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GEOLOGY OF THE SEAL LAKE AREA, CENTRAL LABRADOR (PARTS OF NTS MAP AREAS 13K/3, 4, 5 and 6)

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ABSTRACT

*The middle Mesoproterozoic (*ca. *1270 to 1225 Ma) Seal Lake Group is a sequence of subaerial and shallow-marine sedimentary rocks, including amygdaloidal and porphyritic basalt flows intruded by gabbro sills. The rocks form a regional-scale, doubly plunging syncline at the western edge of the Central Mineral Belt of Labrador.*

The Seal Lake area is underlain by rocks of the east- to northeast-trending core of the regional syncline and includes a near-complete section through the Seal Lake Group. Units on the southern limb of the syncline have been metamorphosed up to greenschist facies, and variably deformed into north- to northwest-verging folds along a thrust contact with older granitoid rocks. Units on the northern limb show only minimal deformation and very low-grade metamorphism.

Previously unreported sulphide mineralization consists of several minor chalcocite occurrences hosted in quartz + carbonate veins, trace chalcopyrite in sedimentary and gabbroic rocks and near-ubiquitous pyrite in gabbroic rocks. Anomalous radioactivity is recorded from black shale units and a volcanic tuff layer of the Wuchusk Lake Formation and sandstone conglomerates of the Majoqua Lake Formation.

INTRODUCTION

This report focuses on the second year of field work related to a regional-scale, detailed bedrock-mapping project of the Seal Lake Group in central Labrador (Figures 1 and 2). Fieldwork covered parts of NTS map areas 13K/3, 4, 5 and 6 (see Figure 3). Ground traverses were carried out at 0.5 to 1.5 km spacings, where possible, and helicopter stops were utilized to fill in between ground-traverses and areas of poor exposure.

LOCATION AND ACCESS

The Seal Lake region is located in central Labrador about 145 km northwest of Happy Valley–Goose Bay (Figure 1). Access to the area is mainly by float plane or helicopter from Goose Bay. A combination of helicopter-, boat- and float-plane supported ground traversing is the most effective means to map the region.

PREVIOUS INVESTIGATIONS

Initial geological investigations of the Seal Lake area began in the mid-1940s and led to the discovery of native copper occurrences in the Adeline Lake area (Halet, 1946;

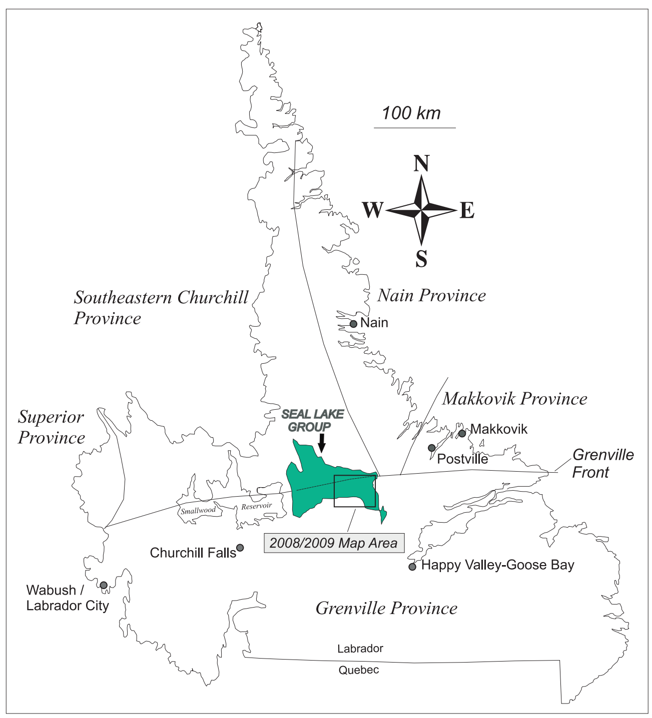

Figure 1. *Location of the Seal Lake Group, the 2009 map area and position of the tectonic boundaries in Labrador.*

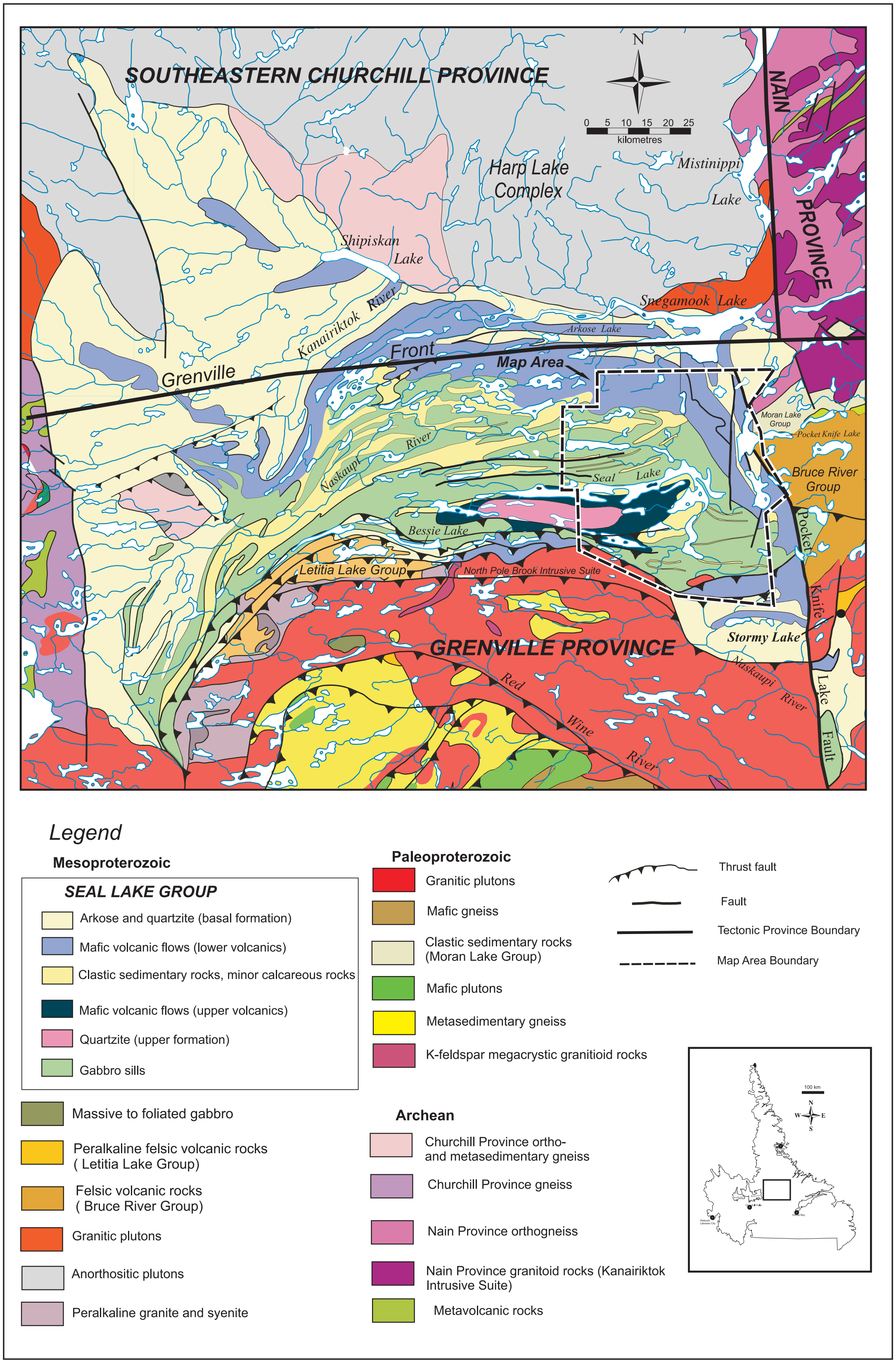

Figure 2. *Regional geology of the Seal Lake Group and surrounding area (modified from Wardle* et al.*, 1997), and the location of the 2008/2009 map area.*

Smith, 1946). Throughout the 1950s, extensive base-metal prospecting and geological mapping of the Seal Lake area resulted in the defining of the stratigraphy, recognition of the synclinal form of the rocks and the discovery of more than 250 mineral occurrences (Scott and Conn, 1950; Evans, 1951, 1952; Christie *et al.*, 1953; Brummer, 1957; Robinson, 1953, 1956; Fahrig, 1959; Brummer and Mann, 1961).

Work continued through the 1970s and 1980s, including field studies of the more significant mineral occurrences (Gandhi, 1971, 1972; Gandhi and Brown, 1975), and detailed- and regional-scale geological mapping (DeGrace, 1969; Knight, 1972; Marten and Smyth, 1975; Hibbs, 1980; Calon and Hibbs, 1980; Thomas, 1981 and Ryan, 1984). Petrochemical studies of the Seal Lake Group igneous rocks were completed by Baragar (1981) and Wilton (1989b). Wilton (1989a) described some of the significant copper occurrences and suggested a epigenetic origin for the mineralization.

During the 1990s, Nunn (1993) included the western limit of the Seal Lake Group in the geology of the northeastern Smallwood Reservoir area and Cadman *et al.* (1993, 1994) carried out comparative geochemical and geochronology studies of the Harp dykes and igneous rocks of the Seal Lake Group. Wilton (1996) summarized his earlier work in a comprehensive study of the metallogeny of the Central Mineral Belt in Labrador.

More recently, Silver Spruce Resources Limited (2006) and Capella Resources Limited (2007) completed airborne geophysical surveys of their Seal Lake area claims to target iron oxide–copper–gold-type deposits and uranium mineralization.

Recently, Kilfoil (2008) released shaded-relief, 1:250 000-scale airborne magnetic and gravity compilations, which include the Seal Lake area. Parts of NTS map sheets 13K/5(southeast) and 13K/6 (southwest) were mapped at 1:50 000 scale in 2008 (van Nostrand, 2009). A more detailed review of previous investigations in the Seal Lake area was discussed in van Nostrand (2009).

