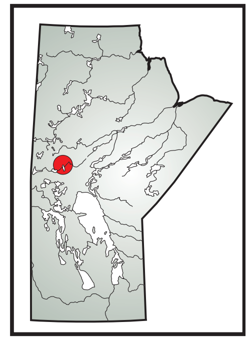
GS-6 Geological investigation of the McLeod Road–Birch Lake allochthon east of Snow Lake, Manitoba (part of NTS 63J13)

by S. Gagné



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Summary

Geological investigation of the bimodal volcanic and volcaniclastic rocks of the McLeod Road–Birch Lake allochthon east of the town of Snow Lake was carried out during the summer of 2009 to complement previous stratigraphic and structural studies and to expand upon the 2008 mapping at a 1:20 000 scale of the area between the southeast end of Squall Lake and the town cemetery. Results from geological mapping provide better constraints on the spatial distribution of the bimodal volcanic and volcaniclastic rocks east of Snow Lake.

In the area of the New Britannia mine, the sequence of mafic and felsic volcanic and volcaniclastic rocks that forms the ‘mine horizon’ has been mapped further east through the southeast bay of Herblet Lake. Further east still, the volcanic sequence is broader at Southeast Bay in Herblet Lake, where the horizontal across-strike separation between the McLeod Road Thrust and the Birch Lake Fault reaches 3.5 km. Eastward from of the mine, volcaniclastic rocks dominate the mafic horizons and pillows or lava flows are rare. Although fieldwork did not reveal the presence of gabbro in the western half of the 2009 map area, it occurs as a few prominent ridges in the eastern portion. No consistent facies variation was observed in the felsic volcanic and volcaniclastic rocks.

A tight northeast-trending synformal D_2 fold structure with a shallow plunge runs through the Whitefish Bay area. The folded sequence comprises gabbro sills and a variety of mafic and felsic volcaniclastic rocks, including a horizon of well-sorted, feldspath-rich volcanic sandstone 200–300 m thick locally overlain by a heterolithic conglomerate, which has not been observed further west. In the Whitefish Bay area, the S_1 foliation and bedding are folded about the moderately east-plunging F_2 fold axis. The southern limb of that synformal structure appears to be truncated against the lower felsic volcanic and volcaniclastic horizon.

Main foliation (S_2) typically dips moderately to steeply north and, as a result of the strong penetrative D_2 deformation, strikes east-west. The S_1 foliation is locally recognized mostly within fine-grained, bedded volcaniclastic rocks. Whereas the McLeod Road Thrust, a late D_2 structural feature, is shown in the map pattern to cut across the volcanic stratigraphy, the Birch Lake Fault seems to extend along strike of the upper mafic volcaniclastic horizon.

Introduction

Several decades of mineral exploration have revealed that the rocks of the Snow Lake area, which form the eastern portion of the Paleoproterozoic Flin Flon–Snow Lake greenstone belt, host a wealth of mineral resources. More than 18 exploited and undeveloped volcanogenic massive sulphide (VMS)-type base-metal deposits have been discovered in the Snow Lake area. These deposits are hosted in oceanic arc-related volcanic rocks and all but a few (Bur, Osborne Lake, and Wim) are located within the main package of Snow Lake arc assemblage rocks (Bailes and Schledewitz, 1998; Bailes and Galley, 1999) forming the footwall of the Snow Lake Fault. The volcanic package that contains the Osborne Lake deposit and forms the hangingwall of the McLeod Road Thrust, defines a narrow arcuate belt traceable over more than 10 km east and west of Snow Lake and is referred to as the ‘McLeod Road–Birch Lake allochthon’ by Bailes and Schledewitz (1998); these same authors interpreted it as a fault-bounded slice of the Snow Lake arc assemblage.

The Snow Lake region is also host to several significant gold deposits, including the Nor-Acme (New Britannia) mine that produced just over 43 540 kg (1.4 million oz) of gold during two periods of mining (from 1949 to 1958 and from 1995 to 2005). Several other smaller satellite deposits occur in the vicinity of the New Britannia mine. All gold occurrences share the common characteristic of being located in the volcanic sequence forming the hangingwall of the McLeod Road Thrust.

The presence of significant gold mineralization and sizable VMS-type base-metal deposits within the McLeod Road–Birch Lake allochthon and the fact this feature has been recognized as a faulted part of the main Snow Lake arc assemblage warrant further geological investigation to provide a more complete understanding of the allochthon’s geological history and internal geometry. Stratigraphic and structural studies were undertaken for this purpose by Beaumont-Smith and Lavigne (2008) and a preliminary map based on geological mapping by Beaumont-Smith and Gagné (2008) was released. Fieldwork in 2009 focused on complementing the previous stratigraphic and structural studies by investigating the bimodal volcanic and volcaniclastic rocks east of the town cemetery. The distribution of lithological units and the geological interpretation of 2009 fieldwork are presented in Preliminary Map PMAP2009-1 (Gagné, 2009).

Previous work

Because it is host to numerous base-metal deposits, the main panel of the Snow Lake arc assemblage, which occupies the footwall of the Snow Lake fault and extends southward over a distance of about 18 km, has been extensively explored and studied (Bailes and Galley, 1996, 1999, 2007).

