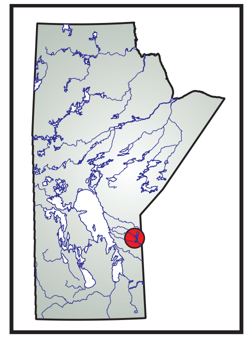
GS-12 Re-evaluation of the geology of the Berens River Domain, east-central Manitoba (parts of NTS 52L, M, 53D, E, 62P, 63A, H)

by M.T. Corkery, L.A. Murphy and H.V. Zwanzig[1]



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Summary

Fieldwork conducted during the summer of 2010 was designed to take advantage of a well-exposed corridor in the Family–Fishing lakes area, which includes the east end of the Horseshoe Lake greenstone belt. The Horseshoe Lake greenstone belt represents one of the only supracrustal belts in Manitoba that has never been systematically mapped by the Manitoba Geological Survey (MGS). The goals of the program are to re-examine the rock types described by previous mapping and to collect a suite of samples for future geochemistry, geochronology and isotopic studies. The new dataset updates the plutonic complex to current nomenclature standards, providing a consistent legend of rock types in the Berens River Domain for use on the 1:250 000 scale digital map of Manitoba. In addition, modern terminology ensures that comparisons can be made to similar adjacent rocks in Ontario.

Preliminary outcrop observations combined with geochemical analyses indicate the mafic to potassic felsic rocks were emplaced in a variety of tectonic environments involving at least five igneous suites. All rocks are metaluminous and rich in alkali elements; gabbro plots in the alkaline field. Preliminary data indicate a continental environment for the entire set of mafic to potassic felsic suites and suggest evolution in a continental arc through its continental collision and postcollisional magmatism. Isotopic dates for one of the potassic rocks and a dacite or hornblende tonalite are needed to provide a time frame for the evolution of this igneous suite.

Introduction

Only limited geological mapping has been performed on the region along the east side of Lake Winnipeg. The Geological Survey of Canada (Johnson, 1936a–f) reported that the area between the Rice Lake and Island Lake greenstone belts had only one supracrustal belt of note in a vast region of granitic rock. Johnson's maps, although based on closely spaced traverse points, provided a limited geological interpretation, as the vast majority of the region within the map area was reported as undivided granitic intrusive rocks with no structural data. Ermanovics (1969, 1970) conducted more comprehensive mapping concentrating on the variation in granitic and gneissic rocks. These maps, although more comprehensive, suffer from inconsistent legends. Baldwin et al. (1984) reported on the mineral potential of the Horseshoe Lake greenstone belt under the auspices of the Mineral Deposit Series program and included a limited description of supracrustal rocks. This area represents one of the only greenstone belts in Manitoba that has never been systematically mapped.

The current reconnaissance field mapping program was designed to take advantage of a well-exposed corridor of exposure on the shorelines of Family and Fishing lakes. The goal was to remap the rock types described by Ermanovics (1969, 1970) that are exposed on these lakes and to collect a suite of samples for future geochemistry, geochronology and isotopic studies. The new dataset provides a review of the old nomenclature, some of which was based on the pre-1970 'clan' classification of plutonic rocks, a review and comparison of the legends from previous geological maps (Johnson, 1936a–f; Ermanovics 1969, 1970) in the transect area, and a comparison to similar adjacent rocks in Ontario and their tectonic setting.

The primary outcome of this study is the rationalization of the various existing geological maps to a common legend. Secondly, extensive mapping by the Ontario Geological Survey (Stone, 1998) is used to help reinterpret the tectonic history of the region.

Regional geology

The Berens River Subprovince, in the northwest of the Archean Superior Province, was defined by Card and Ciesielski (1986) as a large domain of mostly Archean felsic plutonic rocks. This east-trending subprovince reaches approximately 250 km in width at the Manitoba-Ontario border and extends eastward from Lake Winnipeg for approximately 500 km across northwestern Ontario (Figure GS-12-1). In Manitoba, the Berens River Subprovince spans the region from Bissett in the south to Gorman Lake in the north. The bounding Uchi and Sachigo subprovinces are dominated by variably deformed and metamorphosed supracrustal sequences that are extensively intruded by plutonic rocks. In Manitoba, the Rice Lake greenstone belt sits on the south margin and the Gorman Lake greenstone belt on the north margin.

[1] Manitoba Geological Survey (retired)