PHYSIOGRAPHY

The physiography of the map area is dominated by the east-trending Seal Lake, which is approximately 30 km long and 1.5 km at its widest point, is surrounded by rugged, densely wooded hills and steep-sided, north-facing escarpments. Elevations range from 590 m in the northern plateau to 212 m at Seal Lake. The generally narrow, east-trending intervening valleys are occupied by thick alder and spruce forests and, rare, intermittent swamps. Bedrock exposure is poor to moderate, with the exception of shorelines, hilltops, escarpments and some river valleys.

The major ice-flow direction was to the northeast, followed by a later northeast to east-southeast direction (McCuaig and Smith, 2005). Striae directions in the map area are a dominant northeast trend (060° – 070°) and a weaker east-northeast trend (080° – 090°).

REGIONAL SETTING

The middle Mesoproterozoic Seal Lake Group is the youngest of the volcano-sedimentary sequences comprising the Central Mineral Belt. The group unconformably overlies rocks of the Mesoproterozoic Letitia Lake Group to the southwest, the Paleoproterozoic Bruce River Group to the east, the Mesoproterozoic Harp Lake Complex to the north and Paleoproterozoic Churchill Province gneisses to the west. To the south, it is in thrust contact with Paleoproterozoic granitoids of the North Pole Brook Intrusive Suite, part of the Trans-Labrador batholith (Thomas, 1981; Wardle *et al.*, 1997; Figure 2). The southwestern margin of the Seal Lake Group is represented by clastic sedimentary rocks of the Bessie Lake Formation. The latter unconformably overlies volcanic rocks of the Letitia Lake Group, but the unconformity has been largely reworked by north-directed Grenvillian thrust faults

The Seal Lake Group consists of a thick sequence of subaerial and shallow-marine supracrustal rocks including quartzite, sandstone, conglomerate, siltstone, shale, slate, basalt flows, minor calcareous rocks, chert and volcaniclastic rocks. The middle and upper parts of the group are intruded by numerous gabbro sills. The sequence is deformed into a regional-scale syncline structure which, on its southern limb, has been overthrust and overturned by older rocks along Grenvillian thrust faults.

The rocks have been subdivided into several stratigraphic formations (Evans, 1952; Mann, 1959; Brummer and Mann, 1961), which have been slightly modified by subsequent workers (Gandhi and Brown, 1975; Baragar, 1981). These are from oldest to youngest: the stratigraphically equivalent basal Bessie Lake – Majoqua Lake formations, Wuchusk Lake, Whiskey Lake, Salmon Lake, Adeline Island and the Upper Red Quartzite formations.

Brummer and Mann (1961) referred to rocks of the basal formation on the southern limb of the regional syncline as the Bessie Lake Formation. These authors noted that previous workers (*e.g.*, Robinson, 1953) had applied the term Majoqua Lake Formation for undeformed, stratigraphically equivalent rocks of the basal unit on the northern limb and eastern hinge area of the regional syncline. This report will herein use this subdivision for basal unit rocks.

The area surrounding Seal Lake has more than 250 reported copper sulphide and native copper occurrences. These are hosted primarily in quartz ± carbonate veins and

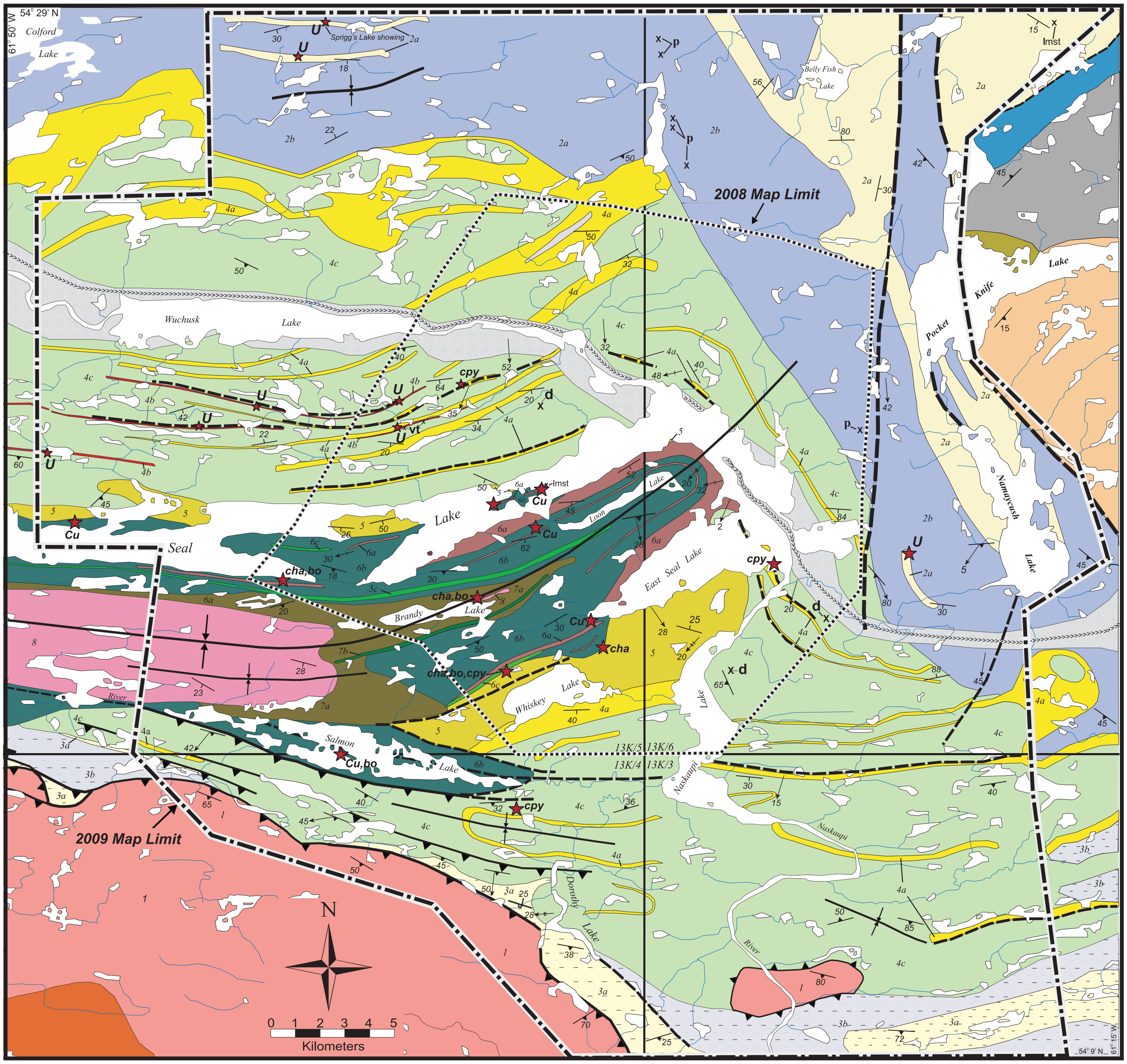

Figure 3. *Regional geology of the Seal Lake area, central Labrador. Data of Fahrig (1959); Brummer and Mann (1961); Thomas (1981) and Ryan (1984) have been incorporated into the map*

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along bedding and cleavage surfaces in sedimentary rocks and basalt flows. Anomalous radioactivity exists at,

- the unconformity at the base of the Bessie Lake Formation with felsic volcanic rocks of the Bruce River Group, located on the southeastern boundary of the Seal Lake Group (Stormy Lake showing),
- in basal conglomerate of the Bessie Lake Formation, associated with the unconformity with the Letitia Lake Group along the southern margin, and
- in conglomerate and sandstone in the Majoqua Lake Formation.

The age of deformation and metamorphism affecting the Seal Lake Group has not been determined. It is assumed that the regional synclinal structure, fabric development and metamorphism are attributable to Grenvillian effects. The Grenville Front zone (Gower *et al.*, 1980, 1996; Wardle *et al.*, 1997) transects the Seal Lake Group and Grenvillian deformation and metamorphism decreases northward from the southern margin of the group.

LEGEND (Figure 3)

Glaciofluvial deposits

Mesoproterozoic

Seal Lake Group

Upper Red Quartzite Formation

8 Mature, red-weathering quartzite.

Adeline Island Formation

7b Fine-to medium-grained, ophitic-textured gabbro sills.

7a Interbedded quartzite, siltstone, minor slate and mafic volcanic flows.

Salmon Lake Formation

6c Fine-to coarse-grained, ophitic-textured gabbro sills.

6b Weakly to strongly foliated mafic volcanic flows and sills with minor intercalated sedimentary rocks.

6a Argillaceous sedimentary rocks. Predominantly red slates, shales and siltstones containing thin arenaceous interbeds and rare limestone and stromatolites.

Whiskey Lake Formation

5 Interbedded siltstone and sandstone, containing minor slate, shale and rare chert.

Wuchusk Lake Formation

4c Fine-to coarse-grained, ophitic- to intergranular-textured gabbro. Contains subordinate basalt flows and volcaniclastic rocks.

4b Fine-grained black shale. Records anomalous radioactive signatures.

4a Arenaceous sedimentary rocks. Predominantly quartz-rich sandstones and siltstones with subordinate argillaceous and calcareous sediments.

Bessie Lake Formation (deformed equivalent of Majoqua Lake Formation)

3b Strongly foliated to locally banded basalt flows gradational to mafic schists exhibiting a pervasive chlorite + epidote alteration.

3a Strongly foliated and recrystallized sandstone, siltstone, quartzite and conglomerate gradational to sericite- and muscovite-bearing schist.

Majoqua Lake Formation

2b Undeformed to weakly deformed amygdaloidal and porphyritic-textured basalt flows with subordinate pillow basalt.

2a Undeformed to weakly deformed quartzite, sandstone, conglomerate and minor siltstone, shale and limestone.