On the other hand, rocks from the McLeod Road–Birch Lake allochthon have received less attention. Some of the early mapping of the area includes work by Russell (1957). Froese and Moore (1980) mapped the Snow Lake area at a 1:50 000 scale, focusing on metamorphic petrology. The setting of gold mineralization at the New Britannia mine was the subject of many studies (Galley et al., 1986; Galley et al., 1988; Gale, 1997; Schledewitz, 1997; Bailes and Schledewitz, 1998; Schledewitz, 1998; Fieldhouse, 1999; Fulton, 1999; Gale and Mihychuk, 2002), yet the nature of the structural controls on gold mineralization in the area remain poorly understood. Fieldhouse (1999) and Galley et al. (1988) proposed that the New Britannia gold deposit was emplaced along early structural breaks that predate peak-metamorphic conditions. The Squall Lake–Varson Lake area was mapped at a 1:20 000 scale by Schledewitz (1997, 1998). Bailes and Schledewitz (1998) examined the volcanic stratigraphy along a cross-section near the New Britannia mine site. Basing themselves on the geochemical signature of the rocks, they stated that the McLeod Road–Birch Lake allochthon represented a faulted portion of the main package of the Snow Lake arc assemblage; they also interpreted the allochthon as representing a moderately to steeply north-dipping monoclinal sequence. Structural and metamorphic studies of the Burntwood metasedimentary rock panel located between the Snow Lake Fault and the McLeod Road Thrust were carried out by Kraus (1998); although this work focused mostly on the Burntwood metasedimentary rocks, the results are readily applicable to the surrounding volcanic and volcaniclastic rocks. In 2008, Beaumont-Smith and Lavigne (2008) investigated the structural history and stratigraphy of the rocks in the immediate vicinity of the New Britannia mine. Only Froese and Moore (1980) and Russell (1957) have investigated the geology of the allochthon's volcanic rocks east of the town cemetery.

Regional setting

The Flin Flon–Snow Lake greenstone belt consists of a complex collage of distinct tectonostratigraphic packages that were joined together during the Trans-Hudson Orogen (THO; 1.9–1.8 Ga). Initial juxtaposition occurred during a period of intra-oceanic accretion ca. 1.88–1.87 (Lucas et al., 1996), with final assembly occurring at the time of terminal collision between bounding Archean cratons. The belt extends east for a distance of more than 250 km and has a width of ~50 km from north to south (Figure GS-6-1); it is bounded to the north by the Kisseynew Domain, to the east by reworked Archean domains of the THO external zone, to the south by unconformably overlying Paleozoic sedimentary rocks and to the west by the Wollaston fold belt.

Researchers (Lucas et al., 1996; Syme et al., 1996) have recognized that the eastern and western portions of the belt present distinct tectonic histories. Moreover, rocks of the Snow Lake area are distinct from those in the central and western portions of the belt, as demonstrated by their contrasting structural style, metamorphic grade and geochemistry. The Snow Lake area consists of tectonically imbricated panels of volcanic and volcaniclastic rocks of ocean-floor and island-arc affinity (ca. 1.9 Ga) and younger (ca. 1.86–1.84 Ga) metasedimentary rocks of the Kisseynew Domain (Kraus and Williams, 1999). The Snow Lake volcanic rocks are part of the Amisk Group and have been subdivided into three distinct sequences based on geochemical and lithological characteristics (Bailes and Galley, 1996, 1999, 2007). The geochemical changes observed between the three distinct volcanic sequences have been interpreted as representing the evolution of the Snow Lake assemblage from a primitive arc setting to an evolved arc-rift environment. The bimodal Anderson sequence is dominated by basalt flows and forms the base of the Snow Lake arc assemblage; above it sits the Chisel sequence, which consists of a thick package of mafic volcaniclastic rocks containing a few small intervening felsic volcanic and volcaniclastic horizons; the Snow Creek sequence, which comprises mostly mafic flows and pillows (Bailes and Galley, 1996, 1999, 2007), tops the assemblage.

The Kisseynew Domain, an east-trending belt of Paleoproterozoic paragneiss and related granitoid plutons measuring 240 x 140 km, is bounded to the north and south by the Lynn Lake and Flin Flon greenstone belts, respectively. In the Snow Lake area, the southern margin of the Kisseynew Domain consists of the Burntwood Group metaturbidites and Missi Group meta-arenite and lithic arenite; it is interpreted as representing a former marginal basin metamorphosed under high-grade conditions and telescoped during continental collision (Kraus, 1998).

The deformation style of the Snow Lake allochthon is typical of fold-thrust belts (Connors et al., 1996; Kraus, 1998; Zwanzig, 1999). The structural pattern of the Snow Lake area is dominated by a series of D_2 thrust faults that juxtaposed panels of older arc-volcanic rocks and younger Burntwood and Missi Group metasedimentary rocks. Juxtaposition of the tectonic slices likely occurred during the regional D_2 phase of deformation as the imbricated panels are affected by F_3 folding.

The Flin Flon Belt records a broad range of peak-metamorphic conditions. The western domain of the Flin Flon Belt, more specifically, has experienced lower-grade metamorphic conditions varying from lower- to middle-greenschist facies: some rocks in the south-western part

