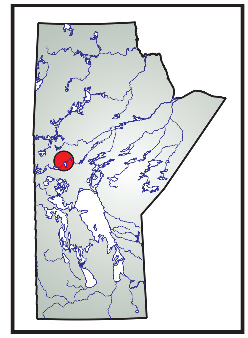
GS-10 Update on geological investigations in the Snow Lake–Squall Lake–Herblet Lake area, west-central Manitoba (parts of NTS 63J13, 63K16)

by S. Gagné



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Summary

During the summer of 2010, additional geological mapping was conducted in the northern portion of the Snow Lake–Squall Lake–Herblet Lake area to complement investigations in the summers of 2008 and 2009. The resulting map, at 1:20 000 scale, includes new geological mapping and integrates results from the previous years' mapping. This map provides better constraints on the spatial distribution of the various lithological and structural elements of the Snow Lake–Squall Lake–Herblet Lake area.

The Birch Lake metavolcanic and associated metavolcaniclastic rocks have been traced around Southwest Bay of Herblet Lake. Although comprising dominantly effusive facies (pillows, massive flows and pillow breccia), the Birch Lake metavolcanic rocks also include several horizons of mafic volcaniclastic rocks (chiefly mafic crystal and lapilli tuffs). A few zones of altered pillows and pillow breccia were identified. The macroscopic open F_3 Threehouse synform that trends southwest through Southwest Bay dominates the map pattern in this area. The Snow Lake Arc metavolcanic and metavolcaniclastic rocks of the McLeod Road thrust panel, the Burntwood metaturbidite and the Missi Group meta-arenite are all affected by F_3 folding and wrap around Southwest Bay. An F_2 syncline with amplitude of 2–3 km has been defined within the Missi Group meta-arenite and is also affected by F_3 folding. Traverses through the outer margin of the Herblet gneiss dome have shown that it is rimmed inward by amphibolitic gneiss and quartzofeldspathic gneiss.

Throughout the newly mapped area, S_2 is the main foliation. It typically dips moderately towards the centre of Southwest Bay. The S_1 foliation is locally recognized, mostly within fine-grained, bedded volcaniclastic rocks. The McLeod Road thrust fault, a late D_2 structural feature, is shown in the map pattern to cut across the volcanic stratigraphy, but it is also affected by the F_3 Threehouse synform. New interpretation suggests that the McLeod Road thrust fault wraps around Southwest Bay of Herblet Lake.

Introduction

The rocks of the Snow Lake area define the eastern portion of the Paleoproterozoic Flin Flon–Snow Lake greenstone belt and host more than 18 volcanogenic massive sulphide (VMS) deposits, as well as several significant gold deposits. Most of the VMS deposits are hosted in the Snow Lake Arc assemblage main thrust panel (SLMP) in the footwall of the Snow Lake Fault, whereas the panel of Snow Lake Arc volcanic rocks that is imbricated between the McLeod Road thrust and the Birch Lake Fault is host to the most significant gold deposits, which together are responsible for production in excess of 1.4 million ounces of gold.

Volcanic rocks in the hangingwall of the McLeod Road thrust fault form a thin arcuate package of bimodal volcanic and associated volcaniclastic rocks that extends more than 10 km east and west of Snow Lake. These rocks will herein be referred to as the 'McLeod Road–Birch Lake thrust panel' (MBP) rather than the 'McLeod Road–Birch Lake allochthon'. Bailes and Schledewitz (1998) suggested, on the basis of geochemical evidence, that these rocks represent a tectonic thrust imbricate of the SLMP. Because of its wealth of base-metal deposits, the SLMP has received much attention and has been mapped at scales varying from 1:5 000 to 1:20 000. In contrast, the rocks in the hangingwall of the McLeod Road thrust fault and farther north have only been mapped at 1:50 000 scale. In order to upgrade the geological map of the Snow Lake–Squall Lake–Herblet Lake area to a level comparable to that for the SLMP, the Manitoba Geological Survey is conducting geological mapping with the objective of providing a new 1:20 000 compilation for this area.

During the 2010 field season, geological mapping was conducted in the Snow Lake–Squall Lake–Herblet Lake area to complement work initiated during the 2008 and 2009 field seasons (Beaumont-Smith and Gagné, 2008; Gagné, 2009b). Fieldwork in 2010 also included an examination of drillcore from various locations. A new 1:20 000 geological map (Gagné and Beaumont-Smith, 2010) has been produced, integrating data from this latest field season with results from the previous years' mapping. This paper discusses the results of the latest geological mapping and briefly describes the main features of the geology for the area covered by the new preliminary map.

Previous work

Earlier geological investigation in the Snow Lake–Squall Lake–Herblet Lake area includes geological mapping by Harrison (1945) and Russell (1957) at 1:31 680 scale, and Froese and Moore (1980) at 1:50 000 scale. Galley et al. (1986, 1988) conducted 1:5 000 scale geological mapping in the immediate vicinity of the New Britannia mine, along with mineral deposit studies. During the late 1990s, several geological studies were undertaken in the Snow Lake area, including geological mapping and mineral deposit studies by the Manitoba Geological Survey and contributions from student theses. The Squall Lake–Varnson Lake area was mapped at a 1:20 000 scale by Schledewitz (1997b), Schledewitz and Bailes (1998), and Bailes and Schledewitz (1999). Bailes and Schledewitz (1998) also examined the volcanic stratigraphy and carried out geochemical sampling along a cross-section near the New Britannia minesite. Gale (2002) conducted mineral deposit studies on the New Britannia mine. Kraus (1998) completed a structural and metamorphic study of the tectonic slice of Burntwood metasedimentary rocks located between the SLMP and MBP. Fieldhouse (1999) completed a study of the structural setting of the New Britannia mine and its satellite deposits, and Fulton (1999) investigated the nature and mineralogical characteristics of the New Britannia gold mineralization. Recent work by Beaumont-Smith and Lavigne (2008) and Gagné (2009b) provided better constraints on structural geology and yielded further evidence that mineralization was emplaced during either D_1 or early D_2.