Paleoproterozoic

1 Granitoid rocks (Trans-Labrador Batholith). Within the map area this unit is a moderate to strongly deformed granodiorite intruded by granite veins.

Rocks outside the map area

Gabbroic and metagabbroic rocks

Metasedimentary gneiss

Bruce River Group (felsic volcanic rocks)

Moran Lake Group (sedimentary rocks)

Archean

Quartzofeldspathic gneiss

SYMBOLS

Sedimentary bedding (tops unknown, overturned) 30 25

Regional S_1 foliation 30

Mineral lineation 30

F_1 minor fold axis 30

F_2 minor fold axis 30

Geological contact (approximate) ....

Brittle and/or thrust fault ....

Thrust fault ....

Axial F_1 fold trace ....

Esker ....

Fine-grained dyke .... d

Pillow basalt .... p

Limestone .... lmst

Volcanic tuff .... vt

Mineral Occurrence .... ★

Abbreviations

- **Cu** - *native copper*
- **cha** - *chalcocite*
- **bo** - *bornite*
- **cpy** - *chalcopyrite*
- **U** - *anomalous radioactivity*

2009 Map area limit

2008 Map area limit

GEOLOGY OF THE STUDY AREA

The study area encompasses the southeastern part of the Seal Lake Group and includes rocks from most of its stratigraphic levels (Figure 3). Sedimentary rocks include quartzite, sandstone, conglomerate, slate, shale, siltstone, phyllite and minor chert and calcareous rocks. Volcanic rocks comprise subaerial, amygdaloidal, and porphyritic basalt flows with subordinate pillow basalt and volcaniclastic rocks. Ophitic-textured gabbro sills intrude the middle and upper formations of the group. Granitoid rocks of the North Pole Brook Intrusive Suite are exposed in the southern part of the map area.

UNIT DESCRIPTIONS

Unit 1 – North Pole Brook Intrusive Suite

Granodiorite of the North Pole Brook Intrusive Suite (Thomas, 1981) outcrops in the map area along the southern thrust contact with rocks of the Seal Lake Group and as an outlier to the south of Naskaupi Lake (Figure 3). The granodiorite is white- to pink-weathering, medium grained and contains about 10% hornblende ± biotite ± magnetite. K-feldspar megacrysts commonly make up 5 to 15% of the rock and range in length from 0.5 to 2 cm. Fine-grained, weak to moderately foliated, pink-weathering, thin, concordant veins and irregular-shaped, thicker granite intrusions are found within the granodiorite. Along the southern thrust contact, the granodiorite exhibits a strong to mylonitic fabric. The relationship of the outlier and rocks of the underlying Seal Lake Group was not examined in this survey; however, Fahrig (1959) mapped the contact as thrust-fault bounded.

SEAL LAKE GROUP

Unit 2 – Majoqua Lake Formation

The Majoqua Lake Formation includes relatively undeformed basal rocks on the northern limb and underlying the eastern hinge area of the regional syncline and is subdivided into two units, namely, sedimentary rocks (subunit 2a) and basalt flows (subunit 2b).

Subunit 2a – Sedimentary Rocks

Sedimentary rocks of the Majoqua Lake Formation predominantly consist of undeformed, white-, grey-, red- to pink-weathering, fine- to medium-grained quartzite, quartz sandstone and conglomerate. These rocks commonly exhibit well-developed planar and trough crossbedding, graded bedding and locally ripple marks.

Conglomerate, containing clasts ranging from 0.5 to 1.5 cm in diameter occurs as graded beds within sandstone and quartzite sequences in the northern map area (Plate 1). Conglomerate containing clasts up to 8 cm in diameter occur near the eastern contact of the Seal Lake Group with the Bruce River Group (Plate 2). The conglomerates in both areas contain subrounded to rounded, matrix-supported clasts and pebbles comprising variable proportions of quartz, K-feldspar, red slate, shale, sandstone and mafic and felsic volcanic rock fragments set in a medium-grained matrix composed of quartz, feldspar, magnetite and hematite. Fine-grained siltstone, slate and shale are subordinate rock types in the basal formation and occur as thin beds intercalated with quartz arenite and quartz sandstone. In the extreme northeast corner of the map area, a rare occurrence of a grey-weathering, fine- to medium-grained, 4-m-thick limestone unit exhibits a near horizontal bedding defined by alternating medium-grained, 'granular' beds and less resistant, fine-grained, partially weathered-out beds, ranging from 0.5 to 3 cm in thickness (Plate 3).

Plate 1. *Graded conglomerate and crossbedded sandstone beds. Subunit 2a, Majoqua Lake Formation, Spriggs Lake showing area. (UTM coordinates 583377E/6015702N)*

Subunit 2b – Basalt Flows

Basalts of the Majoqua Lake Formation (subunit 2b) are green-, red- to mauve-weathering, fine- to medium-grained, massive to weakly foliated, and vary from having a homogeneous, featureless appearance to porphyritic and amygdaloidal varieties and rare pillow basalt. Columnar jointing is present in several flow tops and is commonly outlined by a 2- to 5-cm-wide hematite alteration zone (Plate 4).

Plagioclase phenocrysts range from 0.5 cm to 2 cm in length and comprise 2 to 15% of the rock and are set in a fine-grained homogeneous groundmass (Plate 5). Olivine

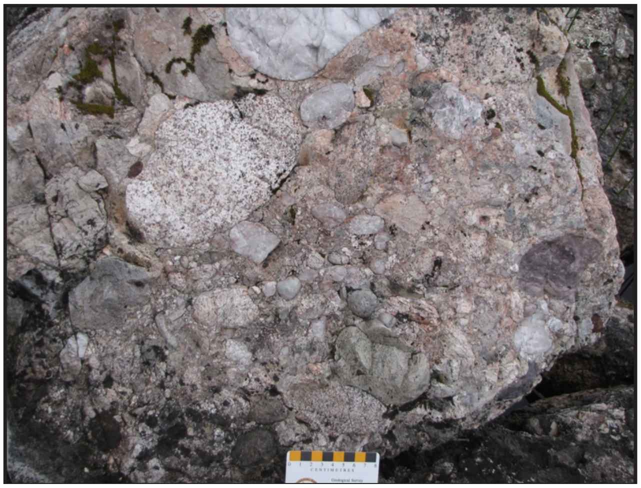

Plate 2. *Coarse-grained conglomerate, consisting of subrounded clasts and pebbles of quartz, slate, sandstone, shale and mafic and felsic volcanic rock fragments. Subunit 2a, Majoqua Lake Formation, northeast of Namaycush Lake. (UTM coordinates 610140E/6023787N)*

Plate 3. *Limestone consisting of alternating 'granular' beds and less resistant, partially weathered-out beds. Exposure is 4 m wide. Subunit 2a, Majoqua Lake Formation, north of Pocket Knife Lake. (UTM coordinates 611419E/6038514N)*

Plate 4. *Polygonal cooling joint pattern developed in homogeneous basalt flow top. Subunit 2b, Majoqua Lake Formation, west of Pocket Knife Lake. UTM coordinates 604826E/6023407N)*

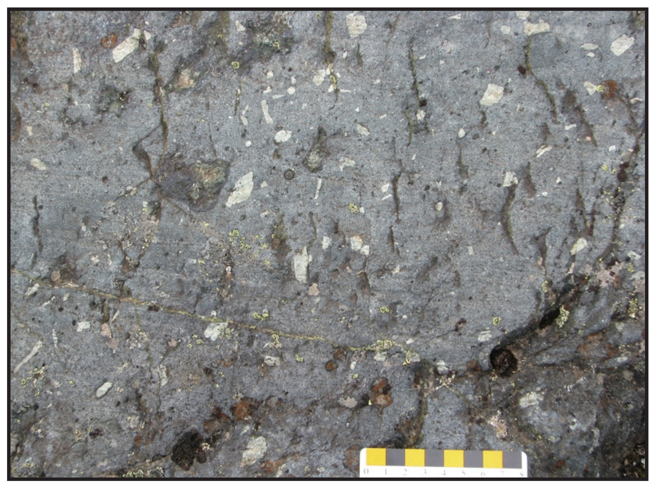

Plate 5. *Plagioclase porphyritic, fine-grained, basalt flow top. Subunit 2b, Majoqua Lake Formation, west of Pocket Knife Lake. (UTM coordinates 595097E/60341089N)*

phenocrysts are usually partially altered to rusty-weathering, anhedral grains, and are up to 0.5 cm in diameter.

The basalt groundmass is composed of fine-grained plagioclase, augite, olivine, magnetite and accessory ilmenite as primary phases. Plagioclase occurs as subhedral to euhedral laths ranging from less than 1 mm up 5 mm in length and comprises up to 70% of the rock. Augite constitutes up to 25% of the rock and forms subhedral to anhedral crystals ranging from <0.1 cm to 0.3 cm in length. Olivine is present as subhedral to anhedral grains. Magnetite is fine-grained and disseminated, and comprises up to 3% of the rock.

Minerals in the amygdules include, in order of abundance, epidote, chlorite, calcite, quartz, and rarely malachite and azurite. The amygdules range in diameter from <0.5 cm to 2 cm and, in some areas, comprise 5 to 15% of the rock.

Pillow basalts are uncommon in the Majoqua Lake Formation, and also in other parts of the Seal Lake Group. They are known from west of Belly Fish Lake, in the northern map area, where they form (a) 1- to 3-m-thick flow (or flows), and southwest of Pocket Knife Lake (Figure 3). At these localities, light green-weathering, subrounded structures, ranging from 20 to 70 cm in diameter, are loosely packed within a green-grey-weathering, fine-grained, massive basalt 'matrix'. A 0.5-cm-wide, diffuse hematite-oxidation alteration halo occurs along the margins of some of these features. The variable shapes and wide spacing of the features suggest that they may be pillow breccias (Plate 6).