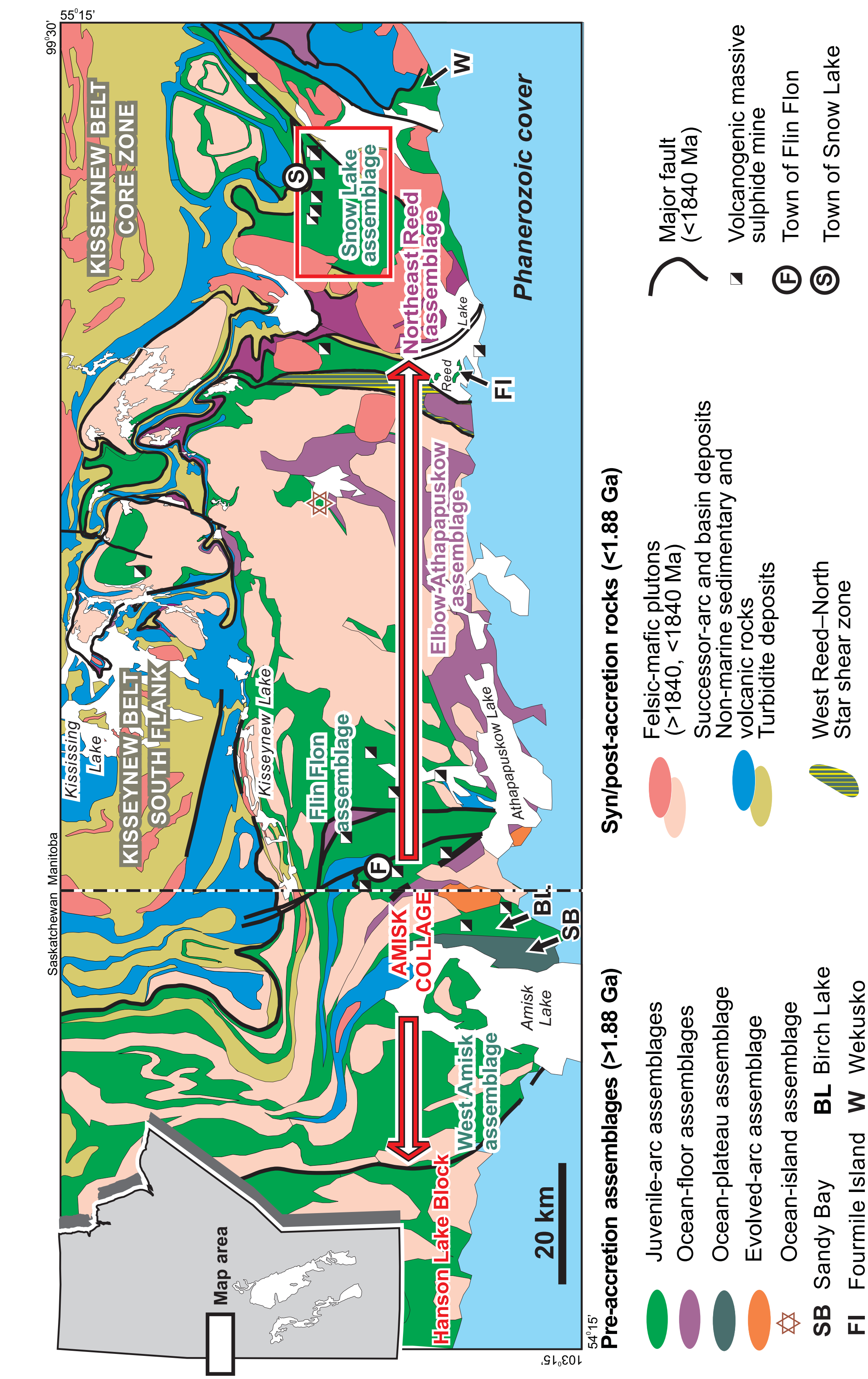


***Figure GS-6-1:** Geology of the Flin Flon–Snow Lake greenstone belt.*

of the Flin Flon area (Bailes and Syme, 1983) record peak metamorphism in the sub-greenschist facies (prehnite-pumpellyite). The eastern domain of the Flin Flon Belt (Snow Lake area) generally experienced higher-grade metamorphism, with peak-metamorphic conditions ranging from lower- to middle-amphibolite facies. The Snow Lake area is characterized by a northward increase in peak-metamorphic temperature from ~500°C to ~700°C, accompanied by only a minor increase in pressure of 4 to 6 kbar (Kraus and Menard, 1997). This northward increase is clearly reflected in the metamorphic mineral assemblages that progress from the chlorite zone in the south, through the staurolite zone (New Brittania mine), to the sillimanite zone near Squall Lake. Froese and Moore (1980) concluded that, based on the absence of folded isograds, peak-metamorphic conditions in the Snow Lake area were reached well after the main deformation episodes occurred. Similarly, Kraus and Menard (1997) demonstrated that the regional peak-metamorphic conditions were achieved during late east-west folding, which event corresponded with F_3 in this area.

Geology of the McLeod Road–Birch Lake allochthon

Geological investigations during the 2009 field season (Gagné, 2009) focused on the segment of the McLeod Road–Birch Lake allochthon that stretches between the town cemetery and the east end of Whitefish Bay. As described by Bailes and Schledewitz (1998), the allochthon consists of a moderately to steeply north-dipping sequence of mafic and felsic volcanic, volcaniclastic and epiclastic rocks with gabbro dikes and sills. The McLeod Road Thrust, which forms the base of the allochthon, is responsible for the thrusting of the older (ca. 1890 Ma) volcanic and volcaniclastic rocks of the Snow Lake arc assemblage (Bailes and Galley, 2007) over the younger (ca. 1845 Ma) Burntwood Group metasedimentary rocks (Figure GS-6-2). The Birch Lake Fault, which forms the upper boundary of the allochthon, separates the younger (ca. 1845 Ma) Missi Group metasedimentary rocks from the older volcanic and volcaniclastic rocks below.

The McLeod Road–Birch Lake allochthon has been interpreted both as a homoclinal sequence (Bailes and Schledewitz, 1998) and an isoclinally folded sequence (Galley et al., 1989). Recent stratigraphic and structural studies by Beaumont-Smith and Lavigne (2008) concluded that the repetition of felsic and mafic volcaniclastic rocks in the allochthon was the result of F_1 folding.

Felsic volcanic and volcaniclastic rocks (unit 1)

The felsic volcanic and volcaniclastic rocks define several mappable horizons. No consistent facies variations were observed eastward along strike. The felsic horizons typically consist of dacite and rhyodacite flows with abundant volcaniclastic rocks; massive lobes interfingered with synvolcanic microbreccia are common (Figure GS-6-3a). Although some of the more felsic flows contain 2–4% quartz phenocrysts (1–4 mm), most of the felsic flows vary from aphyric to feldspar-porphyritic (2–8%; 1–4 mm) and are locally amygdaloidal. The amygdules are filled with quartz and range in size from 2–8 mm. Broken amygdules are commonly found in felsic volcaniclastic rocks, along with quartz and feldspar phenocrysts. Boudinaged quartz veinlets also occur within felsic volcaniclastic rocks.

