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THE LAC JOSEPH TERRANE AND THE CHURCHILL FALLS TERRANE: STRUCTURAL AND METAMORPHIC RELATIONS, OSSOKMANUAN LAKE (NTS 23H/SW) AND LAC JOSEPH (NTS 23A/NW) MAP AREAS, GRENVILLE PROVINCE, WESTERN LABRADOR

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ABSTRACT

The Ossokmanuan Lake–Lac Joseph area of western Labrador contains parts of two, fault-bounded terranes that are of regional extent. The terranes consist primarily of ca. 1670-1620 Ma crust and were tectonically juxtaposed in the ca. 1000 Ma Grenville Orogeny. In the map area, the Churchill Falls Terrane contains granitoid rocks of the ca. 1650 Ma Trans-Labrador batholith and mafic rocks of the ca. 1430 Ma Shabogamo Intrusive Suite. The rocks contain Grenville-age amphibolite-facies metamorphic assemblages. In contrast, the Lac Joseph Terrane is composed of supracrustal rocks, gabbronorite and granitoid intrusive rocks subjected to high-grade metamorphism in the ca. 1700-1600 Ma Labradorian Orogeny. The rocks in the Lac Joseph Terrane display only minor effects of the Grenville Orogeny.

Kinematic indicators and relationships between structures and metamorphic minerals in ductile shear zones adjacent to the terrane boundary, indicate that the Lac Joseph Terrane was emplaced from the southeast-to-northwest over the Churchill Falls Terrane. The high strain developed under medium-grade (Grenville) conditions.

INTRODUCTION

OBJECTIVES AND PREVIOUS WORK

The 1990 field season involved 1:100,000-scale geological mapping of the Ossokmanuan Lake (23H/SW) and Lac Joseph (23A/NW) map areas in western Labrador (Figure 1). Mapping was mainly helicopter-supported and carried out from a base camp on the Labrador City–Churchill Falls section of the Trans-Labrador Highway. A minor portion of the field work was accomplished using ground traverses based from the Trans-Labrador Highway and from boat-supported camps on Lac Joseph and Ossokmanuan Lake.

This project constitutes part of a long-term, regional-scale mapping program, undertaken by the Labrador Mapping Section, that has involved the investigation of the geology of the Grenville Province in Labrador and, in particular, the area marginal to the Grenville Front. The objective of the 1990 survey was to conduct systematic mapping focused on structural and metamorphic relationships, and the nature of major, terrane-bounding shear zones.

The results of the survey are addressed in a regional context, emphasizing the similarities in rock types and pre-Grenvillian structural and metamorphic histories that exist between tectonically juxtaposed domains in the region. These similarities raise the problem of local usage of terrane terminology, which is firmly established from studies in Phanerozoic orogens. Alternative nomenclature for identifying the domains in the map area are discussed.

Parts of the area have been previously mapped by Wynne-Edwards (1961, 23H/W), Stevenson (1967, 23A) and Connelly (1988). The area is adjacent to that mapped by Nunn and Christopher (1983, 23H/SE), Nunn *et al.* (1984, 23A/NE), Connelly and Scowen (1987, 23A/SW and parts of 23B and 22P) and, Rivers (1985a, 23G/SE and, 1985b, 23H/NW).

REGIONAL SETTING

Investigations in southwest Labrador and adjacent parts of eastern Quebec have shown that the Grenville Province can be subdivided into a number of tectonically bounded terranes (Figure 2). These are defined on the basis of contrasting rock types, structural styles and ages of metamorphism, and separated by major, high-strain zones (Rivers, 1983; Rivers and Nunn, 1985; Rivers and Chown, 1986; Wardle *et al.*, 1986). The terranes, variably affected by the ca. 1700-1600 Ma Labradorian Orogeny (Nunn *et al.*, 1984; Nunn *et al.*, 1985; Thomas *et al.*, 1985; Thomas *et*

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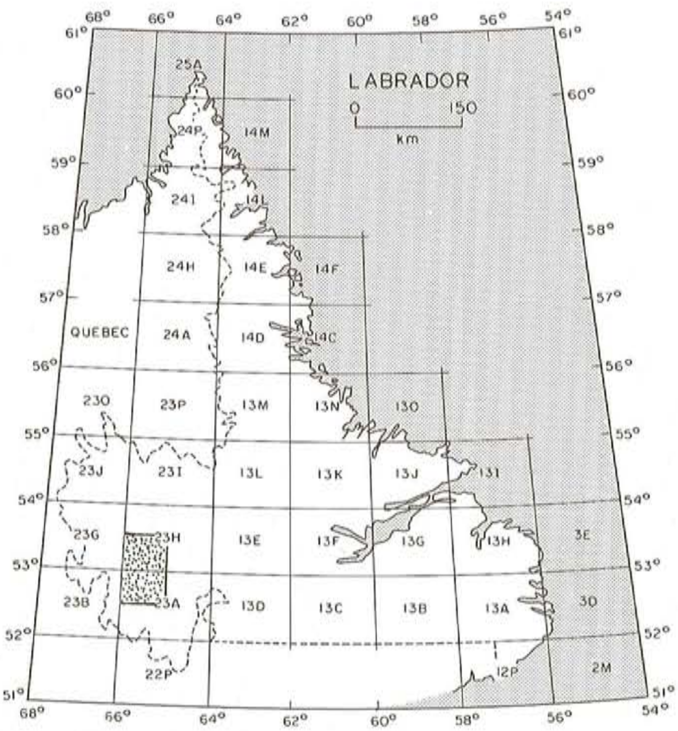

Figure 1. *Index map showing the location of the Ossokmanuan Lake–Lac Joseph map area (stippled area).*

al., 1986) and the ca. 1000 Ma Grenville Orogeny, have been proposed to be parautochthonous and allochthonous with respect to an autochthonous foreland represented by the Superior, Churchill and Makkovik provinces (Rivers and Chown, 1986).

