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# GEOLOGY OF THE ASHUANIPI COMPLEX, WESTERN LABRADOR (NTS MAP SHEETS 23J/02, 03 AND PART OF 23J/04)

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## ABSTRACT

*The Archean Ashuanipi Complex in western Labrador consists of older, migmatitic paragneiss, orthogneiss, strongly foliated granitoid rocks, and subordinate gabbro and pyroxenite-rich ultramafic intrusions and mafic dykes. These rocks predate the formation of extensive diatexite migmatite, weakly deformed granitoid plutons and pegmatite. Orthopyroxene-bearing assemblages in most rock types indicate granulite-facies metamorphic conditions were attained throughout the map area during both $D_1$ and $D_2$ deformation. West-northwest-striking fabrics and late faults dominate the structural pattern. Mineralization is hosted in several rock types and consists of bornite ± pyrrhotite ± chalcopyrite ± arsenopyrite in local, metre-scale, gossan zones. Some syn- to late-stage pegmatite veins have anomalous radioactive element signatures and may have potential to host Th, U and REE mineralization.*

## INTRODUCTION

During July and August, 2016, 1:50 000-scale bedrock mapping was carried out in NTS map sheets 23J/02, 23J/03 and part of 23J/04 using helicopter-supported ground traversing. This work completes a three-year field program (2013, 2015 and 2016) to map the bedrock of the northern Ashuanipi Complex in western Labrador including NTS sheets 23J/02, 03 and 06 and parts of 23J/04, 05, 07, 10, 11, 14 and 23J/03 (Figure 1).

### LOCATION, ACCESS AND PHYSIOGRAPHY

The 2016 map area encompasses approximately 2000 km$^2$ and is centred 75 km southwest of the town of Schefferville, Québec (Figure 1). Access is attained using helicopter support, from the towns of Schefferville or Labrador City–Wabush. Several large lakes and rivers are used for boat-access. Bedrock exposure ranges from poor to fair in low-lying wooded areas to good in the uplands. The topography is of moderate- to high-relief with elevations ranging from 520 to 720 m above sea level, and is characterized by rounded to flat, barren hilltops, broad valleys and coniferous tree-covered slopes.

### PREVIOUS INVESTIGATIONS

The first reconnaissance surveys of Kidd (1950) and Perrault (1951) produced 1 inch to 1-half mile scale maps, along the main waterways in the McPhadyen River area. Parts of three, 1:253 440-scale (1 inch to 4 miles) geological maps include the present map area. Frarey (1961) and Stevenson (1963) mapped the east and west parts, respectively, of NTS map area 23J.

Wardle (1982a, b) included rocks of the Ashuanipi Complex and Proterozoic rocks of the south-central Labrador Trough on 1:100 000-scale bedrock-map compilations. Percival (1989, 1993) produced a 1:125 000-scale map of NTS map areas 23J/3, 4, 5, 6, 11 and 12 and parts of 23J/2, 7 and 10. In addition to the mapping, Percival (1987, 1991a, b), Percival and Girard (1988) and Percival *et al.* (1992, 2003) reported on the geology, geochemistry and geochronology of the Ashuanipi Complex.

The map area is covered by regional lake-sediment geochemistry surveys of NTS map area 23J (Geological Survey of Canada, 1982). Detailed lake-sediment, lake-water and stream-geochemical surveys were completed over all regions of the map area (Butler and McConnell, 1989; McConnell, 2009, 2012a, b). The map area is included in a report on the glacial history and till geochemistry of Labrador (Klassen and Thompson, 1990).

A 1:1 000 000-scale residual total-field aeromagnetic map (Geological Survey of Canada, 1984), has been compiled as a colour, shaded-relief map (Kilfoil, 2013), and as a 1:500 000-scale Bouger gravity anomaly map (Earth Physics Branch, 1975). Map sheet 23J/02 is included in 1:50 000-scale airborne geophysical survey maps of the

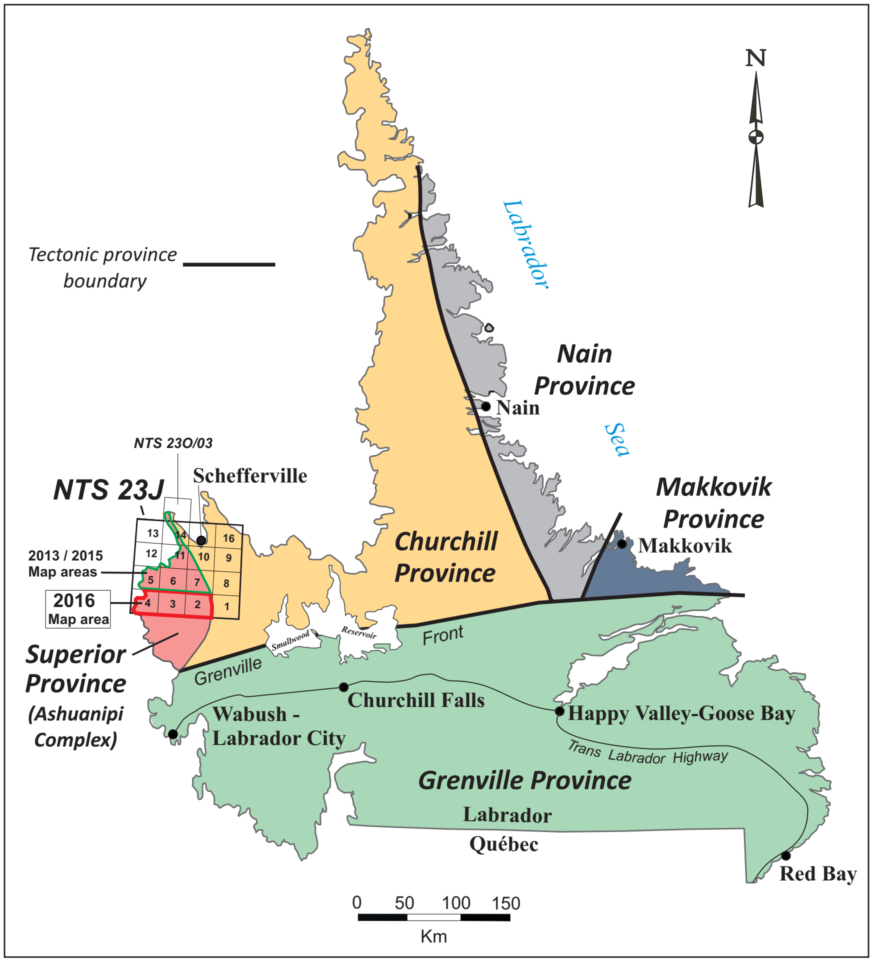



**Figure 1.** *Tectonic subdivisions of Labrador and location of the 2016 study area. Modified from Wardle* et al. *(1997).*

In adjacent Québec, LaPointe (1986), Chevè and Brouillette (1992), LaPointe and Chown (1993) and Ivanov (2012) reported significant gold occurrences hosted in Archean Algoma-type, metamorphosed iron formation, migmatitic gneisses and quartz veins to the north of the map area. Simard *et al.* (2015) compiled an extensive synthesis of the geology, geochronology and metallogenesis of the Ashuanipi Complex in Québec, and parts of adjacent Labrador.

Lake Attikamagen–Schefferville region (Coyle and Kiss, 2011). Part of the area was included in a survey of heavy-mineral concentrates, from esker sand and gravel, collected over rocks of the Ashuanipi Complex and the Proterozoic Labrador Trough (Brushett and Amor, 2013).

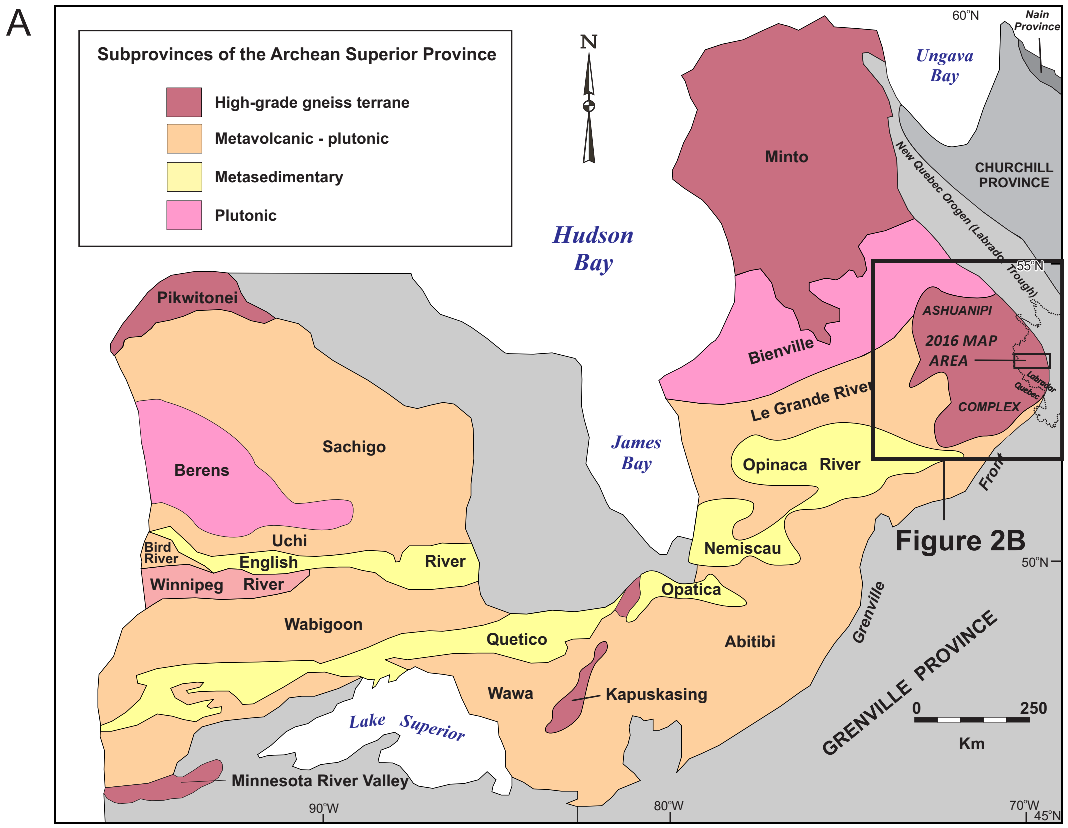
Thomas and Butler (1987) carried out a bedrock-sampling survey of the Ashuanipi Complex in Labrador, to determine the potential for gold mineralization, based on anomalies detected by an earlier regional lake-sediment sampling program (Geological Survey of Canada, 1982). The survey delineated elevated gold values in several gossan zones hosted in gneissic and foliated granitoid rocks. Subsequent gold and base-metal exploration programs focused on bedrock, soil- and stream-sediment sampling and magnetic surveys in the vicinity of these and other gossan zones (Thomas and Butler, 1987; McConnell *et al.*, 1987, 1989; Campbell, 1987, 1989; Dimmell, 1989; Graves, 1992; Leonard, 1997; Montague, 2011).

## REGIONAL GEOLOGY

The Superior Province is an Archean craton divided into several subprovinces (Figure 2A; Card and Ciesielski, 1986; Stott, 1997). The northern subprovinces are predominantly of continental affinity and contain crustal vestiges as old as 3.0 Ga (Percival *et al.*, 2003). The southern subprovinces consist of linear metavolcanic, metaplutonic and metasedimentary belts. Most of the Superior Province formed between 3.0 and 2.65 Ga, and the subprovinces demarcate amalgamated volcanic arcs, sedimentary prisms and composite terranes accreted, progressively, from north to south between 2.75 and 2.70 Ga. A craton-wide, west to east sub-greenschist- to granulite-facies transition, exposing the high-grade and deeper level Minto and Ashuanipi subprovinces in the east, is attributed to a wide-scale crustal tilting (Card and Ciesielski, 1986; Percival and Williams, 1989; Card, 1990; Percival *et al.*, 1992).

## GEOLOGY OF THE ASHUANIPI COMPLEX

The Ashuanipi Complex is a granulite-grade subprovince of the eastern Archean Superior Province and is approximately 90 000 km$^2$ in area (Figure 2A, B). The complex is bounded by Proterozoic rocks of the New Québec Orogen (Labrador Trough) to the east and by Archean rocks of the Le Grande, Bienville and Opinaca subprovinces to the west, north and southwest, respectively. To the southeast, the Ashuanipi Complex is bounded by the Grenville Front, but its reworked continuation extends into the Grenville Province.



