.10	54.50								53.10	3	1.40	amphibolite
03RME-0319b	Mattawan	668170	5135017	GNE	6.70	12.20	30.00	8.93	8.88	11.40	9.90				12.57	7	7.89	megacrystic granodiorite gneiss
03RME-0320	Mattawan	668135	5133628	GNE	18.10	19.90	14.70	5.11	7.12	9.45	11.40	8.81	7.51		11.34	9	5.14	monzogranite gneiss
03RME-0321a	Mattawan	662519	5139138	GNE	0.55	0.58	0.50	0.52	0.47	0.52	0.53				0.52	7	0.04	melanocratic granitoid gneiss
03RME-0321b	Mattawan	662519	5139138	GNE	0.28	0.49	0.43	0.42	0.56	0.49	0.57				0.46	7	0.10	leucocratic granitoid gneiss
03RME-0322	Mattawan	662300	5139279	GNE	2.55	0.76	1.40	2.13	1.82	2.33	0.89	0.68	0.57	0.46	1.36	10	0.79	straight gneiss, with garnet
03RME-0323a	Mattawan	662244	5139362	OTH	3.52	2.81	2.57	3.01	2.50	4.45	2.77	3.00	3.21	3.53	3.14	10	0.58	pseudoecologite
03RME-0323b	Mattawan	662180	5139401	OTH	1.59	1.66	1.50	2.07	1.25	1.24	3.44	1.77	1.39	1.31	1.72	10	0.66	pseudoecologite
03RME-0325a	Mattawan	670123	5135273	GNE	0.70	0.04	0.03	0.37	0.83	0.88	0.84	2.89	1.10	0.05	0.77	10	0.84	monzogranite gneiss
03RME-0325b	Mattawan	671686	5135401	GNE	0.51	0.30	0.83	0.79	0.61	0.08	1.39	0.23	0.25	0.39	0.54	10	0.39	migmatitic gneiss cut by granitic gneiss
03RME-0326a	Mattawan	676500	5132450	GNE	10.10	5.92	0.86	3.40	0.86	3.88	3.18	1.57	3.50	2.93	3.62	10	2.74	grey gneiss, coarse grained, megacrystic
03RME-0326b	Mattawan	676500	5132450	GNE	9.36	12.20	10.20	23.00	17.80	16.50					14.84	6	5.23	grey gneiss, N end of road cut, fine grained, in part megacrystic
03RME-0326c	Mattawan	676500	5132450	GNE	12.50	12.40	13.40	12.60	26.40	21.80					16.52	6	6.06	grey gneiss, N end of road cut, megacrystic
03RME-0326d	Mattawan	676500	5132450	GNE	16.70	20.80	15.70	16.10	29.90						19.84	5	5.98	grey gneiss, fine grained
03RME-0326e	Mattawan	676500	5132450	GNE	19.80	15.50	18.60	12.40	10.80	12.20	19.00	20.20	13.90	21.30	16.37	10	3.85	grey gneiss, fine grained and megacrystic
03RME-0329	Butler	650978	5149659	GNE	0.14	0.49	0.30	0.33	0.44	0.32	0.33	0.48	0.33	0.38	0.35	10	0.10	garnet-kyanite gneiss

Appendix 5. continued.

Station	Township	Easting	Northing	Rock Type	Rdg 1	Rdg 2	Rdg 3	Rdg 4	Rdg 5	Rdg 6	Rdg 7	Rdg 8	Rdg 9	Rdg 10	Avg	Pop (n)	S.D.	Comments
03RME-0330a	Butler	651175	5149620	GNE	0.15	0.15	0.14	0.43	0.09	0.03	0.07				0.15	7	0.13	garnet-muscovite-kyanite gneiss
03RME-0330b	Butler	651175	5149620	GNE	2.64	8.02									5.33	2	3.80	sweats in garnet-muscovite-kyanite gneiss
03RME-0331	Butler	651271	5149438	GNE	0.09	0.41	0.16	0.47	0.17	0.14	0.06	0.40	0.52	2.71	0.51	10	0.79	migmatitic quartz-muscovite gneiss
03RME-0333a	Butler	651330	5149095	GNE	4.97	10.30	14.60	5.66	9.61						9.03	5	3.90	migmatitic quartz-muscovite gneiss, pink sweats
03RME-0333b	Butler	651330	5149095	GNE	2.36	2.80	3.55	3.56	2.57						2.97	5	0.56	migmatitic quartz-muscovite gneiss, quartz-kyanite replaced sweats
03RME-0336	Butler	651455	5418810	GNE	0.22	0.24	0.29	0.21	0.24	0.28	0.29	0.29	0.24	0.31	0.26	10	0.03	garnet-kyanite-biotite gneiss
03RME-0340a	Butler	650311	5149106	GNE	0.41	0.73	0.32	1.46	0.11	0.27	0.11	0.03	0.11	0.58	0.41	10	0.43	quartz muscovite gneiss
03RME-0340b	Butler	650311	5149106	GNE	0.53	0.52	0.53	0.55	0.61	0.60	0.48	0.52	0.79	0.52	0.57	10	0.09	calc silicate gneiss
03RME-0346	Butler	650129	5149177	GNE	6.35	10.10	10.60	8.79	9.23	3.56	8.97	9.84	10.00	8.41	8.59	10	2.13	granodiorite gneiss
03RME-0359	Antoine	653366	5152958	DIO	0.81	0.78	0.71	0.80	0.74	0.84	0.71	0.76	0.79	0.72	0.77	10	0.05	biotite-hornblende diorite to leucoamphibolite
03RME-0372a	Antoine	653421	5153455	GNE	0.21	0.27	0.28	0.23	0.19	0.18	0.16	0.20	0.34	0.22	0.23	10	0.05	sulphide-bearing garnet-kyanite rock
03RME-0372b	Antoine	653421	5153455	GNE	0.35	0.22	0.26	0.37	0.27	0.30	0.29	0.35	0.30		0.30	9	0.05	non-sulphide-bearing garnet-kyanite rock

