ISBN 0-7794-8551-3

THESE TERMS GOVERN YOUR USE OF THIS DOCUMENT

Your use of this Ontario Geological Survey document (the "Content") is governed by the terms set out on this page ("Terms of Use"). By downloading this Content, you (the "User") have accepted, and have agreed to be bound by, the Terms of Use.

Content: This Content is offered by the Province of Ontario's *Ministry of Northern Development and Mines* (MNDM) as a public service, on an "as-is" basis. Recommendations and statements of opinion expressed in the Content are those of the author or authors and are not to be construed as statement of government policy. You are solely responsible for your use of the Content. You should not rely on the Content for legal advice nor as authoritative in your particular circumstances. Users should verify the accuracy and applicability of any Content before acting on it. MNDM does not guarantee, or make any warranty express or implied, that the Content is current, accurate, complete or reliable. MNDM is not responsible for any damage however caused, which results, directly or indirectly, from your use of the Content. MNDM assumes no legal liability or responsibility for the Content whatsoever.

Links to Other Web Sites: This Content may contain links, to Web sites that are not operated by MNDM. Linked Web sites may not be available in French. MNDM neither endorses nor assumes any responsibility for the safety, accuracy or availability of linked Web sites or the information contained on them. The linked Web sites, their operation and content are the responsibility of the person or entity for which they were created or maintained (the "Owner"). Both your use of a linked Web site, and your right to use or reproduce information or materials from a linked Web site, are subject to the terms of use governing that particular Web site. Any comments or inquiries regarding a linked Web site must be directed to its Owner.

Copyright: Canadian and international intellectual property laws protect the Content. Unless otherwise indicated, copyright is held by the Queen's Printer for Ontario.

It is recommended that reference to the Content be made in the following form:

Péloquin, A.S., Houlé, M.G. and Gibson, H.L. 2005. Geology of the Kidd–Munro assemblage in Munro Township, and the Tisdale and Lower Blake River assemblages in Currie Township; Ontario Geological Survey, Open File Report 6157, 94p.

Use and Reproduction of Content: The Content may be used and reproduced only in accordance with applicable intellectual property laws. *Non-commercial* use of unsubstantial excerpts of the Content is permitted provided that appropriate credit is given and Crown copyright is acknowledged. Any substantial reproduction of the Content or any *commercial* use of all or part of the Content is prohibited without the prior written permission of MNDM. Substantial reproduction includes the reproduction of any illustration or figure, such as, but not limited to graphs, charts and maps. Commercial use includes commercial distribution of the Content, the reproduction of multiple copies of the Content for any purpose whether or not commercial, use of the Content in commercial publications, and the creation of value-added products using the Content.

Contact:

FOR FURTHER INFORMATION ON	PLEASE CONTACT:	BY TELEPHONE:	BY E-MAIL:
The Reproduction of Content	MNDM Publication Services	Local: (705) 670-5691 Toll Free: 1-888-415-9845, ext. 5691 (inside Canada, United States)	Pubsales@ndm.gov.on.ca
The Purchase of MNDM Publications	MNDM Publication Sales	Local: (705) 670-5691 Toll Free: 1-888-415-9845, ext. 5691 (inside Canada, United States)	Pubsales@ndm.gov.on.ca
Crown Copyright	Queen's Printer	Local: (416) 326-2678 Toll Free: 1-800-668-9938 (inside Canada, United States)	Copyright@gov.on.ca

Ontario

Ontario Geological Survey
Open File Report 6157

Geology of the Kidd–Munro Assemblage in Munro Township, and the Tisdale and Lower Blake River Assemblages in Currie Township: Discover Abitibi Initiative

2005

ONTARIO GEOLOGICAL SURVEY

Open File Report 6157

Geology of the Kidd–Munro Assemblage in Munro Township, and the Tisdale and Lower Blake River Assemblages in Currie Township: Discover Abitibi Initiative

by

A.S. Péloquin, M.G. Houlé and H.L. Gibson

2005

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

Péloquin, A.S., Houlé, M.G. and Gibson, H.L. 2005. Geology of the Kidd–Munro assemblage in Munro Township, and the Tisdale and Lower Blake River assemblages in Currie Township: Discover Abitibi Initiative; Ontario Geological Survey, Open File Report 6157, 94p.

Discover Abitibi Initiative
The Discover Abitibi Initiative is a regional, cluster economic development project based on geoscientific investigations of the western Abitibi greenstone belt. The initiative, centred on the Kirkland Lake and Timmins mining camps, will complete 19 projects developed and directed by the local stakeholders. FedNor, Northern Ontario Heritage Fund Corporation, municipalities and private sector investors have provided the funding for the initiative.

Initiative Découvrons l’Abitibi
L’initiative Découvrons l’Abitibi est un project de développment économique régional dans une grappe d’industries, projet fondé sur des études géoscientifiques de la ceinture de roches vertes de l’Abitibi occidental. Cette initiative, centrée sur les zones minières de Kirkland Lake et de Timmins, mènera à bien 19 projets élaborés et dirigés par des intervenants locaux. FedNor, la Société de gestion du Fonds du patrimoine du Nord de l’Ontario, municipalités et des investisseurs du secteur privé ont fourni les fonds de cette initiative.

Open File Reports of the Ontario Geological Survey are available for viewing at the Mines Library in Sudbury, at the Mines and Minerals Information Centre in Toronto, and at the regional Mines and Minerals office whose district includes the area covered by the report (see below).

Copies can be purchased at Publication Sales and the office whose district includes the area covered by the report. Although a particular report may not be in stock at locations other than the Publication Sales office in Sudbury, they can generally be obtained within 3 working days. All telephone, fax, mail and e-mail orders should be directed to the Publication Sales office in Sudbury. Use of VISA or MasterCard ensures the fastest possible service. Cheques or money orders should be made payable to the *Minister of Finance.*

Mines and Minerals Information Centre (MMIC) Macdonald Block, Room M2-17 900 Bay St. Toronto, Ontario M7A 1C3	Tel:	(416) 314-3800
Mines Library 933 Ramsey Lake Road, Level A3 Sudbury, Ontario P3E 6B5	Tel:	(705) 670-5615
Publication Sales 933 Ramsey Lake Rd., Level A3 Sudbury, Ontario P3E 6B5	Tel:	(705) 670-5691(local) 1-888-415-9845(toll-free)
	Fax:	(705) 670-5770
	E-mail:	pubsales@ndm.gov.on.ca

Regional Mines and Minerals Offices:

Kenora - Suite 104, 810 Robertson St., Kenora P9N 4J2

Kirkland Lake - 10 Government Rd. E., Kirkland Lake P2N 1A8

Red Lake - Box 324, Ontario Government Building, Red Lake P0V 2M0

Sault Ste. Marie - 70 Foster Dr., Ste. 200, Sault Ste. Marie P6A 6V8

Southern Ontario - P.O. Bag Service 43, 126 Old Troy Rd., Tweed K0K 3J0

Sudbury - Level B3, 933 Ramsey Lake Rd., Sudbury P3E 6B5

Thunder Bay - Suite B002, 435 James St. S., Thunder Bay P7E 6S7

Timmins - Ontario Government Complex, P.O. Bag 3060, Hwy. 101 East, South Porcupine P0N 1H0

Toronto - MMIC, Macdonald Block, Room M2-17, 900 Bay St., Toronto M7A 1C3

Cette publication est disponible en anglais seulement.

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

Péloquin, A.S., Houlé, M.G. and Gibson, H.L. 2005. Geology of the Kidd–Munro assemblage in Munro Township, and the Tisdale and Lower Blake River assemblages in Currie Township: Discover Abitibi Initiative; Ontario Geological Survey, Open File Report 6157, 94p.

Contents

FIGURES

PHOTOS

TABLES

MAP

Abstract

The goal of the Munro and Currie townships Base Metal Subproject of the Discover Abitibi Initiative is to reach a better understanding of the volcanic stratigraphy in the 2 townships, and of the stratigraphic position of the volcanogenic mineralization in both. In Munro Township, the mineralization at both the Potter Mine (formerly known as the Centre Hill Mine) and Potterdoal Mine is hosted in thin volcaniclastic and sedimentary units at mafic–ultramafic flow contacts; in Currie Township, the mineralization at the Currie (Tillex) occurrence is hosted in the volcaniclastic and sedimentary units of the Upper Tisdale assemblage.

In **Munro Township**, the Kidd–Munro assemblage rocks consist of subaqueous tholeiitic basalt and ultramafic flows; felsic and intermediate volcanic rocks are rare. The area is divided into 3 blocks: South Munro, Central Munro and North Munro. The South Munro block is characterized by a basal interlayered spherulitic rhyolite and basalt unit, followed by a basaltic unit, within which a thin rhyolite unit (the Beatty rhyolite) occurs; the uppermost unit in the south block is the “First Komatiitic Lava Succession”. The Central Munro block is characterized by basaltic to komatiitic basaltic units. The difference between the South and Central blocks lies in the presence of rhyolites and andesites in the former. As the displacement along the Munro fault and the folding in the area appear to be of limited extent, it is possible that the South and Central Munro blocks form a continuous stratigraphic sequence consisting of a lower tholeiitic unit comprised of interlayered tholeiitic basalts, tholeiitic andesites and rhyolites capped by the “First Komatiitic Lava Succession” (South Munro block), and an upper tholeiitic basalt unit (Central Munro block). The Centre Hill fault between the Central and North Munro blocks constitutes a major stratigraphic break. In the North Munro block, ultramafic volcanic and intrusive rocks are dominant. The stratigraphic sequence is interpreted to be repeated 3 times within the block by folding (the McCool syncline) and faulting (the Warden Hill fault). The Potter and Potterdoal mines are located in the North Munro block: Potter Mine on the south limb of McCool syncline and Potterdoal in the Warden Hill fault repetition of the north limb of the syncline.

The most complete stratigraphic section is defined at Potter Mine on the south limb of McCool syncline. There, the volcanic succession is divided into 3 units: 1) a Lower Komatiitic Unit, 2) the Middle Tholeiitic Unit; and 3) the Upper Komatiitic Unit. The mineralization at Potter Mine is hosted in the Middle Tholeiitic Unit, which consists of basaltic volcaniclastic rocks, intact and autobrecciated sills and/or dikes of basalt, thin argillaceous and carbonaceous sedimentary units, chert, massive sulphide, and lesser komatiitic flows. The sulphides are hosted within the lapillistone facies of the basaltic volcaniclastic rocks; this facies is interpreted to have accumulated within a primary graben.

The magnetic signatures of the stratigraphic succession at Potter Mine can be traced around the closure of the McCool syncline. North of Potter Mine, on the north limb of the syncline, the succession observed is a mafic unit, overlain by an ultramafic unit. The units are massive, thick, and coarse grained and exhibit no internal structure. They were recognized as flows based on the presence of flow-top breccias. These flows, the lateral extensions of the Potter Mine stratigraphic succession, have also been interpreted to be Theo’s and Fred’s flows, recognized at the Potterdoal Mine north of the Warden Hill fault. Thus, the north limb of McCool syncline is interpreted to be repeated across the Warden Hill fault.

At Potterdoal Mine, the volcanic succession is divided into 2 units structurally repeated by the Buster fault. The lowest unit in the area consists of thick layered tholeiitic flows: Theo’s flow and the Ore flow. The upper unit is a thick layered komatiitic flow: Fred’s flow. Theo’s flow and the Ore flow are interpreted to be at the same stratigraphic level, the present superposition of the flows being due to movement along the Buster fault. The mineralization at Potterdoal Mine occurs in a breccia unit within a

sedimentary and volcaniclastic unit between the Ore flow and Fred’s flow. The breccia was interpreted to be “tectonic” and to have formed in a scarp depression. Along strike from the “tectonic” breccia, mafic volcaniclastic deposits similar to the pyroclastic rocks at Potter Mine were observed.

The mafic to ultramafic volcanic contact favourable to volcanogenic massive sulphide deposits is structurally repeated in the North Munro block: 1) at Potter Mine north of the Centre Hill fault, 2) on the north limb of McCool syncline, south of the Warden Hill fault, and 3) at Potterdoal Mine north of the Warden Hill fault. Thus, the Potter and Potterdoal mines are interpreted to be time-stratigraphic equivalents. In both cases, the massive sulphides are related to volcanic fragmental rocks occurring at the contact between the tholeiitic and komatiitic units. The presence of interflow sedimentary and volcaniclastic units at the mafic–ultramafic contact along strike from the Potterdoal deposit, and between Theo’s and Fred’s flows on the north limb of the McCool syncline (south of the Warden Hill fault), as well as the extension of the mafic–ultramafic contact under the overburden to the east, indicates further potential for volcanogenic massive sulphide mineralization.

Currie Township is dominated by the basaltic rocks of the Lower Tisdale and Lower Blake River assemblages. Although the intermediate to felsic volcaniclastic rocks, argillites and greywackes of the Upper Tisdale assemblage are a lesser component of the geology of the township and very rarely crop out, they are important in that they host the Currie (Tillex) base metal showing.

The stratigraphic succession in Currie Township is generally east-west striking, vertical to southward dipping and southward younging where facing directions were observed. The stratigraphic sequence from north to south is Lower Tisdale, Upper Tisdale and Lower Blake River assemblages. The Lower Tisdale and the Lower Blake River assemblages are dominated by mafic flows. The Upper Tisdale assemblage (also referred to as the “Marker Horizon”) comprises felsic tuffs (including feldspar crystal tuffs) and sediments (argillites and greywackes), and mafic to intermediate tuffs. Proterozoic diabase dikes and Archean porphyry dikes crosscut the volcanic assemblages. The porphyry dikes resemble the feldspar crystal tuffs of the Upper Tisdale assemblage.

Based on limited geochemistry, the basalts in the Lower Tisdale and Lower Blake River assemblages are dominantly tholeiitic. However, one sample from a porphyritic pillowed flow in the Lower Blake River assemblage is geochemically similar to the Upper Tisdale assemblage intermediate volcanic rocks. The geochemistry of the Upper Tisdale assemblage tuffs shows them to be calc-alkalic in affinity. Multiple geochemical populations are recognized in the Upper Tisdale assemblage, possibly due to variations at the source and/or in subsequent crustal contamination.

The volcanic rocks of Currie Township are deformed. In general, the rocks in all of the assemblages exhibit well-developed east-west subvertical schistosity. A large-scale fold is recognized in the magnetic signature of the Lower Blake River assemblage and is interpreted to be synclinal. In drill core of the Upper Tisdale assemblage, the schistosity is seen to be bedding parallel, and zones of strong deformation and fault gouges, also bedding parallel, were observed. In general, the Upper Tisdale assemblage is more deformed than the Lower Tisdale and Lower Blake River assemblages. The Upper Tisdale assemblage tuffs and sediments may have been more susceptible to deformation and acted as a corridor where higher strain was focussed; the existence of a strata-parallel fault occurring at or near the Upper Tisdale–Lower Blake River assemblage contact should not be ruled out.

In the Upper Tisdale assemblage, the porphyritic dikes form 2 main geochemical populations equivalent to populations observed in the volcanic rocks of that assemblage. The porphyritic dikes from the Lower Tisdale and Lower Blake River assemblages are geochemically similar to the volcanic rocks and porphyry dikes of the Upper Tisdale assemblage. This similarity between the porphyry dikes in all the assemblages and to the Upper Tisdale assemblage volcanic rocks suggests that they are co-magmatic.

The magmatic event responsible for the Upper Tisdale assemblage volcanic rocks, therefore, has an intrusive expression, and the event continued during the deposition of the Lower Blake River assemblage.

The Currie (Tillex) showing occurs in the sediments and felsic tuffs of the Upper Tisdale assemblage, and is within the same stratigraphic sequence as the Cross Lake deposit. The mineralization observed in drill core from Kinross Gold Corporation and core in the Kirkland Lake Drill Core Library consisted of pyrite ± sphalerite ± chalcopyrite as small stringers, and along bedding and foliation planes. The mineralized zones are commonly schistose, and numerous bedding parallel faults and sheared zones are observed in drill core.

The mineralization in the Marker Horizon of the Upper Tisdale assemblage in Currie Township appears to be integrally associated with the sediments and felsic tuffs. The unit of particular interest corresponds to a magnetic high on the magnetic map and can be traced with few breaks across the entire township. A second unit with a high magnetic signature occurs 200 to 300 m south of the first. The generally east-west orientation of these magnetic highs is subparallel to the interpreted Upper Tisdale–Lower Blake River assemblage boundary. These magnetic units may be stratigraphic and used as “marker units” within the Marker Horizon of the Upper Tisdale assemblage.

Geology of the Kidd–Munro Assemblage in Munro Township, and the Tisdale and Lower Blake River Assemblages in Currie Township: Discover Abitibi Initiative

A.S. Péloquin[1], M.G. Houlé[2] and H.L. Gibson[3]

Ontario Geological Survey
Open File Report 6157
2005

[1]Mineral Exploration Research Centre, Laurentian University, Sudbury, Ontario speloquin@sympatico.ca
[2]Precambrian Geoscience Section, Ontario Geological Survey, Sudbury, Ontario michel.houle@ndm.gov.on.ca
[3]Mineral Exploration Research Centre, Laurentian University, Sudbury, Ontario hgibson@laurentian.ca

Introduction

The Discover Abitibi Initiative is a regional, cluster economic development project based on geoscientific investigations of the western Abitibi greenstone belt. The initiative, centred on the Kirkland Lake and Timmins mining camps, will complete 19 projects developed and directed by the local stakeholders. Mapping and sampling transects were undertaken in Munro and Currie townships (Figure 1) as part of the Discover Abitibi Initiative: Base Metal Subproject 3. Both areas are in the Abitibi Subprovince of the Archean Superior Province (Figure 2). The 2 study areas will be discussed separately in this report due to their unrelated natures.

Munro Township is part of the Kidd–Munro Assemblage (2719–2710 Ma: Ayer et al. 2002, 2003 (and references therein); Figure 3), which is host to the giant Cu-Zn-Ag Kidd Creek volcanogenic massive sulphide (VMS) deposit (>138.7 million tonnes of 2.35% Cu, 6.50% Zn, 0.23% Pb and 89 g/t Ag) located some 80 km to the east, near the town of Timmins (Hannington and Barrie 1999). Kidd Creek, like many VMS deposits in the Abitibi Subprovince, is spatially associated with felsic volcanism (Bleeker 1999). In the Kidd–Munro assemblage in Munro Township, rhyolites are rare, and the VMS deposits or showings occur in mafic to ultramafic volcanic sequences (Coad 1976; Epp 1997; Gibson and Gamble 2000; Johnstone 1987, 1991a; Satterly 1952a, 1952b). In this report, new data stemming from the Discover Abitibi Initiative will be presented, as well as syntheses of M.G. Houlé's ongoing research on the ultramafic volcanic rocks in the area, and of H.L. Gibson's study of the Potter Mine deposit.

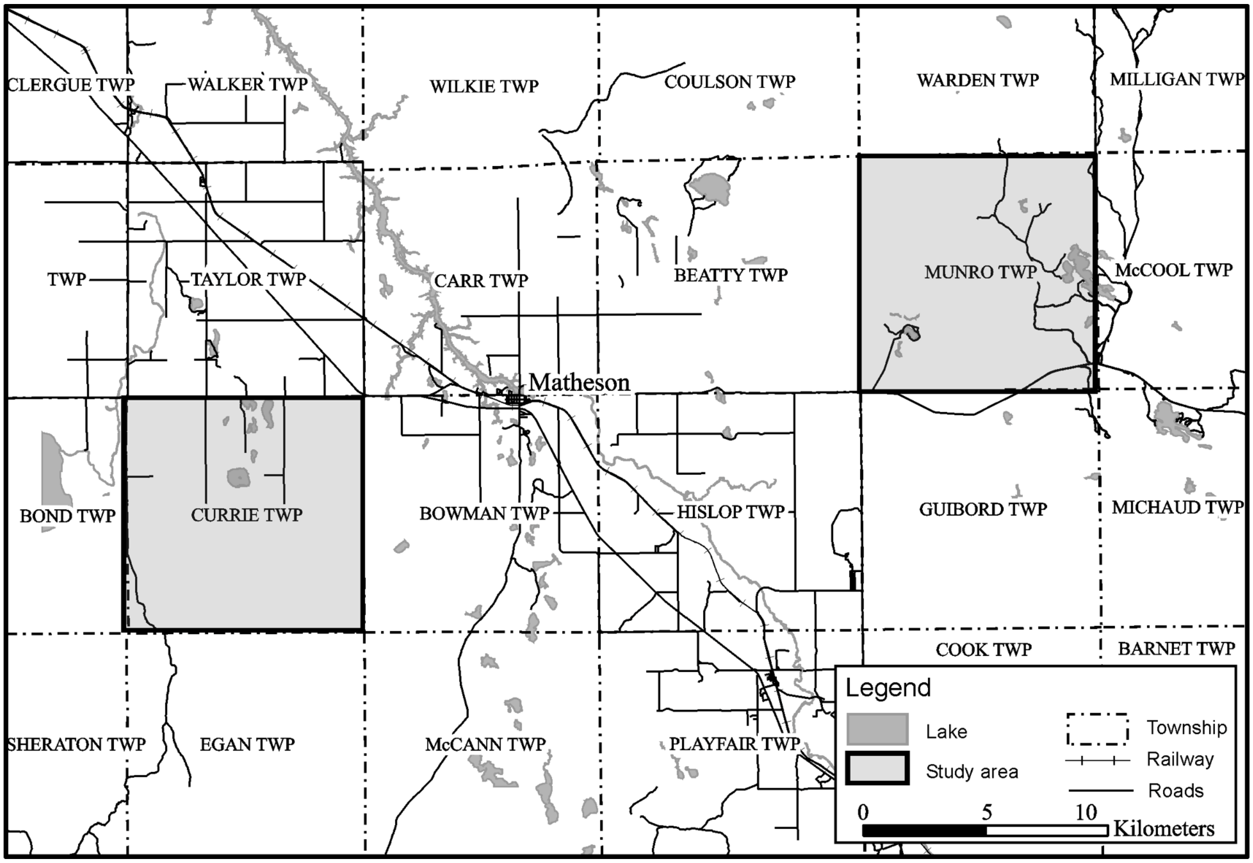


Figure 1. Location map for Munro and Currie townships.

Currie Township was chosen for study as an example of Archean sediment-hosted base metal mineralization. The mineralization occurs in the “Marker Horizon” (Ministère des Ressources Naturelles du Québec–Ontario Geological Survey 1983) that constitutes the Upper Tisdale assemblage in the area and “marks” the boundary between the Tisdale and Lower Blake River assemblages (*see* Figure 3). The eastern extremity of the Upper Tisdale assemblage (Marker Horizon) is terminated in Hislop Township by the Hislop fault near the junction of the Arrow and Porcupine–Destor faults. From Hislop Township, the Upper Tisdale assemblage extends west to Macklem Township and south from Macklem to Timmins Township (Ministère des Ressources Naturelles du Québec–Ontario Geological Survey 1983; Ayer, Berger and Trowell 1999; Ayer and Trowell 2000). It hosts polymetallic, base metal and gold, mineralization (Ontario Geological Survey 2004a; Vaillancourt 2001).

ACKNOWLEDGMENTS

The Discover Abitibi Initiative was managed by the Timmins Economic Development Corporation; FedNor, Northern Ontario Heritage Fund Corporation, municipalities and private sector investors have provided the funding for the initiative. Houlé’s work on komatiites is supported by a “Fonds de la nature et de la technologie” and a Graduate Scholarship from University of Ottawa, and by an Ontario Geological Survey partnership grant and Natural Sciences and Engineering Research Council of Canada

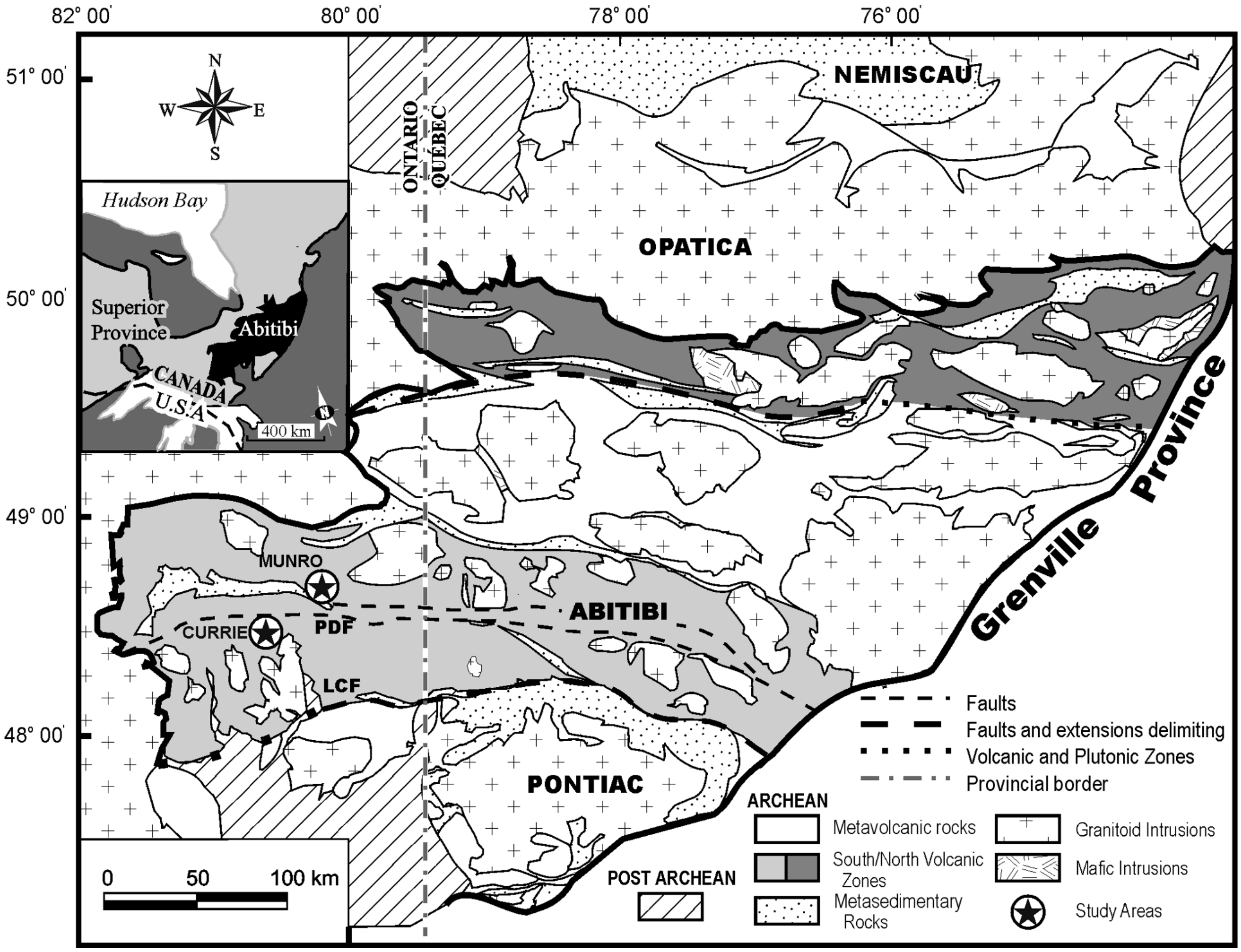


Figure 2. Geology of the Archean Abitibi Subprovince with the locations of Munro and Currie townships. Abbreviations: LCF, Larder–Cadillac fault; PDF, Porcupine–Destor fault.

operating grants to C.M. Lesher. Gibson's work on the Potter Mine deposit is supported by the Natural Sciences and Engineering Research Council of Canada. We thank the Discover Abitibi Research Group in its entirety and, particularly, Drs. John Ayer and Phil Thurston for the conception of this project and their logistical, scientific and moral support. The project was administered by the Mineral Exploration Research Centre at Laurentian University, and we thank Natalie Lafleur-Roy for handling all things administrative. Access to drill core and drill logs was provided by Ryburn Norman (Kinross Gold Corporation: Currie Township), Frank Santaguida (Falconbridge Ltd.: Currie and Munro townships) and Ernie Harrison (Millstream Mines Ltd.: Munro Township). Further drill core was accessed at the Kirkland Lake Drill Core Library, and we thank the Kirkland Lake Resident Geologist Office staff for all their assistance over the past 2 years. The collaboration of Dave Gamble (Dave Gamble Geoservices Inc.) and discussions with Dr. A.D. Fowler (University of Ottawa) are gratefully acknowledged. We thank Sara McIlraith and Zoran Madon of the Ontario Geological Survey for assistance and advice with GIS related issues, and Henrique Izuma for modification, sometimes to the point of creation, of our digital data interface. Figures were drafted by Julie Chartrand.

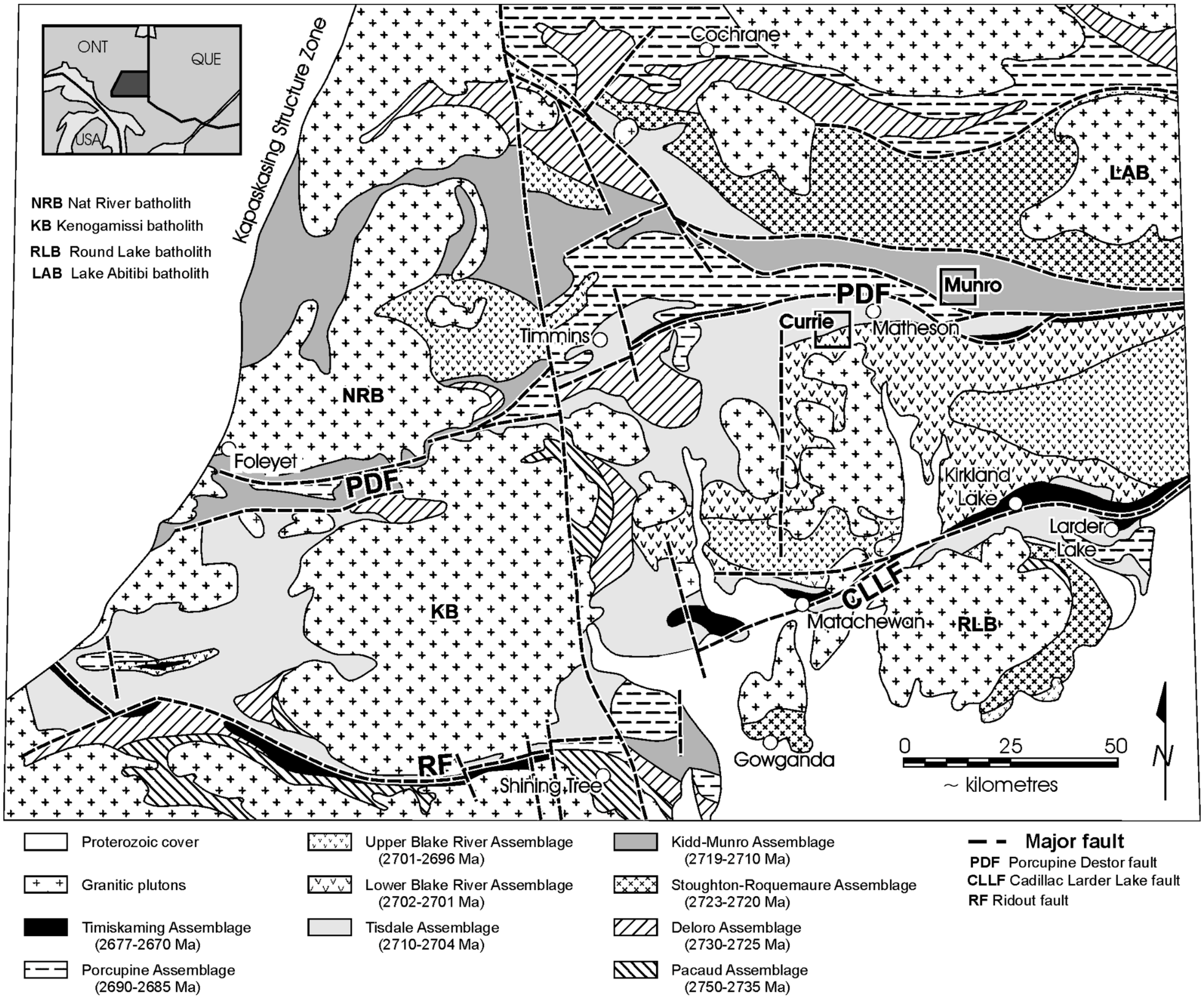


Figure 3. Geological assemblage map of the Abitibi Subprovince in Ontario, and the locations of Munro and Currie townships (*modified from* Ayer et al. 2002).

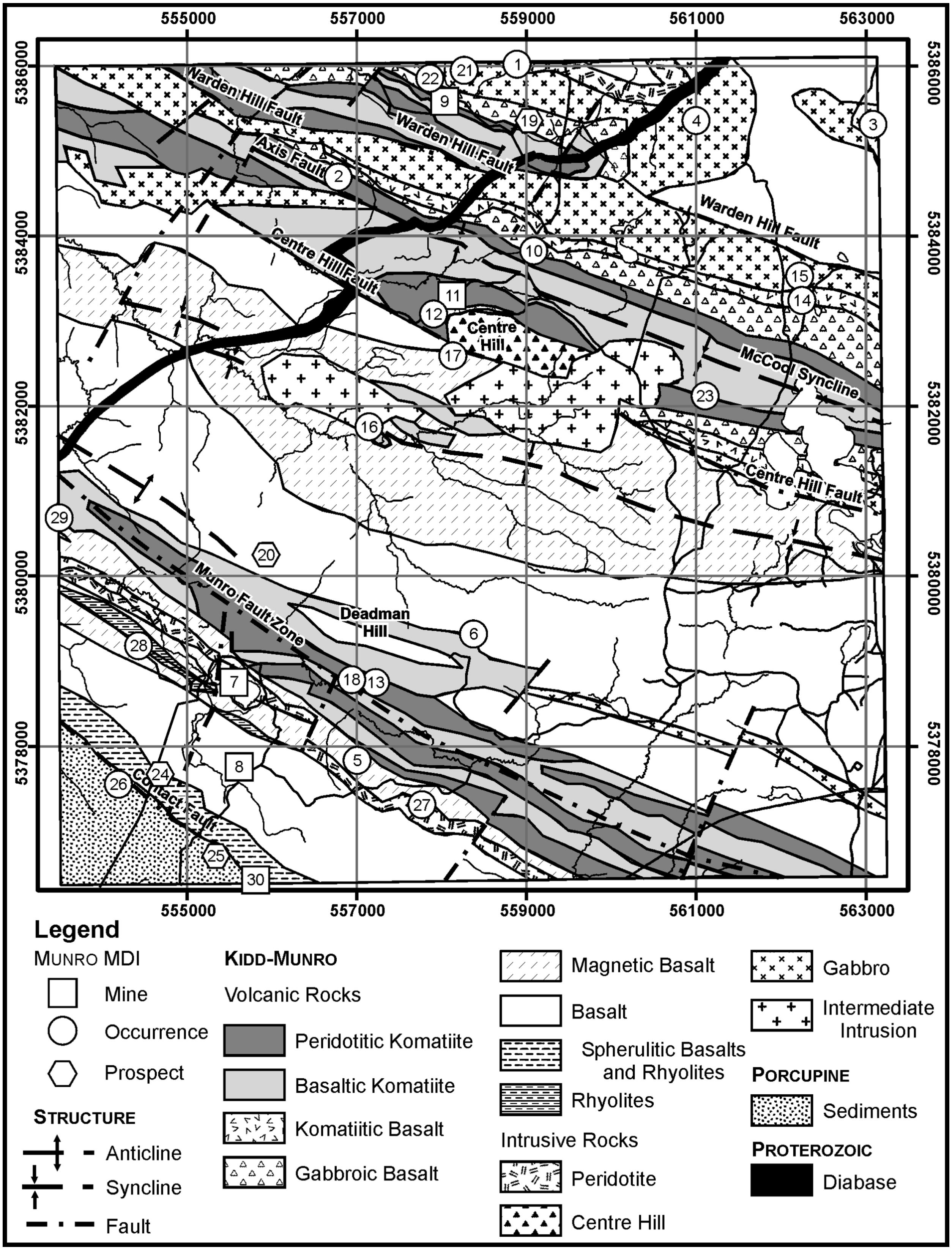


Figure 4. Geological map of Munro Township. Mineral occurrence and deposit numbers are listed in Table 2 and on Preliminary Map P.3557 (back pocket; Ontario Geological Survey 2004a).

Munro Township

LOCATION AND ACCESS

Munro Township is located in the District of Cochrane, 19 km east of the town of Matheson along Highway 101 (*see* Figure 1). The eastern part of the township is accessible from Highway 101 via the Munro Lake–Hedman Mine road, and numerous logging roads and 2 mine access roads branching from the main road. The southwestern part of the township is accessible from Highway 101 via the old Munro Mine road with the secondary Croesus Mine and the Barton Mine roads extending from the main road. Access to the central part of the township is poor. Relief in the area varies; the geodetic station has an elevation of 388 m above sea level (location: Universal Transverse Mercator (UTM) Zone 17, North American Datum 1983 (NAD83) 558843E, 5382831N). Outcrop exposure is extremely good in the area.

PREVIOUS GEOLOGICAL WORK

Due to the incredible exposure of ultramafic flows and sills in Munro Township, numerous studies have been undertaken in the area (e.g., Allen 1986; Arndt 1977; Arndt, Naldrett and Pyke 1977; Canil 1985; Davis 1997; Houlé et al. 2000, 2001, 2002; Johnstone 1987, 1991a; Pyke, Naldrett and Eckstrand 1973; Sproule et al. 2002). Munro Township hosted 4 mines and 1 developed prospect: the Munro asbestos mine, the polymetallic, Cu-Zn-Au-Ag Potter Mine (Centre Hill Mine) and Potterdoal Mine (a developed prospect), and the Croesus, American Eagle and White-Guyatt gold mines. Coad (1976) studied the Potter Mine and Epp (1997) studied the Potterdoal deposit. Twenty-five mineral occurrences and prospects are known in the transect area: 8 asbestos, 13 precious metal (Au ± Ag (± Cu ± Zn)), 3 base metal (Cu ± Co ± Zn ± Ni), and 1 nickel (*see* “Economic Geology”; locations indicated on Figure 4 and Map P.3557 in back pocket).

OBJECTIVES AND METHODS

The goal of the Munro Township Base Metal Subproject of the Discover Abitibi Initiative is to reach a better understanding of the volcanic stratigraphy in the township. Mapping and sampling transects were undertaken by A.S. Péloquin across the stratigraphy where accessible by truck. M.G. Houlé has done detailed work on the ultramafic volcanic rocks in the Potter Mine area as part of his Doctoral thesis research (in progress) and assisted in the work done on the ultramafic rocks in the southern part of Munro Township as part of an Operation Treasure Hunt project (Vaillancourt et al. 2003). H.L. Gibson has been doing detailed work on the Potter Mine (Gamble and Gibson 2000a, 2000b; Gamble 2000; Gibson and Gamble 2000; Tardif et al. 2000) and more recently on the Potterdoal Mine (work in progress).

Field work was conducted in Munro Township by A.S. Péloquin over a 10 week period in the summer of 2004. Transect mapping was done at 1:10 000 scale, using previously published maps (Satterly 1952b; Johnstone 1991b) as base maps. Outcrop positioning was done using a Garmin® e-trex® Venture® GPS with NAD83 and an accuracy varying from 9 to 15 m.

Forty-five samples were collected for geochemical analysis from Munro Township, including 2 by J.A. Ayer for U/Pb radiometric age determinations (Ayer et al. 2005). All samples were analyzed for major, trace and rare earth elements following the methods outlined in MacDonald, Piercey and Hamilton (2005). The samples were crushed at Activation Laboratories Limited, Ancaster, Ontario, using a mild steel mill. Major elements were analyzed using fused-disc X-ray fluorescence (XRF), and Cr, Nb, Y, Zr, Cr and Ni were analyzed using pressed pellet XRF at Activation Laboratories. All other trace elements and the rare earth elements were analyzed at the Ontario Geoscience Laboratories by inductively coupled plasma mass spectrometry (ICP–MS) and inductively coupled plasma atomic emission spectroscopy (ICP–AES) following a closed-beaker digestion (Burnham and Schweyer 2004). Results are listed in Appendix 1; all samples had good major element closures. Details on the analytical methods, precision and accuracy can be found in MacDonald, Piercey and Hamilton (2005). In addition to the samples collected in the course of this study, geochemical analyses of samples taken by M.G. Houlé (Ph.D., in progress), and selected analyses from Shore (1996) and Shore and Fowler (1999) are used in the geochemistry section.

A sample of a pegmatitic gabbroic phase of the Centre Hill Complex was collected by J.A. Ayer (Ayer et al. 2005) for radiometric age determination using U/Pb zircon methods at the Jack Satterly Geochronology Laboratory at the University of Toronto. This sample yielded an age of 2706±1.2 Ma and is reported in detail in Ayer et al. (2005). A sample from the rhyolite at the Kidd–Munro – Porcupine assemblage boundary was collected for radiometric age determination, but yielded no zircons. Details on the methodology for the U/Pb geochronology at the Jack Satterly Geochronology Laboratory are provided in Ayer et al. (2005).

Through the Discover Abitibi Initiative, new airborne geophysical surveys were flown covering Munro Township (Ontario Geological Survey 2003). These data were used in producing the map associated with this report (Map P.3557). Specifically, magnetic signatures were used to interpret the presence or continuation of ultramafic units into areas of no outcrops, to delimit the extent of the intermediate intrusions south of the Centre Hill fault, and to extend the trace of the Centre Hill fault to the west. Two mafic units with high magnetic signatures are indicated on the map. Outcrops observed in these units gave no indication of the cause of the magnetic signatures. However, south of the Munro fault zone, the Beatty rhyolite and the Munro sill both occur at the boundary of the high magnetic signature locally, and within the area of the high magnetic signature elsewhere. It is, therefore, possible that the magnetic signature is not stratigraphic. Maps and other references used in the compilation of Preliminary Map P.3557 (*see* back pocket) are listed on the map.

GEOLOGICAL SETTING

The Abitibi Subprovince is located in the Superior Province of Canada (*see* Figure 2 inset), the largest Archean craton in the world. It is characterized by a high ratio of supracrustal to intrusive rocks and generally low metamorphic grades: predominantly lower greenschist and local prehnite-pumpellyite facies, with amphibolite facies occurring adjacent to large granitic plutons (Jolly 1982). Ludden, Hubert and Gariépy (1986) and Ludden and Hubert (1986) subdivided the Abitibi Subprovince into the “North Volcanic Zone” and the “South Volcanic Zone” separated by a “Central Granite-Gneiss Zone” (*see* Figure 2).

Munro Township is located in the northeastern part of the South Volcanic Zone of the Abitibi Subprovince (*see* Figure 2). The Kidd–Munro assemblage (*see* Figure 3; 2719–2710 Ma: Ayer et al. 2005, 2002, 2003 (and references therein)) is the dominant assemblage in Munro Township. The Porcupine assemblage (*see* Figure 3; 2690–2680 Ma: Ayer et al. 2005, 2002, 2003 (and references therein)) occurs only in the southwest corner of the township and will not be discussed here due to the nature of this project. The Kidd–Munro assemblage consists of 2 suites of metavolcanic rocks (Ayer, Berger and Trowell 1999):

- Mafic to ultramafic metavolcanic suite of tholeiitic to komatiitic affinities,
- An intermediate to felsic metavolcanic suite of calc-alkalic affinity.

The calc-alkalic metavolcanic suite underlies the tholeiitic to komatiitic metavolcanic suite of the Kidd–Munro assemblage and is in conformable contact with it (Epp 1997; Epp and Crocket 1999).The calc-alkalic suite was previously referred to as the Coulson–Rand assemblage by Jackson and Fyon (1991).

In the Munro Township area, the Kidd–Munro assemblage lies between the main Porcupine–Destor fault zone to the south and the subsidiary North Branch of the Porcupine–Destor fault zone to the north (*see* Figure 3; Ministère des Ressources Naturelles du Québec–Ontario Geological Survey 1983; Jensen and Langford 1985; Epp 1997; Epp and Crocket 1999). The contact between the Kidd–Munro assemblage and the Porcupine assemblage to the south is faulted. Epp (1997) considers the Contact fault between these assemblages, and the Munro fault zone further north to be splays off the main Porcupine–Destor fault zone (*see* Figure 4). The dominantly tholeiitic Stoughton–Roquemaure assemblage occurs north of the North Branch of the Porcupine–Destor fault zone.

GENERAL ASPECTS OF KOMATIITIC VOLCANIC ROCKS

Komatiitic rocks account for a large proportion of the rock units observed in Munro Township, occurring throughout the township. The komatiitic sequences are composed of peridotitic komatiite to basaltic komatiite, and ranges in thickness from 200 to 1500 m (Johnstone 1991a). Particularly north of the Centre Hill fault (*see* Figure 4; Map P.3557), the exposure and preservation of the komatiitic rocks is extremely good; outcrop is abundant and metamorphism is prehnite-pumpellyite facies. Since the tremendous work done in the area by Pyke and co-workers, who described and established some of the classical subdivisions of komatiitic flows (Pyke, Naldrett and Eckstrand 1973), the komatiitic rocks in Munro Township have been the subject of numerous studies. Detailed petrological and geochemical studies on specific flow sequences and small study areas have greatly increased our knowledge of komatiitic rocks (e.g., Allen 1986; Arndt 1975, 1977, 1986; Arndt, Naldrett and Pyke 1977; Canil 1985; Davis 1997, 1999; Houlé et al. 2001, 2002; Pyke, Naldrett and Eckstrand 1973), as have studies on the cooling and crystallization history of komatiitic flows (Shore 1996; Shore and Fowler 1999). Some geochemical, isotopic and platinum group element (PGE) studies have also been undertaken at the scale of single flow units (e.g., Puchtel et al. 2004; Walker, Shirey and Stecher 1988).

Because of the volume of work that has been done on the komatiitic rocks of Munro Township, the previous studies are briefly summarized here. For further details and more exhaustive descriptions of the different and typical komatiitic rocks that occur in Munro Township, the reader is referred to Arndt (1975, 1977), Arndt, Naldrett and Pyke (1977) and Johnstone (1987, 1991a, 1991b).

Komatiitic rocks exhibit a wide range of chemical variation (e.g., komatiitic basalt to komatiite), but also exhibit a wide range of textural facies (e.g., cumulate, porphyritic, spinifex, aphyric, and autoclastic textures), lithofacies (i.e., textural facies association: undifferentiated to differentiated), and morphofacies (e.g., pillowed to sheet flows). Komatiitic rocks in Munro Township exhibit much of the complete spectrum of variations that are observed worldwide in ultramafic volcanic rocks.

The nomenclature used in this report to characterize the komatiitic rocks in Munro Township (Table 1) is adapted from Arndt, Naldrett and Pyke (1977) and Johnstone (1991a).

Arndt, Naldrett and Pyke (1977) suggest that classical komatiitic flows as described by Pyke, Naldrett and Eckstrand (1973) represent one end-member of a complete continuum from a well-differentiated flow (exhibiting all the textural subdivisions as described by Pyke, Naldrett and Eckstrand (1973)) to a non-differentiated flow (massive flow devoid of spinifex textures). Arndt, Naldrett and Pyke (1977) proposed 3 profile types, based on Munro’s komatiites, to illustrate this continuum where the flow-types A and C (Figures 5a and 5c) represent the 2 end members, and the flow-type B represents the intermediate member (Figure 5b).

Table 1. Komatiite classification in Munro Township (adapted *from* Arndt, Naldrett and Pyke 1977 and Johnstone 1991a).

This Study (map code)	**Arndt et al. (1977)**	**Johnstone (1991b)**	**Field Characteristic**	**Petrological Characteristic**	**MgO**[1]
Peridotitic Komatiite (1PD)	Peridotitic Komatiite	Peridotitic Komatiite and Pyroxene Peridotite Komatiite	Flows are made up of spinifex-textured upper and cumulate basal zones; consist of massive olivine cumulate devoid of conspicuous volcanic features, massive and characterized by polyhedral jointing.	*High modal olivine.* Olivine grains and chrome spinel in a matrix of fine-grained clinopyroxene and devitrified glass. In cumulates, olivine grains are close-packed, solid, roughly equant; in spinifex texture, olivine forms large skeletal platy grains; and in spinifex-free, non-cumulate rock, olivine may be equant or skeletal.	>20%
Basaltic Komatiite (1PR or 1BK)	Pyroxenitic Komatiite	Pyroxenitic Komatiite (olivine-rich komatiitic basalt)	Form low, flat outcrops of soft, grey-green, crumbly lava that breaks with a hackly fracture; may contain clinopyroxene spinifex, polyhedral jointing, lava toes or varioles.	*Poorer in olivine.* Equant solid, or platy skeletal grains of olivine in fine-grained matrix of clinopyroxene and devitrified glass; or skeletal clinopyroxene needles in devitrified glass groundmass; or closely packed equant grains of pyroxene and olivine. No plagioclase.	12–20%
Komatiitic Basalt (2KO)	Basaltic Komatiite	Basaltic Komatiite (pyroxene-rich komatiitic basalt)	More massive outcrops; harder, paler green rock; may contain lava toes, hyaloclastite flow tops or may be massive. Uncommon examples contain clinopyroxene spinifex or slaggy texture.	*No olivine in ground mass; plagioclase instead.* Clinopyroxene and plagioclase in spinifex texture; clinopyroxene/ plagioclase intergrowths or normal subophitic textures.	10–12%

[1] Anhydrous values

“Flow-type “A” or well-differentiated flows” (*see* Figure 5a) consists of flows that are internally layered with a spinifex-textured (A zone) in the upper part and a cumulus-textured (B zone) in the lower part of the flow. The A unit may be further subdivided into the A1 (fractured upper chill zone–flow-top breccia–microspinifex), A2 (randomly oriented spinifex), and A3 (coarse platy spinifex) zones. The B zone may be further subdivided into the B1 (aligned skeletal « hopper » olivine), B2 (medium- to coarse-grained cumulate), B3 (knobby cumulate), and B4 (fine-grained cumulate and basal chill) zones. All of the igneous textures result from the interaction of 2 fundamental processes: the nucleation of new crystals and the growth of the crystals. The crystal morphologies observed in komatiites may be represented by intermediates forms between 2 end-members: 1) polyhedral olivine crystals developed in slow cooling (lower supercooling and cooling rate), and 2) fine dendritic crystals developed during rapid cooling (high supercooling and cooling rate) (Donaldson 1976).

“Flow-type “B” or poorly differentiated flows” consist of flows that developed limited spinifex textures (*see* Figure 5b). The flow unit can still be subdivided into an A zone and a B zone. However, the A zone is generally composed of thin A1 and A2 zones underlain by a thicker B zone that is generally composed of olivine cumulate to olivine phenocryst rich rocks. Johnstone (1991a) argued that another flow-type should be recognized: flow-type “A-B” or differentiated flows. This flow type is composed of A and B zones, and exhibits a thick spinifex zone, but lacks internal subdivision as the knobby cumulate (B3) and skeletal olivine (B1) zones are missing. Johnstone (1991a) created this new subdivision within the classification scheme of Arndt, Naldrett and Pyke (1977) based on his observation in Munro Township that numerous komatiitic flows in this area correspond to this specific type.

“Flow-type “C” or non-differentiated flows” consists of flows that are completely devoid of spinifex textures (*see* Figure 5c). These flows are characterized by intense polyhedral joints near the top (corresponding to the A zone), which become more spaced and gently curved toward the centre and bottom of the flows. The B zone is generally composed of olivine porphyritic rocks, but is generally much poorer in olivine than the B zone associated with either flow-types A or B. The abundance and size of polyhedral joints tends to decrease with increasing flow thickness of the units. This implied that the polyhedral joints pervade the entire flow within tube-shaped flows morphologies, whereas they pervade only the upper part of sheet-like flows morphologies.

Profiles similar to those defined by Arndt, Naldrett and Pyke (1977) could be used for the basaltic komatiite flows in Munro Township. However, there are some important differences between basaltic komatiite and peridotitic komatiite flows, the most important of which can be summarized as follows:

- The bulk of the A zone is composed of pyroxene spinifex instead of olivine spinifex, but a thin layer of olivine spinifex may occur above the pyroxene spinifex (e.g., olivine-rich basaltic komatiite, such as Fred's flow),
- The bulk of the B zone is generally composed of more differentiated units (olivine cumulate, pyroxene cumulate, and gabbro) instead of dominated by olivine-rich units (olivine cumulate).