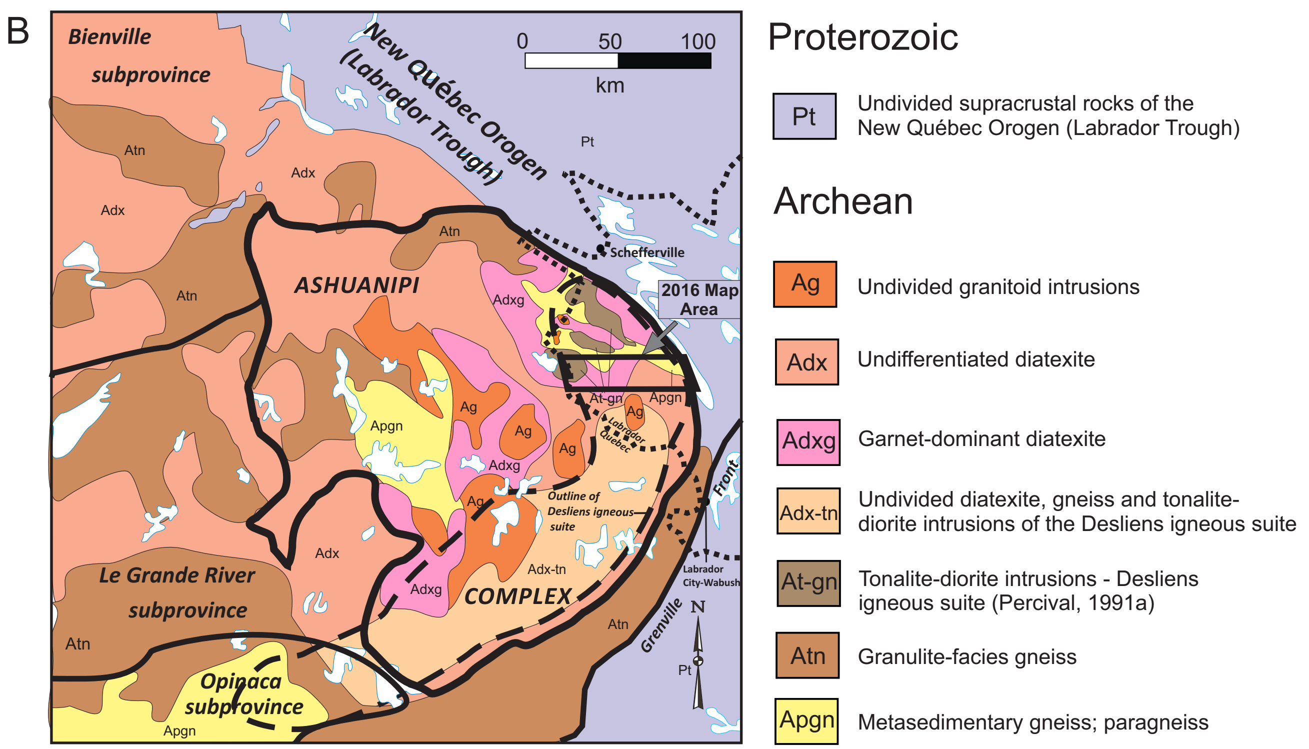




**Figure 2.** *A) Regional subdivision of the Superior Province (after Card, 1990); B) Regional geology of the Ashuanipi Complex (modified after Wheeler* et al., *1996).*

The eastern Ashuanipi Complex consists of migmatitic paragneiss, intruded by pretectonic tonalite, quartz diorite, diorite and gabbro sills and plutons of the Desliens igneous suite, and interpreted as a fractionated series of intrusive rocks (Percival, 1991a; Percival *et al.*, 2003; Figure 2B). Granulite-facies metamorphism produced orthopyroxene-bearing assemblages and migmatitic fabrics, and resulted in the formation of predominantly sedimentary rock-derived, syn-, to late-metamorphic stage diatexite (Percival, 1991b; James, 1997). Mafic and ultramafic rocks occur as isolated boudinaged sills, thin layers and enclaves. Leucogranite, syenite and tonalite plutons are later intrusions that crosscut fabrics in other units. Pre-, to posttectonic granite, alkali-feldspar granite and alkali-feldspar quartz syenite pegmatite intrude most units. The eastern margin of the Ashuanipi Complex is unconformably overlain by siliciclastic sedimentary rocks of the Proterozoic Knob Lake Group of the Labrador Trough.

## GEOCHRONOLOGY OF THE EASTERN ASHUANIPI COMPLEX

The only radiometric dates reported for the map area are 2685.5 +2.3/-2.7 Ma (zircon) and 2649 ± 1.1 Ma (monazite) U–Pb ages from a tonalite of the Desliens igneous suite (Mortensen and Percival, 1987; Figure 3). Several other zircon and monazite U–Pb ages are available from other units in adjacent map areas of Labrador and Québec (Percival, 1991a, b; Simard *et al.*, 2015). Available geochronological data for the eastern Ashuanipi Complex are listed below:

- 3.4 to 2.7 Ga: age range of detrital zircons from metasedimentary rocks; indicates that deposition of sedimentary rocks and minor volcanic rocks was completed by *ca.* 2.7 Ga (Mortensen and Percival, 1987)
- 2.7 and 2.68 Ga: intrusion of tonalite, granodiorite, diorite and mafic rocks of the Desliens igneous suite (Percival, 1991a)
- 2.68 to 2.65 Ga: high-grade metamorphism, development of $S_1$ migmatitic fabric or foliation and intrusion of syn- to late-metamorphic garnet ± orthopyroxene-bearing granite and granodiorite diatexite (Mortensen and Percival, 1987)
- 2.65 to 2.63 Ga: post-peak metamorphic cooling (Percival and Gerard, 1988)
- 2.65 Ga: intrusion of posttectonic granite pegmatites and leucogranite (Percival, 1991b)
- 2.65 to 2.6 Ga: post-metamorphic thermal event resulting in new zircon crystallization in diatexite and new monazite growth in older gneisses (Chevè and Brouillette, 1992)

## GEOLOGY

The geology of NTS map sheets 23J/04, 05, 06, 07, 10, 11, 14 and 23O/03 is comparable to the 2016 map area and the reader is referred to van Nostrand and Bradford (2014), van Nostrand (2015) and van Nostrand *et al.* (2016) for further discussion of the geology and description of rock units.

The map area consists of paragneiss, orthogneiss, diatexite, diorite, gabbro, pyroxenite, mafic dykes, granitoid plutons and pegmatite (Figure 3). The oldest rock type is migmatitic orthopyroxene ± garnet + melt paragneiss. The gneisses are intruded by tonalite to minor diorite of the Desliens igneous suite and gabbro–pyroxenite sills, which predate granulite-facies metamorphism and $D_1$ deformation. Extensive syn- to late-$D_2$ sedimentary-derived, orthopyroxene ± garnet diatexite (Percival, 1991a) underlies approximately 65% of the map area. These rocks are intruded by late-$D_2$, massive to foliated granite and tonalite and granite to alkali-feldspar granite pegmatite veins. Proterozoic gabbro dykes postdate all rock types in the area.

## DESCRIPTION OF ROCK UNITS

### Unit Apgn – Paragneiss

Paragneiss underlies km- to 100s of m-scale areas, and occur as abundant 10s of m- to cm-scale enclaves within all other units, with the exception of late gabbro dykes. The rocks are well-banded migmatitic gneisses consisting of variably developed cm- to 10s of cm-wide layers of alternating biotite + orthopyroxene ± garnet-rich melanosome and quartz-feldspar ± orthopyroxene ± garnet leucosome (Plates 1 and 2). The development of an orthopyroxene-bearing $S_1$ migmatitic layering indicates these rocks predate granulite conditions and $D_1$ deformation.

### Unit Atgn – Tonalite–Quartz Diorite to Diorite (Desliens Igneous Suite)

The rocks of the Desliens igneous suite occur as a 500-km-long belt of pretectonic tonalite to diorite intrusions underlying the southern margin of the Ashuanipi Complex and the western termination of the Opinaca subprovince (Percival, 1991a; Percival *et al.*, 2003; Figure 2B). On the basis of similar field relationships and textures, the authors suggested that gabbro–pyroxenite sills may be mafic end-members of this suite of rocks. In the map area, rocks of this suite occur as irregular-shaped, km-scale plutons, outcrop-scale intrusions and thin sills in paragneiss, and abundant enclaves in diatexite and granitoid rocks. The rocks are

**Plate 1.** *Representative texture of well-banded migmatitic paragneiss (Unit Apgn). Hammer is 33 cm in length.*

**Plate 2.** *Enclave of well-banded garnet–orthopyroxene migmatitic paragneiss (Unit Apgn) enclosed within coarse-grained, homogeneous garnet–orthopyroxene diatexite (Unit Adxhg). Scale card is 8 cm in length.*

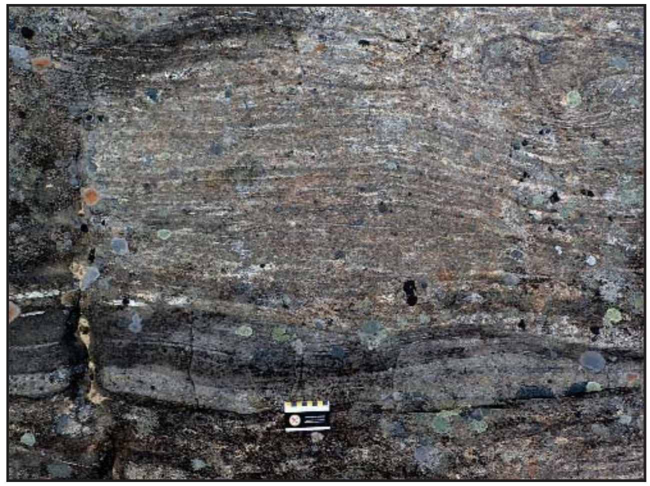


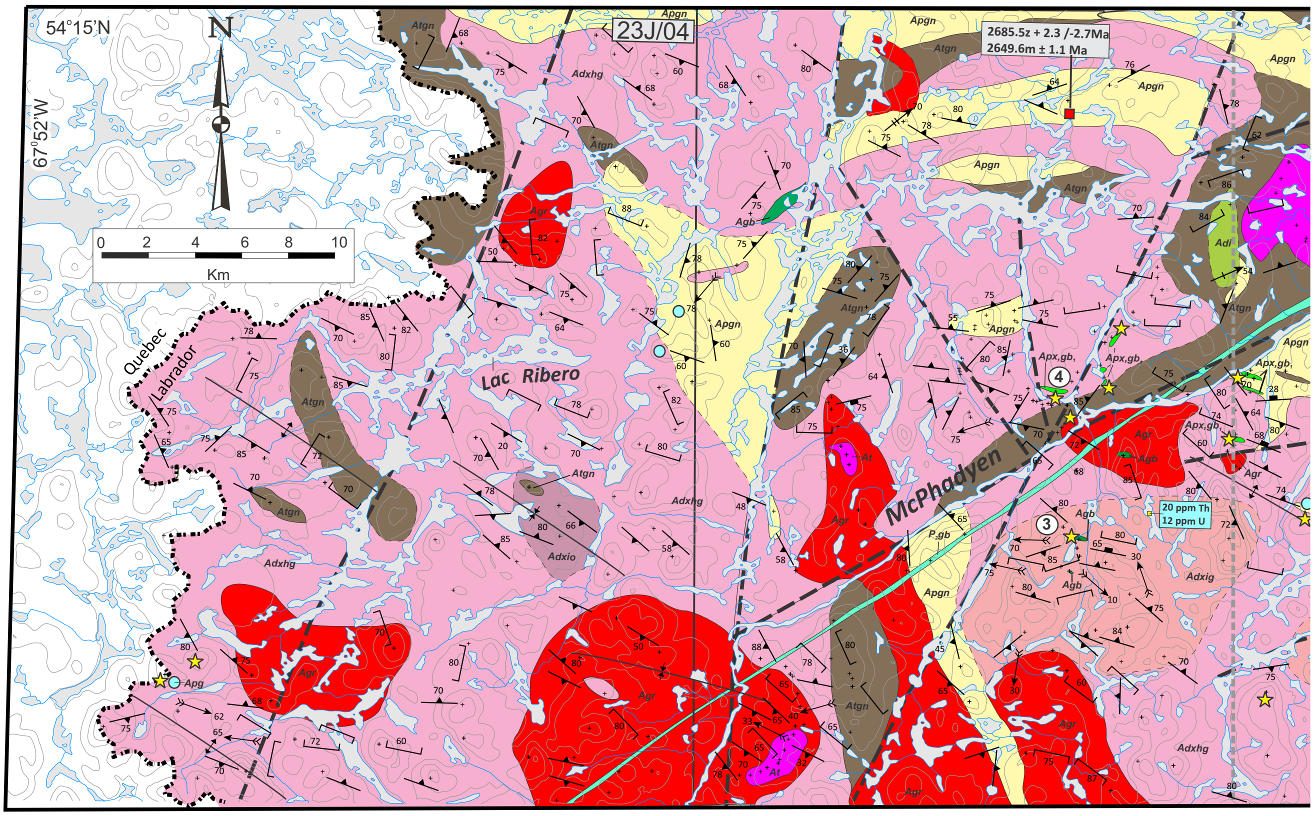
**Plate 3.** *Well-banded, mafic-rich tonalite of the Desliens igneous suite (Unit Atgn). The concordant, dark-grey-weathering layer in the bottom of the photo may be an early, concordant mafic dyke. Scale card is 8 cm in length.*

**Plate 4.** *Strongly foliated, leucocratic tonalite of the Desliens igneous suite (Unit Atgn). Scale card is 8 cm in length.*

dominated by tonalite and minor diorite, and are fine to medium grained, grey- to white-weathering, massive to gneissic and contain ubiquitous orthopyroxene + biotite + magnetite ± rare garnet assemblages. They vary from having a mafic mineral-rich, heterogeneous, well-banded migmatitic layering (Plate 3) to a leucocratic, strongly foliated texture (Plate 4) to a massive and homogeneous rock in which the presence of inclusion-rich orthopyroxene crystals are interpreted as relict igneous oikocrysts (Percival, 1991a; van Nostrand *et al.*, 2016; Plate 5). Oikocrysts are absent in gneissic rocks but metamorphic orthopyroxene occurs in the melanosome component.