Regional setting

The Snow Lake–Squall Lake–Herblet Lake area is located in the eastern portion of the Flin Flon–Snow Lake greenstone belt, in an area that encompasses the transition zone between the Flin Flon–Snow Lake greenstone belt to the south and the Kisseynew Domain to the north.

The Flin Flon–Snow Lake greenstone belt is made up of several distinct lithotectonic domains that were amalgamated during the Trans-Hudson Orogeny (THO; 1.9–1.8 Ga). The exposed belt extends east-west for a distance of more than 250 km and has a width of ~50 km from north to south (Figure GS-10-1). The contrasting structural style, metamorphic grade and geochemistry between the eastern and western portions of the belt have led researchers (Lucas et al., 1996; Syme et al., 1996) to conclude that the eastern and western portions experienced distinct tectonic evolution.

The Snow Lake–Squall Lake–Herblet 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). Kraus and Menard (1997) defined this zone of tectonic interleaving as the Snow Lake allochthon. The Snow Lake allochthon terminates to the west against the Amisk Collage along the Morton Lake Fault (Stern et al., 1995a, b; Lucas et al., 1996). To the north, the Snow Lake allochthon comprises a zone of interleaved rocks of the Kisseynew Domain and the Amisk Collage. This transition zone is also commonly referred to as the south flank of the Kisseynew Domain (Zwanzig, 1990; Ansdell and Norman, 1995; Norman et al., 1995).

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 southwestern part 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 ~500–700°C, accompanied by only a minor increase in pressure from 4 kbar in the south to 6 kbar in the north (Kraus and Menard, 1997). This northward increase is clearly reflected in the metamorphic mineral assemblages, which progress from the chlorite zone in the south, through the staurolite zone at the New Britannia mine, to the sillimanite zone near Squall Lake.

Geology of the Snow Lake–Squall Lake–Herblet Lake area

Geological investigations during the 2010 field season focused on extending the mapping coverage farther north from the areas mapped during the 2008 and 2009 field seasons. Infill traverses were also completed to increase data density in more complex areas. Peak amphibolite-facies metamorphism affected all rocks throughout the map area (except for late felsic pegmatite, unit 11); all primary pyroxene phenocrysts have been pseudomorphed by hornblende. For ease of reading, the prefix 'meta-' will be omitted from the rock descriptions.

Only lithological units that were the focus of this past field season are described in this paper. The reader is referred to Beaumont-Smith and Lavigne (2008) and Gagné (2009a) for detailed description of units 1, 2, 4 and 8 (note: unit 8 corresponds to unit 5 in Gagné, 2009a). Unit numbers refer to Preliminary Map PMAP2010-3 (Gagné and Beaumont-Smith, 2010).

Mafic volcanic rocks (unit 3)

Two main packages of mafic volcanic rocks have been identified within the map area. In the vicinity of the New Britannia mine, a package of aphyric basalt, named 'Birch Lake basalts' by Bailes and Schledewitz (1998), caps the volcanic sequence. These basalts extend over a strike length of ~4.5 km from Canada Creek in the west, along the south side of the New Britannia tailings ponds, to the Birch Lake fault in the east (Figure GS-10-2). West of Canada Creek and east of Cleaver Lake,