Metric Conversion Table

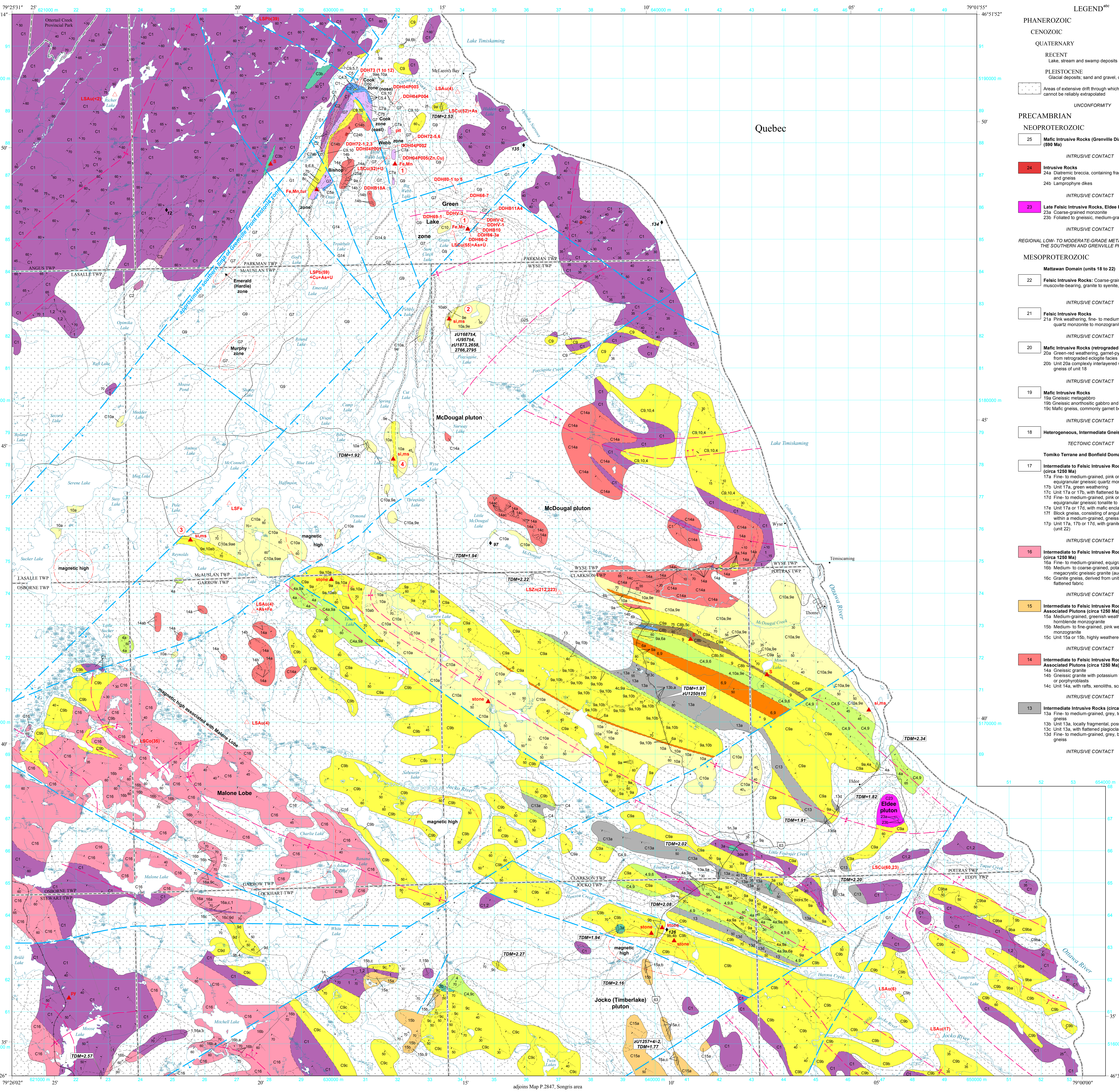
Conversion from SI to Imperial			Conversion from Imperial to SI		
SI Unit	*Multiplied by*	*Gives*	*Imperial Unit*	*Multiplied by*	*Gives*
			LENGTH		
1 mm	0.039 37	inches	1 inch	**25.4**	mm
1 cm	0.393 70	inches	1 inch	**2.54**	cm
1 m	3.280 84	feet	1 foot	**0.304 8**	m
1 m	0.049 709	chains	1 chain	20.116 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	0.061 023	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	1.307 951	cubic yards	1 cubic yard	0.764 554 86	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	0.035 273 962	ounces (avdp)	1 ounce (avdp)	28.349 523	g
1 g	0.032 150 747	ounces (troy)	1 ounce (troy)	**31.103 476 8**	g
1 kg	2.204 622 6	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 3	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 90**	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

	Multiplied by	
1 ounce (troy) per ton (short)	31.103 477	grams per ton (short)
1 gram per ton (short)	0.032 151	ounces (troy) per ton (short)
1 ounce (troy) per ton (short)	20.0	pennyweights per ton (short)
1 pennyweight per ton (short)	0.05	ounces (troy) per 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.

