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GEOLOGY OF THE NORTHERN PORTION OF THE SILVER MOUNTAIN MAP AREA (NTS 12H/11), SOUTHERN LONG RANGE INLIER, NEWFOUNDLAND

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ABSTRACT

In the northern Silver Mountain area (NTS map area 12H/11), 1:50 000-scale mapping has further defined the lithological units that occur within southern Long Range Mountains. The area contains one of the largest exposures of basement rock within the Appalachian Orogen, namely the Long Range Inlier. Regional bedrock mapping focused on characterizing the metamorphic units of the Long Range gneiss complex that contain several phases of orthogneiss, and rare, thin screens of paragneiss. The Long Range gneiss complex was intruded by two periods of Grenvillian felsic magmatism, and also by the aerially extensive, polyphase, Silurian laccolithic intrusion, the Taylor Brook gabbro. A latest Neoproterozoic to Paleozoic marble- dominated sequence is preserved along the flanks of the Taylor Brook gabbro, and likely represents an early Appalachian (Taconic?) thrust sequence that was emplaced onto the Long Range Inlier. The Taylor Brook gabbro utilized this structure during emplacement via multiple magmatic pulses. This relationship explains the peculiar occurrence of the marble-dominated sequence exclusively along the margins of the intrusion. Mineralization in the map area consists of gold showings within deformed quartz veins that are found, most commonly along the eastern margin of the inlier. In addition, disseminated sulphides containing minor nickel and copper mineralization are known to be associated with the Taylor Brook gabbro.

INTRODUCTION

The 2009 field season marked the first year of a multi-year, 1:50 000-scale, bedrock-mapping project that has the goal of mapping and re-interpreting the geology of the southeastern portion of the Long Range Inlier of western Newfoundland. The output from this project will be a detailed, comprehensive, GIS-integrated geological map and associated database, which will be a valuable asset and tool for mineral exploration and land-use planning. The 2009 field season covered the northern portion of the Silver Mountain area (NTS map area 12H/11; *see* Figure 1).

The Long Range Mountains of western Newfoundland contains one of the largest exposures of Proterozoic crystalline basement rocks within the Appalachian Orogen (Heaman *et al.*, 2002) and is known as the Long Range Inlier (Figures 1 and 2). It is not a simple stratigraphic inlier, but rather represents a massif that was reactivated during the Appalachian Orogeny (Owen, 1991a). The approximately 8500 km^2 of basement rocks comprise the largest portion of the external Humber Zone, considered to be the foreland belt of the Appalachian Orogen (Erdmer and Williams, 1995). The Long Range Inlier forms a structural culmination that is bounded to the north, south and locally to the east, by Proterozoic to Paleozoic cover rocks (Figure 1). The western boundary is marked by a southeast-dipping thrust fault (the Long Range frontal thrust) that placed Proterozoic crystalline rocks onto autochthonous Cambro-Ordovician platformal strata and Taconic allochthonous rocks (Owen, 1991a; Heaman *et al.*, 2002). Paleozoic deformation of the inlier is marked by low-grade metamorphism and tectonic overprinting along the Doucers Valley fault system and emplacement of post-deformational intrusions, *e.g.*, Devils Room granite and Taylor Brook gabbro (Figure 2).

PREVIOUS WORK

The current knowledge and understanding of the geology of the Long Range Inlier have resulted from several systematic regional-scale bedrock mapping and related studies of the area (*e.g.*, Bostock *et al.*, 1983; Erdmer 1984, 1986a, b; Owen 1986a, b, 1987, 1991a; Owen and Greenough, 1995; *see* Figure 2). Heaman *et al.* (2002) published the only U–Pb geochronology of the region. More detailed studies of the Silver Mountain area have focused on the economic potential of the Taylor Brook gabbro (Collins, 2007) and on uplift-cooling rates of the inlier (Hendricks *et al.*, 1993).

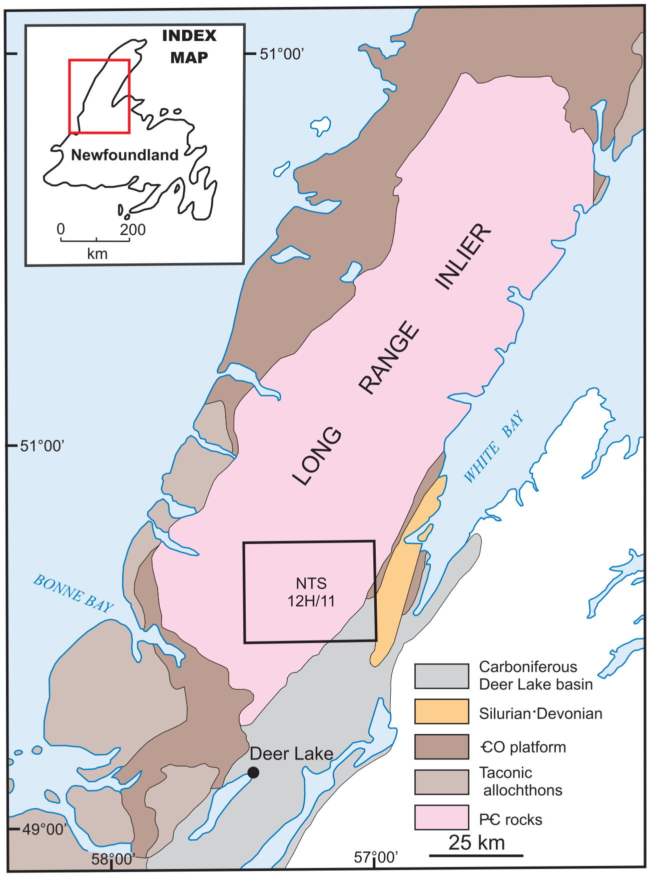


Figure 1. *Schematic diagram of the geology of the Northern Peninsula, showing the main tectonic elements of the Humber Zone. Modified after Owen (1991a). Outline shows the location of the Silver Mountain map area (NTS 12H/11).*

The major findings of the relevant studies are summarized below along with the results of the 2009 mapping.

GEOLOGY OF PARTS OF THE SILVER MOUTAIN MAP AREA

The lithological units mapped during the 2009 field season are described below and are shown on Figure 3. The area is composed largely of amphibolite to granulite orthogneiss with minor paragneiss. The geology of the northern part of the Silver Mountain map area is broadly divisible into the following tectonic divisions:

- High-grade Long Range gneiss complex
- Weakly to strongly foliated plutonic rocks; interpreted to be Grenvillian in age
- Mafic dykes (Long Range dyke swarm)
- Thin remnants of latest Neoproterozoic to Paleozoic cover sequences; and
- Early Silurian gabbroic intrusions and minor felsic dykes, sills and porphyries

LONG RANGE GNEISS COMPLEX

Moderately foliated to gneissic rocks of the Long Range gneiss complex underlie approximately 60% of the map area (Figure 3). The area is dominated by orthogneiss containing locally preserved thin screens of paragneiss and rarely migmatitic phases. All of the units have been metamorphosed at upper-amphibolite to granulite-facies conditions and preserve a complex deformational history. Within the Long Range gneiss complex, the trends of the primary (S_m) foliations define an overall north to northwest orientation (Figure 3).

Paragneiss (Units 1 and 2)

There are two mappable units of paragneiss in the area. Unit 1 is a fine- to medium-grained, recrystallized, interlayered quartzite and quartz-rich paragneiss. This unit is characterized as a grey, medium-grained quartzite having biotite + sillimanite ± magnetite-bearing metapelitic layers that are typically 50 cm wide (Owen, 1986b). This unit is typically preserved as thin (approximately 200 m in width) lenses within Unit 9 (Figure 3). The location of this unit is based on mapping of the unit by Owen (1986b).

Unit 2 is a 500-m-wide lens of rusty-weathering, garnet–biotite ± sillimanite ± muscovite semi-pelitic to pelitic gneiss interlayered with psammitic gneiss (Plate 1) and is only exposed in the north-central part of the map area. The semi-pelitic to pelitic phase locally contains cordierite. Garnet is 1 to 3 mm in diameter and confined to more biotite-rich layers. Compositional layers are 3 to 5 cm thick. The unit has been intruded by syntectonic granitic veins, and is in-folded with Unit 9 (*see* below).

Migmatite (Unit 3)

Although migmatite was only observed as a mappable unit in the western part, some of the basement orthogneiss described below locally preserves migmatitic textures. Unit 3, however, is a metatexite containing 15 to 20% leucosome (Plate 2) and is isoclinally folded. The mesosome is a medium-grained, grey-brown orthopyroxene–biotite psammite. The outcrop is cut by syn- to posttectonic, 2- to 4-cm-wide, potassium-feldspar-porphyritic granite pegmatite veins containing blue-grey quartz eyes typical of granulite-facies rocks.