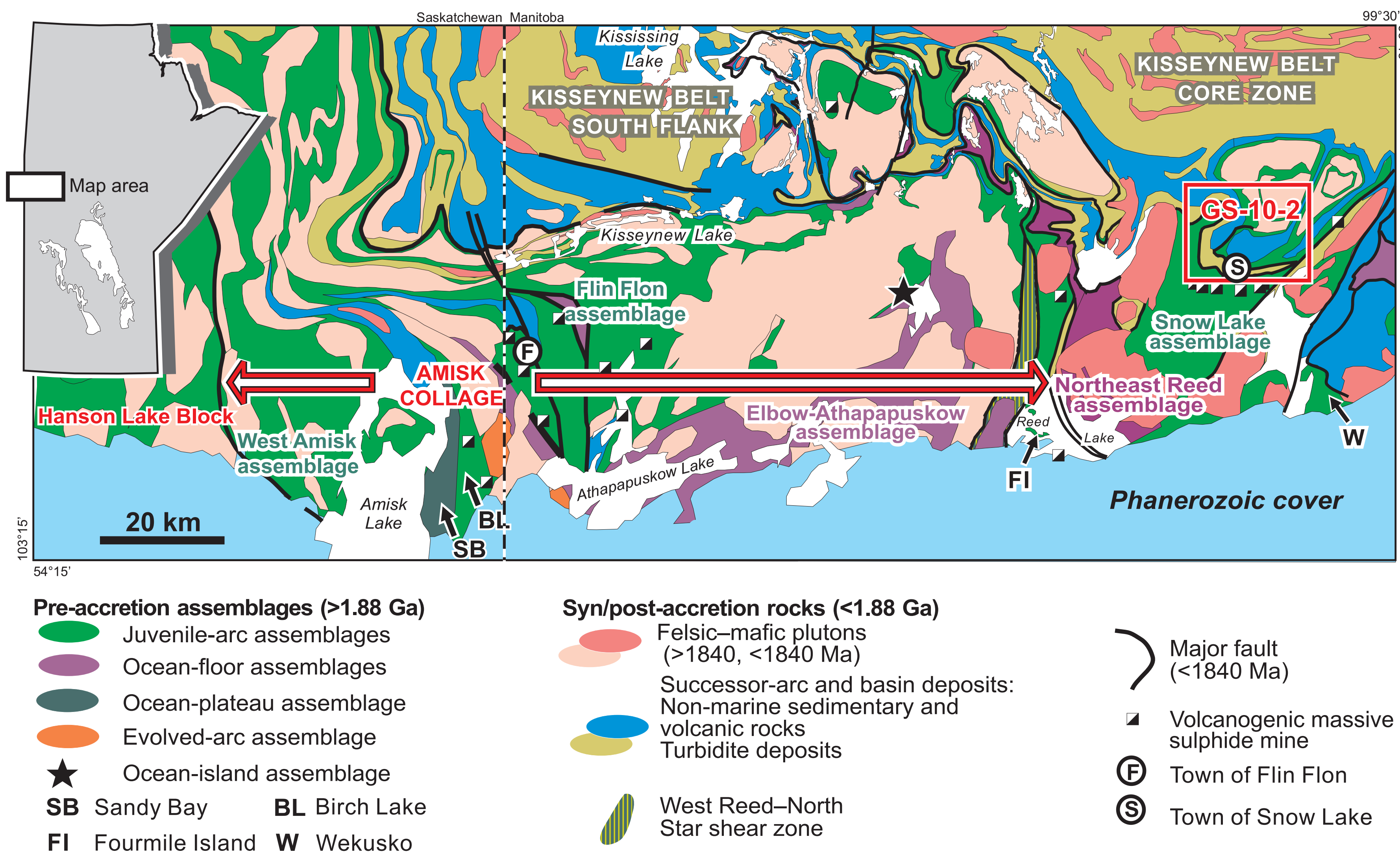

Figure GS-10-1: *Geology of the Flin Flon–Snow Lake greenstone belt.*

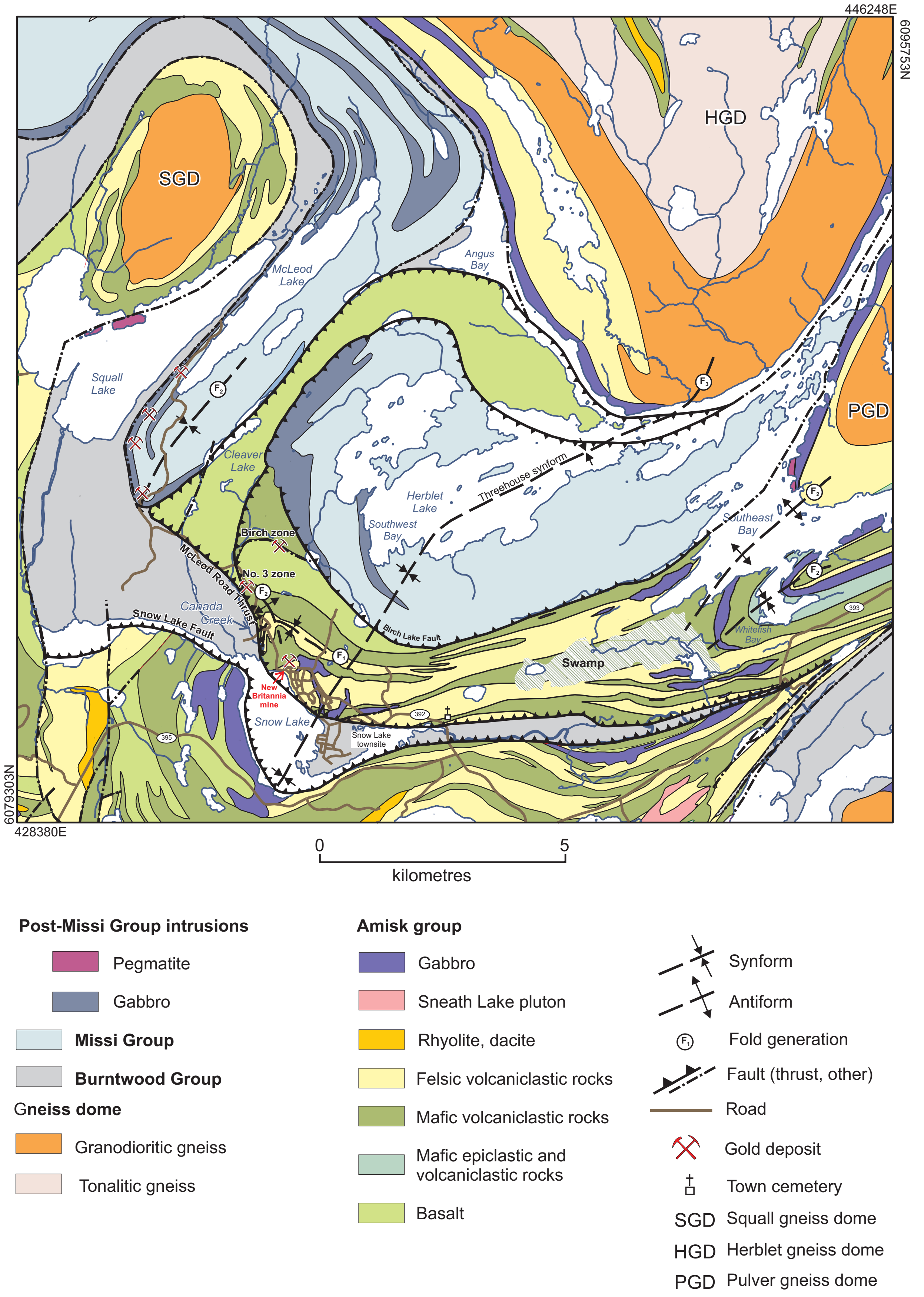

Figure GS-10-2: *Geology of the Snow Lake–Squall Lake–Herblet Lake area.*

another package of the Birch Lake basalts and associated volcaniclastic rocks trends northward for about 6 km to then wrap around Southwest Bay as it folds around the F_3 Threehouse synform. This package of Birch Lake basalt, traceable over 13 km with a maximum thickness of 1.2 km, gets truncated near the central part of Herblet Lake, just south of the Herblet gneiss dome where the McLeod Road thrust fault and the Birch Lake fault meet.