ISSN 0826-9580
ISBN 1-4249-0968-6



adjoins Map P.2847, Songis area

LEGEND[abc]

PHANEROZOIC

CENOZOIC

QUATERNARY

RECENT
Lake, stream and swamp deposits

PLEISTOCENE
Glacial deposits; sand and gravel, clay and till

Areas of extensive drift through which geological contacts cannot be reliably extrapolated

UNCONFORMITY

PRECAMBRIAN

NEOPROTEROZOIC

25 Mafic Intrusive Rocks (Grenville Diabase Dike Swarm) (590 Ma)

INTRUSIVE CONTACT

24 Intrusive Rocks
24a Diatremic breccia, containing fragments of amphibolite and gneiss
24b Lamprophyre dikes

INTRUSIVE CONTACT

23 Late Felsic Intrusive Rocks, Eldee Pluton
23a Coarse-grained monzonite
23b Foliated to gneissic, medium-grained monzonite

INTRUSIVE CONTACT

REGIONAL LOW- TO MODERATE-GRADE METAMORPHISM WITHIN THE SOUTHERN AND GRENVILLE PROVINCES

MESOPROTEROZOIC

Mattawan Domain (units 18 to 22)

22 Felsic Intrusive Rocks: Coarse-grained to pegmatitic, muscovite-bearing, granite to syenite, in crosscutting veins

INTRUSIVE CONTACT

21 Felsic Intrusive Rocks
21a Pink weathering, fine- to medium-grained, gneissic quartz monzonite to monzogranite

INTRUSIVE CONTACT

20 Mafic Intrusive Rocks (retrograded eclogite facies rocks)
20a Green-red weathering, garnet-pyroxene gneiss, derived from retrograded eclogite facies mafic gneiss
20b Unit 20a complexly interlayered with heterogeneous gneiss of unit 18

INTRUSIVE CONTACT

19 Mafic Intrusive Rocks
19a Gneissic metagabbro
19b Gneissic anorthositic gabbro and gabbroic anorthosite
19c Mafic gneiss, commonly garnet bearing

INTRUSIVE CONTACT

18 Heterogeneous, Intermediate Gneiss

TECTONIC CONTACT

Tomiko Terrane and Bonfield Domain

17 Intermediate to Felsic Intrusive Rocks, Bonfield Pluton (circa 1250 Ma)
17a Fine- to medium-grained, pink or grey weathering, equigranular gneissic quartz monzonite to monzogranite
17b Unit 17a, green weathering
17c Unit 17a or 17b, with flattened fabric
17d Fine- to medium-grained, pink or grey weathering, equigranular gneissic tonalite to granodiorite
17e Unit 17a or 17d, with mafic enclaves and schlieren
17f Block gneiss, consisting of angular blocks of gneiss within a medium-grained, gneissic granodioritic matrix
17p Unit 17a, 17b or 17d, with granite pegmatite veins (unit 22)

INTRUSIVE CONTACT

16 Intermediate to Felsic Intrusive Rocks, Mulock Pluton (circa 1250 Ma)
16a Fine- to medium-grained, equigranular gneissic granite
16b Medium- to coarse-grained, potassium feldspar megacrystic gneissic granite (augen gneiss)
16c Granite gneiss, derived from unit 16a or 16b, with flattened fabric

INTRUSIVE CONTACT

15 Intermediate to Felsic Intrusive Rocks, Jocko and Associated Plutons (circa 1250 Ma)
15a Medium-grained, greenish weathering, leucocratic hornblende monzogranite
15b Medium- to fine-grained, pink weathering, leucocratic monzogranite
15c Unit 15a or 15b, highly weathered

INTRUSIVE CONTACT

14 Intermediate to Felsic Intrusive Rocks, McDougal and Associated Plutons (circa 1250 Ma)
14a Gneissic granite
14b Gneissic granite with potassium feldspar phenocrysts or porphyroblasts
14c Unit 14a, with rafts, xenoliths, screens of units 1 or 3a

INTRUSIVE CONTACT

13 Intermediate Intrusive Rocks (circa 1250 Ma)
13a Fine- to medium-grained, grey, tonalite to granodiorite gneiss
13b Unit 13a, locally fragmental, possibly of volcanic origin
13c Unit 13a, with flattened plagioclase feldspar megacrysts
13d Fine- to medium-grained, grey, biotite granodiorite gneiss

INTRUSIVE CONTACT

PALEOPROTEROZOIC TO MESOPROTEROZOIC

Tomiko Supracrustal Rocks (units 4 to 12)