### Units Agb and Apx – Layered Gabbro–Ultramafic Rocks

Gabbro and pyroxene-rich ultramafic rocks occur as isolated bodies within gneissic rocks and foliated pretectonic tonalite and as enclaves in diatexite and granitoid rocks. The contacts of these intrusions are concordant with the $S_1$ fabric in adjacent rocks and locally exhibit fine-grained chilled or sheared margins. Igneous layering is present as alternating cm- to m-scale, fine- to coarse-grain size and gradational to abrupt changes in proportions of pyroxene ±




## LEGEND

### NEOPROTEROZOIC ?

$P_2gb$ Green- to grey-weathering, gabbro to diabase dyke

### PALEOPROTEROZOIC

New Québec Orogen (Labrador Trough)

$P_1t$ Undifferentiated sedimentary and igneous rocks of the New Québec Orogen (Labrador Trough)

$P_1w$ Wishart Formation. Quartz arenite, arenite, siltstone, shale and black chert

### ARCHEAN

Agr Homogeneous, medium-grained, massive to weakly foliated biotite ± hornblende leucogranite, grades locally to granodiorite

At Homogeneous, medium- to coarse-grained, massive to weakly foliated biotite ± hornblende + magnetite tonalite

Adxio Heterogenous, orthopyroxene-dominant diatexite; migmatitic gneiss; foliated granitoid rocks

Adxig Heterogeneous, garnet-dominant diatexite; migmatitic gneiss; foliated granitoid rocks

Adxhg Homogenous, garnet-dominant diatexite; migmatitic gneiss; foliated granitoid rocks

Adi Dark-green- to grey-weathering, massive to strongly foliated, diorite to locally quartz diorite

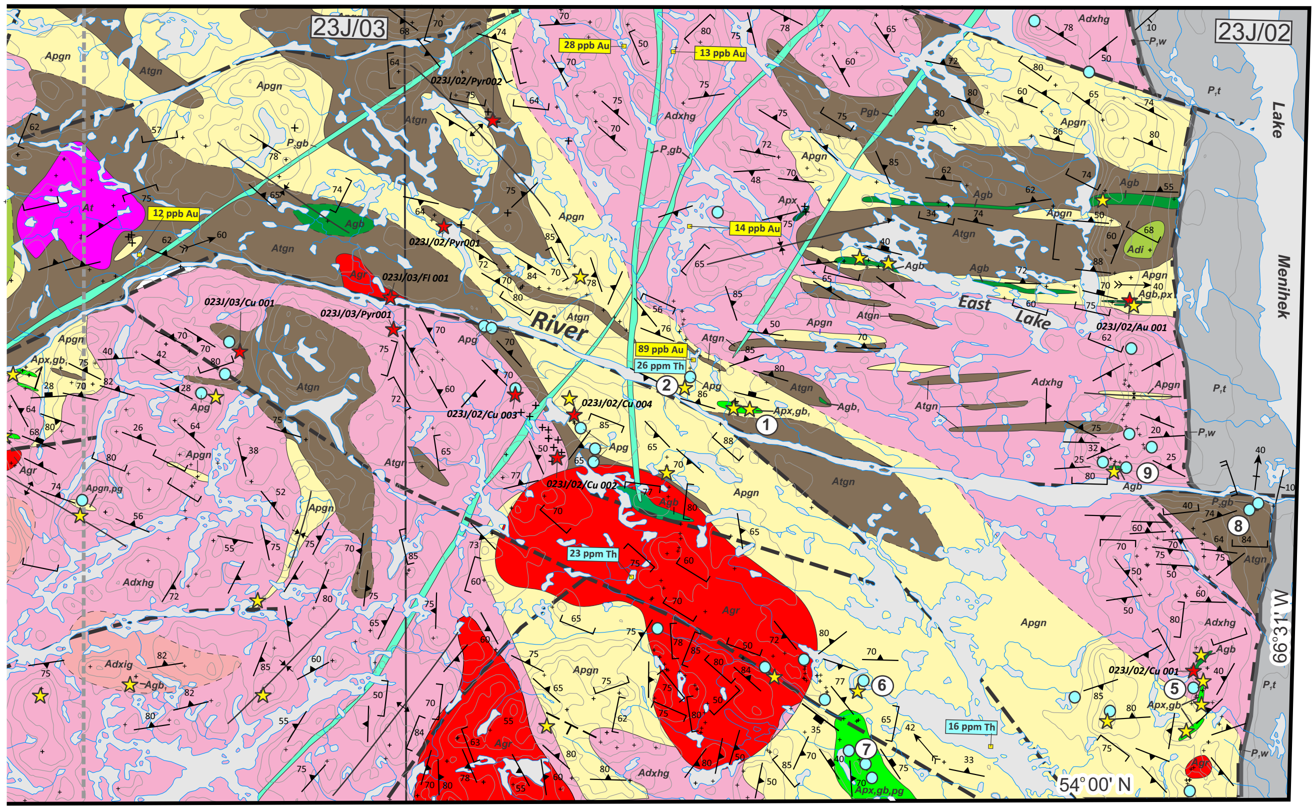
Agb Green-weathering, massive to foliated gabbro. Occurs as m- to 10s of m-scale layers within layered cumulate pyroxenite-gabbro sill boudins and map-scale intrusions

Apx Dark-green- to black-weathering, massive to strongly foliated, locally layered pyroxenite and subordinate melagabbro

Atgn Grey-, white-, brown-, to cream-weathering, massive to gneissic orthopyroxene-bearing tonalite, granodiorite, quartz diorite and minor diorite

Apgn White-, cream-, honey-brown-, dark-brown-, to grey-weathering, garnet+biotite+orthopyroxene migmatitic metasedimentary gneiss

**Figure 3.** *Preliminary geology of the 2016 study area; NTS map areas 23J/02, 23J/03 and part of 23J/04.*




## SYMBOLS

| | |
|---|---|
| Provincial boundary | Antiform structure ($F_2$ plunge direction unknown) |
| Geological contact (approximate, assumed) | Synform structure ($F_2$ plunge direction unknown) |
| | Antiform structure ($F_2$ plunge direction assumed) |
| Bedding (Wishart Formation) | Regional $S_1$ fabric trend (Figure 5) |
| Local, primary igneous layering in mafic and ultramafic rocks. Defined by cm- to m-scale layers of variation in mineral proportions | Outcrop data station |
| $S_1$ gneissosity defined by alternating leucocratic and melanocratic layers in migmatitic gneiss, commonly accentuated by concordant and near-concordant injected granitoid rock veins. Symbols without dip angle are undetermined measurements | 23J/02/Cu001 MODS occurrence. M-scale gossan zones in paragneiss and gabbro-pyroxenite sills. Zones contain disseminated to very local semi-massive pyrrhotite ± bornite ± arsenopyrite ± trace chalcopyrite |
| $S_1$ foliation defined primarily by preferred alignment of mafic minerals in tonalite, diatexite, variably deformed granitoid rocks and mafic and ultramafic rocks | New mineral indication. M- to 10s of metre-scale gossan zone in paragneiss, gabbro and pyroxene-rich ultramafic rocks, orthogneiss and granitoid rocks. Zones contain minor to disseminated pyrrhotite ± bornite ± arsenopyrite ± chalcopyrite mineralization |
| Second-generation, minor $F_2$ fold axis plunge direction. Developed predominantly in migmatitic gneiss, diatexite and coarse granite and alkali feldspar granite veins | Apg Anomalous radioactivity (Th, U) signature in pegmatite with > 1000 total counts per second measured by portable scintillometer |
| Second-generation $L_2$ lineation (plunge direction defined by aligned minerals or sliken striae) | 1 New mineral indication location referenced in text and Figure 3 |
| Brittle to ductile fault structure. Defined in part by brittle fault breccia and ductile features including lineations and offset features | 89 ppb Au / 26 ppm Th Anomalous lake-sediment values |
| Unconformity between Archean rocks of the Ashuanipi Complex and siliciclastic rocks of the Paleoproterozoic New Québec Orogen (Labrador Trough). Symbol is white on Figure 4 | 2685.5z + 2.3 /-2.7Ma 2649.6m ± 1.1 Ma U-Pb zircon (z) and monazite (m) ages of tonalite of the Desliens igneous suite (Mortensen and Percival, 1988) |

**Figure 3.** *Continued.*

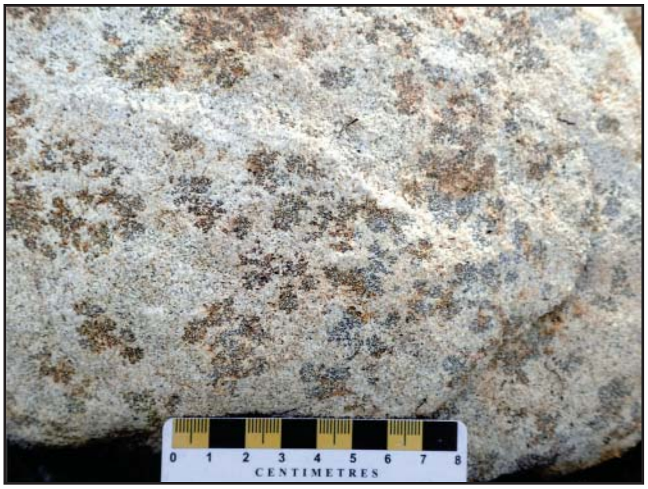



**Plate 5.** *Massive, homogeneous tonalite of the Desliens igneous suite (Unit Atgn). Dark patches are interpreted as relict igneous orthopyroxene crystals along with numerous quartz and biotite inclusions.*

olivine and plagioclase; therefore indicating these are cumulate sills (Plate 6). The rocks are variably deformed and have massive textures in the interior parts of larger intrusions (Plate 7), and are strongly foliated near the contacts with other cumulate layers or adjacent rock types (Plate 8). These bodies have variable strike directions and range from 10 to 200 m wide and up to 200 m in length. These rocks occur as discontinuous bodies having tapered, locally sheared terminations suggesting that they are boudinaged sills (Plate 9). In the eastern part of the map area, semi-continuous, gabbro ± pyroxenite bodies are interpreted as boudinaged fragments of a larger sill forming a northeast-plunging syncline with the fold closure wrapping around the western end of East lake (informal name; Figure 3), although the hinge zone is partially obscured by diatexite and tonalite gneiss. Most of the mafic–ultramafic intrusions in the map area host m- to locally 10s of m-scale, gossan zones that occur primarily within and along the contacts of gabbro layers (*see* Mineralization Section).

### Unit Adi – Diorite

Massive to moderately foliated hornblende + biotite + magnetite diorite occurs as two map-scale intrusions (Figure 3) and as m- to 10s of m-scale xenoliths within diatexite and late granite. The lack of a strong fabric or evidence of

**Plate 7.** *Coarse-grained, massive, homogeneous pyroxenite (Unit Apx) typical of the interiors of the larger mafic–ultramafic sill boudins in the map area. The grey-weathering grains are relict subhedral orthopyroxene crystals. Scale card is 8 cm in length.*

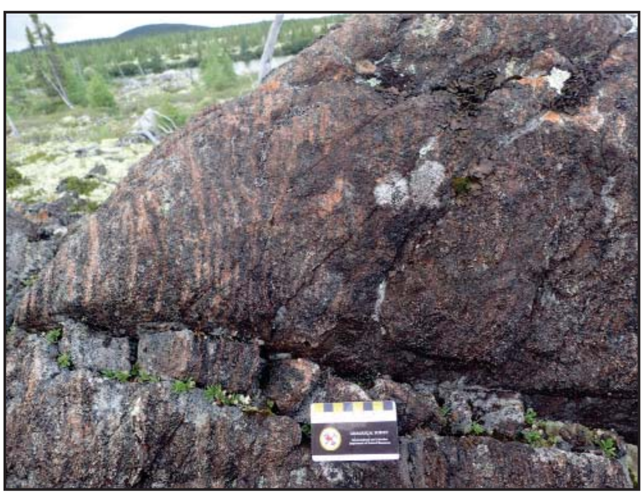


**Plate 6.** *Steeply dipping, igneous layering in ultramafic rock. Layering is defined by alternating dark-green pyroxene-rich layers and reddish-brown, plagioclase + olivine layers. Scale card is 8 cm in length.*

**Plate 8.** *Strongly foliated pyroxenite layer typical of the marginal zones of boudinaged mafic–ultramafic sills. Scale card is 8 cm in length.*

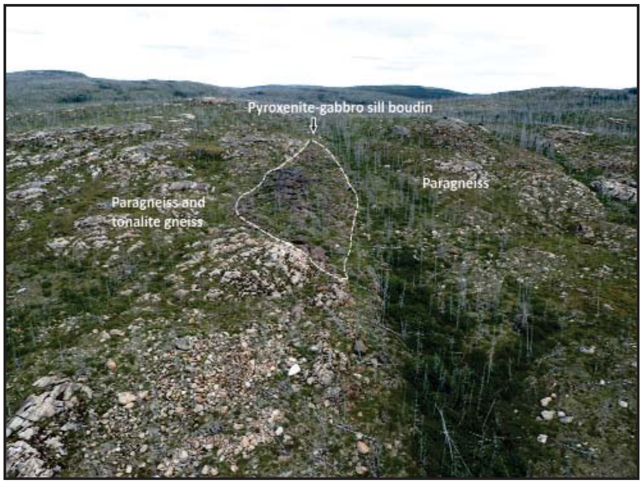



**Plate 9.** *Aerial view of a northwest-striking, gabbro–pyroxenite sill boudin (outlined by white dashed line) enclosed by well-banded paragneiss and foliated to gneissic tonalite. The boudin is approximately 150 m long by 50 m wide.*

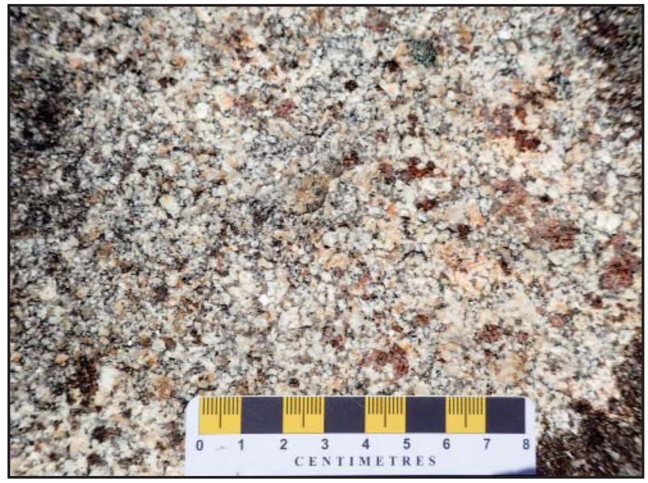



**Plate 10.** *Representative texture of homogeneous garnet-dominant diatexite (Unit Adxhg).*

migmatization in these rocks suggest they postdate dioritic rocks of the Desliens igneous suite.