This unit consists of aphyric to locally plagioclase-porphyritic pillowed and massive basalt flows, proximal mafic volcaniclastic rocks and minor amounts of mafic-derived wacke and mudstone. The pillowed basalt is light green weathering with thin selvages and minor interpillow hyaloclastite (Figure GS-10-3a). Pillows contain ubiquitous thermal-contraction cracks, which are generally filled with carbonate and are locally weakly variolitic. Interbedded with the pillowed basalt are horizons of massive medium-grained basalt, which are interpreted as thick flow units, and rare, finely laminated, mafic sedimentary rocks (Figure GS-10-3b). The northwest block of Birch Lake basalts is similar to the southeast block, but it lacks the fine-grained mafic sedimentary rocks. It also exhibits facies of proximal mafic volcaniclastic rocks, including mafic lapilli tuff and crystal tuff (Figure GS-10-3c). In a few localities, Fe-Mg–altered mafic pillows were recognized. The alteration is evidenced by the presence of abundant anthophyllite and garnet. Several examples of altered pillows with abundant hornblende and garnet within selvages and hyaloclastite were also observed (Figure GS-10-3d).

Amphibolitic rocks (unit 5)

The northeastern portion of the map area, north of Herblet Lake between Angus Bay and Northeast Bay, is characterized by the presence of a large domal structure, the Herblet gneiss dome, exposing granodioritic to tonalitic gneiss in its core (Figure GS-10-2). This gneiss dome is part of a series of domes that extends more than 80 km

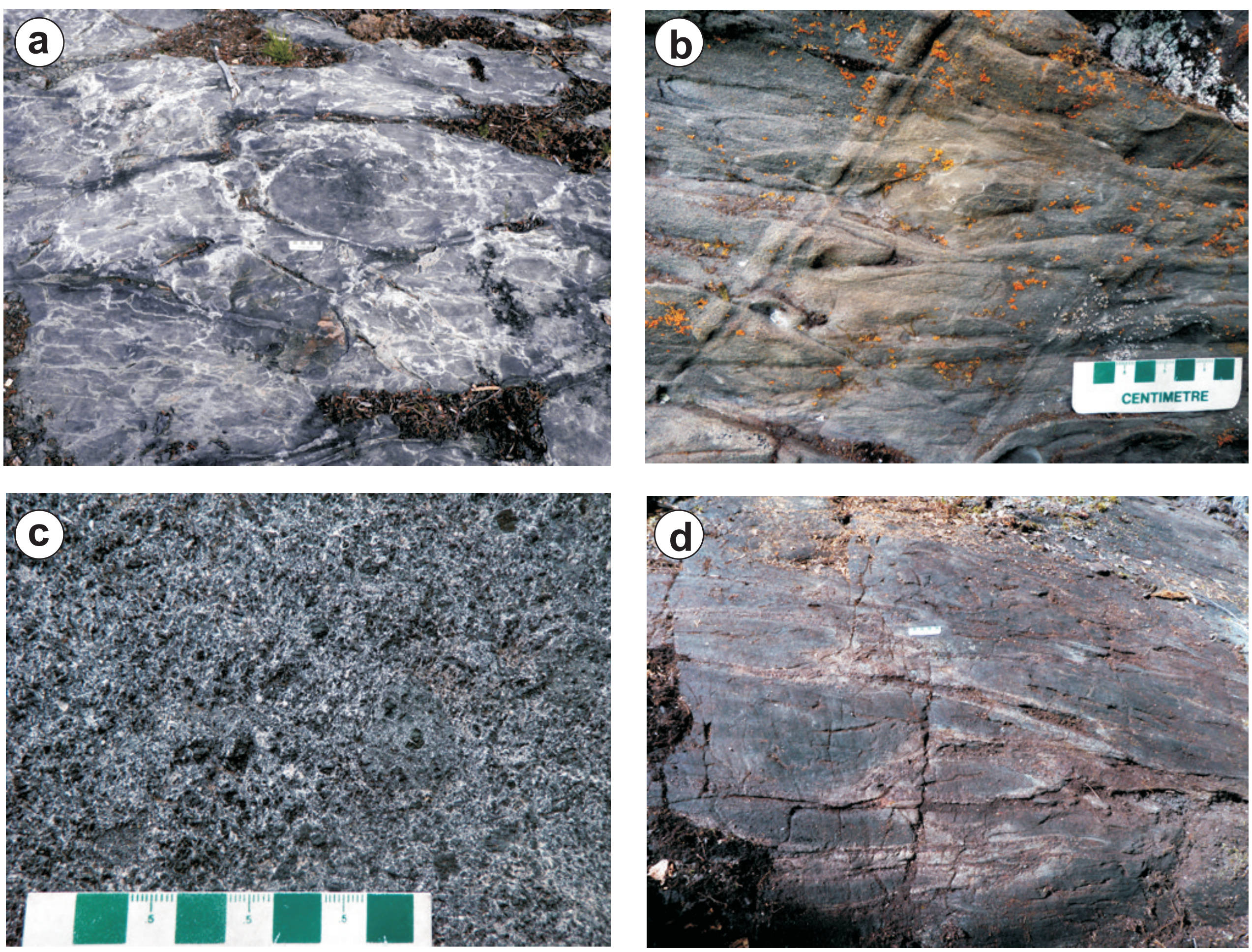

Figure GS-10-3: *Mafic volcanic rocks (unit 3) of the McLeod Road–Birch Lake thrust panel (MBP):* ***a)*** *pillowed basalt with minor carbonate alteration, 2.5 km northeast of Cleaver Lake;* ***b)*** *regularly bedded, fine-grained mafic sedimentary rocks, 700 m east of the 3 zone, New Britannia mine;* ***c)*** *plagioclase-pyroxene–porphyritic mafic lapilli tuff, including 2–4 cm pyroxene-porphyritic dark green clasts, 1 km east of the town of Snow Lake along the powerline;* ***d)*** *pillowed basalt with moderate garnet-hornblende alteration along pillow selvages and between pillows, 800 m north of Southwest Bay. Scale bar is 8.5 cm in all photos.*

west from the Pulver gneiss dome, just east of Herblet Lake, to the Sherridon–Hutchinson Lake complex.