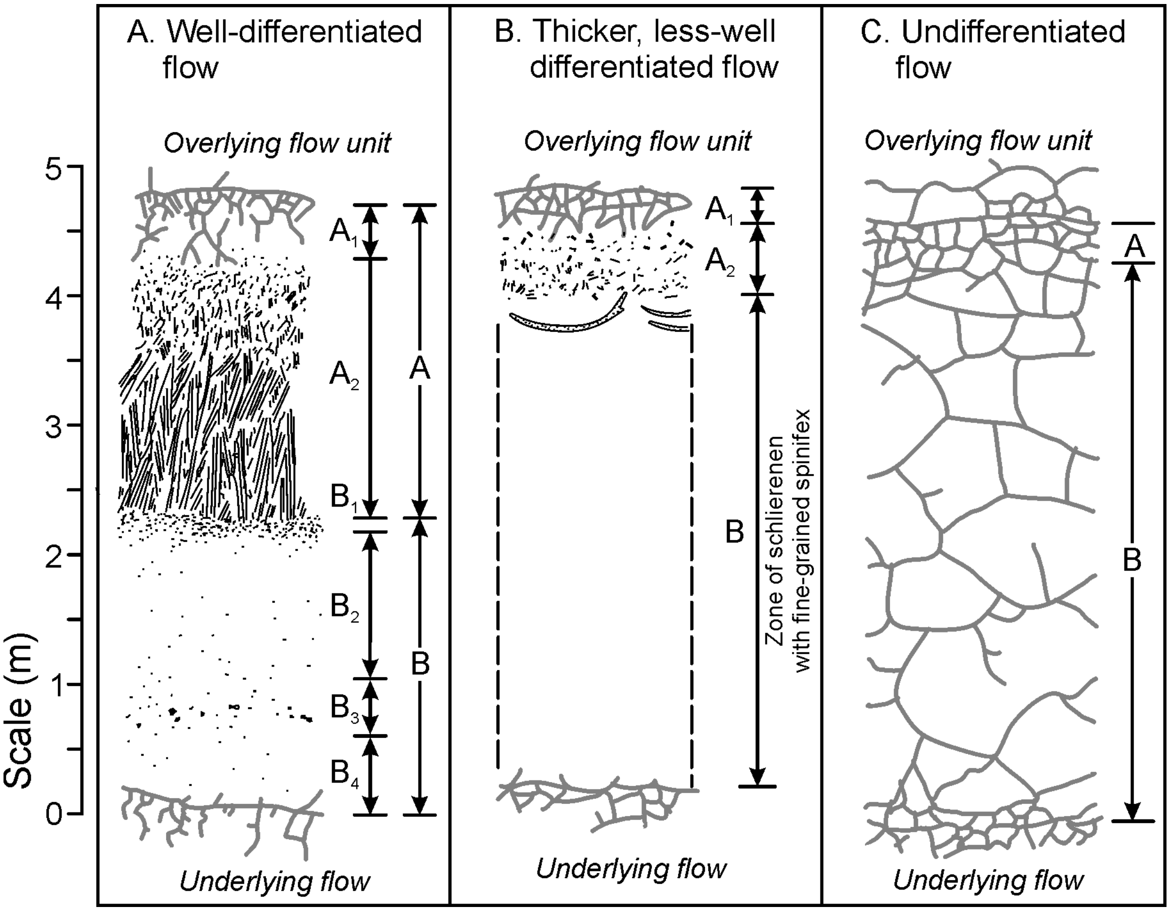


Figure 5. Idealized profiles through 3 types of komatiitic flows (*from* Arndt, Naldrett and Pyke 1977): a) well-differentiated flow (flow with an upper spinifex zone); b) differentiated flow (limited spinifex texture); and c) undifferentiated flow (devoid of spinifex texture).

NOTES ON OTHER TERMINOLOGY

In this report, the lowermost unit of the Kidd–Munro assemblage in Munro Township is referred to as being a “spherulitic/variolitic” unit of interlayered basalts and rhyolites, indicating the interchangeability of the 2 terms. In common usage, the texture of felsic volcanic rocks is referred to as spherulitic. However, in basaltic rocks, both spherulitic and variolitic are used to describe the texture; a variole being a type of spherulite:

> A variole is “a pea-size spherule, usually composed of radiating crystals of plagioclase or pyroxene. This term is generally applied only to such spherical bodies in basic igneous rocks, e.g., variolite. Cf. spherulites.” (Bates and Jackson 1980, p.683)
>
> A spherulite is “a rounded or spherical mass of acicular crystals, commonly of feldspar, radiating from a central point. Spherulites may range in size from microscopic to several centimetres in diameter (Stokes and Varnes 1955, p.140). Cf. variole, spheruloid, orbicule.” (Bates and Jackson 1980, p.601)

Shelf amygdules are also commonly referred to in the literature as table amygdules or quartz chambers. They are half-moon shaped with the convex surface oriented toward the top of the flow (Leduc 1981, p.65).

The Potter Mine was originally named the Centre Hill Mine and is so listed in the Mineral Deposit Inventory (Ontario Geological Survey 2004a; *see also* Table 2). Thus, the name Centre Hill Mine occurs on the Map P.3557 (in the back pocket). However, the name Potter Mine is used in the body of this report as it is the name presently in common usage.

GEOLOGY OF MUNRO TOWNSHIP

In the map area, the Kidd–Munro assemblage comprises only the mafic to ultramafic metavolcanic suite of tholeiitic to komatiitic affinities and constitutes 98% of the map area (*see* Figure 4; Map P.3557). The Kidd–Munro assemblage is in faulted contact with Porcupine assemblage sedimentary rocks in the southwest corner of the township (*see* Figure 4; Map P.3557).

Four major faults crosscut Munro Township parallel to subparallel to the strike of the stratigraphic sequence (*see* Figure 4; Map P.3557): 1) the Contact fault at the Kidd–Munro – Porcupine assemblages boundary, 2) the Munro fault zone centred on the “First Komatiitic Lava Succession” (Johnstone 1991a; *see also* next paragraph) in the southern part of the township, 3) the Centre Hill fault immediately south of the Centre Hill Complex, and 4) the Warden Hill fault in the area of the Munro Lake sill in the north part of the township.

In the following discussion, the map area is divided into 3 blocks based on geological context (map patterns) and major breaks: the “South Munro block”, the “Central Munro block”, and the “North Munro block” (Figure 6). The South Munro block corresponds to the area of the Kidd–Munro assemblage south of, and including, the southern ultramafic unit cut by the Munro fault zone, referred to in this report as the First Komatiitic Lava Succession (*after* Johnstone 1991a). The Central Munro block corresponds to the area located between the First Komatiitic Lava Succession and the Centre Hill fault. The North Munro block corresponds to the area located north of the Centre Hill fault.

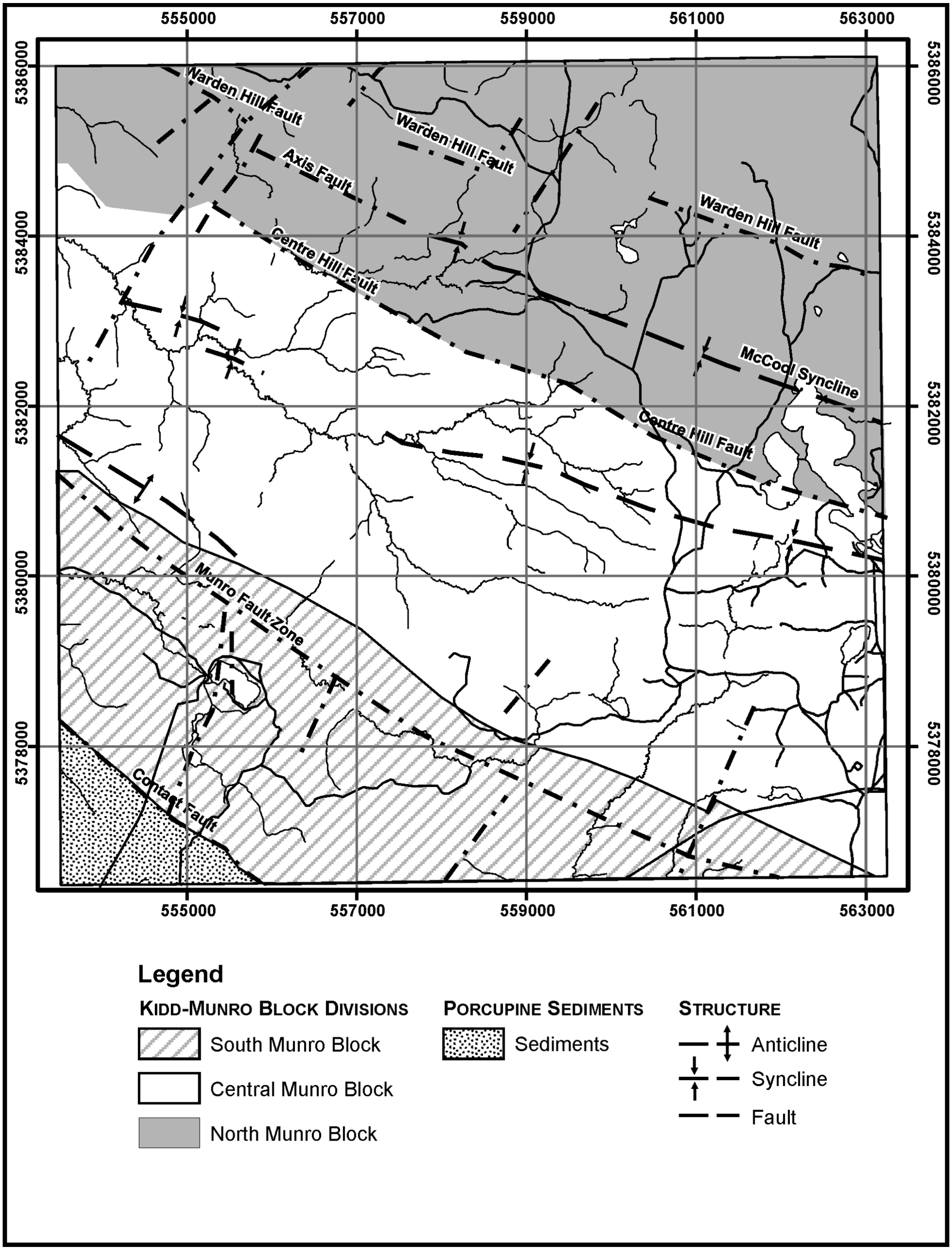


Figure 6. Map showing the 3 block divisions of the Kidd–Munro assemblage in Munro Township as used in this study.

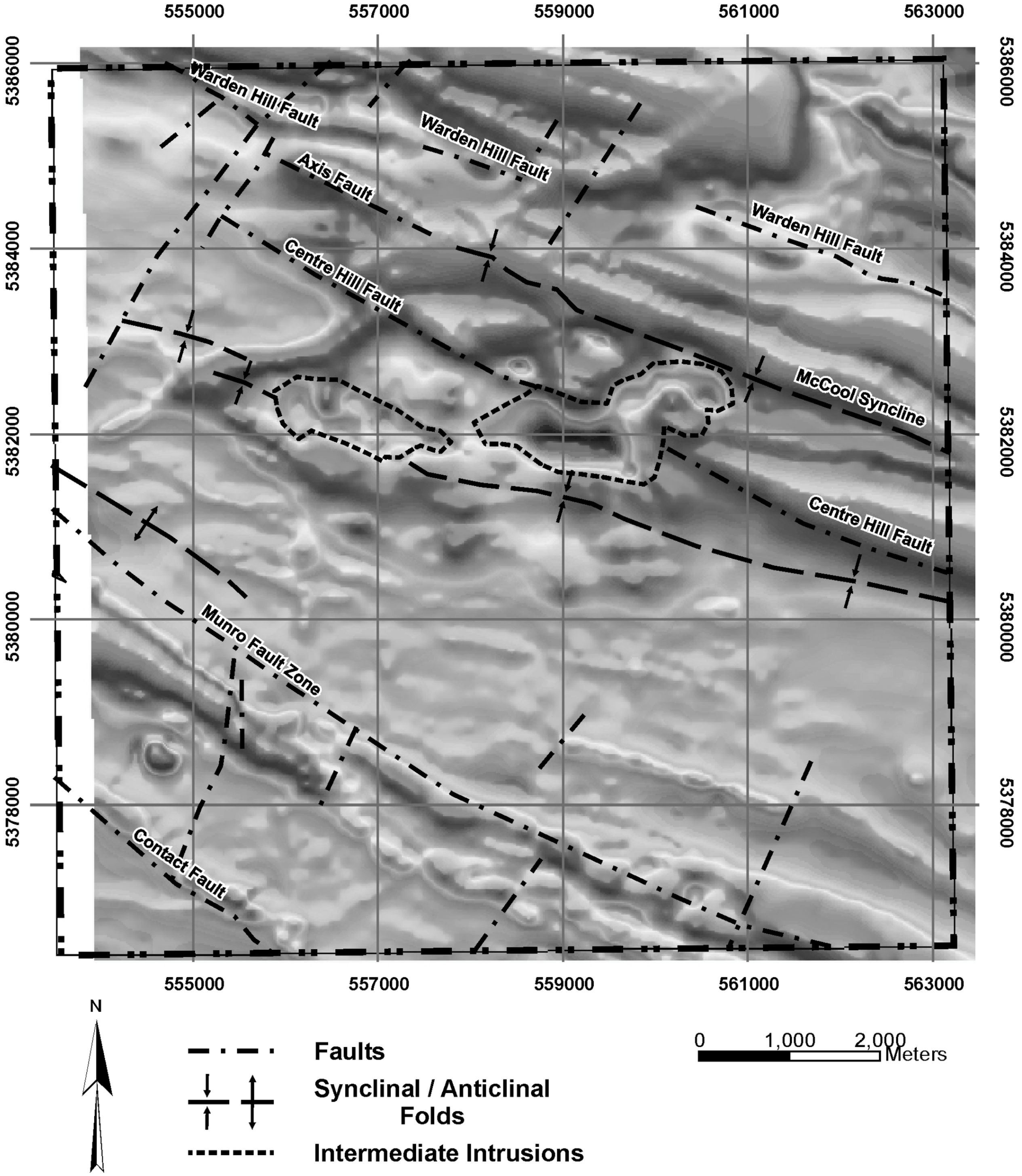


Figure 7. Grey-shaded map of total field and shadow magnetics of Munro Township (Ontario Geological Survey 2003). Note the geophysical data did not extend to the western township boundary.

South Munro Block

In the South Munro block, the Kidd–Munro assemblage is a northwest-striking, northeast-facing, homoclinal volcanic sequence (Map P.3557). The lowest stratigraphic unit in the area is an interlayered felsic and mafic unit. Both rock types are commonly spherulitic/variolitic. Overlying this unit to the northeast are basalts. The upper unit of the basalts is one of the magnetic basalts mentioned above. The Beatty rhyolite occurs near the top of the basalt sequence; locally, it is at the southern limit of the high magnetic signature unit, and elsewhere it is within the magnetic basalts. The magnetic basalts are intruded by the Munro sill, which hosted the abandoned Munro asbestos mine. The Munro sill is an ultramafic to mafic layered sill (Johnstone 1991a; Satterly 1952a). According to these authors, the best descriptions of the sill are to be found in Freeman (1954) and Hendry (1951). A brief characterization of the Munro sill was conducted recently as part of the Ontario government's Operation Treasure Hunt (Vaillancourt et al. 2003). As with the Beatty rhyolite, the Munro sill occurs within the magnetic basalts in some areas and at their southern limit in other areas. Stratigraphically above the basalts is a thick ultramafic volcanic unit (the "First Komatiitic Lava Succession" of Johnstone 1991a). This unit crops out poorly, and much of its extent in interpreted based on the magnetic signature (Figure 7). The Munro fault zone occurs within this unit and strikes parallel to the stratigraphy.

FELSIC METAVOLCANIC ROCKS

Felsic metavolcanic rocks occur in 3 units (*see* Figure 4; Map P.3557): 1) the lowermost unit in the Kidd–Munro stratigraphic sequence—the spherulitic/variolitic unit consisting of interlayered felsic and mafic flows, 2) the Beatty rhyolite occurring in the upper section of the mafic volcanics of the South Munro block, and 3) a single outcrop occurring north of the Beatty rhyolite at the Munro–Beatty townships boundary. The spherulitic/variolitic unit constitutes 6% of the South Munro block, and the Beatty rhyolite and the outlier, 2%.

The spherulitic rhyolites (Photo 1a) are commonly interlayered with spherulitic or variolitic mafic flows, which are commonly pillowed. The spherulitic unit extends across Munro Township for over 3 km and continues into Beatty Township (Barrie 1999). Its apparent thickness in Munro Township varies from 250 to 450 m. The dominant morphology observed in the rhyolites of the unit is lobe-and-breccia flows, which contain high percentages of breccia relative to massive lava lobes and pods. The rhyolites are quartz-feldspar phyric. The quartz phenocrysts occur as equant crystals locally exhibiting resorption embayments, and as laths. Spherulites occurred in both the massive lobes and the breccia; they were generally 2 to 3 mm in size and represented up to 70–85% of the rock. The fibro-radial nature of the spherulites was preserved in 2 of the 3 samples examined in thin section.

The Beatty rhyolite is a thin, 150 m thick unit that pinches out 3.5 km east of the Munro–Beatty townships boundary. It extends a further 4.5 km west into Beatty Township (Barrie 1999) where a sample collected from this area of the unit had a U/Pb age determined to be 2714±2 Ma. The rhyolite exhibits massive, and lobe and breccia flow facies. It is quartz-feldspar phyric with 2 to 7% 1 mm quartz phenocrysts and <1 to 3% 1 to rarely 1.5 mm plagioclase phenocrysts. In the lobe-and-breccia facies, flow banding of the lobe margins is common (Photo 1b).

The third rhyolite, north of the Beatty rhyolite at the Munro–Beatty townships boundary, is of limited extent and crops out very poorly. It is quartz-feldspar phyric and has a granular texture on outcrop. In thin section, the groundmass is seen to be spherulitic and the plagioclase phenocrysts commonly exhibit overgrowths of fibrous quartz.

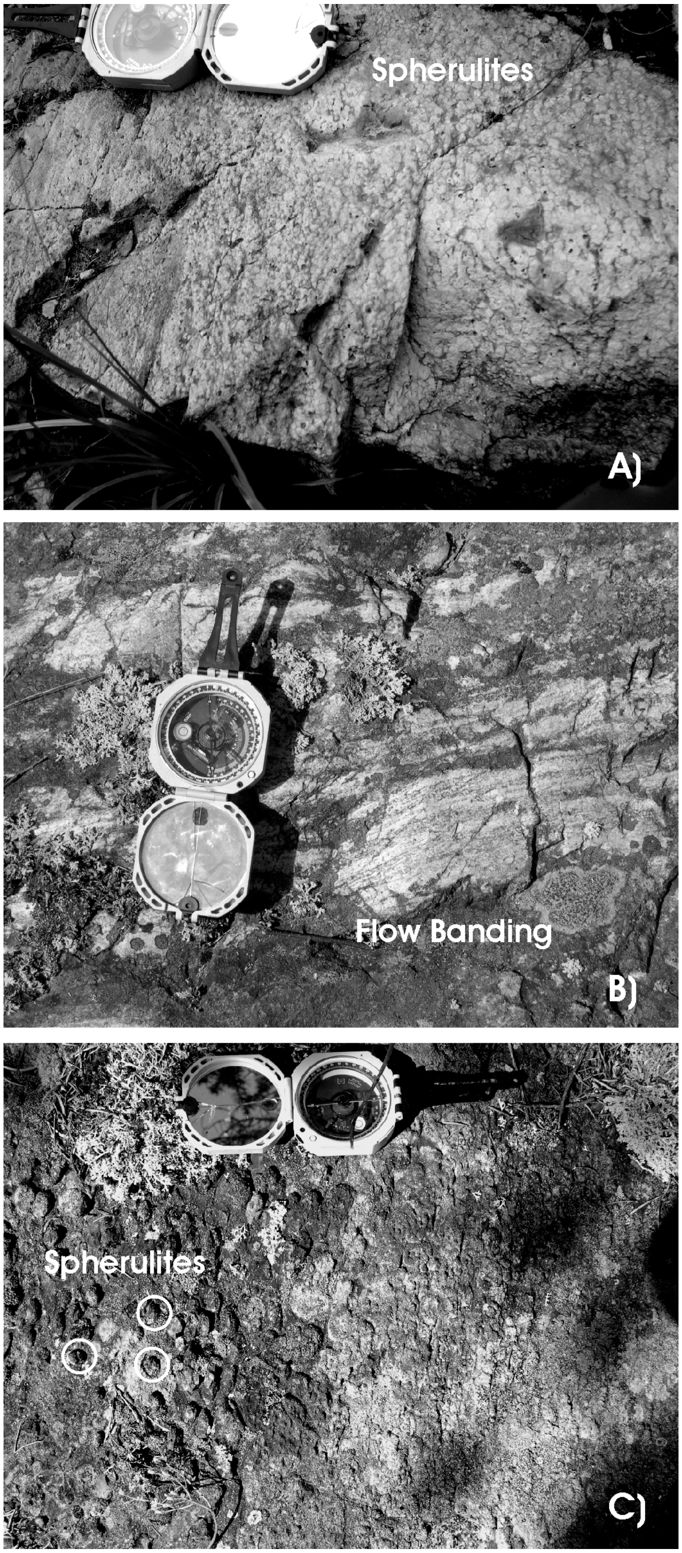


Photo 1. a) Spherulites in a rhyolite from the spherulitic unit at the base of the Kidd–Munro assemblage in Munro Township; b) flow banding in the Beatty rhyolite; and c) spherulites in a basalt from the spherulitic unit at the base of the Kidd–Munro assemblage in Munro Township. For scale, the width of the brunton is 7 cm.

MAFIC METAVOLCANIC ROCKS

The lowest unit in the Kidd–Munro stratigraphy of the South Munro block is the 200 to 450 m thick interlayered spherulitic/variolitic felsic and mafic flows. The mafic flows of this unit are commonly pillowed or massive, and the spherulites are 1 to 3 mm in size and may comprise up to 75% of the rock (Photo 1c). Rare units contain spherulites/varioles up to1 cm. In thin section, a spherulitic pillowed flow was plagioclase microphyric; some of the plagioclase microlites are skeletal. The groundmass exhibits dendritic crystal masses, which produce the spherulitic appearance on outcrop. In a second thin section of a spherulitic pillowed flow, the plagioclase phenocryst are blocky; the spherulites are fibro-radial, but not acicular and exhibit spherulitic overgrowth on previously existing spherulites. The origin of this spherulitic unit, both mafic and felsic members, is presently under investigation (A.D. Fowler, University of Ottawa, personal communication, 2004).

Above the spherulitic unit lies sequence of subaqueous basalt flows (approximately 1 km thick), characterized by massive and pillowed lavas and flow breccias (*see* Figure 4; Map P.3557). The lavas are commonly amygdaloidal with up to 10% 1 mm quartz amygdules; some units have large quartz-filled shelf amygdules. Thick units of flow breccias and pillow breccias with a high percentage of hyaloclastite matrix also occur, as do rare thin units of spherulitic pillowed basalt. The lavas are commonly aphyric, but plagioclase phyric flows do occur.

Overlying the subaqueous basaltic sequence is a basaltic unit that has a high magnetic signature (*see* Figure 4; Map P.3557). This unit is defined solely by its geophysical signature. It has an apparent thickness of 700 m near the Munro–Beatty townships boundary, and thins to the southeast, decreasing to 150 m at the boundary with Guibord Township. Both the Beatty rhyolite and the Munro sill occur within the high magnetic area in the western part of the township. The Beatty rhyolite occurs at the boundary between the magnetic and non-magnetic basalts south of the Munro Mine site, and the Munro sill occurs at that boundary southeast of the mine. These subaqueous basalts are dominantly pillowed; massive flows, pillow breccias and hyaloclastites were observed, but are less common. Concentric cooling fractures, multiple rims, train vesicles and shelf amygdules were observed in the pillows. One thin spherulitic pillowed unit was observed. The magnetic basalt unit is overlain by the “First Komatiitic Lava Succession” defined by Johnstone (1991a) and described below.

ULTRAMAFIC METAVOLCANIC ROCKS

The komatiitic rocks in the South Munro block represent roughly half of the Kidd–Munro assemblage in this area (*see* Figure 4; Map P.3557). The komatiitic sequence thickens toward the east and extends laterally for over 9 km across the township. This komatiitic sequence was recognized by Johnstone (1991a) as the First Komatiitic Lava Succession in Munro Township.

The komatiitic sequence is composed of variable proportions of peridotitic komatiite intercalated with basaltic komatiite. The minimum thickness of this komatiitic succession is 200 to 300 m, whereas at its thickest, it is 1200 to 1500 m thick (Johnstone 1991a).

The western sector of the komatiitic sequence, near the Munro–Beatty townships boundary, is the thinnest. The komatiitic sequence begins with a peridotitic komatiite flow, which is succeeded upward by intercalated peridotitic and basaltic komatiite flows, which are commonly thick, well-differentiated flows with well-developed spinifex-textured zone (Johnstone 1991a). At the base of the sequence, a well-differentiated basaltic komatiite flow, recognized as Dee’s flow, is composed of basal peridotite and pyroxenite overlain by a gabbroic section with a thin discontinuous pyroxene spinifex zone (Arndt 1975, 1986; Johnstone 1991a). Dee's flow has a maximum thickness of 80 m and a strike length of less than 400 m (Johnstone 1991a). However, it is important to note that Dee's flow hosts the best known occurrence of komatiite-associated mineralization, the Mickle occurrence, found near the base of this unit in Munro Township.

The central sector of the komatiite sequence, north to northeast of the Munro asbestos mine, is the thickest exposed part of the sequence. The lower half of the sequence is composed of an intercalation of massive and olivine spinifex-textured peridotitic komatiite flows, and massive and pyroxene spinifex-textured basaltic komatiite flows. Despite the relatively poor exposure of the lower half of the sequence, the peridotitic komatiite flows appear to be dominant in proportion to the basaltic komatiite flows.

The eastern sector of this komatiitic sequence is poorly constrained due to the lack of exposure. The high variation in the magnetic signature and outcrops outside of the map area suggest an intercalation of well-differentiated peridotitic and basaltic komatiite flows in this area. However, the cartographic depiction of the interpreted geology in this area undoubtedly oversimplifies the complexity of the komatiitic volcanism.

Central Munro Block

The major structure in the Central Munro block is a northwest-trending syncline in the centre of the block (*see* Figures 4 and 6; Map P.3557; Johnstone 1991b). A minor northwest-trending anticline of limited extent occurs in the southwestern Central Munro block (Map P.3557; Johnstone 1991a; Satterly 1952a). The south limb of the central syncline is dominated by mafic volcanic rocks (85% of the Central Munro block), with ultramafic volcanic rocks constituting only 5%, concentrated in the south-central part of the block near Deadman Hill, and near the synclinal axis (*see* Figure 4; Map P.3557); no felsic volcanic rocks occur in this block. The uppermost section of the basaltic unit exhibits a high magnetic signature similar to that of the high magnetic basalts of the South Munro block. This area has poor outcrop exposure and has poor access. The units on the north limb of the central syncline are similar to those on the south limb (Map P.3557) with the high magnetic basalts being underlain by mafic volcanic rocks. The north limb of the syncline is cut by the northwest-trending Centre Hill fault. Minor ultramafic volcanic units were mapped between the fold axis and the Centre Hill fault by Johnstone (1991b). The area has very poor outcrop exposure, and the high magnetic signature may be due to unobserved ultramafic volcanic units similar to those mapped by Johnstone (1991b). An intermediate stock in interpreted as occurring on the axis of the syncline (*see* Figure 4; Map P.3557). The presence and extent of this intrusion is interpreted on the basis of outcrops compiled from Johnstone (1991a) and Satterly (1952a), and the low magnetic signature on the new geophysical survey (Ontario Geological Survey 2003). The interpretation of the felsic to intermediate composite intrusion at the northern limit of the Central Munro block is based on mapping during this study, compilation of the existing maps (Johnstone 1991a; Satterly 1952a), and the magnetic low on the geophysical survey (Ontario Geological Survey 2003). This intrusion appears to cross the Centre Hill fault and is, therefore, a late intrusion (Map P.3557).

MAFIC METAVOLCANIC ROCKS

The Central Munro block is dominated by mafic subaqueous volcanic rocks (*see* Figure 4; Map P.3557). Outcrops north of the central syncline are rare, and not easily accessible; interpretation in that area is based on compilation of existing maps (Barrie 1999; Johnstone 1991a; Satterly 1952a) and geophysical signatures (Ontario Geological Survey 2003). The mafic metavolcanic rocks in the Central Munro block have been subdivided into 2 units based on their magnetic signature (*see* Figure 4; Map P.3557; Ontario Geological Survey 2003); also, an area exhibiting a high magnetic signature occurs in the axis of the syncline (Ontario Geological Survey 2003). The lowest mafic unit on the south limb of the syncline is characterized by abundant pillowed flows, with less abundant massive flows, and flow breccias including pillow breccias, isolated and amoeboid pillow breccias, and hyaloclastite layers. The lavas are commonly amygdaloidal, with 1 to 10% of 1 to 7 mm vesicles (commonly quartz-filled); shelf vesicles up to 3 by 10 cm are rare. Most flows were aphyric, but rare flows are plagioclase porphyritic (1–2%, 1–2 mm phenocrysts) to glomeroporphyritic (7–10%, 1–3.5 mm phenocrysts). A unit of spherulitic pillowed basalt occurs immediately north of the Munro fault zone near the Munro–Beatty townships boundary. In thin section, the lava is plagioclase microlitic with an equigranular matrix; fibrous and fan-textures are rare. The breccia units commonly form 0.5 to 5 m beds between massive or pillowed flows, but some units extend beyond the outcrop exposure, and the thickness could not be determined. Fragments in the flow breccias are rounded to angular, with locally broken lava and pillow fragments.

The magnetic basalt exhibits the same flow facies as the underlying basalt; no distinguishing characteristics were observed on outcrop on the south limb of the syncline. The only outcrop of this unit visited on the north limb of the syncline exhibited incipient spinifex texture. The thin section of a sample from this unit consists of pseudomorphs of acicular (pyroxene?) crystals in a fibrous and fan-textured matrix. This observation suggests that some of the high magnetic signatures observed within this basaltic package could, in fact, be komatiite flows or basaltic komatiite flows: a transition from mafic to ultramafic rock units. In particular, the signature of the magnetic basalt unit may be due to the intercalation of ultramafic units.

ULTRAMAFIC METAVOLCANIC ROCKS

The komatiitic rocks in the Central Munro block represent only a small proportion of the rock units observed, with the exception of the Deadman Hill area (*see* southern portion of Figure 4; Map P.3557). However, the scarcity of the exposure combined with some moderate to high magnetic anomalies suggests that the amount of komatiitic units in this area is under-estimated, as suggested above.

The Deadman Hill area consists of intercalated komatiitic and basaltic lava flows. The bulk of the komatiite flows in the area are pillowed and massive basaltic komatiite flows that commonly exhibit pyroxene and/or olivine spinifex-textured zones and polyhedral jointing. Massive peridotitic komatiite flows are rare, and locally exhibit gabbroic zones overlain by thin olivine spinifex-textured zones similar to Fred’s flow. Canil (1985) presents a more exhaustive description of this area.

Elsewhere, the komatiitic sequence is also dominated by basaltic komatiite flows with lesser komatiite flows. Basaltic komatiite flows are dominated by pillowed flows with less common differentiated (massive and pyroxene spinifex-textured) flows and massive flows. Locally, variolitic komatiitic basalt flows are observed. Differentiated (massive and olivine spinifex-textured) and undifferentiated (massive olivine porphyritic units) komatiite flows are the most common facies of peridotitic komatiite flows observed in this area. Massive undifferentiated cumulate units are also observed locally.

North Munro Block

North of the Centre Hill fault (North Munro block; Figures 6 and 8), the major structures are the southeast-striking McCool Syncline and the Warden Hill fault (*see* Figure 4; Map P.3557; Coad 1976; Johnstone 1991a; Gamble 2000). The stratigraphy of the North Munro block also strikes southeasterly. The McCool syncline closes to the east in McCool Township; in Munro Township, north of the northeast-trending diabase dike (Map P.3557), the axis of the syncline is faulted (the Axis fault: Johnstone 1991b;

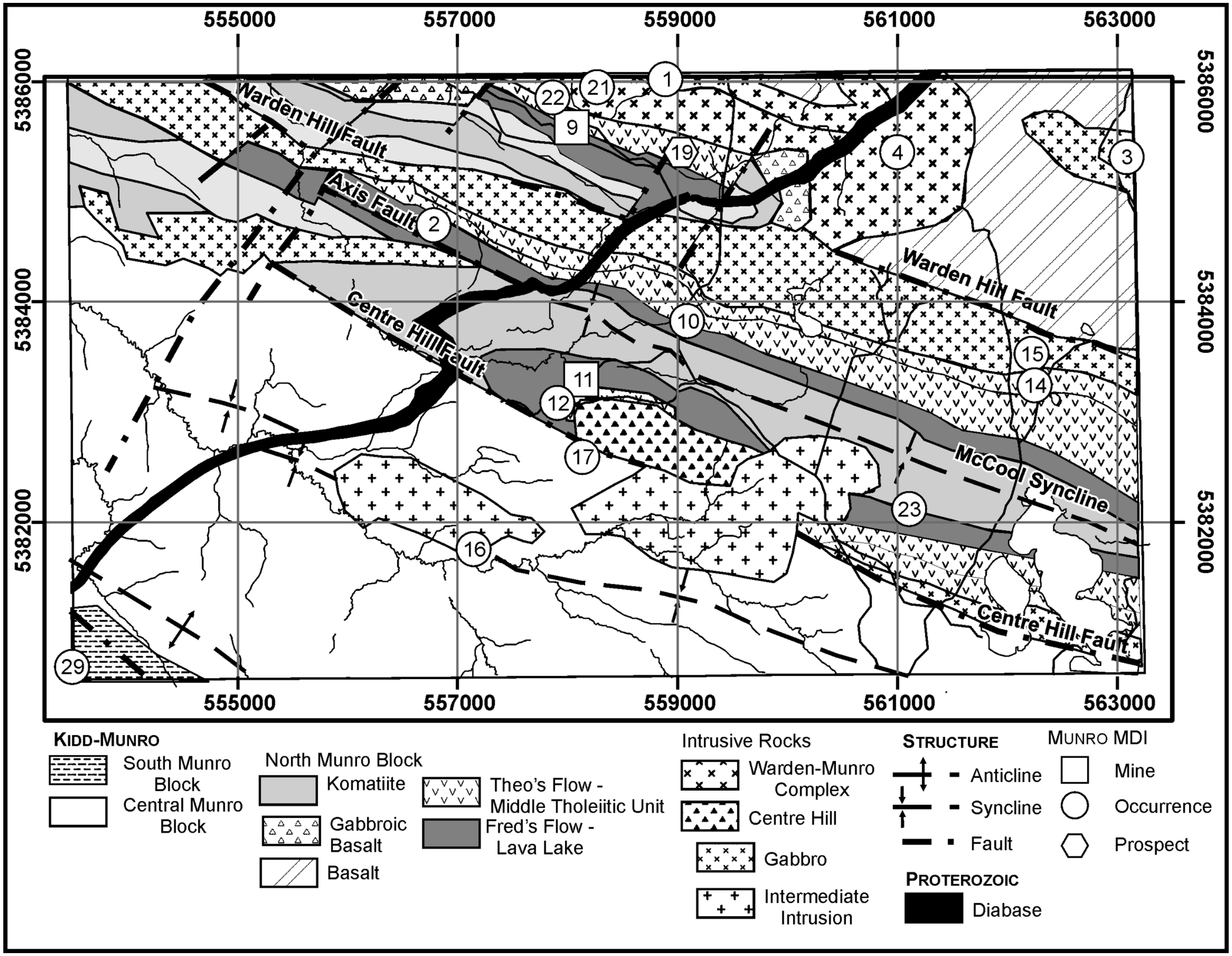


Figure 8. Map of the North Munro block showing the repetition of Fred's and Theo's flows. Mineral occurrence and deposit numbers listed in Table 2 and on Map P.3557 (Ontario Geological Survey 2004a).

see Figure 4; Map P.3557). East of the apophysis of the composite felsic to intermediate intrusion north of the Centre Hill fault, the stratigraphy is based on geophysical signature and the continuation of those signatures around the McCool synclinal axis (Map P.3557; *see* Figures 4, 7 and 8). The succession is interpreted to be the Munro Lake sill, overlain by ultramafic to mafic layered flows, followed by a peridotitic volcanic unit and topped by a basaltic komatiitic unit at the synclinal axis. Following the interpretation that the layered flows on the north limb of the syncline are repetitions of Theo's and Fred's flows (Arndt 1977; Arndt, Naldrett and Pyke 1977), the interpreted layered flows on the south limb of the syncline would also be repetitions of those flows (Arndt, Naldrett and Pyke 1977; Coad 1976). Volcanic rocks and interflow sediments comprise 67% of the Archean rocks in the map area north of the Centre Hill fault; and intrusive rocks, 33%. Ultramafic volcanic rocks constitute 60% of the volcanic rocks compared to 40% for the mafic volcanic rocks.

The stratigraphic sequence exposed of the southern limb of the McCool syncline is dominated by ultramafic volcanic rocks; no felsic volcanic rocks occur (*see* Figures 4 and 8; Map P.3557). This area includes the incredible exposures of the Pyke Hill komatiite flows and the Centre Hill layered intrusive complex. The Centre Hill Complex is at the base of the stratigraphy of the south limb of the McCool syncline and abuts the Centre Hill fault. It cores a small northwest-trending anticline that affects the adjacent volcanic rocks (Houlé et al. 2000; Oliver, Rebagliati and Haslinger 1999). The komatiitic tholeiitic volcanic succession in contact with the Centre Hill Complex at the Potter Mine is divisible into 3 lithostratigraphic and chemostratigraphic units, which are, from oldest to youngest, 1) the "Lower Komatiitic Unit", 2) the "Middle Tholeiitic Unit"; and 3) the "Upper Komatiitic Unit" (Figure 9; Gamble, 2000). Basaltic volcaniclastic rocks of the Middle Tholeiitic Unit host base metal mineralization at the Potter Mine (Centre Hill Mine) copper-zinc deposit (Gamble and Gibson 2000a; Gamble 2000; Gibson and Gamble 2000; Tardif et al. 2000). The Upper Komatiitic Unit consists of a lower peridotitic komatiite unit overlain by a basaltic komatiite unit (Map P.3557). The stratigraphy in this area strikes west to west-northwest and dips steeply (85°) to the north. It is repeated on the north limb of the McCool syncline, where it is underlain by a massive layered gabbroic to pyroxenitic unit. This unit has been interpreted variously as being the repetition of the Munro sill around the fold axis (Johnstone 1987, 1991a, 1991b), and as being a thick layered flow (Barrie 1999a). Here, we adhere to the interpretation of the unit as being extrusive (*see* Figures 4 and 8; Map P.3557). The thickness and extent of the units on the map are based on the geophysical signature (*see* Figure 7; Ontario Geological Survey 2003), and the units are the continuation of thick layered flows occurring west of the northeast-trending diabase dike (*see* Figure 8; Map P.3557, Arndt 1977; Johnstone 1991a, 1991b). A thin breccia unit occurs at the peridotitic komatiite–gabbroic flow contact. Flow breccias also occur within the gabbroic flow. A thick gabbro sill intrudes the stratigraphic sequence north of the pyroxenitic unit of the layered flows. A thin chert unit occurs locally at the pyroxenitic flow–gabbro sill contact (Map P.3557; Johnstone 1991a; Satterly 1952a). From the geophysical data, this sill is interpreted to be the folded repetition of the Munro Lake sill (*see* Figures 7 and 8; Map P.3557) and will be referred to as the north limb of the sill.

The north contact of the north limb of the Munro Lake sill corresponds to the Warden Hill fault. The displacement along this fault is unknown. A layered ultramafic to mafic intrusion occurs at the base of the stratigraphic sequence north of the Warden Hill fault at the Munro–Warden townships boundary, and is cored by mafic volcanic rocks based on mapping by Johnstone (1991b). This intrusion has an oval, not tabular form, based on the magnetic survey (*see* Figure 7) and, although it is contemporaneous with the Centre Hill Complex (*see* "Ultramafic to Mafic Sills"), its form suggests that it is not another folded section of the Munro Lake sill. Historically, this layered intrusion has been called the "Munro–Warden sill"; however, as it is not tabular, it will be referred to here as the Munro–Warden complex. Thin units of cherts and/or mudstones occur within the intrusion parallel to its contacts and at the intrusion–volcanic rock contact. East of the Munro–Warden complex, contacts were placed on the map based on the geophysics, and the unsubdivided mafic nature of the rocks is interpreted.

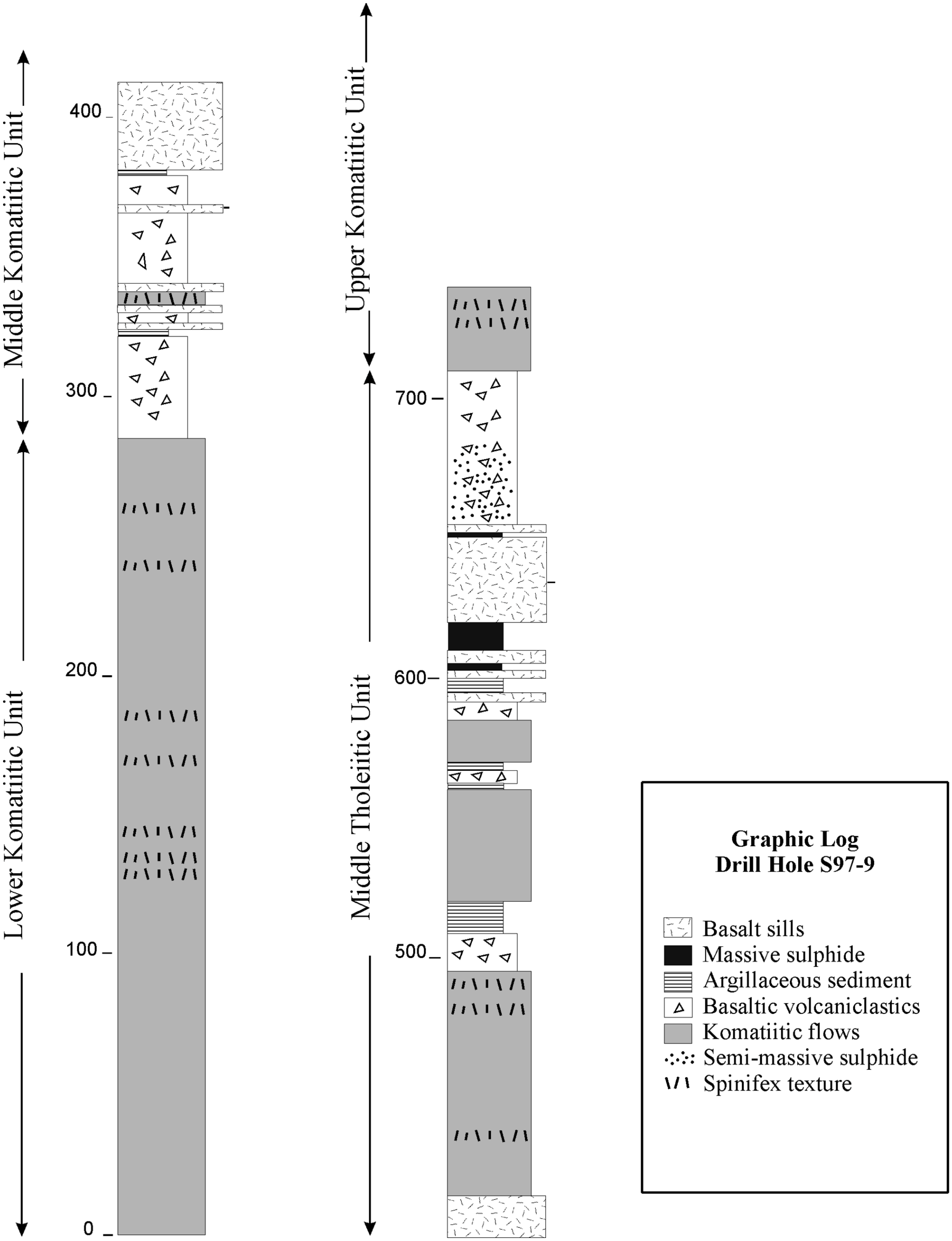


Figure 9. Stratigraphic section of hole S97-09, Potter Mine (Centre Hill Mine) (*modified from* A.P.D. Gamble, Dave Gamble Geoservices Inc., 1999; *see also* http://www.millstreammines.com/PotGeoStrat.jpg [accessed June 20, 2005]).

North of the Warden Hill fault, the lowest unit of the exposed stratigraphy, in contact with the Munro–Warden complex, is Theo's flow (a tholeiitic basalt; Arndt 1977; Arndt, Naldrett and Pyke 1977). Theo's flow is overlain by Fred's flow (a basaltic komatiite; Arndt 1977; Arndt, Naldrett and Pyke 1977). Arndt (1977) suggested that the thick layered flows south of the fault were the repetition of Fred's flow and Theo's flow (*see* Figure 8). As facing directions in the volcanic rocks on either side of the north limb of the Munro Lake sill and Warden Hill fault are to the south; the stratigraphic repetition may be caused by faulting rather than folding.

In the area of the Potterdoal Mine, the Buster fault runs subparallel to stratigraphy (Epp 1997; Epp and Crocket 1999). Epp (1997) proposed that the stratigraphic sequence is repeated across the Buster fault. The tholeiitic flow south of the fault is called the "Ore Flow" (Epp 1997; Epp and Crocket 1999). Epp (1997) describes the massive to pillowed flow facies transition of the Ore flow as being from east to west, opposite to that of Theo's flow (Figure 10). Epp (1997) interpreted the 2 flows to be different "tholeiitic units from the same stratigraphic level". The Potterdoal Mine is hosted within a volcaniclastic and sedimentary unit between the Ore flow and Fred's flow (*see* Figure 10; Epp 1997; Epp and Crocket 1999). Overlying Fred's flow are interlayered ultramafic (peridotitic and basaltic komatiite) flows (*see* Figure 8; Map P.3557; Johnstone 1991a).

MAFIC METAVOLCANIC ROCKS

In the North Munro block, 3 bands of mafic volcanic rocks occur (*see* Figure 9; Map P.3557): 1) the massive, pillowed and pyroclastic basalts at the Potter Mine on the south limb of the McCool syncline into which the Centre Hill Complex was intruded; 2) the thick layered flow on the north limb of the McCool syncline, south of the Munro Lake sill, and 3) Theo's flow and the Ore flow on the north limb of the McCool syncline in the Potterdoal Mine area. These 3 bands are interpreted to be a single, structurally repeated, stratigraphic level, as discussed above.

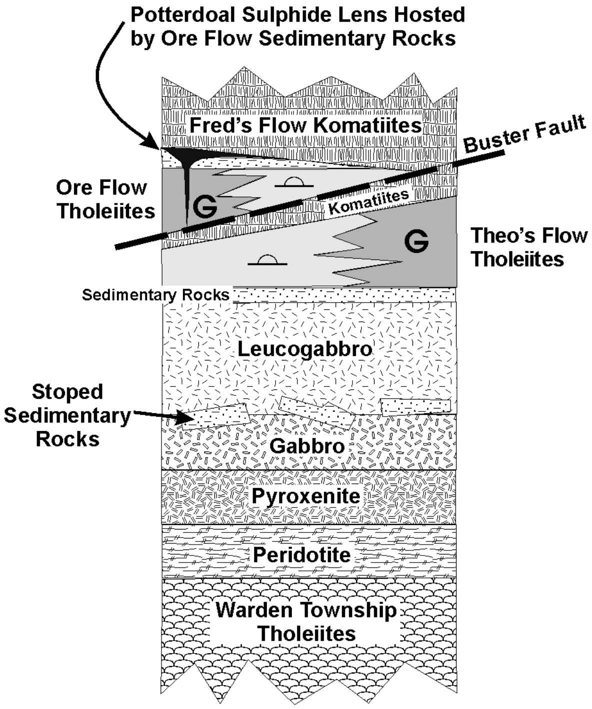


Figure 10. Geological cross-section of the Potterdoal Mine area (*from* Epp 1997).

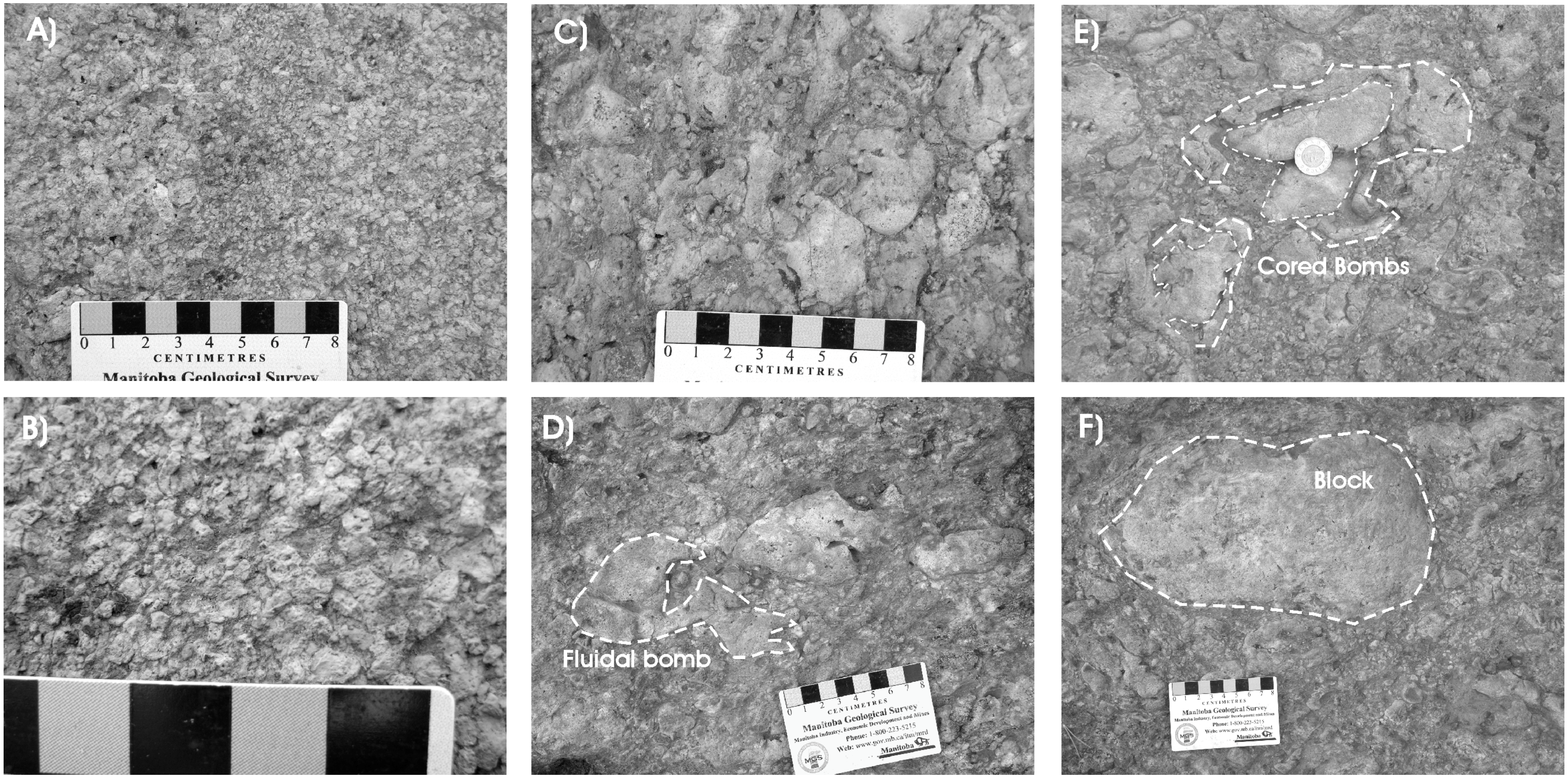


Photo 2. Volcaniclastic rocks of the Middle Tholeiitic Unit at Potter Mine: a) framework-supported lapillistone; b) detail of framework-supported lapillistone; c) “agglutinate” lapilli; d) fluidal bombs; e) cored bombs (for scale, diameter of coin is 28 mm); and f) blocks.

South Limb of the McCool Syncline

The mafic units on the south limb of the McCool syncline make up the Middle Tholeiitic Unit recognized at the Potter Mine (*see* previous section).

THE MIDDLE THOLEIITIC UNIT AT POTTER MINE

The Middle Tholeiitic Unit consists of basaltic volcaniclastic rocks, intact and autobrecciated sills (dikes) of massive quench-textured basalt and komatiite, thin discontinuous deposits of argillaceous and carbonaceous sedimentary rocks, chert, massive sulphide and lesser komatiitic flows (*see* Figure 9). The basaltic sills and volcaniclastic rocks are identical in composition and are chemically distinct from the Upper and Lower Komatiitic units (Gibson and Gamble 2000).

In the immediate mine area, the basaltic volcaniclastic rocks consists of well-bedded (decimetres to metres), framework-supported lapillistone units that are massive, normal graded, and moderately to well sorted (Photos 2a and 2b). Fragment types include amygdaloidal, globular to angular, plate-like lapilli (<1 to 5 mm) of chloritized sideromelane and occasional armoured lapilli with lesser accessory fragments of olivine porphyritic basalt, amygdaloidal aphyric basalt and plagioclase microlitic basalt. The matrix, which rarely exceeds 20% by volume of the hyaloclastite units, consists of 1) carbonate; 2) broken crystals of quartz, plagioclase and pyroxene; 3) fine, massive chlorite; 4) carbonaceous sediment; and 5) massive sulphide. Well-bedded, basaltic hyaloclastite units host the massive sulphide mineralization (Gibson and Gamble 2000; Tardif et al. 2000).

