

GEOLOGY OF THE LITTLE MECATINA RIVER (NTS MAP AREA 13D/NE) AND LAC ARVERT (NTS MAP AREA 13C/SW) AREAS, GRENVILLE PROVINCE, SOUTHERN LABRADOR

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ABSTRACT

Field studies in 2000 involved 1:100 000-scale mapping of parts of the Wilson Lake, Mealy Mountains and Mecatina terranes that make up the Grenville Province in southern Labrador. The Wilson Lake terrane is dominated by upper amphibolite- to granulite-facies metasedimentary gneiss, granitic rocks and minor gabbro that were metamorphosed and deformed in the Labradorian Orogeny. The Mealy Mountains terrane includes variably recrystallized, deformed and locally gneissic, granite, monzonite, monzodiorite, syenite, anorthosite, and gabbro to gabbro-norite that belong to the Labradorian-age Mealy Mountains intrusive suite. Mesoproterozoic (Pinwarian age) rocks, including foliated and gneissic K-feldspar porphyritic granite and granitic orthogneiss, make up the Mecatina terrane. In contrast to the Wilson Lake and Mealy Mountains terranes, the Mecatina terrane was pervasively overprinted by Grenvillian upper amphibolite-facies metamorphism and attendant deformation. Affects of Grenvillian overprinting on the Wilson Lake and Mealy Mountains terranes are uncertain. Plutons of late- to post-Grenvillian granite intrude the Mecatina and Mealy Mountains terranes.

The boundary between the Wilson Lake and Mealy Mountains terranes is interpreted as a Grenvillian ductile, high-strain zone, although it is not a single structure. Instead, it consists of geometrically discordant, mainly northwest- and southeast-dipping segments allowing Wilson Lake terrane rocks to structurally overlie and underlie the Mealy Mountains terrane rocks. The boundary between the Mealy Mountains and Mecatina terranes is not exposed, but it is assumed to be a Grenvillian tectonic boundary.

The Grenville Province in southern Labrador has some exploration potential for hosting Ti (Fe) oxide deposits in anorthosite, and Ni-Co-Cu mineralization in anorthosite and gabbro. A newly discovered anorthosite intrusion in the Mealy Mountains terrane provides a new exploration target. Field work in 2000 did not result in any new or significant discoveries of economic minerals.

INTRODUCTION

The geology of the Grenville Province in southern Labrador within parts of NTS map areas 13D and 13C (Figures 1 and 2), and including an area slightly larger than 12,000 km², is known only from small-scale reconnaissance mapping completed by the Geological Survey of Canada more than 30 years ago (*cf.* Stevenson, 1967, 1969). A continuing program by the Geological Survey of Newfoundland and Labrador and by the Geological Survey of Canada is directed at upgrading the geological database for this region. The northeastern part of NTS map area 13D, including map

areas D/9, D/10, D/15 and D/16, and the southwestern part of NTS 13C, including map areas C/4 and C/5, were mapped at a scale of 1:100 000 in the 2000 field season. Mapping was accomplished by making helicopter landings on isolated outcrops, and was based from a field camp at Gull Island, located 80 km west-southwest of Goose Bay. This mapping was a continuation of 1:100 000-scale mapping in NTS map area 13C by James and Lawlor (1999) and James and Nadeau (2000a, b). The northwestern part of NTS map area 13D was previously mapped by Thomas *et al.* (1994). NTS map area 13C/NW was mapped by Wardle *et al.* (1990, 2000).

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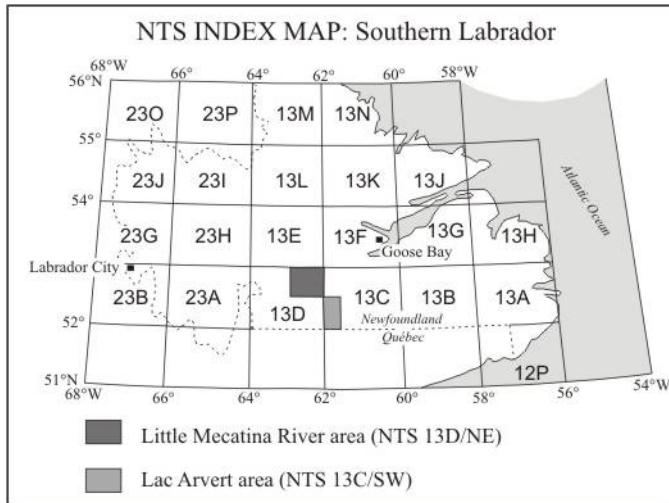


Figure 1. NTS index map of southern Labrador showing location of the study areas.

Bedrock in the study area is variably exposed. High-grade metasedimentary gneiss and granitoid rocks in the northern parts of NTS map area 13D/NE are well exposed. However, rocks in the southern part of this area, and in NTS map areas 13C/4 and C/5, are very poorly exposed; these areas are extensively covered by bog, dense forest, or thick Quaternary deposits. Definitive contact relations between units were not observed. To some extent, the locations of contacts and faults shown on the generalized geological maps were interpreted using regional aeromagnetic data.

REGIONAL GEOLOGY

The study area is situated in the northeastern Grenville Province and straddles the boundary between the Exterior Thrust Belt and Interior Magmatic Belt (see Gower *et al.*, 1991). It includes, from north to south, parts of the Wilson Lake, Mealy Mountains, and Mecatina terranes (Figure 2). These structurally stacked terranes are Grenvillian tectonic divisions, although they consist primarily of late Paleoproterozoic (Wilson Lake and Mealy Mountains terranes) and Mesoproterozoic (Mecatina terrane) crust.

The Wilson Lake terrane (WLT) is dominated by high-grade metasedimentary gneisses having protolith depositional ages predating ca. 1720 Ma (i.e., pre-Labradorian Orogeny). These gneisses are derived primarily from pelitic and semipelitic sedimentary rocks, although very minor amounts of metasedimentary rocks derived from quartzite and siliceous carbonate also occur. The northern part of the terrane, in the Red Wine Mountains area, also includes intrusions of late Paleoproterozoic gabbro and gabbro-norite, and mafic gneisses possibly derived from supracrustal rocks. Intrusions of foliated granite and porphyritic granite, corre-

lated on the basis of rock type with the ca. 1650 Ma Trans-Labrador batholith, and granitoid orthogneisses of uncertain age make up minor amounts of the terrane.

Geochronological studies of monazite contained in sapphirine-bearing diatexite, occurring in the northern part of the WLT and presumed to be derived from anatexis of the metasedimentary gneisses, indicate that high-grade metamorphism and attendant deformation are middle Labradorian (ca. 1640 Ma) (Corrigan *et al.*, 1997). Corrigan *et al.* (*op cit.*) have also shown, on the basis of U–Pb dating of monazite, that the terrane has been locally overprinted by Grenvillian (ca. 1000 Ma) metamorphism. Regionally persistent ductile high-strain zones separating the WLT from the Trans-Labrador batholith to the north, and the Mealy Mountains terrane to the south, are ca. 1010 to 990 Ma structures (Corrigan *et al.*, 1997). The WLT is inferred to be thrust over autochthonous Trans-Labrador batholith rocks in a general south to north direction. However, the nature of the southern boundary is somewhat equivocal. Thomas *et al.* (1986) interpreted the southern boundary of the WLT to be an approximately north-dipping structure, and the terrane to be a klippe resting on top of the Mealy Mountains terrane. In contrast, Wardle *et al.* (1990) and Corrigan *et al.* (1997) interpreted the Mealy Mountains terrane to be thrust over the WLT along a south-dipping structure. The contact between the WLT and Mealy Mountains terrane will be discussed in a subsequent section of this report.

The Mealy Mountains terrane (MMT) (Gower and Owen, 1984) consists primarily of late Paleoproterozoic (Labradorian-age) plutons of the Mealy Mountains intrusive suite (MMIS) (see Emslie, 1976; Emslie and Hunt, 1990; Krogh *et al.*, 1996), minor amounts of Paleoproterozoic pre-Labradorian crust, and Pinvarian (1510 to 1450 Ma) and late- to post-Grenvillian intrusions (Gower, 1996). The MMIS consists mainly of an older group of anorthositic, leucogabbroic and leucotroctolitic rocks, and a younger group of pyroxene-bearing monzonite and quartz monzonite intrusions. Emplacement ages for units of MMIS monzodiorite orthogneiss, porphyritic quartz monzodiorite and pyroxene-bearing monzonite, determined by U–Pb geochronology of zircon and occurring in the Kenamu River area (NTS map area 13C/NE), are 1659 ± 5 Ma, 1650 ± 1 Ma, and 1643 ± 2 Ma, respectively (James *et al.*, 2000). In addition, pyroxene monzonite and pyroxene granite, inferred to be from the younger group of MMIS rocks and occurring in the northeastern part of the MMIS, have emplacement ages of 1646 ± 2 Ma and $1635 \pm 22/8$ Ma (Emslie and Hunt, 1990), respectively. Unlike Mesoproterozoic AMCG suites in Labrador (e.g., Harp Lake intrusive suite, Nain Plutonic Suite and Atikonak AMCG suite), the MMIS is not anorogenic. Emplacement ages of MMIS rocks overlap with regionally significant tectonothermal and mag-

