

# Geochemistry, lithological mapping, and structural geology of volcanic and volcaniclastic rocks east of Squall Creek and north of Snow Lake (parts of 63k16 and 63J13)

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### Project overview

Rocks of the Snow Lake – Squall Lake – Herblet Lake area include, to the east, a panel of Snow Lake arc assemblage (SLA) volcanic rocks imbricated between the McLeod Road thrust and the Birch Lake Fault. To the west lies a narrow ~3 km-wide, north-trending package of volcanic rocks that represents the northern extension of the main panel of Snow Lake arc assemblage rocks.

The objectives of this project were to upgrade the geological map of the Snow Lake–Squall Lake—Herblet Lake area to a level comparable to that for the main panel of Snow Lake arc assemblage rocks to the south. New geological mapping and compilation work has enabled the release of two 1:20 000 geological maps (PMAP2011-2 and PMAP2010-3) which cover almost entirely the project area. An extensive set of representative geochemical analyses were collected along with some Sm/Nd data in order characterize the geochemical and isotopic signature of the various units that make up the geological framework of the area.

The project aims to gain a better knowledge of the stratigraphy of the area, deliver better constraints on the spatial distribution of the various lithological units, provide an updated model of the structural history, document the various gold occurrences and generate a genetic model for the emplacement of the gold mineralization in this area.

# **Project Location** KISSEYNEW BELT Early juvenile assemblages Arc volcanic rocks Successor-arc plutons

Map showing the main geological subdivisions of the Flin Flon - Snow Lake greenstone belt. The project area is highlighted by the red box. The Snow Lake area is dominated by bimodal arc-related volcanic and volcaniclastic rocks. Younger Burntwood and Missi sediments are tectonically interleaved with the volcanic rocks.

Early plutons, mixed gneiss

Missi Group

Arc-rift basalt

Ocean-floor basalt

# Geology

In the eastern portion of the map area, the McLeod Road – Birch Lake thrust panel (MBP) of Snow Lake arc assemblage comprises a 2-3 km thick sequence of bimodal arc-related volcanic and volcaniclastic rocks that form a thin arcuate package extending more than 10 km east and west of Snow Lake (Gagné and Beaumont-Smith, 2010). The rocks were metamorphosed from lower to mid-amphibolite facies. Synvolcanic gabbro dikes and sills are common. The MBP is flanked to the north and south by younger metasedimentary rocks. The MBP is separated from the younger underlying Burntwood metaturbidites by the McLeod Road thrust. The Birch Lake fault, also interpreted as a thrust fault, marks the boundary between the MBP and the overlying younger Missi meta-arenite to the north. The western portion of the MBP comprises two panels of pillowed and massive mafic volcanic flows with ocean-floor signature. 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. This gneiss dome is part of a series of domes that extends more than 80 km west from the Pulver gneiss dome, just east of Herblet Lake, to the Sherridon-Hutchinson Lake