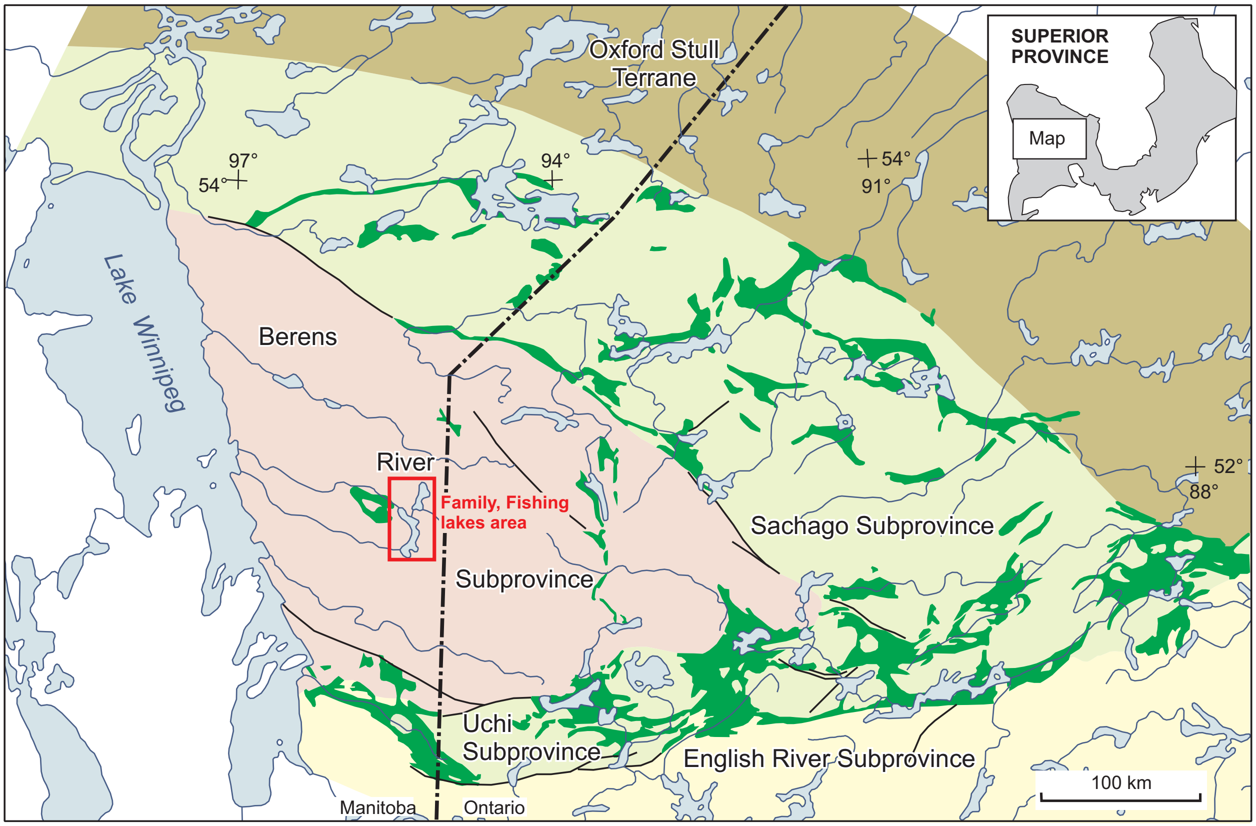

***Figure GS-12-1:** North Caribou Superterrane in Manitoba and northwestern Ontario comprises the granite greenstone Uchi Subprovince and Sachigo Subprovince (pale green with dark green greenstone belts) and cored by the Berens River Subprovince (pink;* after *Corfu and Stone, 1998).*

A wealth of U-Pb geochronological data was generated in the late 1980s through the 1990s for northwestern Ontario, and with this, new tectonic interpretations and a new understanding of the geological history emerged (e.g., Thurston et al., 1991; Williams et al., 1992, Corfu and Stone, 1998). These works indicate that volcanic rocks bounding the subprovince share mainly pre-2900 Ma ages and thus are 200 m.y. older than most greenstone belt sequences in the rest of the northwestern Superior Province. In the area north of the Rice Lake Belt, Turek and Weber (1994) reported 3.0 Ga plutonic rocks within the Berens River Subprovince. Thus, three subprovinces—Uchi, Berens River and Sachigo—were recognized to have a common history and were grouped into what has become known as the North Caribou Superterrane (Thurston et al., 1991).

In Manitoba, the Berens River Domain nomenclature has been retained to define the plutonic core of the North Caribou Superterrane. The central region of the Berens River Domain is underlain predominantly by felsic plutonic rocks and rare metavolcanic or metasedimentary rocks. The greenstone belt at Horseshoe Lake and a thin sliver of supracrustal rocks at Gorman Lake represent the only noteworthy supracrustal sequences in Manitoba. Similarly, Stone (1998) reported three small greenstone belts at McInnes, Hornby and Cherrington lakes with a few small slivers elsewhere.

Geology of the Family–Fishing lakes area

The Family–Fishing lakes area provides a 65 km long corridor in the core of the Berens River Domain. This section is oblique to the structural fabric of the region and provides access to most of the major rock types reported by Ermanovics (1969, 1970). In the following section, field observations of the rocks are described from oldest to youngest as interpreted by Ermanovics (1969, 1970). This is followed by a section interpreting the units in a regional sense.

Lithological description of units investigated

Unit 1: Intermediate volcanogenic rocks

The eastern termination of the Horseshoe Lake supracrustal belt crops out at the northwest end of Family Lake at Night Owl Rapids. The sequence is approximately 2 km thick and comprises felsic volcanogenic sediment and possible tuff and lapilli tuff. In central Horseshoe Lake and on Night Owl Lake, to the west, Baldwin et al. (1984) mapped a well-exposed section of these felsic fragmental rocks. They interpreted the sequence of crystal-rich felsic rocks as resedimented felsic pyroclastic rocks.

In exposures on Family Lake, approximately 25–35% of the rock consists of plagioclase and quartz crystals in a fine-grained homogeneous matrix. Plagioclase crystals are euhedral to subhedral laths ranging from 0.25 to 1 mm in length. Quartz crystals rarely exceed 10% of the total phenoclast population, are typically equant and range in size from 0.25 to 2 mm. Rare, up to 3 cm by 5 cm aggregates more rich in biotite and similar-sized patches with distinct variations in crystal populations or textures are interpreted to represent clasts or fragments (Figure GS-12-2). Variations in crystal content, grain size and the occurrence of possible clasts were commonly observed in outcrop. This is interpreted to indicate the existence of bedding; however, bedding surfaces were not identified anywhere in the rather homogeneous thick sequence.

Unit 2: Hornblende tonalite to granodiorite gneiss

Strongly gneissic rocks are locally exposed in the study area but grade into more extensive units or layers of uniform foliated intrusive rocks with inclusions or schlieren. One small outcrop of typical tonalite gneiss was observed at the south end of Family Lake. A second area, mapped by Ermanovics (1970) as tonalite gneiss northwest of the community of Little Grand Rapids, may belong to this suite of gneisses.

These gneisses are typically defined by areas of well-layered, medium-grained grey to dark grey hornblende tonalite with varying percentages of finer-grained amphibolite (Figure GS-12-3a). The amphibolite typically forms discontinuous bands that form between 10 and 50% of the outcrop. The bands may range from massive to compositionally layered on a scale of 3–20 cm (Figure GS-12-3b). The amphibolite bands are interpreted to represent either an older restite phase of supracrustal origin or transposed boudinaged mafic dikes. Leucocratic fine-grained tonalite–trondhjemite or granodiorite forms a separate intrusive component.