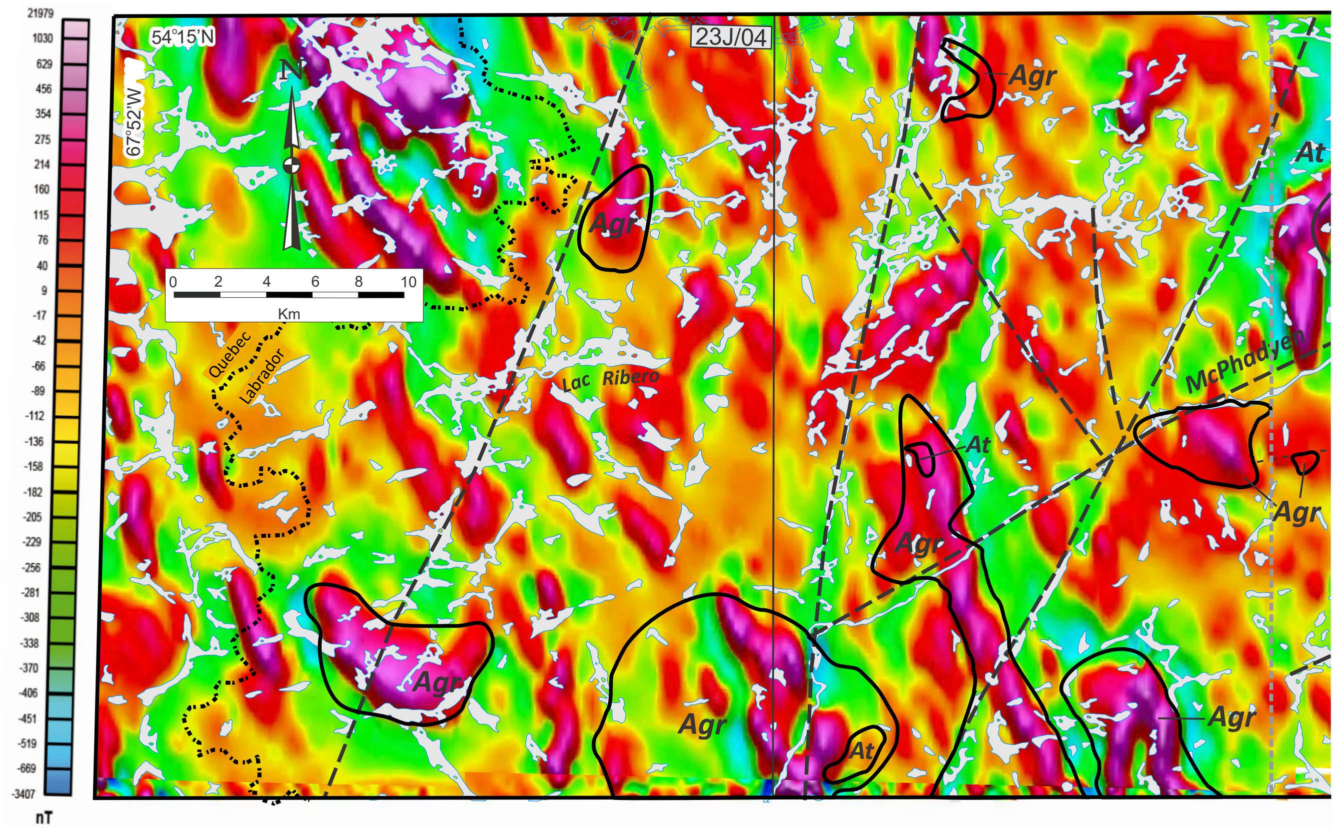
### Units Adxhg, Adxig and Adxio – Diatexite

Diatexite underlies most of the map area and is divided primarily on the basis of the dominance of either garnet or orthopyroxene. The proportion of enclaves of older rocks (<25% and >25% enclave content) is used to subdivide the diatexite into homogeneous and inhomogeneous types, respectively (Percival, 1991a; van Nostrand and Bradford, 2014). The predominant type is homogeneous garnet-dominant diatexite (Unit Adxhg) having 5 to 15% paragneiss, orthogneiss, foliated tonalite, gabbro and ultramafic enclaves. The rock varies from white-, pink-, grey-, or rusty-brown-weathering, medium to coarse grained, massive to weakly foliated and contains 5 to 20% garnet and up to 10% orthopyroxene (Plate 10). Inhomogeneous, garnet-dominant diatexite (Unit Adxig) differs only in the proportion of enclaves at the outcrop scale (Plate 11). Orthopyroxene-dominant diatexites (Units Adxho and Adxio) form subordinate diatexite types and occur as a few map-scale units in the western map area and as outcrop-scale veins and 10s of m-scale intrusions (Plate 12). Identical rocks in adjacent areas of the Ashuanipi Complex have been discussed in detail elsewhere by Percival (1991a, b); Percival *et al.* (1992); Guernina (2007); Simard *et al.* (2015); van Nostrand and Bradford (2014) and van Nostrand *et al.* (2016) and the reader is referred to these studies for detailed descriptions of textures, geochemistry, geochronology and interpretation of these migmatitic rocks.

**Plate 11.** *Inhomogeneous garnet-dominant diatexite (Unit Adxig) having 50% well-banded paragneiss enclaves (Unit Apgn). Hammer is 33 cm in length.*

### Unit At – Tonalite

Massive to weakly foliated tonalite occurs as a km-scale pluton in the central map area and as map-, and outcrop-scale enclaves within later granite intrusions in the southwestern map area (*see* Unit Agr below and Figure 3). The tonalite varies from massive to weakly foliated, white-, grey- to brown-weathering, medium to coarse grained, and contains 10–20% subhedral hornblende + biotite + magnetite (Plate 13). The pluton is coincident with a part of a high-strength aeromagnetic signature although its effect may be masked by foliated to gneissic, mafic-mineral-rich tonalite of the Desliens igneous suite and a diorite intrusion that underlie most of the large positive magnetic anomaly (Figures 3 and 4).




## LEGEND

### NEOPROTEROZOIC ?

| | |
|---|---|
| $P_2gb$ | Green- to grey-weathering, gabbro to diabase dyke |

### PALEOPROTEROZOIC

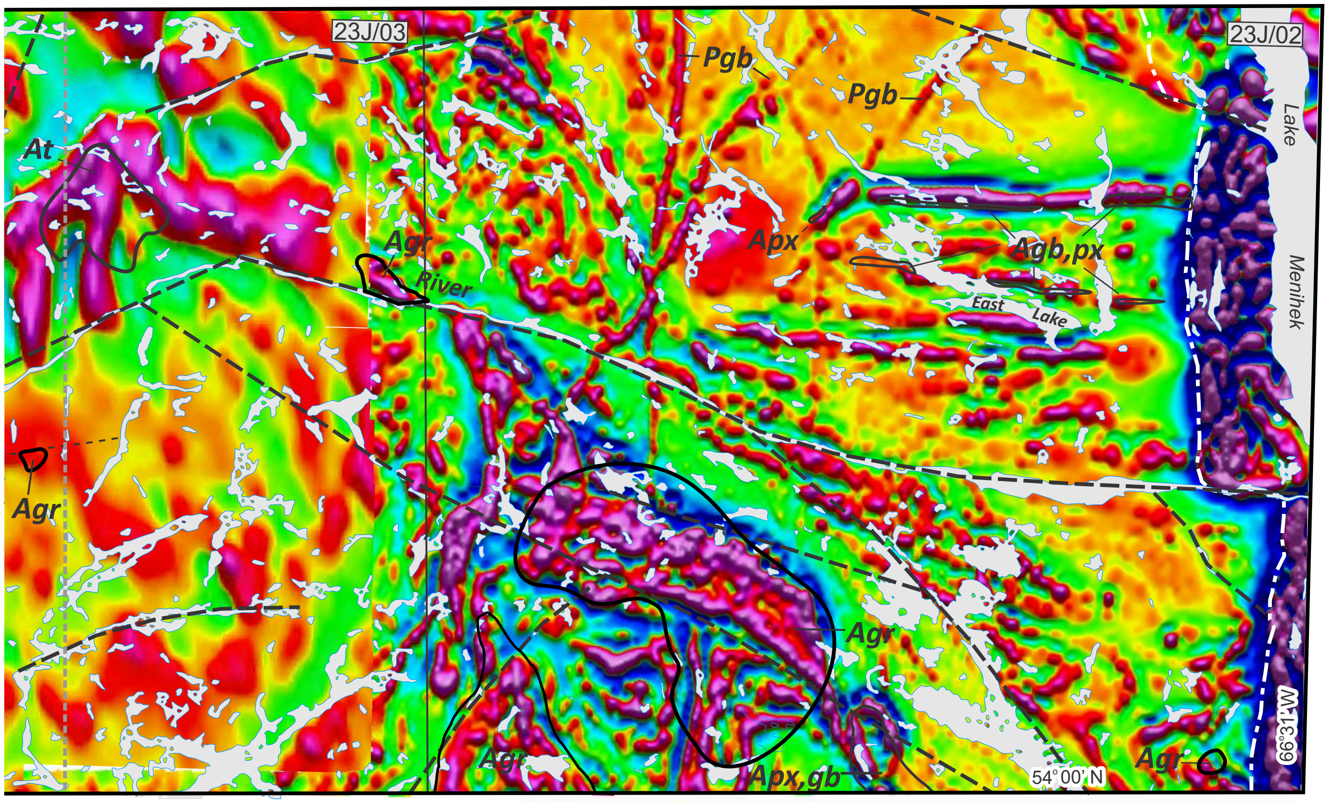
New Québec Orogen (Labrador Trough)

| | |
|---|---|
| $P_1t$ | Undifferentiated sedimentary and igneous rocks of the New Québec Orogen (Labrador Trough) |
| $P_1w$ | Wishart Formation. Quartz arenite, arenite, siltstone, shale and black chert |

### ARCHEAN

| | |
|---|---|
| Agr | Homogeneous, medium-grained, massive to weakly foliated biotite ± hornblende leucogranite, grades locally to granodiorite |
| At | Homogeneous, medium- to coarse-grained, massive to weakly foliated biotite ± hornblende + magnetite tonalite |
| Adxio | Heterogenous, orthopyroxene-dominant diatexite; migmatitic gneiss; foliated granitoid rocks |
| Adxig | Heterogeneous, garnet-dominant diatexite; migmatitic gneiss; foliated granitoid rocks |
| Adxhg | Homogenous, garnet-dominant diatexite; migmatitic gneiss; foliated granitoid rocks |
| Adi | Dark-green- to grey-weathering, massive to strongly foliated, diorite to locally quartz diorite |
| Agb | Green-weathering, massive to foliated gabbro. Occurs as m- to 10s of m-scale layers within layered cumulate pyroxenite-gabbro sill boudins and map-scale intrusions |
| Apx | Dark-green- to black-weathering, massive to strongly foliated, locally layered pyroxenite and subordinate melagabbro |
| Atgn | Grey-, white-, brown-, to cream-weathering, massive to gneissic orthopyroxene-bearing tonalite, granodiorite, quartz diorite and minor diorite |
| Apgn | White-, cream-, honey-brown-, dark-brown-, to grey-weathering, garnet+biotite+orthopyroxene migmatitic metasedimentary gneiss |

**Figure 4.** *Aeromagnetic compilation of the 2016 map area. Outlines of late tonalite (Unit At) and granite (Unit Agr) plutons, as well as gabbro dykes (Unit $P_2gb$) and map-scale mafic–ultramafic bodies (Unit Agb,px) are shown to illustrate the coincidence with magnetic signatures. The figure is modified after Kilfoil (2013) and Coyle and Kiss (2011).*