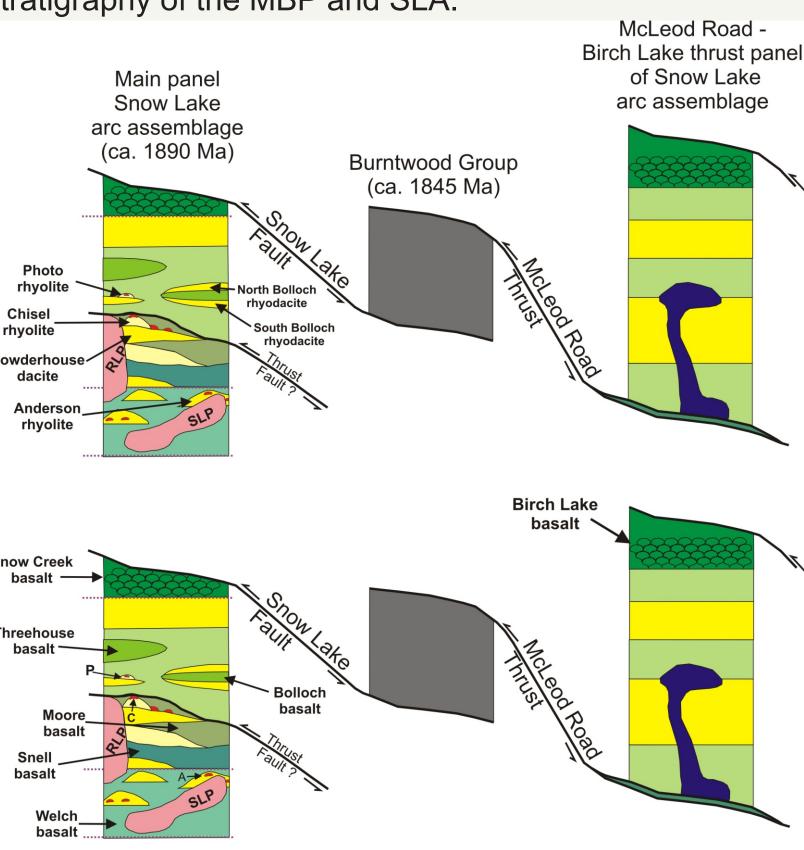
The western portion of the project area is comprised of a narrow 3 km-wide package of volcanic and volcaniclastic rocks consisting mainly of felsic gneiss and amphibolite that represent recrystallized and deformed equivalents of the Chisel and Snow Creek sequences of the Snow Lake arc assemblage, which occurs immediately south of the map area (Bailes, Schledewitz, and Gagné, 2011). In the southern portion of the Squall Lake–Varnson Lake area, the rocks of the SLA consist mostly of massive felsic volcanic rocks and lesser amounts of heterolithic mafic breccia, mafic flows and synvolcanic intrusions (Bailes and Schledewitz, 1999). In the northern half of the map area, the SLA is characterized by felsic quartzofeldspathic gneiss and amphibolite interpreted as the recrystallized equivalents of the recognizable volcanic and volcaniclastic rocks observed in the south. The area is characterized by massive monotonous lithological units, which extend along strike over