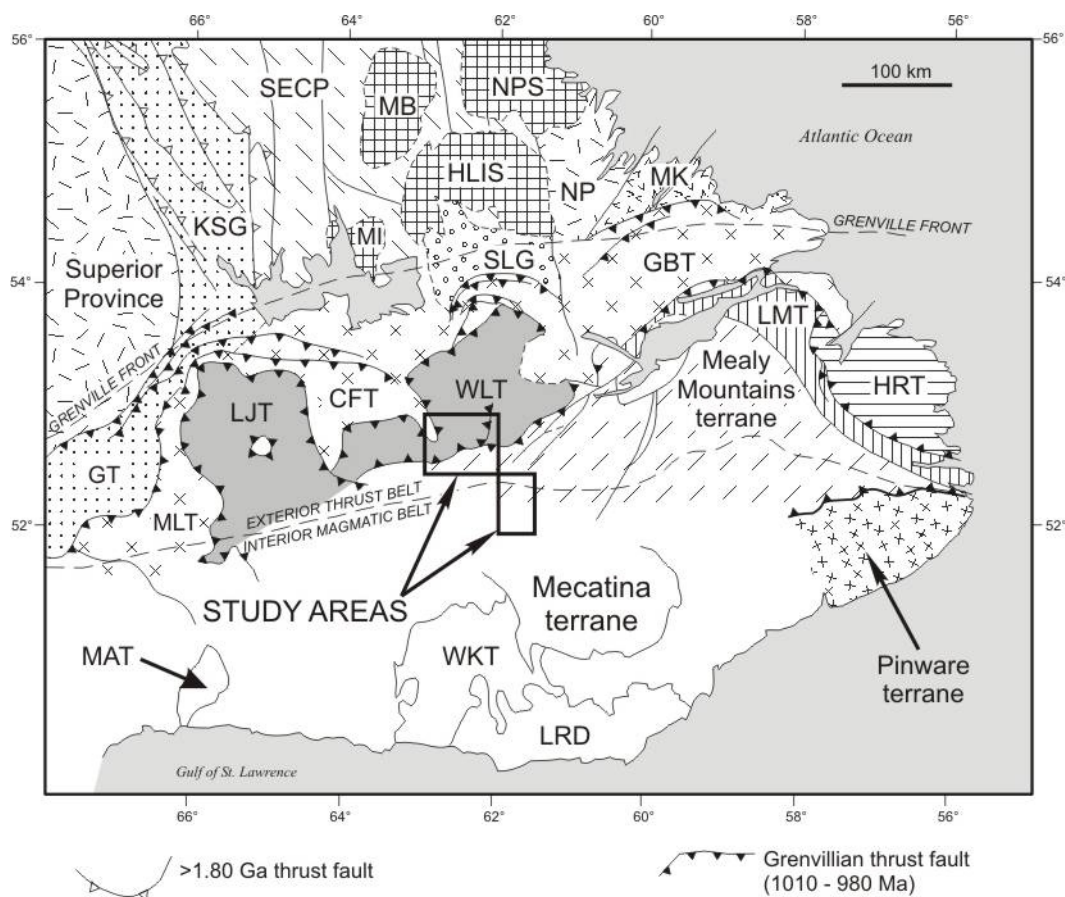


Figure 2. Tectonic and major lithotectonic units of southern Labrador showing location of the study areas. Grenville Province: HRT - Hawke River terrane, LMT - Lake Melville terrane, GBT - Groswater Bay terrane, WLT - Wilson Lake terrane, CFT - Churchill Falls terrane, LJT - Lac Joseph terrane, MLT - Molson Lake terrane, GT - Gagnon terrane, MAT - Matamec terrane, WKT - Wakeham terrane, LRD - La Romaine domain. Archean divisions: Superior Province, NP - Nain Province (Hopedale Block). Archean and Paleoproterozoic divisions: MK - Makkovik Province, SECP - Southeastern Churchill Province (core zone), KSG - Kaniapiskau Supergroup (2.25 to 1.86 Ga). Mesoproterozoic units: NPS - Nain Plutonic Suite, HLIS - Harp Lake intrusive suite, MB - Mistastin batholith, MI - Michikamau Intrusion, SLG - Seal Lake Group.

matic events of the Labradorian Orogeny, which affected northeastern Laurentia in the interval between 1720 Ma and 1600 Ma (see Gower, 1996).

Rocks in the western part of the MMT are variably foliated and locally gneissic; in general, they have northeast- to east-northeast-striking planar fabrics that are inferred to be Labradorian (James and Nadeau, 2000a). However, the local occurrence of deformed, Pinwarian age (ca. 1514 Ma) granite in the Kenamu River area (James *et al.*, 2000) demonstrates that the western part of the terrane has also been affected by Pinwarian and/or Grenvillian deformation. Interpretation of the ages of metamorphic minerals and structures in the MMT without the benefit of detailed geochronological studies is equivocal. The western extent of the MMT and of MMIS rocks are also uncertain, and will be the focus of mapping in 2001.

The location and nature of the boundary between the MMT and the Mocatina terrane is uncertain. In the Fourmont Lake area (NTS map area 13C/SE; see James and Nadeau, 2000a, b), rare occurrences of mylonitic rocks having an undetermined kinematic history, suggest the boundary is a south-dipping high-strain zone. However, in general, the area inferred to contain the terrane boundary is very poorly exposed and reliable field data for its demarcation are lacking.

The Mocatina terrane (MECT) consists of upper amphibolite-facies supracrustal rocks, including quartzite and pelitic gneiss, as well as granitoid orthogneiss, deformed granitic and monzonitic rocks, gabbro and anorthosite belonging to the Petit Mocatina AMCG suite. The metasedimentary rocks, which do not occur in the 2000 study area, are provisionally correlated with the Wakeham Supergroup.

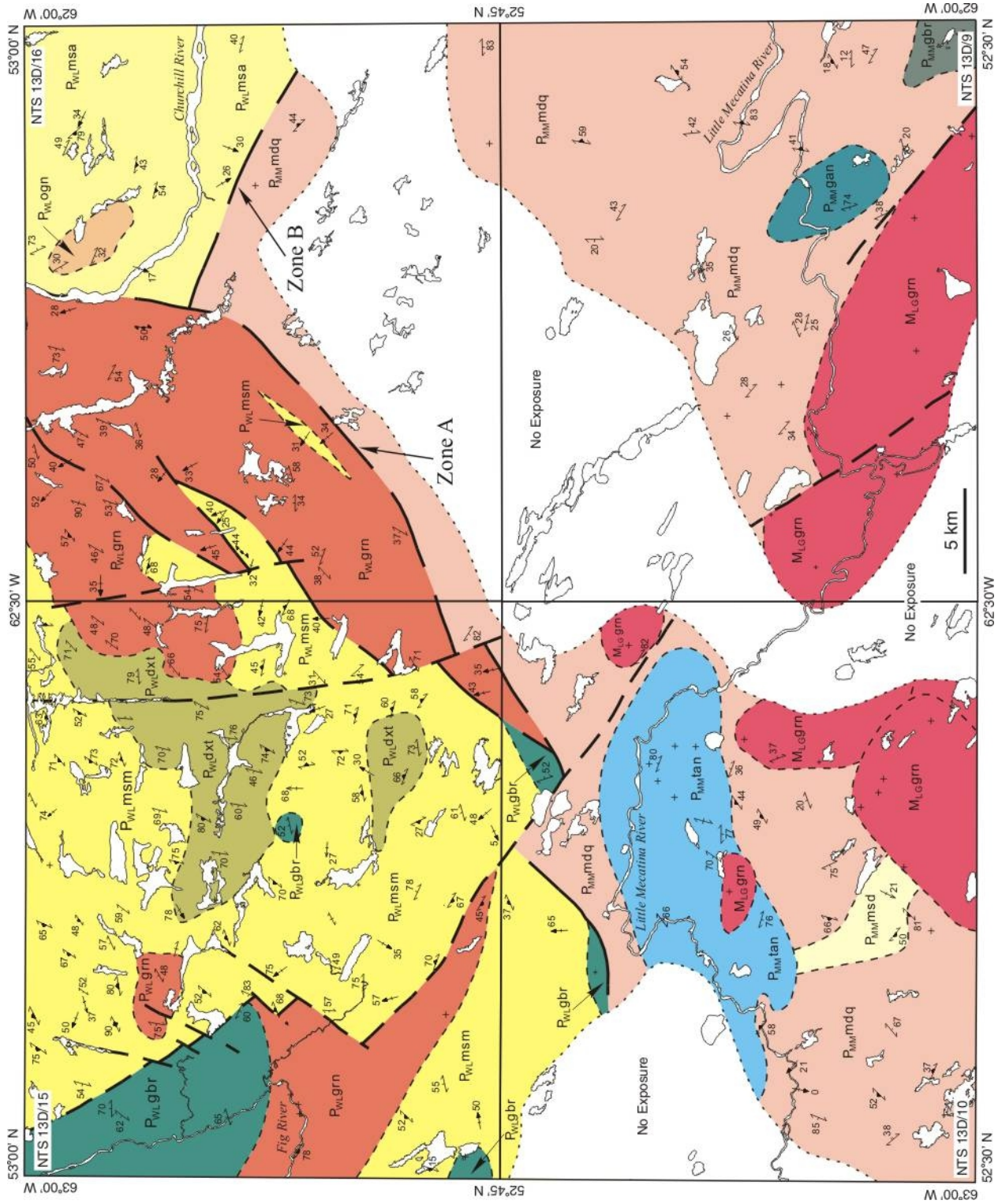


Figure 3. Generalized geological map and legend for the Mecatina River area (NTS map area 13D/NE).