12 Intermediate to Felsic Metavolcanic or Metaplutonic Rocks
12a Fine-grained, pink weathering felsite

11 Mafic Metavolcanic or Metaplutonic Rocks
11a Fine- to medium-grained amphibolite
11b Fine- to medium-grained garnet amphibolite
11c Fine- to medium-grained mafic gneiss, likely derived from metagabbro
11d Unit 11c, migmatitic
11e Unit 11a, interlayered with rocks of unit 9, likely the result of interbedding of thin mafic flows and/or tuffs with quartzose sediment
11k Fine- to medium-grained amphibolite, containing the assemblage hornblende-kyanite

10 Quartzose Sedimentary Rocks
10a Medium- to coarse-grained, glassy, quartz arenite
10b Unit 10a, with cross-bedding

9 Feldspathic and Micaceous Sedimentary Rocks
9a Fine- to medium-grained, thin- to medium-layered, micaceous, quartz arenite and feldspathic arenite, commonly containing white mica porphyroblasts, and 2 to 10% granitic sweats or pods
9b Unit 9a, metatextite (10 to 30% leucosome)
9c Unit 9a, diatextite (>30% leucosome)
9d Units 9b and/or 9c, with strongly flattened fabric
9e Fine- to medium-grained, green, red, or white weathering, muscovite schist, commonly interlayered with rocks of unit 10
9f Fine- to medium-grained, thin- to medium-layered, micaceous, quartz arenite and feldspathic arenite, diatextite (>30% leucosome), leucosome consists of quartz±pale green kyanite
9g Quartz cobble, clast-supported, metaconglomerate and fine- to medium-grained, micaceous, quartz arenite and feldspathic arenite, migmatitic (>10% leucosome), leucosome contains quartz±pale green kyanite

8 Compositionally Unusual Rocks
8a Biotite-garnet-kyanite±muscovite and biotite-kyanite-garnet±muscovite gneiss
8b Pyrrhotite-rich, biotite-plagioclase-quartz gneiss
8c Tourmaline-rich metapelite to tourmalinite; tourmaline may only be visible in thin section
8d Pyrrhotite-epidote-plagioclase-quartz gneiss; epidote may only be visible in thin section

7 Iron Formation and Related Rocks
7a Magnetite-chert iron formation, probably derived from metamorphism of oxide-facies iron formation
7b Ferrosilite gneiss, probably derived from metamorphism of carbonate-facies iron formation

6 Biotite Gneiss (Metapelite)
6a Pelite and or semipelite, thin to medium bedded, locally rusty
6b Fine- to medium-grained, dark grey weathering, biotite gneiss
6c Muscovite-rich pelite

5 Carbonate Rocks
5a Calcite marble
5b Dolomite marble
5c Interlayered biotite gneiss and calcite marble

4 Calc-silicate Rocks
4a Grey-green to green weathering, fine- to medium-layered, calc-silicate gneiss and amphibolite, commonly interlayered with rocks of unit 9
4b Garnet amphibolite
4c Garnet-biotite diorite gneiss, thin layered, with thin leucosomes parallel to foliation

UNCONFORMITY

ARCHEAN TO PALEOPROTEROZOIC

3 Mafic to Ultramafic Gneiss
3a Amphibolite
3b Mafic gneiss derived from gabbro to anorthositic gabbro
3c Orthopyroxene hornblendite, with subrounded to rounded orthopyroxene megacrysts, megacrysts <15 mm in size
3d Mafic to ultramafic gneiss, possibly derived from unit 3c

INTRUSIVE CONTACT

ARCHEAN

NEOARCHEAN

REGIONAL HIGH-GRADE METAMORPHISM AND MIGMATIZATION

2 Intermediate to Felsic Orthogneiss

INTRUSIVE CONTACT

1 Heterogeneous Gneiss
1n Porphyroclastic gneiss to straight gneiss, mostly likely derived from unit 1, but may, in part, be derived from units 9, 10 and 15

[a] This legend is a field legend that incorporates the results of laboratory investigations, including petrography and geochemistry.
[b] The letter "C" preceding a code refers to data interpreted from geological maps listed under "Sources of Information". The letter "D" preceding a code refers to data compiled from diamond drill holes. The letter "G" preceding a code refers to data interpreted from geophysical maps listed under "Sources of Information".
[c] This legend applies to Maps P.2846 and P.2847. Not all rock types may be present on this map.

SYMBOLS[de]