In one exposure, in the northern part of the map area, the pillows are closely spaced, and have a near classic shape. These range from 10 to 30 cm in diameter and are separated by maroon-weathering, hematite-altered 'inter-pillow' material (Plate 7). These features appear to be undeformed, and the down-facing vertices of 'inter-pillow' material suggests that the flow is right-way-up and facing to the south-southwest.

The distribution of pillow breccia in the northern map area and the single exposure farther south indicate they are located near the top of the Majoqua Lake Formation (Figure 3). Despite the fact that pillow features were not observed in the area between the north and south pillow occurrences, they may in fact be a part of the same flow, based on their similarity and stratigraphic position.

Baragar (1981) reported a 5-m-thick pillow breccia–hyaloclasite basalt flow southwest of Snegamook Lake near the base of the Majoqua Lake Formation, northwest of the map area, and he suggested that the extrusion of pillows must have been short-lived, as only one flow seems to have developed these features. A similar interpretation can be applied to the extrusion of pillow basalts at the top of the Majoqua Lake Formation in the map area. On the basis of the apparent rarity of pillow basalts and oxidation of volcanic flows of the Seal Lake Group, Baragar (*op. cit.*) considered most of the volcanic rocks to be subaerial. The presence of pillow basalts observed at the base of the Majoqua Lake Formation and those mapped at the top of the formation in this survey suggests that intermittent marine conditions existed during the extrusion of basalt flows in the basal formation.

Most basalt flow contacts are poorly exposed and thus flow thicknesses are not easily determined. However, columnar jointing, amygdules and phenocrysts are generally associated with flow tops, and massive and homogenous basalt lacking these features are indicative of the base of individual flows. In the eastern and northern map areas, the flows are 5 to 25 m thick. Baragar (1981) reported individual flows thickness to be 2 to 35 m thick and average 12 m thick, to the north and west of Wuchusk Lake.

Unit 3 – Bessie Lake Formation

The Bessie Lake Formation includes, deformed basal rocks on the southern limb of the regional syncline, which are interpreted to be stratigraphically equivalent to the Majoqua Lake Formation on the north limb. These rocks

Plate 6. *Subrounded to elliptical-shaped pillow features in fine-grained basalt matrix. The wide spacing and shape of these features suggest the flow is a pillow breccia. Note the thin hematite-altered halo surrounding the pillow features. Subunit 2b, Majoqua Lake Formation, west of Namaycush Lake. (UTM coordinates 604823E/6023407N)*

Plate 7. *Closely spaced, elliptical-shaped pillow features in 3-m-thick basalt flow. Downward facing vertices of interpillow material suggest the flow top is to the top left of photograph (southwest). Subunit 2b, Majoqua Lake Formation, west of Belly Fish Lake. (UTM coordinates 597813E/6036514N)*

underlie the area southwest of Salmon Lake and south of Naskaupi Lake and are divided into two units, namely deformed sedimentary rocks (subunit 3a) and deformed basalt flows (subunit 3b)

Subunit 3a – Deformed Sedimentary Rocks

In the Dorothy Lake area, extensive units of white- to grey-weathering, recrystallized, quartz-sericite schist, semi-pelitic schist and quartzite occur within and north of the fault contact between the Seal Lake Group and granitoid rocks of the North Pole Brook Intrusive Suite (Figure 3). These rocks, are interpreted to be the deformed equivalents of quartzite, sandstone and subordinate siltstone and shale on the northern limb and eastern hinge area (Majoqua Lake Formation). The quartz–sericite schists are composed primarily of recrystallized quartz and minor K-feldspar, fine-grained muscovite, magnetite, hematite and chlorite and have a moderate to strongly developed schistose to mylonitic fabric (Plate 8). Crossbedding is locally preserved and is overturned at one outcrop (*see* Structure). Chlorite ± muscovite, semi-pelitic schist locally exhibit a pronounced banding defined by the presence of concordant quartz ± feldspar veins.

Subunit 3b – Deformed Basalt Flows

In contrast to basalts of the Majoqua Lake Formation, basalt flows of the Bessie Lake Formation (subunit 3b) are strongly foliated to locally banded and pervasively chloritized and epidotized. Primary igneous features are rarely preserved in these areas although diffuse, attenuated and strongly chloritized and hematized amygdule phases are present in some flow tops. More typically, the basalts are moderately to strongly foliated chlorite schists in which there are no recognizable original features. In the extreme southwest corner of the map area, basalt flows exhibit a pronounced banding defined by 0.5- to 1-cm-wide, concordant plagioclase-rich layers within a strongly foliated chlorite-rich matrix (Plate 9). The igneous mineralogy of the southern basalts is similar to that in the northern flows although primary phases are usually replaced by chlorite- and epidote-bearing assemblages (*see* Metamorphism).

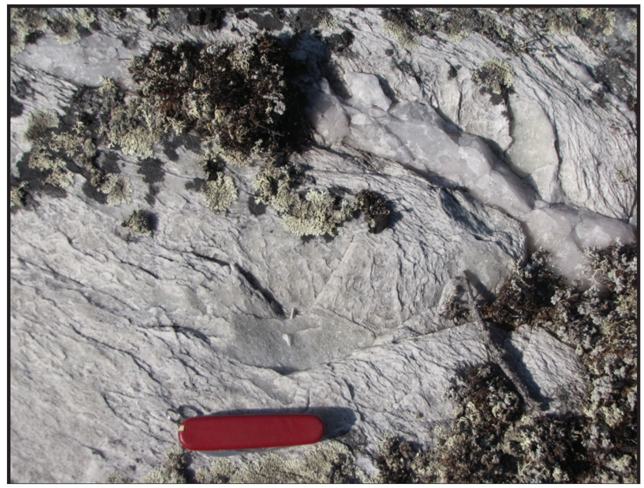

Plate 8. *Strongly foliated to mylonitic quartz-sericite schist and thin quartzite layer. Subunit 3a, Bessie Lake Formation, west of Dorothy Lake. (UTM coordinates 592610E/6007155N)*

Plate 9. *Pronounced leucocratic banding defined by concordant, plagioclase-rich layers in a chlorite-rich, schistose basalt flow. Subunit 3b, Bessie Lake Formation, southwest of Salmon Lake. (UTM coordinates 577270E/6012467N)*

Unit 4 – Wuchusk Lake Formation

The Wuchusk Lake Formation has been subdivided into three units. These are arenaceous sedimentary rocks (subunit 4a), black shale (subunit 4b) and gabbro sills and subordinate volcanic rocks (subunit 4c)

Subunit 4a – Arenaceous and Minor Argillaceous Sedimentary Rocks

Sedimentary rocks of the Wuchusk Lake Formation in the northern and eastern map areas, occur as 50- to 200-m-wide, east- to northeast-trending units of predominantly white-, red- to pink-weathering, fine- to medium-grained quartz sandstone and quartzite. Grey-, brown,- to black-weathering siltstone, slate and shale, are subordinate rock types in this unit and typically occur as cm- to m-scale intercalations with arenaceous sedimentary rocks. These units of sedimentary rocks are interleaved with extensive gabbro sills (Figure 3). East-trending zones of sedimentary rocks up to 2.5 km thick occur at the base of the Wuchusk Lake Formation, north of Wuchusk Lake. In many areas, the sedimentary rocks exhibit well-developed to diffuse bedding accentuated, in part, by thin hematite ± magnetite concentrations on bedding planes. Crossbedding and graded bedding are locally well developed within the quartz-rich units and generally indicate right-way-up attitudes.

South of Salmon Lake, sedimentary rocks in the Wuchusk Lake Formation form thin, southeast-trending units, some of which are deformed into southwest-plunging, km-scale folds (Figure 3). The rocks are quartz-rich, fine to medium grained, partially recrystallized and contain quartz and minor K-feldspar, plagioclase, muscovite, magnetite and chlorite. A diffuse, hematite-accentuated bedding is locally preserved in these rocks.

Subunit 4b – Black Shale

Shale is a subordinate sedimentary rock in the Wuchusk Lake Formation, however, several distinctive 50- to 75-m-thick shale sequences are intercalated with quartzite, basalt flows and thin gabbro sills located between Seal Lake and Wuchusk Lake (Figure 3). The shale varies from black-, brown-, to grey-weathering, and locally exhibits anomalous radioactive signatures (*see* Mineralization).

Subunit 4c – Gabbroic Sills and Subordinate Volcanic Rocks

Gabbroic rocks form sills in the Wuchusk Lake Formation and vary from fine to coarse grained, ophitic to equigranular, massive to foliated, and are predominantly melanocratic. Leucocratic phases are present as compositional gradations within individual outcrops. Ophitic to subophitic textures are prevalent and comprise subhedral to euhedral plagioclase laths wholly to partially enclosed in subhedral to anhedral augite crystals (Plate 10). Equigranular textures are developed locally within fine-grained sill margins. The mineralogy of the gabbro includes ubiquitous plagioclase, clinopyroxene and magnetite and commonly olivine, ilmenite and minor pyrite. Plagioclase occurs as subhedral to euhedral, variably saussuritized and locally zoned laths that range in length from 3 mm to 30 mm. Augite forms anhedral to subhedral, mauve crystals ranging from less than 1 mm to 3.5 mm in diameter. Olivine occurs primarily as rusty-weathering, anhedral, interstitial crystals, ranging from 1 mm to 5 mm in diameter, and as irregularly shaped aggregates up to several centimeters in diameter. Magnetite and ilmenite are common as disseminated crystals, comprising 1 to 5% of the rock, and as local, cm-scale aggregates.

North of Seal Lake and east of Naskaupi Lake, the gabbro is usually massive although a moderate to strong foliation is developed along the faulted contacts of some gabbro sills and sedimentary rocks. A weak fabric is observed locally in the interior of some sills.