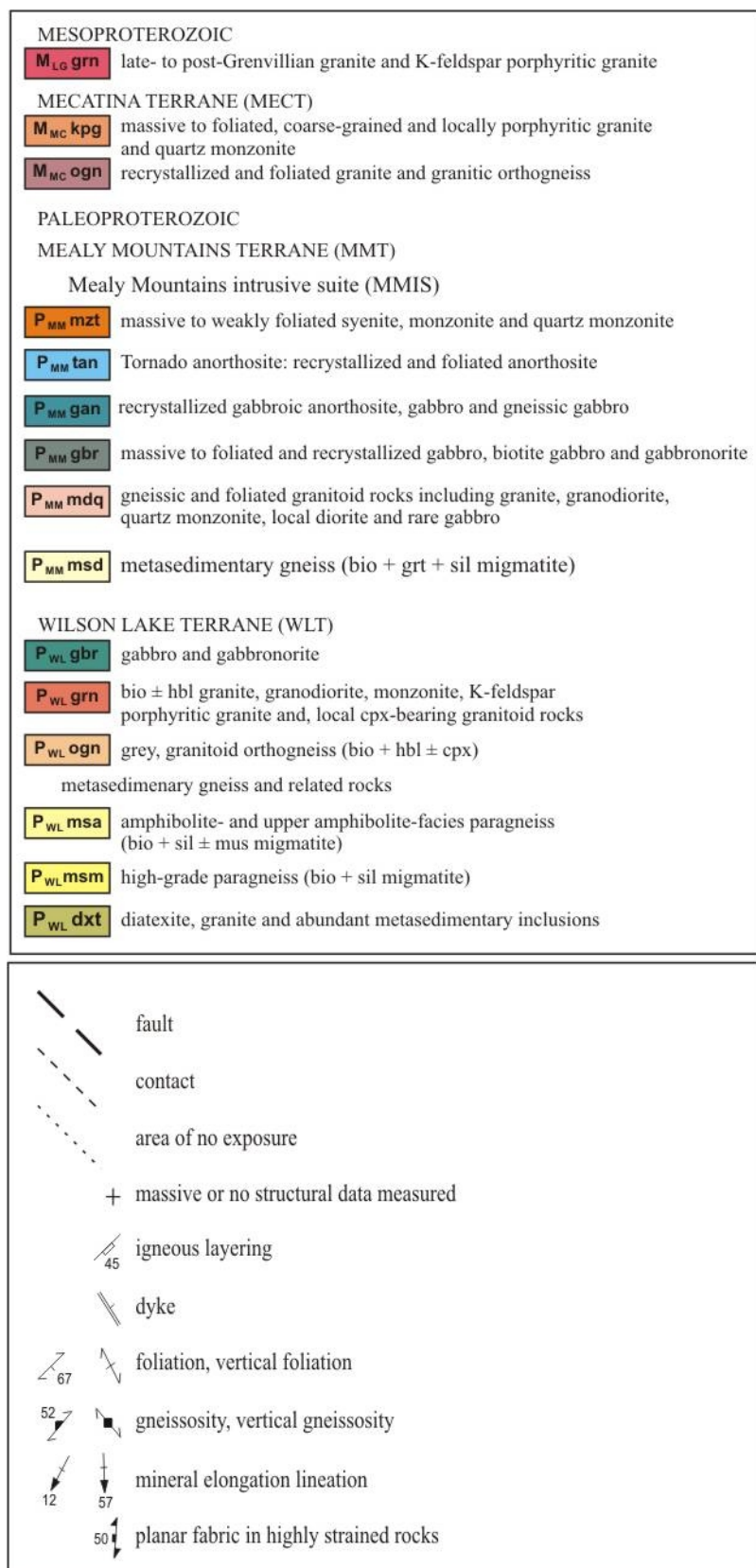


Figure 3. Legend. See opposite page.

Foliated quartz monzonite and K-feldspar porphyritic granite, occurring in the MECT in the Fourmont Lake area, intrude the supracrustal gneisses and have emplacement ages of 1500 ± 4 Ma and 1493 ± 3 Ma, respectively, determined by U–Pb geochronology of zircon (James *et al.*, *this volume*). Titanite in the 1493 Ma porphyritic granite is dated by U–Pb techniques to be 1043 ± 6 Ma (James *et al.*, *this volume*), providing evidence the terrane has been overprinted by Grenvillian metamorphism.

The MECT and the MMT are intruded by plutons of unmetamorphosed, massive to weakly foliated granite. One of these plutons, occurring in the southwestern part of the MMT, is dated by U–Pb techniques on zircon to be 964 ± 3 Ma (James *et al.*, *this volume*). This age is consistent with 966 to 956 Ma ages for widespread granitoid plutons in the Pinware terrane and, locally, in the southeastern MMT (Gower, 1996). The geochronological data and field relationships demonstrate these plutons slightly overlap and postdate, temporally, the late stages of Grenvillian orogenesis.

DESCRIPTION OF ROCK UNITS

PALEOPROTEROZOIC UNITS

Wilson Lake Terrane (WLT)

Metasedimentary Gneiss and Related Rocks (P_{WL} msa, P_{WL} msm, P_{WL} dxt)

The WLT comprises approximately 60 percent metasedimentary gneiss and related rocks, including diatexite and granite in the NTS map area 13D/NE study area (Figure 3). The most common metasedimentary rock type is a high-grade biotite and sillimanite-bearing migmatite (P_{WL} msm) comprising a rusty or grey paleosome and variable amounts of pink- and white-weathering K-feldspar-bearing leucosome (Plate 1). Garnet occurs only rarely in P_{WL} msm gneiss.

The P_{WL} msm gneisses are gradational, at all scales, into pink- and grey-weathering diatexite (P_{WL} dxt). The diatexite is medium to coarse grained, variably foliated, has a granitic to quartz monzonitic composition, and contains biotite and widespread sillimanite (Plate 2). Outcrops include less than 30 percent ‘screens’

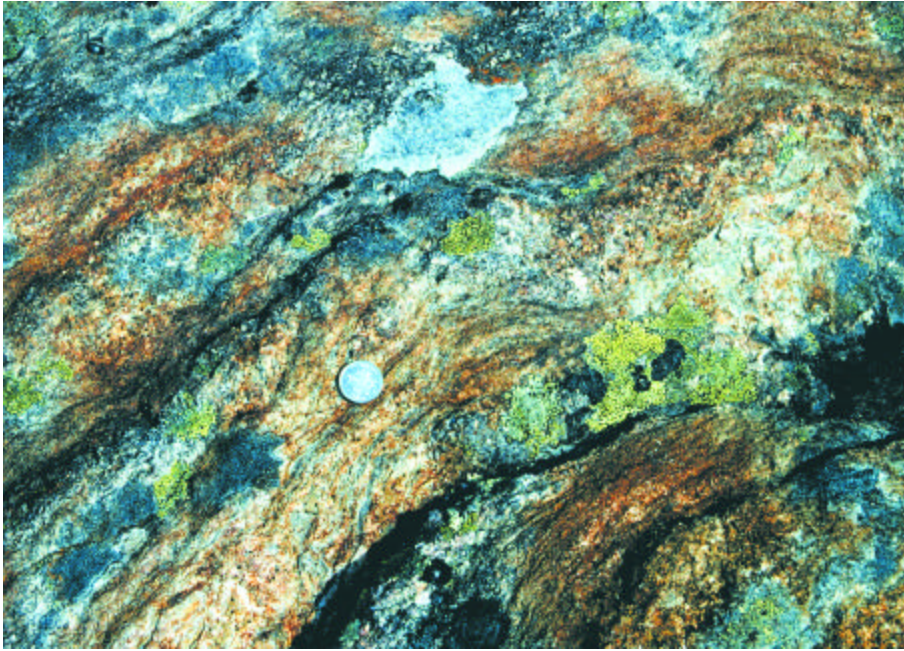


Plate 1. High-grade, biotite + sillimanite metasedimentary migmatite ($P_{WL} msm$), Wilson Lake terrane.

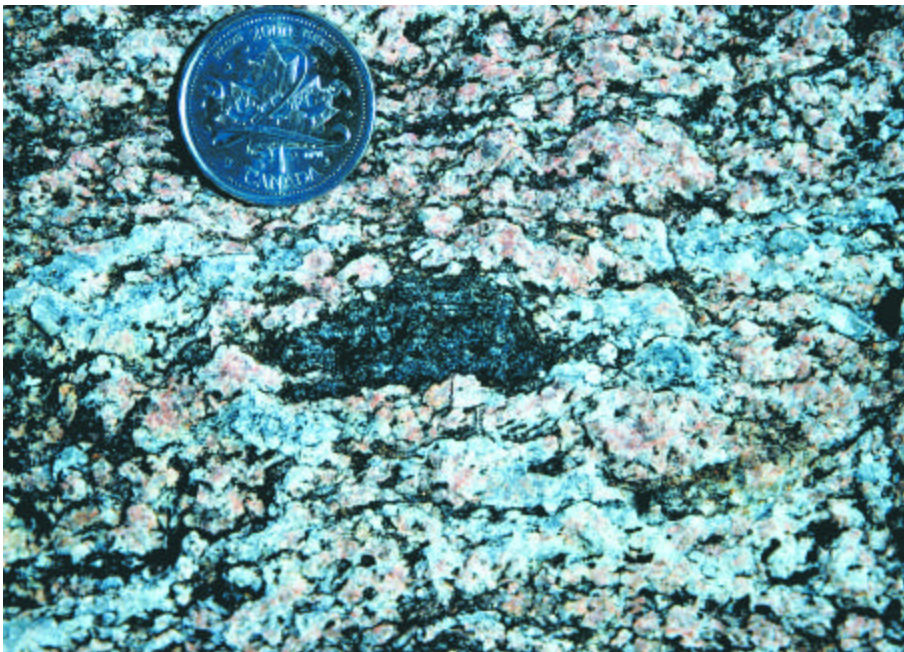


Plate 2. Sillimanite-bearing diatexite ($P_{WL} dxt$), Wilson Lake terrane. The composition of these rocks and their gradational contacts with surrounding $P_{WL} msm$ rocks suggests they are derived from complete, *in situ* melting of the metasedimentary rocks.

of metasedimentary gneiss ($P_{WL} msm$). Locally, outcrops are lacking in the metasedimentary gneiss 'screens' and they can be classified as sillimanite-bearing granite (or sillimanite-bearing homogeneous diatexite). Gradational contacts with the surrounding high-grade metasedimentary gneiss unit, the

widespread occurrence of metasedimentary gneiss 'screens' and the composition of the rocks suggest $P_{WL} dxt$ diatexite is derived from the nearly complete, *in situ* melting of surrounding metasedimentary gneisses.

The northeastern part of NTS map area 13D/16, north and east of the Churchill River, is mainly underlain by grey- and white-weathering or, locally, grey- and pink-weathering metasedimentary migmatite ($P_{WL} msa$). The $P_{WL} msa$ rocks are inferred to be a more lower grade version of the high-grade, $P_{WL} msm$ gneisses previously described. The $P_{WL} msa$ rocks commonly contain muscovite, and have lesser volumes of leucosome than $R_{WL} msm$ gneisses. The leucosome in $P_{WL} msa$ rocks is most commonly white-weathering and K-feldspar-poor, whereas the high-grade $P_{WL} msm$ rocks contain abundant volumes of pink-weathering, K-feldspar-rich leucosome. The area underlain by $P_{WL} msa$ rocks is marked by a magnetic low (Figure 4); in sharp contrast, areas underlain by higher grade $P_{WL} msm$ rocks and diatexite ($P_{WL} dxt$) are marked by a prominent, regional magnetic high.