Approximately 500 m east of the mine area, the basaltic volcaniclastic rocks are massive to poorly bedded, unsorted and consist of globular, irregular “moulded” lapilli that resemble agglutinate (Photo 2c), fluidal bombs (Photo 2d), cored bombs (Photo 2e), blocks (Photo 2f), armoured lapilli and <10% matrix containing fine, plate-like hyaloclastite shards and lapilli (Gibson and Gamble 2000). Accessory fragments of chert, carbonaceous mudstone, argillaceous mudstone, and massive sulphide account for <1% of the breccia.

The basaltic volcaniclastic rocks were previously interpreted to have been derived through quench fragmentation and autobrecciation of basaltic flows. However, the lack of basalt flows and *in situ* hyaloclastite, the abundance of fluidal and cored bombs, armoured lapilli, globular lapilli, and the shear volume of breccia led Gibson and Gamble (2000) to propose an origin through “explosive fragmentation” rather than autobrecciation. The production of large volumes of lapilli-size granules is interpreted to be a product of the rapid eruption of low viscosity mafic magma into a water column where the magma was jetted into the water column, torn apart and quench-fragmented. In this model, massive, poorly sorted volcaniclastic units containing globular, lapilli-size agglutinate, and fluidal bombs are interpreted to represent vent proximal deposits, similar to subaerial fire fountain and spatter rampart deposits. In contrast, well-bedded and well-sorted lapillistone deposits, typical of the mine area, are interpreted as high-particle concentration mass flow and fall deposits that accumulated within a paleotopographic depression in the underlying komatiitic flow topography (Gibson and Gamble 2000).

Thin, discontinuous deposits of argillaceous and carbonaceous sediment and chert within the bedded volcaniclastic deposits define breaks in explosive volcanism that were dominated by fine suspension sedimentation and hydrothermal discharge. Clasts of these sediments within the hyaloclastite deposits probably represent rip-ups from underlying sediments.

Basaltic and komatiitic sills emplaced into the volcaniclastic succession are interpreted by Gibson and Gamble (2000) as high-level synvolcanic intrusions. Evidence for this interpretation includes 1) their fractured and autobrecciated upper and lower contacts with massive volcaniclastic material, massive sulphide and or argillite injected along fractures that penetrate the massive sill interior; 2) locally chilled and sharp upper and lower contacts; 3) the development of hyaloclastite along chilled and perlitic textured sill contacts and the mixing of this hyaloclastite with enclosing argillaceous mudstones and sulphide to form peperite; and 4) a basaltic composition that is identical to the volcaniclastic rocks (Gibson and Gamble 2000).

North Limb of the McCool Syncline

The two bands of thick layered tholeiitic flows on the north limb of the McCool syncline are interpreted to be the same unit (Theo's flow) repeated by the Warden Hill fault (Arndt 1975, 1977; Arndt, Naldrett and Pyke 1977; *see* Figure 8). The recognition of this unit as a flow rather than an intrusion is based on

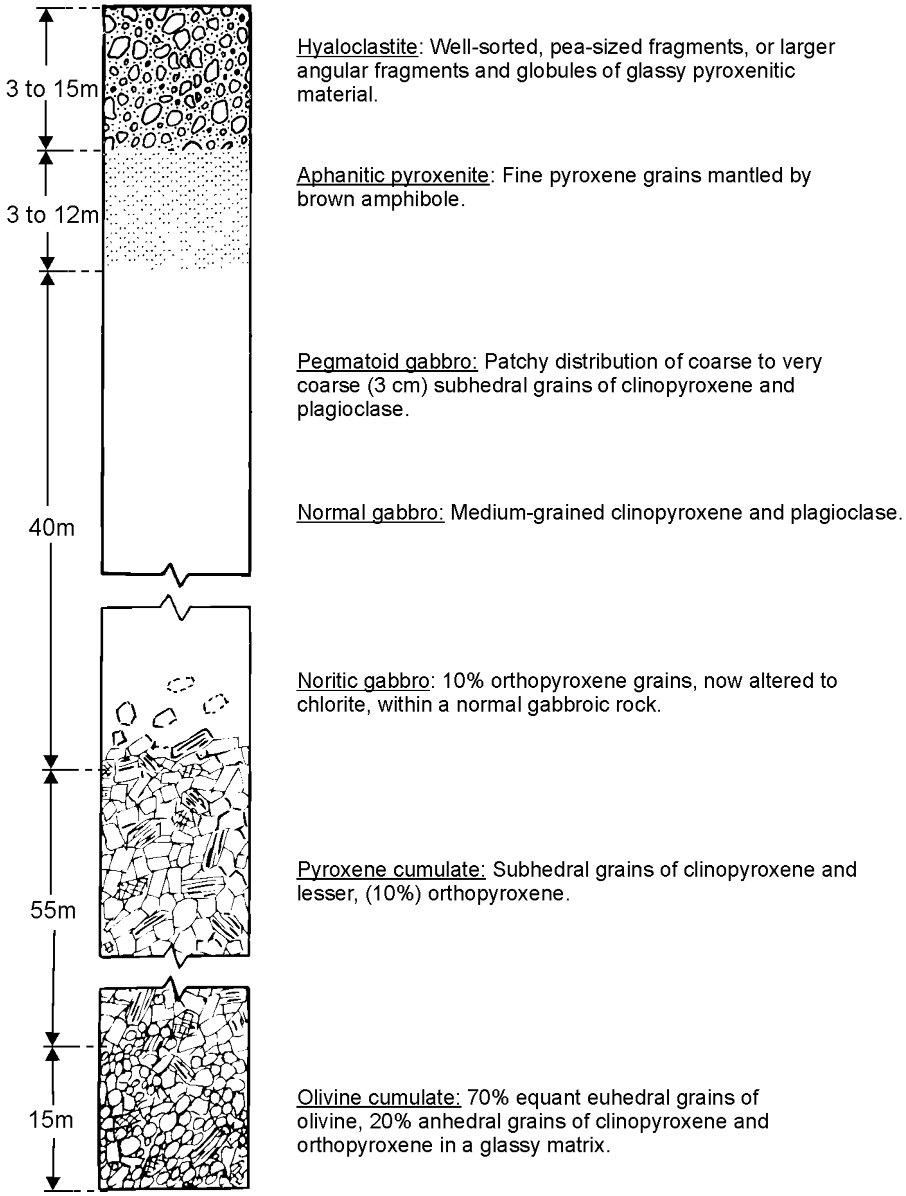


Figure 11. Idealized profile through Theo's flow (i.e., tholeiitic layered flow): a thick well-differentiated tholeiitic basalt flow (*from* Arndt, Naldrett and Pyke 1977).

the presence of a flow-top breccia (Arndt 1975, 1977; Arndt, Naldrett and Pyke 1977). The units comprising this flow are massive, thick and coarse grained, and exhibit no internal structure. Arndt (1975) and Arndt, Naldrett and Pyke (1977) describe an “ideal” cross-section of Theo’s flow (Figure 11) as consisting of a 15 m peridotite base, followed by a 55 m pyroxenite section, grading into a 40 m gabbro section varying up-flow from norite through normal gabbro to pegmatoid gabbro; the final sections of the flow are 3 to 12 m of aphanitic pyroxenite topped by 5 to 13 m of hyaloclastite breccia. On outcrop, these flows resemble intrusions and would be mapped as such (Satterly 1952b) were it not for the breccia facies (Photo 3a). In fact, Arndt (1975) and Johnstone (1991a, 1991b) interpreted the eastern extension of the thick layered unit south of the Warden Hill fault to be intrusive and part of the Munro Lake sill. However, Barrie (1999) reinterpreted the unit to be extrusive, and that interpretation is adhered to in this report. North of the Warden Hill fault in the area of the Potterdoal Mine, the komatiitic unit (Fred’s flow) overlying Theo’s flow is cut by the Buster fault (Cotnoir 1993), a bedding-subparallel fault that repeats the local stratigraphy (*see* Figure 10). The tholeiitic flow underlying Fred’s flow south of the Buster fault is called the Ore flow, but is interpreted to be at the same stratigraphic level as Theo’s flow (Epp 1997; Epp and Crocket 1999). The present superposition of the Ore flow relative to Theo’s flow is due to movement along the Buster fault (Epp 1997; Epp and Crocket 1999). Graphitic cherts and crystal tuffs occur between Fred’s flow and the Ore flow. Epp (1997) and Epp and Crocket (1999) describe a thick breccia that contains fragments of the underlying Ore flow as occurring locally within the volcaniclastic and sedimentary unit; they interpret the breccia as tectonic. This breccia hosts the Potterdoal Mine (Epp 1997; Epp and Crocket 1999). Within the volcaniclastic and sedimentary unit west of the Potterdoal Mine, Epp (1997) and Epp and Crocket (1999) recognized a basaltic komatiite fragmental unit similar to the basaltic volcaniclastic unit of the Middle Tholeiitic Unit at Potter Mine. East of the Potterdoal Mine, the variolitic facies of the Ore flow described by Epp (1997) and Epp and Crocket (1999) was observed (Photo 3b), as were sulphide-rich breccias and cherty interflow sediments (Photo 3c).

ULTRAMAFIC METAVOLCANIC ROCKS

The komatiitic rocks in the North Munro block represent close to the half of the volcano-sedimentary sequence in the North Munro block (*see* Figure 8; Map P.3557). The komatiitic sequence forms 2 bands: the southern band extends laterally for more than 10 km across the township, and the northern band for approximately 5 km. These bands are interpreted to be the result of structural repetition by folding and faulting as discussed above. This komatiitic sequence is recognized by Johnstone (1991a) as the “Second Komatiitic Lava Succession” in Munro Township.

South Limb of the McCool Syncline

The ultramafic volcanic units on the south limb of the McCool syncline make up the Lower Komatiitic Unit and the Upper Komatiitic Unit recognized at the Potter Mine (Gamble and Gibson 2000a; Gamble 2000; Gibson and Gamble 2000; see above section). Some ultramafic volcanic units were also described by Gamble and Gibson (2000a), Gamble (2000) and Gibson and Gamble (2000) within the Middle Tholeiitic Unit. The Lower and Upper Komatiitic units, as well as komatiitic flows within the Middle Tholeiitic Unit, are described together as they consist of massive and differentiated peridotitic komatiite flows.

The komatiitic units from the Lower Komatiitic Unit and the Middle Tholeiitic Unit are generally poorly exposed and were observed mainly in drill core. The komatiitic units from the Upper Komatiitic Unit are relatively well exposed and include the well-known Pyke Hill (Pyke, Naldrett and Eckstrand 1973) and Lava Lake (Arndt 1986) in the Potter Mine area.

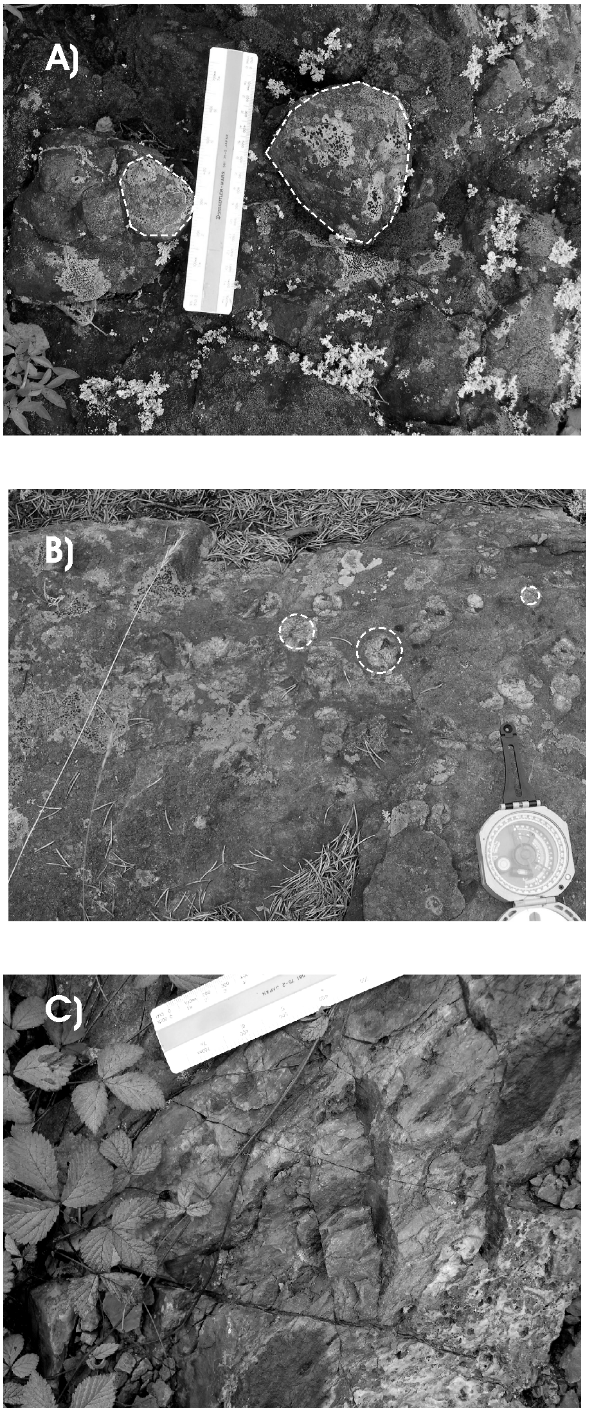


Photo 3. a) Interflow breccia at the top of the thick gabbroic basalt flow on the north limb of the McCool syncline, south of the Munro Lake sill. b) Variolitic basalt in the Potterdoal Mine area. c) Sulphide-bearing cherty sediments in the Potterdoal Mine area.

Differentiated flows are characterized by an upper chilled and polygonally fractured flow top, an underlying spinifex zone and a base of massive pyroxene peridotite as described for komatiitic flows at Pyke Hill, located east of the Potter Mine. Spinifex texture results from the parallel growth of large blade-like olivine crystals, which attain lengths of up to 2.5 cm, comprise up to 60% of the flow and are invariably altered to serpentine. Skeletal crystals of clinopyroxene are altered to fibrous amphibole and chlorite. Massive chlorite, presumably replacing original glass, locally occupies inter-olivine blade areas.

Massive peridotite, from the base of spinifex flows or from massive, non-spinifex-bearing flows consist of closely packed, serpentinized, equant olivine crystals (up to 3 mm in size) that comprise up to 80% (or more) of the flow. The intercumulus groundmass consists of acicular clinopyroxene altered to amphibole, with massive chlorite presumably after original glass. Locally, the intercumulate groundmass consists of subhedral clinopyroxene (lesser orthopyroxene) crystals up to 3 mm in diameter that poikilitically enclose smaller equant crystals of serpentinized olivine.

Peridotitic komatiite flows of the Upper Komatiitic Unit are overlain by basaltic komatiite flows higher in the stratigraphic sequence. The basaltic komatiite flows are poorly exposed and occur as pillowed or massive flows with lesser differentiated flows exhibiting a massive lower olivine-phyric to cumulate zone and an upper pyroxene spinifex-textured zone.

KOMATIITIC FLOWS AT PYKE HILL

Pyke Hill is located approximately 1 km east-southeast of the Potter Mine, and represents one of the best preserved and best exposed sequences of thin differentiated (spinifex-textured) and massive peridotitic komatiite flows in the world. It represents a series of compound flows. At least 60 flows have been identified over an exposure width of approximately 125 m (Pyke, Naldrett and Eckstrand 1973). Individual flows range in thickness from 0.5 to 15 m, averaging approximately 3 m (Pyke, Naldrett and Eckstrand 1973). The relative proportions of spinifex-textured “A” zones and cumulate-textured “B” zones vary within individual flows, owing to irregularities along the contact between the zones in response to different rates of cooling. The ratio of Zone A to Zone B averages approximately 2–1.5:1 at Pyke Hill (Pyke, Naldrett and Eckstrand 1973), confirming that this area contains primarily non-cumulate rather than cumulate flows. However, preliminary data indicate that the proportion of A:B zones decreases with increasing thickness. This is consistent with increases in flow thickness allowing for increases in the amount of olivine accumulation: a trend also observed in Western Australia (Lesher 1989; Lesher, Arndt and Groves 1984). The southern part of Pyke Hill (stratigraphically lower) is dominated by thin and thick differentiated non-cumulate flows, the central part by thin undifferentiated non-cumulate flows, and the northern (stratigraphically higher) part by thin differentiated non-cumulate flows, indicating that the eruption rates waned and waxed through the sequence. However, well-differentiated flows are interlayered within sequences dominated by poorly differentiated flows, indicating that the timing of ponding varied on a flow-by-flow basis. Poorly differentiated, non-cumulate flows, especially those with lobate sheet and flattened-pillow forms (rather than sheet flows) are spinifex textured along their margins and along fractures, indicating rapid crystallization due to extensive hydrothermal cooling and thermally constrained crystallization (Shore and Fowler 1999). Flattened pillows contain shelves that were interpreted by Shore (1996) as molten lava breakouts. However, the thicker parts of some lobate flows exhibit incomplete secondary selvages inside the major external selvages, suggesting that growth may have occurred by progressive inflation.

KOMATIITIC FLOWS AT LAVA LAKE

“Lava Lake” (Arndt 1986) is located immediately west of the Centre Hill Complex, approximately 1 km west of Pyke Hill. The “Lava Lake” area is very well exposed at surface, is dominated by massive to weakly layered, medium-grained olivine adcumulate rocks and has been previously interpreted to represent an approximately 120 m thick “Lava Lake” that youngs toward the north (Arndt 1986). However, the current Doctoral study by Houlé (Houlé et al. 2002) suggests, based on geological mapping and drill core logging, that the “Lava Lake” is stratigraphically equivalent to the rocks exposed at Pyke Hill and youngs toward the south. This interpretation is supported by 1) graded bedding in associated volcaniclastites and thin-bedded sediments within the upper part of the Middle Tholeiitic Unit; 2) chilled margin polarities; 3) asymmetric differentiation within flow units; 4) vesicle orientations; 5) fanned platy olivine spinifex; and 6) local asymmetric contacts in spinifex horizons within the komatiitic sequence. The remapping also suggests that the “Lava Lake” includes at least 6 mappable cooling units, and that it represents a series of thick sheet flows emplaced into a shallow depression or a series of thick sheet flows overlain by thin lava lake, rather than a thick lava lake. Thus, the Upper Komatiitic Unit in the Potter Mine area probably represents sheet flow facies komatiites that were channelized into a pre-existing depression and are flanked by a levee facies represented by the multiple thin undifferentiated to differentiated flows at Pyke Hill.

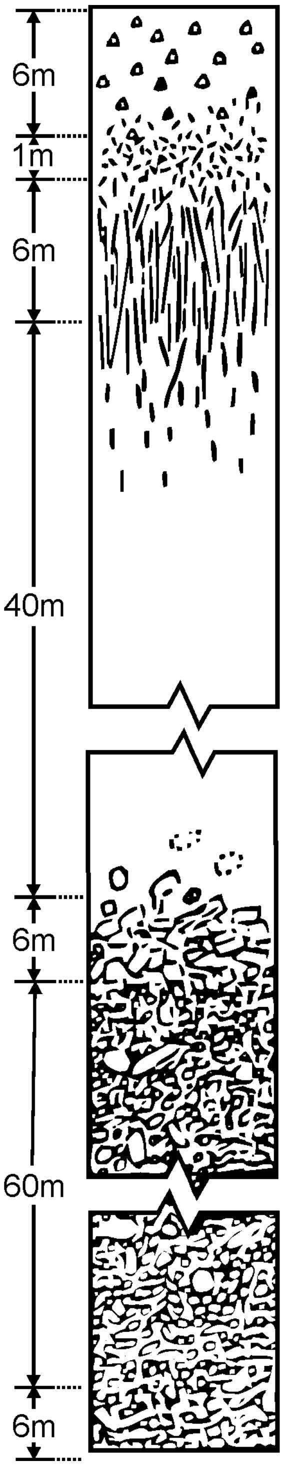
North Limb of the McCool Syncline

The stratigraphic sequence on the north limb of the McCool Syncline consists of a series of peridotitic komatiite and basaltic komatiite flows that includes such well-known komatiitic occurrences as Fred’s flow (Arndt, Naldrett and Pyke 1977). This komatiitic sequence in this part of Munro Township is recognized as the type-section for the “Second Komatiitic Lava Succession” defined by Johnstone (1991a) and described by (Arndt 1975, 1977; Arndt, Naldrett and Pyke 1977).

Fred’s Flow

Fred’s flow is exposed in at least in 2 sections through a structural repetition in the northern part of Munro Township. The northern exposure extends laterally into Munro Township for more than 6 km (Arndt 1975, 1977; Arndt, Naldrett and Pyke 1977) from the southwestern part of Warden Township. The best exposure and the section most described by Arndt (1975, 1977) and Arndt, Naldrett and Pyke (1977) is located around the former Potterdoal Mine. East of the Munro Lake–Hedman Mine access road, Fred’s flow thins rapidly and is truncated by a gabbro intrusion. It should also be noted that, although there is no outcrop east of this intrusion, the absence of a magnetic signature as high as that of Fred’s flow in the area supports the termination of the flow. The exposure of Fred’s flow south of the Warden Hill fault thins rapidly in its western extremity, but, based on its geophysical signature, may extend eastward into McCool Township (*see* Figure 7). The geophysical high representing Fred’s flow can be traced around the nose of the McCool syncline in McCool Township, and back into Munro Township where it aligns with the Pyke Hill komatiites. By this interpretation, Pyke Hill and the “Lava Lake” would be lateral equivalents to Fred’s flow.

Fred’s flow was described in detail by Arndt (1975, 1977) and Arndt, Naldrett and Pyke (1977); it shows the typical internal subdivisions of a well-differentiated, or Type-A, thick komatiitic basalt flow. Fred’s flow consists of a 120 to 160 m thick komatiitic basalt flow that is internally layered. From the top to the base, the flow consists of a flow-top breccia, an olivine spinifex-textured zone, a clinopyroxene spinifex-textured zone, a transition zone, a gabbroic zone, a pyroxenitic zone, a peridotitic zone and a border zone (Figure 12). The reader is referred to the detailed work of Arndt (1975, 1977) and Arndt, Naldrett and Pyke (1977) for an exhaustive description of this komatiitic unit.



Flow-top breccia Fragments composed of 30% equant olivine phenocrysts in a matrix of clinopyroxene and devitrified glass.

Olivine spinifex-textured lava 5% randomly oriented olivine wafers in a clinopyroxene-rich matrix.

Clinopyroxene spinifex-textured lava Large needles of clinopyroxene with orthopyroxene or pigeonite cores oriented perpendicular to the flow top in a matrix of plagioclase and fine acicular pyroxene.

Transition zone Isolated large clinopyroxene grains in a basaltic matrix.

Pyroxene cumulate Subhedral cumulate grains of clinopyroxene and lesser orthopyroxene.

Olivine cumulate Close-packed, equant, euhedral grains of olivine, minor anhedral and acicular clinopyroxene in a glassy groundmass

Border zone 30% olivine, 30% orthopyroxene, 30% clinopyroxene, subhedral equant grains.

Figure 12. Idealized profile through Fred’s flow (i.e., komatiitic layered flow): a thick well-differentiated komatiitic basalt flow (*from* Arndt 1975).

Intrusions

Intrusions were not studied in this project and only a brief overview will be presented here. Five types of intrusions occur in the Munro Township: 1) ultramafic to mafic layered sills and complexes, 2) felsic to intermediate composite stocks, 3) felsic porphyry dikes (possibly related to the composite stocks), 4) Proterozoic dikes and 5) lamprophyre dikes. The last 3 intrusion types will not be discussed here, but are indicated on the map (Map P.3557).

ULTRAMAFIC TO MAFIC SILLS

The most important intrusions in Munro Township are the ultramafic to mafic sills and complexes (Map P.3557). These include, in the South Munro block: the Munro sill host to the Munro Asbestos mine; and, in the North Munro block: the Centre Hill Complex north of the Centre Hill fault, the Munro Lake sill, which is folded around the McCool syncline, and the Munro–Warden complex, north of the Warden Hill fault, host to the Hedman deposit in Warden Township. It has been proposed that the Centre Hill Complex, the Munro Lake sill and the Warden–Munro complex are the same intrusion structurally repeated in the stratigraphy (Johnstone 1991a; MacRae 1969). The interpretation that the Centre Hill Complex is the folded extension of the Munro Lake sill around the McCool synclinal axis is supported by geophysics (Ontario Geological Survey 2003). A new U/Pb radiometric age determination for the Centre Hill Complex shows it to be 2706±1.2 Ma (Ayer et al. 2005), which is within the error of the unpublished age for the Munro–Warden complex (2704.9±1.9 Ma: Barrie 1999b as cited in Ayer et al. 2005). However, the oval form of the Munro–Warden complex, shown by its magnetic signature (Ontario Geological Survey 2003), suggests that, in spite of its being contemporaneous with the Centre Hill Complex and, thus, the Munro Lake sill, it is not an extension of those bodies.

The Centre Hill Complex has been recently studied (Thériault 1992; Thériault and Fowler 1996), and was part of a larger study (Vaillancourt et al. 2003) on mafic to ultramafic intrusions in Ontario. The Centre Hill Complex, the Munro Lake sill and the Warden–Munro complex were studied by MacRae in the 1960s (MacRae 1963, 1966, 1969). The Munro sill was also a part of an Operation Treasure Hunt project (Vaillancourt et al. 2003). Otherwise, few studies have been undertaken on the Munro sill, and both Johnstone (1991a) and Satterly (1952a) refer to the works of Freeman (1954) and Hendry (1951) as the best descriptions of the sill. It should be noted that Johnstone (1991a) reinterpreted some sections of the Munro sill (as described by Freeman 1954; Hendry 1951; Satterly 1952a) to be ultramafic flows, and that Barrie (1999a) also reinterpreted sections of the Munro Lake sill to be flows. Therefore, with the exception of the Centre Hill Complex, the historic descriptions of the layered ultramafic to mafic intrusions in Munro Township must be regarded with a critical eye.

The Munro Lake sill, north of the McCool syncline, and the Warden–Munro complex were visited in the course of this study. The Munro Lake sill, where observed, is a massive gabbro with no internal structure or distinguishing features. In the Warden–Munro complex, beds of chert and fine-grained sediments (mudstones) were observed striking parallel to the strike of the intrusive contact (Photo 4a). Johnstone (1991a) suggested that the "sill" intruded into the sediments along the bedding planes, and the beds within the sill are "xenoliths" separating magma injections. Variations in lithologies from normal gabbro to pyroxenitic gabbro were observed on outcrop, but not in enough detail to determine layering.

INTERMEDIATE TO FELSIC INTRUSIONS

Of the 2 intermediate to felsic intrusions that occur in Munro Township, only one was accessible. Both intrusions are in the Central Munro block. The contacts of the both intrusions are interpreted from the magnetic signature (*see* Figure 7; Ontario Geological Survey 2003), and the dominant rock type indicated is based on observed and compiled outcrops (Johnstone 1991a; Satterly 1952a). Outcrops of the intrusion immediately south of the Centre Hill fault were visited. This intrusion is multiphasic (granodiorite to gabbro) and exhibited xenolithic phases (Photo 4b). The xenoliths are heterolithic and include volcanic (mafic to ultramafic) fragments and intrusive fragments (resembling other phases observed on the outcrop). The geophysical signature of this intrusion suggests that it crosses the Centre Hill fault (*see* Figure 7; Ontario Geological Survey 2003); it is, therefore, interpreted to be a late (post-volcanic) intrusion.

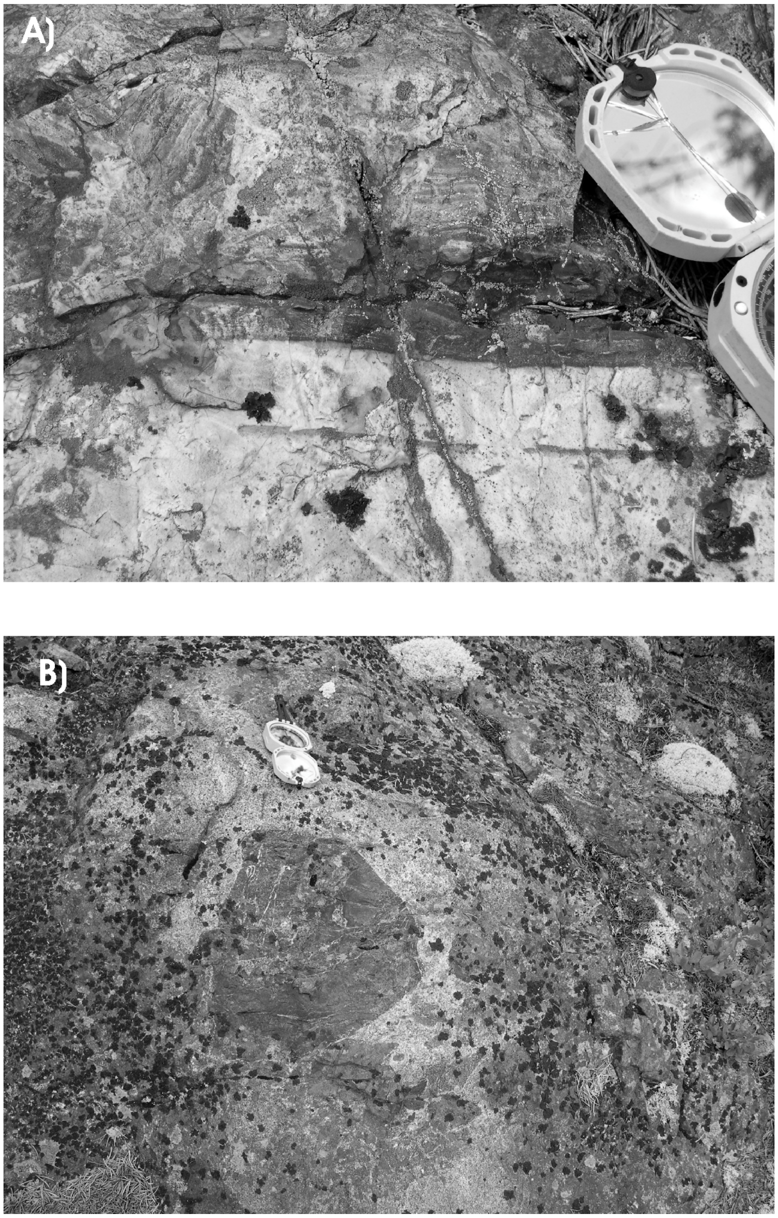


Photo 4. a) Disrupted chert bed in sediment “raft” within the Munro–Warden complex. b) Mafic volcanic xenolith in composite granodioritic intrusion immediately south of the Centre Hill fault. For scale, the width of the brunton is 7 cm.

GEOCHEMISTRY

Volcanic Rocks

The volcanic rocks of Munro Township were classified using Jensen's AFM plot (Jensen 1976); Figure 13). The 2 intrusive samples analyzed in this study are also plotted on Figure 13. This diagram shows that the rocks of ultramafic to mafic compositions of the Kidd–Munro assemblage in Munro Township are komatiitic and tholeiitic; the rocks of intermediate to felsic compositions are also tholeiitic. The volcanic rock samples that fall within the calc-alkalic field are interpreted to be altered, as their chondrite-normalized trace element patterns (Figure 17a) are similar to the tholeiitic and komatiitic rocks of the area. Iron-tholeiites are the dominant mafic affinity in the sample population. For the purposes of this study, the peridotitic and basaltic komatiites are referred to as ultramafic; the basalts, as mafic; the andesites, as intermediate, and the rhyolites and dacites as felsic. The data on the following diagrams (Figures 14 to 17) are grouped into the blocks defined previously (South Munro, Central Munro and North Munro), with the samples for the North Munro block subdivided into their relationship to the McCool synclinal axis and the Warden Hill fault. The ultramafic unit occurring in the area of the Munro fault zone is not represented due to the paucity and poor quality of the outcrops. The only sample taken of this unit falls in the Fe-tholeiite field of the Jensen AFM plot. The samples of the high-level synvolcanic and peperitic dikes from the Potter Mine area are included with the volcanic rocks.

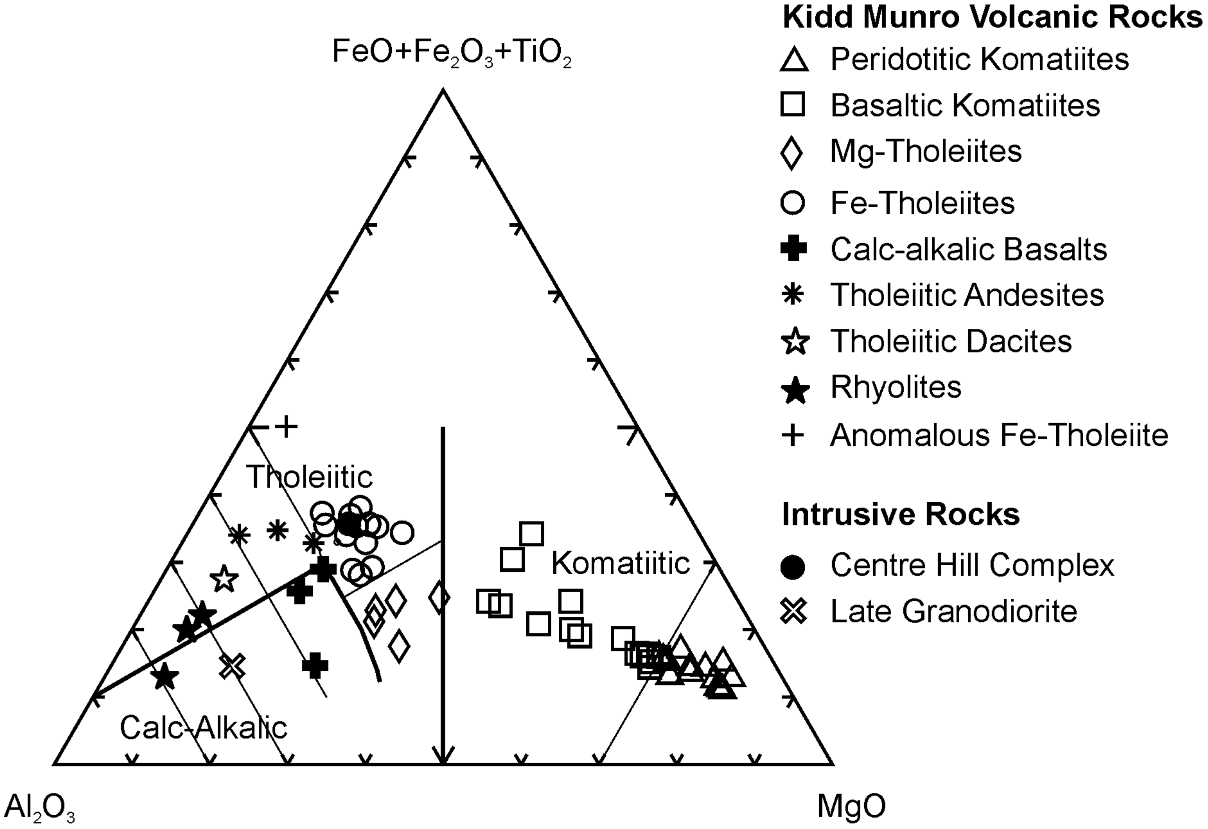


Figure 13. Al_2O_3–FeO_{total}+TiO_2–MgO in cation % (AFM) diagram for volcanic and intrusive rocks of Munro Township (*after* Jensen 1976).

ULTRAMAFIC TO MAFIC ROCKS

On an $FeO_{(total)}$ versus MgO weight % diagram (Figure 14a), 2 lines of descent are seen in the volcanic rocks of the North Munro block: 1) a trend with no Fe-enrichment, culminating in Mg-tholeiites; and 2) a trend with Fe-enrichment, culminating in Fe-tholeiites. All the mafic rock samples from the South Munro block are Fe-tholeiites. In the Central Munro block, the samples are dominantly Fe-tholeiites. Only 1 sample from the Central Munro block fell in the Mg-tholeiite field of the Jensen AFM diagram (*see* Figure 13); this sample was taken east of Deadman Hill within the basaltic komatiite unit. An anomalous sample from the Central Munro block (at 7 wt % $FeO_{(total)}$) fell within the calc-alkalic basalt field of the Jensen AFM diagram (*see* Figure 13), but exhibits acicular skeletal crystal pseudomorphs (microspinifex) in a fibrous fan-textured groundmass in thin section, and is considered an altered tholeiite. In the North Munro block, the 3 samples taken of the Middle Tholeiitic Unit at the Potter Mine (including the synvolcanic and peperitic dikes) fall in the basaltic komatiite field of the Jensen AFM diagram (*see* Figure 13), but have high iron contents, as seen on the $FeO_{(total)}$ versus MgO diagram (*see* Figure 14a). Based on the trace element patterns of these rocks (see below), they are interpreted to be tholeiitic basalts, the major elements having been mobilized. In the Potterdoal Mine area in the North Munro block, both trends are observed (*see* Figure 14a).

On a SiO_2 versus TiO_2 diagram (Figure 14b), 2 trends are also observed: 1) slight Ti-enrichment with increasing SiO_2 contents (Mg-tholeiites), and 2) high Ti-enrichment with increasing SiO_2 contents (Fe-tholeiites). The samples from the Middle Tholeiitic Unit at Potter Mine exhibit high TiO_2 contents for their SiO_2 contents, as do 2 samples from the Potterdoal Mine area. Two trends are also observed on an SiO_2 versus MgO diagram (Figure14c), but are not obvious on either an SiO_2 versus Al_2O_3 or an MgO versus Al_2O_3 diagram (Figures 15a and 15b, respectively). Two of the samples from the Potter Mine area have low SiO_2 contents for their MgO contents (Figure 14c).

On a Y versus Zr/Y diagram for the ultramafic to mafic rocks only (Figure 16a), 2 populations with different Zr/Y ratios for given Y contents are observed for the basaltic komatiites and Fe-tholeiites (Jensen AFM classification from Figure 13): 1) Y = 18.81–25.97 ppm and Zr/Y = 3.65–5.52 (one anomalous sample has Y = 32.55 ppm and Zr/Y = 7.07); 2) Y = 24.9–35.2 ppm and Zr/Y = 2.66–3.67. Both populations exhibit increasing Zr/Y ratios with increasing Y. The sample with anomalously high trace element ratios fell within the Mg-tholeiite field of the Jensen AFM diagram (*see* Figure 13), and showed no iron enrichment on the $FeO_{(total)}$ versus MgO diagram (*see* Figure 14a). This sample, from drill core at the Potterdoal Mine, has a trace element pattern indicating contamination (Figures 17b and 17c) that is interpreted to be due to sediment assimilation. All the samples from the Potterdoal and Potter Mine areas belong to the higher Zr/Y population, with one exception: a basaltic komatiite from drill core at Potterdoal Mine. Both populations of mafic rocks occur in the South Munro block, whereas the Central Munro block is dominated by the lower Zr/Y population. Two populations are also seen on a chondrite-normalized (cn) La/Yb versus Yb diagram of the ultramafic to mafic rocks only (Figure 16b): 1) Yb_{cn} = 11.0–15.94 and $(La/Yb)_{cn}$ = 1.45–2.32 (the contaminated sample discussed above, is not shown on this diagram, but has Yb_{cn} = 12.06 and $(La/Yb)_{cn}$ = 26.28); 2) Yb_{cn} = 17.18–23.18 and $(La/Yb)_{cn}$ = 0.78–1.22. The samples comprising the higher Zr/Y population form the higher $(La/Yb)_{cn}$ population. The majority of samples from the Potterdoal and Potter mine areas belong to the higher $(La/Yb)_{cn}$ population, and the contaminated sample from Potterdoal Mine has extremely high $(La/Yb)_{cn}$.

On a chondrite-normalized trace element plot (Figure 17a) of the mafic to ultramafic rocks not included in the populations defined above, the ultramafic rocks from the North Munro block all have similar light rare earth element (LREE) depleted patterns. One sample from the North Munro block was designated an Mg-tholeiite on the Jensen AFM diagram (*see* Figure 13), but has a depleted light rare earth element (LREE) pattern that resembles the ultramafic rocks. One sample from the Central Munro block

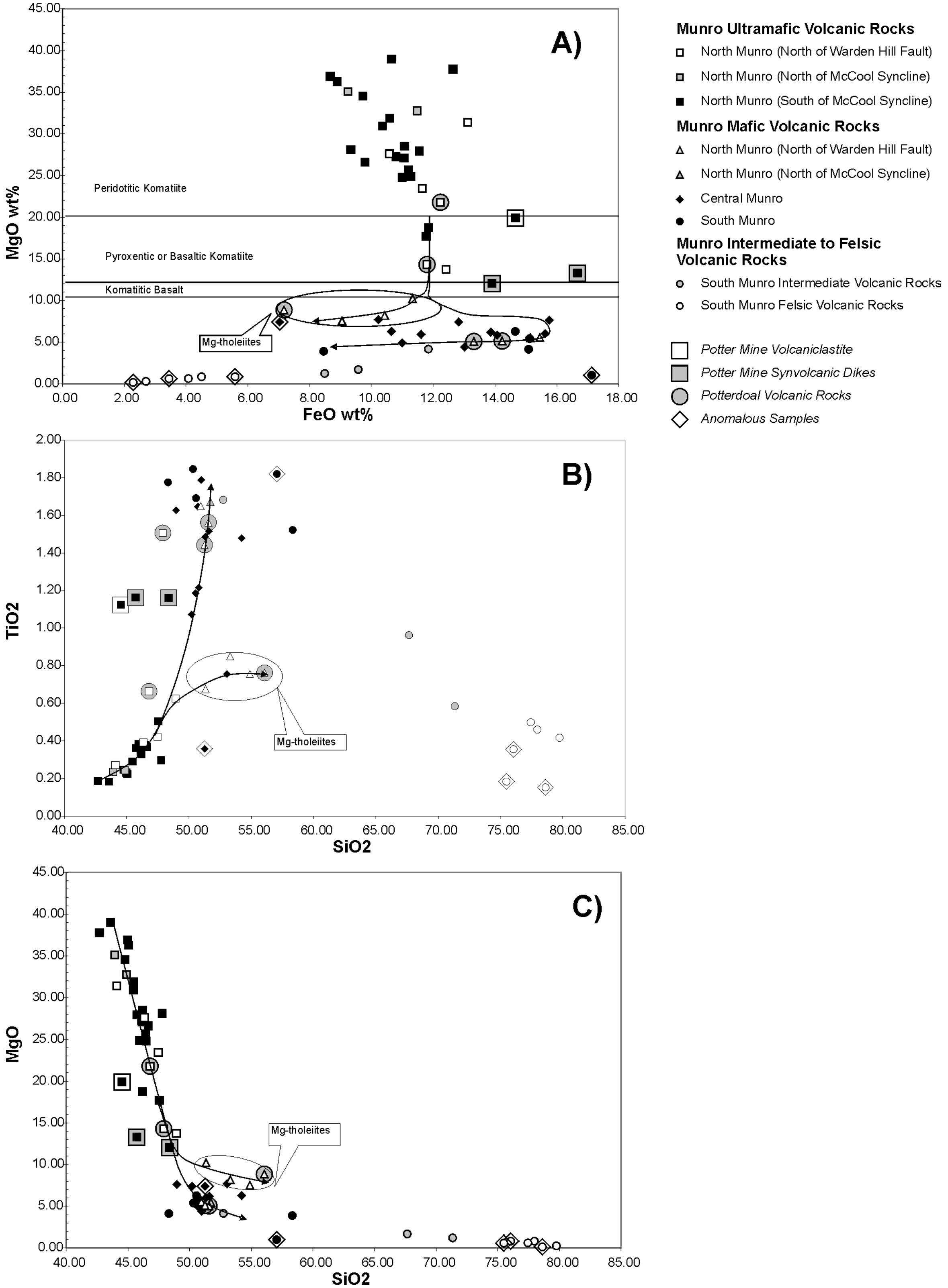


Figure 14. Major element variation diagrams for volcanic rocks of Munro Township: a) $FeO_{(total)}$ versus MgO (rock classification based on criteria from Table 1); b) SiO_2 versus TiO_2; and c) SiO_2 versus MgO. Axes in weight %. Arrows on diagrams indicate approximate lines of descent (trends) for the Mg-tholeiites and Fe-tholeiites.

fell in the calc-alkalic basalt field of the Jensen AFM diagram (Figure 17a), but exhibits LREE depletion; the calc-alkalic nature of this sample defined by the major elements is considered to be due to alteration. The Mg-tholeiites from the Jensen classification have very slightly positively sloped chondrite-normalized trace element patterns (*see* Figure 17a). They also have small negative Nb anomalies that indicate possible contamination. On the chondrite-normalized trace element spider diagram (*see* Figure 17b) of the 2 mafic rock populations defined above, the differences in Yb_{cn} content and $(La/Yb)_{cn}$ ratios are seen. The slope of the lower Yb_{cn} – higher $(La/Yb)_{cn}$ population is similar to that of the Mg-tholeiites (*see* Figure 17b), but the patterns lack convincing negative Nb anomalies. The sample with the anomalously high $(La/Yb)_{cn}$ ratio, however, has a large negative Nb anomaly, which, as stated above, is interpreted to result from the assimilation of sediments. The mafic samples from the Potter and Potterdoal mine areas belong to the higher $(La/Yb)_{cn}$ population (*see* Figures 16b and 17b). The stratigraphy from the Potter Mine area is repeated around the McCool syncline axis south of the Warden Hill fault (Coad 1976; Arndt, Naldrett and Pyke 1977; Barrie 1999; Johnstone 1987, 1991a); it has also been proposed that the stratigraphy of the north limb of the McCool syncline is repeated across the Warden Hill fault in the Potterdoal Mine area (Arndt 1975, 1977; Arndt, Naldrett and Pyke 1977; Epp 1997; Epp and Crocket 1999).

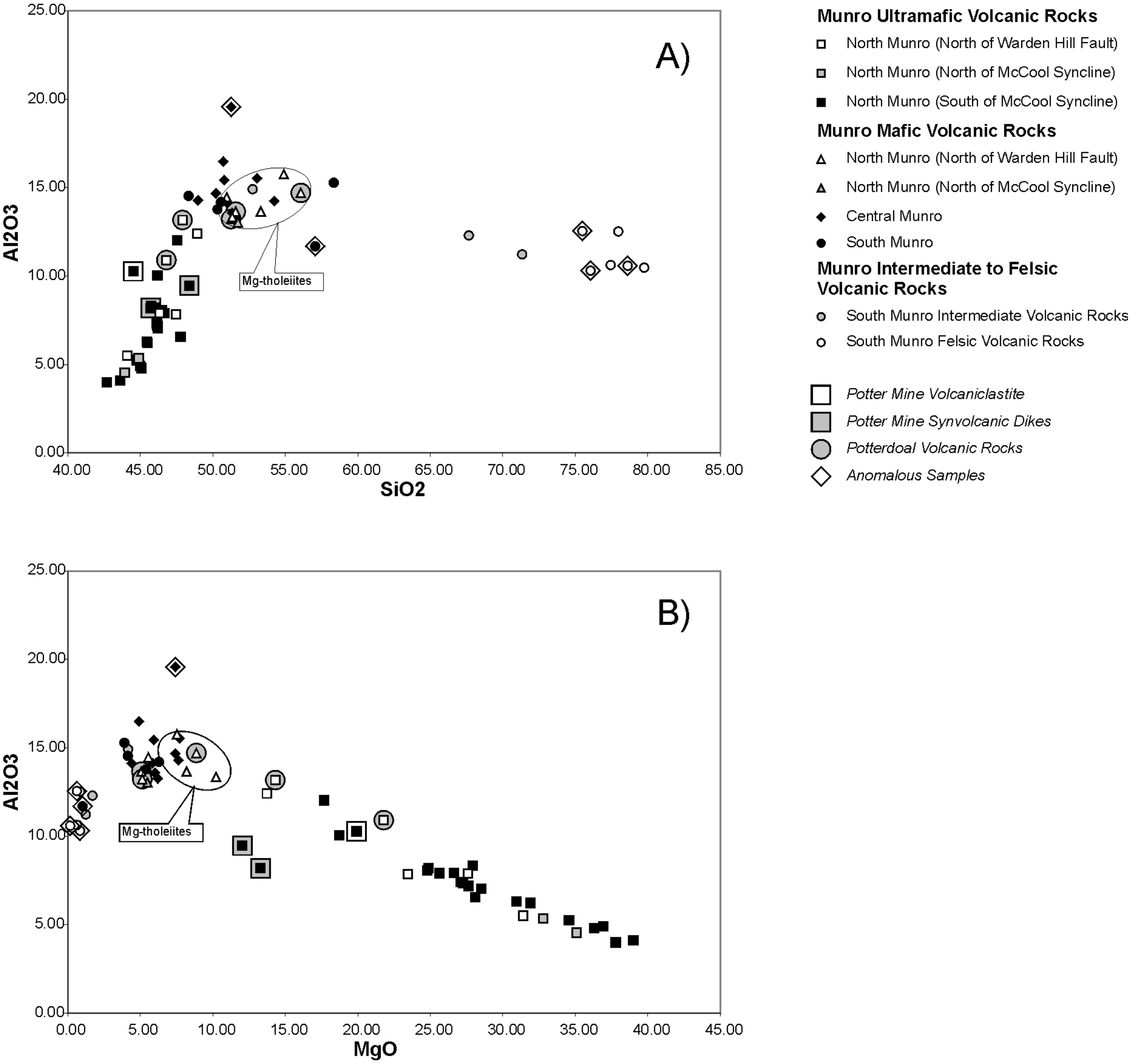


Figure 15. a) SiO_2 versus Al_2O_3; and b) MgO versus Al_2O_3 for Munro Township volcanic rocks. Axes in weight %.

On a chondrite-normalized trace element spider plot of samples from the 3 areas (Potter Mine, north limb of the McCool syncline, and Potterdoal Mine), the similarities in trace element patterns between the areas is obvious (*see* Figure 17c). In spite of the differences in major element chemistry of the Middle Tholeiitic Unit at the Potter Mine (high FeO wt % and low SiO_2 wt % contents for their MgO wt % contents: *see* Figure 14) compared to the tholeiites at Potterdoal Mine and on the north limb of the McCool syncline, the trace element patterns of the Middle Tholeiitic Unit samples are similar to the Fe-tholeiites in those areas. This indicates a process (possibly hydrothermal alteration) at work in the Potter Mine area that affects the major element mobility without affecting the trace elements. Further investigation is necessary to verify and characterize the process. On the chondrite-normalized trace element plot, the effects of contamination on the sole sample designated as a Mg-tholeiite in the Potterdoal Mine area is clearly visible (*see* Figure 17c). The middle rare earth elements (MREE) and light rare earth elements (LREE) are enriched, whereas the heavy rare earth elements (HREE) remained

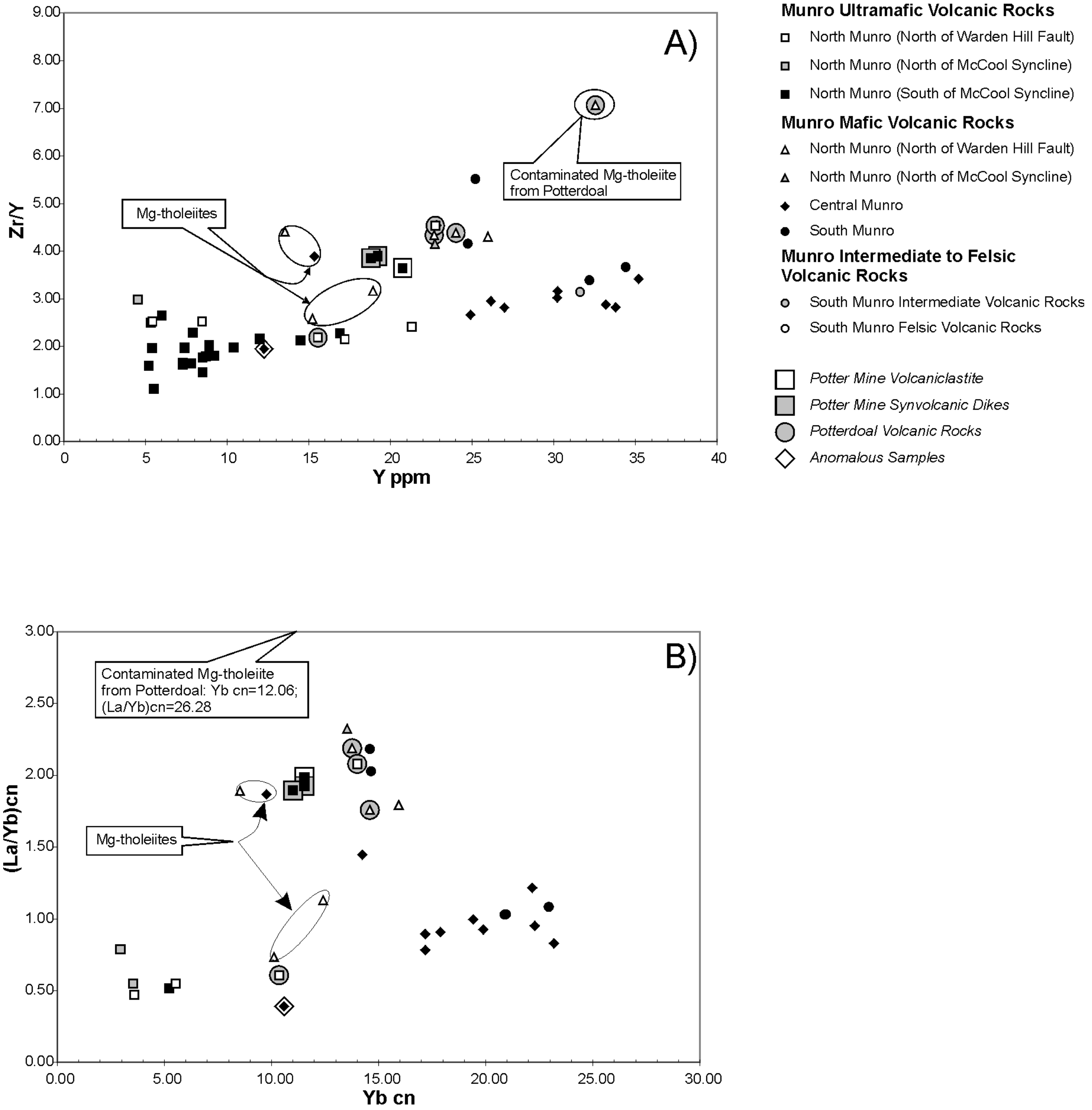


Figure 16. Trace element ratio variation diagrams for Munro Township mafic and ultramafic volcanic rocks: a) Y (ppm) versus Zr/Y; and b) chondrite-normalized Yb versus La/Yb. Chondrite-normalizing values *from* Sun and McDonough (1989).