South of Salmon Lake and in the Dorothy Lake area, the gabbro has a moderate to strong fabric and degree of alteration. These are more pervasive toward the southern margin of the Seal Lake Group gabbros, located within east-southeast-trending faults in this area. The gabbro exhibits a strong foliation defined by alignment of altered mafic mineral grains and aggregates, a preferred orientation of mafic-rich segregations and also discontinuous layers (Plate 11).

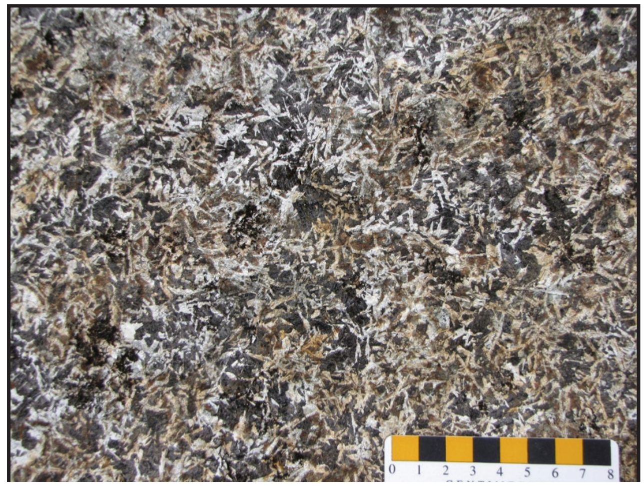

Plate 10. *Medium-grained, massive, ophitic-textured gabbro, typically of the gabbro sill interiors. Subunit 4c, Wuchusk Lake Formation, south of Wuchusk Lake. (UTM coordinates 583704E/6025373N)*

Plate 11. *Strongly foliated to banded gabbro. Banding defined by alignment of chloritized, mafic-rich layers. Note oxidized pyrite cubes. Subunit 4c, Wuchusk Lake Formation, southeast of Salmon Lake. (UTM coordinates 596002E/6009862N)*

Chloritization and epidotization are common (*see* Metamorphism).

Unequivocal intrusive relationships within the gabbroic rocks are rare. In three localities (Figure 3), 20- to 30-cm-wide dykes exhibit a thin, well-developed chilled margin against a medium-grained, massive gabbro. North of the eastern end of Seal Lake, a brown-weathering, fine-grained, massive, mafic dyke has intruded a medium-grained, massive gabbro and is locally dextrally offset (Plate 12). The other two dykes, located east of Naskaupi Lake, appear undeformed.

Plate 12. *Fine-grained mafic dyke intruding medium-grained gabbro. Dextral offset of dyke may be a boudinaged segment of the dyke or a result of shear along a zone of weakness in the host gabbro. Subunit 4c, Wuchusk Lake Formation, north of Seal Lake. (UTM coordinates 592203E/6023510N)*

Coarse-grained gabbro lenses, irregular patches and small veins within fine- and medium-grained gabbros are a common feature of this unit and the contacts between these different gabbro phases are usually gradational (Plate 13).

Volcanic rocks are a minor component of the Wuchusk Lake Formation and are thin, massive basalt flows, and rare tuffaceous rocks. Basalt is best exposed in the area between Wuchusk Lake and Seal Lake where it forms 5-to 15-m-thick, green-weathering, homogeneous and massive flows intercalated with quartzite, sandstone, shale and gabbro sills. Flow tops are locally amygdaloidal.

A distinctive volcanic unit in the Wuchusk Lake Formation is a plagioclase-porphyritic tuff that occurs as a poorly exposed, 10- to 25-m-wide layer adjacent to an east-trending shale unit, approximately 2 km north of the central part of Seal Lake (‘vt’ in Figure 3). The tuff is brown to rusty-weathering, fine grained, and varies from schistose to thinly banded. The tuff contains 5 to 10%, partially altered and locally zoned, grey-weathering plagioclase phenocrysts ranging from 0.5 to 1 cm in length, set in a fine-grained matrix (Plate 14). This rock is locally anomalously radioactive (*see* Mineralization).

Unit 5 – Whiskey Lake Formation

The Whiskey Lake Formation was originally defined by Evans (1952) and subsequently modified by Brummer and Mann (1961) and Gandhi and Brown (1975). Baragar (1981) included sedimentary rocks of the Whiskey Lake Formation in the Salmon Lake Formation. Rocks of the Whiskey Lake Formation are characterized by ubiquitous, mm- to cm-scale

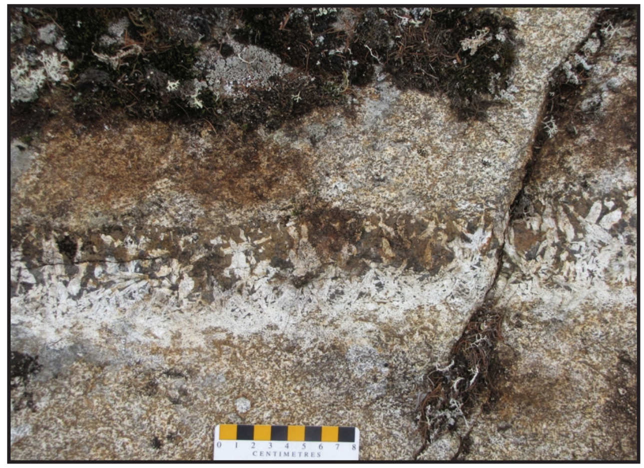

Plate 13. *Coarse-grained leucocratic gabbro vein within medium-grained gabbro. Subunit 4c, Wuchusk Lake Formation, east of Naskaupi Lake. (UTM coordinates 601742E/6016026N)*

Plate 14. *Porphyritic volcanic tuff containing altered and locally zoned, plagioclase phenocrysts ranging from 0.5 to 1 cm in size and comprising 10% of the rock. The tuff exhibits anomalous radioactive signatures up to 1050 counts per second. Subunit 4c, Wuchusk Lake Formation. (UTM coordinates 588400E/6023946N)*

laminae and thin beds of red-, green-, and grey-weathering slate, quartzite, quartz sandstone, siltstone and subordinate silty calcareous layers. Small-scale, crenulated F_1 folds are common (Plate 15) and locally F_2 folds are developed in the Whiskey Lake area (van Nostrand, 2009).

Unit 6 – Salmon Lake Formation

Unit 6 is subdivided into three units, namely, sedimentary rocks (subunit 6a), basalt flows (subunit 6b), and gabbro sills (subunit 6c).

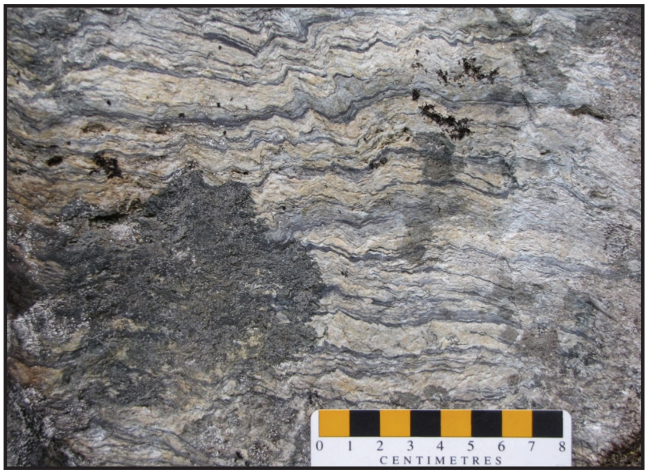

Plate 15. *Crenulated F_1 folds in thinly bedded to laminated siltstone, slate and sandstone. Unit 5, Whiskey Lake Formation, east of Whiskey Lake. (UTM coordinates 596646E/6016270N)*

Plate 16. *Steep-sided, 75-m-high ridge exposing intercalated red slate, sandstone, quartzite and basalt flows. Quartzite layer capping the sequence is about 8 m thick. Note open warping of intercalated layers. Subunits 6a and 6b, Salmon Lake Formation, north of Salmon Lake. (UTM coordinates 587500E/6013800N, approx.)*

Subunit 6a – Sedimentary Rocks

Sedimentary rocks (subunit 6a) in the Salmon Lake Formation are predominantly maroon- to mauve-weathering slates, interbedded with cm- to 10s of m-scale layers of quartz sandstone, siltstone and shale. In the Salmon Lake area, steep-sided, east-trending ridges, up to 75 m high, are composed of intercalated red slate, shale, sandstone, quartzite and dark-weathering basalt flows (Plate 16). These rocks are also exposed in the north-facing escarpments south of Seal Lake (van Nostrand, 2009). Maroon-weathering slate is the dominant sedimentary rock and forms thin-bedded to laminated sequences characterized by a transposition of a mm- to cm-scale bedding along a pervasive slaty cleavage. In many areas, the distinction between the mm-scale bedding and pervasive cleavage is not obvious in outcrop, although shallow-angle bedding–cleavage relationships are observed in some exposures and are locally enhanced by fine-grained quartz ± calcite seams.

The only occurrence of limestone in the Salmon Lake Formation, observed within the map area, is a 50- to 75-cm-wide stromatolite-bearing unit intercalated with a basalt flow and maroon-weathering slate on the east end of Cross Island (van Nostrand, 2009).

Subunit 6b – Basalt Flows

Basalt flows (subunit 6b) are the dominant rock type in the Salmon Lake Formation and are of two main varieties. On the southern shore of Seal Lake and on Cross Island, the basalts are red-, mauve-, to green-weathering, massive, and vary from having a homogeneous and non-descript appearance to possessing amygdaloidal and vesicular textures. The flows are undeformed and are weakly to moderately altered. The basalts are composed primarily of subhedral plagioclase laths ranging 1 to 5 mm in length. Brown- to mauve-weathering, subhedral to anhedral, clinopyroxene grains range up to 3 mm in length and comprise 10 to 15% of the rock. Olivine is typically anhedral and ranges from <1mm to 5 mm in diameter and comprises up 5 to 10% of the rock. Hematite is the dominant oxide phase and occurs as a fine dusting along grain boundaries and as a partial replacement after olivine and clinopyroxene.