Orthogneiss

Mafic Gneiss (Units 4 and 5)

Mafic gneiss in the Long Range gneiss complex has been divided into two distinct units. Unit 4 comprises dark

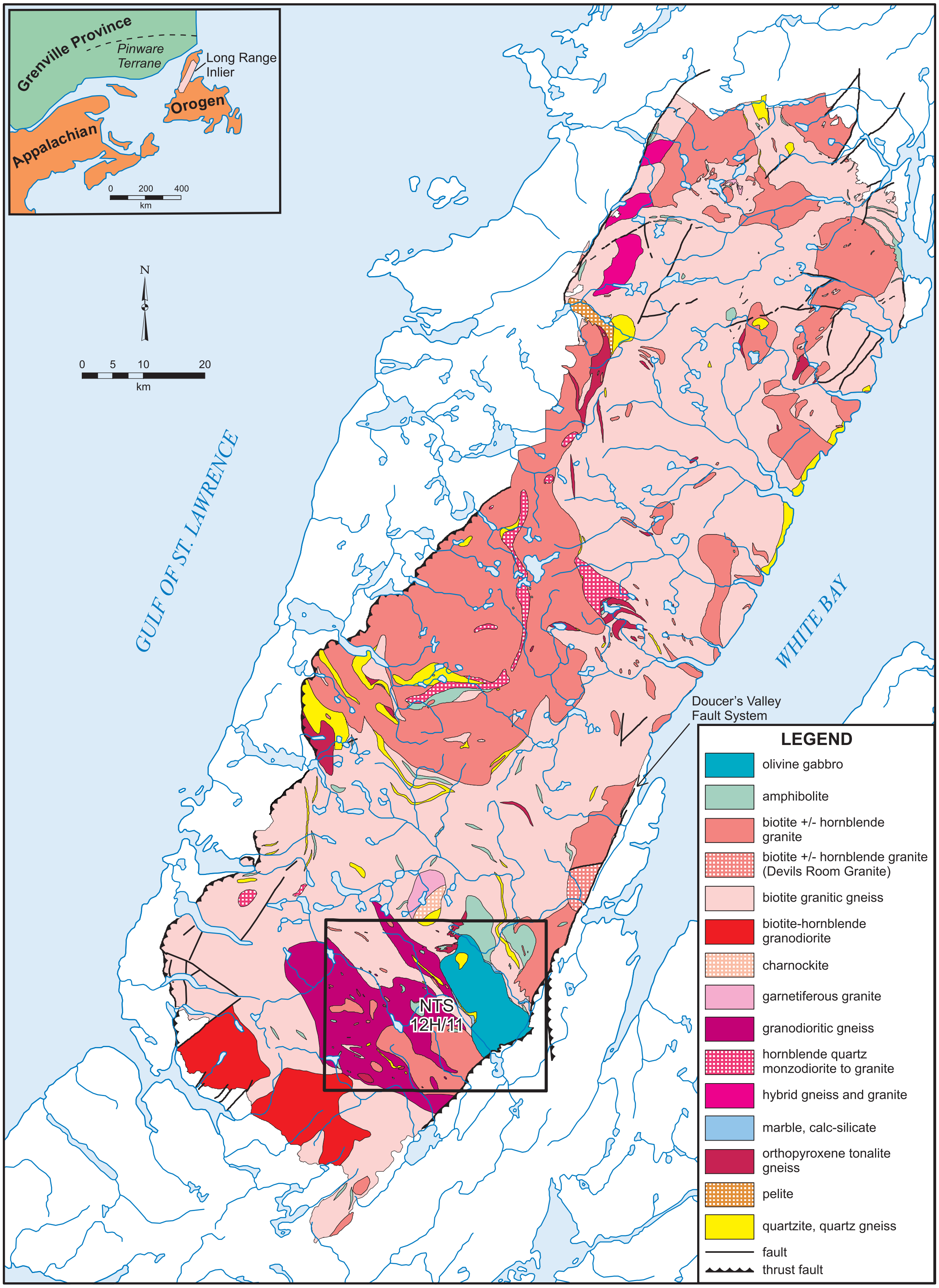


Figure 2. *Simplified geology of the Long Range Inlier, Newfoundland, showing the main components. The location of the inlier relative to the Grenville Province in Eastern Labrador is illustrated in the inset map. Modified from Owen (1991a).*

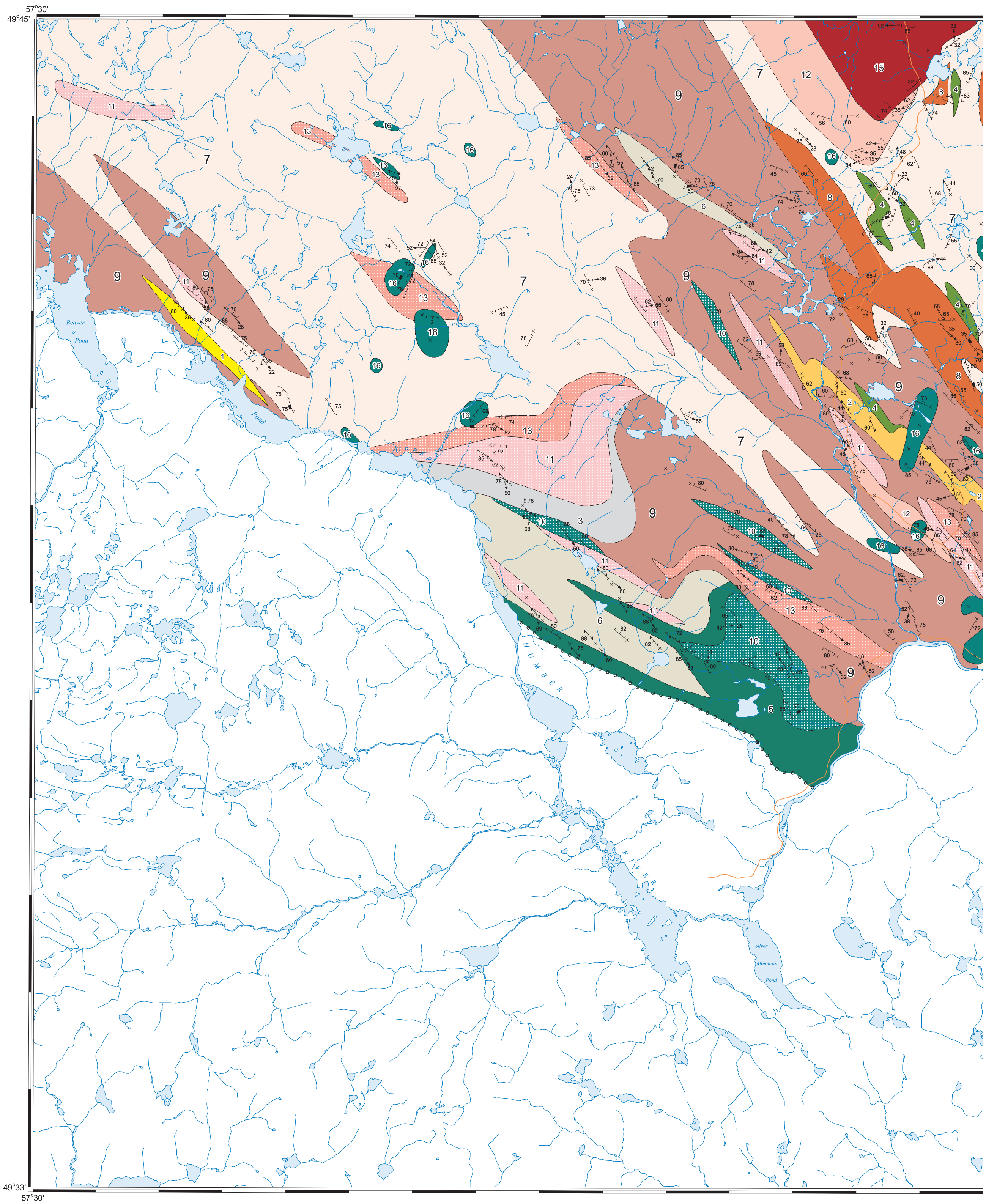

57°30'
49°45'
Beaver Pond
Mattis Pond
HUMBER
RIVER
Silver Mountain Pond
49°33'
57°30'

Figure 3. *Preliminary geological map of the northern part of the Silver Mountain area (NTS map area 12H/11).*

LEGEND (for Figure 3)

EARLY SILURIAN

24 Quartz–feldspar–porphyry dykes that are fine grained, pink, with an aphanitic groundmass and contain euhedral, 1- to 4-mm-long quartz and feldspar phenocrysts.

23 Leucocratic biotite monzogranite that is medium grained, contains pegmatite patches and 2- to 3-cm-wide chilled margins.

Taylor's Brook gabbro (430.5 ± 2.5 Ma; Heamen *et al.,* 2002)

22 Pegmatitic gabbro to melanogabbro that is intruded by fine-grained grey gabbro and clinopyroxenite, possibly related to Unit 20. It is coarse grained to pegmatitic and contains pyroxene crystals up to 15 cm long. This phase locally contains minor pyrite and chalcopyrite. It is cut by large dykes and sills of leucocratic biotite monzogranite (Unit 23) and dykes of fine-grained, quartz–feldspar porphyry (Unit 24).