Along the east side of Angus Bay, a thin horizon (100–200 m) of melanocratic amphibolite defines the outer edge of the Herblet gneiss dome. The amphibolite unit follows the eastern shore of Angus Bay for a distance of about 6 km. This unit is typically strongly foliated, medium-grained, compositionally layered hornblende-plagioclase gneiss. Metamorphic recrystallization in the upper amphibolite facies largely destroyed primary textures in these rocks. Hornblende and plagioclase generally account for greater than 80% of the mineralogy; biotite and garnet are common minor phases (up to 20–25%). The amphibolite bodies are interpreted to represent metamorphosed gabbro sills (Bailes, 1975).

Felsic metavolcanic gneiss (unit 6)

Felsic metavolcanic gneiss that forms a 1–1.5 km wide horizon occupies the southwestern margin of the Herblet gneiss dome, inward from the amphibolitic gneiss. The felsic gneiss trends parallel to the amphibolite of unit 5. The high degree of metamorphic recrystallization and the intensity of deformation have obliterated most primary features. Within the map area, the felsic metavolcanic gneiss forms a distinct mappable horizon. The rock is a white- to buff-coloured, fine- to medium-grained garnetiferous quartzofeldspathic gneiss. Bailes (1975) interpreted the felsic gneiss to represent high-grade felsic volcanic and volcaniclastic rocks. Immediately west of the map area, similar felsic gneiss was identified bordering the Squall Lake gneiss dome. Froese and Moore (1980) and Schledewitz (1997a, b) showed that the felsic gneiss can be traced directly into felsic volcanic and volcaniclastic rocks of the Snow Lake Arc assemblage.

Tonalitic to granodioritic orthogneiss (unit 7)

East of Angus Bay, the interior of the Herblet gneiss dome comprises felsic gneiss that varies in composition from a fine- to medium-grained, pink granitoid gneiss (quartz-oligoclase-microcline-biotite±hornblende) to a light grey, medium-grained tonalitic gneiss that consists of quartz, oligoclase, biotite and hornblende (Bailes, 1975). Outcrops that were examined along the margin of the gneiss dome consist mainly of well-foliated, medium-grained, pink granodioritic gneiss. The Herblet gneiss dome extends to the north into the Guay Lake–Wimapedi Lake area mapped by Bailes (1975).

David et al. (1996) obtained a mixture of zircon ages from Herblet gneiss dome samples that they interpreted to be the product of a high-grade (1.81 Ga) metamorphic overprint on older (1.89 Ga) volcanic and intrusive protoliths. This interpretation is similar to a previous interpretation by Gordon et al. (1990), which concluded that a U-Pb zircon age of 1890 +8/–6 Ma for a sample from the south tip of the gneiss dome was an igneous crystallization age, and the granodioritic gneiss mentioned above was a subvolcanic intrusion coeval with pre–l.88 Ga volcanism.

Sedimentary rocks

The MBP is bounded by two distinct panels of metasedimentary rocks. To the north, it is overlain by younger (1845 Ma) Missi Group arkose atop the Birch Lake Fault; to the south, the younger (1845 Ma) Burntwood Group turbidite forms the footwall of the McLeod Road thrust fault.

Missi Group (unit 9)

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 arenite is also characterized by small (1–3 mm) garnet porphyroblasts and common thin (<2 mm) biotite-rich laminations. The abundant crossbedding is accompanied by a large number of channel lag deposits that commonly include magnetite. The Missi Group clastic sedimentary rocks occupy the core of synformal structures throughout the map area, consistent with its stratigraphic position atop both the Burntwood and the Snow Lake volcanic rocks. The core of the McLeod Lake F_2 synform is blanketed by Missi Group clastic sedimentary rocks. The entire Southwest Bay of Herblet Lake is covered by Missi Group clastic sedimentary rocks and, just east of the map area, the Missi also occupies the core of the Whitefish Bay synformal structure. Throughout the region, the Missi clastic rocks are very homogeneous with minor variation in composition. Near the centre of Herblet Lake, Missi Group sedimentary rocks contain 2–5% granitic and arkosic clasts (1–8 cm in length) that are generally well rounded. Also, in the northern half of Herblet Lake, the Missi Group rocks often display 2–5% small elliptical aggregates of sillimanite (2–8 mm).

Gabbro sill (unit 10)

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

Amphibolite and fine-grained biotite-hornblende gneiss derived from volcanic rocks, volcaniclastic rocks and dikes (Zwanzig, 1984) occur throughout the southern flank of the Kisseynew Domain as thin units at various stratigraphic levels in the Missi Group (Zwanzig, 1999).

These are typically spatially associated with gabbro sills. In the northwest corner of the map area, there are a few occurrences of mafic crystal tuff and lapilli tuff associated with gabbro sills within the Missi Group arenite.