The felsic volcaniclastic rocks include fine-grained crystal tuff, lapilli tuff and tuff-breccia. The rocks generally appear relatively massive, although layering is observed locally and includes examples of graded beds (Figure GS-6-3b). The clasts are generally of similar composition to the matrix and vary in shape from subrounded to subangular. The felsic volcaniclastic rocks are generally matrix supported, although there are local occurrences of clast-supported felsic breccia (Figure GS-6-3c).

Mafic volcanic and volcaniclastic rocks (unit 2a)

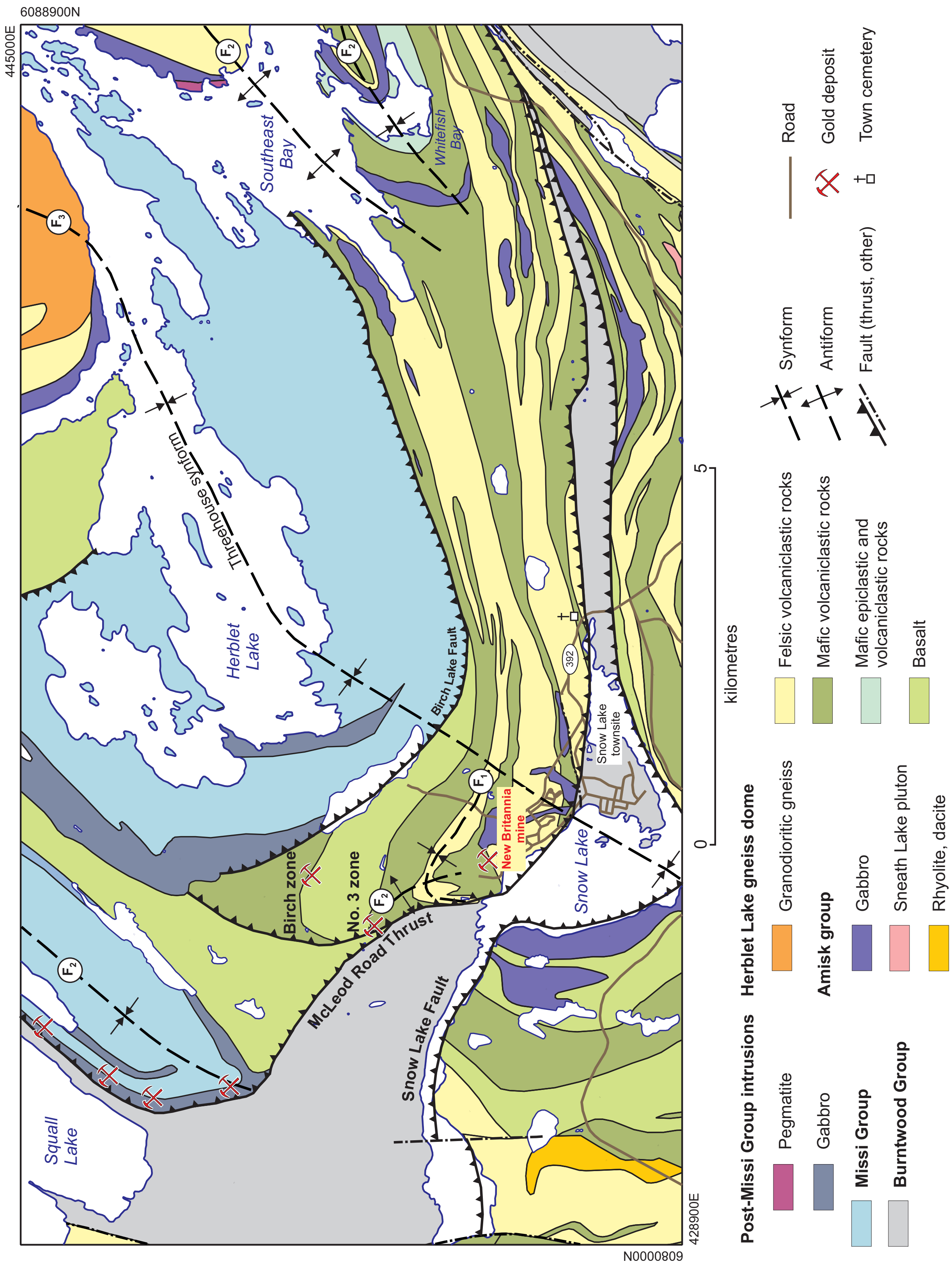
The mafic horizons are dominated by volcaniclastic rocks; effusive rocks are rare. A broad range in composition and abrupt facies changes characterize the mafic volcaniclastic rocks. The composition of the mafic volcaniclastic rocks varies greatly along strike as well as upsection and downsection. The dominant facies of mafic volcaniclastic rocks varies from a monolithic pyroxene-porphyritic lapilli tuff or tuff-breccia, to a monolithic plagioclase-pyroxene–porphyritic lapilli or tuff-breccia, to a heterolithic conglomerate. Due to the peak amphibolite-facies metamorphism of the allochthon, all primary pyroxene phenocrysts have been pseudomorphed by hornblende.

Pyroxene-porphyritic crystal to lapilli tuff

Pyroxene-porphyritic crystal tuff is most abundant close to the western edge of the mapped area. To the east, the crystal tuff contains subangular to subrounded pyroxene-porphyritic mafic clasts. The pyroxene-porphyritic crystal to lapilli tuffs are characterized by a seriate porphyritic matrix (Figure GS-6-3d). Some of the pyroxene crystals show broken edges and the pyroxene phenocrysts range in size from 2–10 mm. The rocks vary in texture from massive to bedded; for example, bedded crystal tuff was recognized in a few locations, generally within the upper mafic horizon, and showed thick graded beds.