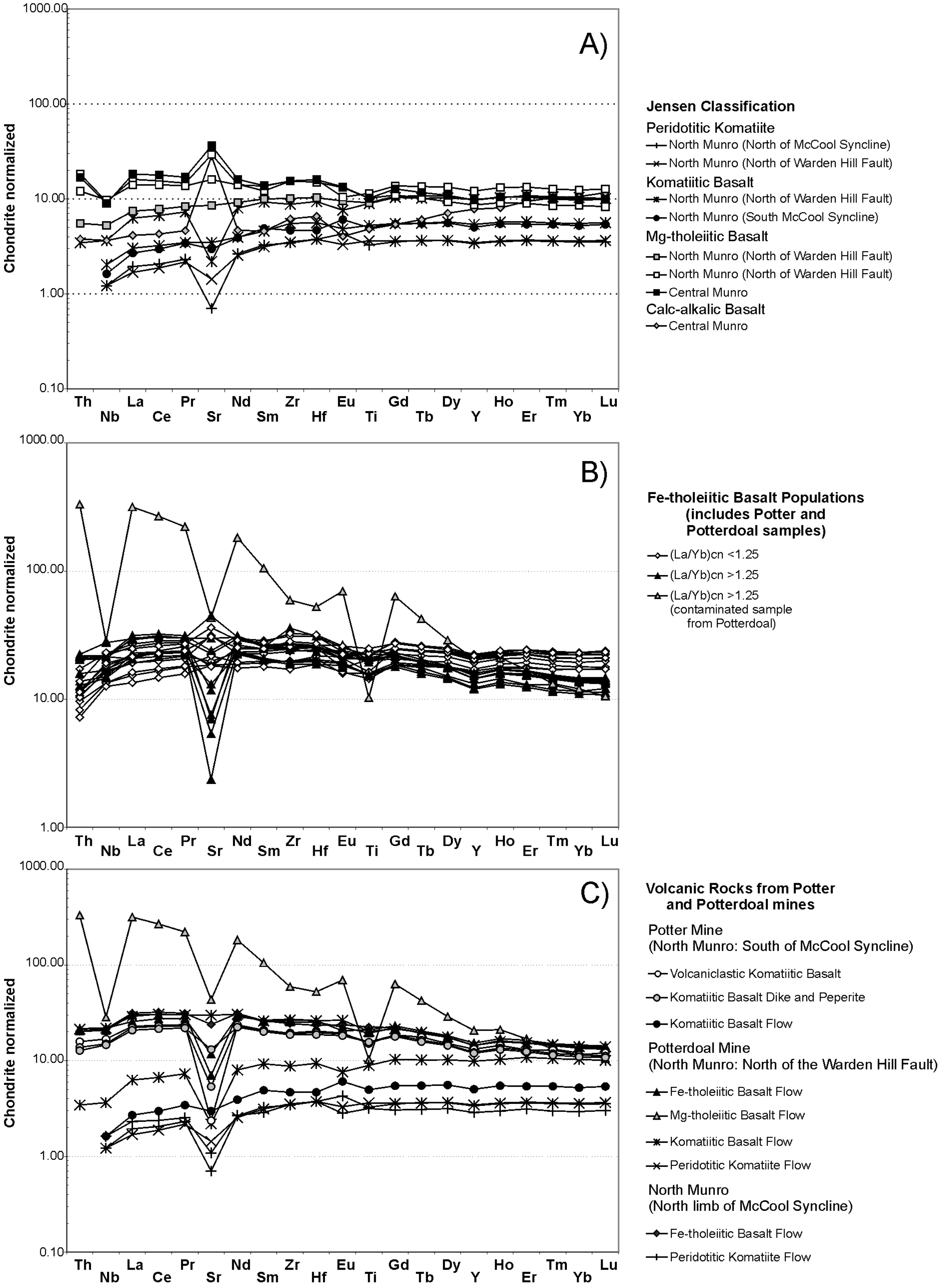


Figure 17. Chondrite-normalized trace element spider plots for mafic and ultramafic rocks of Munro Township: a) peridotitic-komatiites, komatiitic-basalts, Mg-tholeiites and "calc-alkalic" basalt; b) Fe-tholeiites; and c) mafic and ultramafic rocks from the Potter and Potterdoal mine areas and the north limb of the McCool syncline. Chondrite-normalizing values *from* Sun and McDonough (1989).

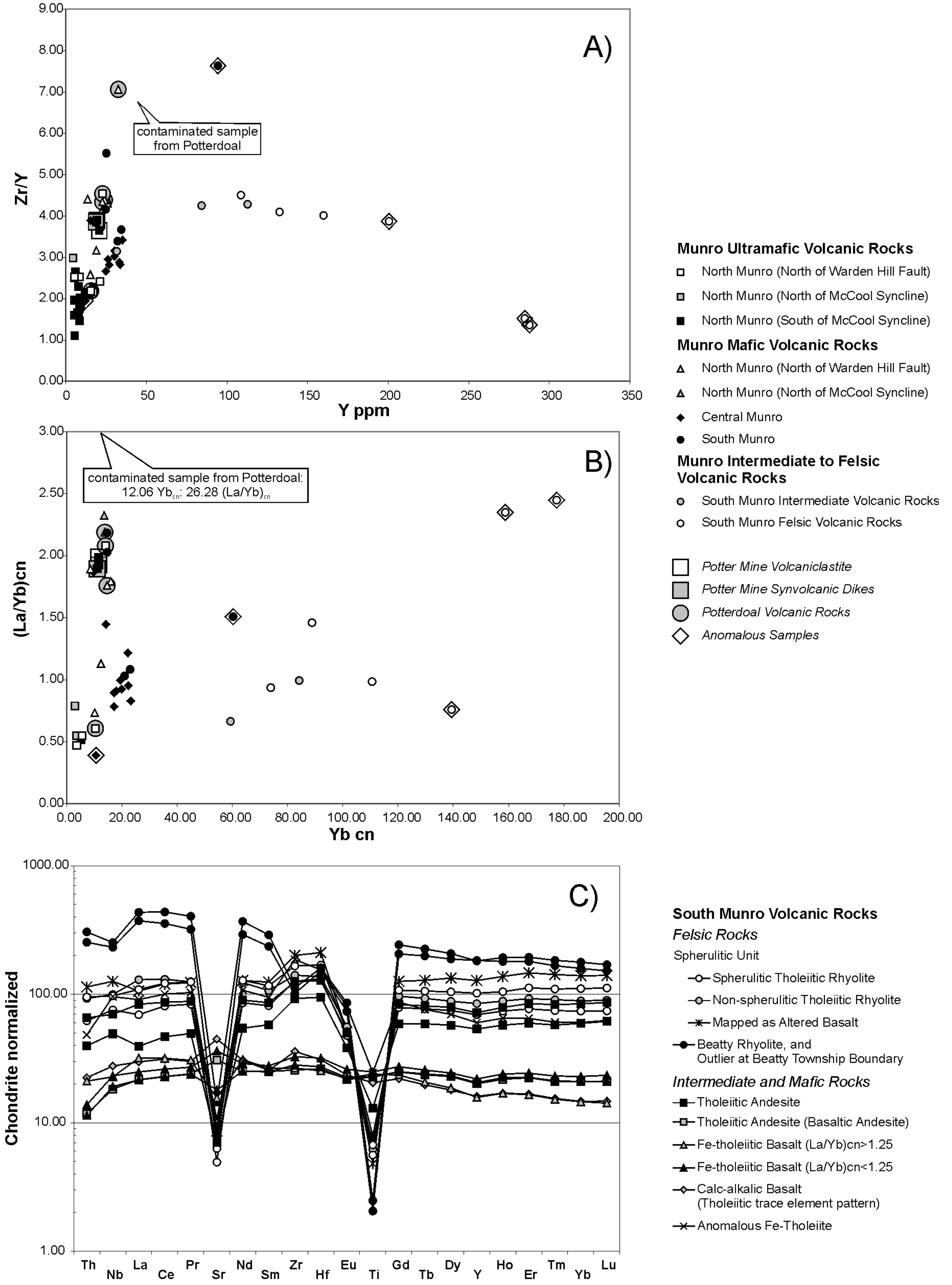


Figure 18. Trace element diagrams for Munro Township intermediate and felsic volcanic rocks: a) Y (ppm) versus Zr/Y; b) chondrite-normalized La/Yb versus Yb; and c) chondrite-normalized trace element spider diagram for the South Munro Block. Chondrite-normalizing values *from* Sun and McDonough (1989).

immobile, and negative Nb, and Ti anomalies are produced. The ultramafic samples from the 3 areas also have similar trace element patterns (*see* Figure 17c). The spinifex flow immediately above the Middle Tholeiitic Unit at the Potter Mine is slightly more evolved than the majority of the ultramafic samples, and one sample from the Potterdoal Mine area is considerably more evolved, having HREE contents equivalent to the tholeiites.

FELSIC AND INTERMEDIATE VOLCANIC ROCKS

Felsic and intermediate volcanic rocks occur only in the South Munro block (*see* Figure 4, Map P.3557). There is a silica gap in the analyses between 58 and 68% SiO_2 (*see* Figures 14b and 14c). On the $FeO_{(total)}$ versus MgO diagram (*see* Figure 14a), the intermediate rocks appear to be related to the Fe-tholeiites. On the SiO_2 versus TiO_2, MgO and Al_2O_3 diagrams (*see* Figures 14b, 14c and 15a, respectively), one of the intermediate samples plots with the Fe-tholeiites, whereas the remaining 2 intermediate samples plot with the felsic samples.

On major element diagrams (*see* Figures 13 and 14), the felsic rocks form a tight or continuous population, with the exception of the SiO_2 versus TiO_2 diagram, where the felsic rocks are more dispersed (*see* Figure 15b). However, on a Y versus Zr/Y diagram (Figure 18a), the felsic rocks form 2 distinct populations: 1) Y between 84.2 and 200.5 ppm and Zr/Y = 3.87–4.50, corresponding to the spherulitic rhyolite unit at the base of the stratigraphic sequence in the South Munro block (*see* Figure 4; Map P.3557); and 2) Y between 284.8 and 287.7 ppm and Zr/Y between 1.36 and 1.52 corresponding to the Beatty rhyolite and the rhyolite outlier north of the Beatty rhyolite at the Munro–Beatty townships boundary (*see* Figure 4; Map P.3557). On a Yb_{cn} versus $(La/Yb)_{cn}$ diagram (Figure 18b), the Zr/Y ~ 4 population (spherulitic rhyolite) has Yb_{cn} between 59 and 140, and $(La/Yb)_{cn}$ ratios of 0.66 to 1.46; the Zr/Y ~ 1.45 population (Beatty rhyolite and outlier) has Yb_{cn} between 158 and 177.4, and $(La/Yb)_{cn}$ ratios of 2.35 & 2.45. The apparently most evolved sample of the Zr/Y ~ 4 population, Y = 200.54 ppm and Yb_{cn} = 139.41, was mapped as an altered andesite; however, its high trace element contents indicate that its high SiO_2 content, 76.05 weight %, is primary. No spherulites were observed on this outcrop.

On a chondrite-normalized trace element spider plot of the South Munro block including the mafic rocks for comparison (Figure 18c), the 2 populations of felsic rocks are easily discernible. The 2 samples from the Beatty rhyolite and the outlier, $(La/Yb)_{cn}$ ratios ~ 2.4, have slight negative Nb and Zr anomalies; a feature not observed on the trace element pattern of the spherulitic rhyolite. The spherulitic rhyolites (Zr/Y ~ 4) have very similar trace element patterns to the andesites intercalated with them and to the andesites in the mafic to intermediate unit overlying them.

Both populations defined above for the Fe-tholeiites occur in the South Munro block. The tholeiitic andesite that plotted with the mafic rocks on the SiO_2 versus TiO_2, Al_2O_3 and MgO diagrams (*see* Figures 14 and 15) belongs to the low $(La/Yb)_{cn}$ population, and all the samples of that Fe-tholeiite population are from the non-magnetic basalt unit overlying the spherulitic rhyolite (*see* Figure 4; Map P.3557). The 2 mafic rock samples from the higher $(La/Yb)_{cn}$ population are from the magnetic basalt unit (calc-alkalic sample), and the ultramafic unit in the Munro fault zone (*see* Figure 4; Map P.3557). However, the trace element pattern of the "calc-alkalic" sample (Jensen AFM plot: *see* Figure 13) indicates that it is tholeiitic (*see* Figure 18c).

Based on the chondrite-normalized trace element patterns (*see* Figure 18c), the andesites and spherulitic rhyolites of the South Munro block may be petrogenetically related to the low $(La/Yb)_{cn}$ Fe-tholeiite mafic rocks. The relationship between the Beatty rhyolite and the outlier north of the Beatty rhyolite at the Munro–Beatty townships boundary and the mafic rocks of the area cannot be inferred without further work.

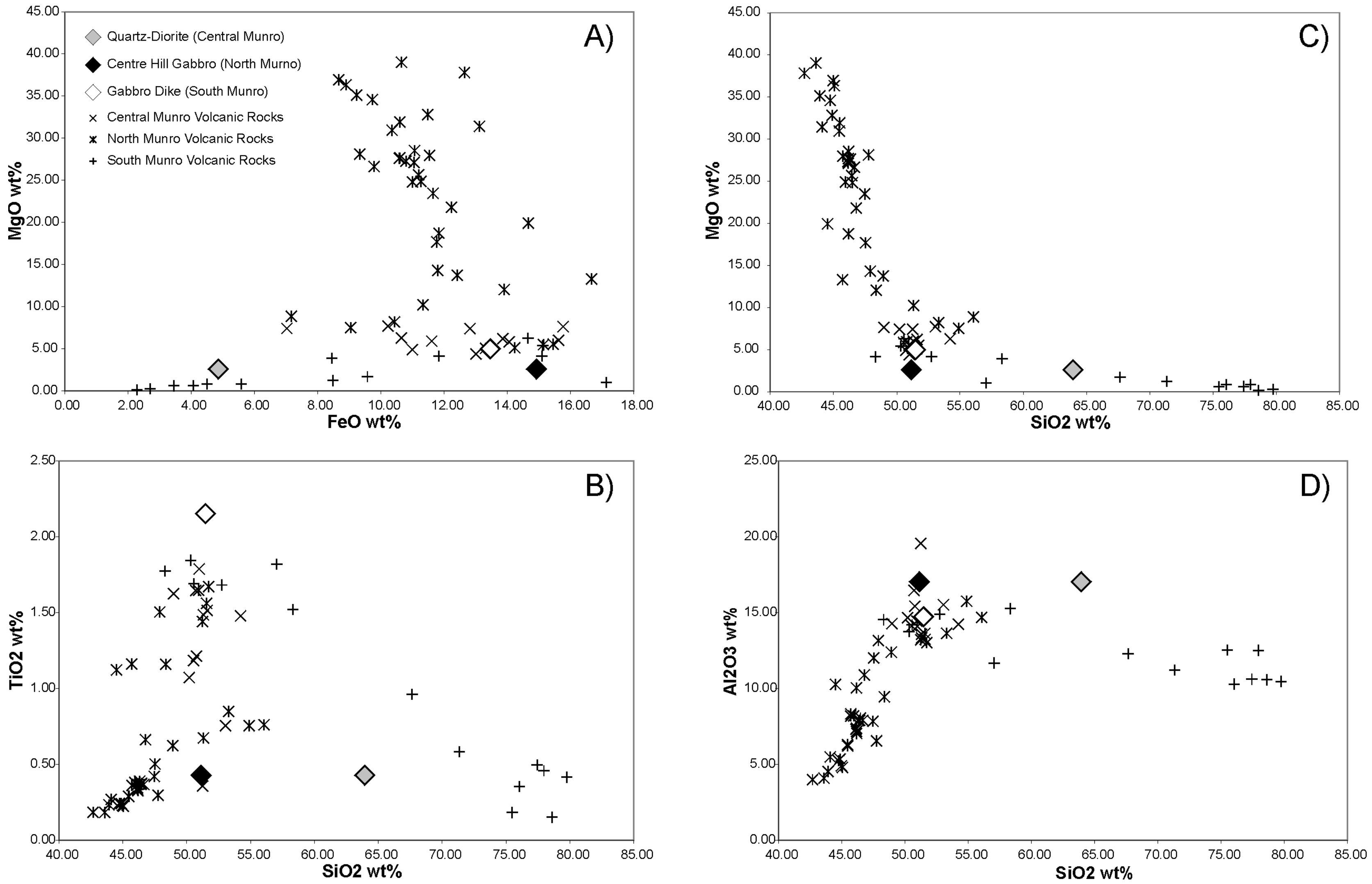


Figure 19. Major element variation diagrams for intrusive rocks of Munro Township: a) $FeO_{(total)}$ versus MgO; b) SiO_2 versus TiO_2; c) SiO_2 versus MgO; and d) SiO_2 versus Al_2O_3. Axes in weight %.

Intrusions

Only 3 samples of intrusive rocks were analyzed in the course of this study: 1) a pegmatitic gabbro from the Centre Hill Complex in the North Munro block, also sampled for geochronology (Ayer et al. 2005); 2) the intermediate composite (quartz-diorite) intrusion immediately south of the Centre Hill fault in the Central Munro block; and 3) a gabbro dike from the South Munro block. On major element variation diagrams (Figures 19a to 19d) including analyses of the volcanic rocks in Munro Township for comparison , the gabbro dike from the South Munro block has higher TiO_2 contents than the volcanic rocks (*see* Figure 19b), but otherwise has major element contents similar to the mafic volcanic rocks. The pegmatitic gabbro from the Centre Hill Complex in the North Munro block has a slightly lower MgO content than the volcanic rocks with similar MgO and SiO_2 contents (*see* Figure 19c), and a significantly lower TiO_2 content (*see* Figure 19b). The intermediate composite intrusion in the Central Munro block falls within the silica gap of the volcanic rocks of Munro Township (*see* Figure 19b); it exhibits low TiO_2 and high Al_2O_3 contents to what would be expected for similar SiO_2 contents in the volcanic rocks (*see* Figures 19b and 19d).

On a Y (ppm) versus Zr/Y diagram (Figure 20a), the Centre Hill Complex gabbro, and the intermediate composite intrusion have anomalously high Zr/Y ratios compared to the volcanic rocks, whereas the gabbro dike from the South Munro block has a Zr/Y ratio within the range of the volcanic rocks. On a Yb_{cn} versus $(La/Yb)_{cn}$ diagram (Figure 20b), the Centre Hill Complex gabbro and the gabbro dike from the South Munro block plot with the volcanic rocks of Munro Township, and the intermediate composite intrusion has a very high $(La/Yb)_{cn}$ ratio.

On a chondrite-normalized trace element spider plot (Figure 20c), the Centre Hill Complex gabbro and the gabbro dike from the South Munro block have similar patterns, with the Centre Hill Complex gabbro having a slightly steeper slope. The trace element pattern of the Centre Hill Complex gabbro is almost identical to that of the Fe-tholeiites with $(La/Yb)_{cn} > 1.25$. The intermediate composite intrusion from the Central Munro block exhibits a distinct trace element pattern. It does not resemble any of the volcanic rocks sampled in Munro Township; it is enriched in light rare earth elements (LREE) for its low heavy rare earth (HREE) content.

Summary

Volcanism in Munro Township is bimodal basalt-rhyolite, with a silica gap occurring between 58 and 68 weight % SiO_2. The volcanic rocks have tholeiitic and komatiitic chemical affinities; in the rare case where a sample fell within the calc-alkalic field of the Jensen AFM plot, the sample was determined to be altered. Felsic volcanic rocks only occur in the South Munro block; the Central Munro block is almost entirely mafic, with ultramafic rocks very rarely observed, and the North Munro block contains both mafic and ultramafic volcanic rocks.

For ultramafic to mafic volcanic rocks, 2 lines of evolution are seen in the ultramafic to mafic volcanic rocks of Munro Township. The first exhibits no Fe-enrichment with decreasing MgO, slight TiO_2 enrichment with increasing SiO_2 and higher MgO contents for a given SiO_2 value; this trend culminates in the Mg-tholeiites as designated by the Jensen AFM plot. The second trend exhibits strong Fe- and Ti-enrichment and lower MgO contents for a given SiO_2 value; this trend culminates in the Fe-tholeiites as designated by the Jensen AFM plot.

The dominant mafic rock type in this study are Fe-tholeiites. The mafic volcanic rocks sampled in the South Munro block are exclusively Fe-tholeiites, as are most of those sampled in the Central Munro block. In the North Munro block, both Fe- and Mg-tholeiites occur, and all the ultramafic samples were collected from the North Munro block.

Two populations of Fe-tholeiites are defined on the basis of trace and rare earth elements. Some basaltic komatiites are included in the populations. The first population of Fe-tholeiites is characterized

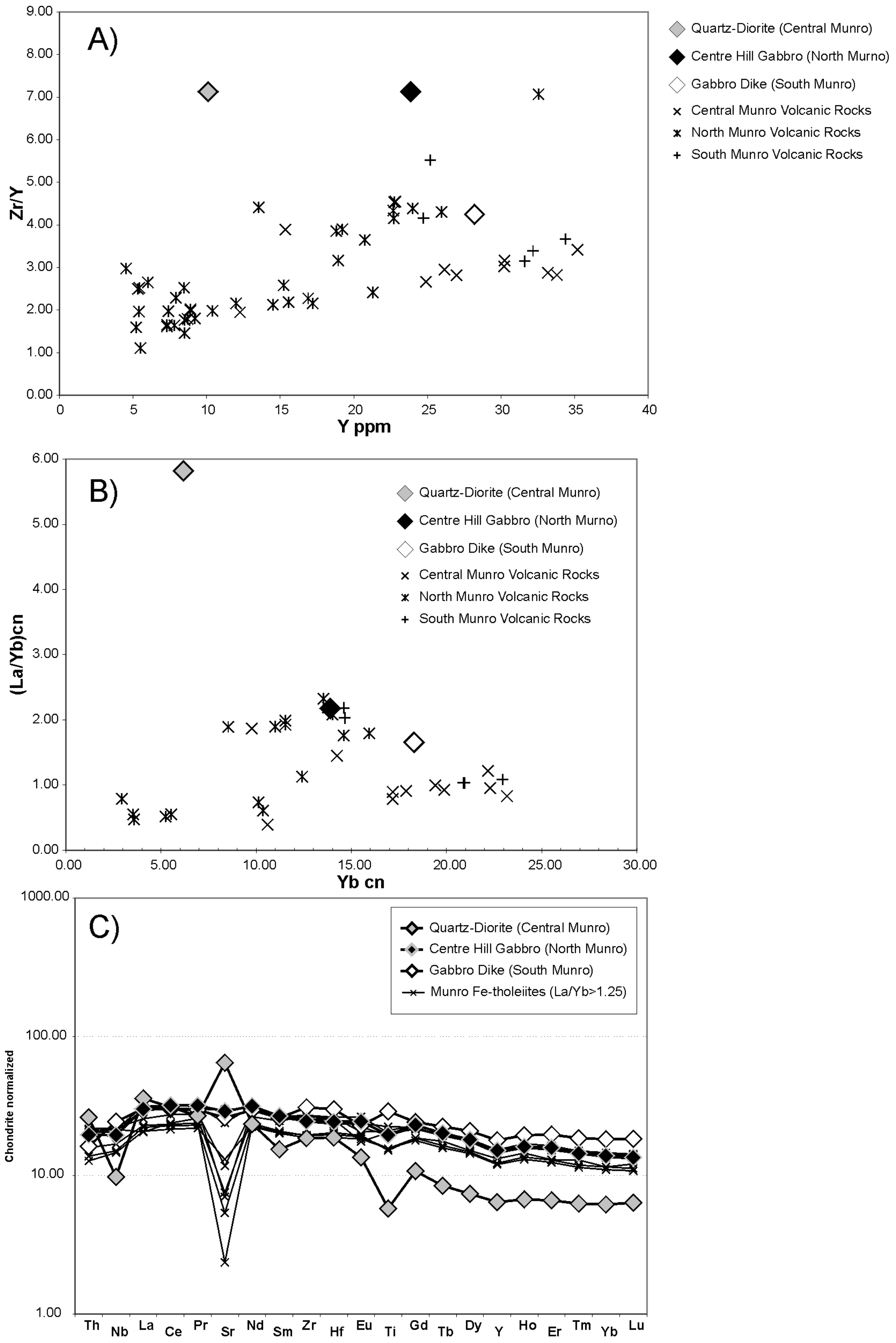


Figure 20. Trace element diagrams for Munro Township intrusive rocks: a) Y (ppm) versus Zr/Y; b) chondrite-normalized Yb versus La/Yb; c) chondrite-normalized trace element spider diagram. Chondrite-normalizing values *from* Sun and McDonough (1989).

by Zr/Y ratios of 3.65–5.52 for Y values of 18.81–25.97 ppm, with one anomalous sample having a Zr/Y ratio of 7.07 for a Y content of 32.55 ppm. This population also has high $(La/Yb)_{cn}$ ratios (1.45–2.32) for relatively low Yb_{cn} values (11.0–15.94); the anomalous sample has an extremely high $(La/Yb)_{cn}$ ratio (26.28) with an Yb_{cn} value of 12.06. The anomalous sample in considered to be the result of contamination by sediment assimilation. The second population of Fe-tholeiites is characterized by Zr/Y ratios of 2.66–3.67 for Y values of 24.9–35.2 ppm, and $(La/Yb)_{cn}$ ratios of 0.78–1.22 for Yb_{cn} values of 17.18–23.18. With the exception of a basaltic komatiite from drill core at Potterdoal mine, the samples from the Potterdoal and Potter Mine areas belong to the higher Zr/Y and $(La/Yb)_{cn}$ ratio population.

The ultramafic rocks in the North Munro block (in the Potter Mine area, on the north limb of the McCool syncline and in the Potterdoal Mine area) have similar LREE depleted trace element patterns. The Mg-tholeiites from the Jensen classification and the major element trends have very slightly positively sloped trace element patterns and small negative Nb anomalies possibly indicating some contamination. The slope of the Mg-tholeiites is similar to that of the Fe-tholeiite population with the lower Yb_{cn} value and higher $(La/Yb)_{cn}$ ratio. However, the Fe-tholeiite population lacks the negative Nb anomalies, with the exception of the sample with the anomalously high $(La/Yb)_{cn}$ ratio, which has a large negative Nb anomaly interpreted to result from the assimilation of sediments.

The stratigraphy from the Potter Mine area is repeated around the McCool Syncline axis (Coad 1976; Arndt, Naldrett and Pyke 1977; Barrie 1999; Johnstone 1987, 1991a); it has also been proposed that the stratigraphy on the north limb of the McCool syncline is repeated across the Warden Hill fault (Arndt 1975, 1977; Arndt, Naldrett and Pyke 1977; Epp 1997; Epp and Crocket 1999). The mafic samples from the mine areas belong to the higher $(La/Yb)_{cn}$ Fe-tholeiite population, and the trace element patterns between the Potter Mine, the north limb of the McCool syncline, and the Potterdoal Mine areas are similar. Although the major element chemistry of the Middle Tholeiitic Unit at the Potter Mine differs from that of the tholeiites at Potterdoal Mine and on the north limb of the McCool syncline, the trace element patterns of the Middle Tholeiitic Unit samples are similar to the Fe-tholeiites in those areas. The Potter Mine area has been subjected to a process (possibly hydrothermal alteration) that affects the major element chemistry without affecting the trace elements. The effects of contamination is seen in the anomalous sample in the Potterdoal Mine area: the middle rare earth elements (MREE) and light rare earth elements (LREE) are enriched, whereas the heavy rare earth elements (HREE) remained immobile and negative Nb, and Ti anomalies are produced. The ultramafic samples from the 3 areas also have similar trace element patterns.

The felsic volcanic rocks in the South Munro block form 2 distinct populations based on trace element chemistry; these populations correspond to textural field observations. The first population corresponds to the spherulitic rhyolite unit at the base of the stratigraphy in the block. It has Zr/Y ratios of approximately 4 for Y values between 84 and 200 ppm, $(La/Yb)_{cn}$ ratios of 0.66 to 1.46 for Yb_{cn} values between 59 and 140, positive Zr and Hf anomalies and no negative Nb anomalies. The second felsic population corresponds to the Beatty rhyolite and a rhyolite outlier north of the Beatty rhyolite at the Munro–Beatty townships boundary. It has Zr/Y ratios of approximately 1.45 for Y contents of approximately 285 ppm, $(La/Yb)_{cn}$ ratios of approximately 2.4 for Yb_{cn} values between 158 and 178, and slight negative Nb and Zr anomalies. The spherulitic rhyolites have similar trace element patterns to the andesites both intercalated with them and in the mafic to intermediate unit overlying them, and to the low $(La/Yb)_{cn}$ ratio (>1.25) Fe-tholeiite mafic rocks in the area in general.

Three samples of intrusive rocks were analyzed in the course of this study: 1) a pegmatitic gabbro from the Centre Hill Complex in the North Munro block, also sampled for geochronology (Ayer et al. 2005); 2) the intermediate composite (quartz-diorite) intrusion immediately south of the Centre Hill fault in the Central Munro block; and 3) a gabbro dike from the South Munro block. The Centre Hill Complex gabbro and the gabbro dike from the South Munro block have similar chondrite-normalized trace element patterns, the Centre Hill Complex gabbro having a slightly steeper slope. The trace element pattern for the Centre Hill Complex gabbro is almost identical to the Fe-tholeiites with $(La/Yb)_{cn}$ >1.25. The intermediate composite intrusion from the Central Munro block, however, exhibits a distinct trace element pattern, which does not resemble any of the volcanic rocks sampled in Munro Township.

Table 2. Summary of mineral properties in Munro Township and their main commodities (compiled by the Resident Geologist Office in Kirkland Lake from assessment files).

Number on Map P.3557	Deposit Name	Deposit Classification	Deposit Type	Commodity
1	Warden	Occurrence	Mafic to Ultramafic Volcanic and Intrusion Associated	**Asbestos**
2	Warden Hill Occurrence	Occurrence	Mafic to Ultramafic Volcanic and Intrusion Associated	**Asbestos**
3	Flagro	Occurrence	Mafic to Ultramafic Volcanic and Intrusion Associated	**Asbestos**
4	Ford, H.M.	Occurrence	Mafic to Ultramafic Volcanic and Intrusion Associated	**Asbestos**
5	Walhart, G.M.L.	Occurrence	Vein / Replacement Deposits	**Au**
6	Stewart, W.T.	Occurrence	Vein / Replacement Deposits	**Au**
7	Munro	Past producer without reserves	Mafic to Ultramafic Volcanic and Intrusion Associated	**Asbestos**
8	Croesus Mine	Past producer without reserves	Vein / Replacement Deposits	**Ag, Au**
9	Potterdoal Mine	Developed prospect without reserves	Volcanic Associated	**Ag, Cu, Zn,** Au, Co
10	Mangan-Dyer	Occurrence	Mafic to Ultramafic Volcanic and Intrusion Associated	**Asbestos**
11	Potter Mine/ Centre Hill Mines Ltd.	Past producer with reserves	Volcanic Associated	**Ag, Cu, Zn,** Au, Ni
12	Potter-Doal Occurrence	Occurrence	Mafic to Ultramafic Volcanic and Intrusion Associated	**Asbestos**
13	Dimmick	Occurrence	Vein / Replacement Deposits	**Au**
14	Reoplata Occurrence	Occurrence	Mafic to Ultramafic Volcanic and Intrusion Associated	**Au, U,** Asbestos
15	Munro Reo Plata	Occurrence	Mafic to Ultramafic Volcanic and Intrusion Associated	**Asbestos**
16	Strongford	Occurrence	Mafic to Ultramafic Volcanic and Intrusion Associated	**Asbestos**
17	Zevely	Occurrence	Not listed	**Au**
18	Bib Game Occurrence	Occurrence	Vein / Replacement Deposits	**Au,** Zn
19	Dyman-1	Prospect	Unknown Hard Rock Deposit Type	**Cu, Co**
20	Lalonde	Prospect	Unknown Hard Rock Deposit Type	**Au,** Ag, As, Cu, Pb, Zn
21	McChristie Trench 1	Occurrence	Not listed	**Au, Cu, Zn**
22	McChristie Trench 3	Occurrence	Not listed	**Cu**
23	Panterra	Occurrence	Not listed	**Cu, Ni, Zn,** Co
24	Brown-Munro	Prospect	Vein / Replacement Deposits	**Au**
25	White-Guyatt	Prospect	Vein / Replacement Deposits	**Au,** Pb, Zn
26	Colossus	Occurrence	Vein / Replacement Deposits	**Au,** Pb, Zn
27	Buff Munro Mine	Occurrence	Vein / Replacement Deposits	**Au,** Asbestos, Pb, Zn
28	Northern Goldbelt	Occurrence	Vein / Replacement Deposits	**Ag, Au,** Cu, Pb, Zn
29	Mickle	Occurrence	Mafic to Ultramafic Volcanic and Intrusion Associated	**Ni,** Pd, Pt
30	American Eagle Mine	Past producer without reserves	Vein / Replacement Deposits	**Au**

Ag = silver; As = arsenic; Au = gold; Co = cobalt; Cu = copper; Ni = nickel; Pb = lead; Pd = palladium; Pt = platinum; U = uranium; Zn = zinc.
Bold type indicates principal commodity.

ECONOMIC GEOLOGY

Introduction

Several commodities, such as precious metals (gold, silver), base metals (copper, zinc, nickel) and industrial minerals (asbestos) have been the focus for mineral exploration in Munro Township over the past 100 years. Gold has been the most prominent of these commodities, followed by asbestos and volcanogenic base metals. Table 2 lists the most significant mineral occurrences in Munro Township (from Ontario Geological Survey 2004a: Mineral Deposit Inventory V2 (MDI2)); their locations are shown on Figure 4 and Map P.3557.

Base Metal and Nickel Mineralization

The base metal showings in Munro Township are dominated by volcanogenic massive sulphide mineralization, but nickel mineralization is also observed. Base metal and nickel mineralization occur along 2 separate horizons in Munro Township (Davis 1997). The Potter and Potterdoal deposits (Cu-Zn-Ag) are associated with basaltic volcaniclastic rocks located in the North Munro block, whereas the Mickle occurrence (Ni-Cu-(PGE)) is associated with komatiitic units near the Munro–Beatty townships boundary in the South Munro block.

VOLCANOGENIC MASSIVE SULPHIDE DEPOSITS

Potter Mine (Centre Hill Mine)

The former Potter Mine (477 572 t @ 1.67% Cu produced 1967–1972; Gamble 2000) is located in the North Munro block. The base metal mineralization at the Potter Mine is hosted by the basaltic volcaniclastic rocks of the Middle Tholeiitic Unit. Mineralization has been encountered during recent deep drill programs below the 8th level (1100 feet) within the same volcaniclastic unit (Gamble 2000).

Massive, semi-massive and disseminated sulphide mineralization at the former Potter mine is entirely hosted within the well-bedded lapillistone facies that is interpreted to have accumulated within a primary graben. Gamble and Gibson (2000a, 2000b), Gamble (2000) and Gibson and Gamble (2000) recognized 2 types of base metal sulphide mineralization: subseafloor replacement and seafloor sulphide. In both types, the predominant sulphide mineral is pyrrhotite with lesser sphalerite and chalcopyrite.

Subseafloor sulphide consists of disseminated and semi-massive sulphide (10–80% sulphides) within the matrix of lapillistone units. Mineralization ranges from disseminated sulphide, often replacing earlier carbonate cement, to semi-massive sulphide where black, chloritized, wispy basaltic shards occur within a massive sulphide matrix. The lapillistone is interpreted to have acted as a trap for sulphide mineralization. The semi-massive sulphide lenses are interpreted to have grown below the seafloor by the precipitation of sulphides within the permeable lapillistone matrix, by replacement of the matrix and, to some extent, the lapilli.

Seafloor sulphide consists of massive sulphide lenses that are devoid of lapilli and range from a few decimetres to metres thick. The sulphide lenses are commonly associated with argillaceous or carbonaceous mudstone beds and are interpreted to have formed by exhalative activity on the seafloor during hiatuses in volcaniclastic deposition. Alternatively, the massive sulphide lenses may have formed below and within argillaceous mudstones that acted as an aquiclude (confining bed or cap rock). The semi-massive replacement sulphides, and the massive sulphide lenses, are enveloped by semi-conformable black chlorite alteration that is characterized by depletion in SiO_2, Na_2O and CaO, and enrichment in MgO and Fe_2O_3 and base metals (Gibson and Gamble 2000; Tardif et al. 2000).

Potterdoal Mine

The Potterdoal Mine was an active producer for a brief period from 1928 to 1930 (data from Sutherland et al. (1928, p.88-89) and Department of Energy, Mines and Resources 1974 as cited in Epp 1997). The initial 28 ton bulk sample from the deposit returned grades of 15.22% Cu, 4.15% Zn, 2.70 ounces Ag per ton and 0.045 ounces Au per ton. During the mining phase, 2577 short tons of high grade ore were extracted grading approximately 11% Cu. The mineralization at the Potterdoal Mine is interpreted to be the time-stratigraphic equivalent of that at the Potter Mine, occurring on the structural repetition of the north limb of the McCool syncline by the Warden Hill fault (Coad 1976; Arndt, Naldrett and Pyke 1977; Epp 1997). The stratigraphic similarity of the 2 areas, lithological and geochemical, has been shown above. The stratigraphy in the Potterdoal area has been truncated by the emplacement of the Warden–Munro complex. Thus, the Lower Komatiitic Unit recognized at the Potter Mine does not occur at the Potterdoal Mine. However, there are equivalents to the Potter Mine Middle Tholeiitic Unit (Theo’s flow and the Ore flow) and Upper Komatiitic Unit (Fred’s flow).

The mineralization in the Potterdoal area occurs as a massive sulphide lens and underlying stockwork (Epp 1997; Epp and Crocket 1999). The massive sulphide lens is spatially related to a volcaniclastic breccia within the sedimentary-tuffaceous unit at the contact between the mafic and ultramafic flows (*see* Figure 10). The breccia is interpreted by Epp (1997), and Epp and Crocket (1999) as tectonic, filling a paleotopographic low (fault scarp). Locally, the ore lens has been deformed by the Buster fault (Epp 1997; Epp and Crocket 1999). It is notable that along strike from the “tectonic” breccia, mafic volcaniclastic deposits, similar to the pyroclastic rocks at Potter Mine, occur (Epp 1997; Epp and Crocket 1999), and that “Potter-type” pyroclastic rocks are recognized in drill core from the Potterdoal area. The stockwork mineralization occurs in fault breccias and joints below the massive ore lens and exhibits strong chlorite alteration (Epp 1997; Epp and Crocket 1999).

The stratigraphic framework proposed here for the North Munro block, based on previous works (Satterly 1952a, 1952b; Coad 1976; Johnstone 1987, 1991a, 1991b; Epp 1997; Epp and Crocket 1999; Gamble and Gibson 2000a; Gamble 2000; Gibson and Gamble 2000), new geophysical surveys (Ontario Geological Survey 2003) and new field observations by the authors, confirms the structural repetition of the stratigraphic contact favourable for VMS exploration. This tholeiitic–komatiitic contact, where 2 former VMS deposits and several Cu-Zn showings occur, is repeated in 3 areas: 1) the contact between the Middle Tholeiitic Unit (Potter Mine) and the Upper Komatiitic Unit (Lava Lake–Pyke Hill) north of the Centre Hill fault, 2) the contact between the tholeiitic Theo’s flow and the komatiitic Fred’s flow south of the Warden fault, and 3) the contact between the tholeiitic Ore and Theo’s flows and the komatiitic Fred’s flow north of the Warden fault.

NICKEL-COPPER-(PLATINUM GROUP ELEMENT) MINERALIZATION

Magmatic sulphide deposits and mafic to ultramafic rocks (extrusive or intrusive) are by far the most common association for nickel-copper-(platinum group element) (PGE) deposits. The high proportion of mafic and ultramafic rocks in Munro Township infers real potential for nickel, copper and platinum-group element deposits in the area.

Nickel mineralization is rare in Munro Township: the Mickle occurrence being the best-known in the area. It consists of blebby, disseminated, net-textured (matrix sulphides in olivine cumulate or in spinifex texture), and massive sulphides (Allen 1986; Satterly 1952b). These sulphide textures are typically associated with the Kambalda style (or Alexo type) found in komatiite-associated deposits. The sulphide mineralization is concentrated in a broad depression approximately 200 m across, which is interpreted by Davis et al. (1993) as a thermal erosion channel, along the contact between the komatiitic unit and the fragmental andesitic flows. Davis (1997) suggested that the mineralization occurs at or near the contact of the lowest and most magnesian komatiitic peridotite and the underlying volcanic rocks, whereas Allen (1986) proposed that the mineralization occurs between a peridotitic komatiite and a pyroxenitic komatiite. This discrepancy could reflect lateral and vertical variations in the sulphide mineralization enhance by the fact that the mineralization occurs in small discontinuous pods over 200 m along the contact. The Mickle occurrence ore is composed mainly of pyrrhotite and minor pentlandite, chalcopyrite, violarite, chromite and magnetite. The mineralization grades around 1% Ni and up to 2.4 g/t Pt+Pd (Allen 1986). Furthermore, some massive sulphide veins that extend into the footwall are more nickel rich and grade between 4.5% and 6% Ni (Davis 1997).

Komatiite-associated Ni-Cu-(PGE) deposits usually occur in clusters, as is demonstrated by examples in the Abitibi greenstone belt (e.g., Shaw Dome area: Redstone Mine, Hart deposit, McWatters deposits, Langmuir #1 and #2) and in Western Australia (*see also* Ayer et al. 2005). Clearly, there is significant potential for the discovery of additional occurrences in areas where only one significant occurrence has been discovered, such as in Munro Township. Certainly more work needs to be done to establish the mineral potential for this type of deposit, but the presence of the Mickle occurrence, irregularities within the basal contacts of the ultramafic units and the local presence of olivine-rich peridotite along this contact make the ultramafic volcanic rocks in the South Munro block a prospective area for exploration for magmatic nickel-sulphide mineralization. Furthermore, the new volcanological interpretation of the Upper Komatiitic Unit at the Potter Mine (Houlé et al. 2002), combined with reported sulphides by Coad (1976) associated with the komatiitic flows, indicate this to be another prospective area.

Certain features of the mafic to ultramafic intrusions (Munro sill, Munro Lake sill, Munro–Warden complex, Centre Hill Complex), such as pegmatitic phases and inclusions of pyrite-rich sedimentary rocks in the gabbros (Johnstone 1991a, 1991b), indicate potential for platinum group element mineralization. However, significant mineralization associated with the pegmatitic phases, and sulphur-rich inclusions which could contain PGE, have not been observed within these mafic to ultramafic bodies. “Reef”-style mineralization is also found in mafic to ultramafic intrusions; this style of mineralization typically occurs in well-differentiated ultramafic bodies near the boundary between the ultramafic and mafic zones where the plagioclase started to crystallize. Recently, grades of up to 342 ppb Pt+Pd were reported by Vaillancourt et al. (2003) for the ultramafic–mafic boundary of the Centre Hill Complex. Stone et al. (1996) also reported anomalous PGE values (up to 338 ppb Ir+Pt+Pd) from near the vesicle-rich upper chill margin of Fred’s flow.

Furthermore, Vaillancourt et al. (2003) suggested that some of the mafic to ultramafic tholeiitic intrusions in Munro Township have moderate to good potential to host “reef”-style PGE mineralization based on high PGE abundances in sulphide undersaturated and sulphide saturated rocks, implying that PGE have not been lost from their magma by segregation of a sulphide phase.

Asbestos Mineralization

Several occurrences of asbestos are found in Munro Township, including the former Munro Mine. At the Munro Mine, the asbestos (chrysotile) ore bodies occurred in the basal dunite or peridotite of the differentiated mafic to ultramafic Munro sill (Kretschmar and Kretschmar 1986). The Munro sill strikes east-southeast and extends for more than 6 km along strike.

In the past decades, health and liability concerns have seen replacements for asbestos in most of its applications. The decline in the asbestos market has discouraged any exploration for this commodity.

However, in a favourable market for industrial minerals such as asbestos or serpentine mine residue (magnesium extraction), the high proportion of intrusive and extrusive ultramafic rocks, the amount serpentine mine residues and the numerous occurrences of asbestos in the area make Munro Township a prospective area for exploration for these industrial minerals.

Precious Metal Mineralization

There are 2 past-producing gold mines and 13 gold showings in Munro Township. The gold mineralization is vein or replacement type (*see* Table 2). The majority of the gold mineralization occurs in the Kidd–Munro assemblage of the South Munro block (6 of the 13 showings and one mine) and in the Porcupine assemblage sediments (2 of the 13 showings and one mine). Three showings occur in the Central Munro block, and 2 in the North Munro block.

Major faults occur in the areas of the 2 gold mines, the Croesus and the American Eagle (Satterly 1952a). The American Eagle Mine is located on the Contact fault between the Porcupine assemblage sediments and the Kidd–Munro assemblage. The Croesus Mine is located within the Kidd–Munro assemblage, but 2 major faults were recognized in the mine: the Croesus fault comprising 2 parallel faults striking 094° and dipping 86° south; and the assumed Wood fault striking 050° to 060° (Satterly 1952a). The ore in the Croesus vein was interpreted to occur in a “wedge” between the 2 faults (Satterly 1952a).

The gold mineralization potential in Munro Township is inferred from the presence of past-producing mines in the South Munro block. Both mines are vein or replacement deposits spatially related to faults. In the case of the American Eagle Mine, the Contact fault between the Kidd–Munro and Porcupine assemblages hosts the deposit, and is interpreted to be a splay off the Porcupine–Destor fault (Epp 1997), one of the most prolific structures in the Abitibi. The relationship of subsidiary faults in the area to the Contact fault should be investigated.

DISCUSSION AND CONCLUSION

The volcanic rocks of Munro Township belong to the upper mafic to ultramafic tholeiitic to komatiitic metavolcanic suite of the Kidd–Munro assemblage (Ayer, Berger and Trowell 1999; 2714.6±2 Ma: Corfu et al. 1989). Subaqueous tholeiitic basalt flows are the most abundant rock type in the study area, comprising approximately 55% of the map area and 68% of the volcanic rocks. Ultramafic flows are the second most abundant rock type in Munro Township, comprising 24% of the map area and 29% of the volcanic rocks. Felsic and intermediate volcanic rocks are rare, occur only in the South Munro block, and are of tholeiitic affinity.

The rhyolites form 3 units in the South Munro block: 1) a spherulitic unit, interlayered with spherulitic mafic flows, at the base of the Kidd–Munro stratigraphy in faulted contact with the Porcupine assemblage sediments, 2) the Beatty rhyolite, near the top of the mafic units, and 3) a single outcrop outlier north of the Beatty rhyolite at the Munro–Beatty townships boundary. All the rhyolites are of tholeiitic affinity, and exhibit massive and lobe-and-breccia flow facies; however, some of the spherulitic rhyolite units have been interpreted as pyroclastic in origin (A.D. Fowler, University of Ottawa, personal communication, 2004). The spherulitic rhyolites have low $(La/Yb)_{cn}$ ratios (0.66–1.46), high Zr/Y ratios (approximately 4), no negative Nb anomaly, and positive Zr and Hf anomalies. The Beatty rhyolite and the outlier to the north have higher $(La/Yb)_{cn}$ ratios (approximately 2.4), lower Zr/Y ratios (approximately

1.45), and slight negative Nb and Zr anomalies. The trace element patterns of the spherulitic rhyolites resemble those of the mafic to intermediate rocks of the area; whereas the Beatty rhyolite and the outlier have steeper patterns with negative Nb and Zr anomalies. The andesites in the South Munro block are intercalated with the spherulitic rhyolites and the overlying mafic unit, are also of tholeiitic affinity and have trace element patterns similar to the rhyolites and the low $(La/Yb)_{cn}$ basalts.

The mafic volcanic rocks in the South and Central Munro blocks are similar, in flow morphologies and geochemistry. All samples from the South Munro block are Fe-tholeiites. Only 1 sample from the Central Munro block is an Mg-tholeiite; Fe-tholeiites are dominant. The Kidd–Munro assemblage Fe-tholeiites sampled throughout Munro Township in this study form 2 populations characterized by 1) high Zr/Y and $(La/Yb)_{cn}$ ratios (3.65–5.52 and 1.45–2.32, respectively) with low Y and Yb_{cn} values (18.81–25.97 ppm and 11.0–15.94, respectively), and 2) low Zr/Y and $(La/Yb)_{cn}$ ratios (2.66–3.67 and 0.78–1.22, respectively) with high Y and Yb_{cn} values (24.9–35.2 ppm and 17.18–23.18, respectively). In the South Munro block, both populations occur. Of the Fe-tholeiites in the Central Munro block, only one sample belongs to the high Zr/Y ratio population; all other samples belonged to the low Zr/Y ratio population. The sole Mg-tholeiite in the Central Munro block has a slightly positively sloped trace element pattern ($(La/Yb)_{cn}$ = 1.87) and a small negative Nb anomaly indicating possible contamination.

The difference between the South and Central Munro blocks lies in the presence of rhyolites and andesites in the former. As the displacement along the Munro fault and the folding in the area appear to be of limited extent, it is possible that the South and Central Munro blocks form a continuous stratigraphic package, consisting of a lower tholeiitic unit comprised of interlayered Fe-tholeiitic basalts, tholeiitic andesites and tholeiitic rhyolites topped by the First Komatiitic Lava Succession of Johnstone (1991a) (South Munro block), and an upper tholeiitic unit dominated by Fe-tholeiitic basalts (Central Munro block). The magnetic basalt occurring south of the Munro sill in the South Munro block may be due to changes in the mafic magmatism before the onset of ultramafic volcanism, or an expression of subsurface phenomenon related to the Munro sill itself. The Deadman Hill komatiites may be the manifestation of the diminishing ultramafic volcanism of the First Komatiitic Lava Succession. The magnetic basalt delineated along the synclinal axis in the Central Munro block may indicate that ultramafic volcanism was imminent in the succession. The appearance of small ultramafic volcanic units near the synclinal axis suggests that this may be the case. However, the relationship between the axial ultramafic units of the Central Munro block and the Second Komatiitic Lava Succession of Johnstone (1991a) in the North Munro block is unknown.

The Centre Hill fault between the Central and North Munro blocks constitutes a major stratigraphic break. In the North Munro block, ultramafic volcanic rocks comprise 38% of the map area; mafic volcanic rocks 25%; and ultramafic to mafic intrusions (excluding the Proterozoic diabases) 32%. The stratigraphy is interpreted to be repeated three times within the block by folding (the McCool syncline) and faulting (the Warden Hill fault). The Potter and Potterdoal mines are located in the North Munro block: the Potter Mine on the south limb of the McCool syncline and the Potterdoal in the Warden Hill fault repetition of the north limb of the syncline.

In all 3 structurally repeated sections, the base of the stratigraphic sequence is truncated by intrusions. The Centre Hill Complex truncates the sequence on the south limb of the McCool syncline; the Munro Lake sill truncates it on the north limb, and the Munro–Warden complex truncates the sequence repeated by the Warden Hill fault. The most complete stratigraphic section is defined at the Potter Mine on the south limb of the McCool syncline. There, the komatiitic–tholeiitic volcanic succession in contact with the Centre Hill Complex is divisible into 3 lithostratigraphic and chemostratigraphic units: 1) a Lower Komatiitic Unit, 2) a Middle Tholeiitic Unit; and 3) an Upper Komatiitic Unit (*see* Figure 9; Gamble 2000). The mineralization at the Potter Mine is hosted in the Middle Tholeiitic Unit (Gamble and Gibson 2000a; Gamble 2000; Gibson and Gamble 2000; Tardif et al. 2000), which consists of basaltic volcaniclastic rocks, intact and autobrecciated sills (dikes) of massive quench-textured basalt, thin discontinuous deposits of argillaceous and carbonaceous sedimentary rocks, chert, massive sulphide and lesser komatiitic flows. Specifically, the massive, semi-massive and disseminated sulphide mineralization is hosted within the well-bedded lapillistone facies of the basaltic volcaniclastic rocks; this facies is interpreted to have accumulated within a primary graben.