The map area (Figure 3) contains parts of the Churchill Falls Terrane (Units 8 and 9) (Connelly and Nunn, 1988) and the Lac Joseph Terrane (Units 1 to 7) (Rivers and Chown, 1986); these consist mainly of ca. 1670-1620 Ma crust, although the Churchill Falls Terrane also contains mafic rocks of the Shabogamo Intrusive Suite (Rivers, 1980). Shabogamo gabbro, from west of the map area, has been dated at 1429 Ma (igneous age) by Connelly *et al.* (1990) using U–Pb (zircon) methods. The Churchill Falls Terrane and the Lac Joseph Terrane are from Rivers and Chown's (1986) parautochthonous and allochthonous zones, respectively.

The Lac Joseph Terrane and the Churchill Falls Terrane are separated by a zone of heterogeneously distributed ductile shear zones that extend for several kilometres on both sides of the boundary. An ensemble of kinematic indicators confirms that the Lac Joseph Terrane (upper structural-deck) was thrust to the northwest over the Churchill Falls Terrane (lower structural-deck). Connelly *et al.* (1990) have concluded that the Lac Joseph Terrane was emplaced on the terranes to the north between 1000 to 990 Ma based on $^{40}Ar-^{39}Ar$ geochronological studies.

To the west of the map area, the Lac Joseph Terrane is in tectonic contact with the Molson Lake Terrane (Connelly *et al.*, 1989), which is composed of metamorphosed 1645 Ma granitic rocks and Shabogamo gabbro. The Molson Lake Terrane and the Churchill Falls Terrane share the same structural position with respect to the Lac Joseph Terrane.

Results from U–Pb geochronology in the Lac Joseph Terrane have shown that the extensive high-grade metamorphism is Labradorian in age and that the Grenville effects are restricted to areas of low-grade retrogression (Connelly *et al.*, 1990). In contrast, Grenvillian metamorphism is significantly more pervasive in the Churchill Falls and Molson Lake terranes (Rivers and Nunn, 1985; Connelly and Nunn, 1988; Connelly *et al.*, 1989). Medium- to high-grade metamorphism of the Shabogamo gabbro and granitic rocks in the Churchill Falls Terrane and the Molson Lake Terrane is presumed to be Grenvillian. Grenvillian metamorphism also overprints Labradorian high-grade assemblages in supracrustal rocks in the Churchill Falls Terrane, east of the map area.

UNIT DESCRIPTIONS

LAC JOSEPH TERRANE

Paragneiss (Unit 1)

The oldest rocks in the Lac Joseph Terrane are high-grade migmatitic paragneisses (Unit 1). These rocks form a homogeneous and monotonous unit of pink- and grey-weathering gneisses derived from semipelitic to psammitic sediments. The rocks contain two, discordant phases of leucosome: an older, grey-weathering, finer grained phase and, a younger, pink-weathering, coarser grained phase. The percentage of leucosome in outcrops is varied, although it is generally greater than 40 percent. Locally, there are outcrop-scale areas where the paragneisses grade into homogeneous diatexite. The rocks commonly contain the high-grade assemblage: K-feldspar–biotite–sillimanite–garnet–magnetite. Connelly (personal communication, 1990) reports that kyanite occurs locally along the northern margin of the Lac Joseph Terrane. Orthopyroxene-bearing assemblages are suspected at several localities, although these remain to be confirmed by petrographic studies.

Within the paragneisses, boudins of structurally concordant, high-grade mafic rock and dark-green-weathering ultramafic rock, presumed to be deformed and metamorphosed mafic and ultramafic dykes, are common. Rarely, the paragneisses are interlayered with thin layers of quartz-rich foliate. (As defined by Ashton and Leclair (1990), a foliate is a foliated metamorphic rock without compositional layering and containing less than 50 percent platey grains that exhibit a parallel orientation.)

The high-grade paragneisses in the Lac Joseph Terrane are presumed to be correlative with the paragneisses that occur in the terranes to the east of the map area, including those in the Churchill Falls Terrane. Collectively, these paragneisses, named the Disappointment Lake gneiss by Thomas (1981), make up a continuous supracrustal belt that