Plagioclase-pyroxene mafic volcaniclastic tuff to lapilli tuff

Plagioclase-pyroxene–porphyritic crystal tuff to lapilli tuff typically shows a seriate texture. Both plagioclase and pyroxene crystals are generally abundant in the matrix with their relative proportion varying locally. Figure GS-6-3e shows an end-member example with a



***GS-6-2:** Geology of the McLeod Road–Birch Lake allochthon.*

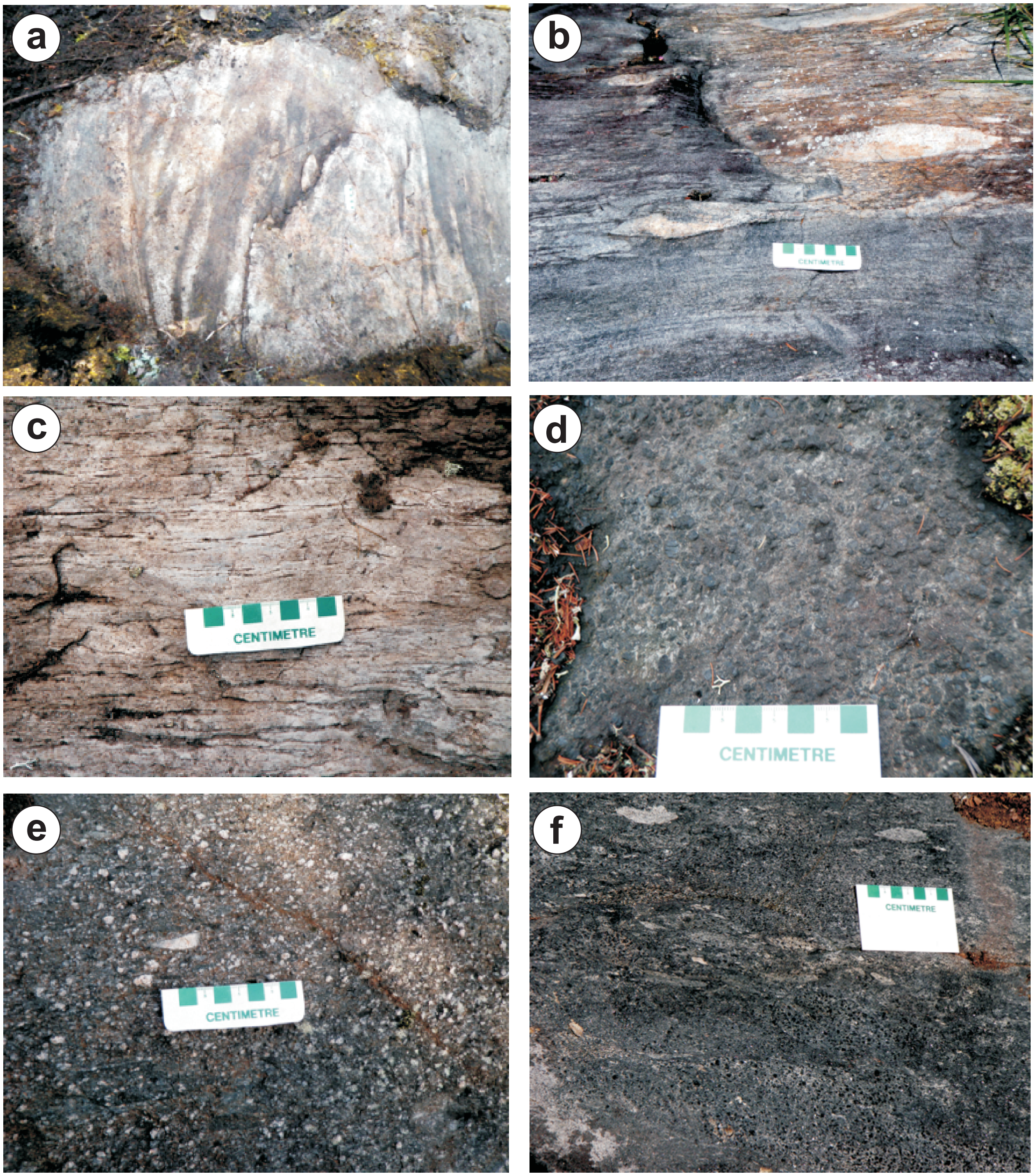


Figure GS-6-3: *Volcanic rocks of the McLeod Road–Birch Lake allochthon:* ***a)*** *massive lobe of rhyodacite interfingered with microbreccia (some larger fragments occur in the microbreccia);* ***b)*** *monolithic felsic tuff-breccia (upper half) is underlain by a fine-grained felsic tuff;* ***c)*** *clast-supported monolithic felsic lapilli tuff;* ***d)*** *mafic pyroxene-porphyritic crystal tuff;* ***e)*** *outcrop of plagioclase-pyroxene–porphyritic crystal tuff with a plagioclase to pyroxene phenocryst ratio of 10 to 1;* ***f)*** *monolithic pyroxene-porphyritic tuff-breccia consisting of pyroxene-porphyritic clasts supported by a fine-grained mafic matrix with 15%–20% small pyroxene phenocrysts (1–4 mm). Scale bar is 8 cm in all photos.*

plagioclase to pyroxene phenocryst ratio of about 10 to 1; the phenocryst proportion is generally more or less equal. The phenocrysts range in size from 2–10 mm and locally display broken edges. These rocks are generally massive, but bedding is locally recognized. Plagioclase-pyroxene–porphyritic lapilli tuff is characterized by a seriate porphyritic matrix similar in texture to that of the crystal tuff. Monolithic tuff is composed of clasts that are similar in composition and texture to the matrix (Figure GS-6-3f), whereas heterolithic lapilli tuff is characterized by a matrix consisting of a mixture of porphyritic and aphyric clasts. The lapilli tuff and tuff-breccia are generally clast supported and fragments vary in shape from subrounded to subangular.

Pyroxene-porphyritic mafic volcanic rocks

Beaumont-Smith and Lavigne (2008) described a thin band of pyroxene-porphyritic basalt units, east of the town of Snow Lake, that consist of a series of thick-pillowed and massive porphyritic flows. This unit only occurs at the very western edge of the map and gives way, along strike, to a compositionally variable monolithic to weakly heterolithic pyroxene-porphyritic lapilli tuff unit. The nature of the contact is unknown due to a lack of exposures.