several kilometres. Very few facing directions are observed in these rocks as a consequence of the intensity of regional metamorphism. Primary rock units are recognized only in the southern half of the map area.

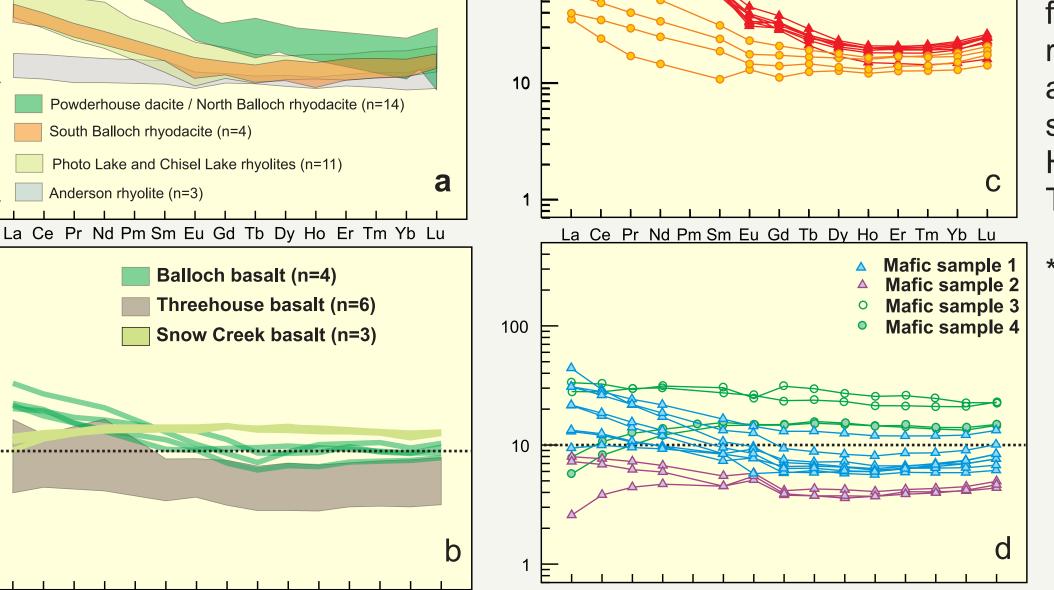
References: Bailes, A. H. and Schledewitz, D. C. P. 1999 Geology of Paleoproterozoic volcanic rocks in the Squall-Varnson Lakes area, Snow Lake, Flin Flon Belt (NTS 63K/16); in Report of Activities 1999, Manitoba Industry, Trade and Mines, Geological Services, p. 4–8. Bailes, A. H., Schledewitz, D. C. P., and Gagné, S. 2011 Updated geology of the Squall Lake-Varnson Lake area, Snow Lake, Manitoba: Manitoba Innovation. Energy and Mines, Manitoba Geological Survey, Preliminary Map PMAP2011-2, scale 1:20 000. **Gagné, S. and Beaumont-Smith, C.J. 2010**: Geology of the Snow Lake-Squall Lake-Herblet Lake area, Manitoba (parts of NTS 63K16, 63J13); Manitoba Innovation, Energy and Mines, Manitoba Geological Survey, Preliminary Map PMAP2010-3, scale 1:20 000.