The composition of $P_{WL} msm$ and $P_{WL} msa$ metasedimentary gneisses suggests they are derived from aluminous, pelitic and semi-pelitic protoliths. Both units have a generally consistent composition over large areas, presumably reflecting a widespread and thick sedimentary precursor of consistent composition. However, there are a few local variations in the metasedimentary gneisses including rare occurrences of mafic gneiss having an uncertain protolith, quartzite (Plate 3), gneisses derived from siliceous carbonate, sil-

icate-oxide iron formation and possible felsic volcanic rocks (Plate 4). Subdivisions of the different rock types in the metasedimentary gneiss units are not shown on Figure 3 because of their very limited extent. The felsic volcanic rocks, although very rare, are worthy of note because they

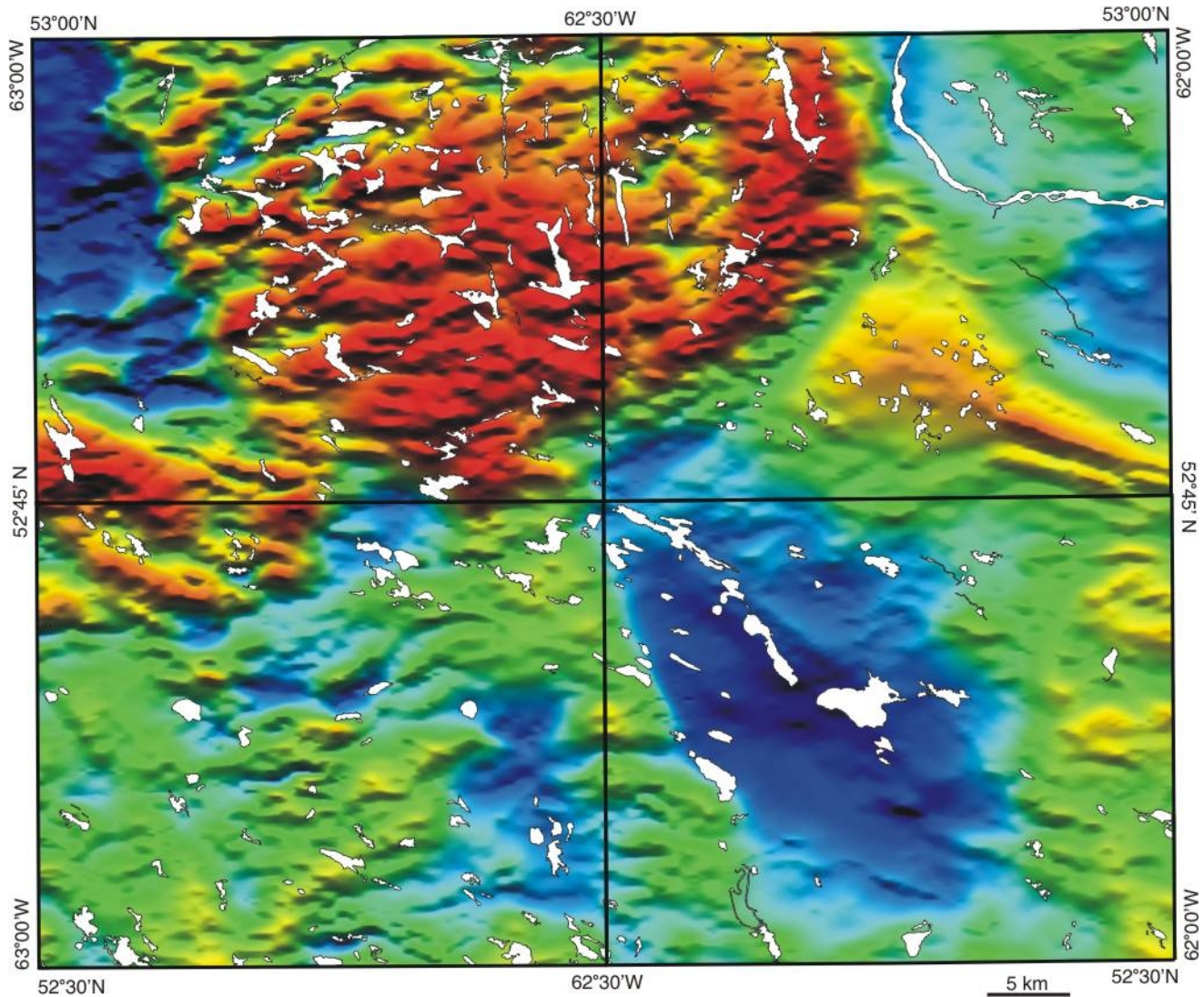


Figure 4. Shaded-relief magnetic anomaly map of the Mecatina River area (NTS map area 13D/NE). False illumination: azimuth - 315°, inclination - 45°. Red end of the spectrum - magnetic highs; blue end of the spectrum - magnetic lows. Map prepared by G. Kilfoil, Geochemistry, Geophysics and Terrain Sciences Section, Geological Survey of Newfoundland and Labrador.

have potential to provide extremely valuable geochronological data that may help to determine the depositional age of the associated metasedimentary rocks. At present, the depositional age of the metasedimentary rocks, that make up a significant proportion of the Wilson Lake, Churchill Falls and Lac Joseph terranes (Figure 2), underlying an area of more than 35 000 km², is only constrained to be older than the onset of Labradorian orogenesis at ca. 1720 Ma.

Orthogneiss (P_{WL} ogn)

Metasedimentary gneisses in the northeastern part of NTS map area 13D/16 are intruded by granodiorite orthogneiss (P_{WL} ogn). This orthogneiss is migmatitic containing thin (centimetre-scale), white- and pink-weathering layers of leucosome, and grey-weathering layers of paleo-

some containing biotite, hornblende, and possible clinopyroxene. The rocks locally contain K-feldspar augen that are presumed to be relicts of K-feldspar phenocrysts.

The emplacement age of the granodiorite is constrained by field relations to be younger than the host metasedimentary gneisses, and older than the upper-amphibolite facies event that overprints the rocks. The metamorphism is undated but presumed to be Labradorian.

Granite, Granodiorite and K-feldspar Porphyritic Granite (P_{WL} grn)

The metasedimentary gneisses are intruded by bodies of variably deformed and recrystallized granite, K-feldspar porphyritic granite, granodiorite and monzonite. The differ-

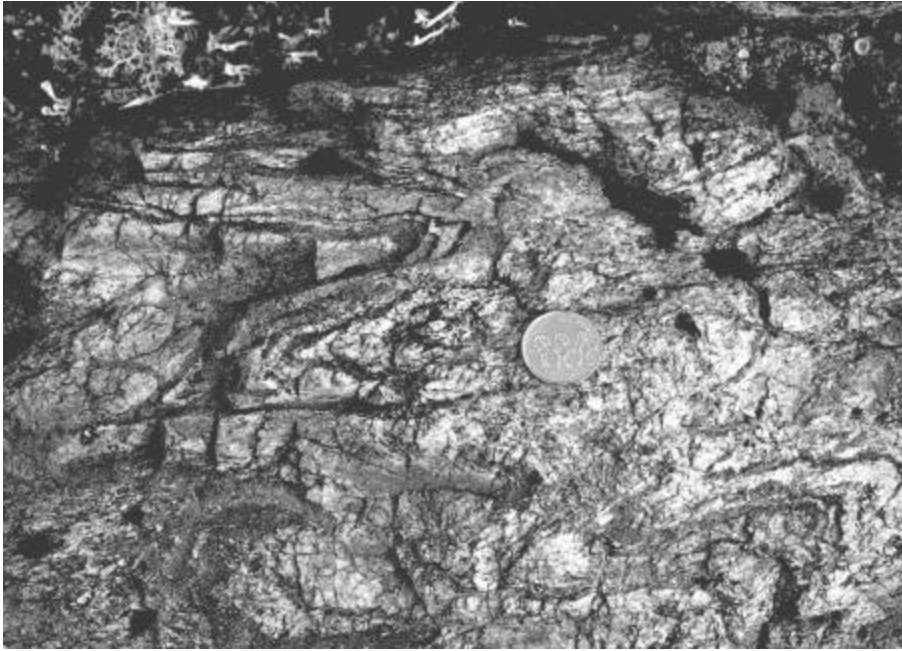


Plate 3. *Metamorphosed quartzite displaying relict sedimentary bedding, $P_{WL} msm$ unit, Wilson Lake terrane.*



Plate 4. *Possible felsic volcanic rock (metamorphosed porphyritic flow or lapilli tuff?) interlayered with metasedimentary gneiss ($P_{WL} msm$), Wilson Lake terrane.*

ent rock types that make up the $P_{WL} grn$ unit are not divided on the map (Figure 3). Medium- to coarse-grained, K-feldspar porphyritic, biotite- and hornblende-bearing granitic rocks are the most common type in the unit (Plate 5). K-feldspar phenocrysts are locally up to 8 cm in diameter. Grey- to pink-weathering monzonitic rocks, locally por-

phyritic, and containing local clinopyroxene are a minor component of the unit. All rocks in the unit are foliated and some are gneissic. Highly strained and mylonitic rocks, forming a high-strain zone several kilometres wide, occur along the boundary with the MMT. Within this high-strain zone, determination of rock type is generally difficult; mylonitized versions of the granitic rocks are very similar in appearance to mylonitic metasedimentary rocks.

The age of the rocks making up the $P_{WL} grn$ unit is undetermined. However, the rocks are provisionally assigned as middle Labradorian (ca. 1650 Ma) because they intrude the metasedimentary gneisses, and they have similar minerals and textures as rocks in the Trans-Labrador batholith.

Gabbro and Gabbonorite ($P_{WL} gbr$)

Metasedimentary gneisses and granitic rocks in the WLT are intruded by bodies of metamorphosed and deformed gabbro, gabbonorite and lesser clinopyroxenite defined as Unit $P_{WL} gbr$. These rocks are mainly fine grained, have granoblastic textures, and comprise varied proportions of plagioclase and pyroxenes. They may also contain minor amounts of biotite and quartz. The rocks are massive to foliated and locally gneissic. However, medium-grained rocks having a preserved igneous, intergranular texture also occur (Plate 6). Relict igneous layers are apparent in a few outcrops.