Felsic pegmatite (unit 11)

Coarse to very coarse, pink granitic pegmatite occurs locally as small pods near the contact between the Burntwood Group and the structurally overlying volcanic rocks of the Snow Lake Arc assemblage along the shores of Angus Bay. The pegmatite is also found near the margin of the Herblet gneiss dome. The pink pegmatite is generally a homogeneous, massive rock composed of microcline, plagioclase, quartz and biotite. The pegmatite appears to be undeformed, and is thus interpreted to post-date the main deformational and metamorphic events.

Structural geology

Deformation structures in the Squall Lake–Snow Lake–Herblet Lake area record four distinct periods of deformation. Fabrics associated with the D_1, D_2 and D_3 deformations are observed throughout the region, whereas the D_4 deformation is only evidenced by map-scale folds.

The oldest fabric recognized in the area is interpreted to record D_1 deformation. Kraus (1998) and Kraus and Williams (1999) recognized inclusion trails within staurolite porphyroblasts in the Burntwood Group as a D_1-related fabric. This fabric does not extend into the matrix. The widespread presence of S_1 inclusion trails in staurolite porphyroblasts indicates that D_1 likely formed a pervasive foliation within the Burntwood Group prior to the development of a penetrative S_2 fabric that obliterated S_1. Beaumont-Smith and Lavigne (2008) and Gagné (2009a) recognized local preservation of the S_1 foliation throughout the volcanic and volcaniclastic rocks of the MBP (Figure GS-10-4a). Although not widespread, the S_1 fabric is locally observed as a layer-parallel cleavage that is best developed in the vicinity of stratigraphic contacts. Layer-parallel foliation of the S_1 generation is also observed in the hinge zone of tight to open, mesoscopic F_2 folds (Gagné, 2009a, b) where S_2 overprinting did not develop as strongly. Throughout the map area, there is no evidence for the presence of an S_1 foliation within the Missi Group clastic sedimentary rocks.

The F_1 folds are typically upright to moderately inclined and isoclinal. An associated axial-planar cleavage is locally observed within the volcanic rocks but is absent from F_1 folds in the Burntwood Group. Mesoscopic (0.5–5 m) folds related to D_1 have been identified throughout the Burntwood metasedimentary rocks and within volcanic and volcaniclastic rocks of the area (Figure GS-10-5a, b). Northeast of the New Britannia mine, Beaumont-Smith and Lavigne (2008) identified younging reversals within the volcanic stratigraphy that outline a macroscopic isoclinal F_1 anticline. They suggested that large-scale isoclinal F_1 folding may account for the interleaving of felsic volcanic and mafic volcaniclastic rocks in the hangingwall of the McLeod Road thrust fault. East of the town of Snow Lake, the paucity of younging direction data hinders the identification of fold repetitions. The McLeod Road–Birch Lake allochthon has been interpreted as both a homoclinal sequence (Bailes and Schledewitz, 1998) and an isoclinally folded sequence (Galley, 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.

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.

The development of D_1 structures in the Burntwood Group constrains the age of D_1 as younger than ca. 1845 Ma, the age of the youngest detrital zircons found within the turbidite (David et al., 1996; Machado et al., 1999). The Snow Lake fault, which defines the southern boundary of the 1.84 Ga Burntwood panel, is continuous to the west with the Loonhead Lake fault at File Lake (Connors, 1996) and is interpreted to be a regional-scale D_1 structure (Kraus and Williams, 1998; Bailes and Schledewitz, 1999).

The second deformation episode (D_2) is associated with the development of a prevalent S_2 foliation throughout the map area. A penetrative S_2 foliation is observed regionally within the Burntwood metasedimentary rocks, the Snow Lake Arc volcanic and volcaniclastic rocks, and the Missi Group arenite (Figure GS-10-4b, c). Mesoscopic F_2 folds form prominent structures in the map area. The McLeod Lake synform (Russell, 1957; Froese and Moore, 1980) can be traced from the south end of McLeod Lake to the north, where its wraps around the Squall Lake gneiss dome before extending farther west. Another major F_2 synclinal structure can be traced from the Northeast Bay of Herblet Lake, between the Pulver gneiss dome and the Herblet gneiss dome, trending southwest to Southwest Bay where it wraps around the broad, open, F_3 Threehouse synform. A synform-antiform pair trends northeast through the Whitefish Bay area. The synform is tight 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 Snow Lake.

The S_2 fabric is a moderately to steeply dipping penetrative foliation. In the south, this foliation dips north. 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 F_2 fold hinges (Figure GS-10-4d, -5d), where S_1 is locally