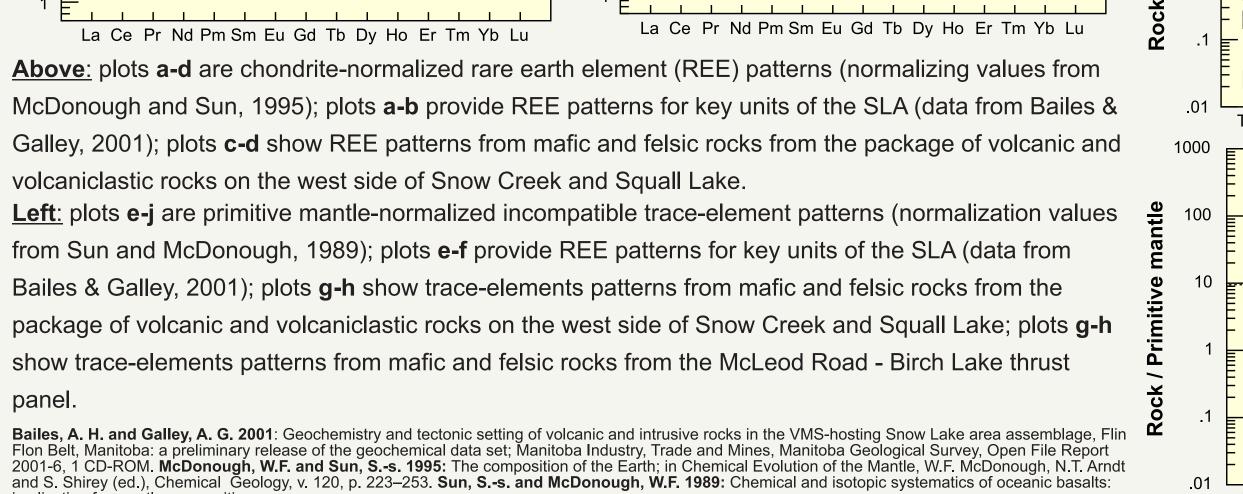
## Geochemistry

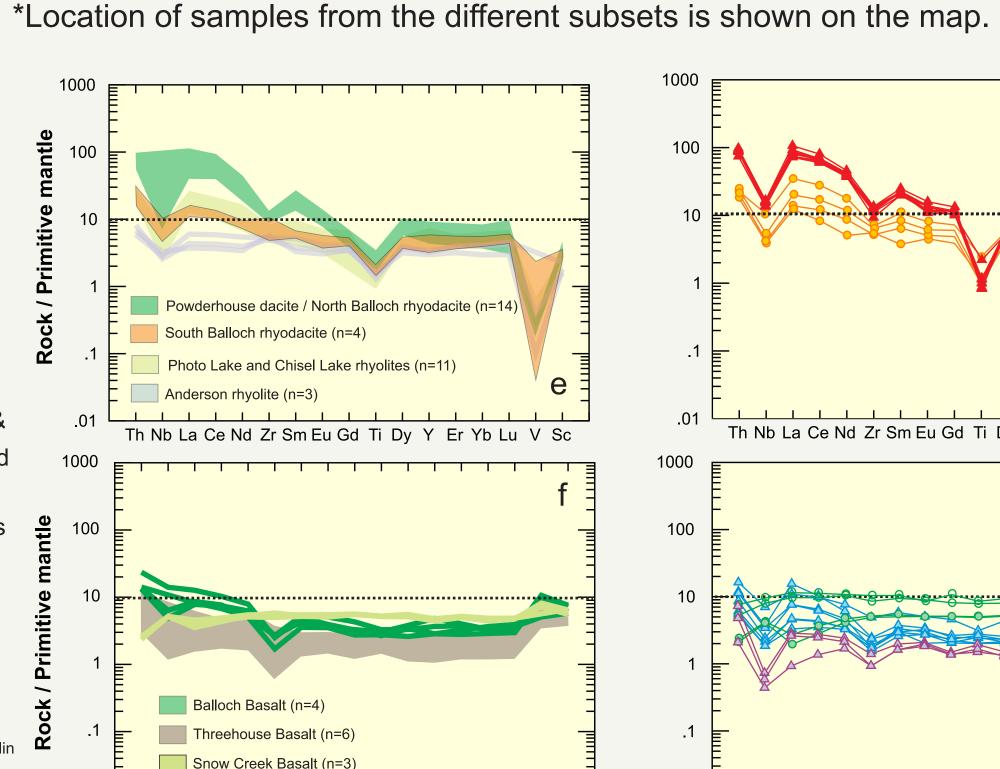
During the 2008-2011 field seasons, rock samples were collected from various representative units over the project area. Selected analyses are presented here. Geochemical data is used to aid comparison and correlation between distinct stratigraphic horizons.