## SYMBOLS

Provincial boundary

Geological contact (approximate, assumed)

Bedding (Wishart Formation)

Local, primary igneous layering in mafic and ultramafic rocks. Defined by cm- to m-scale layers of variation in mineral proportions

$S_1$ gneissosity defined by alternating leucocratic and melanocratic layers in migmatitic gneiss, commonly accentuated by concordant and near-concordant injected granitoid rock veins. Symbols without dip angle are undetermined measurements

$S_1$ foliation defined primarily by preferred alignment of mafic minerals in tonalite, diatexite, variably deformed granitoid rocks and mafic and ultramafic rocks

Second-generation, minor $F_2$ fold axis plunge direction. Developed predominantly in migmatitic gneiss, diatexite and coarse granite and alkali feldspar granite veins

Second-generation $L_2$ lineation (plunge direction defined by aligned minerals or sliken striae)

Brittle to ductile fault structure. Defined in part by brittle fault breccia and ductile features including lineations and offset features

Unconformity between Archean rocks of the Ashuanipi Complex and siliciclastic rocks of the Paleoproterozoic New Québec Orogen (Labrador Trough). Symbol is white on Figure 4

Antiform structure ($F_2$ plunge direction unknown)

Synform structure ($F_2$ plunge direction unknown)

Antiform structure ($F_2$ plunge direction assumed)

Regional $S_1$ fabric trend (Figure 5)

Outcrop data station

23J/02/Cu001 — MODS occurrence. M-scale gossan zones in paragneiss and gabbro-pyroxenite sills. Zones contain disseminated to very local semi-massive pyrrhotite ± bornite ± arsenopyrite ± trace chalcopyrite

New mineral indication. M- to 10s of metre-scale gossan zone in paragneiss, gabbro and pyroxene-rich ultramafic rocks, orthogneiss and granitoid rocks. Zones contain minor to disseminated pyrrhotite ± bornite ± arsenopyrite ± chalcopyrite mineralization

Apg — Anomalous radioactivity (Th, U) signature in pegmatite with > 1000 total counts per second measured by portable scintillometer

1 — New mineral indication location referenced in text and Figure 3

89 ppb Au / 26 ppm Th — Anomalous lake-sediment values

2685.5z + 2.3 /-2.7Ma / 2649.6m ± 1.1 Ma — U-Pb zircon (z) and monazite (m) ages of tonalite of the Desliens igneous suite (Mortensen and Percival, 1988)

**Figure 4.** *Continued.*

**Plate 12.** *Orthopyroxene-dominant diatexite vein (Unit Adxio) intruding strongly foliated tonalite (Unit Atgn) of the Desliens igneous suite. Pencil is 18 cm in length.*

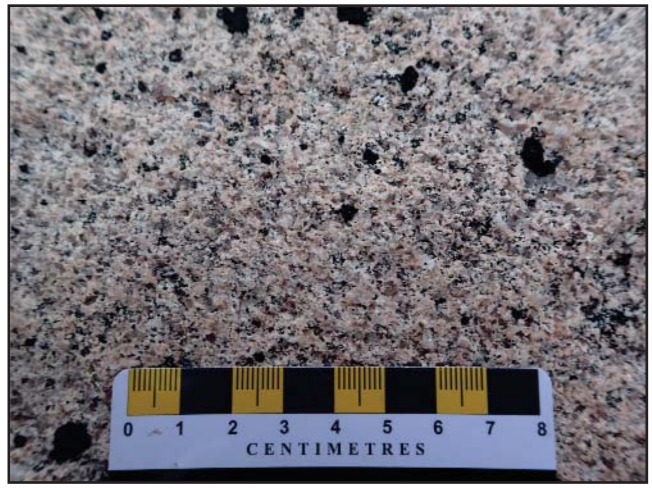



**Plate 14.** *Medium-grained, pink-weathering, biotite + magnetite granite (Unit Agr).*


**Plate 13.** *Medium-grained, massive to weakly foliated hornblende + biotite tonalite (Unit At).*

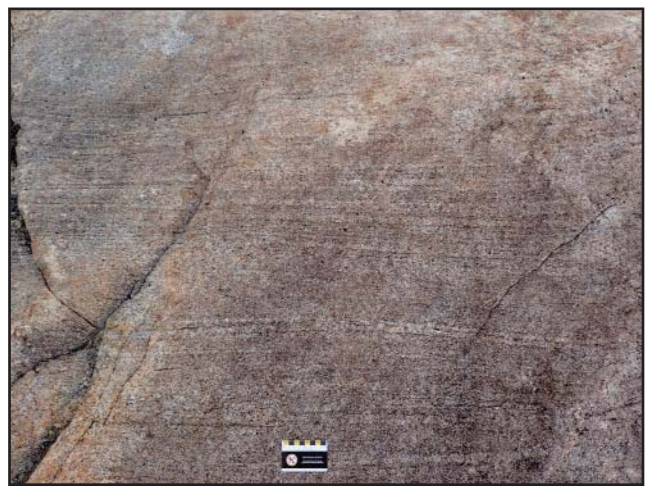


**Plate 15.** *Igneous layering in biotite granite (Unit Agr). Layering is defined by alternating biotite + magnetite-rich and quartz + feldspar-rich layers. Scale card is 8 cm in length.*

### Unit Agr – Granite

Granite occurs as km-scale, irregular- to circular-shaped plutons and veins crosscutting late tonalite (Unit At). The larger granite intrusions are coincident with moderate to high-strength aeromagnetic signatures (Figures 3 and 4). The granite varies from white-, pink-, to buff-weathering, fine to medium grained, massive to locally weakly foliated, homogeneous and contains 5 to 15% biotite + magnetite ± minor hornblende (Plate 14). Local foliations are limited to marginal zones of these intrusions. Igneous layering occurs locally in the large circular-shaped intrusion southeast of Lac Ribero (Figure 3). The layering is defined by alternating, cm-scale biotite + magnetite-rich and quartz + feldspar-rich segregations (Plate 15). Field relationships in several areas indicate that the granite (Unit Agr) postdates the foliated tonalite (Unit At; Plate 16).

### Unit Apg – Pegmatite

Granite, alkali-feldspar granite and subordinate alkali-feldspar–quartz–syenite–pegmatite occurs as abundant veins and small intrusions throughout the map area. These rocks range from concordant, strongly deformed and boudinaged to discordant and relatively undeformed with respect to the $S_1$ fabric in the host rock and indicates at least two generations of pegmatite are present (Plate 17). The pegmatites range from coarse to very coarse grained, strongly deformed to massive, white-, buff-, grey-, to pink-weathering and contain quartz, alkali feldspar + minor plagioclase +


**Plate 16.** *Pink-weathering biotite granite vein (Unit Agr) intruding weakly foliated hornblende + biotite tonalite (Unit At). Hammer is 33 cm in length.*

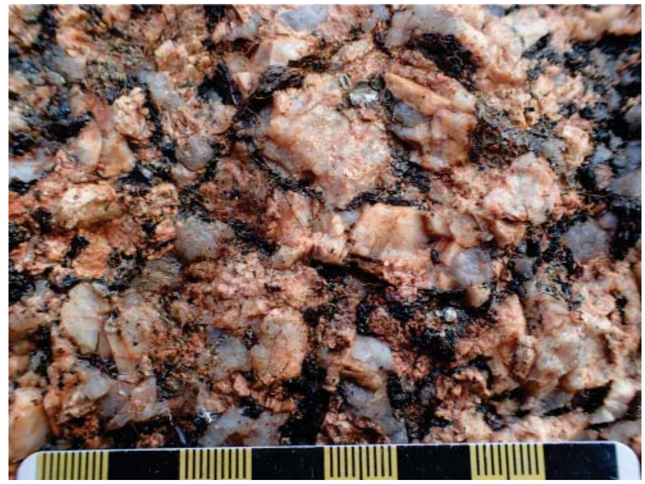


**Plate 18.** *Close-up of leucocratic pegmatite containing quartz + alkali-feldspar + biotite + allanite. Scale card is 8 cm in length.*


**Plate 17.** *Concordant and discordant pegmatite veins intruding moderately banded paragneiss. Scale card is 8 cm in length.*

magnetite ± Fe–Ti-oxides ± garnet ± orthopyroxene ± biotite ± allanite ± monazite (Plate 18). Several pegmatites record local, elevated to anomalous scintillometer readings suggesting that these rocks may have potential to host U, Th and rare-earth-element mineralization (*see* New Radioactive Indications section below).

### Mafic Dykes

Fine-grained, weak to strongly deformed, 1- to 3-m-wide mafic dykes observed in several localities postdate gneissic rocks, gabbro, pyroxenite and diatexite. At least two generations are present. Strongly deformed and boudinaged mafic mineral-rich layers in gneissic rocks in some areas are locally interpreted as pre-$D_1$ dykes (Plate 19). Other mafic dykes are weakly deformed, have local, sharp chilled contacts and are discordant to the main $S_1$ fabric in the host rock suggesting these are young intrusions (Plate 20).

## PROTEROZOIC ROCKS

Proterozoic rocks within the map area include sedimentary rocks of the Wishart Formation (Unit $P_1$w, Figure 3) of the Labrador Trough and late gabbro dykes (Wardle, 1979, 1982a, b; van Nostrand and Bradford, 2014; Unit $P_2$gb, Figure 3). Un-subdivided rocks of the Labrador Trough are labelled as Unit $P_1$t on Figure 3.

### Unit $P_1$w – Wishart Formation

Well-bedded, shallow-dipping arenite to quartz arenite of the Wishart Formation were mapped in a few localities


**Plate 19.** *Fine-grained, folded and boudinaged mafic dyke intruding well-banded paragneiss and diatexite. Scale card is 8 cm in length.*

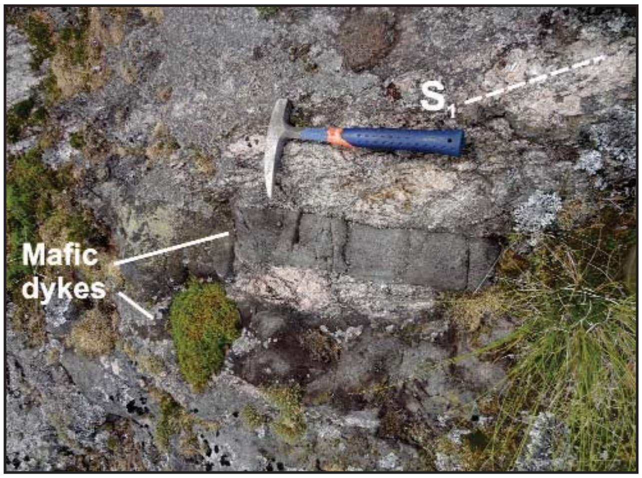



**Plate 20.** *Fine-grained, mafic dyke discordant to the $S_1$ fabric in moderate to strongly foliated diatexite. Hammer is 33 cm in length.*

adjacent to the Archean–Proterozoic unconformity (Plate 21). The unconformity is not exposed in the map area although the position is delineated primarily on the basis of aeromagnetic data (Figure 4), adjacent outcrops and aerial photograph features.

**Unit $P_2$gb – Gabbro Dykes (Mary Jo Diabase Dykes)**

Four, north- to northeast-striking gabbro dykes postdate all rock units in the map area (Figure 3) and cut across the Archean–Proterozoic unconformity (Wardle, 1982a, b; van Nostrand and Bradford, 2014). Leech *et al.* (1963) and Wanless *et al.* (1968) reported K–Ar ages of 1255 ± 52 Ma and 1145 ± 104 Ma for these dykes, and interpreted these dates as intrusion ages. The dykes are coincident with strong linear aeromagnetic signatures and warrant extrapolating these rocks along strike (Figures 3 and 4). They range from 50 to 150 m wide and have well-developed chilled margins against the host rock (Plate 22). The gabbro is fine to medium grained, massive, homogeneous, grey- to brown-weathering, equigranular and has a well-developed subophitic texture. South of the mouth of the McPhadyen River, fine-grained, 5- to 10-cm-wide, north-northeast-striking mafic dykes postdate strongly foliated tonalite and late pegmatite. These dykes are correlated with the larger dykes of the Mary Jo diabase dykes, based on the similar field relationships, orientation and unaltered mineralogy (Plate 23).