21 Gabbronorite to norite, coarse grained; locally contains olivine, which preserves a cumulate texture, commonly contains plagioclase-rich patches. Disseminated magnetite and sulphides occur locally. This unit is cut by finer-grained dykes of co-magmatic gabbro and leucogabbro.

20 Heterogeneous, mesocratic gabbro with minor leucogabbro, melanogabbro, and norite that is typically medium to coarse grained, and preserves igneous layering and textural evidence for repetitive magma mixing. Minor occurrences of disseminated sulphides, primarily pyrite and chalcopyrite, and magnetite are scattered throughout this unit.

LATE NEOPROTEROZOIC TO ORDOVICIAN

19 Thinly layered semi-pelitic gneiss and quartzite. The semi-pelitic layers contain garnet, muscovite, biotite and locally sillimanite. Garnet is typically 1 to 3 mm in diameter and sillimanite needles are 1 to 5 mm long. In the quartz-rich layers, garnet is mantled by biotite.

18 Brown weathering marble displaying grey-white banding, and contains minor accessory minerals. Locally, some 2- to 10-cm-wide beds contain diopside, garnet and biotite, and other beds contain 0.5- to 2-cm-wide, brown, fine-grained, micaceous, quartz-rich concretions that are interpreted to represent metamorphosed clasts of mudstone and sandstone.

17 Dark grey-brown, phyllite (pelitic schist) that is recrystallized, cleaved and locally preserves a mylonitic fabric. It is intruded by late, possibly Silurian, granite dykes.

LATE MESOPROTEROZOIC TO NEOPROTEROZOIC

16 Hornblende metagabbro that is massive to weakly foliated and typically preserves a subophitic texture. Plagioclase and locally biotite form euhedral crystals.

GRENVILLIAN PLUTONIC ROCKS (~1056 – 970 Ma)

Potato Hill Pluton (~999 Ma ± 4 Ma; Heamen *et al.,* 2002)

15 Coronitic orthopyroxene metagranite (charnockite) that preserves granulite-facies metamorphic mineral assemblages. The margins of the pluton are strongly foliated with the foliation decreasing in intensity towards the interior of the pluton. It is cut by undeformed, cm-scaled granite veins.

Main River Pluton

14 Biotite ± hornblende monzogranite to quartz monzonite that is pink, feldpar megacrystic, lineated and foliated. The feldspars form augen within the fabric and are typically 1 to 3 cm long. The unit typically shows an S>L tectonic fabric. There are locally finer-grained layers and dykes that are likely genetically related to the intrusion. The unit is cut by quartz veins, some of which host gold mineralization.

Unnamed Intrusions

13 Biotite ± hornblende, potassium-feldspar augen metamonzogranite and lesser metaquartz monzonite that are weakly to strongly foliated, strongly lineated and typically preserving an L>S fabric. Potassium-feldspar augen are typically 0.5 to 1 cm wide and 1- to 2.5 cm long. Quartz crystals are commonly blue-grey. This unit is correlated with Unit uPgd-k of Owen (1986b).

12 Biotite metamonzogranite that is fine to medium grained, moderately foliated, recrystallized and displays a granoblastic texture. Numerous, 1- to 2-cm-wide quartz cut this unit.

11 Biotite ± hornblende metaquartz monzonite to metamonzogranite that is medium to coarse grained, moderately foliated, moderately lineated, recrystallized and locally contains 1- to 2-cm-long augen of plagioclase and/or potassium feldspar. This unit is locally cut by 1- to 2-cm-wide quartz veins that contain disseminated sulfides. This unit is correlated with Unit uPgr of Owen (1986b).

10 Biotite-hornblende metagabbro containing minor phases of hornblende-bearing, plagioclase-porphyritic metamonzodiorite that is medium to locally coarse grained, moderately to strongly foliated and lineated although relict igneous textures are locally preserved.

LATE PALEOPROTEROZOIC TO EARLY MESOPROTERZOIC

LONG RANGE GNEISS COMPLEX

Orthogneiss

9 Biotite hornblende ± orthopyroxene metagranodiorite to metadiorite that is strongly foliated to locally gneissic, typically medium grained and preserves 1- to 2-cm-wide mafic clots (hornblende ± biotite + magnetite) that give the unit an overall speckled appearance. Cut by foliation-parallel granite veins, locally with diffuse boundaries and containing 10 to 15% blue-grey quartz. The unit is cut by diabase dykes, quartz veins and late brittle faults. This unit corresponds to Unit uPnd of Owen (1986b).

8 Orthopyroxene–biotite metatonalite to metagranodiorite that is typically moderately to strongly foliate, medium grained, recrystallized and preserves granulite-facies mineral assemblages. It is locally hetergeneous containing layers enriched in mafic minerals and local amphibolite boudins. This unit corresponds to Unit uPnt of Owen (1986b)

7 Biotite ± hornblende ± orthopyroxene monzogranitic to granodioritic gneiss that is medium grained and moderately foliated to locally gneissic. It is cut by 2- to 5-cm-wide, coarse-grained granite veins that contain blue-grey quartz crystals and form approximately 10% of the rock. It also contains rare amphibolite boudins. Corresponds to Unit uPng of Owen (1986b).

6 Biotite ± hornblende ± orthopyroxene monzogranite to quartz monzonite gneiss that is pink to grey and contains compositional layers that range from 2 to 4 cm in thickness and are locally enriched in magmeitie. Amphibolite layers are locally preserved. The unit is cut by foliation-parallel, as well as crosscutting granite pegmatite veins that are 2 to 5 cm thick and contain blue-grey quartz crystals. Rare 1- to 2-cm-wide quartz veins were also found.

5 Moderately foliated to locally gneissic metadiorite to metaquartz diorite that contain biotite, hornblende and pyroxene; leucocratic patches are enriched in plagioclase and quartz. The unit also contains minor metre-wide amphibolite screens and is locally cut by millimetre-scale quartz veins.

4 Dark green, foliated and lineated, medium-grained amphibolite that locally contains plagioclase-rich layers parallel to the foliation. The unit also includes minor foliated metadiorite.

Migmatites

3 Metatexite migmatite containing 15 to 20% leucosome and an orthopyroxene–biotite psammite mesosome. The unit is cut by syn- to post-tectonic, 2- to 4-cm-wide, potassium-feldspar-porphyritic granite pegmatite veins that contain blue-grey quartz grains.

Paragneiss

2 Garnet–biotite ± sillimanite ± muscovite semi-pelitic to pelitic gneiss interlayered with psammitic gneiss. The semi-pelitic to pelitic phase locally contains cordierite. Compositional layers are 3 to 5 cm thick.

1 Fine- to medium-grained, recrystallized, interlayered quartzite and quartz-rich paragneiss. The disposition of this unit is largely taken from Owen (1986b).

Symbols

Geological Contact (defined, approximate, assumed, limit of mapping)

Fault (defined, approximate, assumed)

Thrust Fault (defined, approximate)

Bedding (tops unknown)

Fold Axial Plane (1st generation)

S-Fold Axis (1st generation)

U-Fold Axis (generation unknown, 1st generation)

Z-Fold Axis (generation unknown, 1st)

Foliation or Cleavage (generation unknown, 1st, 2nd)

Gneissic Foliation or Banding (1st generation, 2nd)

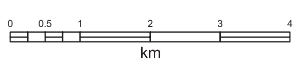
Igneous Layering (tops unknown, known)

Intersection Lineation (2nd generation)

Linear Fabric (1st generation)

Slicken Striae

Shear Zone (sense unknown, dextral, sinistral, normal)



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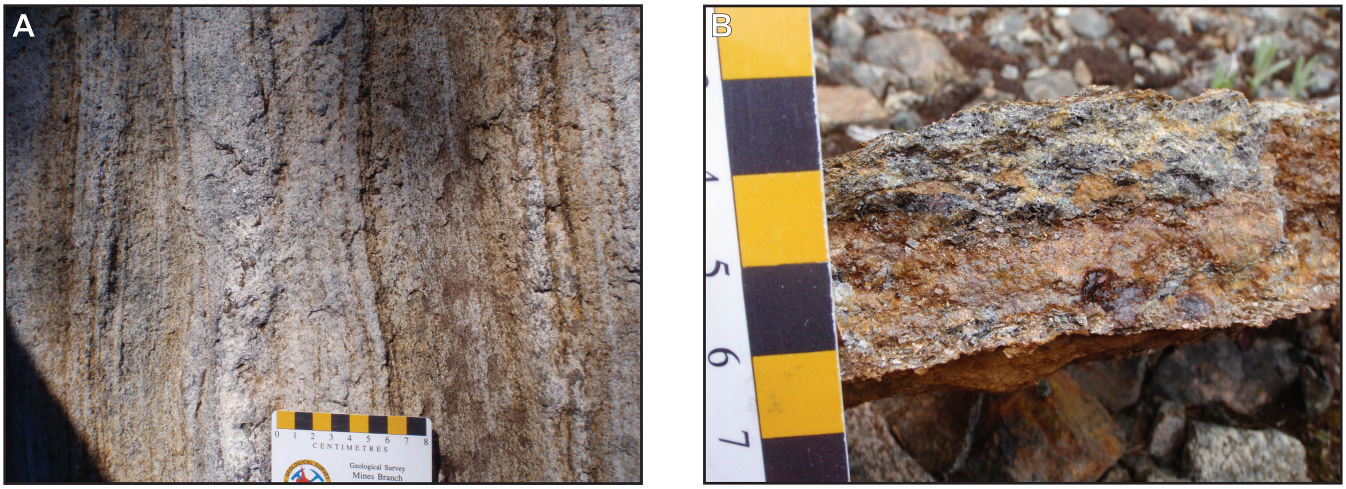