The magnetic signatures of the stratigraphic succession at the Potter Mine can be traced around the closure of the McCool syncline in McCool Township to the east. North of the Potter Mine on the north limb of the syncline, the flows crop out, and the succession observed is a mafic unit, overlain by an ultramafic unit. The units are massive, thick and coarse grained, and exhibit no internal structure. They were recognized as flows rather than intrusions based on the presence of flow-top breccias (Arndt 1975). These flows, the lateral extensions of the Potter Mine stratigraphy around the McCool syncline, were interpreted by Arndt (1975, 1977) and Arndt, Naldrett and Pyke (1977) to be Theo's and Fred's flows, first recognized in the Potterdoal Mine area. Thus, the north limb of the McCool syncline is interpreted to be repeated across the Warden Hill fault.

At the Potterdoal Mine, on the north limb of the McCool syncline repeated by the Warden Hill fault, the volcanic succession is divided into 2 units that are structurally repeated by the Buster fault. The Lower Komatiitic Unit recognized at the Potter Mine does not crop out at the Potterdoal Mine area. The lowest unit in this area consists of thick layered tholeiitic flows: Theo's flow (Arndt 1975, 1977) and the Ore flow (Epp 1997; Epp and Crocket 1999). The upper unit is a thick layered komatiitic flow: Fred's flow (Arndt 1975, 1977). Theo's flow and the Ore flow are interpreted to be at the same stratigraphic level, with the present superposition of the Ore flow relative to Theo's flow being the result of movement along the Buster fault (Epp 1997; Epp and Crocket 1999). The mineralization at Potterdoal occurs in a constrained breccia unit within a more extensive sedimentary and volcaniclastic unit deposited between the Ore flow and Fred's flow south of the Buster fault. The breccia contains fragments of the underlying flow and was interpreted (Epp 1997; Epp and Crocket 1999) to be tectonic in origin, forming in a scarp depression. It is notable that along strike from the "tectonic" breccia, mafic volcaniclastic deposits, similar to the pyroclastic rocks at Potter Mine, occur (Epp 1997; Epp and Crocket 1999), and that "Potter-type" pyroclastic rocks are recognized in drill core from the Potterdoal area.

Komatiites (both peridotitic and basaltic), Mg-tholeiites and Fe-tholeiites were sampled from the North Munro block. The ultramafic lavas, in general, form a coherent population or trend on the major element diagrams and have LREE-depleted trace element patterns with no discernible anomalies. The samples taken from Potter Mine are the exception to the consistency in the ultramafic rocks. The Middle Tholeiitic Unit samples from Potter Mine fall in the komatiitic basalt field of the Jensen AFM diagram, but exhibit trace and rare earth element ratios, and chondrite-normalized trace element patterns similar to the high Zr/Y ratio Fe-tholeiite population and are considered to be tholeiitic. There were only 2 Mg-tholeiite samples taken in the North Munro block, so no population or trend was formed on variation diagrams. On a chondrite-normalized trace element plot, the Mg-tholeiites exhibited slightly negative- to slightly positive-sloped patterns, with no to slightly negative Nb anomalies. All the Fe-tholeiites of the North Munro block belong to the higher Zr/Y ratio population. At the Potter and Potterdoal mines, the samples belong to the higher Zr/Y ratio population of the Fe-tholeiites, with one exception. A basaltic komatiite from drill core at Potterdoal Mine has extremely high Zr/Y and $(La/Yb)_{cn}$ ratios (7.07 and 26.28, respectively), and large negative Nb and Ti anomalies; these characteristics are considered to result from contamination by sediment assimilation. Sediment assimilation is observed in the Middle Tholeiitic Unit at Potter Mine.

The Potter and Potterdoal mines are interpreted to be time-stratigraphic equivalents (Coad 1976; Arndt, Naldrett and Pyke 1977; Epp 1997; Epp and Crocket 1999; Johnstone 1987, 1991a). The lithostratigraphic and chemical similarities between the units at the 2 sites support this hypothesis. Interestingly, in both cases, the massive sulphides are related to volcaniclastic rocks interpreted to have accumulated in paleotopographic lows: the "primary graben" at Potter Mine (Gamble and Gibson 2000a;

Gamble 2000; Gibson and Gamble 2000), and the “fault escarpment” at Potterdoal Mine (Epp 1997; Epp and Crocket 1999). The interpretation of the volcaniclastic tholeiitic unit at Potter Mine as a pyroclastic, rather than hyaloclastite or flow breccia, is recent (Gamble and Gibson 2000a; Gamble 2000; Gibson and Gamble 2000). The volcaniclastic and sedimentary unit at the Potterdoal Mine is being re-examined. Volcaniclastic, breccia and sedimentary interflow units occur at the mafic–ultramafic contact along strike from the Potterdoal Mine and between Theo’s and Fred’s flow on the north limb of the McCool syncline, south of the Warden Hill fault. These fragmental units should be re-examined in light of the new “pyroclastic” interpretation for the fragmental rocks at Potter Mine, and of the relationship between paleotopographic lows and the sulphide mineralization at both the Potter and Potterdoal mines.

Munro Township exhibits potential for volcanogenic massive sulphide, magmatic nickel and vein or replacement gold mineralization. The stratigraphic contact between tholeiitic and komatiitic units in the North Munro block is known to be favourable to volcanogenic massive sulphide deposits and is structurally repeated there: 1) at the Potter Mine, north of the Centre Hill fault, 2) on the north limb of the McCool syncline, south of the Warden Hill fault; and 3) at the Potterdoal Mine, north of the Warden Hill fault. This contact crops out in the north-central part of the township and based on geophysical interpretation, extends under the overburden along strike to the east.

One significant magmatic nickel showing occurs in Munro Township (the Mickle occurrence) at or near a komatiite flow contact south of the Munro fault zone in the First Komatiite Lava Succession. Considering the abundance of komatiitic flows and ultramafic intrusions in Munro Township and the fact that komatiite-associated Ni-Cu-(PGE) deposits usually occur in clusters, there is potential for other deposits to have formed in the area. The report of sulphides in the Upper Komatiitic Unit at the Potter Mine (Coad 1976) coupled with the new volcanological interpretation of that unit (Houlé et al. 2002) indicate potential for magmatic nickel mineralization in that sector.

Although platinum group element mineralization has not been observed within the mafic to ultramafic intrusions of Munro Township (Munro sill, Munro Lake sill, Munro–Warden complex, Centre Hill Complex), certain features, such as pegmatitic phases and inclusions of pyrite-rich sedimentary rocks in the gabbros (Johnstone 1991a), indicate their potential. The ultramafic–mafic boundary of the Centre Hill Complex (Vaillancourt et al. 2003) and the vesicle-rich upper chill margin of Fred’s flow (Stone et al. 1996) returned anomalous PGE values. High PGE abundances in sulphide undersaturated and sulphide saturated rocks in Munro Township imply that PGEs have not been lost from their magma by segregation of a sulphide phase and may have moderate to good potential to host “reef”-style PGE mineralization (Vaillancourt et al. 2003).

Asbestos is presently in disfavour. However, serpentine mine residue for magnesium extraction is abundant in Munro Township and, should the market for asbestos turn around, the high proportion of intrusive and extrusive ultramafic rocks, and the numerous asbestos occurrences in the area make Munro Township a prospective area for exploration.

The gold mineralization potential in Munro Township is inferred from the presence of past-producing mines in the South Munro block as well as several showings. All of the mineralization is vein/replacement, and the 2 mines are spatially related to faults. In the case of the American Eagle Mine, the Contact fault between the Kidd–Munro and Porcupine assemblages hosts the deposit, and is interpreted to be a splay off the Porcupine–Destor fault (Epp 1997), one of the most prolific structures in the Abitibi Subprovince. The relationship of subsidiary faults in the area to the Contact fault should be investigated.

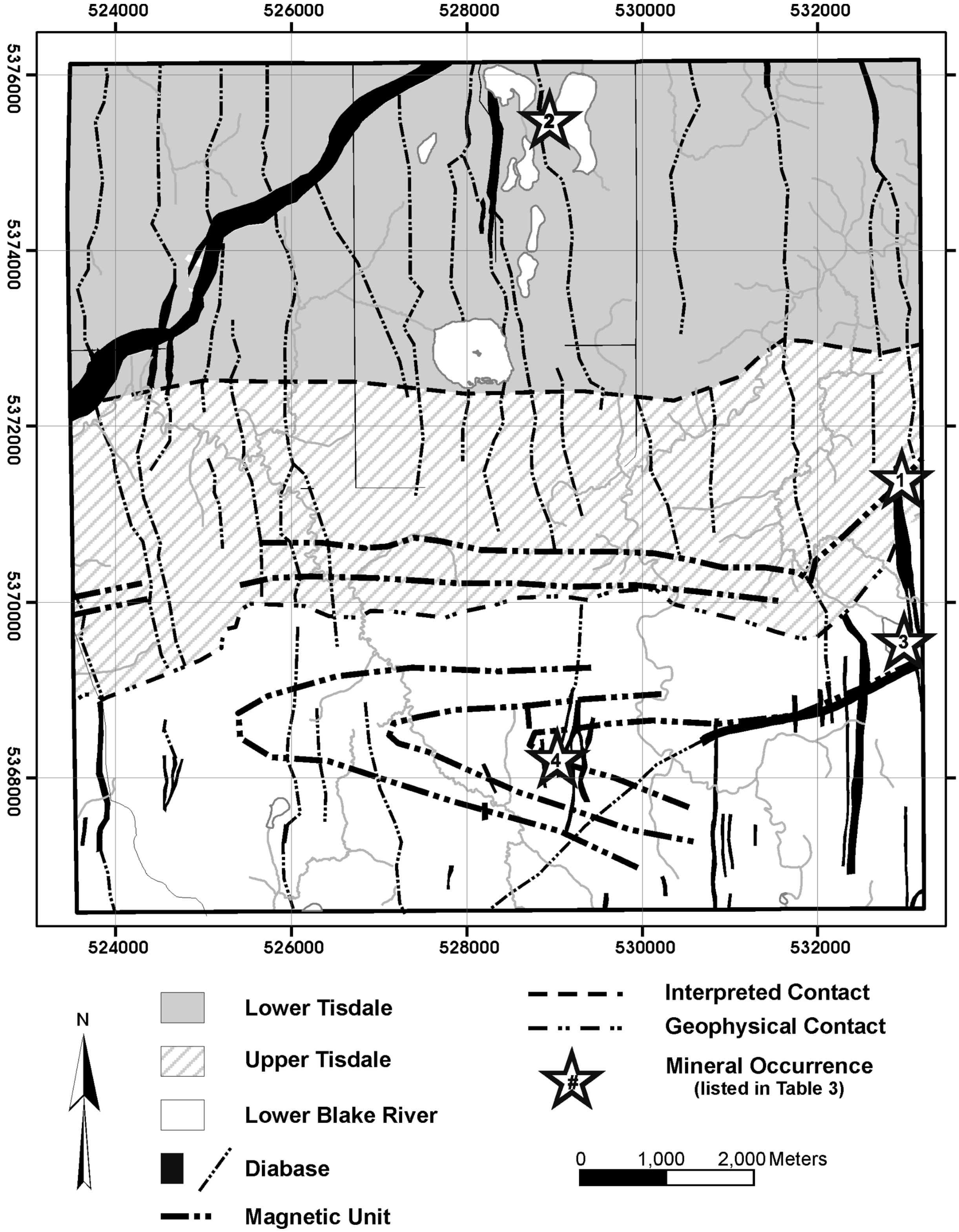


Figure 22. Geological map of Currie Township showing mineral occurrences. Mineral occurrences: 1) Currie (Tillex); 2) Anderson; 3) Foster; and 4) Reid (*see* Table 3 and Figure 21; Ontario Geological Survey 2004a).

Currie Township

LOCATION AND SUCCESS

Currie Township is located in the District of Cochrane, 6 km west of the town of Matheson along Highway 101 (*see* Figure 1). The township is accessible south from Highway 101 via township roads. Private farm and logging roads, and all-terrain vehicle and snowmobile trails branch from the township roads. Many of the township and logging roads shown on the 1965 geological map (Leahy 1965b) are only passable by all-terrain vehicle or on foot; others are completely impassable. This made the southeastern part of the township inaccessible to this study. Relief in the area is low, and outcrop is rare and scattered.

PREVIOUS GEOLOGICAL WORK

Due to the poor exposure, no systematic mapping has been undertaken in Currie Township since 1965 (Leahy 1965a, 1965b). Three gold occurrences and one base metal prospect occur in Currie Township (Table 3; Figures 21 (back pocket), and Figure 22; Ontario Geological Survey 2004a). The gold occurrences are vein/replacement type. The base metal occurrence is sediment associated. Exploration drilling for base metals has been concentrated in the central east-west sector of the township; only 4 outcrops occur in that area.

OBJECTIVES AND METHODS

The goal of the Discover Abitibi Initiative Base Metal Subproject 3 in Currie Township is to reach a better understanding of the stratigraphy in the township, and to characterize the Upper Tisdale assemblage that hosts the base metal mineralization. Field work was conducted by A.S. Péloquin over 10 days in the summer of 2004, and 5 days were spent examining and sampling drill core at the core facilities of Kinross Gold Corporation, Falconbridge Limited and the Kirkland Lake Resident Geologist Office. Leahy (1965b) was used as a base map for the mapping. Outcrop positioning was done using a Garmin® e-trex® Venture® GPS with NAD83 and an accuracy varying from 9 to 15 m.

Thirty-four samples were collected for geochemical analysis from Currie Township: 13 from outcrop and 21 from drill core. All samples were analyzed for major, trace and rare earth elements following the methods outlined in MacDonald, Piercey and Hamilton (2005). The samples were crushed at Activation Laboratories Limited, Ancaster, Ontario, using a mild steel mill. Major elements were analyzed using fused-disc XRF, and Cr, Nb, Y, Zr, Cr and Ni were analyzed using pressed pellet XRF at Activation Laboratories Limited. All other trace elements and the rare earth elements were analyzed at the Ontario Geoscience Laboratories by inductively coupled plasma mass spectrometry (ICP–MS) and inductively coupled plasma atomic emission spectroscopy (ICP–AES) following a closed-beaker digestion (Burnham and Schweyer 2004). All results are listed in Appendix 2; all samples had good major element closures. Two porphyry samples from the Upper Tisdale assemblage had high loss on ignition, but were retained in this study. Details on the analytical methods, precision and accuracy can be found in MacDonald, Piercey and Hamilton (2005).

Through the Discover Abitibi Initiative, new airborne geophysical surveys were flown for Currie Township (Ontario Geological Survey 2004b). These data were used in producing the map (*see* Figure 21). Specifically, magnetic signatures were used to interpret the position of the Upper Tisdale–Lower

Blake River assemblage boundary, and the presence of folding in the Lower Blake River assemblage. Outcrop is sparse to absent in the assemblage contact areas. A three-dimensional geophysical inversion model of Currie Township is presented in Reed (2005).

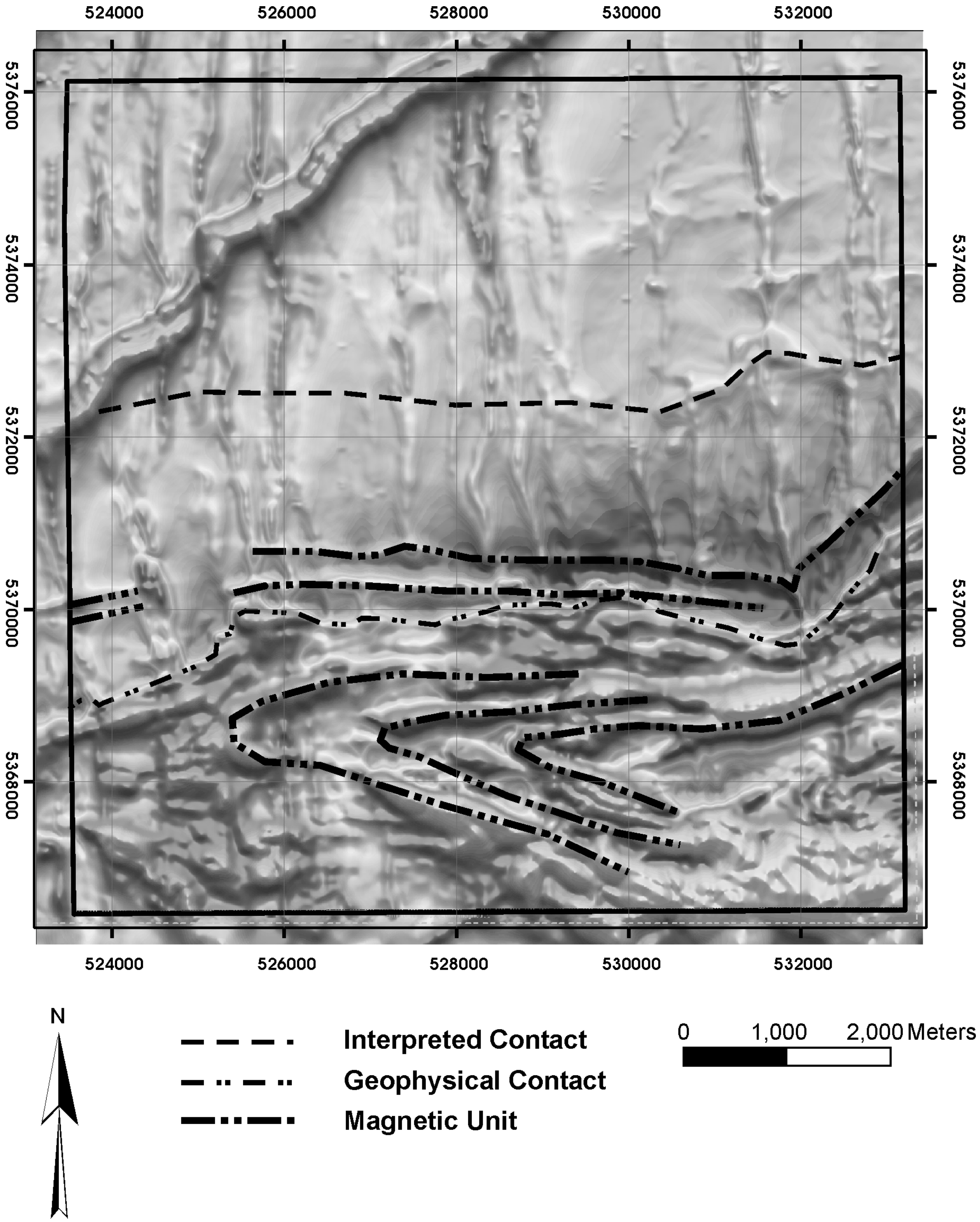


Figure 23. Grey-shaded total field and shadow magnetic map of Currie Township (Ontario Geological Survey 2004b).

GEOLOGICAL SETTING

Currie Township is located in the eastern part of the South Volcanic Zone of the Abitibi Subprovince (*see* Figure 2). The assemblage stratigraphy is southward younging, consisting from north to south of the Lower and Upper Tisdale assemblages, and the Lower Blake River assemblage (Ayer et al. 2005; *see* Figures 3 and 22) formerly identified as the Kinojevis assemblage (Ayer et al. 2002). Archean porphyry dikes and Proterozoic diabase dikes occur in both assemblages. The volcanic rocks of Currie Township are deformed. Large-scale folding is recognized in the magnetic signature of the Lower Blake River assemblage (Figure 23), and deformation zones are observed in drill core in the Upper Tisdale assemblage (Marker Horizon, *see* next paragraph). The apparent absence of folding in the Lower Tisdale assemblage may be due to the low magnetic contrast of the rocks. Reed (2005) interpreted a possible fold in the northeast part of the township based on his three-dimensional geophysical inversion model (Figure 24).

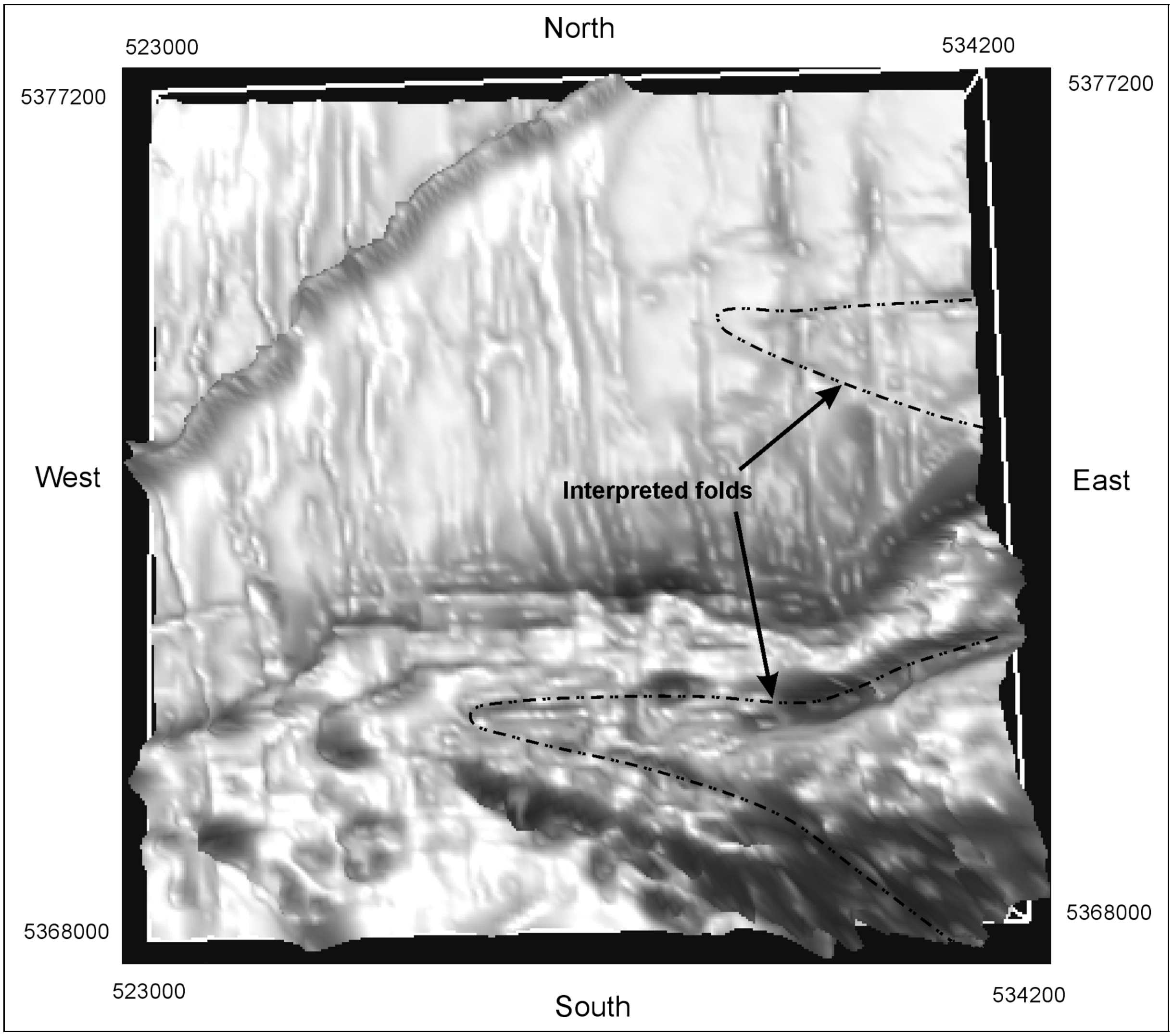


Figure 24. Grey-shaded three-dimensional magnetic inversion model for Currie Township (*from* Reed 2005). Dashed lines indicate interpreted folds (Reed 2005).

The nomenclature for the Tisdale assemblage is well established, and ranges in age from 2710 to 2703 Ma (Ayer et al. 2002). In Currie Township, the Lower Tisdale assemblage consists of mafic volcanic rocks, and is overlain by the Upper Tisdale assemblage (commonly referred to in this area as the Marker Horizon; Ministère des Ressources Naturelles du Québec–Ontario Geological Survey 1983). The Marker Horizon consists of felsic to intermediate and mafic tuffs and tuff breccias, and sediments (argillites and greywackes); it has radiometrically determined (U/Pb) ages of 2706±2 Ma within Currie

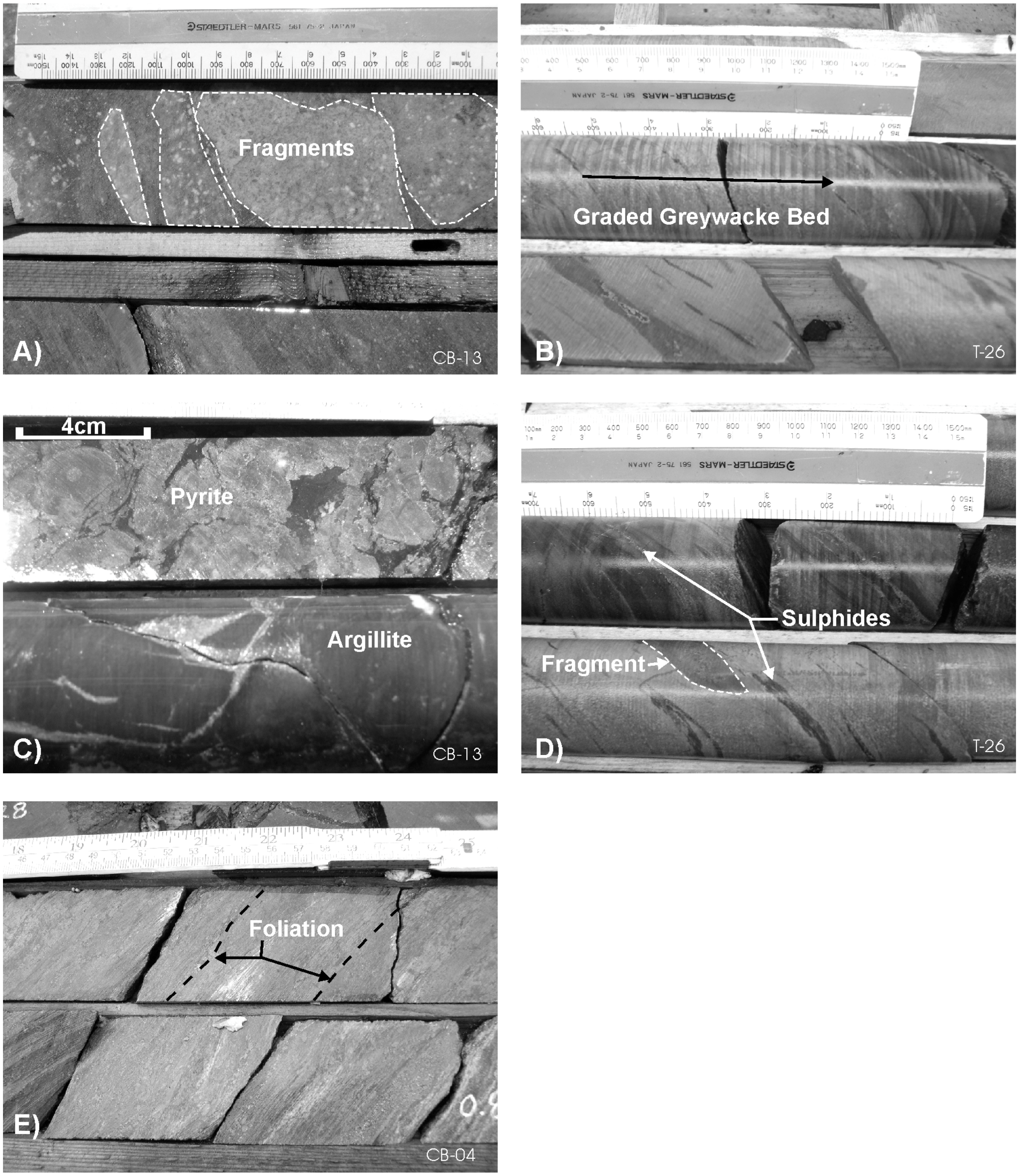


Photo 5. Upper Tisdale assemblage volcaniclastic and sedimentary rocks: a) feldspar crystal tuff (drill hole CB-13); b) graded greywacke bed; tops up-hole (approximately south; drill hole T-26); c) pyritic argillite (drill hole CB-13); d) mineralized felsic tuff (drill hole T-26); and e) mineralized schistose felsic tuff (drill hole CB-04).

Township (Corfu and Noble 1992) and 2703.7±3.9 Ma in Sheraton Township to the southwest (Ayer et al. 2002). The eastern extremity of the Upper Tisdale assemblage (or Marker Horizon) is terminated in Hislop Township by the Hislop fault near the junction of the Arrow and Porcupine–Destor faults. From Hislop Township, the Upper Tisdale assemblage extends west to Macklem Township and south from Macklem to Timmins Township (Ministère des Ressources Naturelles du Québec–Ontario Geological Survey 1983; Ayer, Berger and Trowell 1999; Ayer and Trowell 2000). It hosts polymetallic, base metal and gold, mineralization (Ontario Geological Survey 2004a; Vaillancourt 2001) including the Currie sediment-hosted base metal showing (also known as the Tillex) in Currie Township. The Marker Horizon is interpreted to be conformably overlain by the Lower Blake River assemblage (2702–2701 Ma: Ayer et al. 2002, 2005), but the possibility of a strata-parallel fault at or near the assemblage contact cannot be dismissed. The Lower Blake River assemblage was previously interpreted as belonging to the Kinojevis Group (Ministère des Ressources Naturelles du Québec–Ontario Geological Survey 1983), but its difference in age from the Kinojevis Group in Québec (2718±2 Ma: Zhang et al. 1993) led to the renaming of the unit in Ontario. In Currie Township, the Lower Blake River assemblage consists solely of mafic volcanic rocks.

GEOLOGY OF CURRIE TOWNSHIP

The positions of the assemblage boundaries in Currie Township are interpreted based on the geophysical signature of the units (Ontario Geological Survey 2004b), and/or drill hole data. The Lower Tisdale assemblage comprises approximately 42% of Currie Township; the Upper Tisdale assemblage, approximately 22%; the Lower Blake River assemblage, approximately 33%; and Proterozoic diabase dikes approximately 3% (*see* Figures 21 and 22). Felsic porphyry dikes occur throughout the township.

Volcanic Rocks

The Lower Tisdale assemblage in Currie Township consists of massive, pillow and breccia facies mafic volcanic rocks. Locally, flows were magnetic, slightly amygdaloidal and/or porphyritic. Outcrop is generally poor, and flow morphologies can not always be determined. Bedding trends east to west and faces south in the rare cases where it could be determined. Foliation is also generally east-west and steeply southward dipping to vertical. A possible fold has been interpreted in the northeast part of this assemblage based on the three-dimensional geophysical inversion model (Reed 2005).

The Upper Tisdale assemblage, or Marker Horizon, is dominated by tuffaceous and sedimentary rocks. The tuffs range from mafic to felsic, and although felsic tuffs are the most frequently observed, this may be due to bias in the drill hole locations. Crystal tuffs are common (Photo 5a), and resemble the porphyry dikes. The crystal tuffs commonly contain 10 to 20% of 1 to 3 mm feldspar phenocrysts; chlorite pseudomorphs of mafic phenocrysts are locally observed; quartz microphenocrysts (≤ 1 mm) are rare. The sediments range from greywacke to argillite (Photos 5b and 5c), including graphitic and pyritic argillites. On outcrop, no facing direction was observed. In drill core, facing direction from graded greywacke beds is southward (*see* Photo 5b). Core angle measurements indicate that the bedding is steeply southward dipping to vertical. The east-west strike of the Upper Tisdale assemblage is interpreted from magnetic signatures (*see* Figures 21 and 23). The Upper Tisdale assemblage exhibits variable degrees of deformation (Photos 5d and 5e), with local highly deformed sections and fault gouges. The schistosity is parallel to stratigraphy, and core angle measurements indicate that it is steeply dipping. Bedding parallel faults are observed in drill core.

The Lower Blake River assemblage in Currie Township is generally highly deformed. Flow morphologies can rarely be determined; the rocks are mafic and commonly tectonically banded. Locally, the amygdaloidal and/or plagioclase porphyritic nature of the units is preserved. No bedding strikes or facing directions were determined in the course of this study as the tectonic overprinting masked the primary features (Photos 6a and 6b). However, in the southeast corner of the township, Leahy (1965a, 1965b) measured an east-trending, southward-facing stratigraphic section of the Lower Blake River assemblage. As the area was inaccessible to this study, these measurements were not verified. The foliation in the Lower Blake River assemblage dominantly strikes east or east-southeast, and is steeply dipping. The magnetic map indicates that the stratigraphy is folded around an east-trending, westerly closing fold. There is no evidence for an angular unconformity at the Upper Tisdale–Lower Blake River assemblage boundary, and the south facing direction of the sediments in the Upper Tisdale assemblage, on the north limb of the fold would indicate that the fold is synclinal; an interpretation supported by the three-dimensional geophysical inversion model (Reed 2005). However, the Upper Tisdale assemblage is generally highly deformed and the existence of a strata-parallel fault occurring at or near the assemblage contact cannot be ruled out.

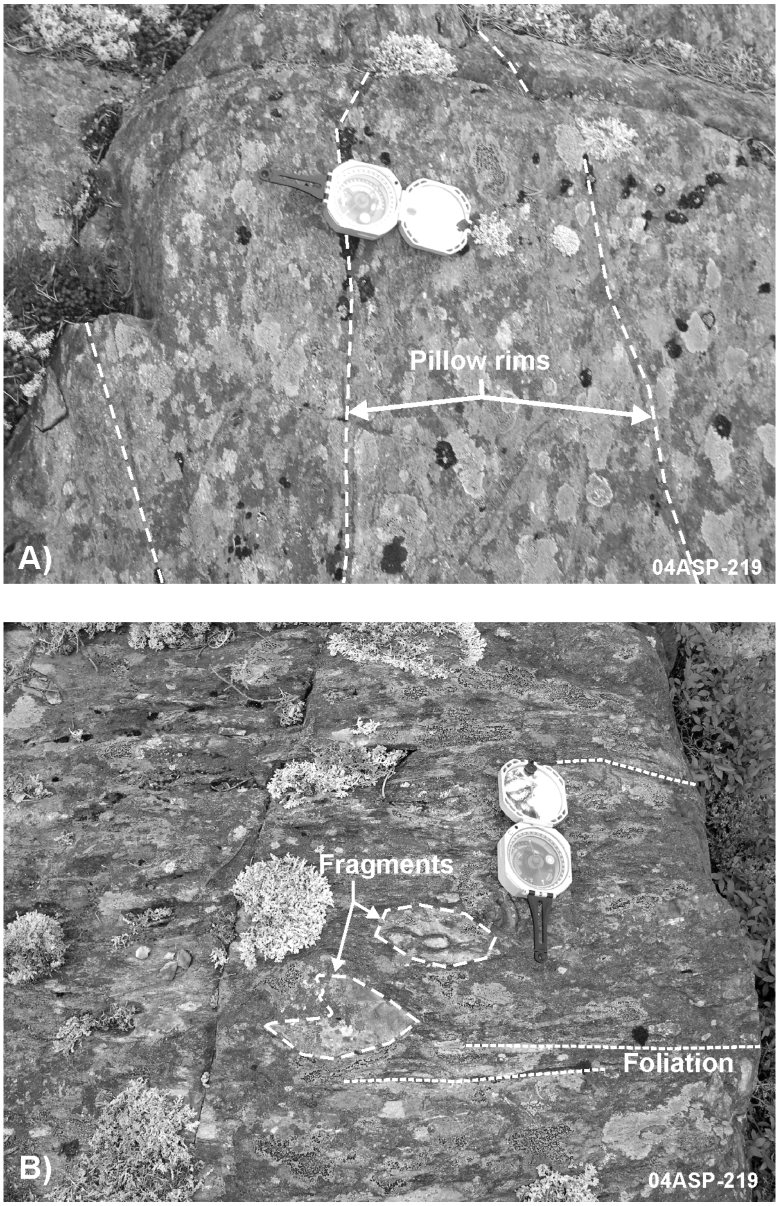


Photo 6. Lower Blake River assemblage volcanic rocks: a) flattened basalt pillows; and b) deformed basalt breccia.

Intrusions

Two main types of intrusions are recognized in Currie Township: Proterozoic diabase dikes, and Archean feldspar porphyries (Photos 7a and 7b). The diabase dikes are commonly responsible for the outcrops in the area, occupying the centre of the outcrops with the volcanic rocks being preserved on the outcrop flanks. The diabases have high magnetic signatures and their traces can thus be mapped in areas of no outcrop. They cut all volcanic units in Currie Township.

The porphyry dikes occur in all 3 assemblages in Currie Township. They commonly have >20% of 2 to 3 mm feldspar phenocrysts, but can attain 50% phenocrysts, 5 mm in size. Hornblende, with varying degrees of actinolite or chlorite alteration, is the most common secondary phenocryst phase, generally comprising 5% of the rock and being 1 to 2 mm in size. Quartz was less common as a phenocryst phase, generally <3% 1 mm crystals.

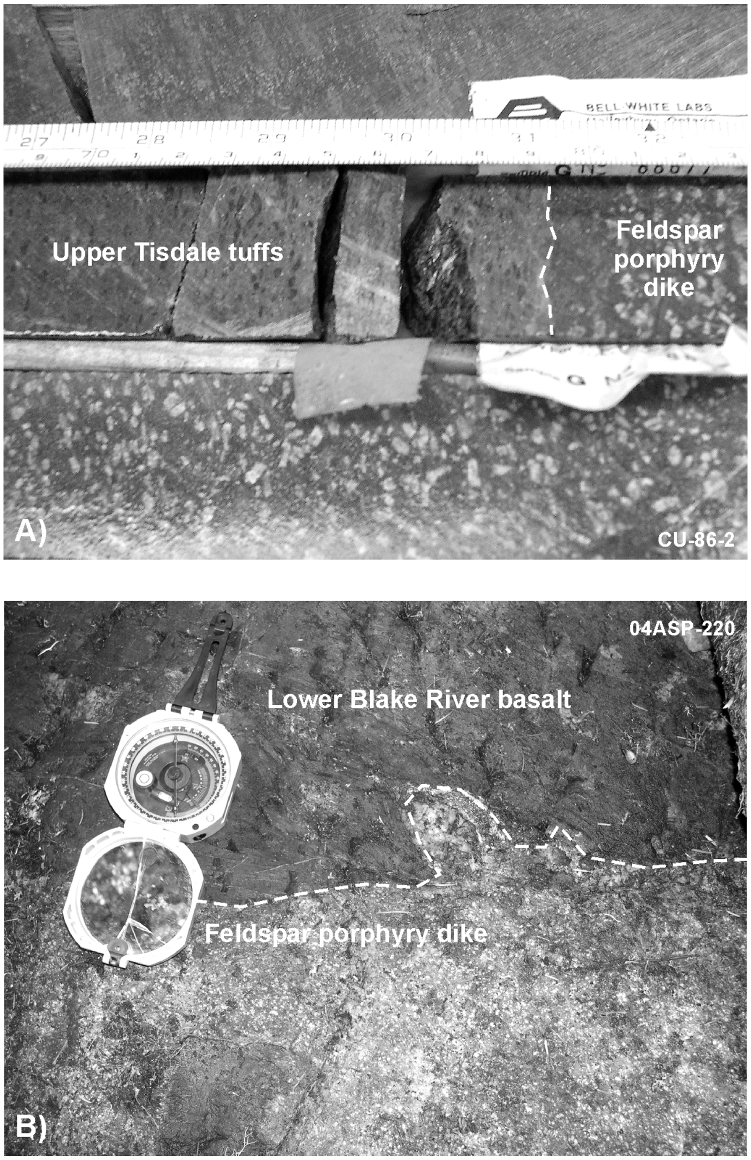


Photo 7. Feldspar porphyry intrusions: a) in drill core in the Upper Tisdale assemblage; and b) on outcrop in the Lower Blake River assemblage.

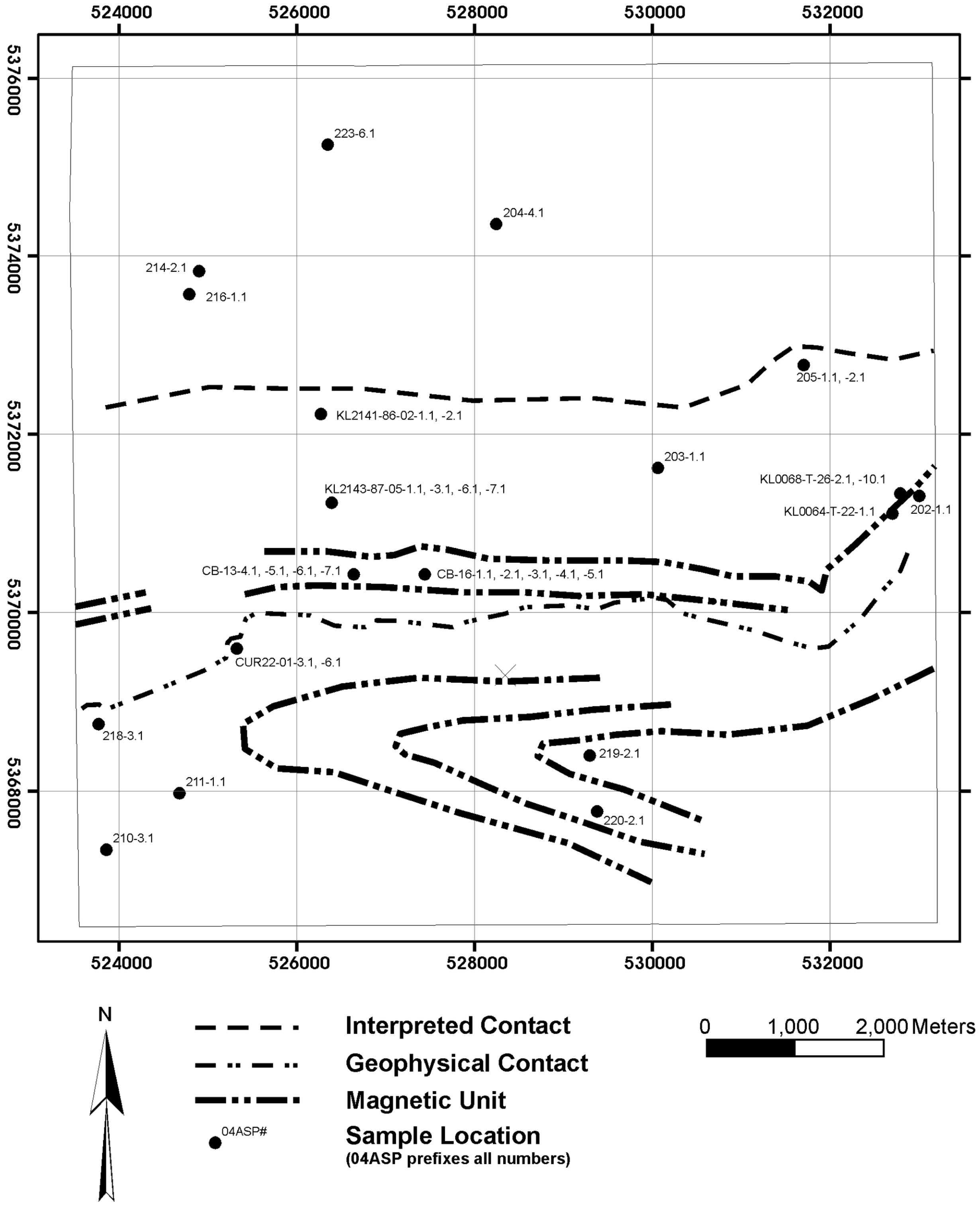


Figure 25. Geochemical sample locations for Currie Township.

GEOCHEMISTRY

Thirty-four samples were analyzed for major, trace and rare earth elements: 4 samples from the Lower Tisdale assemblage (1 mafic volcanic, 1 mafic intrusion and 2 porphyritic dikes); 23 samples from the Upper Tisdale assemblage (Marker Horizon) (9 felsic volcanic, 5 mafic volcanic and 9 porphyritic dikes); 7 samples from the Lower Blake River assemblage (3 mafic volcanic, 1 intermediate volcanic, 1 evolved tuff and 2 porphyritic dikes). The sediments in the Upper Tisdale assemblage (Marker Horizon) were not analyzed. Sample numbers and locations are shown on Figure 25.

Volcanic Rocks

On the LeBas et al. (1986) rock classification diagram (Figure 26a), the sample taken from the Lower Tisdale assemblage volcanic rocks falls in the basaltic andesite field, and the samples from the Lower Blake River assemblage fall in the basalt and basaltic andesite fields with one exception: a tuffaceous rock (04ASP-211.1), which falls in the dacite field. The samples from the Upper Tisdale assemblage are generally andesitic to dacitic, with one rhyolite sampled (*see* Figure 26a); one of the andesite samples (04ASP-223.6) falls in the alkaline field (Irvine and Baragar 1971; *see* Figure 26a). On the Irvine and Baragar (1971) AFM diagram (Figure 27a), the Lower Tisdale assemblage sample falls in the tholeiitic field, and all but one of the Lower Blake River assemblage mafic to intermediate samples fall near the tholeiitic–calc-alkalic field boundary. The dacite from the Lower Blake River assemblage falls in the calc-alkalic field. With 2 exceptions, the Upper Tisdale assemblage samples fall within the calc-alkalic field of the AFM diagram (*see* Figure 27a). Of the 2 “tholeiitic” Upper Tisdale assemblage samples, one is the most mafic rock of the calc-alkalic evolutionary trend observed; the second is the “alkaline” sample from Figure 26a. This sample is from an outcrop at the Currie (Tillex) showing.

Sample populations are clearly distinguished on chondrite-normalized trace element spider diagrams (Figures 28a to 28c), but are not discernible on major element variation diagrams (Figures 29a to 29c). On the chondrite-normalized spider diagram, the Lower Tisdale assemblage sample has a tholeiitic basalt pattern (a slightly light rare earth element (LREE) depleted trace element pattern: chondrite-normalized (cn) La/Yb = 0.79; *see* Figure 28a). It also has a slight negative Nb anomaly; however, generalizations on the Lower Tisdale cannot be made on the basis of a single sample. Lower Blake River assemblage samples also exhibit dominantly tholeiitic basalt signatures (flat to light rare earth element (LREE) depleted trace element patterns: $(La/Yb)_{cn}$ = 0.69–0.98; *see* Figure 28a) in spite of its apparent transitional, tholeiitic to calc-alkalic affinity on Figure 26a. Chondrite-normalized trace element patterns of the Lower Blake River assemblage tholeiites have no negative Nb anomalies. Two samples from the Lower Blake River assemblage are not tholeiitic basalts (*see* Figure 28a). The most evolved sample is the dacitic tuff, which exhibits a parallel trace element pattern to those of the Lower Blake River assemblage tholeiitic basalts and is, therefore, interpreted to have been derived from tholeiitic magma. The intermediate sample (04ASP-219.2), exhibiting the sloped trace element pattern and light-rare-earth element (LREE) enrichment, is a porphyritic pillowed andesite and its trace element pattern resembles those of the intermediate volcanic rocks of the Upper Tisdale assemblage (*see* Figures 28a and 28b).

The Upper Tisdale assemblage comprises intermediate to felsic volcanic rocks, dominantly pyroclastic in origin. The intermediate volcanic rocks are foliated and in drill core were interpreted to be tuffs. Three populations with different $(La/Yb)_{cn}$ ratios are seen on the spider diagrams of these samples (*see* Figure 28b). The sample with $(La/Yb)_{cn}$ = 3.99 is from drill core near the Upper and Lower Tisdale assemblages boundary; it contains 1.67 ppm Yb and 57.35 weight % SiO_2. The 2 samples with slightly higher $(La/Yb)_{cn}$ ratios (6.13 and 7.05) are from well within the Upper Tisdale assemblage, and are more evolved than the first sample with 2.76 ppm Yb and 59.52 weight % SiO_2, and 2.09 ppm Yb and 57.95 weight % SiO_2. The third sample population is distinct from the first 2 populations: the 2 samples from the third population come from the Currie (Tillex) showing area. They have high $(La/Yb)_{cn}$ ratios (20.35 and 17.04) with Yb contents of 1.1 and 1.76 ppm, and SiO_2 contents of 58.24 and 55.82 weight %. The most primitive of these samples (55.82 weight % SiO_2 and 1.1 ppm Yb) is more primitive than the sample near the Upper–Lower Tisdale assemblages boundary. All the intermediate samples from the Upper Tisdale assemblage have pronounced negative Nb anomalies, indicating a subduction component at the source, or crustal contamination.

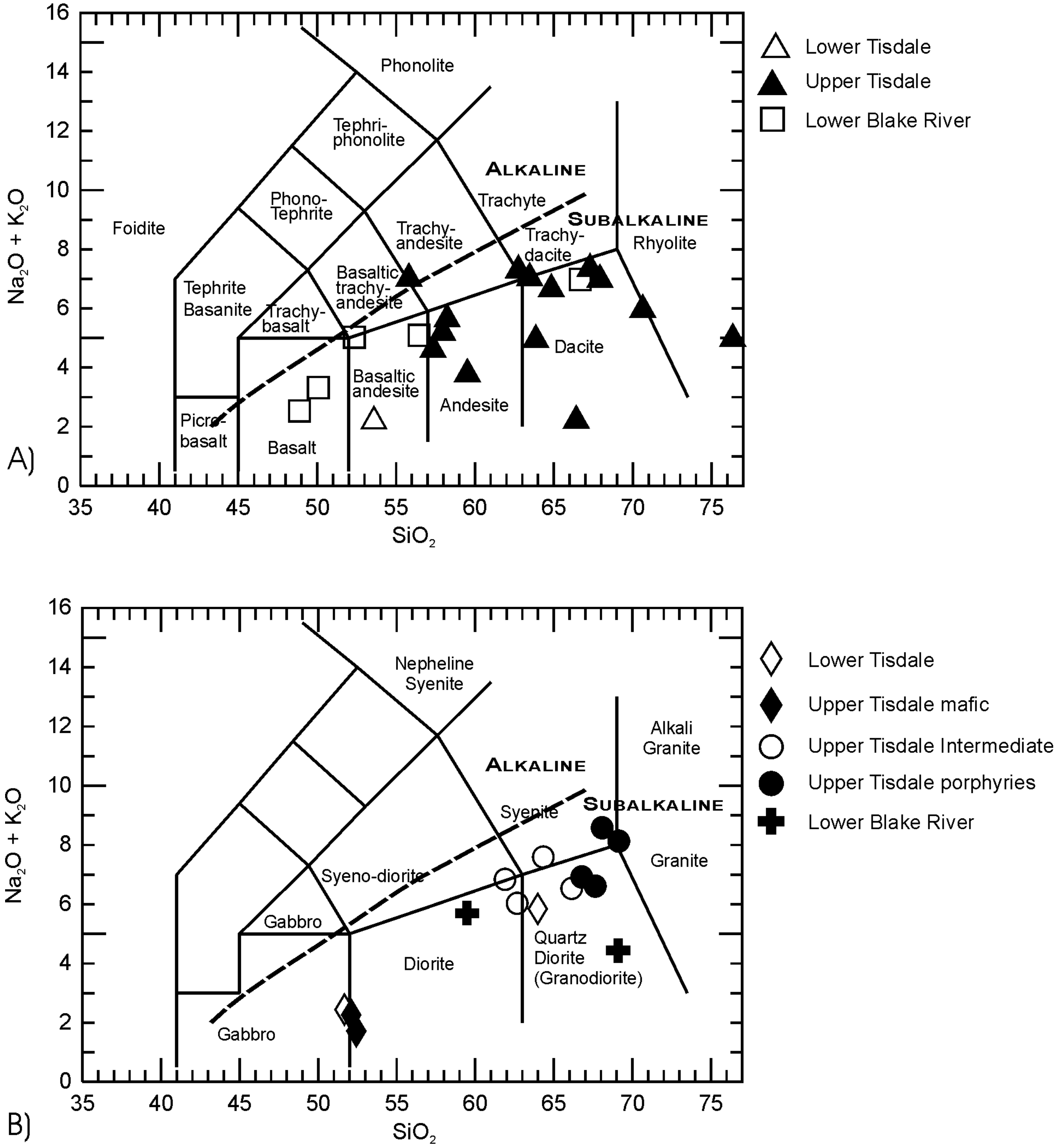


Figure 26. LeBas et al. (1986) rock classification for Currie Township a) volcanic rocks and b) intrusive rocks. Alkaline–subalkaline division *from* Irvine and Baragar (1971).