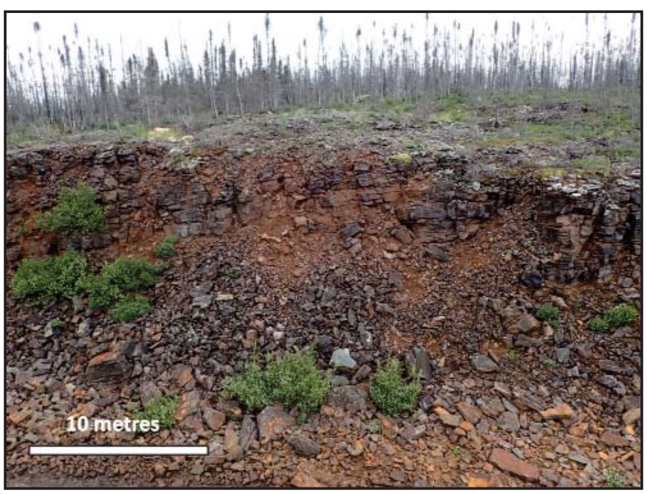



**Plate 21.** *Shallow-dipping bedding in arenite to quartz arenite of the Wishart Formation, Labrador Trough, New Québec Orogen. Outcrop is located 50 m east of gneissic rocks of the Ashuanipi Complex.*

**Plate 22.** *Contact of northeast-striking Proterozoic dyke (Unit $P_2$gb, Mary Jo diabase dykes) intruding garnet-dominant diatexite (Unit Adxhg). Hammer is 42 cm in length.*

## METAMORPHISM

The metamorphic evolution of the map area and adjacent regions in Labrador and Québec has been discussed by Percival (1987, 1991a, b), Percival *et al.* (1992, 2003), Guernina and Sawyer (2003), Guernina (2007), Simard *et al.* (2015), van Nostrand and Bradford (2014) and van Nostrand *et al.* (2016).

The widespread presence of coexisting orthopyroxene + Fe–Ti-oxides ± garnet ± melt assemblages in several rock types indicates that granulite-facies conditions prevailed throughout the map area. Field relationships indicate that development of the diatexite postdated the formation of orthopyroxene in the leucosome of older paragneiss and tonalite gneiss during $D_1$ deformation (Plate 24). Orthopyroxene-bearing diatexite and some pegmatites are folded about $F_2$ axes throughout the area, indicating that their

**Plate 23.** *Fine-grained, 4- to 6-cm-wide, northeast-striking gabbro dykes intruding foliated tonalite of the Desliens igneous suite. Located immediately south of the mouth of the McPhadyen River. These dykes are correlated with the 10s to 100s of m-wide Proterozoic dykes (Mary Jo diabase dykes) in Figure 3. Hammer is 33 cm in length.*

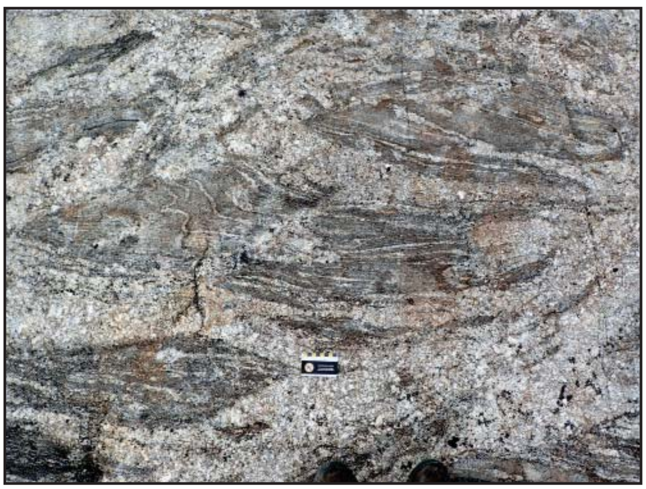


**Plate 24.** *Preferentially aligned paragneiss enclaves in garnet-dominant diatexite. The alignment of enclaves is interpreted as a $D_2$ structural feature. Scale card is 8 cm in length.*

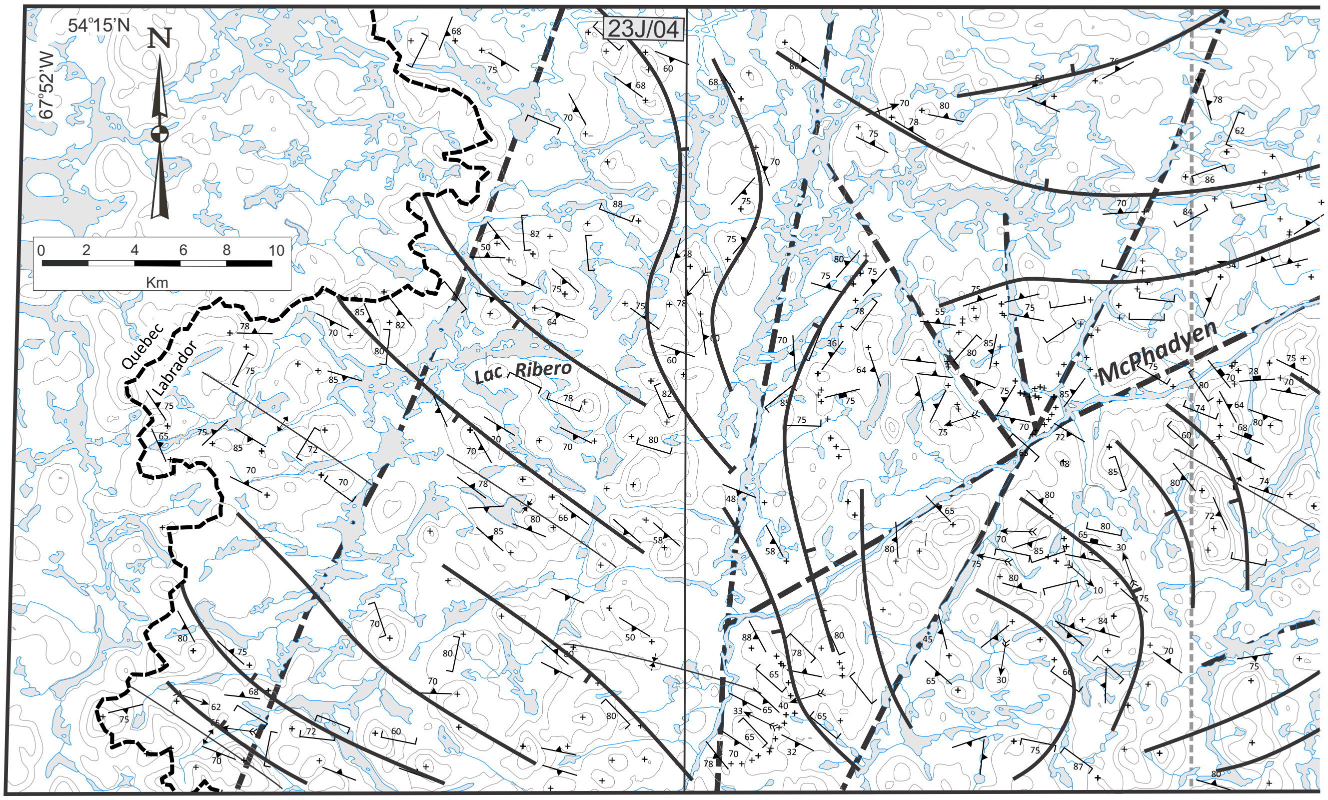
emplacement is constrained to syn- to late peak metamorphic conditions during $D_2$ deformation. Based on these observations, granulite-facies metamorphism is interpreted to have persisted through both $D_1$ and $D_2$ events. Percival (1991b) reported geothermobarometric estimates of orthopyroxene and garnet-bearing assemblages in paragneiss and diatexite ranging from 750 to 800°C and 3.5 to 6.5 kbar immediately north of the 2016 map area. Local retrogression to amphibolite facies is evidenced by the presence of amphibole ± chlorite assemblages in brittle fault zones and adjacent to the margins of some granite plutons.

## STRUCTURE

The earliest Archean structures recognized are preserved igneous layering ($S_0$) in gabbro–pyroxenite sills (Plate 6). The earliest regional tectonic fabric is a $S_1$ migmatitic layering in paragneiss and orthogneiss and variably developed foliation in tonalite, gabbro, pyroxenite, diorite and diatexite. This was concomitant with the onset of regional granulite-facies metamorphism ($M_1$). These structures define the regional $D_1$ deformation. The $S_1$ planar structures are obscured by the effects of $F_2$ folding. Diatexite units contain near-ubiquitous cm- to m-scale enclaves of gneissic and mafic rocks that preserved a relict $S_1$ fabric and, in most outcrops, these enclaves are preferentially aligned parallel to the regional trend (Plate 24). Thus, the aligned enclaves can be considered $D_2$ features. The massive to weakly foliated texture of most diatexite and the presence of aligned gneissic enclaves suggest that diatexite is syntectonic with respect to $D_2$ deformation. Large-scale $D_2$ structures define the map pattern of units in the area. Diatexite was emplaced as sheets and plutons concordant to layering, prior to formation of $F_2$ folds. High-grade metamorphism persisted from $D_1$ migmatization through to the crystallization of orthopyroxene-bearing pegmatites late in the $D_2$ deformation. Second-generation folds ($F_2$) occur throughout the area as open to tight structures and have dominantly moderate to steep, north- to west-plunging axes (Plate 25). Reversals of plunge direction of large-scale $F_2$ synforms control the formation of dome and basin interference patterns. Variations in the competency of the tonalitic intrusions of the Desliens igneous suite result in the warping of the $F_2$ folds.

Figure 5 illustrates the main structural trends of the regional $S_1$ fabric in the map area. The eastern and western map areas are characterized by a dominant west- to north-

**Plate 25.** *Northwest-plunging $F_2$ fold of boudinaged diatexite vein intruding paragneiss. Scale card is 8 cm in length.*




## LEGEND

### NEOPROTEROZOIC ?

- **$P_2gb$** Green- to grey-weathering, gabbro to diabase dyke

### PALEOPROTEROZOIC

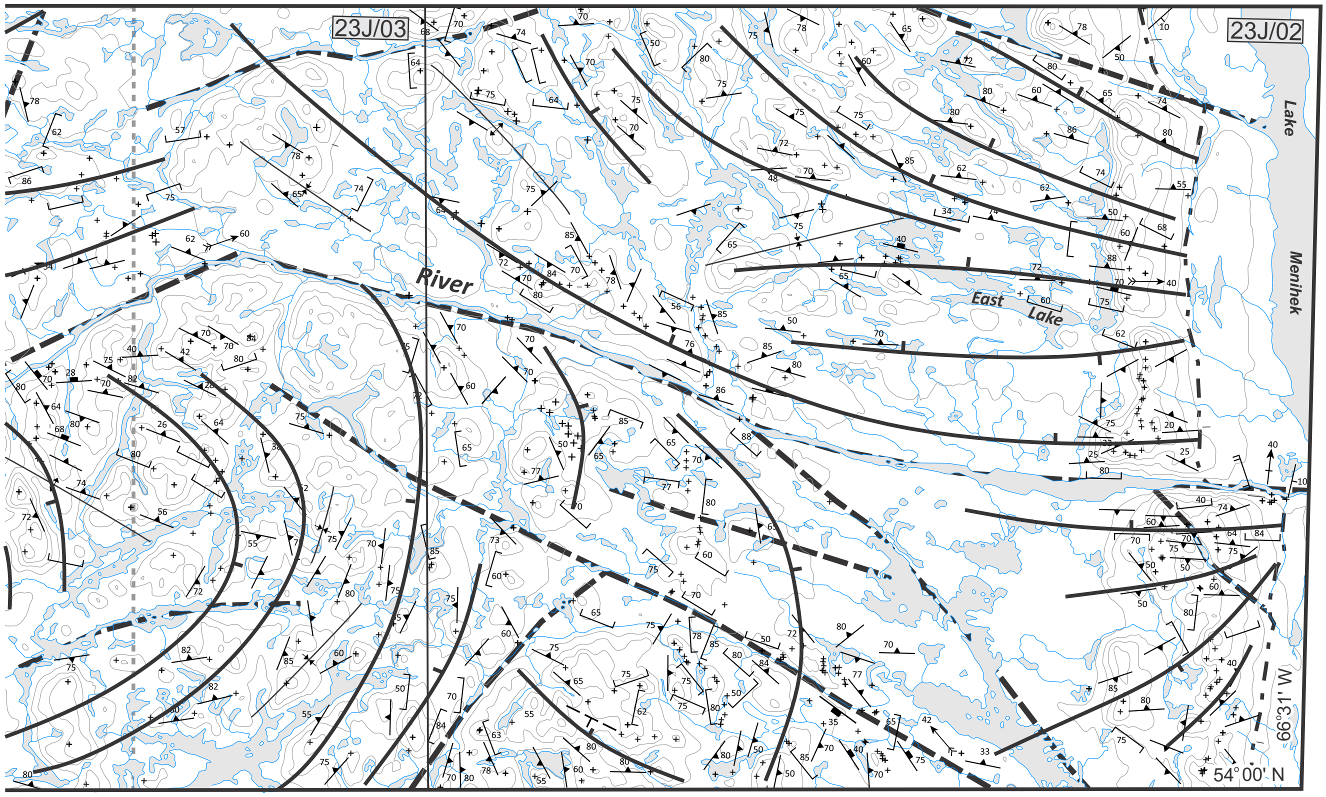
New Québec Orogen (Labrador Trough)

- **$P_1t$** Undifferentiated sedimentary and igneous rocks of the New Québec Orogen (Labrador Trough)
- **$P_1w$** Wishart Formation. Quartz arenite, arenite, siltstone, shale and black chert