Plate 1. *Representative photographs of paragneiss of the Long Range gneiss complex in the northern Silver Mountain map area. A) Interlayered sillimanite–garnet–biotite paragneiss and semi-pelitic to psammitic gneiss (Unit 2). B) Rusty-weathering, sillimanite–garnet–biotite paragneiss layer containing garnet plus blue-grey quartz eyes (Unit 2).*

Plate 2. *Representative photographs of migmatitic gneiss of the Long Range gneiss complex in the northern part of the Silver Mountain map area. The image shows biotite gneiss (psammitic?) containing isoclinally folded leucosome ~15% (Unit 3). The outcrop is cut by syn- to posttectonic, concordant, 2- to 4-cm-wide K-feldspar-porphyritic granitic pegmatite veins, containing blue-grey quartz eyes.*

green to black, massive to foliated, lineated, medium-grained amphibolite and occurs primarily in the northeastern map area. It is poorly exposed, and as such, the extent of this unit is largely interpreted from previous mapping (Owen, 1986b) and regional geophysical surveys. Locally, this unit comprises plagioclase-rich leucocratic layers parallel to the foliation and contain 1- to 2-cm-long clinopyroxene porphyroblasts (Plate 3A); the unit also includes minor foliated metadiorite. The amphibolite gneiss is thoroughly recrystallized and lacks any primary igneous textures.

Unit 5 is a moderately foliated to locally gneissic metadiorite to metaquartz diorite (Plate 3B). This unit occurs as foliated to gneissic bodies in both the eastern and western map area (Figure 3). These rocks contain biotite, hornblende and pyroxene and leucocratic patches that are enriched in plagioclase and quartz. The unit also contains minor metre-wide amphibolite screens and is locally cut by millimetre-scale quartz veins.

Quartzofeldspathic Gneiss (Units 6, 7, 8 and 9)

Unit 6 is a biotite ± hornblende ± orthopyroxene monzogranite to quartz monzonite gneiss. This unit is a pink to grey gneiss and has compositional layers that range from 2 to 4 cm and are locally enriched in magnetite (Plate 3C). Amphibolite layers are locally present and typically comprise discontinuous, medium-grained layers rich in biotite–hornblende–plagioclase. The unit is cut by foliation-parallel, as well as crosscutting granite pegmatite veins that are 2 to 5 cm wide and contain blue-grey quartz crystals indicative of strain. Rare 1- to 2-cm-wide quartz veins are also present.

Unit 7 is a biotite ± hornblende ± orthopyroxene monzogranitic to granodioritic gneiss (Plate 3D). This unit corresponds to Unit uPng of Owen (1986b). It is the most aerially extensive unit in the map area and likely comprises several distinct phases that are not discernable at a regional scale of mapping. The unit is medium grained, moderately foliated to locally gneissic that is cut by 2- to 5-cm-wide, coarse-grained granite veins that contain blue-grey quartz crystals and make up approximately 10% of the outcrop. It also contains rare amphibolite boudins.

Plate 3. *Representative photographs of orthogneiss from the Long Range gneiss complex in the northern Silver Mountain map area. A) Fine-grained amphibolite (Unit 4) containing a plagioclase-rich discontinuous lens. B) Medium-grained, compositionally layered, biotite ± orthopyroxene quartz dioritic gneiss (Unit 5). C) Pink-grey hornblende-biotite ± orthopyroxene monzogranite gneiss (Unit 6), containing magnetite-rich layers, rare mafic (amphibolite) layers (top of image) and cut by foliation-parallel, granite pegmatite veins containing 2- to 5-cm-wide blue-grey quartz eyes. D) Strongly foliated, biotite–monzogranite to granodiorite gneiss contains S-folds, mafic differentiates, and pegmatite layers (Unit 7). E) Medium-grained, moderately foliated, granulite-facies, orthopyroxene–biotite tonalite (Unit 8). F) Medium-grained, foliated to locally gneissic, biotite–hornblende metagranodiorite to metaquartz monzodiorite cut by felsic veins and containing finer-grained patches (Unit 9).*

Unit 8 is an orthopyroxene-bearing, biotite tonalite to granodiorite that is typically moderately to strongly foliated (Plate 3E). It corresponds to Unit uPnt of Owen (1986b). The rocks are medium grained, foliated, recrystallized, and preserve granulite-facies mineral assemblages. Biotite occurs as rims on orthopyroxene, indicative of metamorphic retrogression. The unit is locally, heterogeneous, and it contains layers enriched in mafic minerals and metre-wide amphibolite boudins. Dextral shear zones cut the gneissic fabric.

Unit 9 is biotite–hornblende ± orthopyroxene granodiorite to diorite, which is strongly foliated to locally gneissic (Plate 3F), and typically preserves upper-amphibolite to granulite-facies mineral assemblages (Plate 3F). This unit corresponds to the Unit uPnd of Owen (1986b). These rocks are mostly medium grained although fine-grained variants are preserved. Mafic clots, 1 to 2 cm wide, composed predominately of biotite and hornblende give the unit an overall speckled appearance. The unit locally exhibits compositional layering including homogeneous dioritic layers that may represent older mafic dykes. The rocks are cut by foliation-parallel granite veins, locally with diffuse boundaries and containing 10 to 15% blue-grey quartz grains. Diabase dykes, quartz veins and late brittle faults were noted to cut these rocks.

LATE MESOPROTEROZOIC TO NEOPROTEROZOIC

GRENVILLIAN PLUTONISM

The Long Range gneiss complex has been intruded by foliated, metamorphosed felsic and lesser mafic bodies that are collectively interpreted to represent Grenvillian plutonic phases (Figure 3). Regionally, the granitoid plutons record two phases of Grenvillian magmatism, at *ca.* 1032 to 1022 Ma and 993 to 985 Ma (Heaman *et al.*, 2002). However, none of these ages are from plutons in the current map area. In the Silver Mountain map area, the Grenvillian plutons are generally flattened, metamorphosed, typically foliated and follow the structural grain of the gneiss complex. However, the aerially extensive Main River pluton is also overprinted by a Paleozoic fabric owing to its proximity to the Doucers Valley fault system, lying immediately to the east of the map area.

Unnamed Intrusions (Units 10, 11, 12 and 13)

Unit 10 is a metamorphosed medium- to locally coarse-grained, biotite-hornblende gabbro that contains minor phases of hornblende-bearing, plagioclase-porphyritic metamonzodiorite (Plate 4A). Disseminated magnetite occurs throughout the unit. The gabbro and monzodiorite are moderately to strongly foliated and lineated although relict igneous textures are locally preserved. The plagioclase phenocrysts in the monzodiorite form augen within its foliation. Locally, isoclinal folds in the metagabbro are cut by dextral shear zones.

Unit 11 is composed of a metamorphosed biotite ± hornblende quartz monzonite to monzogranite and forms lenticular bodies throughout the map area. This unit is correlated with Unit uPgr of Owen (1986b). The rocks display light-coloured weathering and are medium to coarse grained, and locally contain 1- to 2-cm-long augen of plagioclase and/or potassium feldspar (Plate 4B). The quartz monzonite to monzogranite are moderately foliated and lineated, and recrystallized. These intrusions are occasionally cut by 1- to 2-cm-wide quartz veins that contain disseminated sulphides.

Unit 12 is a metamorphosed fine- to medium-grained biotite monzogranite that occurs as sheets and veins (Plate 4C). These intrusions locally range up to several hundred metres wide, but also occur as thinner sheets (50 m wide) within Unit 7. The monzogranite is recrystallized and displays a granoblastic texture. A moderate foliation is largely defined by biotite-rich layers. Numerous, 1- to 2-cm-wide quartz veins are present in the intrusions.

Unit 13 is composed of a metamorphosed biotite ± hornblende, potassium-feldspar augen monzogranite and lesser quartz monzonite (Plate 4D). This unit is correlated with Unit uPgd-k of Owen (1986b). A weak to strong foliation is variably developed within these bodies, but the lineation is generally more conspicuous, indicative of an L>S fabric. Potassium-feldspar augen are typically 0.5 to 1 cm wide and 1 to 2.5 cm long. Quartz crystals are commonly blue-grey indicative of granulite-facies metamorphism. Locally, segregations of more felsic layers, thin, centimetre-scale, sheets of finer grained metamonzogranite, and screens of amphibolite are found within the unit.