Mafic-dominated heterolithic volcanic conglomerate

Heterolithic volcanic conglomerate occurs in several locations within the mafic horizon. A distinct facies of heterolithic volcanic conglomerate, which contains a broad range of clast composition including mafic porphyritic, fine-grained mafic aphyric and 15–40% dacitic to rhyolitic (Figure GS-6-4a), was observed in several locations right below the contact with felsic volcanic and volcaniclastic horizons. The matrix is generally mafic in composition with a variable content of pyroxene and plagioclase phenocrysts. The rock shows no evidence of bedding or compositional layering. Further away from the contact, the felsic content of the conglomerate tends to decrease rapidly.

Epiclastic volcanic sandstone (unit 2b)

Within the Whitefish Bay synform, structurally immediately below the felsic- and intermediate-dominated heterolithic volcanic conglomerate, is a distinct horizon of well-sorted, feldspar-rich epiclastic volcanic sandstone about 200 to 300 m thick. The horizon is characterized by a homogeneous texture and a well-sorted fine-grained matrix with high plagioclase content (80–95%) and lesser amounts of biotite (5–10%) and garnet. Massive beds are locally observed. Although the rock appears to contain no clasts or lithic fragments, it may locally contain 10–15% fine hornblende and 5–10% garnet; however, it preserves its fine-grained, bedded and well-sorted texture. This horizon is interpreted as the result of reworking of mafic volcaniclastic rocks.

Felsic- and intermediate-dominated heterolithic volcanic conglomerate (unit 2c)

Within the core of the Whitefish Bay synform (Figure GS-6-2), a distinct horizon of heterolithic volcanic conglomerate comprising 60–70% of mostly felsic and intermediate composition clasts was observed (Figure GS-6-4b). Clast size ranges from a few centimetres to as much as 60–70 cm. Several clasts appear to be refolded and all clast show a strong stretching lineation plunging shallowly to the northeast. The matrix consists of fine- to medium-grained biotite-garnet with minor plagioclase; the rock is matrix-supported. The mostly subrounded felsic clasts generally have a dacitic to rhyolitic composition and are massive and aphyric in most cases. The intermediate clasts are typically porphyritic with 15–20% of small hornblende crystals in a fine-grained, massive plagioclase matrix.

Mafic volcanic rocks (unit 3)

In the vicinity of the New Britannia mine, the structural top of the mine sequence is occupied by the aphyric basaltic rocks of the Birch Lake basalt (Bailes and Schledewitz, 1998). This unit consists of aphyric to locally plagioclase-porphyritic pillowed and massive basalt flows, and mafic-derived sediment. The pillowed basalt is light green weathering, with thin selvages and minor interpillow hyaloclastite. The Birch Lake basalt was only encountered in the northwest corner of the map area, where it is truncated to the southeast by the Birch Lake Fault. A few occurrences of similar-looking pillowed basalt units were observed further east, typically within the first 200 m below the fault footwall. Geochemical analyses will help determine if these occurrences represent the Birch Lake basalt.

Gabbro (unit 4)

Equigranular gabbro intrudes the rhyolite and mafic volcaniclastic rocks in the eastern portion of the study area. The gabbro has a granoblastic texture, varies from weakly to moderately foliated, commonly displays a well-developed mineral lineation and has been recrystallized through metamorphism. It occurs as elongate bodies (up to 2.5 km long) that range up to 400 m in thickness and generally form ridges rising up to 50 m above the surrounding terrain, typically along major lithological contacts. Two significant gabbro sills also occur within the sequence of the Whitefish Bay synform and are folded by the F_2 fold.

Sedimentary rocks

The McLeod Road–Birch Lake allochthon is bounded by two distinct panels of metasedimentary rocks. To the north, it is overlain by younger (1845 Ma) Missi Group meta-arkose along the Birch Lake Fault; to the south, the younger (1845 Ma) Burntwood Group metaturdibites form the footwall of the McLeod Road Thrust.