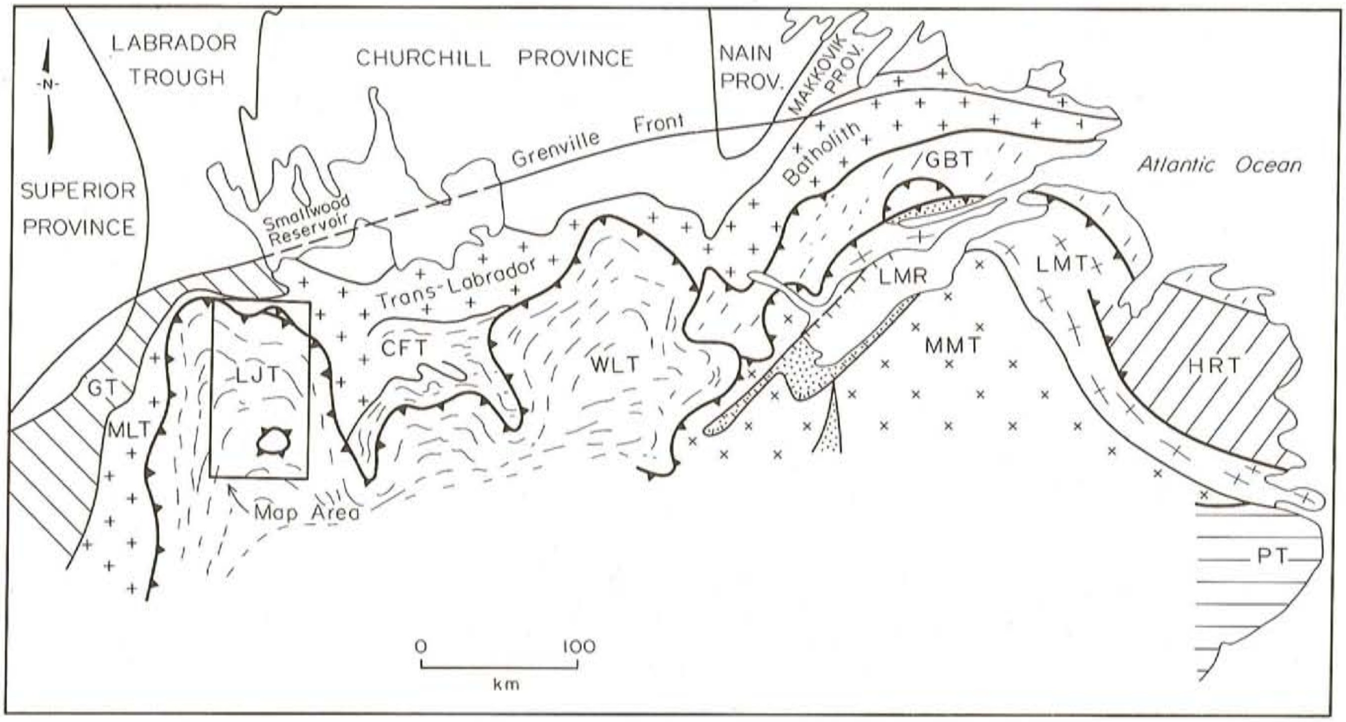

Figure 2. *Principal tectonic subdivisions of the Grenville Province, Labrador (modified after Wardle* et al.*, 1990). GT–Gagnon Terrane, MLT–Molson Lake Terrane, LJT–Lac Joseph Terrane, CFT–Churchill Falls Terrane, WLT–Wilson Lake Terrane, LMR–Lake Melville rift system, MMT–Mealy Mountains Terrane, GBT–Groswater Bay Terrane, LMT–Lake Melville Terrane, HRT–Hawke River Terrane, PT–Pinware Terrane.*

is at least 400 km long. The U–Pb geochronological studies of the paragneisses (Thomas *et al.*, 1986) yielded an age of 1676 Ma, suggesting that the sedimentary protolith is at least Early Proterozoic.

Heterogeneous Supracrustal Gneiss (Unit 2)

Interlayered with the paragneisses in the Lac Joseph area and north-northeast of Lac Joseph are mappable layers of a heterogeneous supracrustal gneiss (Unit 2). This unit is dominated by black- to rusty-weathering mafic gneiss having lesser amounts of intermediate-composition gneiss, pink and grey-weathering paragneiss, rusty paragneiss and quartz-rich foliate. The mafic gneisses are well-layered, two-pyroxene-plagioclase rocks that are migmatitic containing less than 30 percent tonalitic leucosome. These rocks are presumed to be derived from mafic and intermediate volcanic rocks, and interlayered semipelitic and quartzitic sediments.

Granitoid Gneiss (Unit 3)

Outcrops of pink, black and white-weathering granitoid gneisses that occur in a poorly defined body in the central part of the map area, and which occur as isolated outcrops throughout the paragneisses in the Lac Joseph Terrane, are defined as Unit 3.

The gneisses are varied in composition from outcrop to outcrop, from tonalitic to granitic and from relatively mafic, with hornblende, biotite and epidote, to relatively quartzofeldspathic. Garnet occurs in some outcrops. Gneissosity is defined by alternating mafic and quartzofeldspathic layers or by layers of granitoid leucosome.

The contact relationship between the granitoid gneisses and the supracrustal rocks is uncertain; however, it is assumed that these gneisses are derived from Labradorian-age granitoid plutonic rocks that were intruded into the supracrustal rocks.

Ossok Mountain Intrusive Suite (Unit 4)

The paragneisses of the Lac Joseph Terrane are intruded by large bodies and dykes/sills of variably deformed and recrystallized mafic intrusive rocks, here informally named the Ossok Mountain intrusive suite (Unit 4). These rocks are relatively well-exposed, especially in the area south and southwest of Ossokmanuan Lake and they underlie much of the topographically high areas in the Lac Joseph Terrane. Contacts between paragneiss (Unit 1) and the large mafic bodies (Unit 4) are gradational and, where they are relatively well-exposed, are marked by heterogeneous zones of paragneiss having a profusion of mafic dykes, and by mafic rocks containing abundant paragneiss xenoliths. On the map, the contact is placed where the proportion of mafic rocks is greater than paragneiss.