- Small bedrock outcrop
- Compiled small bedrock outcrop (note: outcrops of this type along logging roads or in cleared areas may no longer be exposed due to revegetation, especially those compiled from maps more than 25 years old)
- Area of bedrock outcrop
- Geological contact (trend only, interpreted)
- Geological contact (trend only, in areas of drift, interpreted)
- Geophysical contact (trend only, interpreted)
- Geophysical anomaly, aeromagnetic high (trend only, interpreted)
- Extent of bedrock outcrop (outcrop density and exposure may vary considerably between these generalized areas of outcrop)
- Limit of mapping*
- Fault (trend only, interpreted)
- Fault; downthrown, magnitude of vertical displacement unknown, unknown horizontal displacement (trend only, down-dropped side indicated, interpreted)
- Fault; forms boundary between Tomiko terrane and Mattawan domain (trend only, interpreted)*
- Lineament (trend only, interpreted)
- Fold; antiform, unknown generation (trend only, interpreted)
- Fold; recumbent, antiformal, unknown generation (trend only, both limbs dip in same direction, interpreted)
- Fold; synform, unknown generation (trend only, interpreted)
- Fold; recumbent, synformal, unknown generation (trend only, both limbs dip in same direction, interpreted)
- Bedding; sedimentary, volcanic or other, cross-bedded with facing known (overturned)**
- Compositional layering and/or parallel tectonic foliation; unknown generation (magnitude of dip unknown, horizontal, inclined, vertical*)
- Foliation; unknown generation (magnitude of dip unknown, inclined, vertical**)
- Lineation (with plunge, without plunge*)
- Esker
- Property or occurrence (keyed to "Prospects, Past-Producers and Producers")
- Location of property or occurrence
- Exploration pit
- DDH73 Diamond drill hole; company drill-hole number, location approximate
- 12 Modern alluvium survey anomaly, from Reid (2002), with abbreviated sample number (preface 01JRMA-0)
- LSAu(6) Lake sediment geochemical anomaly, from Hornbrook and Friske (1989), with commodity and value, in ppm
- zU1250±10 U/Pb geochronology sample site, with age in Ma
- TDM=1.97 Nd/Sm geochronology sample site, with age in Ga

[d] * only appear on Map P.2847; ** only appear on Map P.2846
[e] Lake name in parentheses (e.g., Clear (Transparent) Lake) are provided for reference only as those names were former official or local names which were used in the older literature.

Ontario

Ontario Geological Survey

MAP P.2846

PRECAMBRIAN GEOLOGY

JOCKO RIVER AREA

Scale 1:50 000

1000 m 0 1 2 km

NTS References: 31L/10, 11, 14

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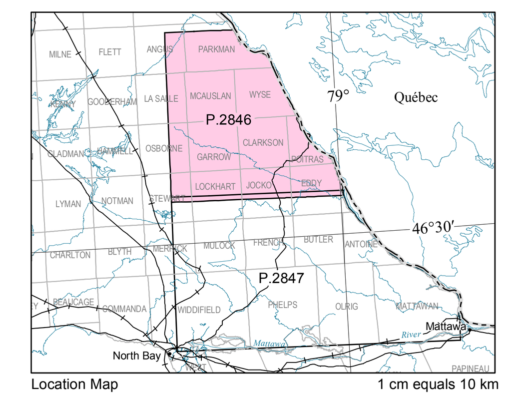

Location Map 1 cm equals 10 km

ABBREVIATIONS

As....arsenic	ms....muscovite
Au....gold	Pb....lead
bldrs....boulders	py....pyrite
Co....cobalt	S....sulphide minerals
Cu....copper	si....silica
Fe....iron	stone....stone
LS....lake sediment anomaly, in ppm	tur....tourmaline
Mn....manganese	U....uranium
	Zn....zinc

r....rutile
TDM....Nd/Sm model age in Ga
z....zircon

PROSPECTS, PAST-PRODUCERS AND PRODUCERS

Number	Name	Mineral Deposit Inventory Number	Commodity
1	Parkman Iron (Iron City Mines Ltd.)	MDI 31L14SW0012, MDI 31L14SW0013, MDI 31L14SE0004	Fe, Mn
2	Porcupine Lake	MDI 31L14SW0006	si, ms
3	Reynolds Lake (McLaren's Bay Mica and Mote)	MDI 31L11NW0004	si, ms
4	Threetails Lake	MDI 31L11NW0003, MDI 31L11NW0005	si, ms

SOURCES OF INFORMATION

Base map information derived from Ontario Land Information Warehouse, Land Information Ontario, Ontario Ministry of Natural Resources, scale 1:20 000.

Mapping conducted using UTM co-ordinates in North American Datum 1983 (NAD83), Zone 17.

Compiled geology and geophysical interpretation derived from:

Giblin, P.E. 1960. Figure 3a, Geological Map, Terrell Iron Project, Parkman Township, Ontario; Sudbury Resident Geologist's office, Parkman Township, assessment file SP#0003, scale 1:2390.

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Lumbers, S.B. 1971. Tomiko area (east half); Ontario Department of Mines and Northern Affairs, Preliminary Map P.679, scale 1:63 360.

Moore, R.L. 1976. Metamorphic petrology of the area between Mattawa, North Bay and Temiscaming, Ontario; unpublished PhD thesis, Carleton University, Ottawa, Ontario, 265p.

Other Sources of Information:

Easton, R.M. 2005. The Grenvillian Tomiko quartzites of Ontario: correlatives of the Baraboo quartzites of Wisconsin, the Mazatzal orogen of New Mexico, or unique? Implications for the tectonic architecture of Laurentia in the Great Lakes region; 51st Institute on Lake Superior Geology, Proceedings, v.51, pt.1, p.15-16.

Easton, R.M. and Kamo, S.L. 2004. The Grenvillian Tomiko quartzites of Ontario: correlative with the Baraboo quartzites of Wisconsin or the Mazatzal orogen of New Mexico? Implications for the tectonic architecture of Laurentia in the Great Lakes region; Geological Society of America, Abstracts with Program, v.36, no.5, p.A-459.

