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GEOLOGY OF THE EASTERN CHURCHILL PROVINCE IN THE SMALLWOOD RESERVOIR AREA, WESTERN LABRADOR

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ABSTRACT

In western Labrador, the eastern Churchill Province is subdivided into two fundamental tectonostratigraphic divisions, separated by a regionally persistent zone of dextral transpressive strain. The Early Proterozoic New Quebec Orogen, a fold-and-thrust belt developed chiefly in Lower Proterozoic supracrustal rocks, makes up the western division, and in the east is a metamorphic–plutonic hinterland. The hinterland, which is the focus of this study, consists of reworked Archean supracrustal rocks and orthogneisses, and Lower Proterozoic plutons, including the 500-km-long De Pas batholith.

In the study area, the hinterland is internally subdivided into three lithotectonic zones; the Western gneiss zone, the De Pas batholith zone, and the Central gneiss zone. The De Pas batholith, consisting of K-feldspar megacrystic granite and charnockite, is in intrusive contact with orthogneisses and high-grade supracrustal rocks of the Central gneiss zone, and is in intrusive and tectonic contact with orthogneisses in the Western gneiss zone. The age of deformation and attendant high-grade metamorphism in the Central and Western gneiss zones is provisionally assigned as Hudsonian, although rocks may contain relict Archean features. Detailed geochronological studies are necessary to test this model. Regionally persistent ductile shear zones, inferred to be elements of the Lac Tudor and George River shear zones, deform rocks in the Western and Central gneiss zones.

Middle Proterozoic anorogenic intrusions, including the Michikamau Intrusion (gabbro–anorthosite suite), and younger bodies of megacrystic granite and syenite, intrude the Central gneiss zone.

INTRODUCTION

OBJECTIVES AND PREVIOUS WORK

In 1992, a 1:100 000-scale bedrock mapping program was initiated in the eastern Churchill Province in western Labrador. The study area occurs between the Smallwood Reservoir and the Quebec border, and is included entirely within the Woods Lake map area, NTS 23I. The 1992 field season mainly involved mapping in the central part of the Woods Lake map area (Figure 1). Only reconnaissance investigations were made in areas outside of the study area outlined in Figures 1 and 2. Mapping was accomplished principally by helicopter-supported ground traverses, which were carried out from a base camp located near the Lobstick Control Structure on the southern shore of the Smallwood Reservoir. A small part of the field work involved examination of shore-line outcrops in the reservoir.

The purpose of this project is to upgrade the geological database from the western part of the eastern Churchill Province. Prior to the 1992 field season, the geology of this area was known only from 1:250 000-scale maps dating from the early 1960's (see Wynne-Edwards, 1960; and Emslie, 1963). In contrast, the Labrador Trough rocks to the west, the northern margin of the Grenville Province to the south, and the Michikamau Intrusion and eastern Churchill Province rocks farther east are better known. Results of this project will help to meet current exploration needs, and will improve our understanding of lithologic, structural and metamorphic relations in the eastern Churchill Province.

Mapping of Archean and Lower Proterozoic rocks in the Woods Lake map area will be completed in 1993.

REGIONAL SETTING

The eastern Churchill Province in Labrador and contiguous northeastern Quebec separates the Archean