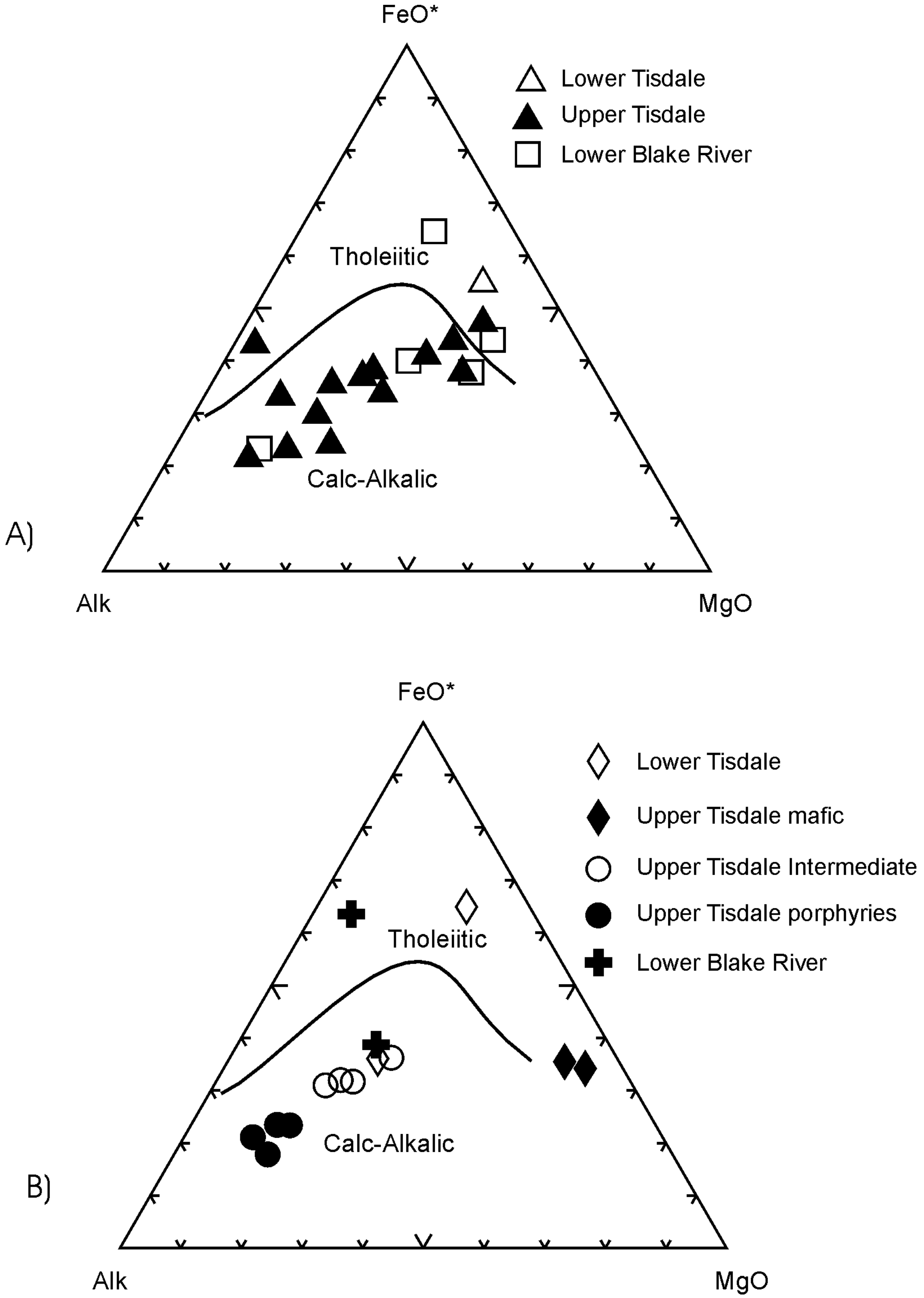


Figure 27. Total alkali–FeO_{total}–MgO (AFM) diagram for Currie Township a) volcanic rocks and b) intrusive rocks (*after* Irvine and Baragar 1971).

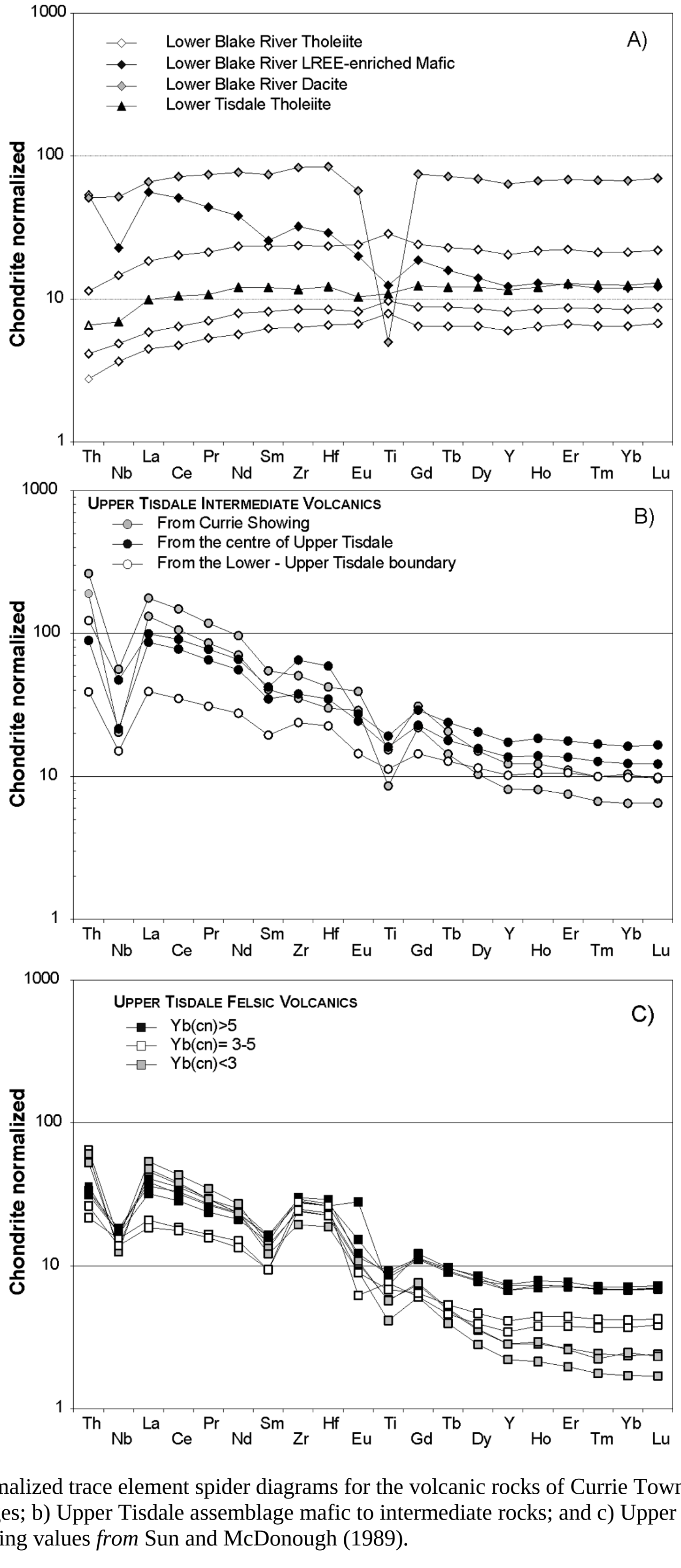


Figure 28. Chondrite-normalized trace element spider diagrams for the volcanic rocks of Currie Township: a) Lower Tisdale and Blake River assemblages; b) Upper Tisdale assemblage mafic to intermediate rocks; and c) Upper Tisdale assemblage felsic rocks. Chondrite-normalizing values *from* Sun and McDonough (1989).

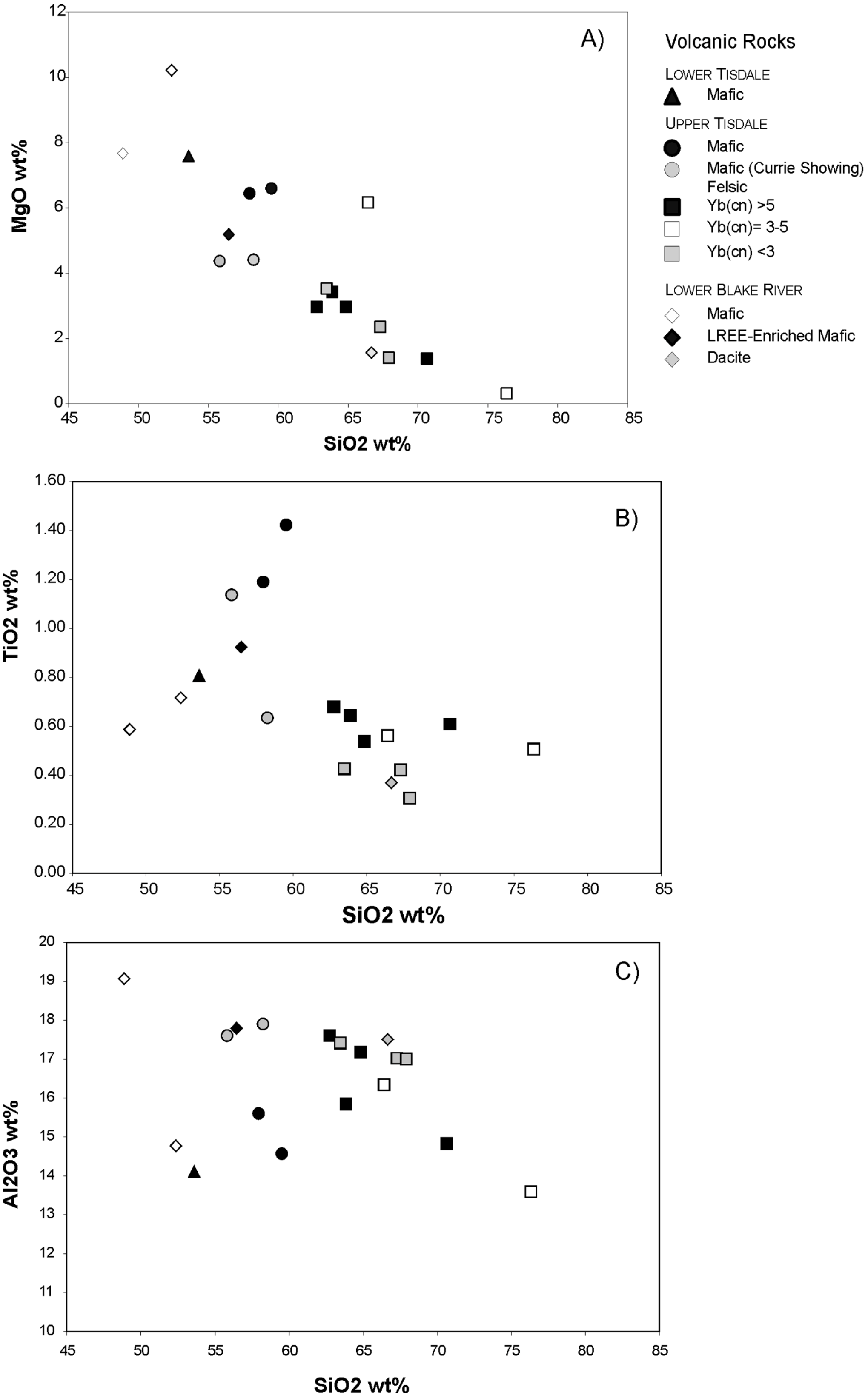


Figure 29. Major element variation diagrams for the volcanic rocks of Currie Township: SiO_2 versus a) MgO, b) TiO_2 and c) Al_2O_3 (all values in weight %).

The Upper Tisdale assemblage felsic tuffaceous rocks exhibit 2 populations (*see* Figure 28c) based on their chondrite-normalized trace element patterns: the first population has a moderately sloped pattern with $(La/Yb)_{cn}$ between 4.43 and 5.99 (*see* Figure 30a), and the second has a steeply sloped pattern with $(La/Yb)_{cn}$ of 18.5–27.9 (*see* Figure 30a). The high $(La/Yb)_{cn}$ felsic tuffs have low Yb contents (0.29 and 0.42 ppm; *see* Figure 30b). The lower $(La/Yb)_{cn}$ population appears to have 2 subpopulations with Yb contents of 0.63 and 0.71 ppm, and 1.15 to 1.21 ppm (*see* Figure 30b). These 2 subpopulations have overlapping SiO_2 weight % contents, with the higher Yb samples having generally lower SiO_2 weight %. On a Yb_{cn} versus $(La/Yb)_{cn}$ diagram (*see* Figure 30a), the similarities in the $(La/Yb)_{cn}$ between the felsic rock populations of the Upper Tisdale assemblage and the intermediate rocks of that assemblage are seen. On a SiO_2 versus Yb diagram (*see* Figure 30b), the Yb content (in ppm) is seen to decrease with increasing SiO_2 content (in weight %).

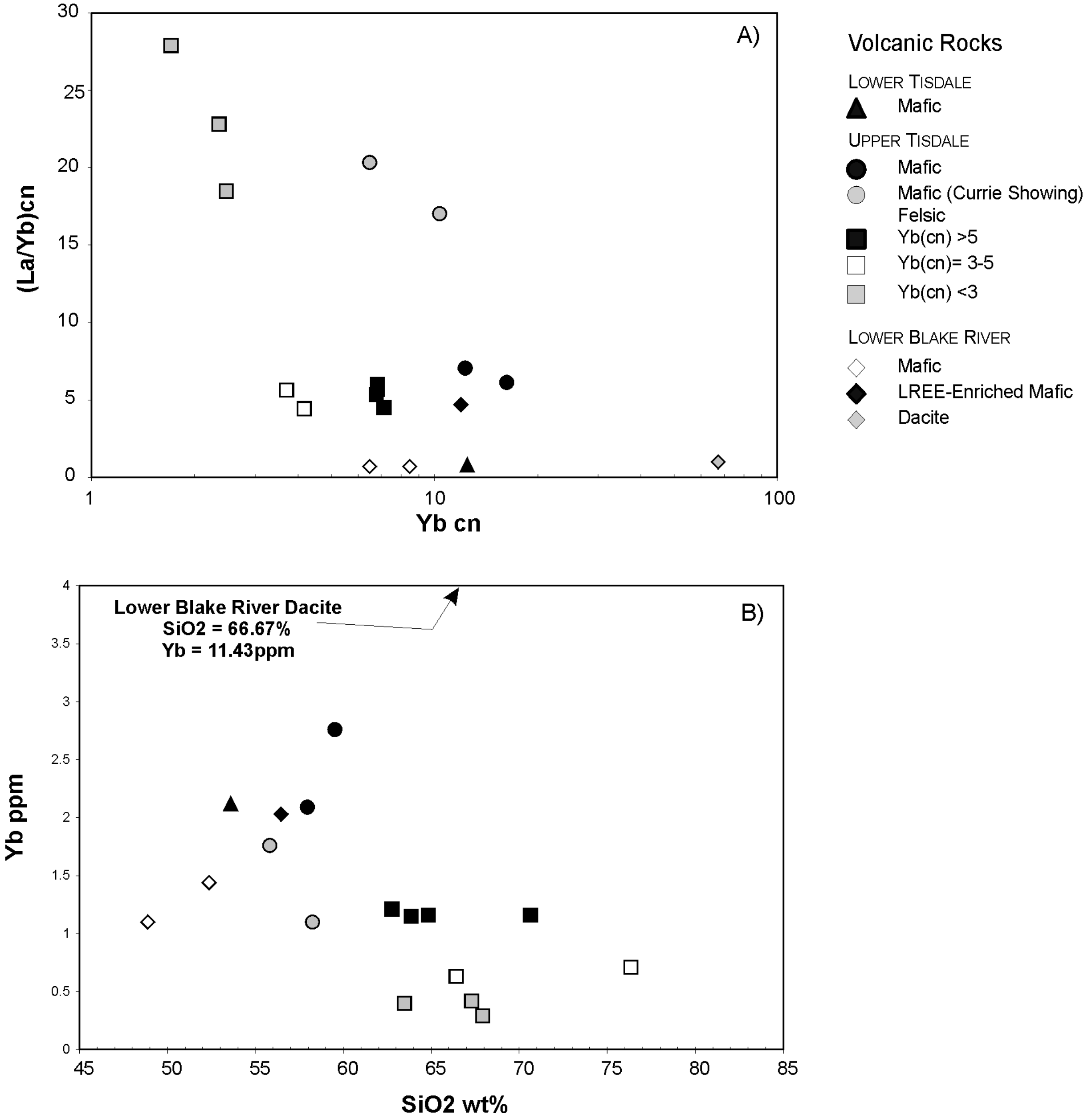


Figure 30. a) Chondrite-normalized Yb (ppm) versus (La/Yb) diagram; and b) SiO_2 (weight %) versus Yb (ppm) diagram for volcanic rocks of Currie Township. Chondrite-normalizing values *from* Sun and McDonough (1989).

Intrusions

Porphyry dikes were preferentially sampled in order to compare them to the volcanic rocks, particularly the felsic crystal tuffs of the Upper Tisdale assemblage. On the LeBas et al. (1986) classification diagram (*see* Figure 26b, original diagram adapted to indicate intrusive rock names), the majority of the porphyry dikes fall in the quartz diorite (granodiorite) field. On the Irvine and Baragar (1971) AFM diagram (*see* Figure 27b), the sampled mafic intrusions fall in the tholeiitic field, whereas the porphyry dikes fall in the calc-alkalic field.

On a chondrite-normalized trace element spider diagram of the intrusions from the Lower Tisdale and Lower Blake River assemblages (Figure 31a), the mafic dike sampled in the Lower Tisdale assemblage has

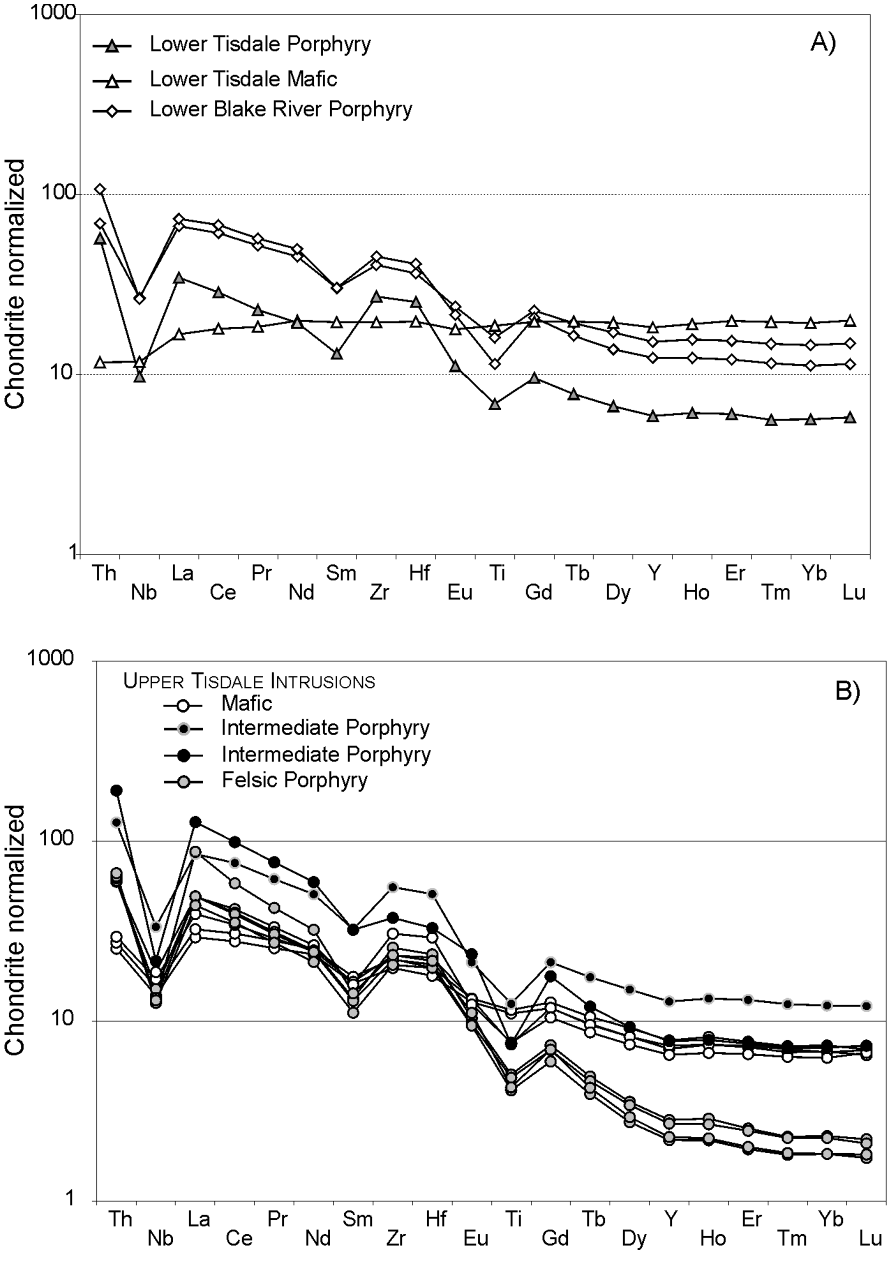


Figure 31. Chondrite-normalized trace element spider plots for Currie Township intrusions: a) Lower Tisdale and Lower Blake River assemblages; and b) Upper Tisdale assemblage. Chondrite-normalizing values *from* Sun and McDonough (1989).

a similar trace element pattern ($(La/Yb)_{cn}$ = 0.87) to the tholeiitic basalts of both assemblages (*see* Figure 28a). The porphyry dike from the Lower Tisdale assemblage has a similar trace element pattern ($(La/Yb)_{cn}$ = 6.13) to the porphyry dikes sampled in the Lower Blake River assemblage ($(La/Yb)_{cn}$ = 4.58 and 6.54), but with lower overall trace element contents. These dikes, from both assemblages, have trace element patterns similar to the porphyritic flow sampled in the Lower Blake River assemblage ($(La/Yb)_{cn}$ = 4.69; *see* Figure 28a), and to the intermediate volcanic rocks in the Upper Tisdale assemblage with $(La/Yb)_{cn}$ ratios of 6.13 and 7.05 (*see* Figure 28b). Again, the Lower Tisdale assemblage sample has lower trace element contents than the volcanic rocks in the Lower Blake River or Upper Tisdale assemblages.

In the Upper Tisdale assemblage, there are 3 populations of porphyritic dikes (Figure 31b). The first population has chondrite-normalized trace element patterns (*see* Figure 31b; $(La/Yb)_{cn}$ = 4.3–7.84) and contents similar to the porphyritic dike sampled in the Lower Tisdale assemblage and to the intermediate tuffs of the Upper Tisdale assemblage (*see* Figure 28b; $(La/Yb)_{cn}$ = 6.13 and 7.05). The second population has trace element patterns similar (*see* Figure 31b; $(La/Yb)_{cn}$ = 21.48-47.76) to the high $(La/Yb)_{cn}$ ratio felsic tuffs of the Upper Tisdale assemblage (*see* Figure 28b). The third population appears to be a slightly more evolved and has $(La/Yb)_{cn}$ ratios overlapping the first population (6.94 and 17.86; *see* Figure 31b); it may be a contaminated subset of that population.

Summary

The limited number of geochemical analyses from the Lower Tisdale and Lower Blake River assemblages precludes major conclusions being drawn for these areas. However, the presence of tholeiitic basalts is noted in both assemblages, as is their absence in the Upper Tisdale assemblage (*see* Figure 28). The Upper Tisdale assemblage comprises 3 populations of intermediate to felsic volcanic rocks (dominantly pyroclastic in nature). Two of the population have moderate $(La/Yb)_{cn}$ ratios, moderate LREE and thorium enrichment; the third population has high $(La/Yb)_{cn}$ ratios, and high LREE and thorium enrichment (*see* Figures 27b and 27c). The chondrite-normalized trace element patterns of the volcanic rocks of the Upper Tisdale assemblage resemble those of the Archean tonalite-trondhjemite-granodiorite (TTG) suite (e.g., Cullers and Graf 1984; Drummond and Defant 1990). The existence of multiple populations is likely due to variations at the source including different degrees of partial melting, or to subsequent crustal contamination, as may be the case of the moderate $(La/Yb)_{cn}$ populations. Within the populations, trace and rare earth element contents decrease with increasing SiO_2 weight % (*see* Figure 30b). Cullers and Graf (1984 after Birk, Koljonen and Rosenberg 1979) suggested that this phenomenon is due to hornblende crystallization. A single sample from the Lower Blake River assemblage has a chondrite-normalized trace element pattern similar to the moderate $(La/Yb)_{cn}$ andesites of the Upper Tisdale assemblage (*see* Figure 28a). This indicates that the type of magmatic event responsible for the emplacement of the Upper Tisdale assemblage also occurred during the formation of the Lower Blake River assemblage.

The majority of intrusions sampled in Currie Township were porphyritic dikes. The mafic dike sampled in the Lower Tisdale assemblage resembles the tholeiitic basalt of that assemblage (*see* Figure 31a). The porphyritic dikes sampled in the Lower Tisdale and Lower Blake River assemblages resemble the moderate $(La/Yb)_{cn}$ andesitic rocks and porphyry dikes of the Upper Tisdale assemblage (*see* Figure 31). In the Upper Tisdale assemblage, the porphyritic dikes form 2 main populations equivalent to the moderate and high $(La/Yb)_{cn}$ populations observed in the volcanic rocks of that assemblage (*see* Figures 31b, 28b and 28c). A third minor population was observed (*see* Figure 31b), and may be a more evolved, contaminated subset of the moderate $(La/Yb)_{cn}$ population. The similarity in the composition of the porphyry dikes and the Upper Tisdale assemblage volcanic rocks suggests that they are co-magmatic. The magmatic event responsible for the Upper Tisdale assemblage volcanic rocks, therefore, has an intrusive expression, and the event continued into the Lower Blake River assemblage.

Table 3. Summary of mineral properties in Currie Township and their main commodities (Ontario Geological Survey 2004a).

Number on Figures 21 and 22	Deposit Name	Deposit Classification	Deposit Type	Commodity
1	Currie (Tillex)	Prospect	Sediment Associated	**Cu**, Au
2	Anderson, J.	Occurrence	Vein / Replacement Deposits	**Au**
3	Foster	Occurrence	Vein / Replacement Deposits	**Au**
4	Reid, S.	Occurrence	Vein / Replacement Deposits	**Au**

Notes: Au = gold; Cu = copper. **Bold type** indicates principal commodity

ECONOMIC GEOLOGY

Three gold occurrences and 1 base metal prospect occur in Currie Township (Ontario Geological Survey 2004a; *see* Table 3; locations indicated on Figures 21 and 22). Leahy (1965a) described all 4 occurrences in his report as gold showings. The Anderson occurrence in the Lower Tisdale assemblage is described as quartz veins in an east-west shear (Leahy 1965a, p.14). Generally, the mineralization consisted of "sparse pyrite", with sphalerite-galena-chalcopyrite-pyrite observed by Leahy (1965a, p.14) in trenches. The 2 gold occurrences in the Lower Blake River assemblage are the Reid and the Foster occurrences. The Reid occurrence is described (Laird 1932 as cited in Leahy 1965a) as quartz lenses and stringers in sheared and altered pillow lavas (Leahy 1965a, p.14). The mineralization is characterized as "zinc-blende"-malachite-chalcopyrite-"iron sulphides" (Laird 1932 as cited in Leahy 1965a, p.14). The Foster occurrence is described (Leahy 1965a, p.15) as quartz ± carbonate with minor pyrite-chalcopyrite-pyrrhotite mineralization in amphibolitized basalts.

The Currie occurrence was described by Leahy (1965a) as a gold showing within the basalts, consisting of garnet-epidote-quartz-carbonate segregates containing finely disseminated pyrite. It was recognized as a base metal occurrence in 1974 and renamed the Tillex showing (information from Pacifica Resources Ltd. (formerly Expatriate Resources Ltd.), http://www.pacifica-resources.com/exp_na_tillex.cfm [accessed June 10, 2005]). It occurs in the Upper Tisdale assemblage, the same unit that hosts the Cross Lake deposit (*see also* Vaillancourt 2001). Pacifica Resources Ltd. (formerly Expatriate Resources Ltd.) describes the mineralization as consisting of disseminated, stringer and conformable laminations of chalcopyrite ± bornite in argillites and tuffs, and recognized synclinal folding in the volcano-sedimentary unit (Pacifica Resources Ltd., http://www.pacifica-resources.com/exp_na_tillex.cfm [accessed June 10, 2005]).

Diamond drilling of the Upper Tisdale assemblage (Marker Horizon) in the central part of Currie Township by Echo Bay Mines Ltd. (now Kinross Gold Corporation) generally confirmed the description by Expatriate Resources Ltd. (now Pacifica Resources Ltd.) (R. Norman, Kinross Gold Corporation, personal communication, 2004). The mineralization observed in the Kinross Gold and Kirkland Lake Core Library drill core consisted of pyrite ± sphalerite ± chalcopyrite as small stringers, and along bedding and foliation planes (*see* Photos 5d and 5e), and the samples assayed by the company returned both high zinc and gold values (R. Norman, Kinross Gold Corporation, personal communication, 2004). The mineralized zones are commonly schistose, and numerous bedding parallel faults and sheared zones are observed in drill core. Although the mafic rocks of the Lower Tisdale and Lower Blake River assemblages also exhibit strong deformation, the Upper Tisdale assemblage tuffs and sediments may have been more susceptible to deformation and acted as a corridor focussing higher regional strain.

DISCUSSION AND CONCLUSIONS

The stratigraphy in Currie Township is southward younging, and, from north to south, consists of the Lower Tisdale, the Upper Tisdale and the Lower Blake River assemblages (Ayer et al. 2005; *see* Figures 3 and 22). The assemblage boundaries are based on the geophysical signature of the units (Ontario Geological Survey 2004b), and/or drill hole data. The Lower Tisdale and the Lower Blake River assemblages are dominated by mafic flows. The Upper Tisdale assemblage (Marker Horizon) is dominated by tuffs (including feldspar crystal tuffs) and sediments (argillites and greywackes). Felsic tuffs were the most commonly observed, but this may be due to drill hole location bias, and intermediate to mafic tuffs may be more abundant in the assemblage than observation and sampling indicate. Flows were only very rarely observed. The stratigraphy in all assemblages strikes approximately east-west; south facing directions were observed in the Lower and Upper Tisdale assemblage, and compiled from Leahy (1965b) for the Lower Blake River assemblage. In drill core of the Upper Tisdale assemblage, the bedding is seen to be steeply south to vertically dipping. Proterozoic diabase dikes and Archean porphyry dikes crosscut the volcanic assemblages. The porphyry dikes occur in all 3 assemblages and resemble the feldspar crystal tuffs of the Upper Tisdale assemblage.

The volcanic rocks of Currie Township are deformed. In general, the rocks in all of the assemblages exhibit well-developed east-west subvertical schistosity. In drill core of the Upper Tisdale assemblage, the schistosity is seen to be bedding parallel, and zones of strong deformation and fault gouges, also bedding parallel, were observed. A large-scale synclinal fold is recognized in the magnetic signature of the Lower Blake River assemblage (*see* Figure 24), and Reed (2005) interpreted a possible fold in the northeast part of the township (Lower Tisdale assemblage) based on his three-dimensional geophysical inversion model.

The volcanic rocks in Currie Township are subalkalic. The only sample analyzed from the Lower Tisdale assemblage is a tholeiitic basaltic andesite. The Upper Tisdale assemblage is calc-alkalic in affinity and ranges from andesitic to rhyolitic in composition. Three populations are recognized in the Upper Tisdale assemblage based on $(La/Yb)_{cn}$ ratios, and LREE and thorium enrichment. Two of the populations exhibit moderate but different $(La/Yb)_{cn}$ ratios, and LREE and thorium enrichment, whereas the third population has high $(La/Yb)_{cn}$ ratios, and LREE and thorium enrichment. Moderate to high $(La/Yb)_{cn}$ ratios, and LREE and thorium enrichment are characteristics of Archean tonalite-trondhjemite-granodiorite (TTG) suites, and the close association of multiple populations may be due to variations at the source and/or in subsequent crustal contamination. The decrease in trace and REE contents with increasing SiO_2 weight % in the Upper Tisdale assemblage populations may be due to hornblende crystallization (Cullers and Graf 1984 after Birk, Koljonen and Rosenberg 1979).

The majority of the Lower Blake River assemblage samples are tholeiitic basalt to basaltic andesite (*see* Figure 26a). One sample, a tuff, is a tholeiitic dacite, which may have evolved from the mafic tholeiitic magma. A plagioclase porphyritic pillowed andesite exhibits LREE enrichment compared to the mafic tholeiites of this assemblage. This unit is geochemically similar to the Upper Tisdale assemblage volcanism and porphyry magmatism suggesting its derivation from a similar source.

In the Upper Tisdale assemblage, the porphyritic dikes form 2 main populations equivalent to the moderate and high $(La/Yb)_{cn}$ populations observed in the volcanic rocks of that assemblage. A third minor population was observed, and may be a more evolved, contaminated subset of the moderate $(La/Yb)_{cn}$ population. The porphyritic dikes sampled in the Lower Tisdale and Lower Blake River assemblages resemble the moderate $(La/Yb)_{cn}$ andesitic volcanic rocks and moderate $(La/Yb)_{cn}$ porphyry dikes of the Upper Tisdale assemblage. The similarity in the composition of the porphyry dikes in all the assemblages and the Upper Tisdale assemblage volcanic rocks suggests that they are co-magmatic. The magmatic event responsible for the Upper Tisdale assemblage volcanic rocks, therefore, has an intrusive expression, and the event continued into the formation of the Lower Blake River assemblage. In the Timmins area, a similar relationship is observed for the porphyry intrusions and the Krist formation (MacDonald, Piercey and Hamilton 2005). Their conclusion was based on petrography, geochemistry and geochronology. Although no geochronology was undertaken here, it should be noted that the Aquarius porphyry in the Lower Tisdale assemblage in Macklem Township, west of Currie Township, had a U/Pb radiometric age of 2705±10 Ma (Corfu et al. 1989) determined, which, in spite of the large error, is similar to the published ages for the Upper Tisdale assemblage (Marker Horizon) (2706±2Ma: Corfu and Davis 1992; 2703.7±3.9 Ma: Ayer et al. 2002).

The Currie showing occurs in the sediments and felsic tuffs of the Upper Tisdale assemblage (*see* Figure 22), and is within the same stratigraphic sequence as the Cross Lake deposit (Vaillancourt 2001). Originally recognized as a gold occurrence (Leahy 1965a), the Currie showing was reclassified as a base metal occurrence in 1974 and renamed the Tillex showing. The mineralization consists of disseminated, stringer and conformable laminations of chalcopyrite ± bornite in argillites and tuffs (Pacifica Resources Ltd. (formerly Expatriate Resources Ltd.), http://www.pacifica-resources.com/exp_na_tillex.cfm [accessed June 10, 2005]), and diamond drilling by Echo Bay Mines Ltd. (now Kinross Gold Corporation) generally confirmed that description (R. Norman, Kinross Gold Corporation, personal communication, 2004). The mineralization observed in the Kinross Gold and Kirkland Lake Core Library drill core consisted of pyrite ± sphalerite ± chalcopyrite as small stringers, and along bedding and foliation planes, and the samples assayed by Kinross Gold Corporation returned both high zinc and gold values (R. Norman, Kinross Gold Corporation, personal communication, 2004). The mineralized zones are commonly schistose, and numerous bedding parallel faults and sheared zones are observed in drill core. Although the mafic rocks of the Lower Tisdale and Lower Blake River assemblages also exhibit strong deformation, the Upper Tisdale assemblage tuffs and sediments may have been more susceptible to deformation and acted as a corridor where higher strain was focussed.

The mineralization described and observed in the Marker Horizon of the Upper Tisdale assemblage, in Currie Township appears to be integrally associated with the sediments and felsic tuffs. The unit of particular interest within the Marker Horizon, based on the location of the Currie showing and the drill holes, corresponds to a magnetic high on the magnetic map (*see* Figure 23; Ontario Geological Survey 2004b), and can be traced with few breaks across the entire township. A second unit with a high magnetic signature occurs 200 to 300 m south of the first. The generally east-west orientation of these magnetic highs differs from the north-south and northeast-southwest orientations of the magnetic diabase dikes in Currie Township, and is subparallel to the interpreted Upper Tisdale–Lower Blake River assemblages boundary. These magnetic units may, therefore, be stratigraphic and used as “marker units” within the Marker Horizon of the Upper Tisdale assemblage. The lithology responsible for the magnetic signature should be defined, and the position of the mineralization in relation to the unit determined.

References

Allen, R.L. 1986. Petrology and chemistry of a komatiite sill and Fe-Ni-Cu sulfide mineralization, Munro and Beatty townships, Ontario; unpublished MSc thesis, Queen's University, Kingston, Ontario, 108p.

Arndt, N.T. 1975. Ultramafic rocks of Munro Township and their volcanic setting; unpublished PhD thesis, University of Toronto, Toronto, Ontario, 192p.

——— 1977. Thick, layered peridotite-gabbro lava flows in Munro Township, Ontario; Canadian Journal of Earth Sciences, v.14, p.2620-2637.

——— 1986. Differentiation of komatiite flows; Journal of Petrology, v.27, p.279-301.

Arndt, N.T., Naldrett, A.J. and Pyke, D.R. 1977. Komatiitic and Fe-rich tholeiitic lavas of Munro Township, northeastern Ontario; Journal of Petrology, v.18, p.319-369.

Ayer, J.A., Amelin, Y., Corfu, F., Kamo, S., Ketchum, J., Kwok, K. and Trowell, N. 2002. Evolution of the southern Abitibi greenstone belt based on U-Pb geochronology: autochthonous volcanic construction followed by plutonism, regional deformation and sedimentation; Precambrian Research, v.115, p.63-95.

Ayer, J.A., Barr, E., Bleeker, W., Creaser, R.A., Hall, G., Ketchum, J.W.F., Powers, D., Salier, B., Still, A. and Trowell, N.F. 2003. Discover Abitibi. New geochronological results from the Timmins area: implications for the timing of late-tectonic stratigraphy, magmatism and gold mineralization; Summary of Field Work and Other Activities 2003, Ontario Geological Survey, Open File Report 6120, p.33-1 to 33-11.

Ayer, J.A., Berger, B.R. and Trowell, N.F. 1999. Geological compilation of the Lake Abitibi area, Abitibi greenstone belt; Ontario Geological Survey, Preliminary Map P.3398, scale 1:100 000.

Ayer, J.A., Thurston, P.C., Bateman, R., Dubé, B., Gibson, H.L., Hamilton, M.A., Hathaway, B., Hocker, S.M., Houlé, M.G., Hudak, G., Lafrance, B., Lesher, C.M., Ispolatov, V., MacDonald, P.J., Péloquin, A.S., Piercey, S.J., Reed, L.E. and Thompson, P.H. 2005. Overview of results from the Greenstone Architecture Project: Discover Abitibi Initiative; Ontario Geological Survey, Open File Report 6154.

Ayer, J.A. and Trowell, N.F. 2000. Geological compilation of the Kirkland Lake area, Abitibi greenstone belt; Ontario Geological Survey, Preliminary Map P.3425, scale 1:100 000.

Ayer, J.A., Trowell, N.F., Amelin, Y. and Corfu, F. 1999. Geological compilation of the Abitibi greenstone belt in Ontario: toward a revised stratigraphy based on compilation and new geochronology results; *in* Summary of Field Work and Other Activities, Ontario Geological Survey, Miscellaneous Paper 169, p.14-24.

Barrie, C.T. 1999a. Geological compilation, Beatty and Munro townships; Ontario Geological Survey, Preliminary Map P.3395, scale 1:20 000.

——— 1999b. Kidd–Munro Extension Project, Year 3 report; unpublished report, C.T. Barrie and Associates Inc., Ottawa, Ontario, 263p.

Bates, R.L. and Jackson, J.A. (eds.) 1980. Glossary of geology, second edition; American Geological Institute, 749p.

Birk, D., Koljonen, J. and Rosenberg, R.J. 1979. Rare earth distribution in Archean granitoid plutons of the Wabigoon volcanic-plutonic belt, northwestern Ontario; Canadian Journal of Earth Sciences, v.16, p.270-289.

Bleeker, W. 1999. Structure, stratigraphy and primary setting of the Kidd Creek volcanogenic massive sulfide deposit: A semiquantitative reconstruction; *in* The giant Kidd Creek volcanogenic massive sulfide deposit, western Abitibi Subprovince, Canada, Economic Geology Monograph 10, p.71-122.

Burnham, O.M. and Schweyer, J. 2004. Trace element analysis of geological samples by inductively coupled plasma mass spectrometry at the Geoscience Laboratories: revised capabilities due to improvements to instrumentation; *in* Summary of Field Work and Other Activities 2004, Open File Report 6145, p.54-1 to 54-20.

Canil, D. 1985. The petrology and geochemistry of komatiites and tholeiites from the Deadman Hill area, Munro Township, Ontario; unpublished MSc thesis, University of Windsor, Windsor, Ontario, 69p.

Coad, P.R. 1976. The Potter Mine; unpublished MSc thesis, University of Toronto, Toronto, Ontario, 239p.

Corfu, F. and Davis, D.W. 1992. A U-Pb geochronological framework for the western Superior Province, Ontario; *in* Geology of Ontario, Ontario Geological Survey, Special Volume 4, Part 2, p.1335-1348.

Corfu, F., Krogh, T.E., Kwok, Y.Y. and Jensen, L.S. 1989. U-Pb zircon geochronology in the southwestern Abitibi greenstone belt, Superior Province; Canadian Journal of Earth Sciences, v.26, p.1747-1763.

Corfu, F. and Noble, S.R. 1992. Genesis of the southern Abitibi greenstone belt, Superior Province, Canada; evidence from zircon Hf isotope analyses using a single filament technique; Geochimica et Cosmochimica Acta, v.56, p.2081-2097.

Cotnoir, A. 1993. Granges Inc. Potterdoal option project #535, Report of 1992 geophysical surveys and diamond drilling, Warden and Munro townships, Larder Lake Mining Division, Granges Inc.; Kirkland Lake Resident Geologist’s office, NTS 42A/9, assessment file AFRI# 42A09NE2001.

Cullers, R.L. and Graf, J.L. 1984. Rare earth elements in igneous rocks of the continental crust: intermediate and silicic rocks - ore petrogenesis; Chapter 8 *in* Rare earth element geochemistry, Elsevier, Developments in Geochemistry, v.2, p.273-316.

Davis, P.C. 1997. Volcanic stratigraphy of the Late Archean Kidd–Munro assemblage in Dundonald and Munro townships and genesis of associated nickel and copper-zinc volcanogenic massive sulphide deposits, Abitibi greenstone belt, Ontario, Canada; unpublished MSc thesis, University of Alabama, Tuscaloosa, Alabama, 201p.

——— 1999. Classic komatiite localities and magmatic Fe-Ni-Cu-(PGE) sulphide deposits of the Abitibi greenstone belt, Ontario–Québec; *in* International Geological Correlation Program. Dynamic processes in ore-forming magmatic systems, Mineral Exploration Research Centre, Laurentian University, Sudbury, Ontario, Guidebook 1, p.70.

Davis, P.[C.], Lesher, C.M., McLaughlin, A.D. and Clemmer, S. 1993. Komatiite lava channelization, thermal erosion of andesite, and localization of Archean Fe-Ni-Cu sulfide mineralization, Munro Township, Ontario; Geological Society of America, Abstracts with Programs, v.25, pt.6, p.400.

Department of Energy, Mines and Resources 1974. Potterdoal Mine mineral inventory assessment; Department of Energy, Mines and Resources, Mineral Resources Branch, File #503143.

Donaldson, C.H. 1976. An experimental investigation of olivine morphology; Contributions to Mineralogy and Petrology, v.57, p.187-213.

Drummond, M.S. and Defant, M.J. 1990. A model for trondhjemite-tonalite-dacite genesis and crustal growth via slab melting: Archean to modern comparisons: Journal of Geophysical Research, Solid Earth and Planets, v.95, p.B21,503-B21,521.

Epp, M.S. 1997. Geology, petrography and geochemistry of the Potterdoal Cu-Zn deposit, Kidd–Munro assemblage, Munro Township, Ontario; unpublished MSc thesis, McMaster University, Hamilton, Ontario, 143p.

Epp, M.S. and Crocket, J.H. 1999. Geology and geochemistry of the Potterdoal Cu-Zn deposit, Munro Township, Ontario, *in* The giant Kidd Creek volcanogenic massive sulfide deposit, western Abitibi Subprovince, Canada, Economic Geology Monograph 10, p.593-612.

Freeman, P.V. 1954. A petrological study of the Munro asbestos 'A' orebody, Matheson, Ontario; unpublished MSc thesis, McGill University, Montreal, Quebec, 92 p.

Gamble, [A.P.]D. 2000. Geology of the Potter Cu-Zn-Co-Ag VMS mineralization and exploration progress report to March 31, 2000 at Millstream Mines Ltd. Potter Mine Exploration project; Dave Gamble Geoservices Inc., unpublished company report, 80p.

Gamble, A.P.D. and Gibson, H.L. 2000a. The geological setting of Cu-Zn-Co-Ag VMS mineralization at the Potter Mine, Munro Township, Ontario; presentation, Ontario Prospectors Association, Northeastern Ontario Mines and Minerals Symposium, April 18-19, Kirkland Lake, Ontario. [abstract available at http://www.millstreammines.com/symposium.html ; accessed June 10, 2005]

——— 2000b. Subseafloor replacement sulphides and zone refining; evidence from the Potter Mine, Ontario; presentation, Ontario Prospectors Association, Northeastern Ontario Mines and Minerals Symposium, April 18-19, Kirkland Lake, Ontario. [abstract available at http://www.millstreammines.com/symposium.html ; accessed June 10, 2005]

Gibson, H.L. and Gamble, A.P.D. 2000. A reconstruction of the volcanic environment hosting Archean seafloor and subseafloor VMS mineralization at the Potter Mine, Munro Township, Ontario, Canada; *in* Volcanic environments and massive sulfide deposits, Centre for Ore Deposit Research, University of Tasmania, Hobart, Tasmania, CODES Special Publication 3, p.65-66.

Hannington, M.D. and Barrie, C.T. eds. 1999. The Giant Kidd Creek volcanogenic massive sulfide deposit, western Abitibi Subprovince, Canada; Society of Economic Geologists, Economic Geology Monograph 10, 672p.

Hendry, N.W. 1951. Chrystolite asbestos in Munro and Beatty townships, Ontario; Canadian Institute of Mining and Metallurgy, Transactions, v.54, p.28-35.

Houlé, M.G., Lesher, C.M., Fowler, A.D., Sproule, R.A., Ayer, J.A., Gibson, H.L. and Thurston, P.C. 2000. Physical volcanology and metallogenesis of komatiites in the Abitibi greenstone belt, Superior Province, Canada*; in* Summary of Field Work and Other Activities 2000, Ontario Geological Survey, Open File Report 6032, p.11-1 to 11-8.

Houlé, M.G., Lesher, C.M., Gibson, H.L., Fowler, A.D. and Sproule, R.A. 2001. Physical volcanology of komatiites in the Abitibi greenstone belt; *in* Summary of Field Work and Other Activities 2001, Ontario Geological Survey, Open File Report 6070, p.13-1 to 13-16.

Houlé, M.G., Lesher, C.M., Gibson, H.L. and Sproule, R.A. 2002. Recent advances in komatiite volcanology in the Abitibi greenstone belt, Ontario; *in* Summary of Field Work and Other Activities 2002, Ontario Geological Survey, Open File Report 6100, p.7-1 to 7-19.

Irvine, T.N. and Baragar, W.R.A. 1971. A guide to the chemical classification of the common volcanic rocks; Canadian Journal of Earth Sciences, v.8, p.523-548.

Jackson, S. L. and Fyon, J. A. 1991. The western Abitibi Subprovince in Ontario, *in* Geology of Ontario; Ontario Geological Survey, Special Volume 4, Part 1, p.405-482.

Jensen, L.S. 1976. A new cation plot for classifying subalkalic volcanic rocks; Ontario Division of Mines, Miscellaneous Paper 66, 22p.

Jensen, L.S. and Langford, F.F. 1985. Geology and petrogenesis of the Archean Abitibi belt in the Kirkland Lake area, Ontario; Ontario Geological Survey, Miscellaneous Paper 123, 130p.

Johnstone, R.M. 1987. Geology of the Stoughton–Roquemare Group, Beatty and Munro townships, northeastern Ontario; unpublished MSc thesis, Carleton University, Ottawa, Ontario, 325p.

——— 1991a. The geology of the northwestern Black River–Matheson area, District of Cochrane; Ontario Geological Survey, Open File Report 5785, 288p.

——— 1991b. Geology of Munro Township; Ontario Geological Survey, Open File Map 159, scale 1:15 840.

Jolly, W.T. 1982. Progressive metamorphism of komatiites and related Archaean lavas of the Abitibi area, Canada; *in* Komatiites, George Allen and Unwin, p.247-266.

Kretschmar, U. and Kretschmar, D. 1986. Talc, magnesite and asbestos deposits in the Timmins–Kirkland Lake area, District of Timiskaming and Cochrane; Ontario Geological Survey, Study 28, 100p.

Laird, H.C. 1932. German–Currie area, District of Cochrane, Ontario Department of Mines, Annual Report, 1931, v.40, pt.3, p.1-22.

Leahy, E.J. 1965a. Geology of Currie and Bowman townships, District of Cochrane; Ontario Department of Mines, Geological Report 40, 22p.

——— 1965b. Precambrian geology, Currie and Bowman townships, Cochrane District; Ontario Department of Mines, Map 2071, scale 1:31 680.

Le Bas, M.J., Le Maitre, R.W., Streckeisen, A. and Zannetin, B. 1986. A chemical classification of volcanic rocks based on the total alkali-silica diagram; Journal of Petrology, v.27, p.745-750.

Leduc, M. 1981. Morphologie des faciès volcaniques et structures associées à des coulées basaltiques du Groupe de Kinojévis, canton d’Aiguebelle, Abitibi; unpublished MSc thesis, Université du Québec à Chicoutimi, Chicoutimi, Québec, 169p.

Lesher, C.M. 1989. Komatiite-associated nickel sulphide deposits; Reviews in Economic Geology, v.4, p.44-101.

Lesher, C.M., Arndt, N.T. and Groves, D.I. 1984. Genesis of komatiite-hosted nickel-sulphide deposits at Kambalda, Western Australia: a distal volcanic model; *in* Sulphide deposits in mafic and ultramafic rocks, Proceedings of IGCP Projects 161 and 91, Third Nickel Sulphide Field Conference, Perth, Western Australia, 23-25 May, 1982, Institute of Mining and Metallurgy, London, p.70-80.

Ludden, J.N. and Hubert, C. 1986. Geologic evolution of the Late Archean Abitibi greenstone belt of Canada; Geology, v.14, p.707-711.

Ludden, J.N., Hubert, C. and Gariépy, C. 1986. The tectonic evolution of the Abitibi greenstone belt of Canada; Geological Magazine, v.123, p.153-166.

MacDonald, P.J., Piercey, S.J. and Hamilton, M.A. 2005. An integrated study of intrusive rocks spatially associated with gold and base metal mineralization in Abitibi greenstone belt, Timmins area and Clifford Township: Discover Abitibi Initiative; Ontario Geological Survey, Open File Report 6160, 190p.

MacRae, N.D. 1963. Petrology of the Centre Hill Complex, northern Ontario; unpublished MSc thesis, McMaster University, Hamilton, Ontario, 102p.

——— 1966. Petrology and geochemistry of ultramafic-gabbroic intrusion in Abitibi area, Ontario; unpublished PhD thesis, McMaster University, Hamilton, Ontario, 163p.

——— 1969. Ultramafic intrusions of the Abitibi area, Ontario; Canadian Journal of Earth Sciences, v.6, p.281-301.

Ministère de l'Énergie et des Ressources du Québec–Ontario Geological Survey 1983. Lithostratigraphic map of the Abitibi Subprovince; Ontario Geological Survey / Ministère de l'Énergie et des Ressources du Québec, Map 2484, scale 1:500 000 (also catalogued as MERQ, DV 83-16 in Québec).

Oliver, J.L., Rebagliati, C.M. and Haslinger, R.J. 1999. Summary exploration report - Potter Mine property, Munro Township, Ontario for the HDG Potter Exploration Limited Partnership of Hunter Dickinson Group Inc. and Millstream Mines Limited; Hunter Dickinson Group Inc., unpublished company report, p.1-1 to 11-3.

Ontario Geological Survey 2003. Ontario airborne geophysical surveys, magnetic and electromagnetic data, Kidd–Munro, Blake River area MEGATEM® II survey; Ontario Geological Survey, Geophysical Data Set 1044.

Ontario Geological Survey 2004a. Mineral Deposit Inventory Version 2 (MDI2) - October 2004 Release; Ontario Geological Survey, Digital Data.

——— 2004b. Ontario airborne geophysical surveys, magnetic data, central Abitibi Destor-Porcupine–Pipestone faults area (Discover Abitibi); Ontario Geological Survey, Geophysical Data Set 1049.

Puchtel, I.S., Humayun, M., Campbell, A., Sproule, R.A. and Lesher, C.M. 2004. Platinum group element geochemistry of komatiites from the Alexo and Pyke Hill areas, Ontario, Canada; Geochimica et Cosmochimica Acta, v.68, p.1361-1383.

Pyke, D.R., Naldrett, A.J. and Eckstrand, A.P. 1973. Archean ultramafic flows in Munro Township, Ontario; Geological Society of America Bulletin, v.84, p.955-978.

Reed, L.E. 2005. Gravity and magnetic three-dimensional (3D) modelling: Discover Abitibi Initiative; Ontario Geological Survey, Open File Report 6163.

Satterly, J. 1952a. Geology of Munro Township; Ontario Department of Mines, Annual Report 1951, v.60, pt.8, 60p.

——— 1952b. Township of Munro, District of Cochrane, Ontario; Ontario Department of Mines, Map 1951-5, scale 1:12 000.