The age of the rocks making up the unit is undetermined. They are, however, provisionally assigned as middle Labradorian because they

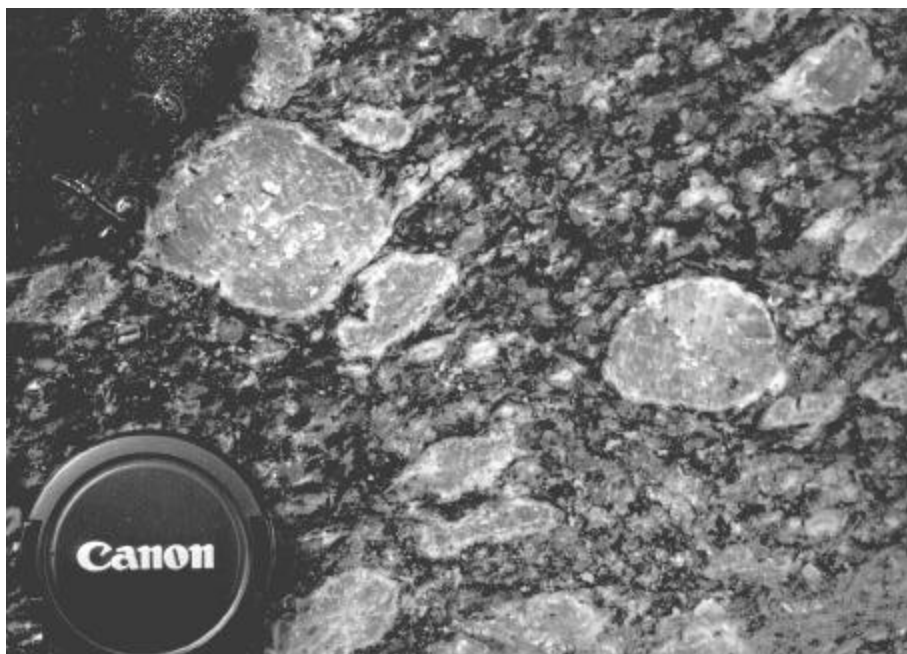


Plate 5. Foliated, K-feldspar porphyritic granite ($P_{WL} grn$), Wilson Lake terrane.

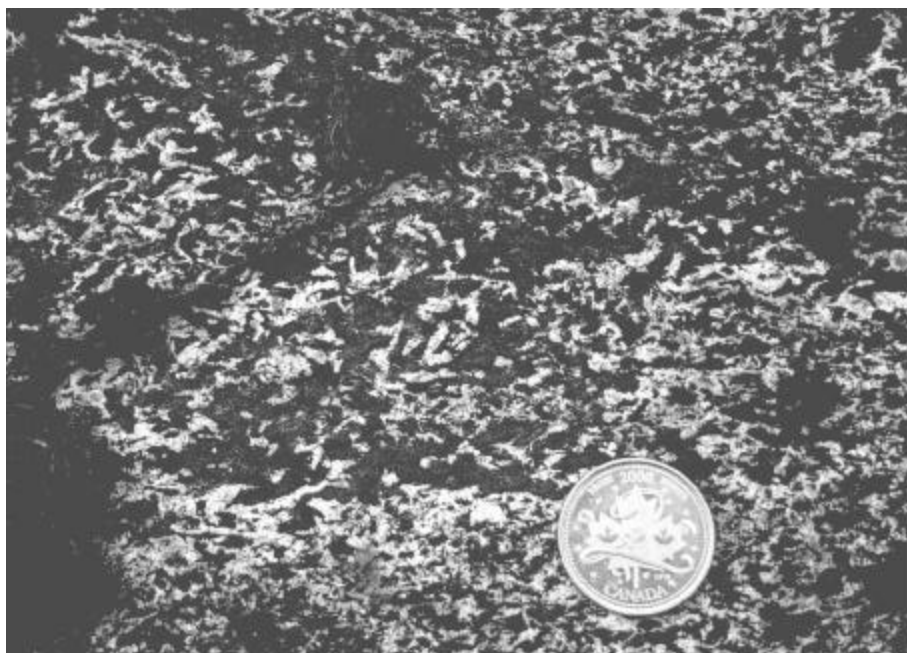


Plate 6. Metamorphosed Labradorian gabbro ($P_{WL} gbr$) containing relict intergranular (gabbroic) texture, Wilson Lake terrane.

Mealy Mountains Terrane (MMT)

Metasedimentary Gneiss ($P_{MM} msd$)

The MMT, in the southwestern part of NTS map area 13D/10, contains several outcrops of pink-, grey- and rusty-weathering, upper amphibolite-facies metasedimentary gneiss ($P_{MM} msd$). These rocks are very well layered, having

a gneissosity defined by alternating biotite + sillimanite-rich, and K-feldspar-rich layers. These metasedimentary gneisses contain abundant garnet, in contrast to the garnet-poor metasedimentary gneisses in the WLT, and are inferred to be derived from a pelitic sedimentary protolith. Occurrences of metasedimentary gneiss, similar to $P_{MM} msd$ gneiss, are relatively common in the eastern parts of the MMT (e.g., Gower and van Nostrand, 1996), although they are rare in the central and western parts of the terrane. The depositional age of the sedimentary protoliths is undetermined, but they must be older than the middle Labradorian rocks of the MMIS that intrude them.

Gneissic and Foliated Granitoid Rocks ($P_{MM} mdq$)

Gneissic and foliated, amphibolite-facies granitoid rocks, mainly including biotite \pm hornblende \pm clinopyroxene granite, granodiorite, quartz monzonite, and local diorite, are widespread in the NTS map area 13D/NE and occur localized in NTS map area 13C/SW (Figure 5). These rocks, especially in NTS map area 13D/NE, are very poorly exposed, and because they could not be reasonably subdivided in the field at the scale of mapping, they are collectively assigned to a single unit. These rocks are similar in most aspects to the gneissic and foliated $P_{MM} mdq$ granitoid rocks, which comprise part of the MMIS and occur in the Kenamu River (NTS map area 13C/NE) and Minipi Lake (NTS map area 13C/S) areas (see James, 1999; James and Nadeau, 2000b). These gneisses and foliated granitoid rocks are equivalent to the Lower Brook

metamorphic suite orthogneisses as defined by Wardle *et al.* (1990). Clinopyroxene-bearing $P_{MM} mdq$ monzodiorite gneiss, occurring at Minipi Lake, has an emplacement age of 1659 ± 5 Ma based on U-Pb dating of zircon (James *et al.*, 2000). However, it is possible the unit may also contain rocks having pre-Labradorian emplacement ages.

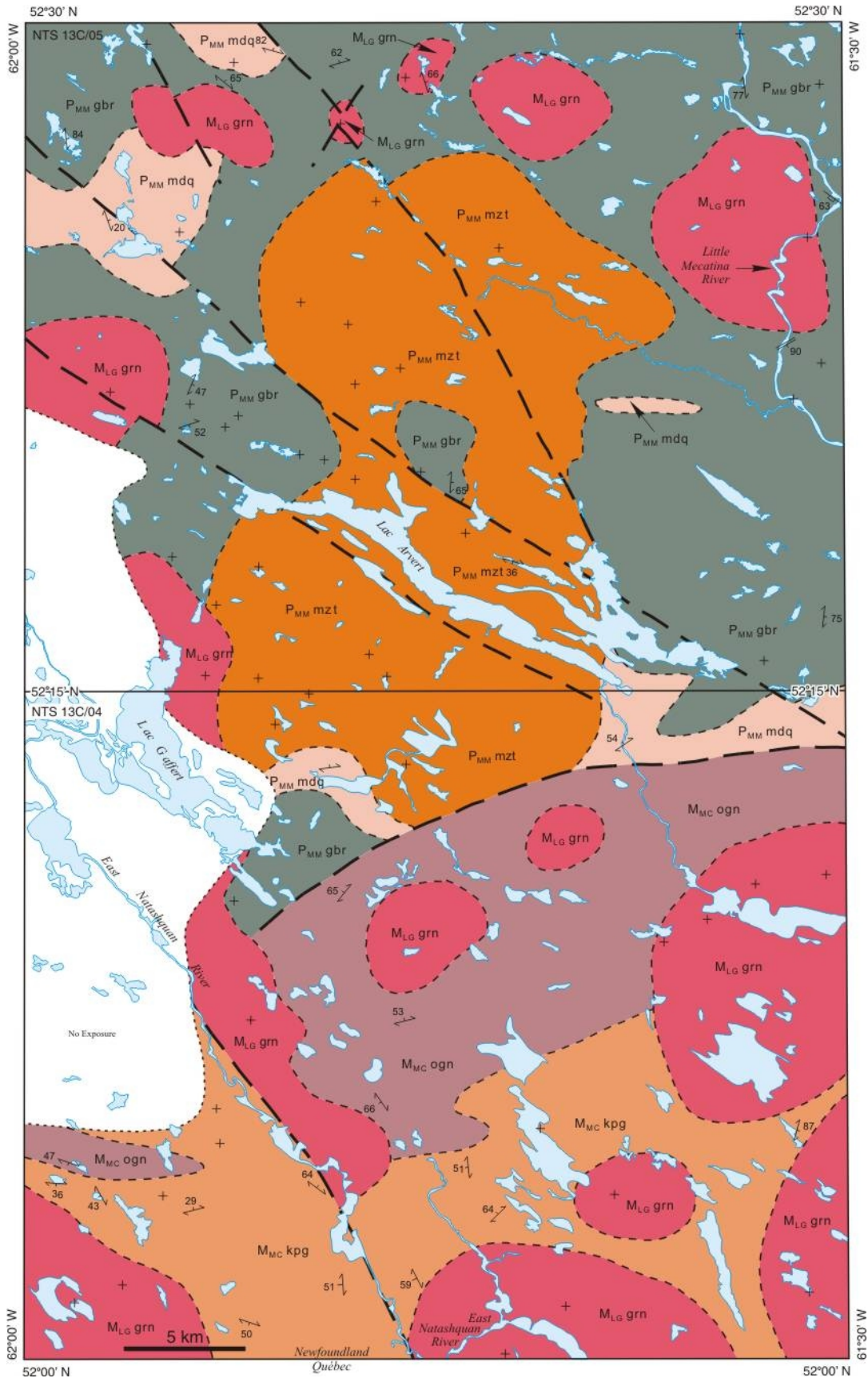


Figure 5. Generalized geological map for the Lac Arvert area (NTS map area 13C/SW).