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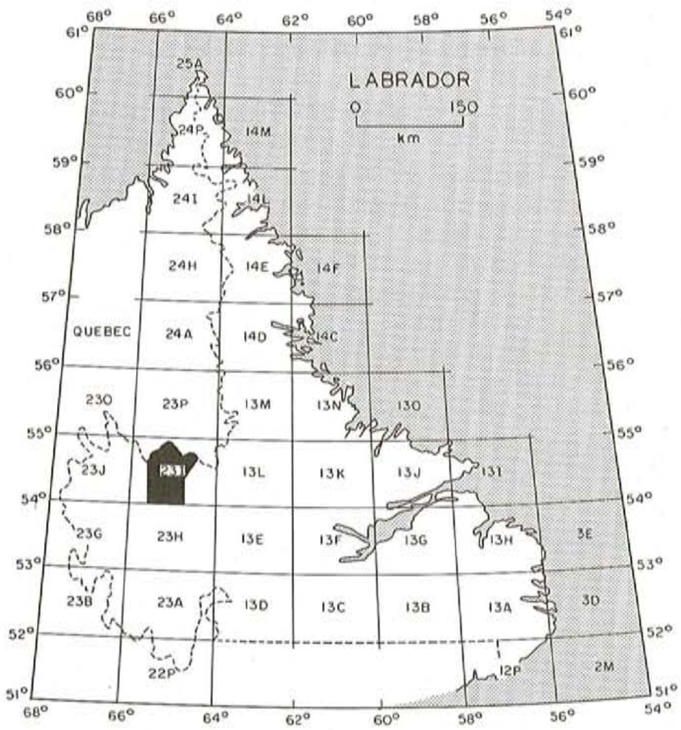
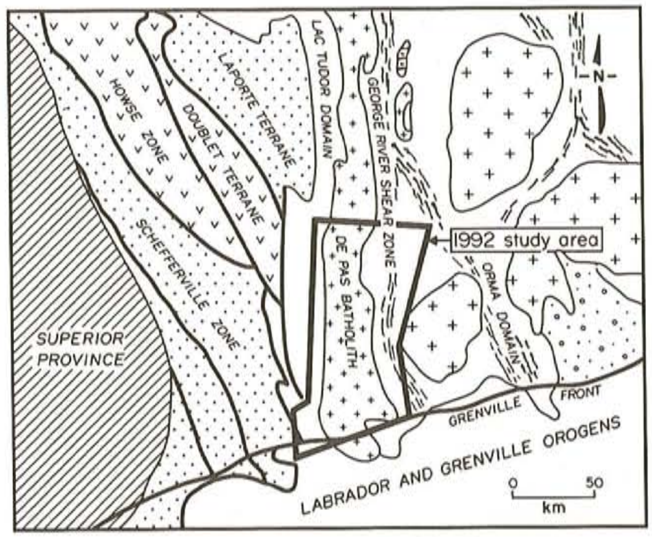


Figure 1. *Index map of Labrador showing the 1992 study area.*



LEGEND

MIDDLE PROTEROZOIC

Sedimentary rocks

Plutonic rocks

LOWER PROTEROZOIC

1.81–1.84 Ga granitic plutons

pre-1.87 Ga mafic volcanic and gabbro belts

ca. 2.1–1.8 Ga metasedimentary rocks

ca. 2.3–2.1 Ga plutonic and volcanic rocks

ARCHEAN

Archean craton

Figure 2. *Regional geological map showing the major subdivisions of the eastern Churchill Province in western Labrador and adjacent parts of Quebec (modified from Wardle* et al., *1990b). LTSZ–Lac Tudor shear zone; GRSZ–George River shear zone.*

Superior and Nain provinces (Figure 2). The interior of the eastern Churchill Province, which Hoffman (1988) refers to as a southeastern extension of the Rae Province, is composed chiefly of reworked Archean rocks and Lower Proterozoic granitoid plutons (e.g., Ashwal *et al.*, 1986; Machado *et al.*, 1988; Ryan, 1990; Nunn *et al.*, 1990), and is sutured against the Superior and Nain cratons by the Early Proterozoic New Quebec and Torngat orogens (Wardle *et al.*, 1990b). These Early Proterozoic transpressional orogens, containing Lower Proterozoic continental margin sequences, have mirror-image craton-verging fold-and-thrust belts associated with dextral (west) and sinistral (east) transcurrent shear on their interior margins with a central hinterland (Wardle *et al.*, 1990b). The southwestern part of the hinterland is the focus of this study.