### ARCHEAN

- **Agr** Homogeneous, medium-grained, massive to weakly foliated biotite ± hornblende leucogranite, grades locally to granodiorite
- **At** Homogeneous, medium- to coarse-grained, massive to weakly foliated biotite ± hornblende + magnetite tonalite
- **Adxio** Heterogenous, orthopyroxene-dominant diatexite; migmatitic gneiss; foliated granitoid rocks
- **Adxig** Heterogeneous, garnet-dominant diatexite; migmatitic gneiss; foliated granitoid rocks
- **Adxhg** Homogenous, garnet-dominant diatexite; migmatitic gneiss; foliated granitoid rocks
- **Adi** Dark-green- to grey-weathering, massive to strongly foliated, diorite to locally quartz diorite
- **Agb** Green-weathering, massive to foliated gabbro. Occurs as m- to 10s of m-scale layers within layered cumulate pyroxenite-gabbro sill boudins and map-scale intrusions
- **Apx** Dark-green- to black-weathering, massive to strongly foliated, locally layered pyroxenite and subordinate melagabbro
- **Atgn** Grey-, white-, brown-, to cream-weathering, massive to gneissic orthopyroxene-bearing tonalite, granodiorite, quartz diorite and minor diorite
- **Apgn** White-, cream-, honey-brown-, dark-brown-, to grey-weathering, garnet+biotite+orthopyroxene migmatitic metasedimentary gneiss

**Figure 5.** *Main $S_1$ structural trends in the 2016 NTS map areas 23J/02, 23J/03 and part of 23J/04.*




## SYMBOLS

- Provincial boundary
- Geological contact (approximate, assumed)
- Bedding (Wishart Formation)
- Local, primary igneous layering in mafic and ultramafic rocks. Defined by cm- to m-scale layers of variation in mineral proportions
- $S_1$ gneissosity defined by alternating leucocratic and melanocratic layers in migmatitic gneiss, commonly accentuated by concordant and near-concordant injected granitoid rock veins. Symbols without dip angle are undetermined measurements
- $S_1$ foliation defined primarily by preferred alignment of mafic minerals in tonalite, diatexite, variably deformed granitoid rocks and mafic and ultramafic rocks
- Second-generation, minor $F_2$ fold axis plunge direction. Developed predominantly in migmatitic gneiss, diatexite and coarse granite and alkali feldspar granite veins
- Second-generation $L_2$ lineation (plunge direction defined by aligned minerals or sliken striae)
- Brittle to ductile fault structure. Defined in part by brittle fault breccia and ductile features including lineations and offset features
- Unconformity between Archean rocks of the Ashuanipi Complex and siliciclastic rocks of the Paleoproterozoic New Québec Orogen (Labrador Trough). Symbol is white on Figure 4
- Antiform structure ($F_2$ plunge direction unknown)
- Synform structure ($F_2$ plunge direction unknown)
- Antiform structure ($F_2$ plunge direction assumed)
- Regional $S_1$ fabric trend (Figure 5)
- + Outcrop data station
- 23J/02/Cu001 — MODS occurrence. M-scale gossan zones in paragneiss and gabbro-pyroxenite sills. Zones contain disseminated to very local semi-massive pyrrhotite ± bornite ± arsenopyrite ± trace chalcopyrite
- New mineral indication. M- to 10s of metre-scale gossan zone in paragneiss, gabbro and pyroxene-rich ultramafic rocks, orthogneiss and granitoid rocks. Zones contain minor to disseminated pyrrhotite ± bornite ± arsenopyrite ± chalcopyrite mineralization
- Apg — Anomalous radioactivity (Th, U) signature in pegmatite with > 1000 total counts per second measured by portable scintillometer
- ① New mineral indication location referenced in text and Figure 3
- 89 ppb Au / 26 ppm Th — Anomalous lake-sediment values
- 2685.5z + 2.3 /-2.7Ma / 2649.6m ± 1.1 Ma — U-Pb zircon (z) and monazite (m) ages of tonalite of the Desliens igneous suite (Mortensen and Percival, 1988)

**Figure 5.** *Continued.*

west-striking $S_1$ fabric that is modified by $F_2$ folding. In contrast, in the central map area south of the McPhadyen River, the main $S_1$ fabric wraps around a large area of predominantly diatexite and late granitoid plutons that form an irregular dome configuration interpreted as fold interference patterns. Rare ductile asymmetric structures and unit offsets within local shear zones indicate a variable sense of movement associated with these structures, as evidenced by both dextral and sinistral indicators (Plate 26).

Several late, brittle fault zones transect the area ($D_3$ structures) and are marked by variable degrees of quartz ± chlorite ± hematite alteration, local brecciation and rare ductile features (Plates 27 and 28). The sense and amount of displacement associated with most of these faults are poorly constrained, however, the Archean–Proterozoic unconformity is offset approximately 2.5 km in a sinistral sense along the fault coincident with the McPhadyen River, and is offset approximately 1.5 km along a fault in the northeastern corner of the map area (Figures 3 and 4). The fault offsets, and the continuation of the late gabbro dykes (and the coincident linear aeromagnetic signatures) across the fault zones, indicate that these structures were active after the deposition of Labrador Trough rocks and predate the intrusion of the Mary Jo diabase dykes (Figure 4). Percival (1991a) suggested these faults may have formed or were reactivated during Proterozoic compression of the Labrador Trough. Shallow, west-plunging, stretching lineations occur locally in these fault zones and suggest subhorizontal movement may have been dominant along many of these structures.

**Plate 26.** *Moderately banded paragneiss intruded by concordant alkali-feldspar granite veins dextrally displaced along late discordant quartz veins. Locality is in the central part of NTS map area 23J/03, along the northeast-striking part of the McPhadyen River. Scale card is 8 cm in length.*

## MINERALIZATION

Mineralization in the map area consists predominantly of pyrrhotite ± bornite ± arsenopyrite ± chalcopyrite ± molybdenite-bearing gossan zones hosted locally in gabbro, pyroxenite, paragneiss, orthogneiss, diorite, granite and pegmatite. Some of these zones (mostly MODS occurrences) have undergone exploratory work, including grab sample assays, cursory mapping, soil- and stream-sediment sampling and ground-based and aeromagnetic surveys (Thomas and Butler, 1987; McConnell *et al.*, 1989; Dimmel, 1989; Graves, 1992; Leonard, 1997; Montague, 2011). During this

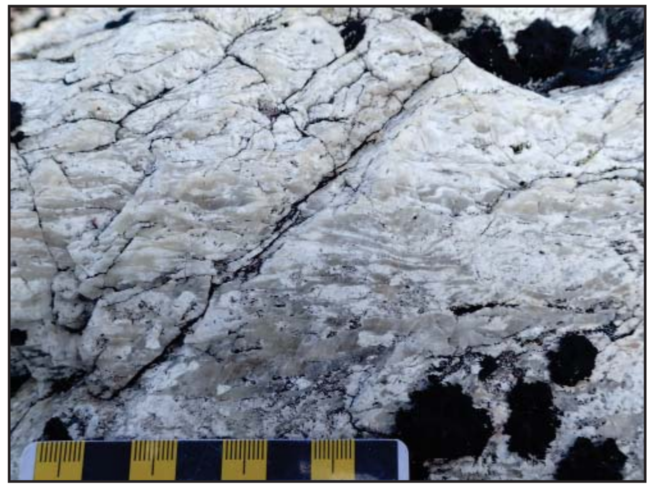


**Plate 27.** *Strongly deformed quartz 'ribbons' in leucocratic alkali-feldspar granite occuring in southeast-striking fault zone cutting a pyroxenite body in the southeastern part of the map area. Scale card is 8 cm in length.*


**Plate 28.** *Silicified and brecciated zone within late biotite granite (Unit Agr) along northeast-striking fault in the southern part of NTS map area 23J/02. Note epidote vein within small shear zone in centre of photograph. Scale card is 8 cm in length.*

study, elevated to anomalous radioactivity signatures were recorded from some granite to alkali-feldspar-granite–pegmatite veins and suggest a potential for these rocks to host U, Th and possibly rare-earth-element-mineralization. The following section provides descriptions of two revisited MODS occurrences and the locations and descriptions of nine new mineral indications that were located during regional mapping in 2016.

## OCCURRENCES IN MINERAL OCCURRENCE DATABASE SYSTEM (MODS)

Most of the Mineral Occurrence Database System (MODS) occurrences, shown as red stars on Figure 3, consist of m-scale, sulphide mineral-bearing limonite-altered gossan zones in paragneiss, orthogneiss, diorite and gabbro. Many of these occurrences were discovered through reconnaissance surveys of the Ashuanipi Complex in Labrador (Kidd, 1950; McConnell *et al.*, 1987; Thomas and Butler, 1987). Brief descriptions of two MODS occurrences in the map area are discussed below. All UTM coordinates are referenced to North American Datum 27, Zone 19.

### MODS Occurrence 23J/02/Au001 (UTM Coordinates 655480E/6003280N)

MODS occurrence 23J/02/Au001 is located in the eastern map area (Figure 3) and consists of a 20- to 35-m-wide by 150-m-long, west-striking, layered gabbro sill along with minor pyroxene-rich layers (Plate 29). The sill is host to several, m- to 10s of m-scale limonitic-altered gossan zones containing disseminated to very local semi-massive pyrite + bornite + pyrrhotite and trace to minor (1 to 2%) chalcopyrite. Elevated gold- and base-metal values and slightly elevated platinum-group-element values are reported from grab samples of this occurrence, including 2.5 g/t Au and 442 ppm Cu, 34 ppb Au and 1164 ppm Ni, and 7 ppb Pt and 6 ppb Pd (Leonard, 1997); 631 ppb Au and 1100 ppm Cu from outcrop, and 759 ppb Au from boulder (Thomas and Butler, 1987), and 225 ppb Au (Dimmel, 1989). Approximately 150 m south of this occurrence, a 10-m-wide, west-striking gabbro sill intrudes paragneiss and contains a 3 by 4 m gossan zone hosting minor bornite and trace chalcopyrite. These two sills occur along strike of gabbroic rocks to the west, some of which host local sulphide-bearing gossan zones (Figure 3).


**Plate 29.** *MODS Occurrence 23J/02/Au001. View looking west of a 150-m-long by 20- to 35-m-wide gabbro–pyroxenite sill boudin containing m- to 10s of m-scale gossan zone along contact of gabbro and pyroxenite layers. Mineralization consists of disseminated to locally semi-massive pyrrhotite + bornite + minor to trace chalcopyrite.*

### MODS Occurrence 23J/02/Cu003 (UTM Coordinates 634600E/5999842N)

The occurrence is located at the top of a vertical cliff and consists of several 1- to 2-m-long by 0.5-m-wide gossan zones in paragneiss containing 5–10% disseminated pyrite, bornite and pyrrhotite and local trace chalcopyrite. A 1- to 1.5-m-wide leucocratic pegmatite vein adjacent to the gossan zones recorded anomalous radioactivity of 15 000 total counts per second (tcps). Thomas and Butler (1987) reported molybdenite at this locality although this study did not. They reported rock assays of 9 ppb Au and 487 ppm Cu from one of these gossan zones.

## NEW SULPHIDE-BEARING MINERAL INDICATIONS

Several new sulphide-bearing mineral indications were located during 2016 and are shown as yellow stars on Figure 3. These indications are gossan zones hosted predominantly in paragneiss, gabbro and pyroxenite, and to a lesser extent, in diorite, tonalite gneiss, diatexite and pegmatite. Six new sulphide-bearing mineral indications are briefly described below and the locations are shown on Figure 3 as white numbered circles.

### Indication 1 (UTM Coordinates 642272E/5999359N)

A layered gabbro–pyroxenite sill intrudes paragneiss and diatexite north of the McPhadyen River in the central part of NTS map area 23J/02 (Figure 3). The west-striking, south-dipping intrusion is approximately 200 m wide and 250 m along strike and is a gabbro layer underlying the north side (top?) of the sill and coarse-grained pyroxenite to the south (Plate 30). A 4- to 8-m-high vertical cliff face coincides with the contact of gabbro and pyroxenite layers and is the site of several m- to 10s of m-scale gossan zones that occur intermittent along a 125-m strike length. These zones contain disseminated bornite and pyrrhotite and trace to minor chalcopyrite. Local, cm-scale quartz veins in the

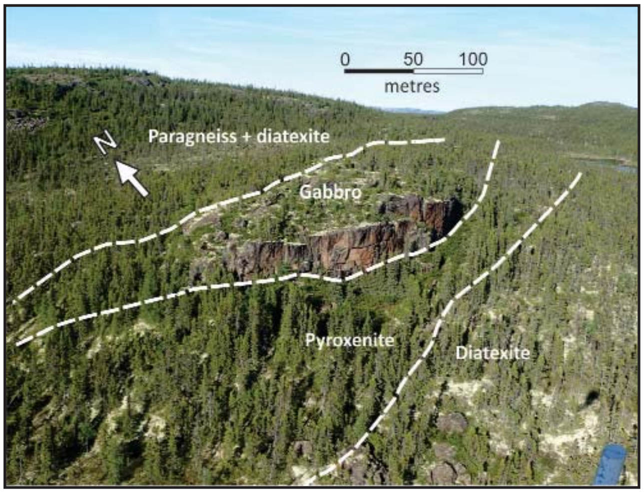



**Plate 30.** *Aerial view of an approximately 250-m-long mafic–ultramafic sill boudin with a 125-m-long, intermittent gossan zone along the east-striking contact of gabbro and pyroxenite layers. The gossan contains disseminated pyrrhotite and bornite and trace chalcopyrite labelled as Indication 1 in text and Figure 3. An anomalous lake-sediment value of 89 ppb Au is located 2 km northwest of the gossan zone.*

western part of the sill contain trace chalcopyrite. The indication is coincident with a small positive aeromagnetic anomaly (Figure 4).