**Below:** schematic diagram showing a simplified stratigraphy of the MBP and SLA.

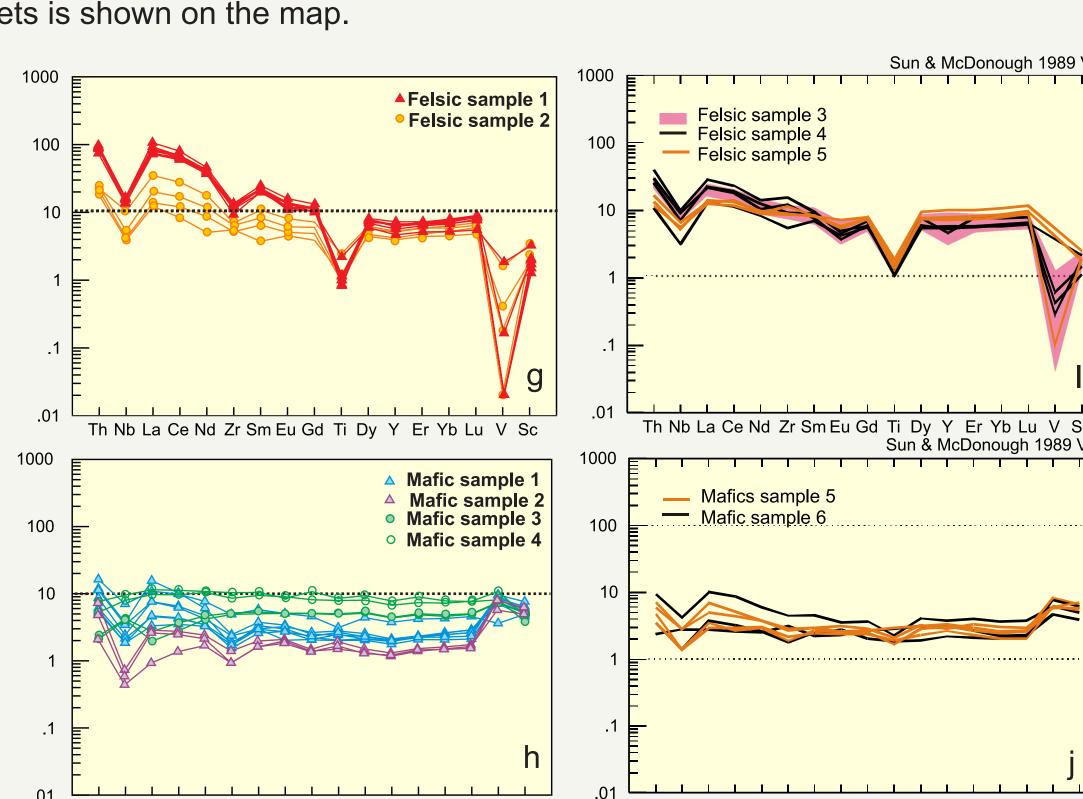








Th Nb La Ce Nd Zr Sm Eu Gd Ti Dy Y Er Yb Lu V Sc



Textural and geochemical similarities allow for identification of potential correlative units from the main SLA with units of

correlation with rocks the SLA, the data suggest that the volcanic and volcaniclastic rocks examined in the western and

the project area. Although the presence of major faults and the lack of geochronological data often prevents unequivocal

eastern part of the project area belong to the upper Chisel and Snow Creek sequences. Felsic rocks (Felsic sample 3-5)

from the MBP display chemical signature similar to that of the Photo Lake rhyolite and the South Balloch rhyodacite. Felsic

rocks from west of Snow Creek can be divided into two subset: one set of samples (Felsic sample 1) covering most of the

Th Nb La Ce Nd Zr Sm Eu Gd Ti Dy Y Er Yb Lu V Sc

area show similarities to the Powderhouse dacite/North Balloch rhyodacite whereas a smaller set of samples from the

Horizons of volcanic and volcaniclastic rocks from the MBP (Mafic sample 5-6) show a signature similar to that of the

southwest corner (Felsic sample 2) show similarities with the Photo Lake rhyolite and the South Balloch rhyodacite.

Threehouse basalt, whereas rock from the western portion of the mmostly show a similarity with the Balloch basalt.

# Structural Geology

The Snow Lake – Squall Lake –Herblet Lake area was affected by four deformations (Kraus, 1998; Kraus and Williams, 1999) but only three generations of fabric elements representing deformations D<sub>1</sub>–D<sub>3</sub> have been identified. The following summary applies best to the rocks of the MBP. Understanding of the structural history of the rocks west of Snow Creek requires further work.

The oldest deformation (D<sub>1</sub>) for which fabric elements are preserved in rocks of the map area produced upright to moderately inclined isoclinal folds and an associated axial-planar slaty cleavage. The presence of F₁ folds is widespread but the penetrative development and preservation of S₁ is rare. The isoclinal geometry of F<sub>1</sub> folds resulted in the development of a layer-parallel foliation, which was either not penetratively developed or was developed but transposed during subsequent deformations. Layer-parallel foliation of the S<sub>1</sub> generation is also observed in the hinge zone of tight to open, mesoscopic F<sub>2</sub> folds where S<sub>2</sub> overprinting did not develop as strongly. Throughout the map area, there is no evidence for the presence of an S₁ foliation within the Missi Group clastic sedimentary rocks. Within the New Britannia mine horizon isoclinal F<sub>1</sub> fold intercalation of volcanic rocks was documented. The plunge of F<sub>1</sub> folds is poorly constrained but appears to be relatively shallow, based on the steep attitude of the L₁ stretching lineation, which is generally oriented perpendicular to the plunge of the associated folds, assuming the folding is cylindrical (Beaumont-Smith and Lavigne, 2008).