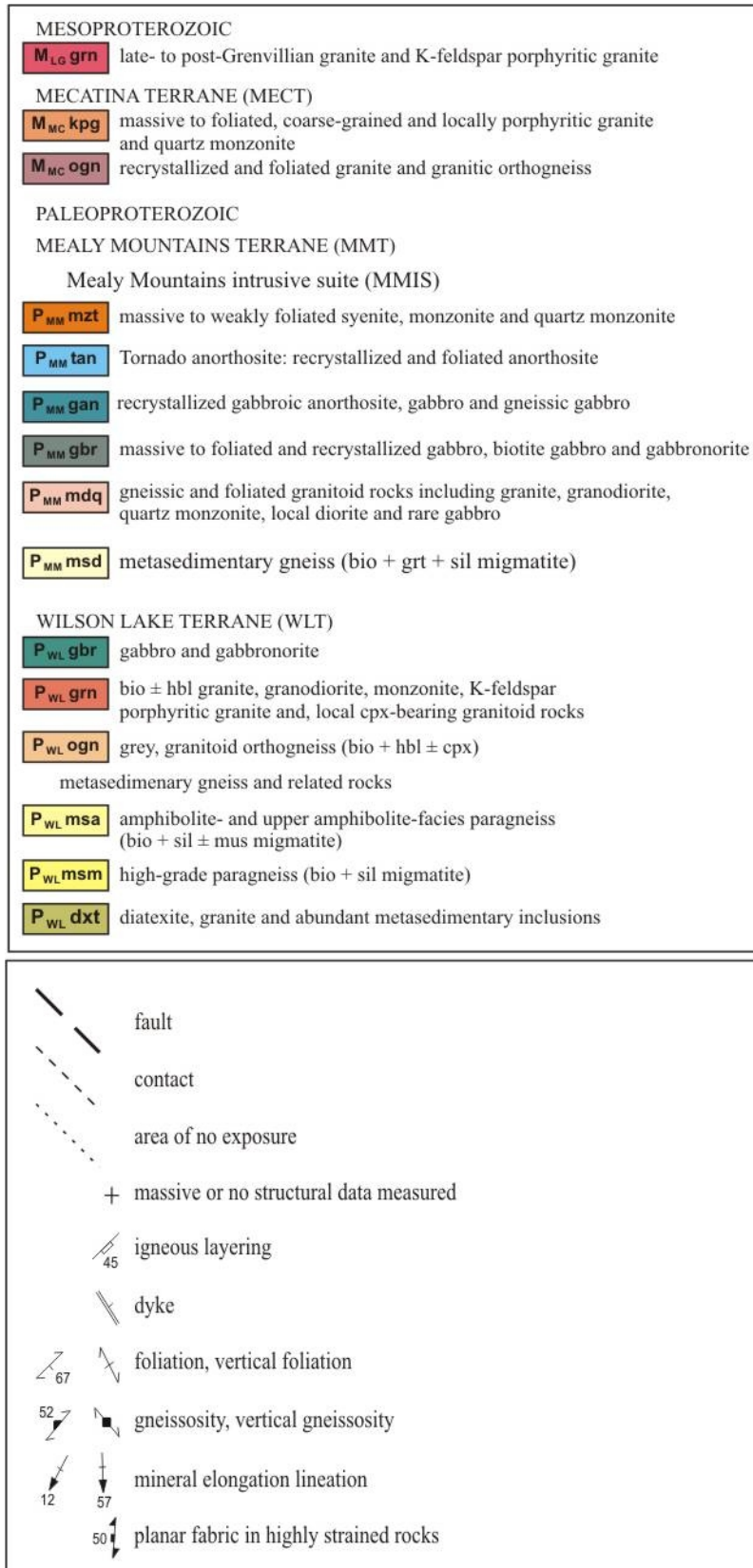


Figure 5. Legend. See opposite page.

Outcrops of P_{MM} mdq rocks are commonly composite; they may contain xenoliths of grey-weathering hornblende + biotite diorite, and younger aplite dykes that are less deformed than the gneiss. In addition, P_{MM} mdq gneisses are locally cut by deformed and metamorphosed mafic dykes. Weakly deformed and massive pegmatites are a minor part of the unit.

Tornado Anorthosite (P_{MM} tan)

The NTS map area 13D/10 includes an elongate, east–west-trending intrusion of metamorphosed and deformed anorthosite covering an area of approximately 250 km² and designated on Figure 3 as Unit P_{MM} tan. The unit is best exposed near its eastern end, occurring on a group of hills centred around 523820m E and 5834241m N (UTM coordinates, NAD 1927 projection). One of these hills (near UTM 520944m E, 5834857m N) is the site of a number of military targets (full-scale model tanks and anti-aircraft weapons) used for tactical exercises by NATO Tornado jets; the aircraft provided the inspiration for the name of the unit. The western part of the intrusion is poorly exposed and contacts are interpreted using regional aeromagnetic data.

The anorthositic rocks are white and grey on the fresh and weathered surfaces. They are variably recrystallized and foliated (Plate 7). Some rocks contain abundant relicts of coarse-grained, bluish-grey primary plagioclase grains that have fine-grained margins of recrystallized plagioclase. In contrast, other rocks consist entirely of fine- to medium-grained granoblastic plagioclase. Primary mafic minerals are replaced by a mixture of biotite and hornblende. Based on similarity of rock types, P_{MM} tan anorthosite is provisionally correlated with Labradorian-age MMIS anorthosite occurring in the central (e.g., Gower, 1999) and north-eastern (e.g., Nunn and van Nostrand, 1996) parts of the MMT.

Gabbro, Gabbronorite and Gabbroic Anorthosite (P_{MM} gbr, P_{MM} gan)

The MMT, in NTS map area 13C/SW, consists of abundant, variably metamorphosed and deformed biotite gabbro, gabbro, gabbronorite and rare diorite, collectively grouped

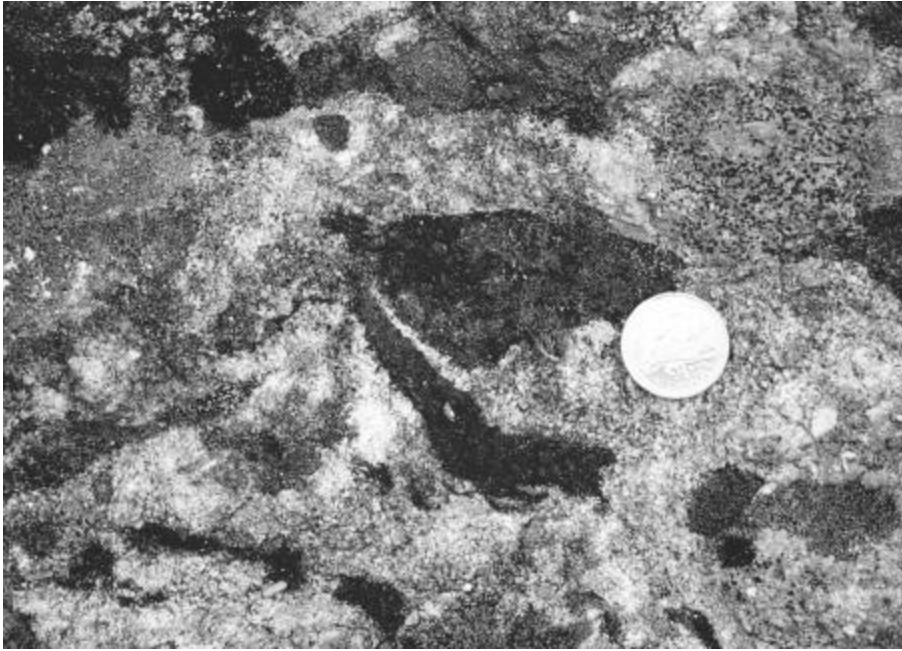


Plate 7. *Metamorphosed Tornado anorthosite ($P_{MM} tan$) correlated with the Labradorian Mealy Mountains intrusive suite, Mealy Mountains terrane.*

as Unit $P_{MM} gbr$ (Figure 5). These rocks are continuous to the north and east where they have been mapped, respectively, by Wardle *et al.* (2000) and James and Nadeau (2000b). To the northwest, in NTS map area 13D/NE (Figure 3), the MMT includes significantly lesser gabbro and related gabbroic anorthosite ($P_{MM} gan$).

The $P_{MM} gbr$ unit, in NTS map area 13C/SW, consists mainly of a medium grey-weathering gabbro, commonly containing up to 10 percent medium-grained biotite. The biotite appears to be primary as opposed to metamorphic. The biotite gabbro has a distinctive porphyritic texture defined by biotite 'phenocrysts' up to 1 cm that consist of an aggregate of biotite grains. The rocks are generally massive to foliated and variably recrystallized, although subtle relicts of igneous layering, defined by composition and grain size, occur locally. The gabbro is better foliated and more pervasively recrystallized in the southern and western parts of NTS map area 13C/SW than in the northeastern part of this area. In well-foliated and recrystallized rocks, the gabbro is converted to biotite amphibolite.

The southwestern part of NTS map area 13D/NE includes several occurrences of metamorphosed leucogabbro and mafic gneiss defined as Unit $P_{MM} gan$. The leucogabbro has a fine-grained granoblastic texture and is strongly foliated. It contains relicts of coarse-grained clinopyroxene, which appear to be mainly replaced by finer grained hornblende and biotite.

The age of $P_{MM} gbr$ and $P_{MM} gan$ rocks is undetermined, although they are assumed to be Labradorian and part of the MMIS. Contact relationships are not exposed, although the map pattern in NTS map area 13C/SW may be interpreted to suggest that $P_{MM} gbr$ rocks are intruded by $P_{MM} mzt$ rocks.