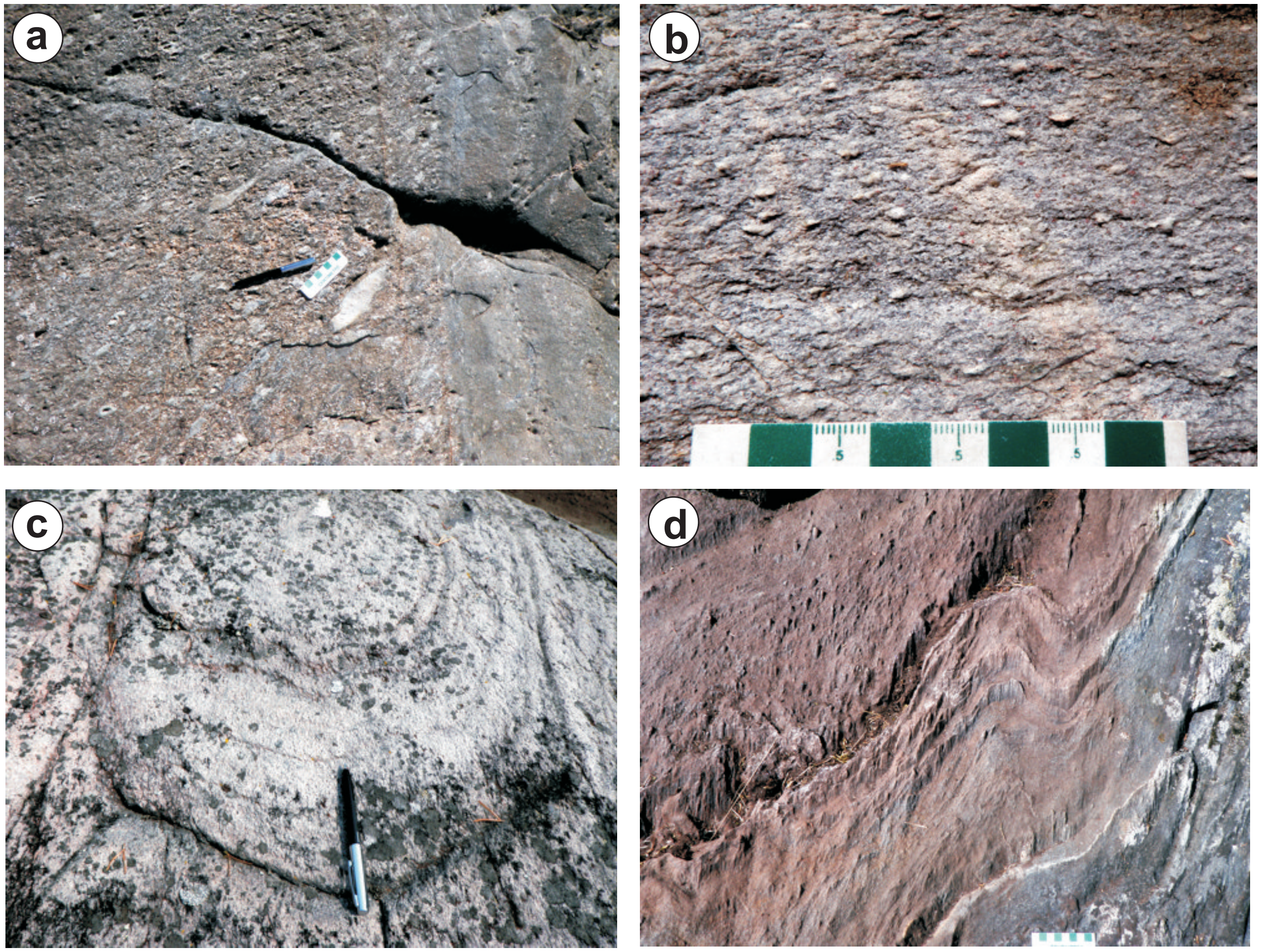

***Figure GS-10-4:** Structural fabrics in the Snow Lake–Squall Lake–Herblet Lake area: **a)** fine-grained bedded tuff (unit 2a) to the right of the image defines S_0, S_1 runs parallel to pen and S_2 runs parallel to ruler, overprints S_1 and contains flattened clasts, 300 m southeast of the New Britannia mine; **b)** Missi Group arenite with sillimanite clots (white ovoid mineral aggregates), near the centre of Southwest Bay, 6 km northeast of the town of Snow Lake; S_0 is defined by thin biotite laminae parallel to the bottom edge of the photo and S_2 is an oblique counter-clockwise spaced cleavage**;** **c)** tight F_2 fold in Missi Group arenite, south side of Southwest Bay, 5 km northeast of the town of Snow Lake; S_0 is defined by thin biotite laminae and is folded around F_2, and S_2 is an axial-planar spaced cleavage that runs parallel to the pen; **d)** asymmetric z-shaped fold in felsic crystal tuff on the south limb of the Whitefish Bay synform; S_2 is an axial-planar spaced cleavage and S_1/S_0 is folded by F_2. Scale bar is 8.5 cm in all photos.*

preserved. In Burntwood Group turbidite, 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 (Kraus and Menard, 1997). The S_2 foliation generally represents the oldest foliation preserved in most rocks. The shallowly northeast-dipping attitude of S_2, in conjunction with the steeper dip of bedding/layering, indicates that the F_2 folds have moderate to shallow plunges.

The D_2 deformation is interpreted to have culminated in thrust imbrication of the Snow Lake allochthon (Beaumont-Smith and Lavigne, 2008). 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 fault to be a post- or late-D_2 structure. In addition, the fact that the thrust is folded by the F_3 Threehouse synform further constrains it to a pre-D_3 event. Finally, the recognition of a local overprint of the mylonitic foliation associated with the thrust fault by the S_2 foliation (Galley et al., 1986; Kraus, 1998; Beaumont-Smith and Lavigne, 2008) constrains the development of the McLeod Road thrust fault as a late-D_2 feature. The thrust is characterized by a 10–30 m wide zone of intense fabric development (Figure GS-10-5c). The fault zone dips moderately north to northeast as it is folded around the Threehouse synform. The thrust fault includes a down-dip stretching lineation and sinistral transcurrent shear-sense indicators, suggesting a component of oblique slip.