In the Smallwood Reservoir area, the hinterland can be subdivided into three zones, following the definitions by Wardle *et al.* (1990a) and van der Leeden *et al.* (1990). These are informally named the Western gneiss zone, De Pas batholith zone, and Central gneiss zone (Figure 3). The Western gneiss zone consists of high-grade granitoid gneisses that are undated but suspected to be Archean based on a lithologic similarity with dated Archean gneisses, which occur in tectonically bound slices and in domes in the New Quebec Orogen (Machado *et al.*, 1989; Wardle *et al.*, 1990a). The Western gneiss zone has been affected by the Lac Tudor shear zone, a transpressive (dextral) shear zone, which is locally up to 20 km wide (van der Leeden *et al.*, 1990). The contractional component of displacement on the Lac Tudor shear zone involved east-to-west transport of Western gneiss zone rocks over the New Quebec Orogen (Labrador Trough rocks).

The Lac Tudor shear zone is one structural element of the tectonic boundary between the Western gneiss zone and the New Quebec Orogen. The boundary, which is marked by an inflection in the regional Bouguer gravity anomaly (Mareschal *et al.*, 1990; Wardle *et al.*, 1990a) and by a zone of prominent, linear magnetic anomalies (Figure 4), has been proposed to be a suture by Thomas and Kearey (1980), although its precise location is equivocal. The boundary is inferred to be several kilometres west of the area studied in 1992 and will be the focus of study in 1993. Farther north, the boundary region has been studied by van der Leeden *et al.* (1990, and references therein) and Poirier *et al.* (1990). Hoffman's (1990) model for the tectonic assembly of northeast Laurentia proposes that accretion of the eastern Churchill Province hinterland (the Rae Province) to the Superior