The unit has a homogeneous composition, predominantly gabbronoritic to gabbroic, and a minor amount of anorthosite. Occurrences of olivine gabbronorite are rare. Texturally, the

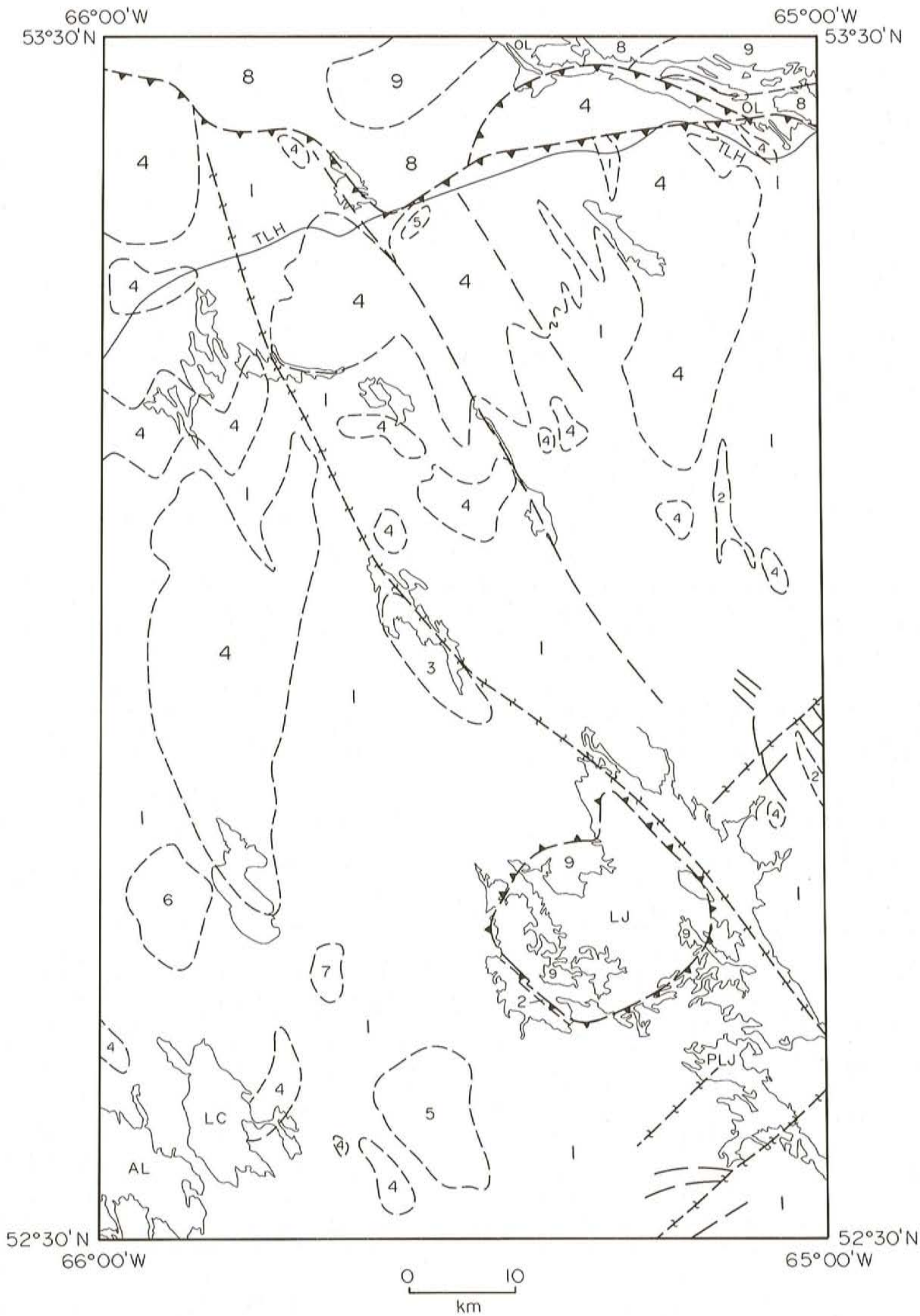

Figure 3. *General geology of the Ossokmanuan Lake (NTS 23H/SW)–Lac Joseph (NTS 23A/NW) map area.*

Legend for Figure 3

CHURCHILL FALLS TERRANE (Lower Structural-Deck)

9 Shabogamo Intrusive Suite
gabbro, gabbronorite, coronitic gabbro

8 Trans-Labrador Batholith
megacrystic granite, granite, granitoid gneiss

LAC JOSEPH TERRANE (Upper Structural-Deck)

7 *quartz syenite*

6 *quartz monzonite, monzonite, monzodiorite*

5 *granite, megacrystic granite (locally rapakivi-textured)*

4 Ossok Mountain Intrusive Suite
gabbronorite, gabbro, mafic gneiss

3 *granitoid gneiss*

2 *mafic gneiss*

1 *paragneiss*

lithological contact

thrust fault (contact between the Churchill Falls and Lac Joseph terranes)

prominent topographic lineament

prominent break in the aeromagnetic pattern

OL-Ossokmanuan Lake, LJ-Lac Joseph, PLJ-Petit Lac Joseph, LC-Lac a l'Eau-Claire, AL- Ashuanipi Lake, TLH-Trans-Labrador Highway

unit is very heterogeneous and is variable, even at the outcrop scale; from massive and coarse-grained having relict igneous textures to foliated, fine-grained and completely recrystallized. Relict cumulate layering, plagioclase lamination and rocks with relict intergranular textures are common. The wide textural variations are thought, at least in part, to reflect original textural variations between multiple intrusive phases that constitute the unit. The composite nature of the unit is clearly displayed in some outcrops where fine-grained, recrystallized and deformed gabbro dykes (having stable orthopyroxene) crosscut non-foliated, coarse-grained gabbronorite or cumulate layered rocks. Deformation and concomitant recrystallization appear to have occurred at granulite-facies conditions. There are also occurrences of undeformed but recrystallized dykes that intrude layered gabbronorite. These dykes are included in the Ossok Mountain intrusive suite. Similar undeformed dykes cut the metamorphic layering in the paragneisses.