The Birch Lake Fault forms the structural top of the MBP and is also interpreted as having formed late during D_2 deformation. However, Beaumont and Lavigne (2008)

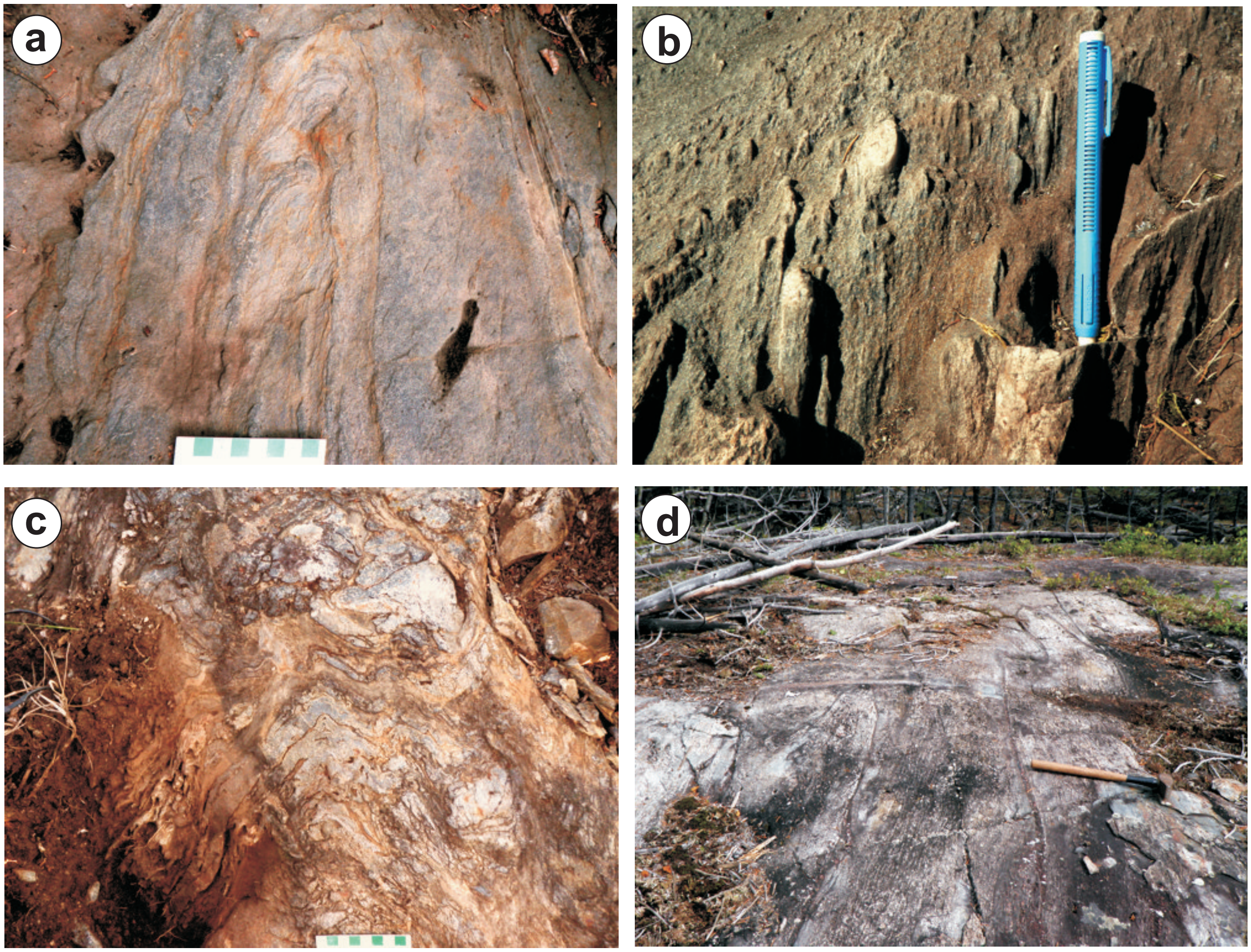

Figure GS-10-5: *Structural fabrics in the Snow Lake–Squall Lake–Herblet Lake area:* ***a)*** *isoclinal intrafolial F_1 fold within fine-grained mafic sedimentary rocks, 400 m northeast of the 3 zone, New Britannia mine;* ***b)*** *L_2 stretching lineation defined by strongly elongated felsic clasts and quartz amygdules in felsic lapilli tuff; south limb of the Whitefish Bay synform;* ***c)*** *McLeod Road thrust fault mafic tectonite displaying F_2 folding, 1.2 km northwest of the 3 zone, New Britannia mine;* ***d)*** *rootless and truncated isoclinal F_1 fold within felsic lapilli tuff; strong S_2 development has caused partial transposition. Scale bar is 8 cm in all photos.*

documented many structural features of this fault that are similar to the McLeod Road thrust fault and 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), macroscopic northeast-trending F_3 folds formed in the Snow Lake area. Locally, an associated axial-planar fabric developed as a spaced cleavage. Decimetre-scale F_3 folds are well developed in Burntwood Group turbidite, whereas the volcanic rocks contain only a local, weak S_3 foliation. Although there is not a very well-developed fabric associated with it, the D_3 deformation has important consequences for the regional map pattern.

East-trending F_4 folds overprint northeast-trending F_3 structures, resulting in a dome-and-basin configuration. No cleavage associated with the F_4 folding has been identified within the map area.

Economic considerations

Key factors controlling the location and geometry of gold mineralization in a given geological region include the nature of the proximal and distal stress regimes, and the presence of strength anisotropies (Robert et al., 1994). Much information on these factors can be obtained through detailed geological mapping.

Fieldwork carried out to date will allow refinement of the current model for the structural evolution of the region. This model has yet to be refined, but it describes accurately the larger scale current distribution of structures, fabrics and lithological units. Strength anisotropies are greatest at or near the contact between rocks of markedly different competency or across shear-zone domains. Within the New Britannia mine horizon, for example, gold mineralization is spatially associated with the McLeod Road thrust fault and is commonly situated along, or adjacent to, lithological contacts. In this regard, a new and updated geological map of the Squall Lake–Snow Lake–Herblet Lake area will help to establish more precisely the geometry of the various lithological units and the location of major structures, which will in turn provide important constraints for gold exploration models. Improved knowledge of the volcanic stratigraphy will also assist when testing the various structural models to explain the internal geometry of the McLeod Road thrust panel. Finally, the results of this detailed structural analysis will help constrain the timing of gold emplacement and the deposit-scale controls on gold mineralization.

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