Main River Pluton (Unit 14)

The Main River pluton (Unit 14) occurs on the eastern side of the map area (Figure 3). It is a laterally extensive body of pink, feldspar-megacrystic, lineated and foliated biotite ± hornblende monzogranite to quartz monzonite (Plate 4E). The feldspars form augen within the fabric and are typically 1 to 3 cm long. The rocks typically show an S>L tectonic fabric. Mafic minerals define the foliation whereas the feldspar augen defines the lineation. Within the pluton there are locally finer grained layers and dykes that are likely genetically related to the intrusion. The pluton is cut by quartz veins some of which host the gold mineralization at the Viking prospect of Northern Abitibi Mining Corp.

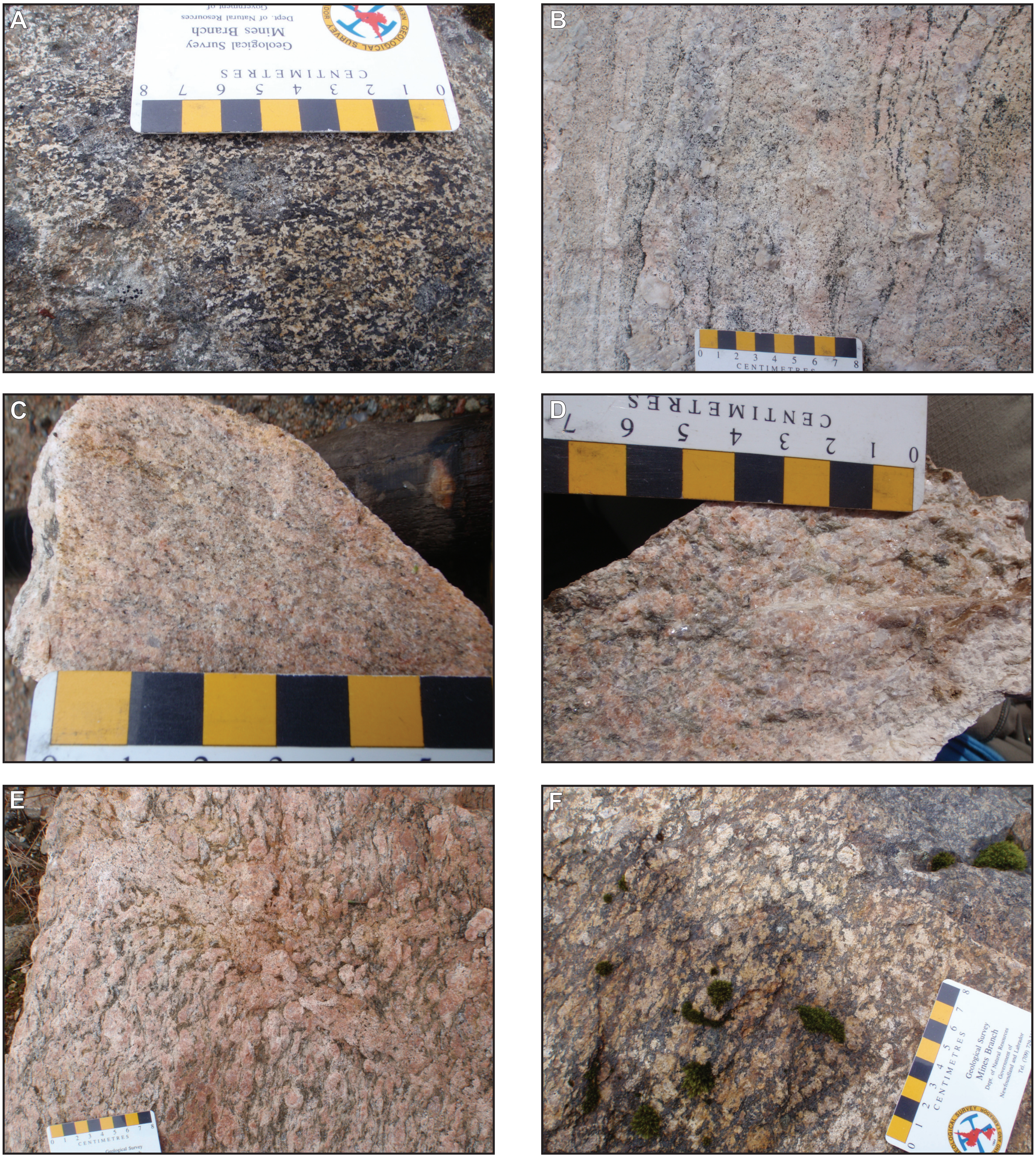

Plate 4. *Representative photographs of Grenvillian intrusions in the northern Silver Mountain map area. A) Medium-grained, foliated, light-weathering metagabbro containing coarser grained patches (Unit 10). B) Typical medium-grained, locally feldspar-porphyritic, foliated, biotite ± hornblende metaquartz monzonite (Unit 11). C) Fine- to medium-grained, moderately foliated, recrystallized biotite metamonzogranite (Unit 12). D) Coarse-grained, moderately foliated hornblende-biotite metamonzogranite (Unit 13) commonly containing feldspar augen and blue-grey quartz. E) Foliated biotite–hornblende syenogranite of the Main River pluton (Unit 14) containing K-feldspar augen, and an S > L tectonic fabric. Mafic minerals and feldspar augen define the foliation (S_2) that is cut by a cm-scale late shear zone (D_3 or D_4). F) Medium-grained, granulite-facies, coronitic-textured biotite–orthopyroxene metamonzogranite (charnockite) of the Potato Hill pluton (Unit 15). This phase contains an S > L tectonic fabric.*

The Main River pluton and the quartz veins are locally affected by a low-grade greenschist-facies metamorphism and associated ductile deformation, preserved as cm-scale shear zones. This metamorphism and deformation are interpreted to have resulted from Paleozoic overprinting due to shearing along the Doucers Valley fault system, located just to the east of the map area.

Potato Hill Pluton (Unit 15)

Part of the Potato Hill pluton (Unit 15) outcrops in the north-central map area, and extends to the north of the NTS 12H/11 map area (Figure 3). An outcrop of the intrusion, located to the north of the current map area, was dated at 999 ± 4 Ma (Heaman *et al.*, 2002). Within the map area, the pluton is typically a coronitic orthopyroxene metagranite (charnockite; Plate 4F). This intrusion preserves granulite-facies metamorphic mineral assemblages. The unit is grey to pink, medium grained and locally preserves feldspar augen that are 1 to 2 cm wide. The margins of the pluton are weakly foliated with the foliation decreasing in intensity toward the interior of the pluton where it is massive. The corona texture is due to a variety of disequilibrium equations. This results in the partial enveloping of: a) hornblende, quartz and garnet enclosing orthopyroxene; or less commonly, b) hornblende and garnet rims on intergrowths of ilmenite ± magnetite and clinopyroxene (Owen, 1991). The pluton is cut by cm-scale late undeformed granite veins.

OTHER PLUTONIC UNITS (UNIT 16)

Throughout the map area, small circular to lenticular intrusions of hornblende metagabbro occur (Figure 3). These intrusions are massive to weakly foliated and preserve relict igneous textures, typically a subophitic texture. Plagioclase, amphibole and locally biotite occur as euhedral crystals. Pyroxene was not observed in these intrusions. These intrusions could be related to late-stage Grenvillian plutonism but may represent a later magmatic event.

LONG RANGE DYKES

North-northeast-trending mafic dykes are documented sporadically throughout the map area; however, they cannot be shown at the scale of the map (Figure 3). These dykes are generally less then 5 m wide, preserve chilled margins and crosscut most of the units in the map area. The dykes have been correlated with the Long Range dykes, defined as Neoproterozoic northeast-trending tholeiitic dykes (Owen, 1986a, 1988). Two samples of Long Range dykes from southeastern Labrador yielded U–Pb baddeleyite ages of *ca.* 615 Ma (Kamo *et al.*, 1989; Kamo and Gower, 1994), consistent with the interpretation that the Long Range dykes were emplaced during the initial rifting associated with the opening of the proto-Atlantic ocean (Strong and Williams, 1972; Strong, 1974).

LATE NEOPROTEROZOIC TO PALEOZOIC ROCKS

METASEDIMENTARY UNITS (UNITS 17 TO 19)

A sequence of three sedimentary units are preserved flanking the edges of the Taylor Brook gabbro (Figure 3). This sequence includes a thin phyllite unit (Unit 17), a marble (Unit 18) and semi-pelitic quartzite (Unit 19).

Unit 17 is found along the east side of the Taylor's Brook intrusion where it forms a 100-m-wide belt of dark grey-brown, recrystallized phyllite (psammitic schist), and is not preserved on the western side of the intrusion. Along its contact with the Long Range gneiss complex (Unit 7), the phyllite has a mylonitic fabric (Plate 5A). Away from the contact, the phyllite has a strong cleavage and has been intruded by late, possibly Silurian, granite dykes. Within the mylonite zone, deformed quartz-feldspar lenses preserve a top to the northeast sense of shear.