The second deformation episode (D<sub>2</sub>) is associated with the development of a prevalent S<sub>2</sub> foliation throughout the map area. D<sub>2</sub> deformation is characterized by shallowly inclined F<sub>2</sub> folds and D<sub>2</sub> thrust faulting. Mesoscopic F<sub>2</sub> folds form prominent structures in the map area: the McLeod Lake synform, the Whitefish bay synform, and another major F<sub>2</sub> synformal structure that can be traced from the Northeast Bay of Herblet Lake trending southwest to Southwest Bay where it wraps around the F<sub>3</sub> Threehouse synform.

During D<sub>3</sub> macroscopic northeast-trending broad, open F<sub>3</sub> folds formed in the Snow Lake area. Locally, an associated axial-planar fabric developed as a spaced cleavage. Decimetre-scale F<sub>3</sub> folds are well developed in Burntwood Group turbidite, whereas the volcanic rocks contain only a local, weak S<sub>3</sub> foliation.

East-trending F<sub>4</sub> folds overprint northeast-trending F<sub>3</sub> structures, resulting in a dome-and-basin configuration just north of the map area. No cleavage associated with the F₄ folding has been identified within the map area.

References: Beaumont-Smith, C.J. and Lavigne, J. 2008: Structural geology and gold metallogenesis of the New Britannia mine area, Snow Lake, Manitoba (NTS 63K16); in Report of Activities 2008, Manitoba Science, Technology, Energy and Mines, Manitoba Geological Survey, p. 7–17. Kraus, J. 1998: Structural and metamorphic studies in the Snow Lake area, Trans-Hudson Orogen, Manitoba, central Canada; Ph.D. thesis, University of New Brunswick, Fredericton New Brunswick, 229 p. Kraus, J. and Williams, P.F. 1999: Structural development of the Snow Lake allochthon and its role in the evolution of the southeastern Trans-Hudson Orogen in Manitoba, central Canada; Canadian Journal of Earth Sciences, v. 36, no. 11, p. 1881–1899.

#### Granitic pegmatite: homogeneous, massive, microcline-plagioclase-quartz-biotite-muscovite Gabbro dikes and sills; massive to foliated, equigranula locally plagioclase porphyritic Squall Lake pluton: homogeneous, foliated medium to coarse-grained granite Ham Lake pluton: foliated medium- to coarse-grained biotite-hornblende granodiorite and tonalite Chisel Lake layered ultramafic intrusion: undivided peridotite, pyroxenite, gabbro Missi Group (1.85 - 1.84 Ga) Arenite: through crossbedded; biotite-garnet; biotite-garnet-sillimanite Burntwood Group (1.85 - 1.84 Ga) Herblet Gneiss Dome (>1.88 Ga) Felsic gneiss: fine- to medium-grained garnetiferous Amphibolite: strongly foliated, medium grained, compositionally layered hornblende-plagioclase gneiss Snow Lake arc assemblage (>1.88 Ga) Gabbro: fine-grained, equigranular; weakly foliated with granoblastic texture Margaret zones Mafic volcanic rocks: aphyric to plagioclase-phyric pillowed basalt; massive basalt; minor volcaniclastic rocks Felsic volcanic and volcaniclastic rocks; amygdaloidal PMAP2010-3 Squall - Varnson lakes area Gabbro, diorite, quartz-diorite, derived amphibolite c, pyroxene-plagioclase phyric medium-grained, equigranular gabbro coarse-grained gabbro with large amphibole crystals quartz-diorite with large amphibole crystals No. 3 zone Rhyodacite tuff, lapilli tuff: massive , plagioclase-phyric, ocally altered to hornblende (10-40%) and garnet (5-309) Aphyric mafic flows, mafic gneiss and amphibolite a) massive flows, locally amygdaloidal, rare pillows New Britannia mine FS-1 Felsic sample 1 Bailes, A.H., Schledewitz, Gagné, S. 2011: Geology of the Snow Lake - Squall Lake -Herblet Lake area, Manitoba (NTS 63K16); Manitoba Innovation, Energy and Mines, Manitoba Geological Survey, Preliminary Map PMAP2011-2, scale 1:20 000 Gagné, S. and Beaumont-Smith, C.J. 2011: Geology of the Snow Lake - Squall Lake -Herblet Lake area, Manitoba (parts of NTS 63K16, 63J13); Manitoba Innovation, Energy and Mines, Manitoba Geological Survey, Preliminary Map PMAP2010-3, scale 1:20 000