Unit 3: Hornblende tonalite to granodiorite

Grey tonalite, weathering dark- or light-grey to buff, occurs along the west shore of Fishing Lake and at the south end of Family Lake. In most locations, the tonalite is associated with the tonalite to granodiorite gneiss. It can be traced into the gneiss and is herein interpreted as one or more of its components that is better preserved than the rest and often occurs in larger bodies. Typically the biotite±hornblende–bearing tonalite-suite rocks are homogeneous, equigranular and medium to coarse grained. They are weakly to strongly foliated.

In the southwest bays at Family Lake, hornblende tonalite is gradational into weakly megacrystic tonalite to granodiorite. Textures range from homogeneous equigranular through seriate to porphyritic. Plagioclase varies from groundmass up to approximately 1.5 cm megacrysts and may occur as random sparsely megacrystic patches to entirely megacrystic outcrops with up to 20% plagioclase.

Unit 4: Megacrystic quartz monzonite to granite

Megacrystic quartz monzonite is exposed in two bodies in the southern bays of Family Lake. Although similar in composition to younger intrusions, in this unit the abundant alkali-feldspar phenocrysts are generally 1.5 cm long, some up to 6 cm and most have a 2:1 aspect ratio. The microcline is rimmed by both quartz and plagioclase, and has quartz cores. Inclusions comprise intermediate and mafic rocks. The rock is composed of 55–60% microcline, 15–20% quartz, 15% matrix plagioclase and 10% hornblende+biotite (hornblende dominant).

Figure GS-12-2: *Massive felsic volcanogenic sediment with 1–4 cm angular felsic and mafic fragments in a fine-grained feldspar crystal–rich matrix.*

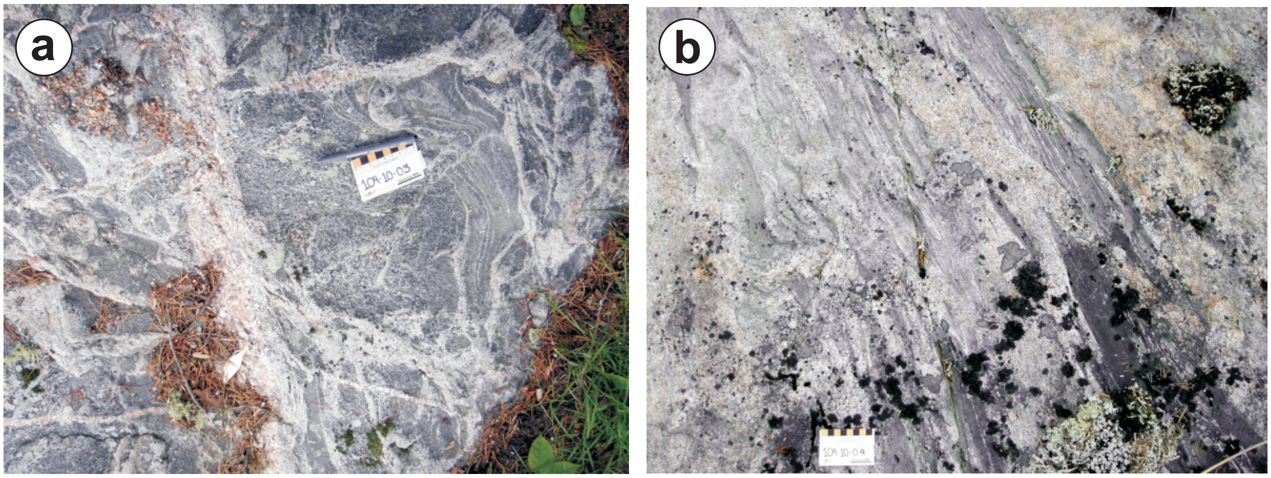

***Figure GS-12-3:** Hornblende tonalite gneiss shows the multicomponent nature of the gneissic suite: **a)** Old, strongly foliated and layered amphibolitic gneiss (right of pen) associated with early gabbro/diorite is injected by young tonalite and late granite pegmatite; **b)** tonalite gneiss intruded by hornblende tonalite to granodiorite (unit 3).*

Unit 5: Mafic to intermediate intrusive rocks

On one large outcrop at Fishing Lake, elongate rafts of black-weathering, fine-grained gabbro to diorite occur in the hornblende-tonalite to granodiorite. This gabbro might represent the oldest intrusive phase in the area. The rock contains some injections of tonalite; the diorite may be an altered version of the gabbro affected by tonalite.

Unit 6: Leucocratic granodiorite to tonalite

Pale grey to beige granodiorite to tonalite is the dominant rock type in the southern half of the Family–Fishing lakes area. It is generally medium to coarse grained. Textures vary from homogeneous equigranular through seriate to porphyritic. In most locations, the rock has a weakly to moderately developed northwest-trending foliation, parallel to the regional trends. The granodiorite–tonalite is typically cut only by straight-sided, microcline-dominated pegmatite dikes. There are two textural end members in this unit: homogeneous equigranular medium- to coarse-grained rock and alkali-feldspar megacrystic rock. Alkali-feldspar megacrysts have a wide range in both abundance and size. In sparsely megacrystic rocks, equant alkali-feldspar crystals range from the size of groundmass up to 1 cm. The megacrysts are randomly distributed throughout the outcrop. The granite is typically cut by alkali-feldspar–dominated, pink/iron-stained, straight-sided pegmatite dikes that are coarse grained and 2–20 cm thick. Also, patches of nebulitic pegmatite pods occur in the granite and may represent late phases in the crystallization of granite.

Unit 7: Biotite±muscovite granite

A buff to light grey granite, weathering beige to grey-brown, forms a northeast-trending oval body on south-central Fishing Lake. Three distinct granitic intrusive phases were observed in the body. The dominant phase is a homogeneous, equigranular, medium- to coarse-grained granite. A second, alkali-feldspar megacrystic phase forms irregular zones throughout the granite. Although textures are very distinct within each phase, the contacts between each are always gradational over several centimetres. The third, fine-grained phase is interpreted to represent late fluid taken into hydraulically fracturing crystal-rich mush to form a web pattern giving the outcrop an agmatitic appearance. Contacts are gradational over several centimetres. In thin section, the rock comprises equal proportions of quartz, plagioclase and alkali feldspar with green–brown biotite and minor muscovite.