**Indication 2 (UTM Coordinates 640662E/5999808N)**

A 4-m-long by 2.5-m-wide gossan zone is hosted in a mafic mineral-rich zone in paragneiss (Plate 31). The zone contains 5–10% disseminated pyrrhotite and bornite and is cut by several, concordant and boudinaged quartz veins. A garnet-rich granite pegmatite intruding paragneiss occurs 300 m north of the gossan zone and records up to 3500 tcps.

Indications 1 and 2 are located 2 km southeast and 800 m south, respectively, of an anomalous 89 ppb Au in lake-sediment value (Butler and McConnell, 1989; Figure 3). The source for this anomaly has not been identified, however assays are pending for these sulphide-bearing gossan zones and it is possible that these indications may be potential sources for the elevated Au value in lake sediment. Notably, an anomalous value of 23 ppm Th is reported from this lake-sediment site and may be related to the anomalous scintillometer reading recorded from the garnet-rich pegmatite to the north of Indication 2.

**Indication 3 (UTM Coordinates 611646E/5993960N)**

Several m-scale, limonite-altered gossans occur along a 75-m-long by 40-m-wide, northwest-striking layered gabbro sill occurring as a boudin, enveloped by paragneiss and diatexite in the central map area (Figure 3). The gossan zones range from 0.5 to 4 m wide and contain minor to 15% disseminated bornite and pyrrhotite and trace chalcopyrite (Plate 32).

**Plate 31.** *A 4-m by 2.5-m gossan zone hosted in a mafic mineral-rich zone in well-banded paragneiss. The zone contains local 5–10% disseminated pyrrhotite and bornite and several concordant and boudinaged cm-scale quartz veins. Labelled as Indication 2 in text and Figure 3. Hammer in right-centre of photograph is 33 cm in length.*

**Indication 4 (UTM Coordinates 610615E/5998978N)**

Four variably oriented, gabbro–pyroxenite sill boudins occur near the junction of several faults immediately north

**Plate 32.** *One of several m-scale gossan zones in a strongly deformed, layered gabbro sill boudin; Indication 3 in text and Figure 3. Gossan zone is approximately 4 m wide and contains 5–15% disseminated pyrrhotite and bornite. Hammer in centre-left of photograph is 33 cm in length.*

of the McPhadyen River on NTS map area 23J/03 (Figure 3). Gossan zones ranging from 1 to 3 m wide and 2 to 6 m long occur within the gabbro layers and locally along the contact with pyroxene-rich layers. Mineralization consists of minor to locally 20% disseminated pyrrhotite and bornite. One zone, on the margin of the sill, contains 15% disseminated sulphides and 15% graphite (Plate 33).

**Indication 5 (UTM Coordinates 658767E/5989530N)**

Several, south- to south-southwest-striking layered gabbro–pyroxenite sill boudins ranging up to 75 m wide and 100 m long occur enveloped within paragneiss and diatexite in the extreme southeastern map area (Figure 3). These rocks host several m-scale gossan zones containing disseminated to stringer pyrrhotite and bornite and trace chalcopyrite (Plate 34).

**Indication 6 (UTM Coordinates 646797E/5989341N)**

Several m-scale gossan zones containing 5% disseminated pyrrhotite and minor (<1%) chalcopyrite are hosted in well-banded paragneiss at a locality in the southeastern NTS map area 23J/023 (Figure 3). A 1-m-wide, concordant biotite ± allanite (?) bearing pegmatite vein locally records 3500 tcps (Plate 35). (*See* New Radioactive Indications section.)

**NEW RADIOACTIVE INDICATIONS**

Most visited outcrops in the map area were scanned using Radiation Solutions RS-120 and RS-230 BGO portable scintillometers. Background readings range from 40 to 300 tcps depending on the underlying rock type. Mafic and ultramafic rocks recorded signatures ranging 40–100 tcps, gneissic rocks recorded 100–250 tcps and diatexite and granite recorded background levels of 200–300 tcps. Elevated readings (300–1000 tcps) were recorded in numerous biotite ± orthopyroxene ± garnet-bearing pegmatites, garnet-dominant diatexite and, locally, in late granite plutons. Anomalous readings of >1000 tcps were recorded in several pegmatites. The locations of these anomalous sites are

**Plate 33.** *Limonitic-altered pyrrhotite–bornite–graphite-bearing gossan zone on the margin of a layered gabbro–pyroxenite sill boudin in paragneiss and diatexite. The occurrence is labelled as Indication 4 in text and Figure 3. The zone contains 5 to 20% disseminated pyrrhotite + bornite, trace chalcopyrite and locally 15% graphite. Scale card is 8 cm in length.*

**Plate 34.** *Gossan zones in layered gabbro–pyroxenite sill in southeast corner of map area. Labelled as Indication 5 in text and Figure 3. Several sill boudins are host to numerous sulphide-bearing gossan zones that occur within gabbro layers and along contact of gabbro and pyroxenite cumulate layers. Hammer is 100 cm in length.*

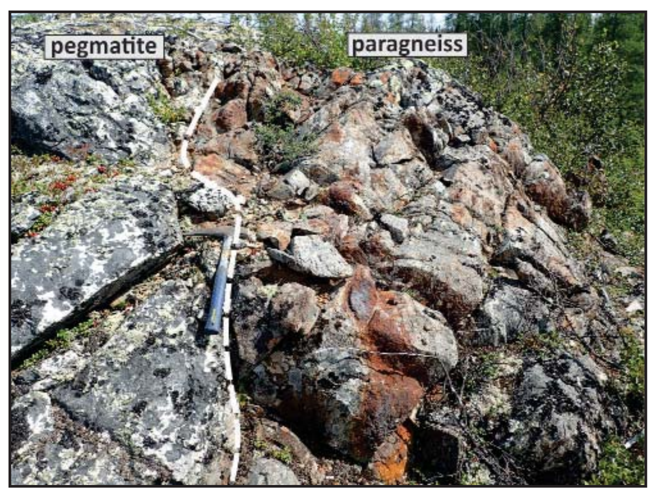



**Plate 35.** *Pyrrhotite-bearing gossan zone in paragneiss. The gneiss is intruded by a concordant leucocratic pegmatite that recorded an anomalous radioactivity signature up to 3500 tcps. Labelled as Indication 6 in text and Figure 3. Hammer is 33 cm in length.*

shown as blue circles on Figure 3 and three significant pegmatite-hosted radioactive indications are briefly discussed below.

**Indication 7 (UTM Coordinates 646625E/5987334N)**

Two parallel, or a single splayed alkali-feldspar granite pegmatite vein(s) that have anomalous radioactive signatures, intrude strongly foliated pyroxenite and gabbro near the southern edge of NTS map area 23J/02 (Figure 3). The vein(s) are exposed, 15 m apart, at the north end of the outcrop, are northwest-striking and range from 2 to 4 m in width (Plate 36). Readings of 31 000 tcps were recorded from two spot locations and intermittent signatures ranging from 1000 to 12 000 tcps can be traced for approximately 1500 m along a south-southeasterly strike direction within exposed pegmatite outcrop and boulders. Several anomalous zones in pegmatite occur to the northwest of this locality across a southeast-striking fault (Figure 3).

**Indication 8 (UTM Coordinates 660782E/5996189N)**

South of the mouth of the McPhadyen River, several granite to alkali-feldspar granite pegmatites having anomalous radioactive signatures intrude foliated to gneissic tonalite of the Desliens igneous suite (Figure 3). The pegmatites are white- to grey-weathering, very coarse grained, weakly deformed and contain quartz + alkali-feldspar + minor plagioclase + biotite + coarse magnetite ± orthopyroxene ± allanite(?) (Plate 37). Scintillometer readings ranging up to 8000 tcps were recorded from this locality.

**Plate 36.** *Northwest-striking, coarse-grained pegmatite intruding pyroxenite body in southeastern map area. The pegmatite appears to be two, closely spaced, parallel veins or possibly a single splayed intrusion that records anomalous radioactive signatures. Labelled as Indication 7 in text and Figure 3. Hammer in the centre of photograph is 33 cm in length.*

**Indication 9 (UTM Coordinates 655908E/5997699N)**

On NTS map area 23J/02, north of the mouth of the McPhadyen River, several granite to alkali-feldspar granite pegmatite veins intrude diatexite, tonalite gneiss and paragneiss (Figure 3). These pegmatites locally record anomalous radioactive signatures (up to 18 000 tcps). The rocks are coarse grained, massive, weakly deformed to undeformed and contain quartz + alkali-feldspar + biotite + magnetite ± plagioclase ± orthopyroxene ± allanite ± monazite. The apparent offset of the anomalous pegmatites located south and north of the mouth of the McPhadyen River (Indications 8 and 9, respectively) is consistent with a 2.5-km sinistral offset along the west-striking fault coincident with the McPhadyen River.

Cursory examination of several coarse-grained leucocratic pegmatite veins indicates anomalous Th and U are associated with some of these rocks. Some of these localities are proximal to elevated Th values in lake sediment (Figure 3). Geochemical assays and petrographic analyses are pending for these anomalous occurrences, however van Nostrand and Bradford (2014) reported anomalous radioactivity (2500 tcps) in a molybdenite-bearing pegmatite vein located 18 km to the north of the map area on the western shore of Lake Menihek. This zone returned 154 ppm Th, 2.9 ppm U and 727 ppm Mo (T. van Nostrand, unpublished geochemical data, 2015).

## SUMMARY

This work completes the third and final season of a 1: 50 000-scale bedrock-mapping project of the northern half

**Plate 37.** *Coarse-grained biotite + magnetite ± allanite-bearing pegmatite recorded anomalous radioactivity signatures, south of the mouth of the McPhadyen River. Labelled as Indication 8 in text and Figure 3. Coarse, black grains are magnetite. Scale card is 8 cm in length.*

of the Ashuanipi Complex in western Labrador including all or parts of NTS sheets 23J/02, 03, 04, 05, 06, 07, 10, 11, 14 and 23O/03 (van Nostrand and Bradford, 2014; van Nostrand *et al.*, 2016 and *this study*).

The 2016 map area consists predominantly of migmatitic rocks derived from sedimentary and igneous protoliths, subordinate boudinaged sill- or dyke-like intrusions of mafic and ultramafic composition and massive to weakly foliated tonalite and granite plutons. Pegmatite is a ubiquitous rock type in outcrops throughout the map area. Field relationships indicate that production of the diatexite units postdated the growth of orthopyroxene in the leucosome of older paragneiss and tonalite gneiss during $D_1$ deformation. Orthopyroxene-bearing diatexite and some pegmatites are folded about $F_2$ axes throughout the area, indicating that their emplacement is constrained to syn- to late peak metamorphic conditions during $D_2$ deformation. Based on these observations, granulite-facies metamorphism is interpreted to have persisted through both $D_1$ and $D_2$ deformation events.

The mineral potential of the map area and adjacent regions of the Ashuanipi Complex in Labrador and Québec has focused primarily on gold and base-metal potential associated with paragneiss, metamorphosed iron formation, and to a lesser extent, with gabbro, pyroxenite, tonalite gneiss and diatexite (Percival, 1987; Thomas and Butler, 1987; Campbell, 1989; Dimmel, 1989; Graves, 1992; LaPointe and Chown, 1993; James, 1997; Ivanov, 2012; van Nostrand and Bradford, 2014; Simard *et al.*, 2015).

The discovery of several new sulphide-bearing mineral indications, hosted primarily in layered gabbro–pyroxenite sills and paragneiss, indicates that further targeted exploration for gold, base-metal and, in the case of mafic and ultramafic rocks, platinum-group-element mineralization, is warranted throughout the region. Several potential mineral exploration targets exist. A source(s) for the anomalous lake-sediment value of 89 ppm Au in the east-central map area should be investigated as well as other areas where anomalous or elevated values are present. Noteworthy are three lake-sediment values of 14 ppb Au, 28 ppb Au and 13 ppb Au located to the north of the 89 ppb Au anomaly and a 12 ppb Au in lake-sediment value occurs to the southeast of the tonalite pluton (Unit At) in the central map area (Figure 3). Several gossan zones in gabbro–pyroxenite sills need to be examined through detailed mapping, sampling and ground-geophysical surveys (magnetic and induced polarization) to define the grade and the extent of these mineralized zones. Considering i) the anomalous radioactive signatures recorded from pegmatites and the coincidence of some of these with elevated Th lake-sediment values, ii) the abundance of these veins and small intrusions in the region, and iii) the untested potential of these rocks to host radioactive and rare-earth-element mineralization suggests that they may be a viable exploration target.

Most of the Ashuanipi Complex in Labrador is underexplored and vast areas remain untested for mineral potential, particularly in areas that are proximal to the Québec–Labrador border but also in the vicinity of known occurrences in the more accessible eastern areas. The presence of occurrences that have elevated gold and base-metal contents in Labrador and adjacent Québec, numerous new sulphide-bearing indications in gabbro and paragneiss, and, anomalous radioactive signatures in pegmatite, located during regional mapping efforts in the current map area and adjacent regions, indicate that additional, systematic gold, base-metal, platinum-group element, U, Th and rare-earth-element exploration is needed to realize the potential of the Ashuanipi Complex in Labrador.

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