#### **Economic Considerations**

Gold: In the eastern part of the project area, there is a strong spatial association between gold mineralization and the McLeod Road Thrust. Gold mineralization is located in the hangingwall of the thrust and is hosted by a wide variety of rock types. Two common characteristics are the hosting of mineralization within high-strain zones and the location of gold mineralization along or adjacent to lithological contacts. The quartz-vein-hosted gold mineralization and its alteration are overprinted by F2 folding, which constrains the age of gold emplacement to pre- to syn-D2. However, there are also textural relationships that suggest later gold mineralization stages during D2. The current interpretation constrain the initial gold mineralization to syn-D2 or older accompanied by significant local remobilization during D2. Although there has been no significant gold deposit found in association with the Snow Lake Fault, the presence of several small gold occurences and associated silica alteration suggest that this maybe a favourable structure. Quartz vein-hosted W-Au mineralization occurs along the west side of Snow Creek (Jacknutt deposit).

VMS: Volcanic and volcaniclastic rocks of the Squall - Varnson lakes area share geochemical characteristics with and, on this basis, can be correlated to the upper Chisel sequence. Historically, all of the VMS deposits from the Chisel sequence have been found within the lower sequence. The Photo Lake VMS deposit, just south of the map area, may possibly belong to the upper Chisel sequence, but its stratigraphic position is still uncertain. Rocks from the Snow Lake – Squall Lake -Herblet Lake area appear to contain only minor alteration zones, unlike the lower Chisel sequence. Despite the apparent absence of intense synvolcanic alteration and the historical lack of base-metal mineralization associated with the upper Chisel sequence, the Squall-Varnson lakes area is considered to represent a prospective area for fertile VMS systems at depth. The large, base-metal poor, subeconomic Cook Lake deposit lies beneath the northern shore of Cook Lake, in the southwestern corner of the map area.

The presence of upper Chisel rocks throughout the Squall - Varnson Lakes area and the lack of Snow Creek sequence rocks within the main package of volcanic rocks west of Snow Creek indicate that present-day surface consists of rocks from a relatively narrow stratigraphic range. Hence, it is possible that at depth, below the upper Chisel sequence, rocks of the lower Chisel sequence extend through the western side of Snow Creek. The presence of a large-scale antiformal structure and the reversal in the plunge direction of the stretching lineation suggest that the stratigraphy may be brought up closer to the surface in the northern portion of the map area.

#### **Outcomes & Future Plans**

The geological and geochemical data from the Squall – Varnson lakes area (PMAP2011-2) will be integrated with data from the Snow Lake – Herblet lakes area (PMAP2010-3) in order to produce a new 1:20 000 scale geological map for the entire area with accompanying geological report. A final summer of field work will focus on known showing and gold occurences outside the New Britannia Mine vicinity. Ultimately, results from this study will constitutes the framework of an Economic Geology Report that will discuss the metallogeny of gold in the Eastern portion of the Flin Flon belt.

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