To the south of Brandy Lake and in the Salmon Lake area, the basalts are predominantly green-weathering, have a pervasive, moderately foliated to strongly schistose fabric, and locally contain strongly altered and diffuse, green- to mauve-weathering amygdules. In most areas, original igneous features are totally eradicated.

Subunit 6c – Gabbro Sills

Gabbro sills (subunit 6c) in the Salmon Lake Formation were mapped during the 2008 field season, and are described by van Nostrand (2009). The sills are not as extensive as the sills in the Wuchusk Lake Formation, and generally exhibit a higher degree of alteration and finer grain size. The sills are 50 to 100 m thick, are east to northeast trending and a few can be traced for several kilometres along strike. Not all the Salmon Lake Formation gabbro sills are shown on Figure 3 as some are too thin to be accurately depicted. The gabbros are primarily ophitic-textured, fine- to medium-grained, massive, and consist of saussuritized plagioclase; clinopyroxene and olivine are partially to completely replaced by chlorite. Magnetite and lesser ilmenite are also present.

Unit 7 – Adeline Island Formation

The Adeline Island Formation (Unit 7) is the most intensely studied unit of the Seal Lake Group due to its potential for sediment-hosted copper sulphide mineralization (Gandhi and Brown, 1975; Gandhi, 1972). The Adeline Island Formation consists of interbedded sandstone, siltstone, slate, shale, phyllite, quartzite (subunit 7a, Figure 3) intercalated with minor basalt flows and thin gabbro sills (subunit 7b, Figure 3), in the core of the regional syncline (Figure 3). North of Salmon Lake, the rocks are exposed in low-lying valleys and stream beds but also within steep-sided, east-trending ridges, up to 50 m high.

Unit 8 – Upper Red Quartzite Formation

The main body of the Upper Red Quartzite Formation (Unit 8) underlies an elliptical area in the core of the regional syncline. A small outlier of quartzite is located northeast of Brandy Lake (Figure 3). The formation consists almost exclusively of homogeneous, fine- to medium-grained, well-sorted, pink- to red-weathering quartzite and quartz sandstone commonly exhibiting well-defined planar and trough crossbedding (Plate 17). *En-echelon* quartz veins in tension fractures are common.

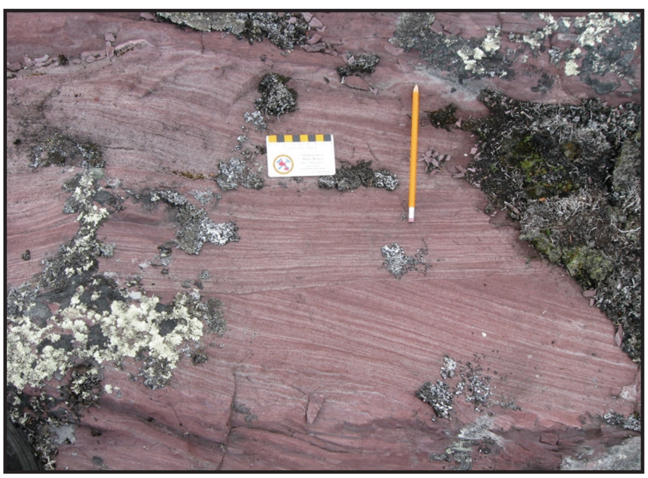

Plate 17. *Well-developed, planar crossbedding in quartzite. Unit 8, Upper Red Quartzite Formation, northwest of Salmon Lake. (UTM coordinates 584900E/6016036N)*

The contact of the Adeline Island Formation with the Upper Red Quartzite Formation appears to be conformable in the Salmon Lake area, although Gandhi and Brown (1975) indicate that, northeast of Brandy Lake, this contact is, in part, faulted.

STRUCTURE

The overall structure of the Seal Lake Group is dominated by a regional-scale, doubly plunging syncline having its axial trace situated south of, and parallel to, Seal Lake (Figure 3). Within the map area, the regional fabric is defined by a northeast-to southeast-trending, southeast- to southwest-dipping foliation, cleavage or banding. Fabrics are locally developed in rocks to the north and east of Seal Lake, as a weak foliation in gabbro and basalt flows, and as a diffuse cleavage in sedimentary rocks. A moderate to strong foliation is developed in areas adjacent to faults, in particular, along contacts of gabbro sills and thin sedimentary units.

A pervasive fabric is developed in most rocks to the south of Salmon Lake. South-plunging mineral lineations and slicken striae are developed within, and adjacent, to several faults and have a predominant southerly plunge direction. Minor folds are well-developed south of Salmon Lake and have a prevalent southwest plunge direction.

Kilometre-scale folds are interpreted on the basis of variable dipping fabrics, local bedding–cleavage relationships developed in slates and shales and locally in quartz-rich rocks. These folds can also be delineated, in part, using aerial photographs. These F_1 folds have been interpreted as 'drag' structures because they have similar plunge directions to the regional Seal Lake syncline structure (Brummer and Mann, 1961). Northwest of Salmon Lake, the eastern edge of the Upper Red Quartzite Formation is exposed in large-scale F_1 fold closures, in which the axes plunge moderately to the southwest (Plate 18).

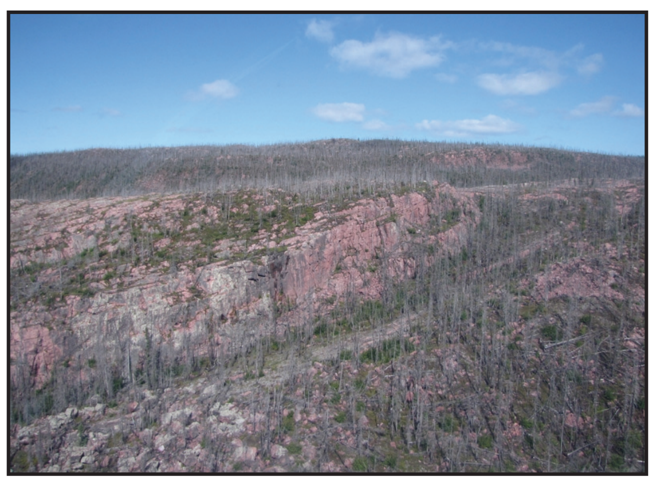

Plate 18. *Large-scale, F_1 fold on the eastern edge of the Upper Red Quartzite Formation. Fold axis plunges to the southwest. Area in photograph is approximately 250 m across. View looking north. Unit 8. (UTM coordinates 585100E/6015300N, approx.)*

In the Dorothy Lake area and south of Salmon Lake, the contact of strongly deformed granodiorite of the North Pole Brook Intrusive Suite and rocks of the Seal Lake Group, is defined as an east- to southeast-trending thrust-fault zone (Brummer and Mann, 1961; Thomas, 1981). Several similar-trending thrust faults are also present immediately north of the main thrust.

Asymmetric, S-shaped foliation trends, adjacent to quartz-rich schist and semi-pelitic layers, indicate a dominantly dextral sense of shear along some bedding surfaces (Plate 19). Granodiorite, immediately south of, and within, the thrust zone, exhibits a pervasive strongly foliated to mylonitic, recrystallized fabric. One example of asymmetric recrystallized 'tails' on rotated K-feldspar phenocrysts within a strongly foliated matrix indicates a dextral (top to the north) sense of rotation (Plate 20).

West of Dorothy Lake area, a small, flat-lying fold closure is kinked into a north-verging fold in a quartzite layer. In a separate exposure, weakly defined, downward-facing, trough crossbedding indicates these beds have been overturned. These structures, along with the development of southwest-plunging fold axes, south-plunging lineations and dextral kinematic features associated with the thrust contact, are consistent with the interpretation of north- to northwest-directed overthrusting along the southern margin of the Seal Lake Group.

Marten and Smyth (1975) and Thomas (1981) documented similar structural relationships along this contact, and Kontak (1978) reported comparable, early, flat-lying folds near Stormy Lake. Calon and Hibbs (1980), working along the contact of the Letitia Lake Group and conglomerates of the Bessie Lake Formation, interpreted an early stage of recumbent folding along the thrust contact, which they proposed pre-dates the regional Grenvillian deformation, which is evident in the Seal Lake Group rocks. Calon and Hibbs (*op. cit.*) proposed that the predominant regional easterly fabric in the Seal Lake Group is associated with upright folding of these earlier recumbent structures along the southern boundary of the Seal Lake Group.

The Pocket Knife Lake fault zone (DeGrace, 1969; Marten and Smyth, 1975; Ryan, 1984) is defined by predominantly north-striking normal faults, which delineate, in part, the eastern limit of the Seal Lake Group, with the exception of a synclinal outlier of Bessie Lake Formation rocks in the Stormy Lake area (Figure 2). The fault zone is part of a 100-km-long regional structure that extends southward from Snegamook Lake toward the interior of the Grenville Province (Wardle *et al.*, 1997). Marten and Smyth (1975) interpreted the structure as a rejuvenated crustal break, possibly a continuation of the Nain–Churchill boundary. DeGrace (1969) referred to the northwest-trending

Plate 19. *Deflection of foliation trend adjacent to contact of quartz-sericite schist and mafic-rich semi-pelitic schist. Asymmetry of the fabric suggests a dextral sense of shear along the contact. Subunit 3a, Bessie Lake Formation, southern margin of Seal Lake Group. (UTM coordinates 592610E/6007155N)*

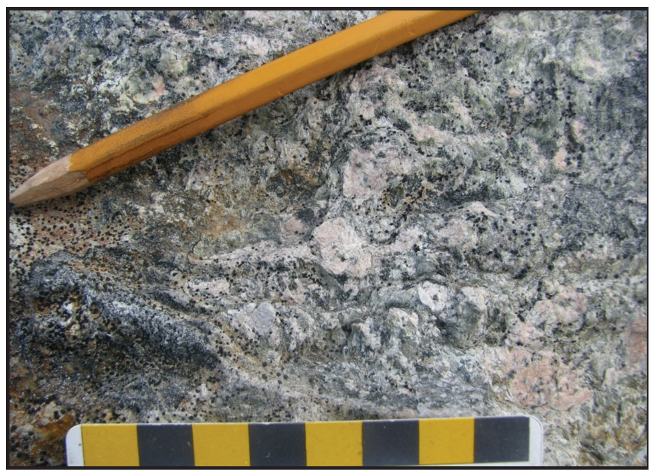

Plate 20. *Recrystallized 'tails' on K-feldspar megacryst in submylonitic hornblende granodiorite. Asymmetry of the tail suggests a dextral shear sense. Unit 1, North Pole Brook Intrusive Suite, southern margin of Seal Lake Group, west of Dorothy Lake. (UTM coordinates 589655E/6008502N)*

fault, which delineates the contact of Seal Lake Group and Bruce River Group rocks east of Namaycush Lake, as the Pocket Knife Lake fault (Figures 2 and 3).