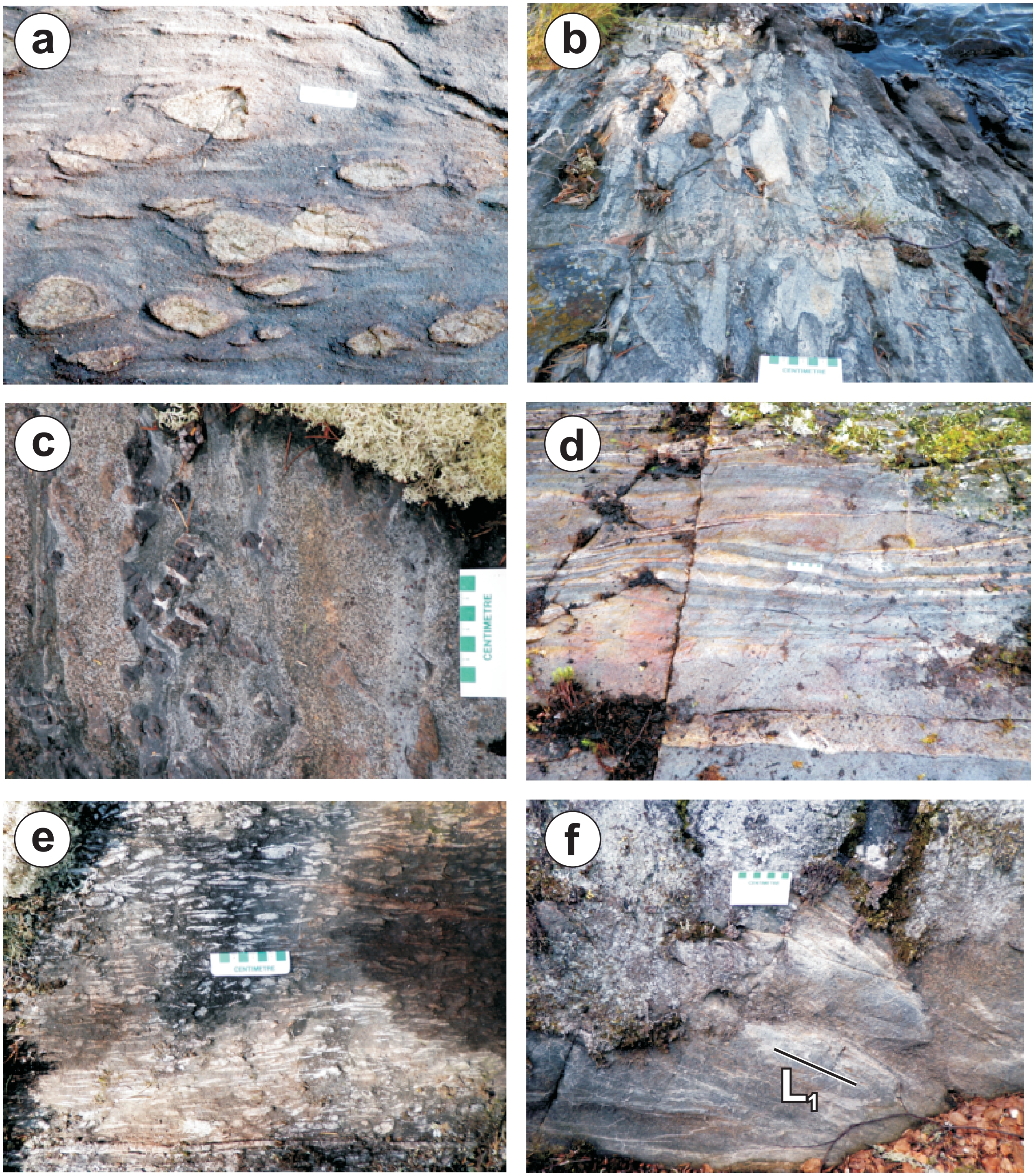


Figure GS-6-4: *Volcanic and sedimentary rocks of the McLeod Road–Birch Lake allochthon:* ***a)*** *heterolithic volcanic conglomerate with a broad range of clast composition varying from mafic porphyritic to fine-grained aphyric clasts and including 40% of light-coloured dacitic to rhyolitic clasts (in positive relief on the picture);* ***b)*** *heterolithic volcanic conglomerate, at the core of the Whitefish Bay synform, comprising 60–70% of mostly felsic and intermediate composition clasts;* ***c)*** *staurolite-garnet-biotite–bearing Burntwood Group metaturbidites with characteristic large staurolite crystals (aligned parallel to* S_2*) in the pelitic-bed tops;* ***d)*** *outcrop just south of the McLeod Road Thrust interpreted as an exposure of the Corley Lake Member, a portion of the Burntwood Group characterized by more semi-pelitic to psammitic horizons with fine (1-2 mm) garnet porphyroblasts and lacking the large staurolite porphyroblasts* ***e)*** *example of plagioclase-megaporphyritic gabbro intruding the Missi Group arenite;* ***f)*** *intermediate clasts elongated along* L_1*; matrix is composed of fine-grained Pl-Bt-Hb. Scale bar is 8 cm in all photos.*

Burntwood Group (unit 5)

The Burntwood Group rocks consist of medium- to thick-bedded metaturbidites; these are the product of sedimentation in a submarine fan environment within the Kisseynew basin (Bailes, 1980b). Due to their origin as turbidites, the Burntwood Group metasedimentary rocks display regular within-bed compositional variation characterized by a psammitic to semipelitic base and a pelitic top. Graded beds are commonly observed and may be used to determine the direction of younging. In the Snow Lake area, the Burntwood Group metaturbidites have developed a staurolite-garnet-biotite mineral assemblage, with characteristic large staurolite crystals (1–10 cm) in the pelitic-bed tops and common small (1–4 mm) euhedral garnet crystals (Figure GS-6-4c). Garnet is often found as inclusions in the staurolite porphyroblasts. The upper part of the Burntwood Group comprises a sequence of more semipelitic to psammitic horizons that have developed fine (1–2 mm) garnet porphyroblasts and lack the characteristic large staurolite porphyroblasts (Figure GS-6-4d). This horizon is correlated to the Corley Lake Member (Bailes, 1980a; Bailes and Schledewitz, 1998).The occurrence of Corley Lake rocks for several kilometres along strike in the immediate footwall of the McLeod Road Thrust is used in support of the statement arguing that the Burntwood Group metasedimentary rocks are in structural concordance with the fault.

Missi Group (unit 6)

Rocks from the Missi Group are the product of fluvial-alluvial sedimentation along the margin of the Kisseynew basin. The Missi Group, which occupies the hangingwall of the Birch Lake Fault, is characterized by thick-bedded often crossbedded lithic arenite. The meta-arenite is also characterized by the growth of small (1–3 mm) garnet porphyroblasts.

Gabbro dikes and sills (unit 7)

In the Snow Lake area, Missi Group arenite is commonly intruded by medium- to coarse-grained mafic gabbroic dikes, which generally form sill-like bodies within the Missi metasedimentary rocks. The sills vary in thickness and continuity from a few metres to a few hundred metres in thickness and from a few tens of metres to a few hundreds of metres in length. In one location, a sill 50 to 60 m thick contains very large (15–45 mm in length) plagioclase crystals (Figure GS-6-4e). The gabbro is homogeneous in composition, is weakly foliated and, in one location, was found to contain enclaves (2%; 5–80 cm long) of fine-grained mafic volcaniclastic rocks.

Structural geology

Four episodes of deformation have been recognized in the Snow Lake area (Kraus, 1998; Kraus and Williams, 1999); fabrics associated with the D_1, D_2 and D_3 deformations are observed in the McLeod Road–Birch Lake allochthon.