Narrow (less than 1 km wide) zones of well-layered, mafic granulite gneisses occur around the margins of several of the gabbronorite bodies in the Lac Joseph Terrane. These rocks are included with the Ossok Mountain intrusive suite.

The U–Pb zircon geochronology by Connelly *et al.* (1990) of a coarse-grained gabbronorite from the Ossok Mountain intrusive suite (from west of the map area) gave an igneous age of 1.62 Ga.

Granitoid Intrusive Rocks (Units 5 to 7)

Dykes and small bodies of granitoid intrusive rocks intrude both the supracrustal rocks and rocks of the Ossok Mountain intrusive suite. The intrusive rocks include K-feldspar megacrystic granite, equigranular granite, quartz monzonite–monzonite–monzodiorite and quartz syenite. The contacts of the three granitoid bodies that occur in the southwestern part of the map area are poorly constrained and have been interpreted in part with the aid of 1":1 mile aeromagnetic maps (Geological Survey of Canada, 1973). The contact around the small body of granite in the northern part of the Lac Joseph Terrane is relatively well-constrained by outcrops.

Occurrences of K-feldspar megacrystic granite, locally rapakivi-textured, and equigranular granite are recrystallized and variably foliated (Unit 5). The textural variation from megacrystic to equigranular rocks is gradational on the outcrop scale. The rocks contain biotite. Orthopyroxene is suspected at several localities. Apart from the mapped bodies of granite, dykes of megacrystic and equigranular granite are common in the paragneisses and the Ossok Mountain intrusive suite, especially in the area immediately south of Ossokmanuan Lake, where highly strained sheets of megacrystic granite in the gabbronorite (Unit 4) are abundant.

The body of quartz monzonite–monzonite–monzodiorite (Unit 6) that occurs in the southwestern part of the map area is variably foliated and recrystallized. The rocks are fine- to medium-grained and contain hornblende. Locally, the body contains outcrops of megacrystic granite (Unit 5?), although the poor exposure prevents examination of the contact relationships.

The southwestern part of the map area also contains a small body of quartz-syenite (Unit 7). The rocks, which are pink- to mauve-weathering, fine- to medium-grained, non-foliated and phaneritic in texture, contain less than 10 percent fine-grained biotite and local clinopyroxene. The non-foliated and non-recrystallized character of this unit suggest that it is post-Labradorian.

Pink, coarse-grained, non-foliated and non-recrystallized pegmatites occur throughout the Lac Joseph Terrane. Commonly, the pegmatites contain muscovite and, where they intrude high-grade paragneisses, they may be surrounded by a muscovite halo that overprints high-grade assemblages in the country rock. Their unmetamorphosed and undeformed character suggest that these pegmatites are Grenvillian.

CHURCHILL FALLS TERRANE

Trans-Labrador Batholith (Unit 8)

Granitoid rocks in the Churchill Falls Terrane include variably foliated and recrystallized, equigranular and megacrystic granite and granitoid gneiss that are assigned to the Trans-Labrador batholith (as defined by Wardle *et al.*, 1986). Generally, these granitoid rocks are poorly exposed in the map area, although outcrops are somewhat more abundant southwest of Ossokmanuan Lake and on some of the islands in the lake. In areas with a paucity of outcrop, the contacts between the Trans-Labrador batholith (Unit 8) and the significantly more magnetic Shabogamo gabbro (Unit 9) have been interpreted with the aid of 1":1 mile aeromagnetic maps (Geological Survey of Canada, 1973).

The granitic rocks are varied in texture from fine- to medium-grained and equigranular to coarse grained, containing abundant K-feldspar megacrysts and local orbicular K-feldspar megacrysts. The textural relationship between the equigranular rocks and the megacrystic rocks appears to be gradational. The rocks commonly contain 5 to 10 percent biotite, and local muscovite, which is presumed to be a Grenvillian metamorphic mineral. The unit contains a subordinate amount of granodiorite.

The granitoid gneisses that are included with the Trans-Labrador batholith make up less than 30 percent of the unit in the map area. They consist of granitic, granodioritic and tonalitic gneiss and migmatite. Layering is defined by alternating mafic and quartzofeldspathic layers or by layers of grey-weathering leucosome. Biotite, in variable quantities, is the predominant mafic mineral present. At one location, the contact between gneiss and megacrystic granite, although not sharply defined, appears to be discordant to the gneissosity, suggesting that the gneisses are older than the granite.

The U–Pb zircon dates of Trans-Labrador batholith rocks indicate a ca. 1650 Ma age of emplacement (e.g., Brooks, 1983; Krogh, 1983; Thomas *et al.*, 1985; Nunn *et al.*, 1985; Connelly *et al.*, 1990).