Syenite, Monzonite and Quartz Monzonite ($P_{MM} mzt$)

The NTS map area 13C/SW includes an elongate intrusion consisting mainly of syenite, monzonite and lesser amounts of quartz monzonite. The intrusion covers an area of more than 500 km² (Figure 5). The rocks are medium pink on the fresh and weathered surfaces. They are medium to coarse grained having a subhedral granular texture, and they contain up to 15 percent medium-

grained clinopyroxene and biotite. These rocks are typically massive; weakly foliated rocks occur only rarely. A notable feature of the $P_{MM} mzt$ unit is that it has very consistent texture and structure throughout the study area.

$P_{MM} mzt$ rocks are identical to units of clinopyroxene-bearing syenite and monzonite that occur in the MMT to the east (James and Nadeau, 2000a, b) and northeast (James, 1999), and interpreted to be part of the MMIS. A pyroxene-bearing $P_{MM} mzt$ monzonite in the Kenamu River area has an emplacement age of 1643 ± 2 Ma (James *et al.*, 2000).

MESOPROTEROZOIC UNITS

Mecatina Terrane (MECT)

Granitic Orthogneiss ($M_{MC} ogn$) and Porphyritic Granite ($M_{MC} kpg$)

Rocks provisionally interpreted to be part of the MECT occur in the southern part of the NTS map area 13C/SW. The rocks include granitic orthogneiss ($M_{MC} ogn$) and deformed K-feldspar porphyritic granite ($M_{MC} kpg$). The orthogneiss is variably layered and contains biotite and local hornblende. The gneiss is derived from granitic and quartz monzonitic protoliths, although locally, the unit also includes gneissic K-feldspar porphyritic granite that could be a gneissic version of the porphyritic granite unit ($M_{MC} kpg$).



Plate 8. Foliated and recrystallized, Mesoproterozoic K-feldspar porphyritic granite (M_{MC} kpg), Mecatina terrane.



Plate 9. Undeformed, late- to post-Grenvillian K-feldspar porphyritic granite (M_{LG} grn) containing biotite.

The M_{MC} kpg unit consists of variably foliated and recrystallized K-feldspar porphyritic granite containing biotite and hornblende (Plate 8). Locally, rocks are extensively recrystallized, strongly foliated and have an augen structure. The M_{MC} kpg granite is correlated, on the basis of

composition and texture with K-feldspar porphyritic granite occurring in the Fourmont Lake area, 75 km to the east (see James and Nadeau, 2000b). The latter has an emplacement age of 1493 ± 3 Ma (i.e., Pinwarian age) determined by U-Pb geochronological studies of zircon (James *et al.*, *this volume*). The same rock contains titanite that formed at ca. 1043 Ma, demonstrating the MECT has been overprinted by Grenvillian metamorphism and suggesting the fabric in the granitic orthogneiss (M_{MC} ogn) and porphyritic granite (M_{MC} kpg) units is also Grenvillian.

Late- to Post-Grenvillian Granite (M_{LG} grn)

The MECT and the southern MMT are intruded by plutons of granite and, locally, K-feldspar porphyritic granite defined as Unit M_{LG} grn (see Figures 3 and 5). These rocks are pink on the fresh and weathered surfaces, medium to coarse grained and contain less than 10 percent biotite (Plate 9). They are generally massive, although weakly foliated rocks also occur. Of note, some plutons are marked by prominent circular or elliptical, magnetic highs, whereas others are marked by magnetic lows. A good example of the latter occurs in the northeast corner of the NTS map area 13C/SW (Figure 6), centred around UTM 597872m E, 5808590m N. These rocks are correlated, on the basis of composition and texture, with granites occurring in the NTS map area 13C/South (see James and Nadeau, 2000b), where one pluton has an emplacement age of 964 ± 3 Ma determined by U-Pb geochronology of zircon (James *et al.*, *this volume*).

The MECT and the southern MMT also have widespread occurrences of massive, pink- or white-weathering pegmatites containing muscovite \pm biotite. They are interpreted, on the basis of their undeformed character, to be late- to post-Grenvillian intrusions.

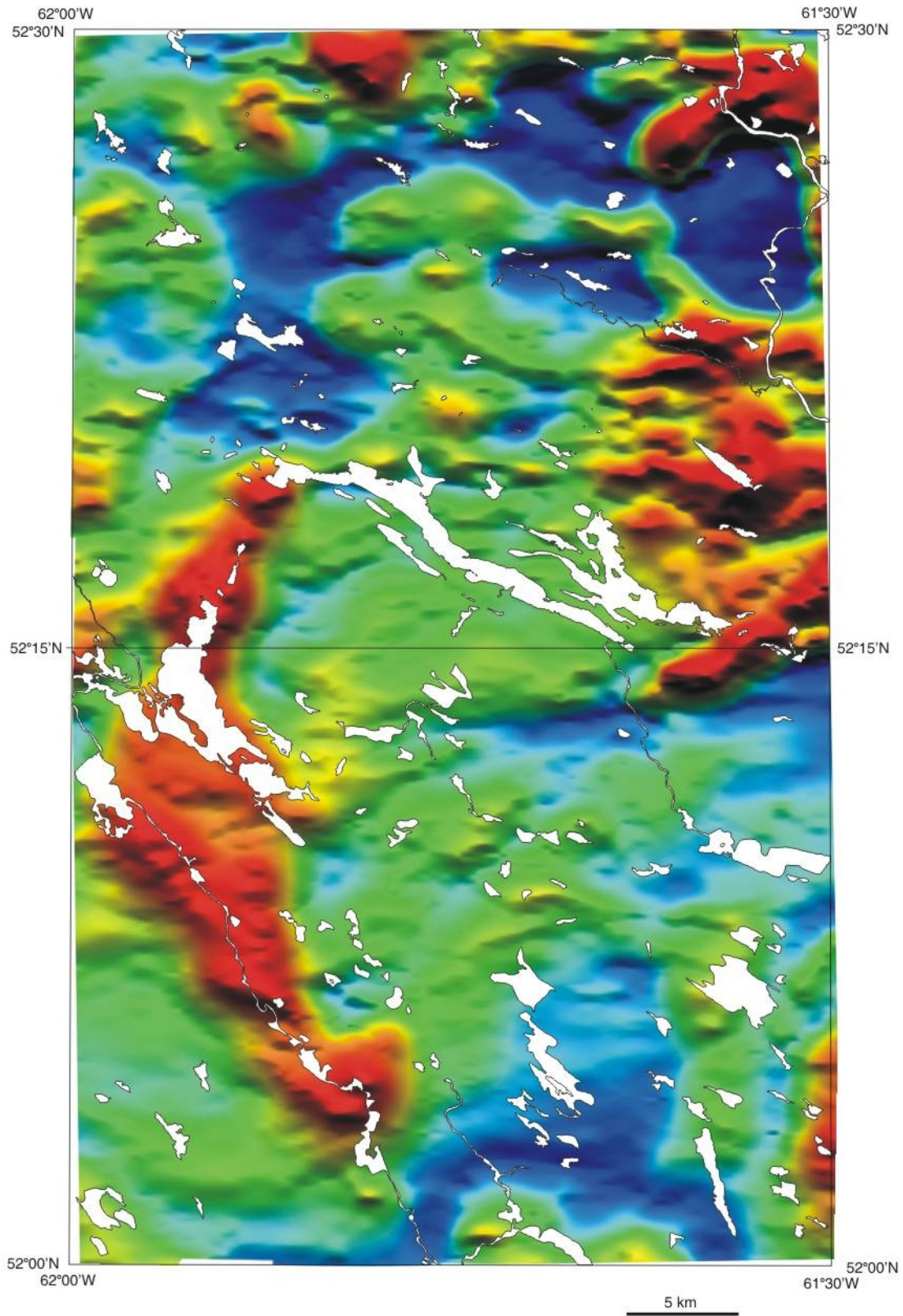


Figure 6. Shaded-relief magnetic anomaly map of the Lac Arvert (NTS map area 13C/SW). False illumination: azimuth - 315°, inclination - 45°. Red end of the spectrum - magnetic highs; blue end of the spectrum - magnetic lows. Map prepared by G. Kilfoil, Geochemistry, Geophysics and Terrain Sciences Section, Geological Survey of Newfoundland and Labrador.

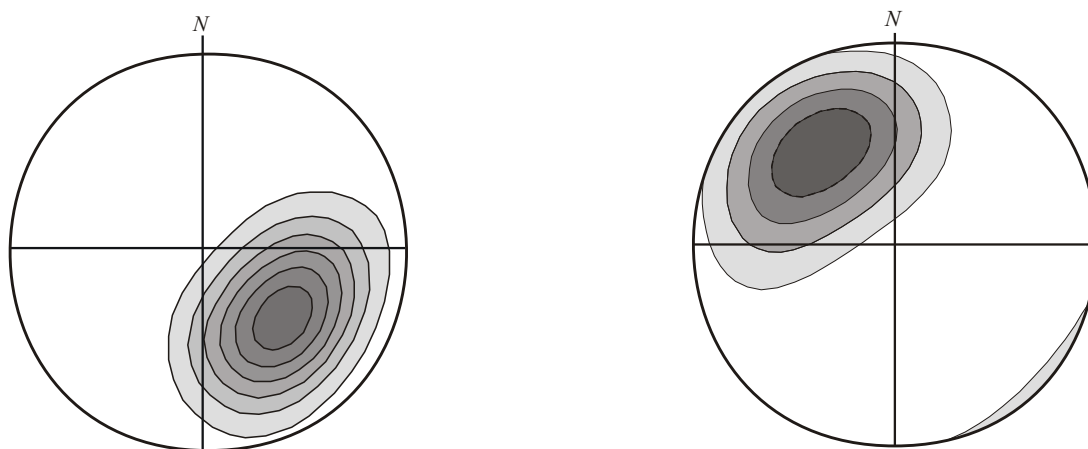


Figure 7. Contoured, lower-hemisphere, equal-area projections of poles to planar fabrics (7A, $n=29$, peak pole position = $128^\circ/45^\circ$) and mineral elongation lineations (7B, $n=20$, peak position = $320^\circ/40^\circ$) in highly strained rocks, Zone A segment of the boundary between the WLT and MMT.