Unit 8: Migmatite

A unique suite of rocks in the study area is a complex mixture of variably deformed rocks. The suite typically comprises varying percentages of older rock types intruded by granite (unit 7) to granodiorite to tonalite (unit 6). It forms a complex and highly variable package ranging from weakly foliated agmatite to orthogneiss. This migmatite does not contain obvious anatectic derivatives but is dominated by intrusive phases ranging from granite to tonalite with zones containing deformed and partially assimilated older gneiss (unit 2) and supracrustal rocks. Outcrops vary from strongly layered straight gneiss (Figure GS-12-4a) to broad exposures of weakly deformed agmatite with a matrix of granite–granodiorite (Figure GS-12-4b), including varying percentages of blocks of older intrusive rocks and rare supracrustal xenoliths.

Northwest of Little Grand Rapids, an area of weakly to strongly deformed agmatite comprises varying percentages of hornblende tonalite, quartz diorite and diorite. Magnetite and pyrite are common. In one weakly deformed agmatitic outcrop, the content of magnetite rises to approximately 5% with minor pyrite and trace

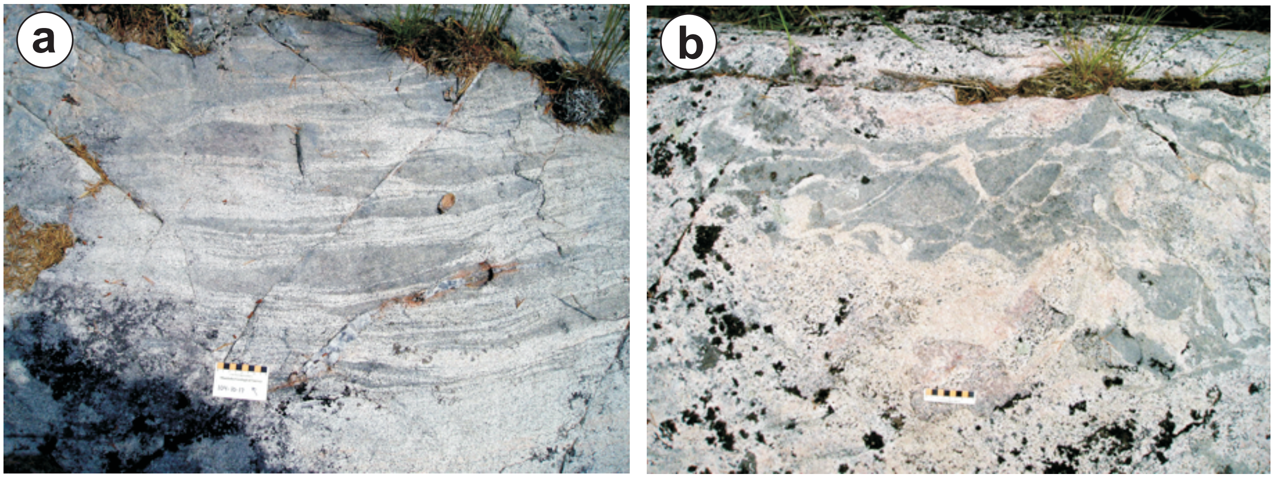

***Figure GS-12-4:** Outcrop photos of the end members of this migmatite suite: **a)** layered orthogneiss to **b)** weakly foliated agmatite.*

chalcopyrite. Local inclusions are interpreted as recrystallized dacite, some of which retain fragmental textures. Fine-grained granite or granodiorite is another local, presumably younger, component of these outcrops. A northwest-trending high-strain zone defines the northern extent of the unit where the agmatite is transposed into banded gneiss. The uncharacteristically high oxide and minor sulphide content make this occurrence unique.

Unit 9: Late intrusive rocks

Pink medium- to coarse-grained leucocratic granite forms a small intrusive plug approximately 3 km in diameter, north of the intermediate volcanic rocks in northwest Family Lake. The rock is homogeneous, equigranular and unfoliated and comprises subequal amounts of quartz, plagioclase and microcline, with minor biotite.

Medium- to coarse-grained biotite-muscovite–bearing granite occurs as a late phase in the leucocratic granodiorite to granite on Fishing Lake. Ermanovics (1970) also describes a two-mica granite pluton intruding the core of the Horseshoe Lake greenstone belt. In Ontario as well, Stone (1998) reports numerous small plutons of peraluminous granite are restricted to areas near supracrustal belts.

An unusual suite of small intrusions was encountered in the northern portion of Fishing Lake. This diverse set of rock types includes quartz-poor, potassium-feldspar–rich quartz monzonite and local boudinaged mafic dikes forming a stockwork that cut all intrusive phases except the late tectonic granite with which they are associated.

Geochemistry

Twelve samples representing all major rock types in the regional reconnaissance were collected for chemical analysis. Weathered surfaces were removed in the field on outcrops of the sampled rocks prior to crushing with a tungsten-carbide mill in the MGS rock laboratory. Chemical analyses were carried out by Activation Laboratories Ltd. (Actlabs; Ancaster, Ontario). Major and minor elements were analyzed by inductively coupled plasma–optical emission spectrometry (ICP-OES) and trace elements were analyzed using inductively coupled plasma–mass spectrometry (ICP-MS). Analyses and selected element ratios were published in Data Repository Item DRI2010002[2]. Assay results for precious metals in two samples of the hornblende tonalite to granodiorite agmatitic rocks are pending.

All rocks are metaluminous and rich in alkali elements but only gabbro plots within the alkaline field (Figure GS-12-5a). The linear alkali versus SiO_2 trend suggests a loose genetic relationship of the various igneous suites. However, the trend line from this suite of samples crosses the alkaline divide, unlike rocks related by fractional crystallization. Gabbro to granodiorite samples are medium-K igneous rocks, whereas quartz monzonite to granite samples are high-K.