Shabogamo Intrusive Suite (Unit 9)

The Trans-Labrador batholith is intruded by mafic rocks of the Shabogamo Intrusive Suite. The unit is composed of fine- to coarse-grained, massive to foliated gabbro and, locally, olivine gabbro. Relict cumulate layering and evidence of multiple intrusive phases are common. Locally, gabbros are gradational into coronitic gabbro in which the coronas consist of garnet around pyroxene, olivine or ilmenite. Garnet coronas are presumed to be a Grenvillian feature. The rocks may also have a poikiloblastic texture defined by abundant, 1- to 5-cm diameter garnets. Occurrences of gabbro and coronitic gabbro at Lac Joseph have been tentatively correlated with the Shabogamo Intrusive Suite in the Churchill Falls Terrane (after Connelly, 1988) on the basis of textural relations. The gabbro is interpreted to be exposed in a structural window through the Lac Joseph Terrane as opposed to an intrusion of Shabogamo gabbro into the paragneisses. There are no known intrusions of Shabogamo gabbro in high-grade, Labradorian paragneisses and a high-strain zone, which separates the gabbro from the paragneisses, supports this theory. A sample of the gabbro from Lac Joseph has been collected for U–Pb zircon geochronology and geochemical studies to test this model.

The gabbros at Lac Joseph are commonly massive, coarse-grained rocks having preserved igneous plagioclase and interstitial clinopyroxene. Locally, outcrops are cumulate layered. Garnet coronas occur around clinopyroxene and magnetite. Rarely, the unit includes well-layered mafic gneiss, mapped as part of the intrusive suite and xenoliths of black and rusty-weathering quartzofeldspathic gneiss containing biotite and garnet. The xenoliths are of uncertain origin. Outcrops may contain sets of undeformed, rectilinear pegmatite dykes.

STRUCTURE AND METAMORPHISM

LAC JOSEPH TERRANE

The paragneisses within the Lac Joseph Terrane are variably strained and can be observed in all states of a structural progression between two characteristic end-members. The lowest strained rocks are foliated gneisses that have open to tight, variably-plunging folds and refolded, Type 3 folds of the older leucosome and, lesser strained, discordant layers of the younger leucosome. The main biotite foliation is axial planar to the folds of the gneissosity. An older, locally preserved, biotite foliation that is folded with the gneissosity demonstrates that the main biotite foliation in most outcrops is at least the second generation of foliation in the paragneisses. In the highest strained end-member, both leucosomes are isoclinally folded, somewhat disrupted and completely transposed about the main biotite foliation. In both end-members, the main biotite foliation and the traces of axial planes of folds generally strike north-northwest to north-northeast. South of Lac Joseph, the main foliation is variable from north- to east-striking. Within the Lac Joseph Terrane, there is a random pattern of distribution between the lesser strained and the more highly strained paragneisses.

Locally, the main foliation and the metamorphic layering are openly folded about an approximately west-trending and steeply plunging fold axes. Folds may have a weak, axial-planar fabric defined by biotite. Because of the absence of retrogression, these structures are also presumed to be part of the high-grade deformation.

Sillimanite, present in most outcrops of paragneiss in the Lac Joseph Terrane, occurs as both fine- to medium-grained individual needles and needle-aggregates and, as medium- to coarse-grained, blue-grey, sillimanite-quartz nodules. Both varieties can occur either randomly oriented on the foliation surface, folded with the metamorphic layering, or lineated parallel to the fold axis. This suggests that growth of sillimanite occurred throughout the high-grade deformation. Kyanite occurrences in paragneisses are reported adjacent to the Lac Joseph Terrane–Churchill Falls Terrane boundary in the northern part of the map area (J. Connelly, personal communication, 1990). This suggests that there may be a south-to-north increase in metamorphic pressure and paleo-depth toward the terrane boundary.

The U–Pb monazite geochronology by Connelly *et al.* (1990) has dated the two leucosomes in the paragneisses at 1645 Ma (grey phase) and 1635 Ma (pink phase), thus, the high-grade metamorphism and synchronous deformation in the Lac Joseph Terrane is entirely Labradorian.

The state of strain and the metamorphic assemblages in Ossok Mountain intrusive suite rocks and in the metamorphosed granitoid rocks are compatible with the Labradorian, high-grade assemblages and structures in the paragneisses. In the Ossok Mountain intrusive suite, recrystallized and variably foliated rocks contain the mineral assemblage: clinopyroxene–orthopyroxene–plagioclase and, local garnet. Fabrics in the granitoid rocks are defined by biotite or hornblende. Some outcrops of the megacrystic granite (Unit 5) may be orthopyroxene-bearing.

It is uncertain if the paragneisses were deformed prior to the intrusion of the Ossok Mountain intrusive suite. Local mafic dykes, which are undeformed but recrystallized under high-grade conditions, are discordant to structures and metamorphic layering in the paragneisses and the gabbronorite. This demonstrates that there are some post-main deformation mafic intrusive phases. This relationship also demonstrates that high-grade metamorphic conditions persisted past the end of the main Labradorian deformation.

Locally, rocks within the Lac Joseph Terrane are deformed by narrow (outcrop-scale), ductile, high-strain zones that strike from northwest to northeast. These shear zones cannot be traced from outcrop to outcrop and their regional significance is uncertain. Rocks within these shear zones are not retrogressed suggesting that these structures are late syn-(Labradorian) metamorphic.

In the field, the recognizable effect of Grenvillian metamorphism is the presence of local muscovite in paragneiss. Commonly, the muscovite-bearing rocks lack K-feldspar and sillimanite and have a distinctive black- and white-weathered appearance. With the exception of a few occurrences of deformed muscovite in highly strained paragneiss adjacent to the Lac Joseph Terrane–Churchill Falls Terrane boundary and around the tectonic window at Lac Joseph, muscovite is randomly oriented. The distribution of muscovite-bearing paragneiss is sporadic throughout the Lac Joseph Terrane, although occurrences are most common in a poorly defined, 1- to 15-km-wide zone around Lac Joseph. The retrogression may be related to concentration of Grenvillian strain along the Lac Joseph Terrane–Churchill Falls Terrane boundary.