The phyllite (Unit 17) is in contact with the marble of Unit 18 along the east side of the Taylor Brook gabbro (Figure 3). The western contact between the marble and the Long Range gneiss complex is not exposed; the marble unit is up to 900 m wide at its thickest preserved section. The marble is brown-weathering, displays grey-white banding, and contains few accessory minerals. Locally, some 2- to 10-cm-wide beds contain diopside, garnet and biotite, and other beds contain 0.5- to 2-cm-wide, brown, fine-grained, micaceous, quartz-rich concretions that are interpreted to represent metamorphosed clasts of mudstone and sandstone (Plate 5B). Layering in the marble is defined by colour, clasts and/or grain size and is interpreted to represent primary bedding. Small Z-folds were documented on the eastern exposure of the marble. Dykes of fine-grained gabbro, interpreted to be equivalent to the Taylor Brook gabbro, are locally found to crosscut the marble.

Unit 19 is a thinly layered semi-pelitic gneiss and quartzite (Plate 5C). This unit occurs primarily on the western margin of the Taylor Brook gabbro where it preserves textural evidence of contact metamorphism and is extensively intruded by the gabbro. The semi-pelitic layers contain garnet, muscovite, biotite and locally sillimanite. Garnet is typically 1 to 3 mm in diameter and sillimanite needles are 1 to 5 mm long. In the quartz-rich layers, garnet is mantled by biotite.

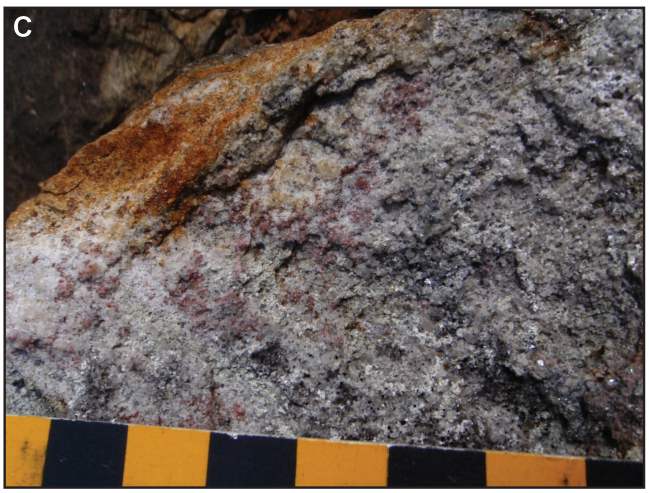

Plate 5. *Representative photographs of Neoproterozoic to Paleozoic metasedimentary sequence preserved in the northern Silver Mountain map area. A) Grey mylonitic phyllite (Unit 17) from near the contact with orthogneiss of the Long Range gneiss complex. Quartz–feldspar lens indicates a top to the northeast sense of motion. B) Banded grey-white, yellow-brown weathering marble (Unit 18). This outcrop locally preserves 1- to 10-cm-thick beds that contain cm-wide, rounded pods of brown, biotite–quartz– feldspar ± epidote interpreted to be clasts of metamorphosed mudstone and/or sandstone. C) Foliated, muscovite–biotite–garnet psammite to semi-pelitic schist containing 5- to 10-cm-wide compositional layers (Unit 19).*

TAYLOR BROOK GABBRO (UNITS 20 TO 22)

The Taylor Brook gabbro (Units 20–22) is an oblong intrusion that outcrops in the east-central part of the map area and has an area of 175 km^2 (Figure 3). There are three mappable phases of the Taylor Brook gabbro consisting of a laterally extensive medium-grained to coarse-grained gabbro (Unit 20), a sporadically mappable phase of gabbronorite (Unit 21) and a coarse-grained to pegmatitic gabbro–melanogabbro (Unit 22). The most striking feature of this intrusion is its textural and compositional heterogeneity probably indicating that there were numerous phases of magma. Igneous layering is locally persevered, typically displaying moderate dips toward the centre of the body (Figure 3). However, the dip direction of this layering is not always consistent, and it locally dips outward. This is possibly due to rotation by later phases of the intrusion. Heaman *et al.* (2002) have reported a U–Pb zircon date of 430.5 ± 2.5 from a fine-grained gabbro in the south of the pluton (Unit 20).

Unit 20 is a medium- to coarse-grained mesocratic heterogeneous gabbro that includes minor phases of leucogabbro, melanogabbro and norite phases. Along the margins of the intrusion, the gabbro is fine grained. This phase typically preserves igneous layering and evidence for repetitive magma mixing (Plate 6A). Compositional igneous layering varies from a few centimetres to a few metres and is highlighted by variations in grain size and mineralogy. Cumulate textures are apparent in coarser grained rocks of this unit.

Along the northwestern margin of the intrusion, the gabbro (also part of Unit 20) contains prominent flattened/compacted igneous layers having 2- to 10-cm-thick discontinuous layers of massive magnetite. The magnetite-rich layers alternate with layers that are enriched in plagioclase relative to pyroxene and vice versa. This gabbroic phase has been intruded by medium-grained melanogabbro dykes that display chilled margins (Plate 6B).

Plate 6. *Representative photographs illustrating the lithological complexities of the Taylor Brook gabbro in the northern Silver Mountain map area. A) Igneous layering is defined by variations in the proportions of plagioclase, magnetite and pyroxene in a medium-grained gabbro to leucogabbro (Unit 20). The gabbro is cut by a late, sinistral brittle fault that offsets the igneous layering. B) Medium- to coarse-grained, compositionally heterogeneous leucogabbro to melanogabbro (Unit 20). Igneous layering is dominantly controlled by the abundance of plagioclase and pyroxene and locally discontinuous layers of magnetite (by hammer). The outcrop is cut by a metre-wide melanogabbro dyke containing chilled margins. C) Coarse-grained gabbronorite to norite, containing disseminated sulphides, dominantly pyrite, and magnetite (Unit 21). The presence of olivine is suspected due to the crumbly nature of the rock. The texture is variable and contains more plagioclase-rich patches and locally preserves a cumulate texture. D) Coarse- to very coarse-grained melanogabbro containing patches of gabbro (Unit 22) and cut by finer grained gabbro dykes (no chilled margins). Along with the inclusions of fine-grained grey gabbro, these features illustrate the complex intrusive history of this complex.*

Dykes of leucocratic gabbro and locally clinopyroxenite are also found in fine- and coarse-grained gabbro phases of Unit 20. Textures indicative of magma-mingling between leucocratic and melanocratic phases are found in isolated outcrops. Plagioclase porphyritic gabbroic dykes with chilled margins are rare in this unit, and these are interpreted to represent the final phase of plutonism. Minor occurrences of disseminated sulphides, primarily pyrite and chalcopyrite, and magnetite are scattered throughout Unit 20.

Unit 21 is a coarse-grained gabbronorite to norite that occurs as small mappable phases throughout the complex and also as outcrop-scale variations of Unit 20 (Figure 3). Olivine is locally present. The unit preserves a cumulate texture and locally contains more plagioclase-rich patches (Plate 6C). Disseminated magnetite and sulphides occur locally within the unit and it is cut by finer grained dykes of co-magmatic gabbro and leucogabbro.

Unit 22 is a pegmatitic gabbro to melanogabbro that outcrops as a small body in the northern part of the complex (Figure 3) and has intruded fine-grained grey gabbro and clinopyroxenite, possibly related to Unit 20. This phase is coarse grained to pegmatitic and contains pyroxene crystals up to 15 cm long. The pyroxene is typically subhedral, although cumulate textures are locally preserved. The gabbro and melanogabbro contain patches that are richer in plagioclase. As with other units in the complex, this phase locally contains minor iron and copper sulphide (pyrite, chalcopyrite) and iron oxides (magnetite). Co-magmatic to late, 10s cm wide, fine-grained dykes of melanocratic gabbro and locally clinopyroxenite, intruded Unit 22 and are included within it. Unit 22 is cut by large dykes and sills of leucocratic biotite monzogranite assigned to Unit 23 and dykes of fine-grained quartz-feldspar porphyry (Unit 24) (*see* Felsic Magmatism below).

The Taylor Brook gabbro is heterogeneous at all scales. The fluidity of the intrusive phases is indicated by syn-crystallization deformational features such as compacted igneous layering, dropped pendants that have disrupted igneous layers, magma mingling of leucocratic and melanocratic phases, multiple phases of dyke emplacement and commonly repeated rock types. The intrusion contains significant variability of the modal abundance of magnetite, which ranges from units containing 2- to 5-cm-thick layers of massive magnetite to other phases that are virtually devoid of magnetite. This heterogeneity likely exerts control on the regional magnetic anomalies associated with this unit, as the aeromagnetic signature does not appear to correspond with the known boundaries and phases of the intrusion. The intrusion should perhaps be renamed the Taylor Brook gabbroic suite as this would better reflect the compositional variability of the intrusion.