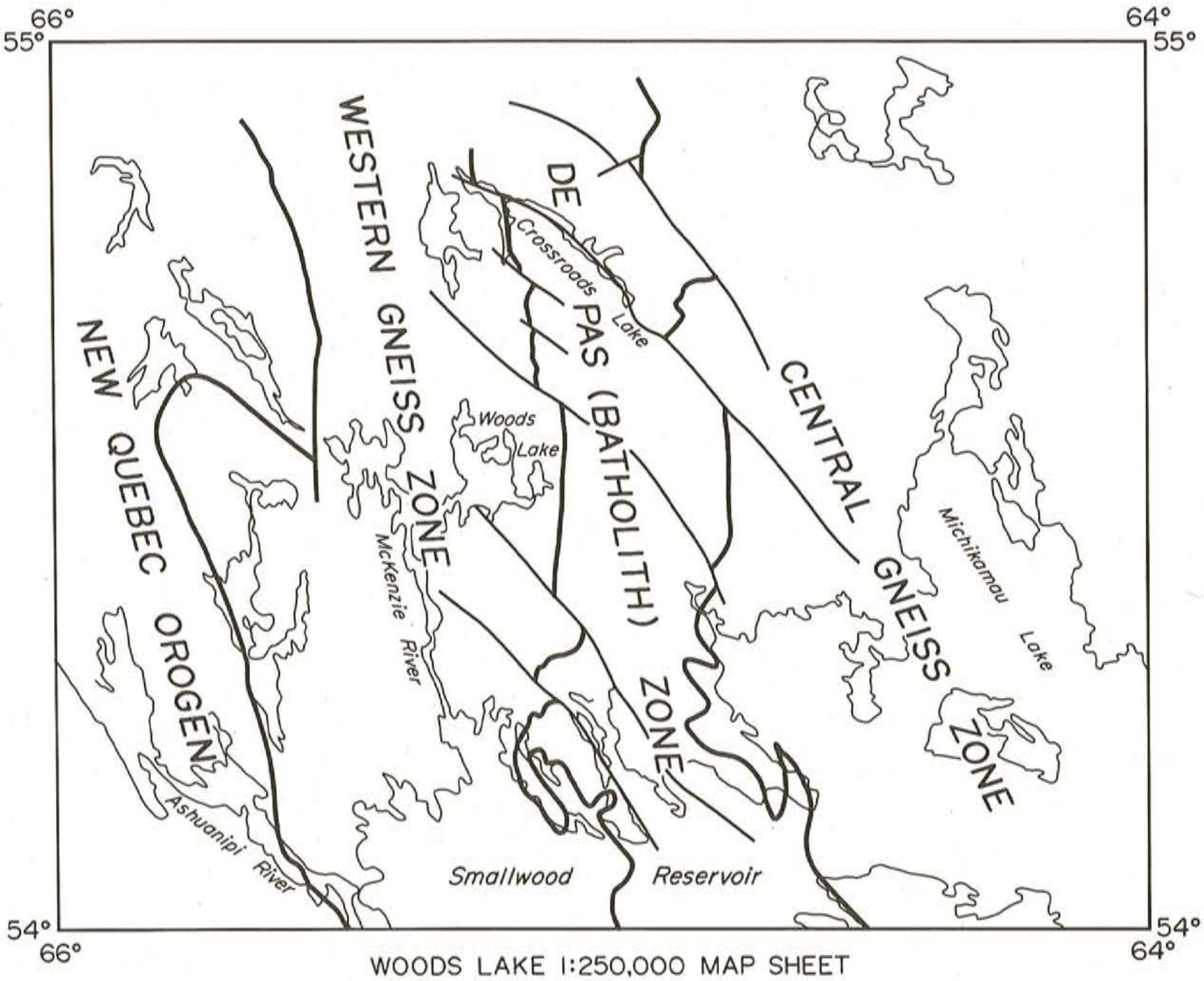


Figure 3. *Subdivisions of the eastern Churchill Province hinterland, in the study area.*

Province and contraction of the intervening Labrador Trough, occurred in the approximate interval from 1880 to 1840 Ma.

To the east, the Western zone gneisses are in intrusive and tectonic contact with the De Pas batholith zone consisting of a 500-km-long, composite batholith of K-feldspar porphyritic granite, charnockite and younger granite and granodiorite phases that display calc-alkaline trends (van der Leeden *et al.*, 1990). Field relations demonstrate that intrusion of the batholith postdated the development of gneissosity in host gneisses of the Western and Central gneiss zones (Wardle, 1985). A U–Pb zircon age of 1811 ±3 Ma (Krogh, 1986) is interpreted to represent the igneous age of a phase of the batholith located near its southern end.

The Central gneiss zone consists of foliated and gneissic, tonalite to granite bodies, which intrude metasedimentary and mafic metavolcanic rocks. East of the study area, where the Central gneiss zone has been examined in some detail by Nunn and Noel (1982), U–Pb zircon geochronology of four tonalite gneiss samples indicates that the gneisses were emplaced in the range from 2682 to 2675 Ma (Nunn *et al.*, 1990). These data demonstrate that much of the Central gneiss zone may consist of reworked Archean crust. In the study area, the Central gneiss zone is cut by the regionally persistent, dextral transcurrent, George River shear zone (see van der Leeden *et al.*, 1990; Girard, 1990; and Wardle *et al.*, 1990b).

The U–Pb studies of zircon and titanite from hinterland orthogneisses by Nunn *et al.* (1990) not only confirmed the occurrence of Archean rocks but also demonstrated the apparent absence of any significant Hudsonian (i.e., ca. 1900–1800 Ma) thermal events in the samples examined. Furthermore, the only post-Archean event recorded by the rocks, indicated by the resetting or growth of new titanite, is Labradorian in age (Nunn *et al.*, 1990). These data suggest that in the present study area, the medium- to high-grade metamorphic assemblages and the penetrative fabrics in at least some of the rocks from the Central gneiss zone may be Archean and not related to Hudsonian tectonothermal and magmatic events.