STRUCTURE AND METAMORPHISM

Wilson Lake Terrane (WLT)

Foliation and gneissosity in metasedimentary migmatite, diatexite, orthogneiss and granitic rocks in the WLT are generally southwest-striking and moderately northwest dipping. Foliation is defined by alignment of the metamorphic minerals, or recrystallized mineral aggregates in the granitic rocks. In P_{WL} msm metasedimentary migmatite, the metamorphic assemblage includes biotite + sillimanite + K-feldspar + granitic melt. This assemblage, and the fact that P_{WL} msm migmatite is gradational into diatexite (P_{WL} dxt), indicates upper-amphibolite to granulite-facies metamorphism. In the study area, metamorphic leucosome in P_{WL} msm migmatite and diatexite have not been dated, although they are interpreted to be the product of ca. 1640 Ma Labradorian metamorphism. This interpretation is based on geochronology of monazite by Corrigan *et al.* (1997), collected from diatexite occurring in the northwestern part of the WLT.

In contrast to the P_{WL} msm rocks, P_{WL} msa metasedimentary migmatite, occurring in the northeastern part of NTS map area 13D/16, commonly contains muscovite. Neither the age of the migmatization nor the muscovite growth is certain, but one possible scenario is that migmatization is Labradorian and the same age as high-grade metamorphism in P_{WL} msm migmatite, whereas the muscovite is Grenvillian and represents the effects of a lower grade (amphibolite facies?) metamorphic overprint. This provisional model is consistent with data presented by Corrigan *et al.* (1997) indicating that some rocks in the southeastern part of the WLT have been overprinted by ca. 1000 Ma metamorphism.

Boundary between the WLT and the MMT

In the study area, the tectonic boundary between the WLT and the MMT is not a single structure. Rather, it appears to consist of at least two geometrically discordant structures that separate MMT rocks from a structurally imbricated package of WLT rocks.

Mylonitic rocks, derived from metasedimentary migmatite and granite, along the section of the boundary designated as Zone A (*see* Figure 3) suggest this section is a ductile high-strain zone. In Zone A rocks, high-strain planar fabrics are southwest striking, moderately northwest dipping, and contain a northwest-trending mineral elongation lineation (Figures 7a and b). Rare kinematic indicators suggest a hangingwall down (i.e., WLT to the northwest) sense of displacement. The highly strained rocks do not appear to be retrogressed, suggesting that the high-strain event was synchronous with high-grade metamorphism. The interpretation of Zone A as a mainly northwest-dipping structure having a top-to-the-northwest kinematic sense is in general agreement with the interpretations made by Thomas *et al.* (1986).

The area along Zone B (Figure 3) is very poorly exposed, and the relationship between zones A and B is undetermined. The location of Zone B is interpreted primarily on the basis of magnetic anomaly patterns. One outcrop consisting of interlayered and strongly foliated mafic and metasedimentary gneisses near the inferred location of Zone B exhibits a very strong, moderately south southwest-dipping foliation and a southeast-plunging mineral elongation lineation. This single observation is consistent with mapping by Wardle *et al.* (1990, 2000) in NTS map area 13C/NW that has shown the boundary between the WLT and the MMT to

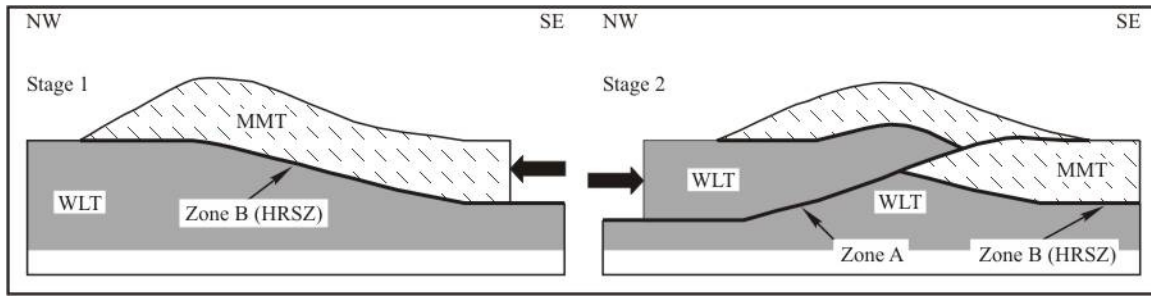


Figure 8. Simplified 'cartoon' cross-sections showing two-stage development of the tectonic contacts (i.e. Zone A and Zone B) defining the boundaries between the Wilson Lake terrane (WLT) and the Mealy Mountains terrane (MMT).

be a mainly southwest- to southeast-dipping high-strain zone. Wardle *et al.* (1990) defined this boundary (i.e., the east continuation of Zone B) as the Hamilton River Shear Zone (HRSZ). On the basis of U–Pb geochronological studies of mylonitized samples from the NTS map area 13C/NW, Corrigan *et al.* (1997) determined that thrusting of the MMT over the WLT, along the HRSZ, occurred at 1010 ± 4 Ma. A model involving early, northwest-directed Grenvillian transport of the MMT over the WLT on the HRSZ (Zone B), followed by southeast-directed "back-thrusting" of WLT rocks over the MMT on Zone A, could explain the apparent geometry of structures defining the terrane boundary (Figure 8).

Mealy Mountains Terrane

Foliation and gneissosity in metasedimentary gneiss (P_{MM} msd) and rocks of the MMIS are highly varied in attitude, although planar fabrics are southwest striking. These fabrics, and the metamorphic minerals that define them, are tacitly assumed to be Labradorian. Geochronological studies are required to test this model.

The metasedimentary and MMIS rocks indicate upper amphibolite-facies metamorphism was reached. The former are migmatitic rocks containing biotite + sillimanite + garnet + K-feldspar. The latter include gneissic and migmatitic granitoid rocks, and gabbroic rocks that have been converted to amphibolite. Primary mafic minerals in the Tornado anorthosite have been replaced by hornblende and biotite.

Boundary between the MMT and the MECT

In the study area, the boundary between the MMT and the MECT is not exposed, and the location, shown in Figure 5, is determined primarily from aeromagnetic patterns. It is assumed to be a Grenvillian tectonic feature based on two outcrops of mylonitic rocks occurring along the interpreted boundary in the Fourmont Lake area, approximately 75 km to the east. The mylonitic rocks, which have an undetermined kinematic history, suggest the boundary is a south-dipping structure (*see* James and Nadeau, 2000a, b).

Mecatina Terrane

Pinwarian-age granitic rocks (M_{MC} kpg) and orthogneiss (M_{MC} ogn) in the MECT are metamorphosed to upper-amphibolite facies. Foliation, defined by the metamorphic minerals and recrystallized mineral aggregates, and gneissosity are varied from southwest- to south-southeast-striking. The age of metamorphism and attendant deformation in these rocks is interpreted to be Grenvillian based on U–Pb data from a deformed M_{MC} kpg granite occurring in NTS map area 13C/S, which demonstrated new titanite growth at ca. 1043 Ma (James *et al.*, *this volume*).

LATE- TO POST-GRENVILLIAN STRUCTURES

M_{LG} grn granite is unrecrystallized, although locally the rocks are weakly foliated. This suggests that deformation outlasted Grenvillian metamorphism, although these late- to post-Grenvillian fabrics are not pervasive.

The region also includes several northwest- to north-striking faults that are interpreted to cut the Grenvillian terrane boundaries and M_{LG} grn granite plutons. The faults are interpreted to be late- to post-Grenvillian structures, perhaps Neoproterozoic structures related to the opening of Iapetus.

EXPLORATION POTENTIAL

The Grenville Province of southern Labrador is under-explored and does have some exploration potential (*see* Swinden *et al.*, 1991; Gower, 1992; and Gower *et al.*, 1995), although field work in 2000 did not result in any significant or promising discoveries of economic minerals. A brief discussion of potential exploration targets in the region follows.

Mesoproterozoic and Paleoproterozoic anorthosite intrusions are potential exploration targets for Ti (Fe) oxide and magmatic Ni-sulphide deposits. The QIT Fer et Titane Inc. Ti-oxide deposits in Mesoproterozoic anorthosite near Harve-St.-Pierre, Québec, provide the best local example of economic Ti-oxide mineralization in Grenville Province

anorthosite (Perreault and Jacob, 1999). Of note, the Mesoproterozoic (ca. 1130 Ma) Atikonak anorthosite, occurring in NTS map area 13D/SW, is approximately the same age as the intrusion that hosts the QIT deposits. The Tornado anorthosite (P_{MM} tan), discovered in the 2000 field season and inferred to be Paleoproterozoic, offers a new exploration target in the region for magmatic Ni-sulphide deposits. In addition, Paleoproterozoic gabbro and gabbro-norite intrusions (P_{WL} gbr, P_{MM} gbr, and P_{MM} lgr units) in the study area, and elsewhere in the region, also have some potential for hosting Ni mineralization. Several outcrops in the study area contain a few percent pyrite, although no significant sulphide occurrences were discovered.

Granitic rocks may be of some exploration interest. The extent of Pinwarian granitic magmatism in the area is uncertain, although anorogenic Pinwarian-age granitic rocks in the St. Francois terrane of southeastern Missouri, host magmatic Cu-Fe mineralization. Polymetallic (Sn-W-Ag-Pb-As-Sb) quartz veins are linked with this mid-continent plutonism. Late- to post-Grenvillian granite plutons in Baltica (e.g., in southwestern Norway) are hosts to Mo mineralization and are locally anomalous in U and F. Also associated with these intrusions are fault-controlled polymetallic (Au-Ag-Cu-Pb-Zn) veins (*see* Gower, 1992). There is no known Mo mineralization in the late- to post-Grenvillian granite plutons in Labrador, although typically these intrusions are very poorly exposed and have not been mapped in any detail.

An outcrop of gossanous P_{MM} mdq orthogneiss (Sample: NK-00-8060, UTM 522150m E, 5826410m N) contains several percent sulphide mineralization and 2788 ppm copper. In addition, an outcrop of granite and associated pegmatite, inferred to be late- to post-Grenvillian, contains several percent pyrite and 215 ppm copper (Sample: DJ-00-9026, UTM 546365m E, 5828086m N).

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