Holmden, C. and Dickin, A.P. 1995. Paleoproterozoic crustal history of the southwestern Grenville Province; Canadian Journal of Earth Sciences, v.32, p.472-485.

Hornbrook, E.H. and Friske, P.W. 1989. National Geochemical Reconnaisance lake sediment and water data, central Ontario (31E/N2, parts of 31K, 31L); Geological Survey of Canada, Open File Report 1956.

Reid, J.L. 2002. Regional modern alluvium sampling survey of the Mattawa–Cobalt corridor, northeastern Ontario; Ontario Geological Survey, Open File Report 6088, 235p.

Metric conversion factor 1 foot = 0.3048 m.

Geology is not tied to survey lines.

Magnetic declination for centre of map area, approximately 11°45′W in 2006.

CREDITS

Geology by R.M. Easton, 2003.

Geological compilation by R.M. Easton, 2004–2006.

Digital drafting by R.M. Easton and S. Josey.

Cartographic production by A. Evers.

To enable the rapid dissemination of information, this map has not received a technical edit. Discrepancies may occur for which the Ontario Ministry of Northern Development and Mines does not assume liability. Users should verify critical information.

Issued 2006.

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

Easton, R.M. 2006. Precambrian geology, Jocko River area; Ontario Geological Survey, Preliminary Map P.2846, scale 1:50 000.

PROSPECTS, PAST-PRODUCERS AND PRODUCERS

Number	Name	Mineral Deposit Inventory Number	Commodity
1	Butler vermiculite	MDI 31L11SE0003	verm
2	North American kyanite (now Kyanite Mining Corporation)	MDI 31L11SE0012	ky, gr
3	O'Brien and Fowler feldspar mine	MDI 31L07SW0013	fel
4	Purdy mica mine	MDI 31L07SW0006	mica

ABBREVIATIONS

Au........gold
cp........chalcopyrite
Cu........copper
Fe........iron
fel........feldspar
gr........garnet
ky........kyanite
LS........lake sediment anomaly, in ppm
mi........mica
Ni........nickel
U........uranium
verm........vermiculite
Zn........zinc

meta........metamorphic
TDM......Nd/Sm model age in Ga
wR........whole-rock Rb/Sr age
z........zircon

LEGEND[abc]

PHANEROZOIC

CENOZOIC

QUATERNARY

RECENT
Lake, stream and swamp deposits

PLEISTOCENE
Glacial deposits; sand and gravel, clay and till

Areas of extensive drift through which geological contacts cannot be reliably extrapolated

UNCONFORMITY

PRECAMBRIAN

NEOPROTEROZOIC

25 Mafic Intrusive Rocks (Grenville Diabase Dike Swarm) (590 Ma)

INTRUSIVE CONTACT

24 Intrusive Rocks
24a Diatremic breccia, containing fragments of amphibolite and gneiss
24b Lamprophyre dikes

INTRUSIVE CONTACT

23 Late Felsic Intrusive Rocks, Eldee Pluton
23a Coarse-grained monzonite
23b Foliated to gneissic, medium-grained monzonite

INTRUSIVE CONTACT

REGIONAL LOW- TO MODERATE-GRADE METAMORPHISM WITHIN THE SOUTHERN AND GRENVILLE PROVINCES

MESOPROTEROZOIC

Mattawan Domain (units 18 to 22)

22 Felsic Intrusive Rocks: Coarse-grained to pegmatitic, muscovite-bearing, granite to syenite, in crosscutting veins

INTRUSIVE CONTACT

21 Felsic Intrusive Rocks
21a Pink weathering, fine- to medium-grained, gneissic quartz monzonite to monzogranite

INTRUSIVE CONTACT

20 Mafic Intrusive Rocks (retrograded eclogite facies rocks)
20a Green-red weathering, garnet-pyroxene gneiss, derived from retrograded eclogite facies mafic gneiss
20b Unit 20a complexly interlayered with heterogeneous gneiss of unit 18

INTRUSIVE CONTACT

19 Mafic Intrusive Rocks
19a Gneissic metagabbro
19b Gneissic anorthositic gabbro and gabbroic anorthosite
19c Mafic gneiss, commonly garnet bearing

INTRUSIVE CONTACT

18 Heterogeneous, Intermediate Gneiss

TECTONIC CONTACT

Tomiko Terrane and Bonfield Domain

17 Intermediate to Felsic Intrusive Rocks, Bonfield Pluton (circa 1250 Ma)
17a Fine- to medium-grained, pink or grey weathering, equigranular gneissic quartz monzonite to monzogranite
17b Unit 17a, green weathering
17c Unit 17a or 17b, with flattened fabric
17d Fine- to medium-grained, pink or grey weathering, equigranular gneissic tonalite to granodiorite
17e Unit 17a or 17d, with mafic enclaves and schlieren
17f Block gneiss, consisting of angular blocks of gneiss within a medium-grained, gneissic granodioritic matrix
17p Unit 17a, 17b or 17d, with granite pegmatite veins (unit 22)

INTRUSIVE CONTACT

16 Intermediate to Felsic Intrusive Rocks, Mulock Pluton (circa 1250 Ma)
16a Fine- to medium-grained, equigranular gneissic granite
16b Medium- to coarse-grained, potassium feldspar megacrystic gneissic granite (augen gneiss)
16c Granite gneiss, derived from unit 16a or 16b, with flattened fabric