Shore, M. 1996. Cooling and crystallization of komatiite flows; unpublished PhD thesis, University of Ottawa, Ottawa, Ontario, 211p.

Shore, M. and Fowler, A.D. 1999. The origin of spinifex texture in komatiites; Nature, v.397, p.691-693.

Sproule, R.A., Lesher, C.M., Ayer, J.A., Thurston, P.C. and Herzberg, C.T. 2002. Spatial and temporal variations in the geochemistry of komatiites and komatiitic basalts in the Abitibi greenstone belt; Precambrian Research, v.115, p.153-186.

Stokes, W.L. and Varnes, D.J. 1955. Glossary of selected geological terms, with special reference to their use in engineering; Colorado Scientific Society, Denver, Colorado, Proceedings, v.16, 165p.

Stone, W.E., Crocket, J.H., Fleet, M.E. and Larson, M.S. 1996. PGE mineralization in Archean volcanic systems: geochemical evidence from thick, differentiated mafic–ultramafic flows, Abitibi greenstone belt, Ontario, and implications for exploration; Journal of Geochemical Exploration, v.56, p.237-264.

Sun, S-s. and McDonough, W.F. 1989. Chemical and isotopic systematics of oceanic basalts: implications for mantle composition and processes; *in* Magmatism in the ocean basins, Geological Society, Special Publication No.42, p.313-345.

Sutherland, T.F., McMillan, J.G., Sinclair, D.G., Cole, G.E. and Webster, A.R. 1928. Mines of Ontario in 1926; Ontario Department of Mines, Annual Report 1927, v.36, pt.1, p.75-178.

Tardif, N.P., Gibson, H.L., Whitehead, R.E.S., MacDonald, C.A. and Gamble, A.P.D. 2000. Subaqueous fire-fountaining, hyaloclastite and massive sulphide mineralization; presentation, Ontario Prospectors Association, Northeastern Ontario Mines and Minerals Symposium, April 18-19, Kirkland Lake, Ontario. [abstract available at http://www.millstreammines.com/symposium.html ; accessed June 10, 2005]

Thériault, R. 1992. Disequilibrium textures in the Centre Hill Complex, Munro Township, Ontario; unpublished MSc thesis, University of Ottawa, Ottawa, Ontario, 207p.

Thériault, R.D. and Fowler, A.D. 1996. Gravity driven and *in situ* fractional crystallization processes in the Centre Hill Complex, Abitibi Subprovince, Canada: evidence from bilaterally-paired cyclic units; Lithos, v.39, p.41-55.

Vaillancourt, C. 2001. Precambrian geology of the Watabeag Lake area; Ontario Geological Survey, Open File Report 6042, 61p.

Vaillancourt, C., Sproule, R.A., MacDonald, C.A. and Lesher, C.M. 2003. Investigation of mafic–ultramafic intrusions in Ontario and implications for platinum group element mineralization: Operation Treasure Hunt; Ontario Geological Survey, Open File Report 6102, 335p.

Walker, R.J., Shirey, S.B. and Stecher, O. 1988. Comparative Re–Os, Sm–Nd and Rb–Sr isotope and trace element systematics for Archean komatiite flows from Munro Township, Abitibi belt, Ontario; Earth and Planetary Science Letters, v.87, p1-12.

Zhang, Q.-Z., Machado, N., Ludden, J.N. and Moore, D.M. 1993.Geotectonic constraints from U-Pb ages for the Blake River Group, the Kinojévis Group and the Normétal Mine area, Abitibi, Québec; Geological Association of Canada–Mineralogical Association of Canada, Annual Meeting, Program with Abstracts, v.18, p.A114.

Appendix 1

Geochemical Analyses for Munro Township

XRF: X-ray Fluorescence

ICP-AES: Induced Coupled Plasma Atomic Emission Spectroscopy

ICP-MS: Induced Coupled Plasma Mass Spectroscopy

Negative values indicate analyses above or below detection limits

Appendix 1. Geochemical analyses for Munro Township.

Sample Number				04ASP016-1.1	04ASP076-3.1	04ASP091-4.1	04ASP080-1.1	04ASP086-1.1
Township				Munro	Munro	Munro	Munro	Munro
Easting	**UTM NAD83**			555947	554237	555491	553905	556103
Northing	**UTM NAD83**			5378397	5378323	5377146	5378227	5376681
Phase				Volcanic	Volcanic	Volcanic	Volcanic	Volcanic
Block				South Munro	South Munro	South Munro	South Munro	South Munro
Block Division								
Rock Type				Basalt - Massive	Basalt - Massive	Basalt - Massive	Basalt - Spherulitic	Basalt - Pillowed
Reference				Péloquin	Péloquin	Péloquin	Péloquin	Péloquin
Actlab	method	units	2004 d.l.					
SiO2	XRF	wt%	0.01	55.57	47.81	68.32	65.36	47.41
TiO2	XRF	wt%	0.01	1.45	1.6	0.56	0.93	1.74
Al2O3	XRF	wt%	0.01	14.56	13.43	10.75	11.88	12.98
Fe2O3	XRF	wt%	0.01	8.95	15.4	9.03	10.28	15.83
MgO	XRF	wt%	0.01	3.71	5.94	1.18	1.64	5.09
CaO	XRF	wt%	0.01	8.94	8.76	2.31	2.38	10.53
Na2O	XRF	wt%	0.01	2.53	2.52	4.03	4.7	1.65
K2O	XRF	wt%	0.01	0.07	0.24	0.22	0.16	0.12
MnO	XRF	wt%	0.001	0.187	0.24	0.148	0.106	0.26
P2O5	XRF	wt%	0.01	0.2	0.16	0.13	0.21	0.19
Cr2O3	XRF	wt%	0.01	0.03	0.02	0	0	0.02
LOI	XRF	wt%	0.01	3.87	3.6342	3.3736	2.4927	4.3736
TOTAL				100.067	99.7542	100.0416	100.1287	100.1936
ActLab								
C	Infrared	%	0.01					
S	Infrared	%	0.01					
ActLab								
Ni	XRF	ppm	5	106	70	-4	-4	63
Cr	XRF	ppm	5	257	136	-8	-8	120
Nb	XRF	ppm	2	11	2	17	11	9
Y	XRF	ppm	2	24	30	104	79	33
Zr	XRF	ppm	5	127	102	460	338	119
V	XRF	ppm	5	222	371	-5	38	380
OGL								
Al	ICP-AES	ppm	100	65996	67149	53020	57213	64637
Ba	ICP-AES	ppm	1	25	81	84	28	45
Be	ICP-AES	ppm	0	0.3	0.39	0.64	0.61	0.44
Ca	ICP-AES	ppm	50	60553	62263	16989	17518	76518
Cd	ICP-AES	ppm	2					
Co	ICP-AES	ppm	1	42	50	5	12	48
Cr	ICP-AES	ppm	1	174.19	114.85	15.33	9.03	105.19
Cu	ICP-AES	ppm	3	66	80		12	76
Fe	ICP-AES	ppm	100	56137	-100000	64600	72295	-100000
K	ICP-AES	ppm	60	293	1643	1558	1043	809
Li	ICP-AES	ppm	1	19	19	19	19	15
Mg	ICP-AES	ppm	70	19869	34174	6839	8880	29381
Mn	ICP-AES	ppm	1	1151	1629	1032	708	1800
Mo	ICP-AES	ppm	8					
Na	ICP-AES	ppm	150	18576	19033	29829	34803	12415
Ni	ICP-AES	ppm	3	103	88	7	10	81
P	ICP-AES	ppm	10	754	619	483	868	756
S	ICP-AES	ppm	43	148	-400	289	84	-400
Sc	ICP-AES	ppm	0.3	24.7	39.2	11.7	16.1	39.9
Sr	ICP-AES	ppm	0.7	267.2	116.8	68	49.2	238.1
Ti	ICP-AES	ppm	10	6997	8180	2516	4491	9016
V	ICP-AES	ppm	1	202.4	-320		26.3	-320
W	ICP-AES	ppm	2	4		2		
Y	ICP-AES	ppm	0.2	18.1	26.2	101.8	73.3	28.8
Zn	ICP-AES	ppm	2	97.7	116.06	150.783	142.01	142.15
OGL								
Ce	ICP-MS	ppm	0.07	19.15	13.96	53.03	28.53	15.98
Cs	ICP-MS	ppm	0.007	0.112	0.407	0.278	0.701	0.285
Dy	ICP-MS	ppm	0.008	4.557	5.897	20.124	14.561	6.192
Er	ICP-MS	ppm	0.008	2.764	3.727	13.988	9.864	4.017
Eu	ICP-MS	ppm	0.005	1.362	1.304	2.897	2.216	1.509
Gd	ICP-MS	ppm	0.009	4.525	5.129	17.118	12.122	5.608
Hf	ICP-MS	ppm	0.1	3.3	2.9	13.6	10.1	3.4
Ho	ICP-MS	ppm	0.003	0.96	1.268	4.471	3.256	1.355
La	ICP-MS	ppm	0.02	7.04	5.1	19.83	9.33	5.89
Lu	ICP-MS	ppm	0.003	0.374	0.535	2.189	1.562	0.594
Nb	ICP-MS	ppm	0.2	6.8	4.7	17.2	12.1	5.7
Nd	ICP-MS	ppm	0.03	14.3	11.82	42.04	25.44	13.49
Pr	ICP-MS	ppm	0.006	2.849	2.268	8.356	4.694	2.572
Rb	ICP-MS	ppm	0.05	0.72	4.65	5.31	2.14	1.69
Sm	ICP-MS	ppm	0.01	3.91	3.8	13.14	8.86	4.24
Sr	ICP-MS	ppm	0.5	325.5	130.7	67.7	51.2	263.2
Ta	ICP-MS	ppm	0.17	0.4	0.28	1.1	0.8	0.34
Tb	ICP-MS	ppm	0.003	0.738	0.897	3.026	2.204	0.961
Th	ICP-MS	ppm	0.06	0.65	0.33	1.9	1.15	0.4
Tm	ICP-MS	ppm	0.003	0.394	0.542	2.115	1.469	0.588
U	ICP-MS	ppm	0.007	0.203	0.118	0.519	0.334	0.113
Y	ICP-MS	ppm	0.02	25.2	32.18	112.78	84.2	34.4
Yb	ICP-MS	ppm	0.01	2.49	3.55	14.31	10.08	3.9
Zr	ICP-MS	ppm	4	139	109.1	483.1	357.9	126.2

Appendix 1. Geochemical analyses for Munro Township.

Sample Number	04ASP086-2.1	04ASP067-1.1	04ASP019-1.1	04ASP107-1.1	04ASP021-2.1	04ASP091-3.1
Township	Munro	Munro	Munro	Munro	Munro	Munro
Easting	556103	555609	555975	554191	555952	555491
Northing	5376681	5377517	5377961	5380594	5378050	5377146
Phase	Volcanic	Volcanic	Volcanic	Volcanic	Volcanic	Volcanic
Block	South Munro	South Munro	South Munro	South Munro	South Munro	South Munro
Block Division						
Rock Type	Basalt - Pillowed	Basalt - Pillowed	Basalt - Pillowed	Komatiite - Sill	Rhyolite - Lobe & Breccia	Rhyolite - Spherulitic
Reference	Péloquin	Péloquin	Péloquin	Péloquin	Péloquin	Péloquin
Actlab						
SiO2	74.88	49.51	52.96	40.54	73.99	76.14
TiO2	0.35	1.58	1.69	1.49	0.18	0.49
Al2O3	10.15	14	10.85	12.2	12.3	10.45
Fe2O3	6.11	12.35	17.67	14.07	3.76	4.45
MgO	0.82	3.9	0.94	3.47	0.6	0.61
CaO	1.44	11.21	6.5	6.86	2.04	1.46
Na2O	4.31	1.9	2.57	5.44	2.01	4.36
K2O	0.88	0.24	0.28	0.87	3.42	0.63
MnO	0.107	0.27	0.36	0.248	0.085	0.075
P2O5	0.03	0.14	0.77	0.12	0.01	0.11
Cr2O3	0	0.02	0	0	0	0.01
LOI	1.3178	4.6249	5.5336	15.0914	1.3973	1.753
TOTAL	100.3848	99.7449	100.1136	100.3894	99.7823	100.538
ActLab						
C						
S						
ActLab						
Ni	-4	74	-4	20	-4	-4
Cr	-8	131	-8	-8	-8	-8
Nb	35	6	15	3	78	16
Y	182	29	84	25	240	101
Zr	735	90	659	98	370	475
V	-5	338	22	268	-5	-5
OGL						
Al	43290	70705	50504	59508	54888	47371
Ba	144	104	149	62	858	131
Be	1.33	0.37	0.85	0.45	3.71	0.64
Ca	10950	82499	43871	45988	14129	11419
Cd				0		
Co	2	55	17	30	2	5
Cr	21.02	119.86	4.95	9.41	15.19	17.11
Cu	7	88	22	108		3
Fe	44041	84335	-100000	95390	24484	31716
K	6273	1695	1840	6556	23704	4592
Li	7	21	13	0	9	11
Mg	1498	22562	5004	19724	2820	1654
Mn	708	1863	2393	1505	536	497
Mo				0		
Na	31654	14510	19124	38589	14929	32175
Ni	5	88	14	41	6	5
P	126	543	3294	441		438
S	-400	-400	-400	260	103	-400
Sc	5.2	40.3	26.6	15.6	1.4	8.2
Sr	62	202.5	67	111.5	90.4	45.8
Ti	1603	8020	8798	9654	766	2323
V	0.7	-320		214.2		2.9
W	4		5	9		2
Y	-120	25.8	69.8	23.8	-120	96
Zn	136.44	133.58	203.218	79	182.645	98.47
OGL						
Ce	73.37	14.02	61.28	19.4	267.174	49.6
Cs	0.766	0.317	3.92	0.192	1.337	0.443
Dy	33.929	5.815	17.715	4.734	52.59	18.994
Er	24.282	3.703	10.736	2.732	32.112	12.729
Eu	2.962	1.264	4.681	1.286	4.97	2.769
Gd	25.904	5.103	17.839	4.828	49.832	16.155
Hf	22.5	2.8	16.5	2.7	17.1	14
Ho	7.783	1.233	3.684	0.959	10.918	4.18
La	25.09	5.12	21.53	7.55	102.9	16.39
Lu	3.552	0.533	1.586	0.361	4.312	1.883
Nb	31	4.5	23.5	5.6	62.1	18.6
Nd	59.6	11.74	50.12	14.49	172.163	39.98
Pr	11.715	2.278	9.787	2.906	38.406	7.936
Rb	16.72	5.15	10.8	14.15	85.93	13.1
Sm	19.02	3.84	14.48	4.04	44.275	12.46
Sr	62.6	223.1	77.3	113.2	104.8	45.6
Ta	1.95	0.28	1.29	0.34	3.8	1.18
Tb	4.797	0.883	2.842	0.773	8.413	2.878
Th	3.3	0.34	1.4	0.61	8.86	1.8
Tm	3.628	0.533	1.543	0.389	4.681	1.901
U	0.998	0.104	0.398	0.179	2.196	0.573
Y	200.538	31.61	94.37	24.74	284.785	108.65
Yb	23.699	3.56	10.24	2.48	30.159	12.56
Zr	775.8	99.4	720.5	102.9	432.7	489.1

Appendix 1. Geochemical analyses for Munro Township.

Sample Number	04ASP079-2.1	04ASP025-1.1	04ASP062-2.1	04ASP062-3.1	04ASP070-1.1	04ASP057-1.1	04ASP065-1.1
Township	Munro	Munro	Munro	Munro	Munro	Munro	Munro
Easting	553958	553521	559367	559367	558290	560374	559576
Northing	5378295	5380490	5378043	5378043	5379260	5379390	5378343
Phase	Volcanic	Volcanic	Volcanic	Volcanic	Volcanic	Volcanic	Volcanic
Block	South Munro	South Munro	Central Munro	Central Munro	Central Munro	Central Munro	Central Munro
Block Division							
Rock Type	Rhyolite - Spherulitic	Rhyolite - Massive	Basalt	Basalt	Basalt - Komatiitic	Basalt - Massive	Basalt - Pillowed
Reference	Péloquin	Péloquin	Péloquin	Péloquin	Péloquin	Péloquin	Péloquin
Actlab							
SiO2	78.55	77.34	52.41	47.27	51.26	48.67	48.73
TiO2	0.41	0.15	1.43	1.57	0.73	1.04	1.71
Al2O3	10.32	10.42	13.77	13.79	15.01	14.22	13.49
Fe2O3	2.96	2.5	11.44	16.91	10.98	13.81	13.82
MgO	0.27	0.15	6.06	7.36	7.44	7.18	4.2
CaO	0.93	0.61	8.14	7.07	9.42	11.09	12.52
Na2O	4.57	1.52	4	3.58	2.17	1.75	1.55
K2O	0.69	5.91	0.22	0.2	0.47	0.25	0.5
MnO	0.028	0.025	0.22	0.32	0.17	0.215	0.287
P2O5	0.07	0.01	0.11	0.15	0.07	0.08	0.15
Cr2O3	0	0	0.01	0.02	0.04	0.03	0.01
LOI	1.2659	0.4826	2.2806	1.9732	2.276	1.9627	3.4464
TOTAL	100.0539	99.1076	100.0906	100.2132	100.036	100.2977	100.4134
ActLab							
C							
S							
ActLab							
Ni	-4	-4	46	84	61	88	55
Cr	-8	-8	86	140	184	153	106
Nb	25	80	4	3	4	2	7
Y	143	256	28	31	16	24	32
Zr	603	355	76	95	58	61	91
V	-5	-5	387	375	208	278	385
OGL							
Al	52589	48037	66191	63472	75103	62768	68107
Ba	143	1149	102	169	115	44	150
Be	0.81	3.9	0.27	0.28	0.19	0.19	0.27
Ca	7256	4315	54646	46580	69989	71672	88534
Cd							
Co	3	2	48	57	46	50	58
Cr	20.4	18.86	77.99	119.62	220.22	131.75	108.16
Cu	13	7	96	80	77	100	103
Fe	22065	16819	73695	-100000	76384	84234	93036
K	5117	42570	1515	1099	3575	1624	3859
Li	13	2	7	13	11	10	6
Mg	1618	787	34119	40328	43336	38107	24469
Mn	209	164	1505	2076	1209	1278	1947
Mo							
Na	34813	10903	27413	24915	16945	11929	11127
Ni	4	4	65	97	83	94	81
P	247		397	559	226	222	564
S	-400	-400	-400	173	152	-400	-400
Sc	7.8	1.1	42.5	38.8	29.4	34.7	45
Sr	35.6	50.5	151.2	80.3	235.9	102.6	238.7
Ti	1902	683	7499	7816	3331	4699	9725
V	2.7		-320	-320	209.7	258.8	-320
W	5		5				
Y	-120	-120	23.5	24.2	13.1	17.8	27.6
Zn	75.5	39.09	89.07	101.07	100.47	90.83	120.16
OGL							
Ce	74.6	217.424	10.59	12.35	10.93	9.02	12.16
Cs	0.69	0.55	0.187	0.591	0.822	0.352	0.191
Dy	26.534	47.669	4.965	5.459	2.774	4.493	5.437
Er	18.551	29.747	3.2	3.485	1.731	2.91	3.491
Eu	2.97	4.261	1.249	1.17	0.779	0.947	1.197
Gd	22.065	42.334	4.261	4.86	2.619	3.851	4.648
Hf	18	16.1	2.3	2.6	1.7	2	2.6
Ho	5.924	10.18	1.063	1.162	0.594	0.976	1.169
La	25.81	88.42	3.85	4.36	4.32	3.19	4.58
Lu	2.842	3.862	0.452	0.513	0.251	0.436	0.506
Nb	23.9	57	3.3	4.3	2.2	3.1	4.1
Nd	59.81	136.016	9.05	10.65	7.52	8.15	10.53
Pr	11.829	30.404	1.726	2.006	1.612	1.502	1.971
Rb	13.93	94.48	5.07	2.9	13.55	7.99	10.37
Sm	17.8	36.03	3.04	3.49	2.11	2.75	3.46
Sr	35.8	53.2	158.5	91.7	263.9	132.9	229.4
Ta	1.51	3.46	0.2	0.32		0.18	0.25
Tb	3.952	7.425	0.742	0.833	0.437	0.676	0.819
Th	2.76	7.36	0.24	0.3	0.49	0.21	0.3
Tm	2.8	4.249	0.467	0.518	0.253	0.434	0.508
U	0.753	1.82	0.075	0.086	0.136	0.065	0.093
Y	159.931	287.672	26.98	30.24	15.34	24.9	30.22
Yb	18.8	27.004	3.04	3.38	1.66	2.92	3.3
Zr	641.7	392.3	76	95.6	59.7	66.3	91.4

Appendix 1. Geochemical analyses for Munro Township.

Sample Number	04ASP103-1.1	04ASP074-2.1	04ASP065-2.1	04ASP049-1.1	04ASP105-3.1	04ASP110-1.1	04ASP111-3.1
Township	Munro	Munro	Munro	Munro	Munro	Munro	Munro
Easting	554813	558620	559576	560721	554354	558220	558027
Northing	5381090	5379695	5378343	5379873	5380816	5382552	5383049
Phase	Volcanic	Volcanic	Volcanic	Volcanic	Volcanic	Volcanic	Volcanic
Block	Central Munro	Central Munro	Central Munro	Central Munro	Central Munro	Central Munro	North Munro
Block Division							South McCool Syncline
Rock Type	Basalt - Pillowed	Basalt - Pillowed	Basalt - Pillowed	Basalt - Pillowed	Basalt - Pillowed	Basalt - Pillowed	Basalt - Peperite
Reference	Péloquin	Péloquin	Péloquin	Péloquin	Péloquin	Péloquin	Péloquin
Actlab							
SiO2	49.05	48.16	48.34	48.5	50.05	50.13	45.82
TiO2	1.42	1.13	1.57	1.16	1.47	0.35	1.1
Al2O3	12.98	13.47	15.71	14.74	12.85	19.14	8.97
Fe2O3	16.59	14.89	11.65	12.32	14.94	7.64	14.64
MgO	5.74	5.55	4.67	5.65	6.01	7.25	11.4
CaO	7.89	11.16	11.51	11.57	8.33	10.06	11.87
Na2O	2.82	1.78	2.24	1.99	4.41	2.31	1.81
K2O	0.33	0.29	0.41	0.41	0.08	1.37	0.25
MnO	0.298	0.264	0.235	0.255	0.215	0.273	0.241
P2O5	0.12	0.09	0.15	0.14	0.13	0.04	0.09
Cr2O3	0.01	0.01	0.01	0.03	0	0.08	0.14
LOI	2.8251	3.6895	3.6826	3.4429	1.6005	1.7394	4.1049
TOTAL	100.0731	100.4835	100.1776	100.2079	100.0755	100.3824	100.4359
ActLab							
C						0.01	0.65
S						0.02	0.02
ActLab							
Ni	33	54	39	56	47	252	332
Cr	49	71	64	203	23	536	1019
Nb	3	2	5	5	1	2	1
Y	33	26	32	33	24	14	20
Zr	89	75	103	95	101	25	67
V	346	313	331	271	259	190	249
OGL							
Al	65779	68003	76507	65652	62396	97628	44715
Ba	100	139	137	135	30	655	229
Be	0.37	0.22	0.26	0.23	0.4	0.14	0.33
Ca	56701	80754	78877	76206	53956	67840	81305
Cd					0	0	0
Co	54	51	44	46	38	51	69
Cr	54.61	72.96	76.3	208.68	36.12	-400	-400
Cu	93	114	70	87	136	0	100
Fe	-100000	-100000	76073	75918	-100000	51309	99489
K	2224	1975	2813	2749	347	10116	1594
Li	8	13	8	6	1	9	6
Mg	33656	31766	26186	30343	33990	41289	-60000
Mn	2030	1729	1521	1536	1500	1932	1687
Mo					0	0	0
Na	21662	13361	16036	13902	30507	16177	12901
Ni	57	73	58	70	78	270	367
P	453	290	584	463	475	55	308
S	-400	-400	-400	-400	0	0	0
Sc	41.7	38.2	33.2	33.9	23.1	41.7	30.9
Sr	134	120.4	141.9	115.3	53	195.3	91.8
Ti	7032	5438	8608	5317	9582	2097	7006
V	-320	298	308	233.9	246.7	173.8	228
W					14	5	5
Y	29.3	21.4	26.3	25.1	21.5	11.7	17.8
Zn	117.76	115.22	141.73	117.07	127	54	119
OGL							
Ce	12.56	10.19	17.46	14.12	14.62	2.62	13.19
Cs	1.565	0.312	0.314	0.571	0.763	0.787	0.178
Dy	6.011	4.554	6.396	5.903	4.481	1.797	3.662
Er	4.038	2.964	4.004	3.846	2.597	1.561	2.055
Eu	1.363	0.923	1.464	1.213	1.019	0.234	1.062
Gd	5.013	3.967	5.728	5.052	4.457	1.107	3.68
Hf	2.7	2.2	3.3	2.7	2.7	0.7	2
Ho	1.314	1.001	1.351	1.292	0.909	0.456	0.74
La	4.55	3.64	6.39	5.03	4.88	0.98	4.94
Lu	0.606	0.439	0.567	0.573	0.36	0.296	0.275
Nb	4	3.3	5.6	4.2	5.3	0.9	3.6
Nd	10.89	8.83	13.92	11.59	12.39	2.19	10.48
Pr	2.065	1.701	2.727	2.213	2.453	0.44	2.088
Rb	6.92	6.7	12.7	15.24	1.1	39.03	1.34
Sm	3.62	2.93	4.39	3.78	3.78	0.7	3.08
Sr	143.7	134.2	164.9	133.8	54.8	204.5	95.3
Ta	0.24	0.2	0.33	0.25	0.33		0.23
Tb	0.897	0.696	0.979	0.877	0.723	0.227	0.591
Th	0.31	0.28	0.5	0.33	0.6	0.11	0.37
Tm	0.602	0.436	0.578	0.566	0.376	0.262	0.292
U	0.103	0.081	0.139	0.1	0.175	0.03	0.116
Y	33.8	26.16	35.2	33.19	22.83	12.26	18.81
Yb	3.94	2.92	3.77	3.79	2.42	1.8	1.87
Zr	95.4	77.2	120.3	95.5	103.8	23.9	72.5

Appendix 1. Geochemical analyses for Munro Township.

Sample Number	04ASP111-2.1a	04ASP109-1.1	04ASP128-1.1	04ASP126-1.1	04ASP123-1.1
Township	Munro	Munro	Munro	Munro	Munro
Easting	558027	558538	557949	557870	558348
Northing	5383049	5383177	5384244	5384177	5384188
Phase	Volcanic	Volcanic	Volcanic	Volcanic	Volcanic
Block	North Munro	North Munro	North Munro	North Munro	North Munro
Block Division	South McCool Syncline	South McCool Syncline	North McCool Syncline	North McCool Syncline	North McCool Syncline
Rock Type	Basalt - Sill	Komatiite - Spinifex	Basalt - Gabbroic	Komatiite	Komatiite
Reference	Péloquin	Péloquin	Péloquin	Péloquin	Péloquin
Actlab					
SiO2	42.87	43.65	50.42	40.69	39.28
TiO2	1.09	0.35	1.63	0.22	0.21
Al2O3	7.69	9.5	12.7	4.86	4.06
Fe2O3	17.37	12.44	16.4	11.57	9.18
MgO	12.45	17.7	5.35	29.72	31.39
CaO	12.81	11.58	7.64	4.48	5.88
Na2O	0.7	0.28	4.46	0.05	0.02
K2O	0.18	0.05	0.19	0.04	0.04
MnO	0.275	0.204	0.205	0.179	0.265
P2O5	0.09	0.03	0.12	0.02	0.03
Cr2O3	0.2	0.28	0	0.52	0.77
LOI	4.1833	4.2959	1.1265	8.0532	9.0015
TOTAL	99.9083	100.3599	100.2315	100.4022	100.1265
ActLab					
C	0.58	0.01			
S	0.14	0.03			
ActLab					
Ni	433	499	31	1462	1601
Cr	1355	1610	10		
Nb	-1	-1	4	-1	-1
Y	18	10	23	9	8
Zr	68	18	90	16	16
V	256	219	298	89	82
OGL					
Al	39075	48680	64861	24507	20257
Ba	48	8	49	4	9
Be	0.33	0.13	0.51		0.11
Ca	90250	80488	49900	29995	39568
Cd	0	0	0		
Co	81	97	36	129	117
Cr	-400	-400	17.34	-400	-400
Cu	38	7	29	40	14
Fe	-100000	86262	-100000	79145	62615
K	1225	135	934	75	154
Li	9	9	9	1	1
Mg	-60000	-60000	29437	-60000	-60000
Mn	1934	1407	1349	1161	1760
Mo	0	0	0		
Na	5397	2124	31270	616	400
Ni	508	530	55	1411	1502
P	322	51	440	75	80
S	-400	0	0	122	
Sc	32.2	33.6	20.3	18	15.1
Sr	37.2	20.7	165.3	4.8	7.4
Ti	7201	2095	10127	1180	1118
V	241.4	251.1	297.2	84.1	69.2
W	4	5	0		
Y	18.5	8.3	20.2	6	5.3
Zn	145	82	96	65	83
OGL					
Ce	14.02	1.82	19.76	1.26	1.46
Cs	0.439	0.267	0.175	0.612	0.274
Dy	3.755	1.419	4.46	0.923	0.801
Er	2.136	0.895	2.525	0.6	0.519
Eu	1.104	0.352	1.379	0.249	0.164
Gd	3.815	1.123	4.561	0.726	0.628
Hf	2.1	0.5	2.5	0.4	0.4
Ho	0.769	0.31	0.893	0.202	0.169
La	5.26	0.64	7.45	0.46	0.55
Lu	0.286	0.137	0.335	0.09	0.077
Nb	3.7	0.4	5.3	0.3	0.4
Nd	11.09	1.83	14.59	1.24	1.26
Pr	2.186	0.326	2.977	0.22	0.241
Rb	3.06	0.92	1.62	0.99	1.4
Sm	3.2	0.75	4.01	0.5	0.44
Sr	39	21.6	173.8	5.1	7.9
Ta	0.23		0.32		
Tb	0.614	0.206	0.724	0.137	0.116
Th	0.4		0.59		
Tm	0.303	0.138	0.366	0.091	0.076
U	0.119	0.015	0.172	0.009	0.013
Y	19.22	7.91	22.72	5.32	4.53
Yb	1.96	0.89	2.3	0.6	0.5
Zr	74.9	18.1	94.4	13.3	13.5

Appendix 1. Geochemical analyses for Munro Township.

Sample Number	04ASP101-4.1	04ASP122-4.1	04ASP-KDS-00-01-1.1	04ASP-KDS-00-01-2.1	04ASP-KDS-00-01-3.1
Township	Munro	Munro	Munro	Munro	Munro
Easting	558428	558101			
Northing	5385486	5385575			
Phase	Volcanic	Volcanic	Volcanic	Volcanic	Volcanic
Block	North Munro	North Munro	North Munro	North Munro	North Munro
Block Division	North Warden Fault	North Warden Fault	North Warden Fault	North Warden Fault	North Warden Fault
Rock Type	Basalt - Brecciated	Basalt	Basalt - uphole from tuff	Basalt - downhole from tuff	Basalt - downhole from tuff
Reference	Péloquin	Péloquin	Péloquin	Péloquin	Péloquin
Actlab					
SiO2	53.73	45.15	49.38	53.68	42.99
TiO2	0.74	1.42	1.39	0.73	0.61
Al2O3	15.43	12.42	12.74	14.08	10.02
Fe2O3	9.84	12.36	15.24	7.63	12.49
MgO	7.36	13.48	4.94	8.48	20.02
CaO	7.96	7.75	12.72	5.72	6.55
Na2O	2.6	1.8	0.97	4.12	0.11
K2O	0.95	0.72	0.13	1.37	0.04
MnO	0.179	0.177	0.251	0.124	0.25
P2O5	0.08	0.21	0.12	0.58	0.05
Cr2O3	0.03	0	0	0.08	0.19
LOI	1.4149	4.6158	2.5895	3.6036	6.8165
TOTAL	100.3139	100.0928	100.4605	100.1976	100.1365
ActLab					
C		0.01	0.14	0.22	0.09
S		0.02	0.22	0.04	0.02
ActLab					
Ni	70	34	47	169	214
Cr	198	23	34	572	1205
Nb	2	6	2	10	-1
Y	15	23	24	32	17
Zr	59	98	94	221	36
V	215	264	258	154	220
OGL					
Al	78460	60533	60136	66965	48869
Ba	338	493	65	358	12
Be	0.32	0.37	0.53	1.33	0.4
Ca	54384	52274	83514	38059	43249
Cd	0	0	0	0	0
Co	45	38	40	32	62
Cr	218.65	37.16	38.37	-400	-400
Cu	16	73	156	43	65
Fe	67124	83244	97386	50266	82912
K	7155	5448	770	10267	70
Li	9	8	2	10	23
Mg	43692	-60000	27058	48234	-60000
Mn	1252	1155	1650	831	1623
Mo	0	0	0	0	0
Na	18384	11925	6894	28276	752
Ni	105	59	70	194	234
P	245	462	411	2390	147
S	-400	0	-400	193	46
Sc	30.9	18.1	20.7	17.9	38.5
Sr	204	200.2	47.7	299.4	14.6
Ti	4683	8953	8672	4385	3703
V	214.3	238	235.5	125.6	226.5
W	10	4	7	0	0
Y	13.1	20.3	19.5	29.6	14.3
Zn	48	117	133	72	95
OGL					
Ce	9.49	18.8	18.59	164.01	4.1
Cs	0.632	1.008	0.143	0.399	0.968
Dy	2.381	4.499	4.45	7.356	2.595
Er	1.487	2.563	2.527	2.806	1.795
Eu	0.764	1.538	1.301	4.046	0.442
Gd	2.26	4.42	4.53	13.026	2.128
Hf	1.6	2.8	2.7	5.6	1
Ho	0.517	0.902	0.917	1.196	0.584
La	3.82	6.9	7.14	75.11	1.49
Lu	0.211	0.356	0.345	0.268	0.256
Nb	2.3	5.4	5.1	7	0.9
Nd	6.68	14.27	14.17	85.37	3.74
Pr	1.394	2.861	2.87	21.111	0.694
Rb	29.06	9.74	1.12	14.63	1.09
Sm	1.86	3.98	3.93	16.13	1.42
Sr	213	216.8	50.9	315.8	15.9
Ta		0.34	0.32	0.32	
Tb	0.382	0.738	0.734	1.588	0.381
Th	0.53	0.62	0.59	9.61	0.1
Tm	0.217	0.376	0.367	0.338	0.268
U	0.146	0.179	0.171	3.191	0.032
Y	13.54	22.75	22.68	32.55	15.56
Yb	1.45	2.38	2.34	2.05	1.76
Zr	59.7	103.2	98.4	230	34

Appendix 1. Geochemical analyses for Munro Township.

Sample Number	04ASP114-1.1	04ASP119-1.1	04ASP100-2.1	04ASP122-1.1	04ASP121-1.1	04ASP118-1.1
Township	Munro	Munro	Munro	Munro	Munro	Munro
Easting	557741	558023	558486	558101	558136	557968
Northing	5385071	5385361	5385588	5385575	5385507	5385260
Phase	Volcanic	Volcanic	Volcanic	Volcanic	Volcanic	Volcanic
Block	North Munro	North Munro	North Munro	North Munro	North Munro	North Munro
Block Division	North Warden Fault	North Warden Fault	North Warden Fault	North Warden Fault	North Warden Fault	North Warden Fault
Rock Type	Basalt - Komatiitic	Basalt - Komatiitic	Basalt - Massive	Basalt - Variolitic	Komatiite - Massive	Komatiite - Massive
Reference	Péloquin	Péloquin	Péloquin	Péloquin	Péloquin	Péloquin
Actlab						
SiO2	51.42	50.13	49.14	49.17	40.83	42.65
TiO2	0.82	0.66	1.59	1.49	0.25	0.36
Al2O3	13.17	13.03	13.94	13.01	5.09	7.27
Fe2O3	11.18	12.3	16.56	14.11	13.5	10.82
MgO	7.9	9.98	5.35	4.83	29.07	25.41
CaO	7.82	10.15	6.55	8.91	4.64	5.86
Na2O	4.97	2.35	4.46	4.84	0.26	0.32
K2O	0.07	0.05	0.17	0.06	0.09	0.23
MnO	0.156	0.195	0.205	0.215	0.189	0.18
P2O5	0.08	0.05	0.13	0.13	0.03	0.04
Cr2O3	0.04	0.08	0	0	0.51	0.33
LOI	2.6468	1.4509	2.1437	3.4624	6.0182	6.7423
TOTAL	100.2728	100.4259	100.2287	100.2174	100.4772	100.2123
ActLab						
C				0.65		
S				0.38		
ActLab						
Ni	79	103	32	44	950	1519
Cr	211	551	9	23		2163
Nb	1	-1	8	3	-1	-1
Y	21	17	27	25	8	10
Zr	60	39	108	100	15	21
V	245	226	274	260	101	118
OGL						
Al	70050	64926	70955	62694	24898	34712
Ba	67	22	93	29	8	15
Be	0.22	0.17	0.41	0.44	0	0.11
Ca	51560	66940	45241	58666	30131	38212
Cd	0	0		0	0	0
Co	41	56	52	37	142	96
Cr	232.34	-400	19.51	35.08	-400	-400
Cu	78	91	135	163	36	25
Fe	74407	83620	-100000	91647	89741	70825
K	170	236	1220	188	329	1523
Li	0	0	4	0	0	1
Mg	45052	58863	31629	27109	-60000	-60000
Mn	1083	1361	1407	1448	1242	1112
Mo	0	0		0	0	0
Na	33298	16442	32158	33670	2160	2375
Ni	105	140	60	72	911	1250
P	276	152	513	478	97	97
S	278	-400	-400	-400	222	308
Sc	36.5	38.7	21.7	21.6	18.3	22.1
Sr	113.6	59.8	207.9	81.3	9.6	23.9
Ti	5002	4007	8307	9557	1398	2031
V	242.3	237	258.5	248.1	92	126.2
W	0	0		0	4	0
Y	18	14.2	23	21.7	5.9	8.6
Zn	81	90	119.33	107	80	71
OGL						
Ce	8.63	4.77	19.32	16.78	1.15	1.98
Cs	0.637	0.325	1.173	0.35	0.264	1.431
Dy	3.398	2.728	5.065	4.641	0.935	1.458
Er	2.208	1.776	2.993	2.709	0.612	0.953
Eu	0.606	0.553	1.543	1.193	0.192	0.282
Gd	2.827	2.196	5.11	4.748	0.739	1.131
Hf	1.7	1.1	3.1	2.8	0.4	0.6
Ho	0.747	0.589	1.041	0.961	0.205	0.322
La	3.32	1.76	6.77	6.08	0.4	0.72
Lu	0.323	0.256	0.4	0.362	0.093	0.143
Nb	2.4	1.3	5.9	5.4	0.3	0.5
Nd	6.58	4.3	15.21	13.51	1.19	1.85
Pr	1.304	0.794	3.009	2.642	0.206	0.33
Rb	1.26	0.71	3.97	0.64	1.8	10.9
Sm	2.09	1.53	4.47	4.06	0.48	0.7
Sr	116.3	62.2	218	85.2	10.4	25.2
Ta			0.37	0.34		
Tb	0.504	0.401	0.836	0.765	0.135	0.207
Th	0.35	0.16	0.66	0.63		
Tm	0.324	0.262	0.416	0.383	0.093	0.142
U	0.088	0.052	0.199	0.187	0.011	0.018
Y	18.94	15.23	25.97	24.01	5.43	8.47
Yb	2.11	1.72	2.71	2.48	0.61	0.94
Zr	60	39.3	111.8	105.3	13.7	21.4

Appendix 1. Geochemical analyses for Munro Township.

Sample Number	04ASP038-1.2	04ASP046-1.1		04JAA-0001	04JAA-0002
Township	Munro	Munro		Munro	Munro
Easting	555606	559670	**UTM NAD83**	555107	558199
Northing	5377849	5382058	**UTM NAD83**	5377699	5383067
Phase	Intrusive	Intrusive		Volcanic	Intrusive
Block	South Munro	Central Munro		South Munro	North Munro
Block Division					South McCool Syncline
Rock Type	Peridotite	Granodiorite - Xenoliths		Rhyolite - Massive	Gabbro
Reference	Péloquin	Péloquin	**Lab and methods not listed**	Ayer	Ayer
Actlab					
SiO2	46.1	62.53		76.21	49.88
TiO2	1.93	0.42		0.45	1.42
Al2O3	13.2	16.68		12.24	13.21
Fe2O3	13.4	5.28		4.89	16.17
MgO	4.47	2.54		0.82	5.21
CaO	7.82	4.93		0.26	8.96
Na2O	3.42	4.78		0.27	3.72
K2O	0.16	0.94		2.96	0.24
MnO	0.21	0.089		0.07	0.192
P2O5	0.19	0.14		0.07	0.15
Cr2O3	0.03	0		0	0
LOI	8.7351	1.4066		2.1243	1.2857
TOTAL	99.6651	99.7256		100.3543	100.4277
ActLab					
C					
S					
ActLab					
Ni	105	12			
Cr	166	37			
Nb	6	11			
Y	29	13			
Zr	111	96			
V	393	96			
OGL					
Al	61158	80335			
Ba	59	424		247	67
Be	0.25	0.51			
Ca	52210	35912			
Cd	2				
Co	58	17			
Cr	121.35	43.79		-8	16
Cu	59				
Fe	86129	35892			
K	1015	7563			
Li	21	6			
Mg	24732	14546			
Mn	1340	581			
Mo					
Na	23943	36681			
Ni	109	23			
P	736	530			
S	-400				
Sc	28.8	10			
Sr	163.5	422.7			
Ti	10322	2054			
V	283.3	88.5			
W					
Y	22.1	8.1			
Zn	115.59	43.95			
OGL					
Ce	18.44	19.02		80	19.63
Cs	0.244	0.521		2.676	0.172
Dy	5.315	1.874		22.378	4.6
Er	3.266	1.094		15.303	2.625
Eu	1.327	0.786		3.235	1.429
Gd	4.99	2.209		19.811	4.752
Hf	3.2	2		14.6	2.6
Ho	1.102	0.381		5	0.914
La	7.18	8.52		30.73	7.15
Lu	0.466	0.162		2.28	0.343
Nb	6	2.4		24.5	4.8
Nd	13.81	11.01		57.52	14.8
Pr	2.822	2.558		11.896	3.033
Rb	2.51	19.98		84.75	2.7
Sm	3.98	2.36		16.32	4.1
Sr	189.5	471.5		53.2	210.6
Ta	0.36			1.5	0.3
Tb	0.842	0.316		3.476	0.754
Th	0.47	0.76		2.69	0.57
Tm	0.473	0.16		2.312	0.367
U	0.124	0.158		0.743	0.165
Y	28.2	10.1		132.647	23.86
Yb	3.11	1.05		15.1	2.36
Zr	119.8	72		543.6	95.1

Appendix 2

Geochemical Analyses for Currie Township

XRF: X-ray Fluorescence

ICP-AES: Induced Coupled Plasma Atomic Emission Spectroscopy

ICP-MS: Induced Coupled Plasma Mass Spectroscopy

Negative values indicate analyses above or below detection limits

Appendix 2. Geochemical analyses for Currie Township.

Sample Number				04ASP-CUR22-01-6.1	04ASP-CUR22-01-3.1	04ASP-210-3.1	04ASP-219-2.1
Township				Currie	Currie	Currie	Currie
Easting UTM NAD83				525331	525331	523869	529300
Northing UTM NAD83				5369598	5369598	5367340	5368399
Depth (m)				237.25-237.5	197.15-197.35	--	--
Phase				Volcanic	Volcanic	Volcanic	Volcanic
Assemblage				Lower Blake River	Lower Blake River	Lower Blake River	Lower Blake River
Rock Type				Basalt - porphyritic	Basalt	Basalt - massive	Andesite - porphyritic
Notes				DDH	DDH	Outcrop	Outcrop
Actlab	method	units	2004 d.l.				
SiO2	XRF	wt%	0.01	47.42	49.63	48.51	55.56
TiO2	XRF	wt%	0.01	0.57	0.68	2.06	0.91
Al2O3	XRF	wt%	0.01	18.50	14.00	13.44	17.51
Fe2O3	XRF	wt%	0.01	8.64	9.73	17.43	7.47
MgO	XRF	wt%	0.01	7.45	9.69	5.39	5.11
CaO	XRF	wt%	0.01	12.65	7.05	8.09	7.28
Na2O	XRF	wt%	0.01	1.87	3.73	2.72	4.49
K2O	XRF	wt%	0.01	0.58	1.02	0.49	0.52
MnO	XRF	wt%	0.001	0.16	0.17	0.24	0.12
P2O5	XRF	wt%	0.01	0.04	0.05	0.27	0.19
Cr2O3	XRF	wt%	0.01	0.07	0.05	0.02	0.02
LOI	XRF	wt%	0.01	2.47	3.95	0.81	1.35
TOTAL				100.42	99.75	99.47	100.52
ActLab							
Ni	XRF	ppm	5	119	147	50	74
Cr	XRF	ppm	5	462	321	93	105
Nb	XRF	ppm	2	2	-1	3	9
Y	XRF	ppm	2	12	14	33	20
Zr	XRF	ppm	5	24	33	87	121
V	XRF	ppm	5	229	261	500	181
OGL							
Al	ICP-AES	ppm	100	92533	69163	68805	89288
Ba	ICP-AES	ppm	1	136	572	99	115
Be	ICP-AES	ppm	0	0.11	0.32	0.41	0.53
Ca	ICP-AES	ppm	50	87482	48064	56643	49491
Cd	ICP-AES	ppm	2	0	0		
Co	ICP-AES	ppm	1	41	43	24	18
Cr	ICP-AES	ppm	1	354.24	295.28	91.69	106.51
Cu	ICP-AES	ppm	3	65	57	78	53
Fe	ICP-AES	ppm	100	56942	64259	-100000	49954
K	ICP-AES	ppm	60	4251	8050	3769	3910
Li	ICP-AES	ppm	1	38	27	14	14
Mg	ICP-AES	ppm	70	43157	54687	31208	29598
Mn	ICP-AES	ppm	1	1067	1121	1736	804
Mo	ICP-AES	ppm	8	0	0		
Na	ICP-AES	ppm	150	13044	26342	20285	30893
Ni	ICP-AES	ppm	3	139	168	77	91
P	ICP-AES	ppm	10	41	106	1110	713
S	ICP-AES	ppm	43	-400	-400	-400	-400
Sc	ICP-AES	ppm	0.3	28.6	31	42.5	24.4
Sr	ICP-AES	ppm	0.7	211	122	121.2	304.7
Ti	ICP-AES	ppm	10	3412	4026	13243	5216
V	ICP-AES	ppm	1	213.6	231.6	-320	170.4
W	ICP-AES	ppm	2	0	2	4	
Y	ICP-AES	ppm	0.2	9	12.3	29.6	18
Zn	ICP-AES	ppm	2	69	68	147	86
OGL							
Ce	ICP-MS	ppm	0.07	2.9	3.93	12.4	31.15
Cs	ICP-MS	ppm	0.007	0.537	0.522	0.5	0.637
Dy	ICP-MS	ppm	0.008	1.64	2.174	5.624	3.549
Er	ICP-MS	ppm	0.008	1.108	1.434	3.672	2.086
Eu	ICP-MS	ppm	0.005	0.388	0.474	1.392	1.157
Gd	ICP-MS	ppm	0.009	1.326	1.806	4.949	3.843
Hf	ICP-MS	ppm	0.1	0.7	0.9	2.5	3.1
Ho	ICP-MS	ppm	0.003	0.363	0.481	1.233	0.728
La	ICP-MS	ppm	0.02	1.06	1.39	4.37	13.26
Lu	ICP-MS	ppm	0.003	0.171	0.222	0.557	0.31
Nb	ICP-MS	ppm	0.2	0.9	1.2	3.6	5.6
Nd	ICP-MS	ppm	0.03	2.64	3.7	10.92	17.8
Pr	ICP-MS	ppm	0.006	0.505	0.668	2.023	4.176
Rb	ICP-MS	ppm	0.05	18.03	22.19	13.77	18.16
Sm	ICP-MS	ppm	0.01	0.95	1.25	3.58	3.92
Sr	ICP-MS	ppm	0.5	211.2	119.7	118.9	303.9
Ta	ICP-MS	ppm	0.17			0.23	0.36
Tb	ICP-MS	ppm	0.003	0.241	0.329	0.855	0.593
Th	ICP-MS	ppm	0.06	0.08	0.12	0.33	1.55
Tm	ICP-MS	ppm	0.003	0.165	0.219	0.54	0.303
U	ICP-MS	ppm	0.007	0.047	0.038	0.096	0.378
Y	ICP-MS	ppm	0.02	9.4	12.78	31.99	19.15
Yb	ICP-MS	ppm	0.01	1.1	1.44	3.61	2.03
Zr	ICP-MS	ppm	4	24.4	32.8	91.5	124.5

Appendix 2. Geochemical analyses for Currie Township.

Sample Number	04ASP-211-1.1	04ASP-223-6.1	04ASP-KL0068-T-26-10.1	04ASP-205-1.1	04ASP-202-1.1	04ASP-KL2143-87-05-1.1
Township	Currie	Currie	Currie	Currie	Currie	Currie
Easting	524687	526356	532999	531704	532789	526399
Northing	5367971	5375250	5371309	5372777	5371334	5371229
Depth (m)	--	--	214.0-214.2	--	--	66.9-67.2
Phase	Volcanic	Volcanic	Volcanic	Volcanic	Volcanic	Volcanic
Assemblage	Lower Blake River	Lower Tisdale	Upper Tisdale	Upper Tisdale	Upper Tisdale	Upper Tisdale
Rock Type	Dacite - tuff	Basalt	Andesite - porphyritic	Andesite - schistose	Andesite	Andesite - tuff
Notes	Outcrop	Outcrop	DDH	Outcrop	Outcrop	DDH
Actlab						
SiO2	66.60	52.44	55.91	58.13	54.46	54.52
TiO2	0.37	0.79	0.61	1.39	1.11	1.12
Al2O3	17.49	13.80	17.19	14.23	17.18	14.68
Fe2O3	2.88	12.80	5.46	8.75	7.21	8.42
MgO	1.57	7.43	4.24	6.45	4.27	6.07
CaO	4.13	9.45	7.27	5.52	6.64	4.88
Na2O	5.89	1.96	4.80	2.77	5.62	4.76
K2O	1.08	0.18	0.60	0.92	1.22	0.11
MnO	0.04	0.21	0.11	0.10	0.14	0.11
P2O5	0.14	0.07	0.35	0.29	0.44	0.25
Cr2O3	0.00	0.01	0.01	0.04	0.01	0.02
LOI	-0.35	1.23	3.72	1.66	2.08	5.34
TOTAL	99.82	100.36	100.28	100.25	100.38	100.28
ActLab						
Ni	-4	69	20	102	22	87
Cr	-8	97	65	244	80	131
Nb	16	-1	24	12	28	13
Y	94	20	15	28	21	22
Zr	307	46	132	234	182	138
V	9	270	169	194	160	202
OGL						
Al	54917	66720	82832	74569	89855	72581
Ba	151	34	690	340	1390	34
Be	0.95	0.16	1.64	0.79	1.26	0.46
Ca	24576	62484	50725	39811	47619	34238
Cd			0		0	
Co		42	19	14	11	25
Cr	17.81	90.2	62.39	235.88	99.55	109.64
Cu		115	90	81	219	39
Fe	70050	83276	36329	60168	49033	56494
K	2400	974	4500	7413	9711	512
Li	4	12	16	26	25	34
Mg	4835	42074	23737	38639	24725	34263
Mn	995	1417	780	682	1012	637
Mo			0		0	
Na	28603	12958	32723	20641	41439	33768
Ni	12	93	41	125	38	79
P	952	186	1448	1151	1731	990
S	218	215	-400	-400	-400	53
Sc	20.2	41.5	12	20.9	13	16.2
Sr	128.5	81.7	779	300.1	694.2	379.5
Ti	4722	4274	3676	8150	6642	5188
V	0.9	257.7	146.8	170.8	139.8	149.3
W	3		0		4	
Y	90.2	16.2	10.8	25.7	17.8	17.1
Zn	112	99	71	122	81	90
OGL						
Ce	43.9	6.42	64.81	55.6	90.66	47.49
Cs	0.233	0.165	0.794	1.084	0.57	0.105
Dy	17.575	3.081	2.621	5.175	3.822	3.968
Er	11.329	2.123	1.242	2.926	1.828	2.251
Eu	3.316	0.6	1.676	1.582	2.277	1.413
Gd	15.373	2.538	4.507	5.968	6.355	4.681
Hf	9	1.3	3.2	6.3	4.5	3.7
Ho	3.801	0.685	0.457	1.042	0.692	0.788
La	15.64	2.34	31.2	23.57	41.8	20.54
Lu	1.774	0.329	0.165	0.42	0.243	0.309
Nb	12.8	1.7	5	11.6	13.8	5.3
Nd	35.98	5.63	32.96	30.73	45.01	25.99
Pr	7.055	1.021	8.148	7.341	11.197	6.188
Rb	4.29	2.03	17.57	26.7	28.14	1.14
Sm	11.37	1.84	6.2	6.45	8.37	5.32
Sr	126.2	86.5	798.2	290.8	690.9	436.5
Ta	0.77		0.24	0.65	0.83	0.28
Tb	2.689	0.452	0.535	0.891	0.769	0.666
Th	1.48	0.19	5.5	3.57	7.61	2.59
Tm	1.723	0.321	0.17	0.429	0.253	0.324
U	0.397	0.052	1.994	0.88	2.262	0.495
Y	100.13	18.1	12.71	27.18	19.14	21.45
Yb	11.43	2.12	1.1	2.76	1.76	2.09
Zr	322.3	45.1	136.2	251.6	195.7	145.9

Appendix 2. Geochemical analyses for Currie Township.