Previous interpretations of the Pocket Knife Lake fault zone in the map area suggest that the faults have a predominantly normal sense of movement, in which Seal Lake Group rocks have been downdropped, relative to rocks of the Bruce River Group. A strike-slip movement is implied along some of these structures. DeGrace (1969) postulated that the development of the Pocket Knife Lake fault zone was contemporaneous with folding of the Seal Lake Group, and Ryan (1984) suggested that fault movement has been largely post-Seal Lake Group deposition.

Two faults, located immediately west and southwest of Namaycush Lake within the map area, are interpreted to be related to the Pocket Knife Lake fault zone. The point where the westernmost fault intersects the bay off East Seal Lake lies a vertical, 10-m-high cliff along the western side of a south-trending valley. The outcrop consists of green-weathering, strongly foliated to mylonitic basalt containing strongly attenuated epidote amygdules (Plate 21). A weak asymmetry of deformed amygdule 'tails' suggest a dextral movement along the fault, and corroborates the offset along the gabbro–basalt contact. Moderate to steep, south-plunging lineations imply a component of vertical movement along this fault. A dextral sense of movement is also interpreted along the fault which trends into Namaycush Lake, based on the offset of the gabbro–basalt contact. A moderate south-plunging lineation was measured along this fault.

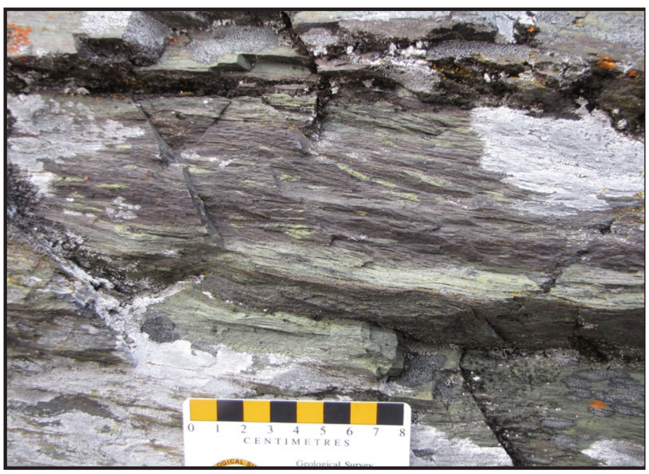

Plate 21. *Strongly attenuated and slightly asymmetrical epidote amygdules in mylonitic basalt flow in a north-trending fault zone. Asymmetry suggests a dextral shear sense. Subunit 2b, Majoqua Lake Formation, west of Namaycush Lake. (UTM coordinates 604760E/6020958N)*

The eastern margin of Seal Lake Group rocks, east of Namaycush Lake (Figure 3) has been defined as a faulted unconformity (DeGrace, 1969; Ryan, 1984). No evidence of faulting was observed during the present survey, due, in part, to very poor exposure in this area, however, undeformed conglomerate containing Bruce River Group felsic volcanic clasts was mapped along this contact in one locality.

The dextral offsets of rock units and the development of moderate to steep, south-plunging lineations along the north and northeast-trending faults observed in the eastern map area, are consistent, at least in part, with the interpretation of a normal downthrow movement and a dextral strike–slip component along some faults associated with the Pocket Knife Lake fault zone.

The timing of movement along these faults is unclear. Considering the premise that normal faults should be developed on the margins of the Seal Lake Group basin to accommodate the large thickness of supracrustal rocks, some of these structures could be related to basin development, and may have been reactivated during north-directed Grenvillian deformation

METAMORPHISM

Baragar (1981) indicated a south to north transition from greenschist facies to very low-grade metamorphic assemblages in igneous rocks of the eastern Seal Lake Group. He reported chlorite-bearing assemblages of pseudomorphed pyroxene and olivine in gabbro and basalt northeast of Brandy Lake, tremolite alteration in gabbro sills, immediately north of Seal Lake, and pumpellyite in basalt flows and sedimentary rocks, to the north of Wuchusk Lake. These assemblages indicate a progressive decrease in metamorphic grade to the north related to diminishing effects of Grenvillian thrusting along the southern margin of the Seal Lake Group. Field observations and preliminary petrographic analyses of gabbro sills, basalt flows and sedimentary rocks from the eastern Seal Lake map area undertaken during this survey are consistent with the findings of Baragar (*op. cit.*).

Figure 4 shows the general distribution of main metamorphic mineral assemblages observed in the eastern Seal Lake area, based on field evidence and preliminary petrography. Secondary mineral assemblages in gabbros and basalt flows, south of Seal Lake, consist of chlorite pseudomorphs of clinopyroxene and olivine. Epidote occurs as fine-grained aggregates along the rims of some clinopyroxene grains. Plagioclase is strongly saussuritized to fine-grained aggregates of epidote, clay minerals and sericite. Hematite is a near-ubiquitous alteration phase. These igneous mineral phases are partially replaced just south of Seal Lake in the Brandy Lake area and almost complete psuedomorphs of plagioclase, clinopyroxene and olivine have developed south of Salmon Lake. This is most evident in gabbroic rocks and to a lesser extent within the basalts. In the Dorothy Lake area, muscovite and minor chlorite have replaced fine-grained clay mineral phases in quartz-rich and semi-pelitic schists.

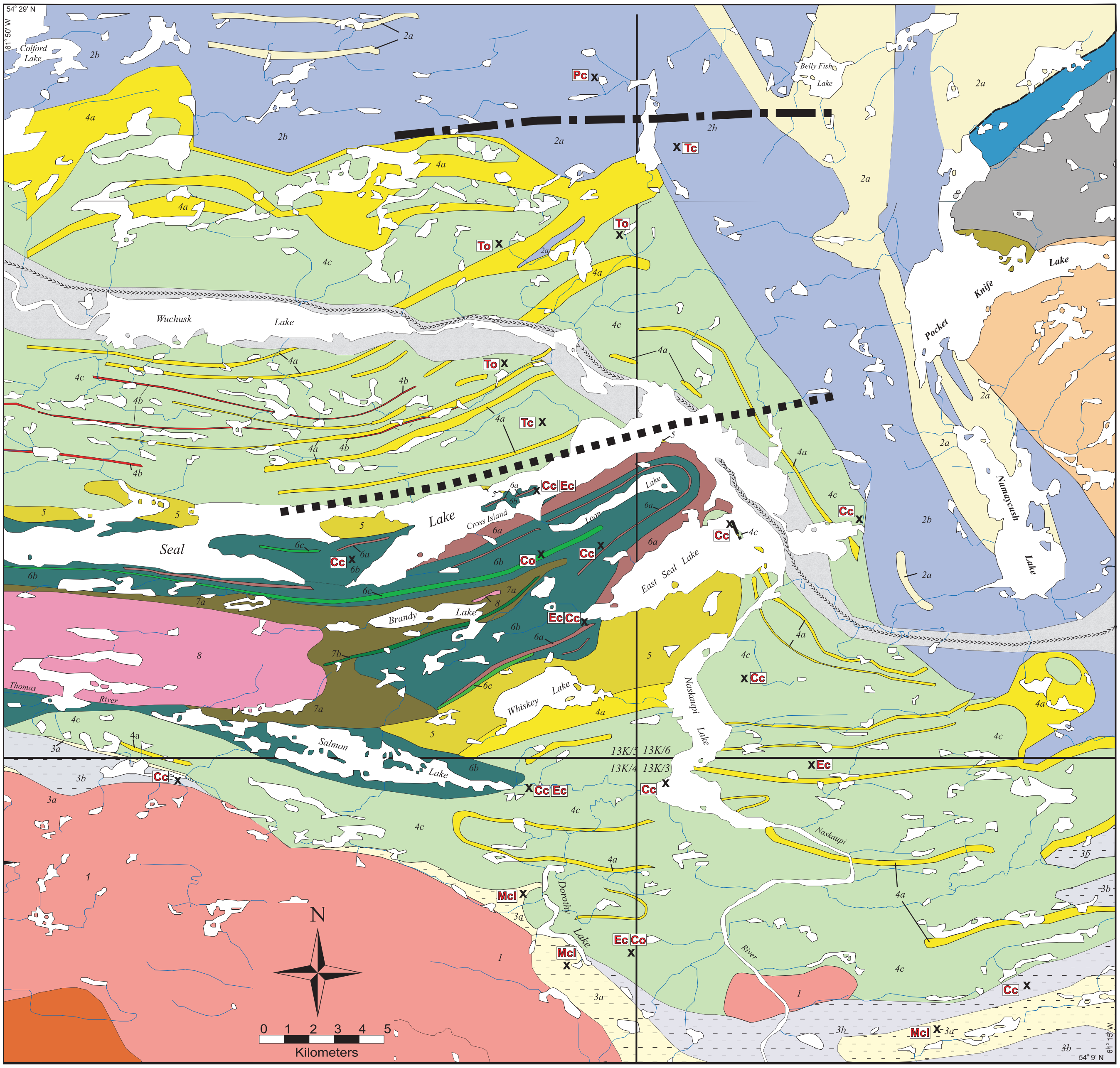

Figure 4. *Distribution of main metamorphic assemblages in the eastern Seal Lake area.*

North of Seal Lake, fine-grained tremolite occurs as partial rims surrounding clinopyroxene and olivine grains in gabbro sills of the Wuchusk Lake Formation. In the northern map area, colourless to light-green pumpellyite occurs as a partial replacement of relatively fresh augite and as partial rims around saussuritized plagioclase laths within basalt flows of the Majoqua Lake Formation.