Primitive-mantle–normalized extended-element plots indicate a range of tectonic environments from the mafic to potassic felsic rocks, apparently involving at least five igneous suites (Figure GS-12-5b–f). Gabbro and diorite have a moderately negative slope from the large-ion lithophile elements (LILE) through the middle rare earth elements (MREE) and show negative high-field-strength element anomalies (HFSE, e.g., Nb, Zr and Hf) and a very slight to distinct negative Ti anomaly (Figure GS-12-5b). This pattern indicates an origin in a mature volcanic arc or by crustal contamination of the melt or melt source. Hornblende tonalite and fragmental dacite share this pattern

[2] MGS Data Repository Item DRI2010002, containing the data or other information sources used to compile this report, is available online to download free of charge at http://www2.gov.mb.ca/itm-cat/web/freedownloads.html, or on request from minesinfo@gov.mb.ca or Mineral Resources Library, Manitoba Innovation, Energy and Mines, 360–1395 Ellice Avenue, Winnipeg, Manitoba R3G 3P2, Canada.

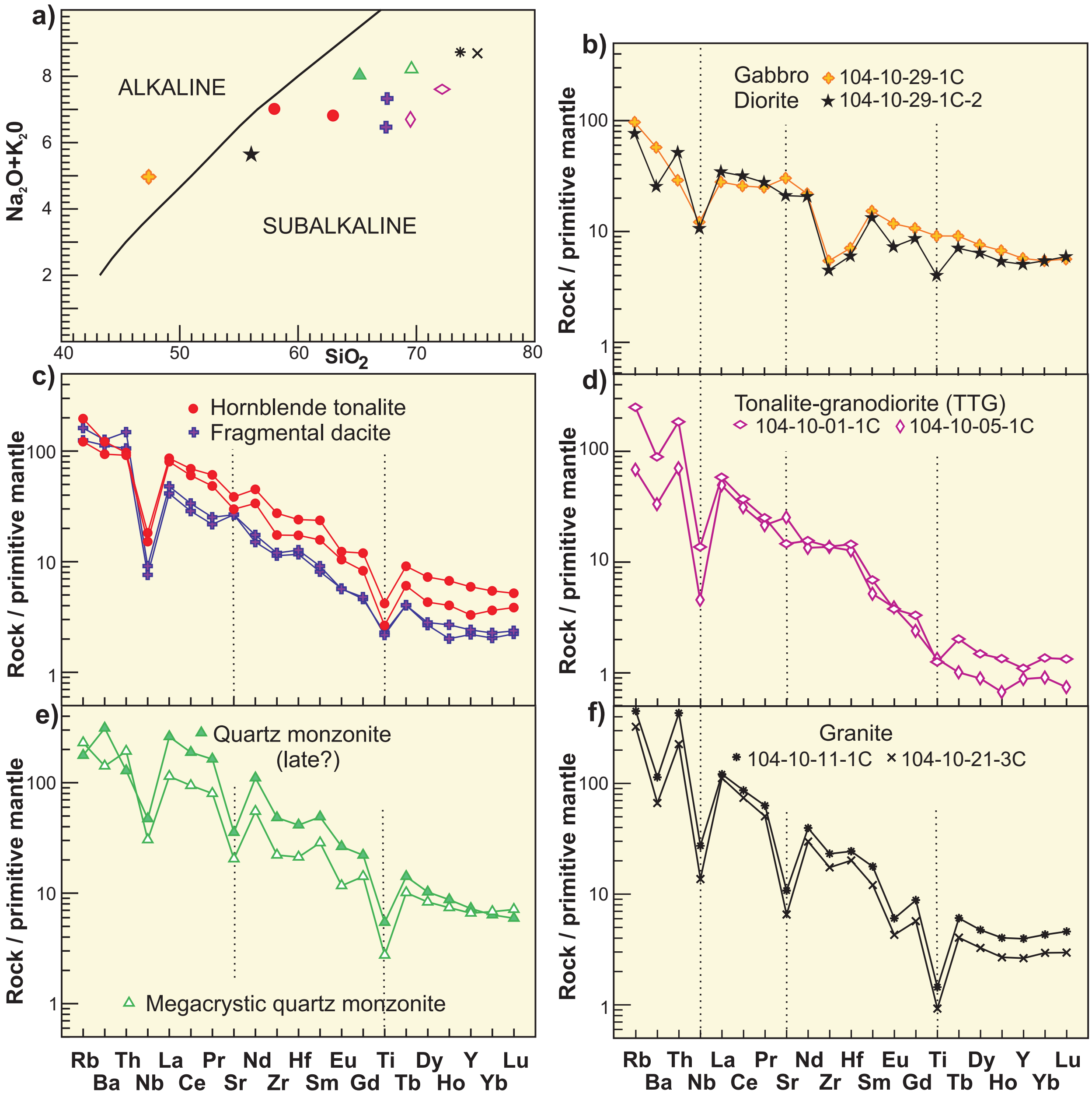

***Figure GS-12-5: a)** Alkali-silica diagram (Irvine and Baragar, 1971); **b–f)** primitive-mantle–normalized multi-element diagrams (Sun and McDonough, 1995).*

but with a steeper slope that implies a component from a different source of melting (Figure GS-12-5c).

Leucocratic tonalite–granodiorite is highly enriched in LILE and strongly depleted in heavy REE (HREE), typical of trondhjemite-tonalite-granodiorite suites (TTG) or Phanerozoic adakite (Figure GS-12-5d). Such sodic rocks have been suggested to have involved crustal melting of mafic rocks with garnet and hornblende and/or older TTG (Defant et al., 1991; Percival et al., 2006; Condie, 2008).

The potassic rocks have normalized element anomalies typical of fractionated volcanic-arc or postcollisional granite (Figure GS-12-5e, f). The more mafic composition (late quartz monzonite) having the highest contents of LILE and light REE (LREE) suggests a source for these elements in subcontinental lithospheric mantle with a history of previous subduction. This is consistent with the gabbro–diorite crossing the alkaline divide. The multi-element pattern of the late quartz monzonite is identical to that of a sanukitoid intrusion in the Thompson Nickel Belt (Zwanzig, unpublished geochemical data on the Bucko pluton, 2003; Zwanzig et al., 2003).