The absence of significant, regional retrogression of the high-grade Labradorian assemblages is in agreement with U–Pb evidence that suggests that the Lac Joseph Terrane did not experience significant Grenville heating (Rivers and Nunn, 1985; Connelly *et al.*, 1990).

The Lac Joseph Terrane contains a conjugate set (?) of lineaments, striking 325° and 055°, that are defined by topographic lineaments and linear breaks in the aeromagnetic anomaly pattern. The northwest-striking set is the most prominent. Neither set of structures is known to displace lithological contacts, however, in most cases, given the limited outcrop control, contacts could be re-interpreted to show minor separations across these structures.

The most westerly of the northwesterly-striking structures is marked by a conspicuous aeromagnetic lineament and is at least 100 km long. Several outcrops of paragneiss that are located along the trace of this structure around the north end of Lac Joseph contain medium- to high-grade, steeply east-dipping, ductile shear zones. At one location, C/C' structures indicate an east-side-down kinematic sense (i.e., normal displacement), however, the paucity of kinematic indicators and the uncertainty in the temporal correlation between the structures in outcrop and the aeromagnetic break, hinder any definitive interpretation of this structure.

THE CHURCHILL FALLS TERRANE

The ages of the fabrics and the metamorphic layering in the Trans-Labrador batholith are equivocal. The U–Pb sphene dates reported by Rivers and Nunn (1985) from the

Churchill Falls Terrane indicate metamorphic ages between 1000 and 990 Ma, although there could still be older, Labradorian assemblages and structures preserved in the Trans-Labrador batholith. The Grenvillian metamorphism in the area reached amphibolite facies (Rivers and Nunn, 1985) and may have been high enough to produce migmatites in the Churchill Falls Terrane (Nunn and Christopher, 1983). Geothermobarometry from the Churchill Falls and Molson Lake terranes (Connelly and Nunn, 1988; Connelly *et al.*, 1989) indicates that the Grenvillian metamorphic pressures were significantly higher than Labradorian pressures and that temperatures reached 750°C in the Molson Lake Terrane.

The ductile, high-strain zones that obliterate older foliations and layering in the granitoid rocks are inferred to be Grenvillian structures related to Lac Joseph Terrane–Churchill Falls Terrane juxtaposition. This correlation is based on similarity of attitudes between the high-strain zones and the Lac Joseph Terrane–Churchill Falls Terrane boundary. Local muscovite may be a product of medium-grade, medium- to high-pressure Grenville-age metamorphism or late-Grenville retrogression.

Locally, gabbro and garnet-coronitic gabbro of the Shabogamo Intrusive Suite are foliated and mylonitized. These structures are restricted to zones that are marginal to the Lac Joseph Terrane–Churchill Falls Terrane boundary and, like the high-strain zones in the Trans-Labrador batholith, are also judged to be related to Grenvillian terrane juxtaposition. The high-strain zones deform amphibolite-facies garnet coronas that were formed in the Grenvillian Orogeny (Rivers and Mengel, 1987) demonstrating that the high-strain cannot be older than the peak of Grenville metamorphism. Outside of the high-strain zones the state of strain in the gabbro and coronitic gabbro is very low.

THE LAC JOSEPH TERRANE–CHURCHILL FALLS TERRANE BOUNDARY

The rocks adjacent to, and on both sides of, the Lac Joseph Terrane–Churchill Falls Terrane boundary are cut by heterogeneously distributed, ductile high-strain zones that strike parallel to the terrane boundary and are presumed to be related to juxtaposition. The boundary itself is not exposed and where outcrops are scarce, its position has been inferred from aeromagnetic data.

Within the Lac Joseph Terrane in the Ossokmanuan Lake area, the high-strain is concentrated within layers of megacrystic granite and paragneiss that are (tectonically?) interlayered with gabbronorite. In most cases, rocks in these high-strain zones apparently preserve their high-grade, Labradorian assemblages with only local retrogression in the paragneisses and mafic rocks. The retrogressed paragneisses contain variably deformed muscovite and the mafic rocks are retrogressed to amphibolite facies having deformed hornblende and plagioclase defining the high-strain structures. These relations suggest that high-strain in the Lac Joseph Terrane, in zones contiguous with the Lac Joseph Terrane–Churchill Falls Terrane boundary, occurred at medium-grade.

South of Ossokmanuan Lake, strain is heterogeneously distributed, although ductile, high-strain is locally concentrated along a zone that is interpreted to be a splay from the main Lac Joseph Terrane–Churchill Falls Terrane boundary. Exposure in the area is limited, however, it appears that the high-strain may be concentrated in a narrow zone of mylonitic paragneiss that is coincident with a significant topographic lineament and aeromagnetic break.

Ductile high-strain zones within the Churchill Falls Terrane, presumed to be related to Lac Joseph Terrane–Churchill Falls Terrane juxtaposition on the basis of orientation and structural-metamorphic relations, deform Trans-Labrador batholith rocks and Shabogamo gabbro. Although limited in number, an ensemble of kinematic indicators from gabbro, including C/C' structures, rolled feldspar porphyroclasts and tails, asymmetric folds and the margin-to-centre variation in foliation attitude across shear zones, demonstrates a southeast over northwest (i.e., thrust) sense of transport. The apparent stability of the coronitic assemblage in the highly strained gabbro also suggests that strain occurred under medium-grade conditions that may have been relatively close to the peak conditions of Grenvillian metamorphism in this area.