INTRUSIVE CONTACT

15 Intermediate to Felsic Intrusive Rocks, Jocko and Associated Plutons (circa 1250 Ma)
15a Medium-grained, greenish weathering, leucocratic hornblende monzogranite
15b Medium- to fine-grained, pink weathering, leucocratic monzogranite
15c Unit 15a or 15b, highly weathered

INTRUSIVE CONTACT

14 Intermediate to Felsic Intrusive Rocks, McDougal and Associated Plutons (circa 1250 Ma)
14a Gneissic granite
14b Gneissic granite with potassium feldspar phenocrysts or porphyroblasts
14c Unit 14a, with rafts, xenoliths, screens of units 1 or 3a

INTRUSIVE CONTACT

13 Intermediate Intrusive Rocks (circa 1250 Ma)
13a Fine- to medium-grained, grey, tonalite to granodiorite gneiss
13b Unit 13a, locally fragmental, possibly of volcanic origin
13c Unit 13a, with flattened plagioclase feldspar megacrysts
13d Fine- to medium-grained, grey, biotite granodiorite gneiss

INTRUSIVE CONTACT

PALEOPROTEROZOIC TO MESOPROTEROZOIC

Tomiko Supracrustal Rocks (units 4 to 12)

12 Intermediate to Felsic Metavolcanic or Metaplutonic Rocks
12a Fine-grained, pink weathering felsite

11 Mafic Metavolcanic or Metaplutonic Rocks
11a Fine- to medium-grained amphibolite
11b Fine- to medium-grained garnet amphibolite
11c Fine- to medium-grained mafic gneiss, likely derived from metagabbro
11d Unit 11c, migmatitic
11e Unit 11a, interlayered with rocks of unit 9, likely the result of interbedding of thin mafic flows and/or tuffs with quartzose sediment
11k Fine- to medium-grained amphibolite, containing the assemblage hornblende-kyanite

10 Quartzose Sedimentary Rocks
10a Medium- to coarse-grained, glassy, quartz arenite
10b Unit 10a, with cross-bedding

9 Feldspathic and Micaceous Sedimentary Rocks
9a Fine- to medium-grained, thin- to medium-layered, micaceous, quartz arenite and feldspathic arenite, commonly containing white mica porphyroblasts, and 2 to 10% granitic sweats or pods
9b Unit 9a, metatextite (10 to 30% leucosome)
9c Unit 9a, diatextite (>30% leucosome)
9d Units 9b and/or 9c, with strongly flattened fabric
9e Fine- to medium-grained, green, red, or white weathering, muscovite schist, commonly interlayered with rocks of unit 10
9f Fine- to medium-grained, thin- to medium-layered, micaceous, quartz arenite and feldspathic arenite, diatextite (>30% leucosome), leucosome consists of quartz±pale green kyanite
9g Quartz cobble, clast-supported, metaconglomerate and fine- to medium-grained, micaceous, quartz arenite and feldspathic arenite, migmatitic (>10% leucosome), leucosome contains quartz±pale green kyanite

8 Compositionally Unusual Rocks
8a Biotite-garnet-kyanite±muscovite and biotite-kyanite-garnet±muscovite gneiss
8b Pyrrhotite-rich, biotite-plagioclase-quartz gneiss
8c Tourmaline-rich metapelite to tourmalinite; tourmaline may only be visible in thin section
8d Pyrrhotite-epidote-plagioclase-quartz gneiss; epidote may only be visible in thin section

7 Iron Formation and Related Rocks
7a Magnetite-chert iron formation, probably derived from metamorphism of oxide-facies iron formation
7b Ferrosilite gneiss, probably derived from metamorphism of carbonate-facies iron formation

6 Biotite Gneiss (Metapelite)
6a Pelite and or semipelite, thin to medium bedded, locally rusty
6b Fine- to medium-grained, dark grey weathering, biotite gneiss
6c Muscovite-rich pelite

5 Carbonate Rocks
5a Calcite marble
5b Dolomite marble
5c Interlayered biotite gneiss and calcite marble

4 Calc-silicate Rocks
4a Grey-green to green weathering, fine- to medium-layered, calc-silicate gneiss and amphibolite, commonly interlayered with rocks of unit 9
4b Garnet amphibolite
4c Garnet-biotite diorite gneiss, thin layered, with thin leucosomes parallel to foliation

UNCONFORMITY

ARCHEAN TO PALEOPROTEROZOIC

3 Mafic to Ultramafic Gneiss
3a Amphibolite
3b Mafic gneiss derived from gabbro to anorthositic gabbro
3c Orthopyroxene hornblendite, with subrounded to rounded orthopyroxene megacrysts, megacrysts <15 mm in size
3d Mafic to ultramafic gneiss, possibly derived from unit 3c

INTRUSIVE CONTACT

ARCHEAN

NEOARCHEAN

REGIONAL HIGH-GRADE METAMORPHISM AND MIGMATIZATION

2 Intermediate to Felsic Orthogneiss

INTRUSIVE CONTACT

1 Heterogeneous Gneiss
1n Porphyroclastic gneiss to straight gneiss, mostly likely derived from unit 1, but may, in part, be derived from units 9, 10 and 15

[a] This legend is a field legend that incorporates the results of laboratory investigations, including petrography and geochemistry.
[b] The letter "C" preceding a code refers to data interpreted from geological maps listed under "Sources of Information".
The letter "D" preceding a code refers to data compiled from diamond drill holes.
The letter "G" preceding a code refers to data interpreted from geophysical maps listed under "Sources of Information".
[c] This legend applies to Maps P.2846 and P.2847. Not all rock types may be present on this map.