Elevated ratios of Zr/Y and Nb/Yb indicate a continental environment for the entire set of mafic to potassic felsic suites and suggest an evolution in a continental arc through its continental collision and postcollisional magmatism. The early TTG suite suggests crustal melting, probably still during subduction. Isotopic dating of one of the potassic rocks and the dacite or hornblende tonalite is needed to provide a time frame for the evolution of this igneous suite.

The biotite muscovite granite is enriched in SiO_2 and alkali elements, has relatively low alumina and is depleted in most other major elements compared to other plutonic suites. Stone (1998) described this association as a peraluminous (S-type) granite suite. He also reported that these rocks are strongly elevated in Rb, Sr and Nb and strongly depleted in Ba, Sr and Ti (e.g., sample 104-10-21-3C in DRI2010002).

Regional context of Family, Fishing lakes geology

Calcic to sodic intrusive suites

These are the least chemically evolved rocks in the area but still show strong fractionation of REE and high contents of LILE. They are probably the oldest rocks and include volcanic rocks (fragmental dacite), most mafic tonalite and possibly the minor occurrences of gabbro to diorite. Our limited geochemical sampling did not include granodiorite as suggested by the more extensive earlier work (discussed later in this paper).

Hornblende tonalite to granodiorite gneiss and intermediate volcanic rocks

The oldest rock types described by Ermanovics (1969, 1970) and Stone (1998) from past mapping are consistently reported as banded tonalite to granodioritic gneiss with variable percentages of mafic restite. Ermanovics (1969, 1970) subdivide these quartzofeldspathic gneisses using three major criteria: composition, style of banding and percentage of mafic restite. In the last group, the gneissic rocks are dominated by generally granoblastic to weakly foliated restite. Restite is typically massive to layered and laminated amphibolite and less commonly greywacke gneiss. Mafic restite bands are predominantly plagioclase-hornblende–rich amphibolite with variable percentages of quartzofeldspathic leucosome injected parallel to the dominant fabric. Granitic injection of various compositions ranging from tonalite through granodiorite and rarely granite are observed in the map area.

This unit is not observed in the study area but is common in the region immediately north of the Rice Lake Belt (Bailes and Percival, 2000). The gneisses common in the study area are a mix of gneissic rock dominated by tonalite leucosome and a second more leucocratic gneiss with both tonalitic and granodioritic leucosome of the trondhjemite-tonalite-granodiorite (TTG) suite described below.

Two suites of gneiss have been defined in previous mapping by Ermanovics (1969, 1970): granodiorite gneiss and quartz monzonite to granodiorite gneiss. In the study area, compositions of the dominant leucosome portion of the gneissic rocks range from hornblende tonalite to granodiorite. These rocks are interpreted on the basis of both unit description and geochemical affinity as equivalent to rocks described by Stone (1998) as tonalite to granodiorite gneiss.

Tonalite, granodiorite

The biotite±hornblende tonalite to granodiorite was originally described by Ermanovics (1969, 1970) as granodiorite with minor diorite and quartz monzonite to granodiorite. These rocks are not voluminous in the study area but occur as discrete, tabular, northwest-trending plutons in southwest Family Lake. However, this tonalite to granodiorite suite is reported to represent a major regional intrusive event (Ermanovics 1969, 1970; Stone, 1998) and is the main intrusive component in the tonalite to granodiorite gneiss. The tonalite to granodiorite gneiss is texturally and geochemically similar to the biotite tonalite–hornblende tonalite described by Corfu and Stone (1998), who report hornblende tonalite and hornblende granodiorite suite ages ranging from 2750 to 2708 Ma. In our limited dataset, the biotite tonalite suite ranges to granodiorite and is geochemically part of the trondhjemite-tonalite-granodiorite association.

Granodiorite

The biotite granodiorite suite is the most voluminous suite of intrusions in the study area. It occurs as a large intrusion from southern Family Lake to south of the community of Little Grand Rapids and is the dominant leucosome phase in the migmatitic suite (Ermanovics, 1970). It also forms discrete bodies and leucosome in the migmatite on the west shore of Fishing Lake. Maps published by Ermanovics (1969, 1970) and Stone (1998) indicate that this magmatic event occurred throughout the Berens River subterrane. Corfu and Stone (1998) describe this as a ‘granitic suite’ with ages ranging from 2743 to 2705 Ma. A single analysis (sample 104-10-1-1C, Figure GS-12-5d), however, shows that the large granodiorite on Family Lake belongs to the TTG association.

Younger potassic intrusive suites

Biotite±muscovite granite

Late granite intrusive rocks are limited in the study area and include a small granite plug in northwest Family Lake and biotite-muscovite–bearing granite on Fishing Lake.

The young leucocratic biotite granite occurs as a small oval pluton on Family Lake (Figure GS-12-5f, sample 104-10-11-1c) and is interpreted to belong to a series of biotite granite batholiths that range in age from 2712 to 2693 Ma (Corfu and Stone, 1998). A second young batholith (Figure GS-12-5f, sample 104-10-21-3a) contains minor muscovite but is not peraluminous and likely belongs to this same suite of late granite rather than to the younger peraluminous granite suite of Corfu and Stone (1998).

Late intrusive rocks

On a first pass of field relationships and the unique geochemistry, Stone (1998) included late intermediate to granitic intrusions in his sanukitoid suite. He indicated rocks of this suite vary widely in composition from diorite through quartz monzonite to granite and characteristically granite phases may have up to 1% BaO and only trace amounts of Cr_2O_3. The late quartz monzonite (sample 104-10-21-3C in DRI2010002) in the Family–Fishing lakes area shares these characteristics and other geochemical characteristics outlined by Stone (1998). The late 'mafic' dikes that were not sampled may in fact have been emplaced in the final stages of Berens River magmatism at a time when subduction had ceased and the sanukitoid magmas were able to differentiate and intrude as hot high-level plutons at approximately the same time as peraluminous S-type granite was intruded. Corfu and Stone (1998) reported ages ranging from 2700 to 2696 Ma for the sanukitoid suite.