The Taylor Brook gabbro is interpreted to represent a laccolitic intrusion that utilized an existing structure, possibly a Taconic thrust, as a conduit for the multiple pulses of magma. Thus, rather than representing a massive batholith, it is possibly a thinner sheet-like, composite intrusion. This would explain the large aerial extent of this pluton (>175 km^2), which would otherwise have required a regionally extensive chamber to produce such a large batholith. The utilization of an older thrust for emplacement of a sheet-like body also explains the distribution of the marble-metasedimentary sequence along the margin of the intrusion (Figure 3).

FELSIC MAGMATISM

Two phases of felsic magmatism are present in the Taylor Brook gabbro (Figure 3). One forms dykes and sills that are locally mappable, at 1:50 000 scale, and are leucocratic biotite monzogranite (Unit 23). These bodies are generally northeast trending, and range from 10 to 100 m in thickness and are found within the pegmatitic Unit 22 of the complex. The monzogranite is medium grained, contains pegmatite patches and preserves 2- to 3-cm-wide chilled margins (Plate 7A).

The second phase of felsic magmatism is fine-grained quartz-feldspar porphyry that occurs as dykes located in the southern portion of the complex (Figure 3). These dykes are pink, have an aphanitic groundmass and contained euhedral, 1- to 4-mm-long quartz and feldspar phenocrysts (Plate 7B). Erdmer (1986a) interpreted these as hypabyssal intrusions that are correlated with Silurian volcanic rocks located to the east of the Long Range Inlier.

STRUCTURAL AND METAMORPHIC INTERPRETATIONS

PRELIMINARY INTERPRETATION OF THE STRUCTURAL EVOLUTION

The Long Range gneiss complex contains a regional foliation, metamorphism and folding ($D_{1?}$) that was developed prior to the intrusion of the Grenvillian plutons illustrated in Plate 8A. The complex is dominated by a regional, northeast-trending, moderately to steeply dipping structural fabric that is primarily defined by gneissic layering and/or the main foliation (S_m, possibly S_2) and locally preserved shear zones and migmatites (Plate 8B). This fabric controls the overall distribution of units within the map area (Figure 3).

Post- or possibly during the later phases of D_1, the Long Range gneiss complex was intruded by Grenvillian plutons. This post-intrusion D_2 event resulted in the foliation, flattening and boudinaging of many of the Grenvillian intrusions as well as a regional isoclinal folding ($F_{2?}$), which transposed the earlier F_1 structures (Plate 8C). This second generation of folding is parallel to the S_2 fabric, which is defined within the granitoid intrusions by the alignment of mafic minerals, feldspar augen and elongate quartz lenses. This S_2 fabric, along with the L_2 lineation, is variably developed within the Grenvillian plutons (Plate 8D). The intensity of the development of this fabric within these plutons likely reflects the timing of emplacement relative to Proterozoic deformation. An exception to this is the Main River pluton, which also preserves a north-trending, low-grade schistosity (S_4) and a moderately developed, east-plunging, mineral lineation (L_4) that are interpreted to be related to overprinting associated with deformation along the eastward-lying Doucers Valley fault system.

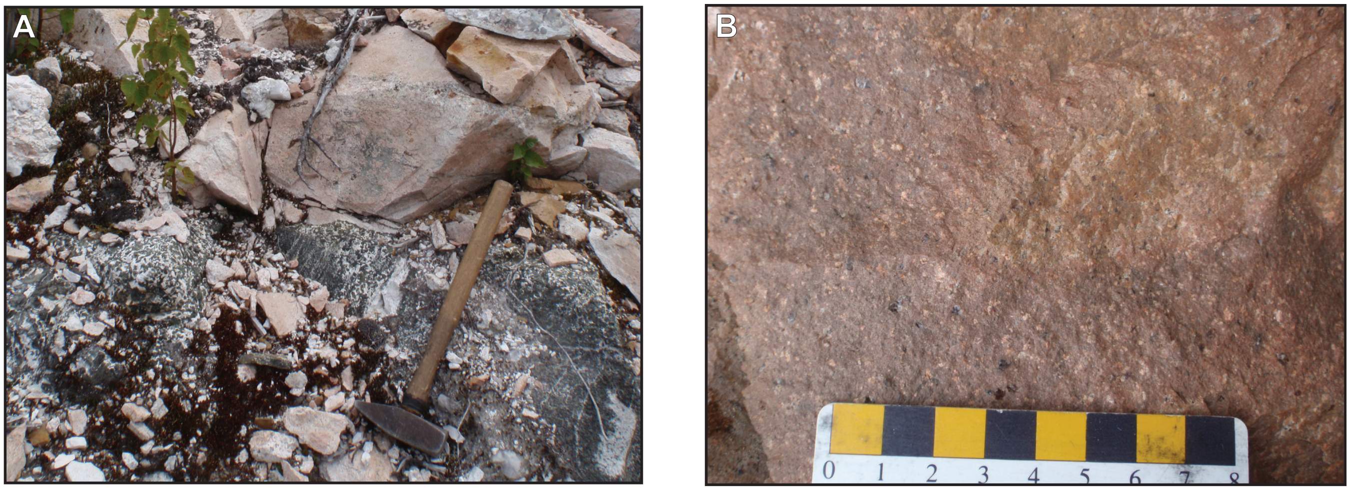

Plate 7. *Representative photographs of Silurian felsic rocks in the northern Silver Mountain map area. A) Leucocratic, fine-grained, biotite–monzogranite dykes, containing pegmatitic layers and chilled margins (Unit 23) has intruded coarse-grained melanogabbro (Unit 22) of the Taylor Brook gabbro. B) Pink, quartz–feldspar-porphyry dykes, interpreted as a hypabyssal intrusions, contain 1- to 2-mm long, randomly orientated phenocrysts (Unit 24).*

The metasedimentary rocks (Units 17–19), which flank the Taylor Brook gabbro, preserve a weak bedding-parallel foliation ($S_{3?}$). This foliation is moderately west dipping on the eastern side of the intrusion and steeply east dipping to vertical on the western side of the intrusion with exception to near the contact with the Long Range gneiss complex where the foliation becomes mylonitic. Locally, small-scale, southeast-dipping Z-folds (F_3 or F_4) are found within the marble of Unit 18 on the eastern side of the intrusion (Plate 8E). Unlike the Long Range gneiss complex that records multiple phases of deformation and high-grade metamorphism with several syn- to post-deformation intrusions, the sedimentary units record a simple history. For these reasons, the sedimentary units are interpreted as possibly being late Neoproterozoic to Paleozoic in age. The contact of the sedimentary units with the Long Range gneiss complex is preserved only in the eastern part of this sequence. At the contact, the phyllite is mylonitic and sheared with a foliation that is moderately east dipping and structural features indicate a top to the northeast sense of motion. This contact is interpreted to represent the base of a possible Paleozoic thrust fault along which the sedimentary units were emplaced onto the Precambrian rocks. Long Range dykes are absent within the sedimentary units, further suggesting that the sedimentary units, and also, therefore, the thrust, postdate the 615 Ma Long Range dyke swarm.

The Silurian Taylor Brook gabbro was intruded discordantly across the sedimentary sequence (Units 17–19) and the gneisses of the Long Range complex. The igneous fabrics in the gabbroic units generally dip toward the interior of the unit. The intrusion is interpreted to represent a composite laccolithic body that was intruded along an existing thrust structure. This interpretation would explain several features of the Taylor Brook gabbro including: a) the lateral extent of the intrusion as a thin sheet-like body; b) the preservation of the metasedimentary sequence (Units 17–19) only along the margins of the intrusion; and c) the variable rock types and complex textural relationships documented in the intrusion. The metasedimentary rocks (Units 17–19) would have been contact metamorphosed by the Taylor Brook gabbro.

PRELIMINARY INTERPRETATION OF THE METAMORPHIC HISTORY

The Long Range gneiss complex experienced a high-grade, upper amphibolite- to granulite-facies metamorphism that is recorded in the mineral assemblages of the gneisses. Orthopyroxene is generally well preserved in the orthogneisses (Units 3–9) of the complex, with the orthopyroxene only locally retrogressed to amphibolite. Evidence for this amphibolite-facies retrogression is locally preserved in the map area. This high-grade metamorphism has been termed M_1 and is interpreted to represent peak metamorphic temperatures of 700–800°C and pressures of 6–8 Kbar (Owen, 1991a) and was likely synchronous with D_1 deformation. This metamorphism would have pre-dated the intrusion of the Grenvillian granites, the oldest of which is *ca.* 1032 Ma and was dated from rocks collected from south of the map area (Heaman *et al.*, 2002), and this provides a minimum estimate on the age of M_1.