SYMBOLS[de]

- Small bedrock outcrop
- Compiled small bedrock outcrop (note: outcrops of this type along logging roads or in cleared areas may no longer be exposed due to revegetation, especially those compiled from maps more than 25 years old)
- Area of bedrock outcrop
- Geological contact (trend only, interpreted)
- Geological contact (trend only, in areas of drift, interpreted)
- Geophysical contact (trend only, interpreted)
- Geophysical anomaly, aeromagnetic high (trend only, interpreted)
- Extent of bedrock outcrop (outcrop density and exposure may vary considerably between these generalized areas of outcrop)
- Limit of mapping*
- Fault (trend only, interpreted)
- Fault; downthrown, magnitude of vertical displacement unknown, unknown horizontal displacement (trend only, down-dropped side indicated, interpreted)
- Fault; forms boundary between Tomiko terrane and Mattawan domain (trend only, interpreted)*
- Lineament (trend only, interpreted)
- Fold; antiform, unknown generation (trend only, interpreted)
- Fold; recumbent, antiformal, unknown generation (trend only, both limbs dip in same direction, interpreted)
- Fold; synform, unknown generation (trend only, interpreted)
- Fold; recumbent, synformal, unknown generation (trend only, both limbs dip in same direction, interpreted)
- Bedding; sedimentary, volcanic or other, cross-bedded with facing known (overturned)**
- Compositional layering and/or parallel tectonic foliation; unknown generation (magnitude of dip unknown, horizontal, inclined, vertical*)
- Foliation; unknown generation (magnitude of dip unknown, inclined, vertical**)
- Lineation (with plunge, without plunge*)
- Esker
- Property or occurrence (keyed to "Prospects, Past-Producers and Producers")
- Location of property or occurrence
- Exploration pit
- DDH73 Diamond drill hole; company drill-hole number, location approximate
- 12 Modern alluvium survey anomaly, from Reid (2002), with abbreviated sample number (preface 01JRMA-0)
- LSAu(6) Lake sediment geochemical anomaly, from Hornbrook and Friske (1989), with commodity and value, in ppm
- zU1250±10 U/Pb geochronology sample site, with age in Ma
- TDM=1.97 Nd/Sm geochronology sample site, with age in Ga

[d] * only appear on Map P.2847; ** only appear on Map P.2846
[e] Lake name in parentheses (e.g., Clear (Transparent) Lake) are provided for reference only as those names were former official or local names which were used in the older literature.

Ontario

Ontario Geological Survey

MAP P.2847

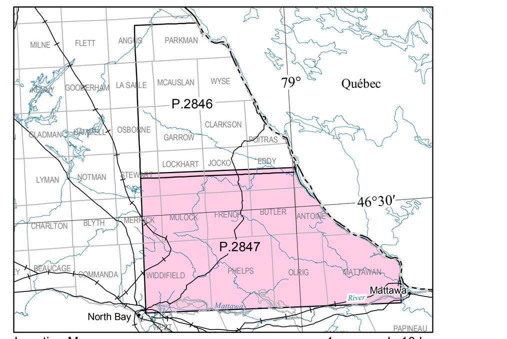
PRECAMBRIAN GEOLOGY

SONGRIS AREA

Scale 1:50 000

1000 m 0 1 2 km

NTS References: 31L/6, 7, 11



Location Map 1 cm equals 10 km

SOURCES OF INFORMATION

Base map information derived from Ontario Land Information Warehouse, Land Information Ontario, Ontario Ministry of Natural Resources, scale 1:20 000.

Mapping conducted using UTM co-ordinates in North American Datum 1983 (NAD83), Zone 17.

Compiled geology and geophysical interpretation derived from:

GSC–ODM 1965. Aeromagnetics, Mattawan; Geological Survey of Canada–Ontario Department of Mines, Aeromagnetic Map 1468G, scale 1:63 360.

GSC–ODM 1965. Aeromagnetics, North Bay; Geological Survey of Canada–Ontario Department of Mines, Aeromagnetic Map 1478G, scale 1:63 360.

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Metric conversion factor 1 foot = 0.3048 m.

Geology is not tied to survey lines.

Magnetic declination for centre of map area, approximately 11°45′W in 2006.

CREDITS

Geology by R.M. Easton, 2003.

Geological compilation by R.M. Easton, 2004–2006.

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Cartographic production by A. Evers.

To enable the rapid dissemination of information, this map has not received a technical edit. Discrepancies may occur for which the Ontario Ministry of Northern Development and Mines does not assume liability. Users should verify critical information.

Issued 2006.

Information from this publication may be quoted if credit is given. It is recommended that reference to this map be made in the following form.
Easton, R.M. 2006. Precambrian geology, Songris area; Ontario Geological Survey, Preliminary Map P.2847, scale 1:50 000.