Results

This project's objective to investigate the rock types described by Ermanovics (1969, 1970) in the Family–Fishing lakes area was successful in replacing the old nomenclature with modern terminology and reviewing and comparing the legends in existing geological maps (Johnson, 1936a–f; Ermanovics 1969, 1970) in the transect area.

The comparison of Manitoba maps with the adjacent maps in Ontario, however, remains problematic. Stone (1998) subdivided the most abundant rock types in the region—the 2.75–2.70 Ga granitic rocks—into a hornblende±biotite–bearing suite and a biotite-bearing 'granitic' suite. These suites can be recognized in the current study area; however, as Ermanovics (1969, 1970) did not document nor separate the major granitic units into a hornblende±biotite suite and a biotite suite in this way, rationalizing the legends and rock types along the Manitoba-Ontario border will not be a simple task.

The systematic terminology for igneous intrusive rocks (Streckeisen, 1976) has been applied to all previously mapped rock types in the study area (Figure GS-12-6). The process of applying the new terminology to the region (parts of NTS 52L, M, 53D, E, 62P, 63A, H) is in progress. Although the correlation will be less than 100%, the result will provide a significant improvement and will rationalize the terminology with the legend and descriptions of the seamless digital 1:250 000 geological map of Manitoba.

Regional synthesis and tectonic implications

The Berens River Domain (Subprovince) in Manitoba and northwestern Ontario provides a unique look at the geological history of the core of the North Caribou Superterrane (Figure GS-12-1). This terrane was described as a small isolated Meso- to Neoarchean continent (Thurston, 1991; Percival, 2006) that developed in relative isolation from ca. 3.0 Ga until it was incorporated into the Archean Superior Province during a major orogenic event at 2.7 Ga. The current study area, in the core of the Berens Domain, is dominated by plutonic rocks with highly variable composition, textures and mineralogy.

Stone (1998) indicated that there are six distinct suites of intrusive/gneissic rocks in the Berens River Subprovince in Ontario and that they span the history of the geological development of the subprovince. Three of these are aerially significant: 1) tonalite associated with the tonalite gneiss, 2) calcalkaline hornblende tonalite to granodiorite and granodiorite to granite, and 3) a granitic suite. Three aerially less-extensive suites representing important tectonic indicators are 4) tonalite to gneiss (generally associated with the more voluminous tonalite), 5) peraluminous granite and 6) a rare sanukitoid suite. Equivalents of suites two and three dominate the Family–Fishing lakes area.

The hornblende tonalite and associated gneiss are well described and delineated by both Ermanovics (1969, 1970) and Stone (1998). North of the Rice Lake Belt on the south margin of the Berens River Domain tonalitic rocks have U-Pb ages ranging from 3006 to 2998 Ma (Turek and Weber, 1994), who interpreted them to represent remnants of basement rock. To the north, in the Berens River–Sachigo region, numerous isotopic studies of these suites (e.g., Skulski et al. [2000] and Parks et al. [2002] have reported consistent Sm-Nd model ages ca. 3.1 Ga). This isotopic signature is common to the entire North Caribou Superterrane and has been interpreted to indicate this small continental mass originated ca. 3.0 Ga and developed in isolation for a 300 m.y. period.

Corfu and Stone (1998) documented two magmatic/metamorphic events in the North Caribou Superterrane ca. 2.9 Ga and 2.85 Ga. The only indication of these events in the study area is a strong foliation and gneissic layering in the tonalite gneiss that is distinctly absent in the tonalite granodiorite and granite granodiorite intrusive rocks. Therefore, in the study area, only the strongly layered gneiss and restite is interpreted to present features from these older tectonic events.

The tonalite, granodiorite (unit 3) and granodiorite (unit 6) in the study area are interpreted to be equivalents of Corfu and Stone's (1998) hornblende tonalite and hornblende granodiorite suites, and the biotite tonalite suite. These are the most voluminous suites of intrusive rocks in both the study area and region, in Manitoba and in Ontario. Geochemical data is limited in this study;