The second metamorphic event is syn- to post-intrusion of the Grenvillian granites and was synchronous with D_2 deformation. The associated metamorphism generally pre-

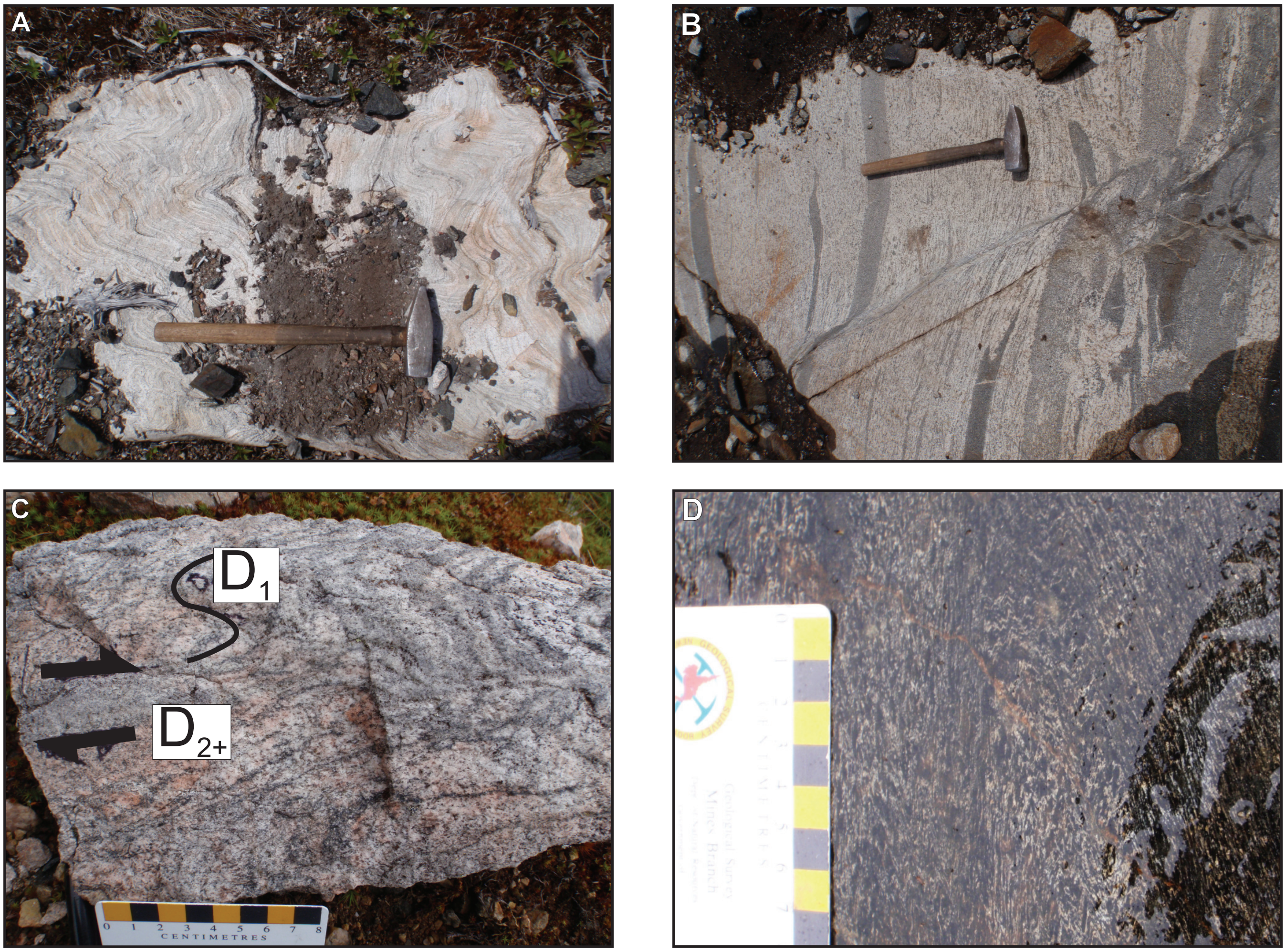

Plate 8. *Representative photographs of the fabrics in the Long Range Inlier. A) Disharmonic folding (F_1) in the heterogeneous, strongly foliated, biotite–monzogranite to granodiorite gneiss (Unit 7). This unit is cut by pre-D_2, fine-grained granite veins. B) A cm-scale shear zone with a dextral sense of motion preserved within the orthopyroxene–biotite tonalite (Unit 8) of the Long Range gneiss complex. Kinematic indicators include: rotation of a pre-existing foliation, rotation of deformed mafic layers, and mylonite is developed in the central part of the shear zone ($D_{3\ or\ 4}$). C) Foliated to gneissic (D_1), veined, biotite–monzogranite orthogneiss (Unit 7). The pre-existing fabric (D_1) is cut by later shear bands, which are at least D_2. D) Hornblende metagabbro (Unit 16) containing mm-scale isoclinal folds (at least D_2) preserved within a late dextral shear zones (at least D_3). E) Centimetre-scale Z folds ($F_{3\ or\ 4?}$) preserved within marble (Unit 18).*

serves upper amphibolite-facies conditions; however, the Potato Hill pluton preserves granulite-facies metamorphism that is locally retrogressed to amphibolite facies and is assumed to correlate with this event. Owen (1991a) determined that the Potato Hill pluton had undergone peak metamorphic temperatures in the range of 705–670°C. The D_2 fabric is cut by the 615 Ma Long Range dyke swarm and this provides a minimum age on this metamorphic event. However, it is possible that M_2 represents more then one metamorphic event. Heaman *et al.* (2002) reported a regional (*i.e.*, encompassing the entire Long Range complex) M_2 event at *ca.* 1022 Ma and a M_3 event at *ca.* 989 Ma. Evidence for the division of this metamorphism into two distinct events has yet to be clearly identified in the Silver Mountain area.

The third metamorphic (M_3; possibly regionally M_4) event is preserved within the metasedimentary rocks (Units 17–19). The sedimentary units are metamorphosed, preserving lower grade, muscovite-bearing rocks away from the contact with Unit 20 of the Taylor Brook gabbro. Closer to the contact, the metasediments contain sillimanite, garnet and locally cordierite. This event has been interpreted to be a contact metamorphism related to the intrusion of the Taylor Brook gabbro (Owen, 1991b); however, the rocks may also preserve an older low-grade metamorphism that was subsequently overprinted by the metamorphism associated with the intrusion of the gabbro. This will be determined through petrographic analysis of the metasediments.

The final metamorphic event(s) preserved in the map area is the schistosity related to greenschist-facies metamorphism (M_4) that locally overprints the Long Range gneiss complex and Grenvillian granites along narrow shear zones and late brittle faults. The intensity of this metamorphism and accompanying deformation increases to the east of the map area and was correlated with Palaeozoic tectonism (Owen, 1991a).

MINERALIZATION

The Silver Mountain area is known to host gold and base-metal mineralization. Recent exploration has focussed on gold prospects hosted in sheared quartz veins that are thought to be related to the Doucers Valley fault system (just to the east of the map area). These include the Viking Project, currently being explored by Northern Abitibi Mining Corp. This prospect is also the focus of research by Minnett *et al.* (*this volume*). Other gold prospects include the extensive Rattling Brook gold zone, to the northeast of the current map area, which comprises several gold occurrences. Within the map area, samples from the previously known, as well as newly documented mineral occurrences, including a pyrite-rich quartz vein (Plate 9A), were collected for assay as part of this regional mapping study.

CONCLUSIONS

The Long Range Inlier in the northern half of the Silver Mountain map area includes evidence for a complex multi-orogenic history. Major tectono-magmatic components include:

- High-grade metamorphism and deformation of the Long Range gneiss complex,
- Intrusion, deformation and metamorphism of Grenvillian plutons,

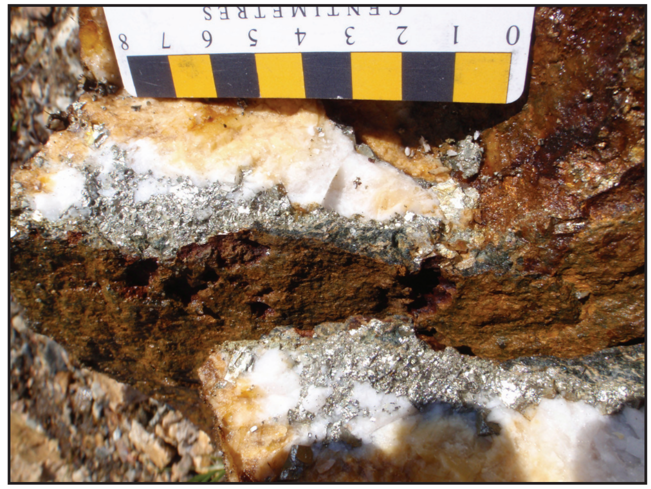

Plate 9. *Representative photograph of a newly documented sulphide mineralized quartz vein in the northern part of the Silver Mountain map area.*

- Uplift, rifting and emplacement of Long Range dyke swarms,
- Thrusting of a sedimentary sequence onto the Long Range Inlier; and
- Regional, Silurian mafic and felsic plutonism that contact metamorphosed the adjacent units.

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