The earliest deformation fabrics preserved in the allochthon correspond to D_1; this deformation episode generated upright to moderately inclined isoclinal folds with an associated axial-planar cleavage. Although F_1 folds are widespread throughout the Amisk and Burntwood groups, the associated planar fabric S_1 is rare. This may be explained by the development of a layer-parallel fabric that was not penetratively developed or could, alternatively, be the result of the transposition of an early penetrative S_1 fabric by subsequent deformations. Kraus (1998) and Kraus and Williams (1999) have reported that preservation of the S_1 fabric as inclusion trails in staurolite porphyroblasts is common, which suggests that S_1 was once widespread throughout the Burntwood Group. In volcanic rocks, S_1 is locally observed as a layer-parallel cleavage in areas adjacent to stratigraphic contacts; however, it is most obvious in the nose of F_2 folds, such as the Whitefish Bay synform, where it defines a bedding-parallel foliation that is folded by F_2. Elsewhere, strong S_2 fabric overprinting has obliterated all signs of S_1.

Beaumont-Smith and Lavigne (2008) recognized within the volcanic stratigraphy younging reversals that define macroscopic isoclinal F_1 folds and they suggested that such folds may be responsible for the intercalation of felsic volcanic and mafic volcaniclastic rocks in the hangingwall of the McLeod Road Thrust. These intercalated rocks extend to the east of the cemetery; however, the data available is insufficient to verify the presence of fold-induced stratigraphic repetitions. The plunge of F_1 folds is poorly constrained. Beaumont-Smith and Lavigne (2008) recognized the presence of a moderately to steeply plunging stretching lineation, which is best developed in lapilli and breccia facies of volcaniclastic rocks that often have a well-developed clast lineation (Figure GS-6-4f).

The second deformation episode (D_2) is interpreted as a progressive deformation that produced shallowly inclined open to close folds, a regionally penetrative axial-planar S_2 foliation; and culminated in thrust imbrication of the Snow Lake allochthon (Beaumont-Smith and Lavigne, 2008).

In the eastern portion of the allochthon, S_2 is a moderately to steeply north-dipping penetrative foliation and in areas where bedding is recognized, S_2 generally dips more shallowly. In volcanic rocks S_2 is the main foliation, except in the vicinity of lithological contacts and in the nose region of F_2 folds, where S_1 is locally preserved. In Burntwood Group metaturbidites, transposition of S_1 by S_2 led to the development of a spaced, differentiated S_2 schistosity. Staurolite porphyroblasts have a weak to well-developed S_2-parallel preferred orientation and are locally boudinaged along S_2. Macroscopic D_2 structures are evidenced by the presence of a synform-antiform pair in the Whitefish Bay area. The synform is tight, northeast-trending and shallowly plunging, its amplitude reaching ~1 km. The southeastern limb appears to have been truncated against a felsic volcaniclastic horizon that is traced almost continuously from the townsite.

The truncation of F_1 and F_2 fold axes, shown on the map pattern developed by Beaumont-Smith and Gagné (2008), constrains the McLeod Road Thrust to post- or late-D_2. In addition, the fact that the thrust is folded by the F_3 Threehouse synform further constrains the McLeod Road Thrust to a pre-D_3 event. Finally, the recognition of a D_2 overprinting of the mylonitic foliation associated with the thrust fault by previous workers (Galley et al., 1986; Kraus, 1998; Beaumont-Smith and Lavigne, 2008) pinpoints the development of the McLeod Road Thrust as a late-D_2 feature.

The Birch Lake Fault forms the structural top of the McLeod Road–Birch Lake allochthon and is also interpreted as having formed late during D_2 deformation. No exposures of the Birch Lake Fault were recognized in the area mapped in 2009. However, Beaumont and Lavigne (2008) documented that the fault had many structural features similar to the McLeod Road Thrust and they concluded that, although there is no stratigraphic requirement for it to be a thrust fault, these similarities support its interpretation as one.

During the third episode of deformation (D_3), large-scale megascopic northeast-trending F_3 folds formed in the Snow Lake area. The associated axial-planar fabric varies from a spaced cleavage to a penetrative foliation. At outcrop scale, whereas decimetre-scale F_3 folds are developed in Burntwood Group metaturbidites, S_2 is only locally overprinted by a weak S_3 foliation in the volcanic rocks. Although there is not a very well-developed penetrative fabric associated with it, the D_3 deformation has important consequences for the regional map pattern.

Economic considerations

In the McLeod Road–Birch Lake allochthon, gold mineralization is spatially associated with the McLeod Road Thrust, and is commonly situated along, or adjacent to, lithological contacts. For these reasons, establishing more precisely the geometry of the various lithological units within the McLeod Road–Birch Lake allochthon will help provide better constraints for gold exploration models. Improved knowledge of the volcanic stratigraphy will also assist when testing the various structural models for the internal geometry of the McLeod Road–Birch Lake allochthon.

During 2009 fieldwork, a dozen occurrences of gossanous or silicified mafic volcaniclastic rocks and gabbro were documented. These occurrences are mostly found in the western part of the mapped area, more specifically in the vicinity of the Whitefish Bay synform. These gossanous or silicified horizons are generally observed near the base of outcrops and typically occur at, or very close to, a lithological contact. The silicified horizons have a fine-grained sugary texture and locally still preserve remnants of the mafic protolith. An apparent increase in finite strain and the presence of quartz veining are commonly associated with the occurrences. Minimum thicknesses observed for the various altered horizons range from 0.6 – 1.5 m. In most cases, only traces to a few percents (<3%) of fine-grained pyrite was associated with the altered zones. However, two occurrences located along the same lithological contact and separated by about 2 km along strike, showed 1–2% fine-grained arsenopyrite accompanied by intense silicification. Quartz veins are abundant (5–10%) in the surrounding unaltered outcrops. These two mineralized occurrences share similarities with gold-bearing quartz-sulphide replacements in other portions of the New Britannia mine horizon. Although both occurrences have been trenched, recent mapping confirms that these two showings occur along the same lithological contact and define a prospective horizon at least 2 km long, which has to date been the object of minimal prospecting.

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