Sample Number	04ASP-KL2141-86-02-1.1	04ASP-CB-16-1.1	04ASP-CB-16-4.1	04ASP-CB-13-5.1	04ASP-KL0064-T-22-1.1	04ASP-CB-13-4.1
Township	Currie	Currie	Currie	Currie	Currie	Currie
Easting	526279	527446	527446	526646	532699	526646
Northing	5372229	5370429	5370429	5370429	5371109	5370429
Depth (m)	143.3-143.8	102.6-102.8	241.8-242.0	383.2-383.4	29.65-29.85	3521.5-352.7
Phase	Volcanic	Volcanic	Volcanic	Volcanic	Volcanic	Volcanic
Assemblage	Upper Tisdale	Upper Tisdale	Upper Tisdale	Upper Tisdale	Upper Tisdale	Upper Tisdale
Rock Type	Basalt - tuff	Felsic - crystal tuff	Felsic - crystal tuff	Felsic - crystal tuff	Felsic - flow	Felsic - tuff
Notes	DDH	DDH	DDH	DDH	DDH	DDH
Actlab						
SiO2	52.94	65.23	66.26	60.01	62.42	68.36
TiO2	0.77	0.41	0.30	0.65	0.42	0.59
Al2O3	14.29	16.50	16.59	16.84	17.13	14.35
Fe2O3	8.09	3.16	2.47	4.60	3.65	3.90
MgO	7.78	2.29	1.38	2.84	3.48	1.34
CaO	4.74	2.37	3.86	3.99	4.48	2.68
Na2O	4.20	5.57	5.16	6.50	5.85	4.72
K2O	0.05	1.54	1.64	0.47	1.06	1.04
MnO	0.14	0.05	0.04	0.05	0.07	0.04
P2O5	0.12	0.13	0.11	0.14	0.15	0.15
Cr2O3	0.03	0.00	0.00	0.01	0.02	0.01
LOI	6.96	2.90	2.57	4.33	1.67	2.74
TOTAL	100.10	100.14	100.36	100.43	100.40	99.92
ActLab						
Ni	69	23	18	49	81	25
Cr	223	29	21	76	119	55
Nb	5	2	10	2	6	4
Y	17	8	7	14	8	13
Zr	90	94	75	120	92	116
V	197	85	55	119	83	95
OGL						
Al	69215	83602	80690	81776	83918	69171
Ba	440	431	556	175	463	214
Be	0.34	0.59	0.61	0.43	0.56	0.53
Ca	32219	16032	25564	26845	29722	18178
Cd	0	0	0	0	0	0
Co	24	9	7	14	15	11
Cr	160.45	38.17	27.69	76.72	107.32	66.45
Cu	167	11	4	17	40	15
Fe	53209	21105	16590	31183	24550	25956
K	156	11825	12490	3579	7989	7485
Li	30	33	12	19	21	18
Mg	44088	12900	7497	16285	19592	6416
Mn	886	348	215	294	514	233
Mo	0	0	0	0	0	0
Na	28227	37650	35124	44932	39727	32135
Ni	83	35	24	55	96	40
P	460	498	387	533	568	548
S	115	-400	211	-400	-400	-400
Sc	23.7	4.8	3.3	10.9	6.5	8.2
Sr	228.6	253.5	460.9	173.9	328.4	235.2
Ti	4564	2624	1775	4001	2490	3580
V	163.8	71.4	50	95.9	79.1	71.3
W	0	3	0	0	0	2
Y	14.7	4.3	3.4	10.5	4.4	9.1
Zn	79	49	34	69	68	28
OGL						
Ce	21.42	22.76	23.44	17.44	26.5	21.73
Cs	0.097	0.838	0.788	0.292	1.465	0.893
Dy	2.904	0.917	0.715	2.161	0.9	1.977
Er	1.749	0.429	0.326	1.275	0.438	1.182
Eu	0.835	0.626	0.532	0.663	0.606	0.883
Gd	2.954	1.562	1.243	2.329	1.516	2.275
Hf	2.4	2.5	2	3.1	2.4	2.9
Ho	0.595	0.166	0.121	0.445	0.161	0.399
La	9.29	10.83	11.28	7.59	12.73	9.68
Lu	0.25	0.059	0.043	0.184	0.061	0.179
Nb	3.7	3.3	3.1	4.1	3.8	4.2
Nd	12.9	10.95	10.92	9.87	12.66	11.75
Pr	2.94	2.795	2.783	2.256	3.289	2.771
Rb	0.15	38.81	49.08	8.04	38.36	24.2
Sm	2.97	2.03	1.86	2.25	2.14	2.51
Sr	230.1	248.4	463.9	178.3	317.2	249.1
Ta	0.21	0.19	0.18	0.26	0.19	0.26
Tb	0.476	0.188	0.148	0.36	0.184	0.338
Th	1.13	1.53	1.76	1.04	1.87	0.96
Tm	0.254	0.057	0.045	0.182	0.062	0.175
U	0.266	0.594	0.659	0.352	0.634	0.432
Y	15.96	4.46	3.47	11.62	4.46	10.6
Yb	1.67	0.42	0.29	1.21	0.4	1.16
Zr	91.9	96.5	75.1	116.4	92.9	113.5

Appendix 2. Geochemical analyses for Currie Township.

Sample Number	04ASP-CB-13-6.1	04ASP-CB-16-2.1	04ASP-KL2143-87-05-3.1	04ASP-CB-13-7.1	04ASP-218-3.1	04ASP-220-2.1
Township	Currie	Currie	Currie	Currie	Currie	Currie
Easting	526646	527446	526399	526646	523778	529379
Northing	5370429	5370429	5371229	5370429	5368750	5367768
Depth (m)	442.2-442.4	185.8-186.0	117.35-117.65	513.8-514.0	--	--
Phase	Volcanic	Volcanic	Volcanic	Volcanic	Intrusive	Intrusive
Assemblage	Upper Tisdale	Upper Tisdale	Upper Tisdale	Upper Tisdale	Lower Blake River	Lower Blake River
Rock Type	Felsic - tuff	Felsic - tuff	Felsic - tuff	Felsic - tuff	Porphyry - felsic	Porphyry - intermediate
Notes	DDH	DDH	DDH	DDH	Outcrop	Outcrop
Actlab						
SiO2	73.78	62.57	59.50	62.55	67.47	58.82
TiO2	0.49	0.52	0.60	0.53	0.83	1.18
Al2O3	13.14	16.58	14.77	15.39	11.07	16.97
Fe2O3	4.30	5.67	5.33	7.81	10.18	6.31
MgO	0.31	2.87	3.20	5.81	0.92	3.35
CaO	0.18	1.79	5.50	0.53	3.49	6.89
Na2O	0.89	4.18	3.06	0.43	3.97	4.49
K2O	3.91	2.24	1.54	1.64	0.35	1.15
MnO	0.01	0.51	0.08	0.14	0.14	0.12
P2O5	0.07	0.14	0.13	0.13	0.23	0.25
Cr2O3	0.00	0.00	0.02	0.01	0.04	0.01
LOI	3.22	3.31	6.54	4.83	1.70	0.81
TOTAL	100.29	100.37	100.26	99.80	100.39	100.35
ActLab						
Ni	16	17	107	26	83	29
Cr	40	38	154	52	243	48
Nb	-1	-1	1	-1	10	12
Y	10	12	14	10	23	24
Zr	97	107	111	104	167	149
V	81	93	100	103	165	221
OGL						
Al	61674	83778	75290	38819	78543	85355
Ba	497	343	229	120	243	315
Be	0.3	0.69	0.32	0.61	0.57	0.52
Ca	1294	13224	40036	3363	46186	47807
Cd	0	10		0		
Co	10	10	18	9	13	15
Cr	56.38	40.67	132.62	51.7	216.35	66.92
Cu	30	42		0	34	71
Fe	29402	38954	37986	50621	41390	42901
K	29394	17672	11810	12092	6805	8699
Li	15	34	42	51	12	6
Mg	1335	16686	18522	16001	27859	19290
Mn	37	-2500	443	906	784	828
Mo	0	0		0		
Na	6105	30077	22404	3091	24858	31710
Ni	37	33	95	44	96	46
P	240	549	507	555	835	920
S	-400	-400	51	-400	-400	156
Sc	7.6	9.5	9.1	4.1	16.1	22.1
Sr	44.3	118.7	134.3	46	328	360.2
Ti	2966	3307	2647	3216	5088	6909
V	73.7	79.3	75.6	55.1	141	194.1
W	0	15		0		
Y	5.7	9.5	9.3	4.6	17.5	21.3
Zn	52	2772	64	162	87	93
OGL						
Ce	10.83	19.5	20.24	11.33	41.52	37.47
Cs	0.846	1.009	1.099	0.686	0.67	0.682
Dy	1.182	2.109	2.004	0.999	3.511	4.363
Er	0.731	1.191	1.186	0.625	2.009	2.558
Eu	0.52	1.626	0.708	0.36	1.249	1.384
Gd	1.325	2.501	2.315	1.252	4.264	4.671
Hf	2.4	2.8	2.8	2.8	4.4	3.9
Ho	0.25	0.415	0.415	0.214	0.702	0.887
La	4.38	9.16	8.56	4.95	17.41	15.82
Lu	0.108	0.176	0.175	0.098	0.291	0.379
Nb	3.4	4.2	4.5	3.8	6.5	6.6
Nd	6.28	10.78	10.96	6.97	23.32	21.15
Pr	1.492	2.53	2.58	1.577	5.42	4.963
Rb	77.1	35.12	36.16	29.54	26.05	39.33
Sm	1.44	2.43	2.46	1.44	4.65	4.62
Sr	46.9	110.4	153.6	48.5	332.8	366.8
Ta	0.21	0.26	0.27	0.24	0.41	0.44
Tb	0.2	0.363	0.346	0.172	0.615	0.723
Th	0.76	0.91	0.97	0.63	3.12	2.01
Tm	0.108	0.174	0.177	0.094	0.295	0.378
U	0.236	0.26	0.254	0.219	0.781	0.502
Y	6.47	10.57	11.51	5.43	19.5	23.92
Yb	0.71	1.16	1.15	0.63	1.91	2.48
Zr	94.3	110	107	108.2	175.3	157.5

Appendix 2. Geochemical analyses for Currie Township.

Sample Number	04ASP-216-1.1	04ASP-204-4.1	04ASP-CB-16-3.1	04ASP-CB-16-5.1	04ASP-CB-13-1.1	04ASP-205-2.1	04ASP-KL0068-T-26-2.1
Township	Currie	Currie	Currie	Currie	Currie	Currie	Currie
Easting	524799	528250	527446	527446	526646	531704	532999
Northing	5373567	5374354	5370429	5370429	5370429	5372777	5371309
Depth (m)	--	--	151.8-152.0	329.2-329.35	136.2-137.0	--	57.8-58.0
Phase	Intrusive	Intrusive	Intrusive	Intrusive	Intrusive	Intrusive	Intrusive
Assemblage	Lower Tisdale	Lower Tisdale	Upper Tisdale	Upper Tisdale	Upper Tisdale	Upper Tisdale	Upper Tisdale
Rock Type	Mafic Dyke	Porphyry - felsic	Porphyry - felsic	Porphyry - felsic	Porphyry - felsic	Porphyry - felsic	Porphyry - intermediate
Notes	Outcrop	Outcrop	DDH	DDH	DDH	Outcrop	DDH
Actlab							
SiO2	50.57	62.60	67.50	66.85	65.92	66.02	60.75
TiO2	1.36	0.50	0.31	0.30	0.35	0.37	0.54
Al2O3	13.40	15.99	16.19	16.76	17.07	17.21	17.08
Fe2O3	16.53	5.80	2.35	2.92	2.77	2.86	5.01
MgO	5.66	3.54	1.84	1.41	1.74	1.55	2.88
CaO	9.28	4.11	1.58	1.67	3.29	4.13	5.34
Na2O	2.11	4.61	6.97	7.58	4.63	5.77	5.09
K2O	0.27	1.11	0.97	0.84	1.81	1.07	1.62
MnO	0.21	0.06	0.03	0.04	0.04	0.04	0.09
P2O5	0.11	0.10	0.12	0.11	0.12	0.13	0.24
Cr2O3	0.02	0.01	0.00	0.00	0.00	0.00	0.01
LOI	1.04	1.61	1.93	1.75	2.72	1.25	1.78
TOTAL	100.57	100.04	99.79	100.22	100.45	100.39	100.43
ActLab							
Ni	57	69	14	15	17	16	25
Cr	84	121	22	20	26	23	52
Nb	6	2	4	-1	8	12	21
Y	29	11	7	7	8	8	15
Zr	73	101	80	78	88	95	133
V	373	107	56	55	72	65	132
OGL							
Al	67592	83568	84190	81589	82025	87908	81394
Ba	72	212	260	230	559	367	1014
Be	0.39	0.57	0.45	0.45	0.65	0.68	1.23
Ca	63652	30879	10978	11749	22956	28864	36160
Cd			0	0	0		0
Co	41	18	8	7	7	6	15
Cr	75.47	126.08	18.99	20.21	36.02	60.13	47.08
Cu	132	3	5	0	11	5	113
Fe	-100000	41338	15730	19898	18748	20069	32702
K	1778	8855	7442	6312	13797	8808	12905
Li	15	14	28	12	18	13	12
Mg	32813	21314	10437	7897	9625	8993	15880
Mn	1473	460	197	241	267	259	587
Mo			0	0	0		0
Na	14875	34818	46711	51177	31571	43318	33840
Ni	81	80	25	25	27	27	45
P	391	362	403	404	425	434	926
S	-400		-400	368	115	-400	-400
Sc	41.8	12.5	3.5	3.6	4	4	9.5
Sr	231.1	220.5	277.6	172.4	356.2	531.2	665.3
Ti	7953	2892	1864	1803	2124	2083	3096
V	-320	96.8	47.9	47.5	57.8	61	113.6
W			0	3	6		4
Y	26.2	8.7	3.4	3.4	4	4.2	9.6
Zn	110	38	36	30	43	49	107
OGL							
Ce	11.02	17.57	35.56	21.51	23.98	24.44	60.32
Cs	0.344	0.69	0.515	0.333	1.256	0.84	1.209
Dy	4.947	1.697	0.742	0.695	0.864	0.902	2.348
Er	3.291	1.001	0.33	0.321	0.406	0.418	1.238
Eu	1.037	0.649	0.642	0.547	0.561	0.599	1.363
Gd	4.046	1.97	1.424	1.224	1.415	1.508	3.636
Hf	2.1	2.7	2.3	2.1	2.2	2.5	3.5
Ho	1.081	0.347	0.126	0.123	0.151	0.162	0.444
La	3.98	8.21	20.64	10.41	11.66	11.68	30.13
Lu	0.508	0.147	0.046	0.044	0.053	0.056	0.185
Nb	2.9	2.4	3.2	3.1	3.3	3.7	5.3
Nd	9.31	9.08	14.97	9.95	11.27	11.5	27.6
Pr	1.751	2.176	4.031	2.584	2.88	2.964	7.236
Rb	4.67	45.59	22.46	18.43	50.01	29.75	40.34
Sm	3	2	2.18	1.7	1.98	2.04	4.91
Sr	231.1	215.1	269.3	169.7	376.1	522.7	704.1
Ta	0.17		0.19	0.18	0.19	0.21	0.3
Tb	0.737	0.292	0.159	0.147	0.173	0.184	0.449
Th	0.34	1.66	1.92	1.84	1.8	1.74	5.52
Tm	0.501	0.143	0.047	0.046	0.057	0.058	0.18
U	0.092	0.408	0.65	0.77	0.631	0.651	1.735
Y	28.76	9.27	3.56	3.42	4.22	4.43	12.12
Yb	3.29	0.96	0.31	0.31	0.38	0.39	1.21
Zr	75.6	105.3	89.9	79.2	84.6	98.7	144.5

Appendix 2. Geochemical analyses for Currie Township.

Sample Number	04ASP-203-1.1	04ASP-214-2.1	04ASP-KL2143-87-05-6.1	04ASP-KL2143-87-05-7.1	04ASP-KL2141-86-02-2.1
Township	Currie	Currie	Currie	Currie	Currie
Easting	530062	524906	526399	526399	526279
Northing	5371621	5373828	5371229	5371229	5372229
Depth (m)	--	--	281.7-281.95	283.45-283.7	157.1-157.5
Phase	Intrusive	Intrusive	Intrusive	Intrusive	Intrusive
Assemblage	Upper Tisdale	Upper Tisdale	Upper Tisdale	Upper Tisdale	Upper Tisdale
Rock Type	Porphyry - intermediate	Porphyry - felsic	Porphyry - Intermediate	Porphyry - Intermediate	Porphyry - intermediate
Notes	Outcrop	Outcrop	DDH - Extremely High LOI	DDH - Extremely High LOI	DDH
Actlab					
SiO2	61.04	64.62	42.12	43.61	61.52
TiO2	0.90	0.55	0.66	0.71	0.53
Al2O3	16.22	15.61	9.00	9.31	16.02
Fe2O3	6.36	4.91	8.01	8.70	4.93
MgO	4.21	3.15	11.31	13.66	2.64
CaO	3.11	2.77	8.43	6.34	2.99
Na2O	4.99	5.68	1.71	1.39	6.95
K2O	0.89	0.70	0.11	0.03	0.31
MnO	0.10	0.08	0.17	0.17	0.09
P2O5	0.21	0.13	0.12	0.14	0.13
Cr2O3	0.01	0.01	0.15	0.15	0.01
LOI	2.25	1.82	18.49	15.93	3.66
TOTAL	100.29	100.03	100.27	100.14	99.78
ActLab					
Ni	35	41	329	337	34
Cr	79	60	1077	1094	40
Nb	9	5	2	1	1
Y	22	13	13	14	13
Zr	202	116	74	80	103
V	131	82	171	172	83
OGL					
Al	83481	78365	43241	44921	79442
Ba	319	266	31	17	278
Be	0.71	0.56	0.32	0.27	0.36
Ca	22578	18815	55728	42692	21644
Cd			0	0	0
Co	10	11	42	47	14
Cr	82.58	71	-400	-400	40.39
Cu	61		26	25	0
Fe	44416	34310	51348	56550	34330
K	7198	5602	623	112	2172
Li	27	16	25	35	20
Mg	24727	18528	-60000	-60000	14827
Mn	734	528	934	897	587
Mo			0	0	0
Na	35789	40742	11478	9411	48487
Ni	53	54	289	310	37
P	822	502	474	531	494
S	-400	104	0	0	58
Sc	12.9	8.6	19.8	20.7	7.4
Sr	301.4	260.2	180	136.9	157.2
Ti	5319	3195	3938	4289	2259
V	113.6	79.5	119.7	124.7	64.6
W	5		5	5	0
Y	18	9.3	10.5	11.5	9.4
Zn	98	65	76	85	65
OGL					
Ce	46.2	25.59	16.92	18.74	20.98
Cs	0.491	0.321	0.151	0.162	0.228
Dy	3.793	1.878	2.077	2.318	2.072
Er	2.167	1.082	1.184	1.27	1.203
Eu	1.228	0.716	0.738	0.772	0.768
Gd	4.35	2.15	2.42	2.602	2.428
Hf	5.4	3.1	1.9	2.1	2.4
Ho	0.754	0.376	0.418	0.461	0.418
La	20.04	11.59	6.9	7.66	9.31
Lu	0.307	0.169	0.164	0.177	0.175
Nb	8.2	4.6	3.4	3.8	4.2
Nd	23.63	12.29	10.94	11.72	11.48
Pr	5.83	3.156	2.409	2.65	2.724
Rb	19.02	15.74	1.17	0.12	6.85
Sm	4.94	2.43	2.47	2.69	2.52
Sr	296.2	255.5	184.4	142.9	177
Ta	0.5	0.3	0.19	0.2	0.24
Tb	0.655	0.323	0.36	0.394	0.356
Th	3.67	1.72	0.73	0.79	0.85
Tm	0.316	0.161	0.171	0.185	0.178
U	0.907	0.411	0.169	0.191	0.244
Y	20.11	10.18	10.98	12.22	11.44
Yb	2.07	1.06	1.15	1.24	1.14
Zr	214.1	118.3	76.2	85.5	89.3

Metric Conversion Table

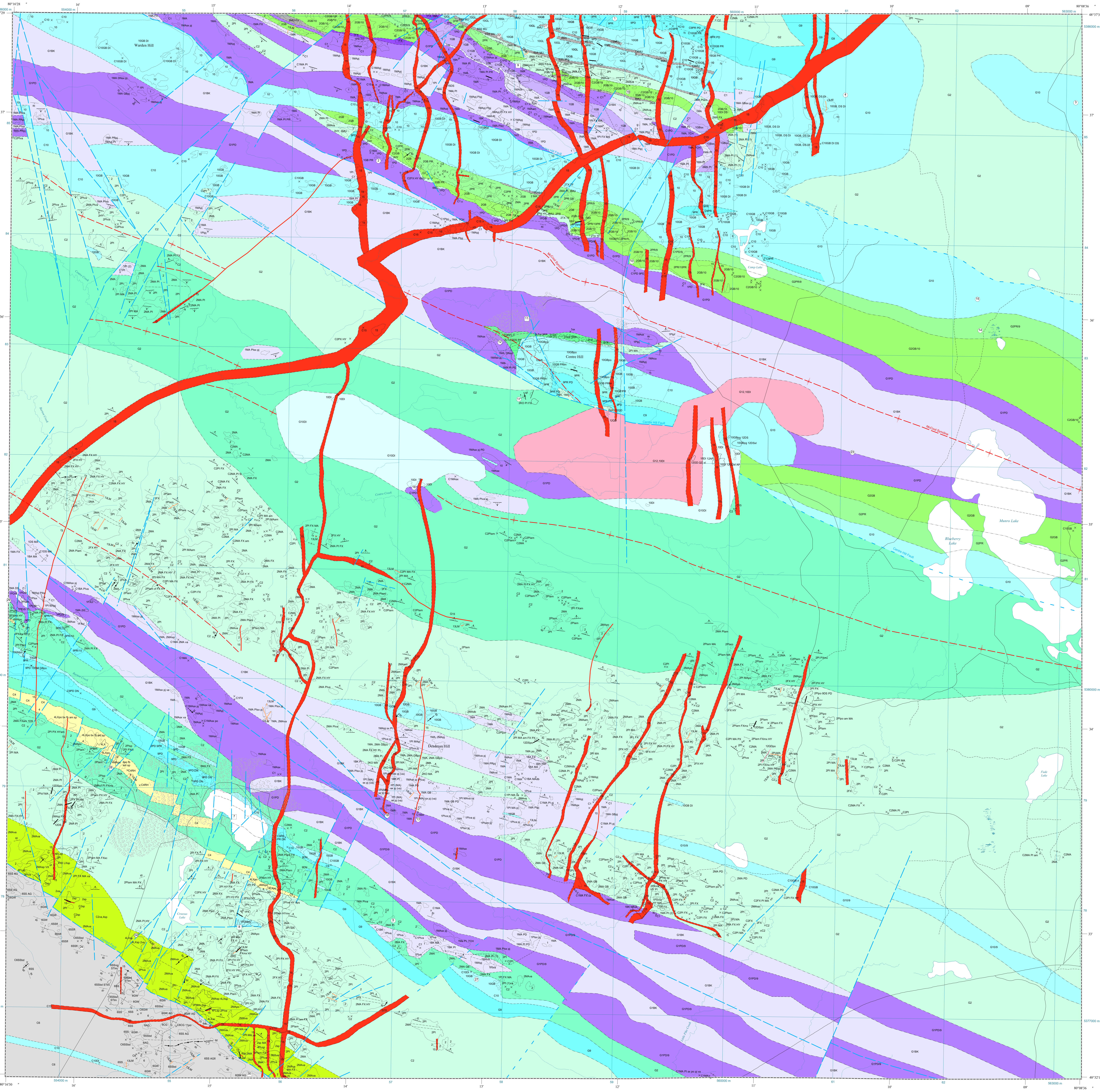
Conversion from SI to Imperial			**Conversion from Imperial to SI**		
SI Unit	*Multiplied by*	*Gives*	*Imperial Unit*	*Multiplied by*	*Gives*
			LENGTH		
1 mm	0.039 37	inches	1 inch	**25.4**	mm
1 cm	0.393 70	inches	1 inch	**2.54**	cm
1 m	3.280 84	feet	1 foot	**0.304 8**	m
1 m	0.049 709	chains	1 chain	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 0–7794–8551-3



LEGEND[abcd]

PHANEROZOIC

CENOZOIC

QUATERNARY

RECENT and PLEISTOCENE

UNCONFORMITY

PRECAMBRIAN

PROTEROZOIC

15 Mafic Intrusive Rocks (Matachewan and Sudbury Diabase Dike Swarms)

13 Alkalic Intrusive Rocks

- Lamprophyric dikes

INTRUSIVE CONTACT

ARCHEAN

REGIONAL METAMORPHISM

KIDD–MUNRO ASSEMBLAGE

12 Felsic to Intermediate Intrusive Rocks

10 Mafic Intrusive Rocks

- Unsubdivided
- Intermediate intrusive rocks
- Interlayered mafic and ultramafic intrusive rocks

9 Ultramafic Intrusive Rocks

6/7 Clastic and Chemical Sedimentary Rocks

- Interflow sedimentary rocks: siltstone, argillite and chert

4 Felsic Volcanic Rocks

- Rhyolite

2 Mafic Volcanic Rocks

- Unsubdivided basalt; basalt interflow breccia
- Basalt (with high magnetic signature)
- Interbedded spherulitic and variolitic basalt and rhyolite
- Gabbroic basalt
- Pyroxenitic basalt
- Basalt lapilli tuff with peperites, and fluidal pyroclastic breccia

1 Ultramafic Volcanic Rocks

- Basaltic ultramafic volcanic rocks
- Gabbroic ultramafic volcanic rocks
- Peridotitic-pyroxenitic ultramafic volcanic rocks
- Ultramafic interflow breccia

PORCUPINE ASSEMBLAGE

6 Clastic Sedimentary Rocks

[a] The rock unit codes for this legend were designed for use with a database of geoscience information related to the Discover Abitibi Initiative. As a result, not all codes used in the database are shown in this legend.
[b] The letter "C" preceding a code refers to data interpreted from geological maps and data.
[c] The letter "G" preceding a code refers to data interpreted from geophysical maps.
[d] The letter "D" preceding a code refers to data interpreted from drill core.

EXPLANATION OF ROCK CODES

This map uses codes that are to be read from left to right.

$$\overset{①}{8}C\underset{②}{G}\overset{③}{tf}\,\underset{②}{BX}$$

① The lithology code (8) identifies the main lithologic unit within a polygon or outcrop. Lithology codes correspond to units listed in LEGEND, above. The letters "C", "G" or "D" preceding a lithology code refer to, respectively, information compiled from previously published sources, information interpreted from geophysical data, and information derived from drill-hole logs.

② The primary rock type code (CG) identifies subdivisions of the main lithologic unit. Explanations of rock type codes are listed below under "Rock Type".

③ The texture code (tf) supplies additional information about the texture of the rock. Explanations of texture codes are listed below under "Textural Description".

④ The secondary codes (BX), where present, identify a second, less abundant lithologic unit and rock type within the polygon or outcrop. These codes are the same as those listed under LEGEND, "Rock Type" and, where applicable, "Textural Description".

Using the explanations listed below, therefore, 8CGtfBX indicates a polygon or outcrop of felsic volcanic rock composed of porphyritic rhyolite with secondary felsic to intermediate intrusive rocks composed of microdiorite.

8CGtfBX

Rock Type	
AG	Argillite
AK	Arkose
AP	Aplite
AT	Ash Tuff
BK	Basaltic Komatiite
BT	Block Tuff
BX	Breccia
CC	Carbonate
CF	Carbonate Fuchsite Schist
CG	Conglomerate
CH	Chert
CP	Clinopyroxenite
CS	Chlorite Schist
CT	Cherty Tuff
CU	Cumulate
DA	Dacite
DI	Diorite
DN	Dunite
DS	Dikes, Sills
EX	Exhalite
FL	Flow
FP	Feldspar Porphyry
FX	Flow Breccia
GB	Gabbro
GD	Granodiorite
GH	Hornblende Gabbro
GL	Leucogabbro
GM	Melanogabbro
GN	Gabbronorite
GP	Graphitic Phyllite
GR	Granite
GS	Graphitic Shale
GT	Graphitic Tuff
GW	Greywacke
HY	Hyaloclastite
IF	Iron Formation
JA	Jasper
KI	Kimberlite
KO	Komatiite
LA	Litharenite
LG	Leucogranite
LM	Lamprophyre
LS	Lapillistone
LT	Lapilli Tuff
LX	Lobe and Microbreccia
MA	Massive
MD	Microdiorite
MU	Mudstone
MZ	Monzonite
NO	Norite
PD	Peridotite
PG	Porphyritic Granite
PI	Pillows
PL	Parallel Laminated
PP	Peperite
PR	Pyroxenite
PT	Crystal Tuff
PX	Pillow Breccia
PY	Pyroclastic Rock
QD	Quartz Diorite
QM	Quartz Monzonite
QP	Quartz Porphyry
QS	Quartz Syenite
QZ	Quartzite
RH	Rhyolite
SE	Serpentinite
SL	Sandstone-Siltstone
SP	Spinifex
SS	Sandstone
ST	Siltstone
SY	Syenite
TA	Trachyandesite
TB	Trachybasalt
TC	Talc Chlorite Schist
TF	Tuff
TN	Tonalite
TR	Trachyte
TS	Talc Schist
TX	Tuff Breccia
VB	Volcaniclastic Breccia
VC	Volcaniclastic Rock
VS	Volcaniclastic Sandstone
VX	Volcanic Breccia
WA	Wacke
WT	Welded Tuff
YX	Pyroclastic Breccia
ZD	Monzodiorite
ZG	Monzogabbro
ZP	Quartz Feldspar Porphyry

Textural Description	
am	amygdaloidal
ap	aphyric
ax	alteration breccia
bd	bedded
bx	brecciated
cb	cross bedded
cf	cooling fractures
cg	coarse grained
cl	clast supported
cu	cumulate
cy	cyclic
db	diabasic
ec	elongated clasts
ep	elongated pillows
ey	eyes
fb	flow banding
fc	flattened clasts
fg	fine grained
fl	finely laminated
fp	flattened pillows
ft	fluidal texture
fx	fractured
gp	glomeroporphyritic
hu	hummocky cross-stratified
ib	intrusive breccia
ig	inverse grading
lm	laminated
mg	medium grained
mm	monomictic
mx	matrix supported
my	mylonite
ng	normal grading
op	ophitic
pg	pegmatitic
pj	polygonal joints
pm	polymictic
po	porphyritic
ps	polysutured
re	reworked
sc	schistose
sh	sheared
sp	spherulitic
ss	soft-sediment deformation
sx	spinifex
tb	turbidite
tc	trachytic
tf	tuffaceous
tx	tectonic breccia
va	variolitic
ve	vesicular
vf	aphanitic
xl	xenoliths

SYMBOLS

Small outcrop
Area of outcrop (observed)
Area of outcrop (compiled)
Geological contact (trend only, interpreted)
Geophysical contact (trend only, interpreted)
Fault (trend only, interpreted)
Fault (trend only, interpreted from geophysical data)
Fold; anticline, unknown generation (trend only, interpreted)
Fold; syncline, unknown generation (trend only, interpreted)
Bedding; unsubdivided, facing not known (trend only, magnitude of dip unknown)
26 Bedding; unsubdivided, facing not known (inclined, vertical)
26 Bedding; graded, facing direction known (trend only, inclined)
38 Bedding; facing direction known (trend only, inclined)
38 Bedding; facing direction known (vertical, overturned)
Bedding; pillows, facing not known (trend only)
38 Bedding; pillows, facing direction known (trend only, inclined)
Bedding; pillows, facing direction known (vertical)
52 Igneous layering; facing not known (inclined)
36 Foliation; unknown generation, compiled (trend only, inclined, vertical)
Foliation; second generation (trend only)
56 Foliation; second generation (inclined, vertical)
42 Foliation; third generation (inclined)
47 Cleavage; dextral horizontal displacement, unknown vertical displacement, (inclined)
Brittle-ductile fault (trend only)
46 Brittle-ductile fault; unknown horizontal displacement, unknown vertical displacement, unknown generation (inclined, vertical)
Vein (map scale)
Igneous contact (trend only)
47 Igneous contact (inclined, vertical)
8 Mine
⑤ Occurrence
19 Prospect
Township boundary
Roads, trails
Bogs
Mine workings

Ontario

Ontario Geological Survey

MAP P.3557

PRECAMBRIAN GEOLOGY

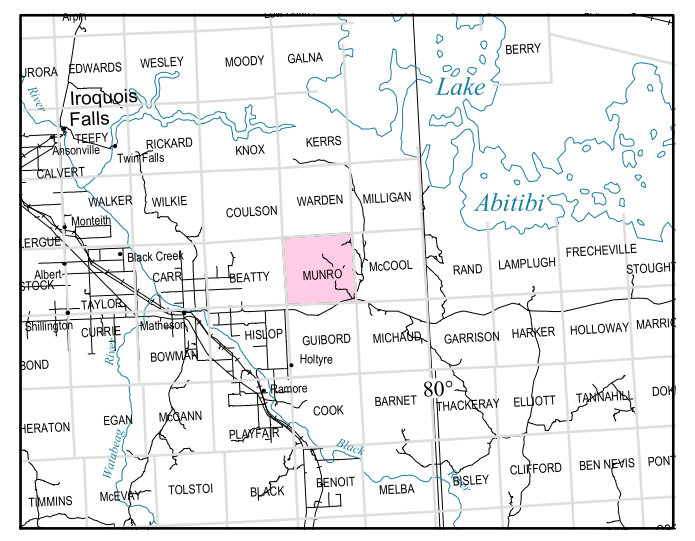
MUNRO TOWNSHIP

Scale 1:10 000

250 m 0 0.25 500 m

NTS Reference: 42 A/9

This map is published with the permission of the Director, Ontario Geological Survey.



Location Map 1cm equals 10 km

This geologic map represents one of the products of the Greenstone Architecture project of the Discover Abitibi Initiative, which was designed to stimulate mineral exploration in the Ontario portion of the Abitibi greenstone belt and has components that range from geophysical surveying to deposit-scale mapping (*see* Ayer et al. 2003, 2004). This map presents results from the second year of Base Metal Subproject 3, as summarized in Péloquin and Gibson (2004).

Cette carte géologique représente un des produits découlant du projet relatif à la ceinture de roches vertes architecturale, lequel s'inscrit dans le cadre de l'initiative *Découvrons l'Abitibi*, conçue pour stimuler l'exploration minérale dans la section ontarienne de la ceinture de roches vertes de l'Abitibi et constituée de diverses composantes, depuis les levés géophysiques jusqu'aux cartes à l'échelle du gisement (voir Ayer et al. 2003, 2004). Cette carte présente les résultats de la deuxième année de l'étude portant sur le sous-projet 3 relatif aux métaux communs, résumée dans Péloquin et Gibson (2004).

Ayer, J.A., Thurston, P.C., Dubé, B., Fowler, A.D., Gibson, H.L., Hudak, G., Lafrance, B., Lesher, C.M., Piercey, S.J., Reed, L.E. and Thompson, P.H. 2003. Overview of the Discover Abitibi Greenstone Architecture project: subprojects, goals and results; *in* Summary of Field Work and Other Activities 2003, Ontario Geological Survey, Open File Report 6120, p.32-1 to 32-12.

Ayer, J.A., Thurston, P.C., Dubé, B., Gibson, H.L., Hudak, G., Lafrance, B., Lesher, C.M., Piercey, S.J., Reed, L.E. and Thompson, P.H. 2004. Discover Abitibi Greenstone Architecture project: overview of results and belt-scale implications; *in* Summary of Field Work and Other Activities 2004, Ontario Geological Survey, Open File Report 6145, p.37-1 to 37-15.

Péloquin, A.S. and Gibson, H.L. 2004. Discover Abitibi. Base Metal Subproject 3. Geology of the Kidd–Munro, Tisdale and Kinojevis assemblages in Munro and Currie townships; *in* Summary of Field Work and Other Activities 2004, Ontario Geological Survey, Open File Report 6145, p.40-1 to 40-10.

SOURCES OF INFORMATION

Base map information derived from the Ontario Land Information Warehouse, Land Information Ontario, Ontario Ministry of Natural Resources, scale 1:20 000. Universal Transverse Mercator (UTM) co-ordinates are in North American Datum 1983 (NAD83), Zone 17.

Assessment files, Resident Geologist's office, Kirkland Lake.

Allen, R. 1986. Petrology and chemistry of a differentiated komatiite sill and Fe-Ni-Cu sulphide mineralization, Munro and Beatty townships, northeastern Ontario; unpublished MSc thesis, Queen's University, Kingston, Ontario, 110p.

Arndt, N.T. 1975. Ultramafic rocks of Munro Township and their volcanic setting; unpublished PhD thesis, University of Toronto, Toronto, Ontario, 192p.

Barrie, C.T. 1999. Geological compilation, Beatty and Munro townships; Ontario Geological Survey, Preliminary Map P.3395, scale 1:20 000.

Canil, D. 1985. The geochemistry of komatiites and tholeiites from the Deadman Hill area, Munro Township, Ontario; unpublished BSc thesis, University of Windsor, Windsor, Ontario, 69p.

Davis, P.C. 1997. Volcanic stratigraphy of the Late Archean Kidd–Munro assemblage in Dundonald and Munro townships and genesis of associated nickel and copper-zinc volcanogenic massive sulphide deposits, Abitibi greenstone belt, Ontario, Canada; unpublished MSc thesis, University of Alabama, Tuscaloosa, Alabama, 201p.

Gamble, D. 2000. Geology of the Potter Cu-Zn-Co-Ag VMS mineralization and exploration progress report to March 31, 2000 at Millstream Mines Ltd. Potter Mine exploration project; unpublished report, Dave Gamble Geoservices Inc., 80p.

Houlé, M.G., Lesher, C.M., Gibson, H.L. and Sproule, R.A. 2002. Recent advances in komatiite volcanology in the Abitibi greenstone belt, Ontario; *in* Summary of Field Work and Other Activities 2002, Ontario Geological Survey, Open File Report 6100, p.7-1 to 7-19.

Johnstone, R.M. 1991. The geology of the northwestern Black River-Matheson area, District of Cochrane; Ontario Geological Survey, Open File Report 5785, 288p.

——— 1991. Geology of Munro Township; Ontario Geological Survey, Open File Map 159, scale 1:15 840.

Hunter Dickenson Group. 2005. Interpretive map of the Millstream Mines Ltd. Potter Project Property: surface geology; Millstream Mines Ltd. Web site: http://www.millstreammines.com/potterpics/potgeo.jpg [accessed January 20, 2005]

Oliver, J.L., Rebagliati, C.M. and Haslinger, R.J. 1999. Summary exploration report - Potter Mine property, Munro Township, Ontario for the HDG Potter Exploration Limited Partnership of Hunter Dickinson Group Inc. and Millstream Mines Limited; Hunter Dickinson Group Inc., unpublished company report, p.1-1 to 11-3.

Ontario Geological Survey 2002a. Mineral Deposit Inventory Version 2 (MDI2), October 2002 Release; Ontario Geological Survey, Digital Data.

——— 2002b. Ontario airborne geophysical surveys, magnetic and electromagnetic data, Kidd–Munro, Matheson area; Ontario Geological Survey, Geophysical Data Set 1101.

——— 2003. Ontario airborne geophysical surveys, magnetic and electromagnetic data, Kidd–Munro, Blake River area MEGATEM® II survey; Ontario Geological Survey, Geophysical Data Set 1044.

Satterly, J. 1952a. Geology of Munro Township; Ontario Department of Mines, Annual Report 1951, v.60, pt.8, 60p.

——— 1952b. Township of Munro, District of Cochrane, Ontario; Ontario Department of Mines, Map 1951-5, scale 1:12 000.

Magnetic declination approximately 11°57'W in 2004.

Geology not tied to surveyed lines.

CREDITS

Geology and compilation by A.S. Péloquin, M.G. Houlé and H.L. Gibson, 2004.

Digital map preparation by A.S. Péloquin, 2004–2005.

Cartographic production by A. Evers.

Geological mapping and research supported by the Discover Abitibi Initiative under contract awarded to the Mineral Exploration Research Centre (MERC), Laurentian University, Sudbury, Ontario.

Contract management, project management by Robert Calhoun, Project Manager, Discover Abitibi Initiative.

Overall project management by Timmins Economic Development Corporation.

FedNor
Canada

Ontario
Northern Ontario Heritage Fund
Fonds du patrimoine du Nord de l'Ontario

Discover Abitibi
A project of innovation, cooperation and revitalization
Découvrons l' Abitibi
Un projet d' innovation, de coopération et de renouvellement

Discover Abitibi Initiative
The Discover Abitibi Initiative is a regional, cluster economic development project based on geoscientific investigations of the western Abitibi greenstone belt. The initiative, centred on the Kirkland Lake and Timmins mining camps, will complete 19 projects developed and directed by the local stakeholders. FedNor, Northern Ontario Heritage Fund Corporation, municipalities and private sector investors have provided the funding for the initiative.

Initiative Découvrons l'Abitibi
L'initiative *Découvrons l'Abitibi* est un projet de développement économique régional dans une grappe d'industries, projet fondé sur des études géoscientifiques de la ceinture de roches vertes de l'Abitibi occidental. Cette initiative, centrée sur les zones minières de Kirkland Lake et de Timmins, mènera à bien 19 projets élaborés et dirigés par des intervenants locaux. FedNor, la Société de gestion du Fonds du patrimoine du Nord de l'Ontario, municipalités et des investisseurs du secteur privé ont fourni les fonds de cette initiative.

Timmins

KIRKLAND LAKE
THE RIGHT ENVIRONMENT

Issued 2005.

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.

Péloquin, A.S., Houlé, M.G. and Gibson, H.L. 2005. Precambrian geology of Munro Township; Ontario Geological Survey, Preliminary Map P.3557, scale 1:10 000.

PROPERTIES AND OCCURRENCES

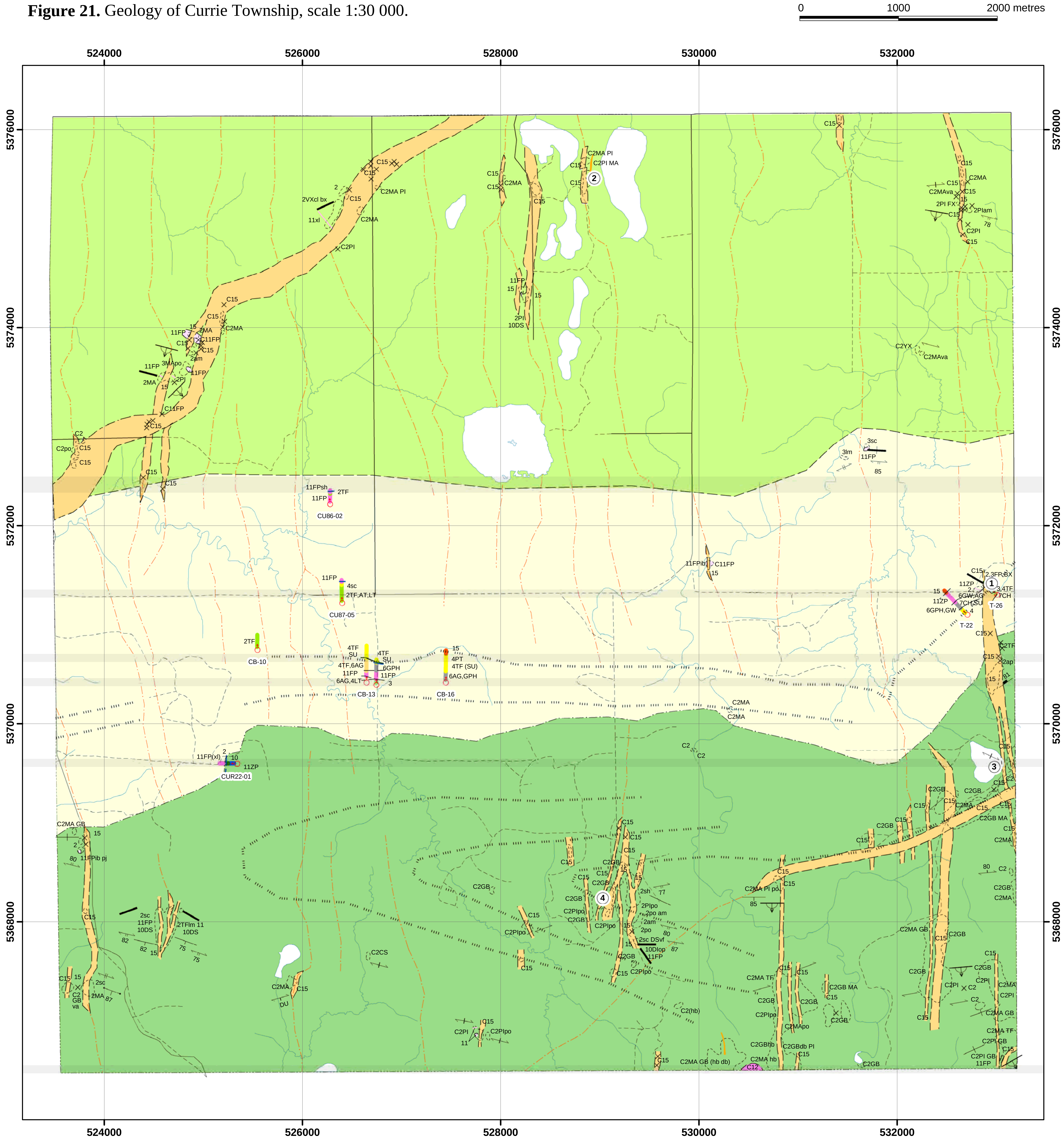
Number on Map	Deposit Name	Deposit Classification	Commodity
1	Warden	Occurrence	Asbe
2	Warden Hill Occurrence	Occurrence	Asbe
3	Flagro	Occurrence	Asbe
4	Ford, H.M.	Occurrence	Asbe
5	Walhart, G.M.L.	Occurrence	Au
6	Stewart, W.T.	Occurrence	Au
7	Munro	Mine	Asbe
8	Croesus Mine	Mine	Ag, Au
9	Potterdoal Mine	Mine	Ag, Cu, Zn, Au, Co
10	Mangan–Dyer	Occurrence	Asbe
11	Centre Hill (Potter) Mine Ltd.	Mine	Ag, Cu, Zn, Au, Ni
12	Potter–Doal Occurrence	Occurrence	Asbe
13	Dimmick	Occurrence	Au
14	Reoplata Occurrence	Occurrence	Au, U, Asbe
15	Munro Reo Plata	Occurrence	Asbe
16	Strongford	Occurrence	Asbe
17	Zevely	Occurrence	Au
18	Big Game Occurrence	Occurrence	Au, Zn
19	Dyman-1	Prospect	Cu, Co
20	Lalonde	Prospect	Au, Ag, As, Cu, Pb, Zn
21	McChristie Trench 1	Occurrence	Au, Cu, Zn
22	McChristie Trench 3	Occurrence	Cu
23	Panterra	Occurrence	Cu, Ni, Zn, Co
24	Brown–Munro	Prospect	Au
25	White–Guyatt	Prospect	Au, Pb, Zn
26	Colossus	Occurrence	Au, Pb, Zn
27	Buff Munro Mine	Occurrence	Au, Asbe, Pb, Zn
28	Northern Goldbelt	Occurrence	Ag, Au, Cu, Pb, Zn
29	Mickle	Occurrence	Ni, Pd, Pt
30	American Eagle Mine	Mine	Au

ABBREVIATIONS

Ag	Silver
As	Arsenic
Asbe	Asbestos
Au	Gold
Co	Cobalt
Cu	Copper
Ni	Nickel
Pb	Lead
Pd	Palladium
Pt	Platinum
U	Uranium
Zn	Zinc

Figure 21. Geology of Currie Township, scale 1:30 000.

Accompanies OFR 6157.



Unit

2	Mafic Volcanic Rocks
3	Intermediate Volcanic Rocks
4	Felsic Volcanic Rocks
6	Clastic Sedimentary Rocks
7	Chemical Sedimentary Rocks
10	Mafic Intrusive Rocks
11	Porphyry Suite
12	Felsic Intrusive Rocks
15	Mafic Intrusive Rocks (Matachewan and Sudbury diabase dike swarms)

Legend

Volcanic Assemblages

🟩 Lower Blake River Assemblage (dominantly basalts)

Lithology in Drill Core

- Basalt

🟩 Upper Tisdale Assemblage (dominantly tuffs and sediments)

Lithology in Drill Core

- Basalt Tuff
- Andesite
- Felsic Tuff
- Interbedded Felsic Tuffs and Sediments
- Interbedded Sediments and Tuffs
- Sediments (greywackes and argillites)

🟩 Lower Tisdale Assemblage (dominantly basalts)

Intrusive Rocks

🟪 Porphyry Suite (including lithology in drill core)

🟪 Granitic Intrusion

Gabbro (lithology in drill core)

🟧 Proterozoic Diabase Dike (including lithology in drill core)

Diabase Dike (based on geophysics)

Symbols

C Designates compiled outcrop

Outcrop and outcrop areas

× Outcrop

DDH (with company drill hole identification)

Geological contact: Interpreted/Compiled

Geological contact: Based on Geophysics

Magnetic Lineament

Bedding: Trend only, Vertical, Inclined, Pillows with facing

Foliation - measured: Vertical, Inclined

DU Foliation - compiled: Trend only, Vertical, Inclined, Inclined dip unknown

Igneous Contact: Trend only, Vertical

Igneous Layering: No facing

Joint: Inclined

Mineral Occurrences

① Curie (Tillex)

② Anderson

③ Foster

④ Reid

Mapping and compilation by A.S. Péloquin.

Sources of data:
Falconbridge Ltd., unpublished data.
Kinross Gold Corporation, unpublished data.
Kirkland Lake Drill Core Library.
Leahy, E. J. 1965. Currie and Bowman Townships; Ontario Department of Mines, Map 2071, 1:31 680.
Ontario Geological Survey 2004b. Ontario airborne geophysical surveys, magnetic data, central Abitibi Destor-Porcupine–Pipestone faults area (Discover Abitibi); Ontario Geological Survey, Geophysical Data Set 1049.

Rock Unit Modifier

AG	argillite
AT	ash tuff
BX	breccia
CH	chert
CS	chlorite schist
DI	diorite
DS	dike/sill
FL	flow
FP	feldspar porphyry
FX	flow breccia
GB	gabbro/gabbroic
GPH	graphitic phyllite
GR	granite
GW	greywacke
LT	lapilli tuff
MA	massive
PI	pillowed
PT	crystal tuff
SU	sulphides
TF	tuff
VX	volcanic breccia
YX	pyroclastic breccia
ZP	quartz feldspar porphyry

Texture or Descriptor

am	amygdaloidal
bx	brecciated
cl	clast supported
db	diabasic
hb	hornblende
ib	intrusive breccia
lm	laminated
op	ophitic
pj	polygonal joints
po	porphyritic
sc	schistose
sh	sheared
va	variolitic
vf	aphanitic
xl	xenoliths

FedNor
Canada
Ontario
Northern Ontario Heritage Fund
Fonds du patrimoine du Nord de l'Ontario
Discover Abitibi
A project of innovation, cooperation and revitalization
Découvrons l' Abitibi
Un projet d' innovation, de coopération et de renouvellement

Discover Abitibi Initiative
The Discover Abitibi Initiative is a regional, cluster economic development project based on geoscientific investigations of the western Abitibi greenstone belt. The initiative, centred on the Kirkland Lake and Timmins mining camps, will complete 19 projects developed and directed by the local stakeholders. FedNor, Northern Ontario Heritage Fund Corporation, municipalities and private sector investors have provided the funding for the initiative.

Initiative Découvrons l'Abitibi
L'initiative *Découvrons l'Abitibi* est un projet de développement économique régional dans une grappe d'industries, projet fondé sur des études géoscientifiques de la ceinture de roches vertes de l'Abitibi occidental. Cette initiative, centrée sur les zones minières de Kirkland Lake et de Timmins, mènera à bien 19 projets élaborés et dirigés par des intervenants locaux. FedNor, la Société de gestion du Fonds du patrimoine du Nord de l'Ontario, municipalités et des investisseurs du secteur privé ont fourni les fonds de cette initiative.

Timmins
KIRKLAND LAKE
THE RIGHT ENVIRONMENT