The Central gneiss zone is intruded by Middle Proterozoic anorogenic mafic and granitic plutons. In the study area, these are represented by the Michikamau Intrusion

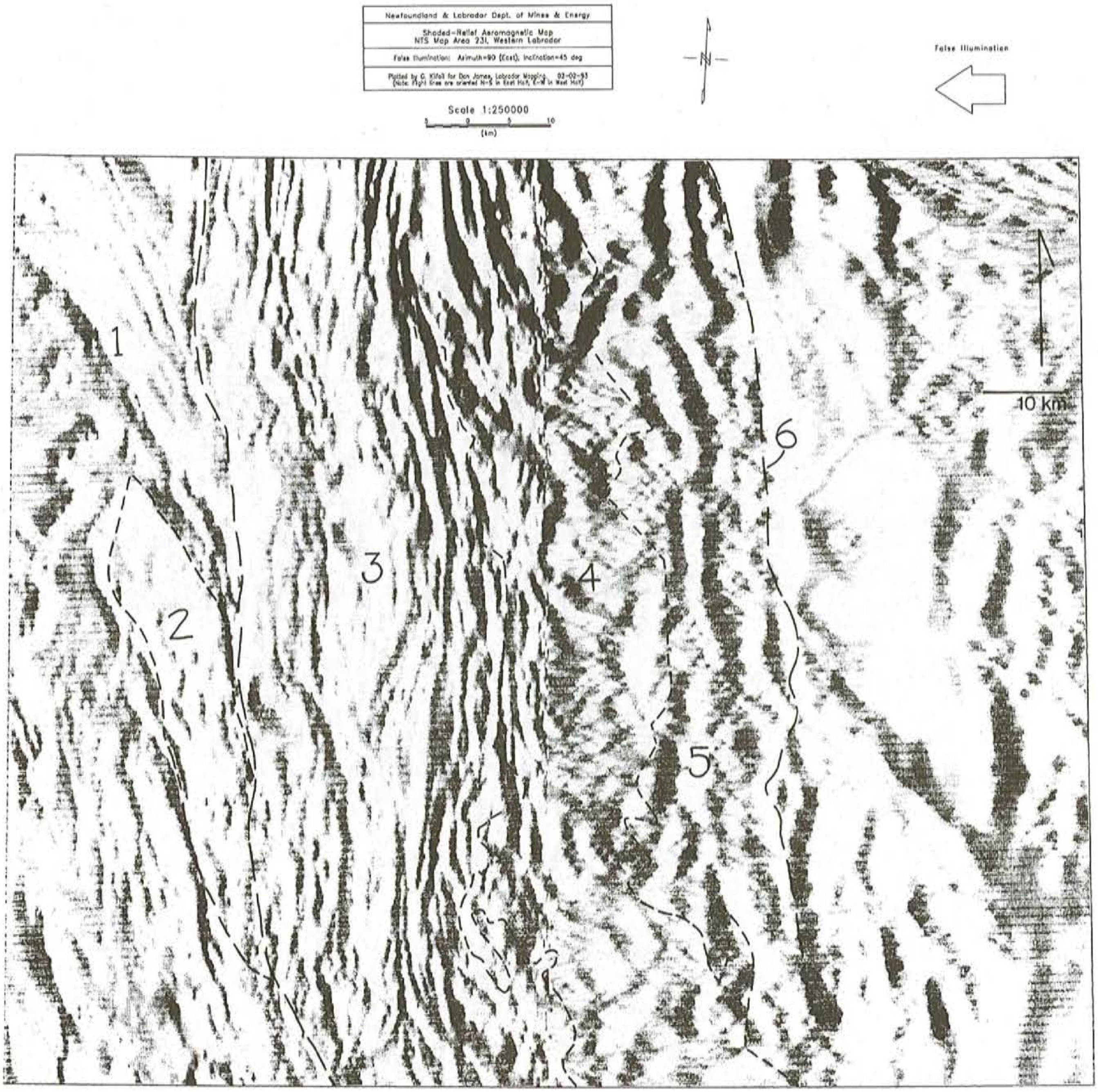


Figure 4. *Shaded-relief aeromagnetic map of NTS map area 23I. False illumination azimuth = 90 (east); inclination = 45. 1–Knob Lake Group (Labrador Trough), 2–tectonically bound Archean rocks exposed through the Knob Lake Group, 3–Western Gneiss zone, 4–De Pas batholith, 5–Central Gneiss zone, 6–approximate western limit of structures correlated with the George River shear zone.*