Sedimentary rocks north of Wuchusk Lake exhibit very little evidence of alteration, apart from widespread hematite and local secondary calcite developed along mineral grain boundaries, and variable degrees of saussuritization of plagioclase and K-feldspar.

MINERALIZATION

COPPER MINERALIZATION

Copper mineralization in the Seal Lake area is present as two main types: i) chalcocite, native copper, bornite, chalcopyrite, malachite and azurite mineralization hosted primarily in discordant and concordant quartz ± calcite veins

LEGEND (Figure 4)

Glaciofluvial deposits

Mesoproterozoic

Seal Lake Group

Upper Red Quartzite Formation

8 Mature, red-weathering quartzite.

Adeline Island Formation

7b Fine-to medium-grained, ophitic-textured gabbro sills.

7a Interbedded quartzite, sillstone, minor slate and mafic volcanic flows.

Salmon Lake Formation

6c Fine-to coarse-grained, ophitic-textured gabbro sills.

6b Weakly to strongly foliated mafic volcanic flows and sills with minor intercalated sedimentary rocks.

6a Argillaceous sedimentary rocks. Predominantly red slates, shales and siltstones containing thin arenaceous interbeds and rare limestone and stromatolites.

Whiskey Lake Formation

5 Interbedded siltstone and sandstone, containing minor slate, shale and rare chert.

Wuchusk Lake Formation

4c Fine-to coarse-grained, ophitic- to intergranular-textured gabbro. Contains subordinate basalt flows and volcaniclastic rocks.

4b Fine-grained black shale. Records anomalous radioactive signatures.

4a Arenaceous sedimentary rocks. Predominantly quartz-rich sandstones and siltstones with subordinate argillaceous and calcareous sediments.

Bessie Lake Formation (deformed equivalent of Majoqua Lake Formation)

3b Strongly foliated to locally banded basalt flows gradational to mafic schists exhibiting a pervasive chlorite + epidote alteration.

3a Strongly foliated and recrystallized sandstone, siltstone, quartzite and conglomerate gradational to sericite- and muscovite-bearing schist.

Majoqua Lake Formation

2b Amygdaloidal and porphyritic-textured basalt flows with subordinate pillow basalt.

2a Undeformed to weakly deformed sandstone, siltstone, quartzite, conglomerate and minor limestone.

Paleoproterozoic

1 Granitoid rocks (Trans-Labrador Batholith). Within the map area this unit is a moderate to strongly deformed granodiorite intruded by granite veins.

Rocks outside the map area

Gabbroic and metagabbroic rocks

Metasedimentary gneiss

Bruce River Group (felsic volcanic rocks)

Moran Lake Group (sedimentary rocks)

Archean

Quartzofeldspathic gneiss

Legend

Geological contact (approximate) .... ———

Esker .... >>>>>>

Metamorphic minerals

Muscovite replacing fine-grained clay minerals .... Mcl

Chlorite pseudomorphs after olivine .... Co

Chlorite pseudomorphs after clinopyroxene Cc

Epidote replacing clinopyroxene .... Ec

Tremolite psuedomorphs after olivine in gabbro .... To

Tremolite psuedomorphs after clinopyroxene in basalt .... Tc

Pumpellyite partially replacing clinopyroxene in basalt .... Pc

Northern limit of chlorite occurrences .... ■ ■ ■ ■ ■ ■ ■

Northern limit of tremolite occurrenc .... ▬ ■ ▬

localized along the margins of basalt flows, slates and gabbro sills, typical of the Salmon Lake Formation, and ii) chalcocite, bornite and Cu-carbonate staining present along bedding, cleavage and fracture surfaces in slates, phyllites and basalt flows of the Adeline Island Formation. Most of these occurrences in the map area are previously reported copper indications and showings (as recorded in the Geological Survey's Mineral Occurrence Database System) and are typically of limited aerial extent. For descriptions of the more significant showings and prospects in the eastern Seal Lake area, refer to Wilton (1996) and van Nostrand (2009).

New copper occurrences include chalcocite and malachite hosted in discordant quartz ± calcite veins within basalt in three localities northeast of Whiskey Lake (Figure 3). The chalcocite occurs as small aggregates, up to 3 cm long, of irregular-shaped grains and flakes and as fine-grained, disseminated grain dustings along vein margins (Plate 22). Exposure is very poor in this area and these occurrences could not be traced beyond individual outcrops. The occurrences are proximal to maroon slate layers of the Salmon Lake Formation. It is noteworthy that native copper and chalcocite, hosted in quartz ± calcite veins cutting basalt flows, occur 750 m north of this locality (MODS Occurrence 013K/05/Cu 020).

Newly discovered trace chalcopyrite is associated with strongly altered, rusty-weathering schists and cm-scale gossan zones in gabbros south of Salmon Lake. Minor (1 to 2%) disseminated, fine-grained pyrite and isolated pyrite cubes are common in gabbro sills and also occur locally in sedimentary rocks and basalt flows. Magnetite and ilmenite are common accessory phases in gabbroic rocks and in some exposures comprise up to 10% of the rock, forming local, mafic-rich layers and lenses.

Minor pyrite is also present within rocks of the Majoqua Lake, Bessie Lake and Whiskey Lake formations. No sulphide occurrences are known from the Upper Red Quartzite Formation.

ANOMALOUS RADIOACTIVITY

Most outcrop surfaces were analyzed using a portable, hand-held GR-110 or RS-120 scintillometer. Gabbroic rocks yielded the lowest range of readings ranging from 30 to 60 counts per second (cps). Basalt flows ranged from 50 to 90 cps. Fine-grained siltstones, slates, and shales typically yielded 150 to 250 cps. Quartzites and quartz-rich sandstones recorded 100 to 200 cps.

Anomalous readings were recorded from brown- to black-weathering, fine-grained, east-trending shale sequences located midway between Seal Lake and Wuchusk

Plate 22. *Chalcocite and malachite hosted in discordant veins cutting foliated basalt flow. Chalcocite occurs as aggregates up to 3 cm across, and as fine-grained 'dustings' along quartz veins margins. Subunit 6b, Salmon Lake Formation, northeast of Whiskey Lake. (UTM coordinates 596227E/6016500N)*

Lake (subunit 4b, Figure 3). The units vary from 50 to 75 wide, and some are at least 15 km long. Some parts of shale units yielded consistent readings of 400 to 800 cps and several spot readings of 1500 cps. Several 1500 to 2000 cps readings were obtained along the base of two vertical, 3- to 4-m-high cliff faces approximately 50 m apart and a maximum reading of 3100 cps was recorded from one locality (Plate 23). In these two exposures, shallow, hand-dug pits were excavated adjacent to the cliff faces and the scintillometer readings increase downward beneath the overburden to a depth of at least 75 cm, suggesting higher values could be present at depth.

Adjacent to one of these black shale units, is a poorly exposed, brown-weathering, fine-grained, plagioclase porphyritic tuff. The tuff yielded spot readings up to 1050 cps, and are highest where small lenses of black shale are present. These lenses appear to be the same shale unit as described above. The western extent of the shale and volcanic tuff units is unmapped. However, they are delineated, in part, by topographic lows, suggesting these units extend farther to the west. The relatively consistent anomalous signatures of 400 to 800 cps and spot readings of 1000 to 3100 cps along strike provide distinct, prospective units for further exploration.

These units were not observed on the southern limb or in the eastern hinge area of the regional syncline structure. Considering the likelihood that equivalent rocks in these areas would be strongly deformed schists, they may not be recognizable as the same unit except by the presence of an

Plate 23. *Fine-grained, black- to brown-weathering shale that exhibits anomalous radioactivity of up to 3100 counts per second. This exposure is part of a 50-m-wide, east-trending shale layer. Subunit 4b, Wuchusk Lake Formation, mid-way between Seal Lake and Wuchusk Lake. (UTM coordinates 582785E/6024836N)*

elevated radioactive signature. These rocks may, in fact, be absent on the southern limb due to thrusting and folding south of Salmon Lake.

The Sprigg's Lake U showing is located on the northern map area boundary (Figure 3; MODS Occurrence 013K/05/Cu194). At this locality, conglomerate, sandstone and quartzite beds are intercalated with fine-grained basalt flows of the Majoqua Lake Formation. Spriggs (1969) and Baragar (1969) noted that elevated uranium signatures are associated with a single conglomerate bed in this area and analyses ranging from 0.015 to 0.006 percent U_3O_8 were obtained (Baragar, 1969). Cursory examination of the Sprigg's lake showing area during the present survey recorded elevated scintillometer readings ranging from 400 to 1050 counts per second along approximately a 50 m strike length of a conglomerate bed adjacent to thin quartzite layers. These readings were not consistent within the bed and the elevated signatures were typically recorded from areas containing coarse-grained clasts. No anomalous radioactivity was noted in the quartzite beds. Readings up to 1200 cps were recorded from conglomerate beds interbedded with sandstone located approximately 1.5 km southwest of the Sprigg's Lake showing.

The only other evidence of anomalous radioactivity in the map area is a slightly elevated reading of 350 cps recorded along joint surfaces in a fine-grained siltstone west of Namaycush Lake (Figure 3). This is an isolated reading in the unit and appears to be limited to a small area in the outcrop containing extensive fractures.

ACKNOWLEDGMENTS

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