Similar structural and metamorphic relationships in Lac Joseph Terrane and Churchill Falls Terrane rocks occur around the margin of the inferred tectonic window at Lac Joseph. Highly strained and retrogressed paragneisses, mafic supracrustal gneisses and coronitic Shabogamo gabbro having amphibolite-facies assemblages demonstrate that Grenvillian strain in the Lac Joseph area proceeded under medium-grade conditions.

ECONOMIC GEOLOGY

Previously reported mineralization is restricted to occurrences of disseminated pyrite within gabbroic rocks and, disseminated chalcopyrite and pyrite at the Wynne Showing (UTM coordinates 365450 E, 5865900 N; Newfoundland Department of Mines and Energy, 1976). Mapping in 1990 has also revealed several occurrences of disseminated pyrite in the gabbronoritic and gabbroic rocks and the supracrustal rocks in the Lac Joseph Terrane. Several of the more notable gossans occur in gabbronorite at 334550 E, 5885250 N and, 355100 E, 5919300 N and, in supracrustal rocks at 334050 E, 5885250 N (UTM coordinates). Although these showings are only minor, the layered gabbronoritic and gabbroic rocks have potential for PGE mineralization and the supracrustal rocks have some potential for preserving sediment-hosted massive sulphide mineralization.

Meyer (1989) reports occurrences within the map area of muscovite-bearing pegmatites intersected by road construction at kilometre 90 and kilometre 137 (measured from Labrador City) on the Trans-Labrador Highway. These occurrences may have potential for high-quality sheet muscovite.

DISCUSSION

One of the more notable results from the mapping is that the Trans-Labrador batholith has been recognized to extend continuously from the Churchill Falls Terrane (east of the map area) into the Molson Lake Terrane (west of the map area). The structural continuity of the batholith around the northern margin of the Lac Joseph Terrane suggests that the Churchill Falls Terrane and the Molson Lake Terrane are the same pre-Grenville tectonic entity and that they occupy the same structural and tectonic position with respect to the Lac Joseph Terrane. Linkage between the Molson Lake Terrane and the Churchill Falls Terrane has also been proposed by Connelly *et al.* (1989).

Another regional lithological correlation can be made between terranes. High-grade Labradorian paragneisses within the Churchill Falls Terrane, east of the map area, are interpreted to be correlative with the high-grade paragneisses in the Lac Joseph Terrane on the basis of composition (Rivers and Nunn, 1985). This correlation and the present structural disposition of the terranes suggest that the Lac Joseph Terrane and the Churchill Falls Terrane represent two structural decks of a structurally telescoped, but once lithologically continuous pre-Grenville terrane that was composed principally of ca. 1670 to 1620 Ma crust. The absence of both voluminous granitoid intrusions and Shabogamo gabbro in the Lac Joseph Terrane can be explained if the Lac Joseph Terrane originally lay to the present-day southeast of both the main part of the Trans-Labrador batholith and the most southerly intrusions of Shabogamo gabbro. This implies a minimum displacement on the Lac Joseph Terrane–Churchill Falls Terrane boundary in the order of 100 km, assuming that the displacement was consistently from southeast to northwest.

These lithological correlations illustrate that there are significant pre-Grenville similarities between the parautochthonous and allochthonous zones of Rivers and Chown (1986). These similarities, also recognized by Rivers and Nunn (1985) and Connelly and Nunn (1988), raise the problem of usage of terrane terminology and the term allochthonous (see definitions of terrane by Berg *et al.*, 1978; Jones *et al.*, 1983; and in the AGI Glossary of Geology, Bates and Jackson, 1987 and; allochthonous terrane by Howell and Jones, 1983). Perhaps to avoid problems with the firmly established definitions of terrane and allochthonous terrane, the word terrane could be replaced by lithotectonic zone or block or structural deck, depending on the lithological and structural relationships between neighbouring terranes and within terranes.

The Lac Joseph Terrane and the Churchill Falls Terrane have some differences in their geological histories. One of these differences is the disparate nature of Grenvillian metamorphism in the terranes. The medium-grade and high-pressure Grenville-age metamorphism in parts of the Churchill Falls Terrane (Rivers and Nunn, 1985; Connelly *et al.*, 1989) may be related to the emplacement of the Lac Joseph Terrane (Connelly and Nunn, 1988), although this raises the problem of how the Lac Joseph Terrane almost completely escaped Grenvillian metamorphism and penetrative strain. The absence of significant Grenville-age features could be explained if the Lac Joseph Terrane were emplaced at a relatively high crustal level where rocks were relatively cold and dry and, thus, not amenable to new (Grenville) mineral growth and concomitant development of penetrative mineral fabrics, except in the high-strain zones at the structural base of the Lac Joseph Terrane. Alternatively, Grenville-age metamorphism may have occurred in the Churchill Falls Terrane prior to emplacement of the Lac Joseph Terrane, which may have arrived relatively late and did not significantly contribute to the tectonic loading of the Churchill Falls Terrane.

The structural and metamorphic relationships in mylonitic rocks along the Lac Joseph Terrane–Churchill Falls Terrane boundary in the map area indicate that Grenvillian juxtaposition occurred under medium-grade conditions that were probably near the peak conditions of Grenvillian metamorphism for this area. This suggests that the former model might best explain the Grenville-age differences between the Lac Joseph Terrane and the Churchill Falls Terrane.

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