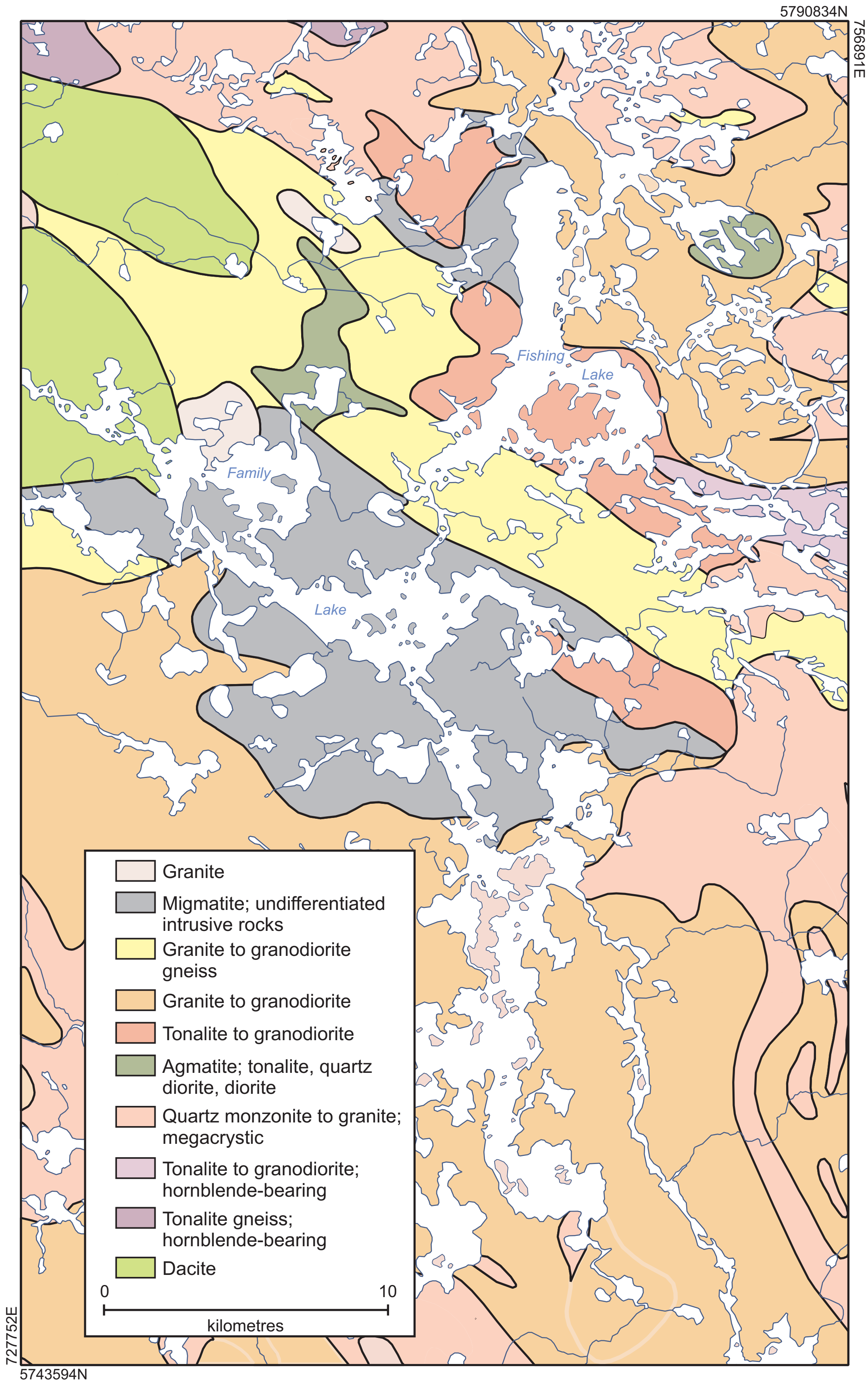

Figure GS-12-6: *Re-interpreted geology of the Family–Fishing lakes study area. All geological contacts are from Ermanovics (1969, 1970).*

however, signatures of the small sample set indicate that both units belong to a TTG association and are therefore most likely to represent the hornblende tonalite. Stone (1998) reported an age range for these rocks of 2750–2705 Ma. He indicated that this extensive magmatic event is coincident with major periods of volcanism and plutonism in the adjacent greenstone belt to the south.

In the study area, two small intrusions indicating magmatism at the closing stages of the Kenoran orogeny are represented by the biotite granite and quartz monzonite. The equivalents of these intrusive rocks in Ontario are interpreted by Stone (1998) to have been emplaced in the final stages of the Berens River magmatism. Corfu and Stone (1998) reported ages ranging from 2712 to 2693 Ma for the young biotite granite. They also indicate that late in the orogenic cycle when subduction had ceased (ca. 2700 to 2696 Ma), sanukitoid magma was able to differentiate and intrude as hot high-level plutons.

Economic considerations

An outcrop area approximately 1 km long, in a channel to a bay northwest of Little Grand Rapids (location of high-Fe agmatite shown on Figure GS-12-6), is dominated by an unusual tonalite-granodiorite-diorite agmatite with elevated magnetite content. The various intrusive phases in outcrops all contained elevated magnetite content reaching approximately 5% in quartz diorite xenoliths (Figure GS-12-7). These also contain minor pyrite and trace chalcopyrite. Precious metals assay analyses of this rock type are pending.

The supracrustal sequence at Horseshoe Lake has the potential for gold (Baldwin et al., 1984). In the Family Lake area, the western termination of the supracrustal was investigated and neither shear zones nor alteration nor veining was observed. The Horseshoe Lake greenstone belt, however, remains the only significant greenstone belt that the Manitoba Geological Survey has never systematically mapped.

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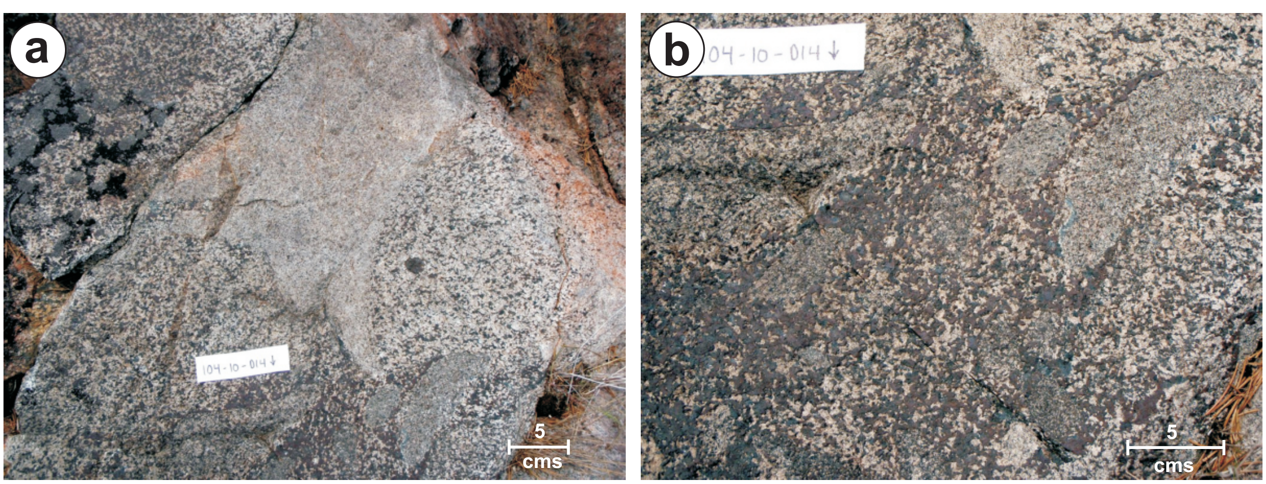

Figure GS-12-7: *Tonalite-granodiorite-diorite agmatite with elevated magnetite, minor pyrite and chalcopyrite northeast of Little Grand Rapids:* ***a)*** *nature of the agmatite,* ***b)*** *close-up showing the abundance of magnetite in the quartz diorite.*

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