(Emslie, 1970, 1978), determined by U–Pb zircon methods to have an igneous age of ca. 1460 Ma (Krogh and Davis, 1973), and by younger K-feldspar megacrystic granite and syenite plutons. The granitic rocks may be related to the 6000 km² Mistastin batholith, which occurs 20 km to the northeast of the study area. Locally, Middle Proterozoic intrusions in the Central gneiss zone are unconformably overlain by clastic sedimentary and volcanic rocks of the Middle Proterozoic Seal Lake Group.

South of the study area, the eastern Churchill Province hinterland rocks are in intrusive and tectonic contact with granitoid rocks of the ca. 1650 Trans-Labrador batholith (see Wardle, 1985). The Grenville Front, defined in the study area and areas to the east as the northern limit of Grenvillian structures (which have attitudes that are approximately parallel to the Grenville orogen), is thought to transect the southern part of the study area (see Nunn *et al.*, 1990).

LITHOLOGY

ARCHEAN and LOWER PROTEROZOIC UNITS

Biotite Migmatite (Unit 1)

Based on intrusive relations observed in the field, the biotite–migmatite unit is inferred to be the oldest in the study area (Figure 5).

Subunit 1a is the most common subunit of the biotite–migmatite unit. Rocks consist of a brown-, rusty-, or black-weathering paleosome, which contains abundant biotite, common garnet, and a few occurrences of orthopyroxene. Local occurrences of layering in the paleosome, defined by percentage of biotite, defines relict sedimentary bedding (Plate 1). The rocks contain common occurrences of metamorphosed mafic dykes of several ages, defined by crosscutting relationships, and rocks inferred to be metamorphosed, layered mafic intrusions, which are up to several tens of metres thick. This unit also contains local occurrences of iron formation, which are interlayered with the biotite migmatite. The iron formations are generally less than 1 m thick and consist of 10- to 15-cm-thick, alternating layers of quartz, which is inferred to be metamorphosed chert, and magnetite. Minor amounts of pyrite are contained within the iron formations.

Subunit 1b, which occurs in the northern part of the study area, consists of biotite–migmatite gneiss containing abundant amounts of interlayered mafic gneiss, orthogneiss intrusions, and minor amounts of gabbroic anorthosite pods. The mafic gneiss in this subunit is inferred to be equivalent to the mafic gneiss defined as Unit 2. Tonalitic and granitic orthogneisses included in subunit 1b are probably related to Units 3 and 4.

The pods of gabbroic anorthosite in subunit 1b are white-weathering, fine- to coarse-grained rocks composed of plagioclase and 15 to 20 percent hornblende, which overgrows clinopyroxene. The pods are poorly exposed, but are thought to be several tens of metres wide, and form lenticular bodies. They may represent structurally dismembered, elongate gabbroic anorthosite intrusions. The age and significance of these rocks are uncertain, and detailed mapping is required to outline their extent and understand their importance.

Outcrops of both subunits contain one or two phases of white-weathering leucosome, which makes up approximately 40 percent of outcrops, although the amount locally exceeds 50 percent. The most abundant phase is the older of the two phases and forms thin (<15 cm), roughly parallel to anastomosing layers, which contain minor amounts of biotite and garnet. The leucosomes are locally intruded by several generations of recrystallized and variably deformed granitic dykes (Plate 2).

The biotite migmatite is inferred to be derived from greywacke and interbedded greywacke and mudstone sedimentary rocks. The age of the sedimentary precursors is equivocal although they may be Archean based on a lithologic correlation with metasedimentary rocks in Nunn *et al.'s* (1990) Eastern Supracrustal unit, which occurs 80 km to the east of the present study area, and is of known Archean age.

Mafic Gneiss (Unit 2)

The Central gneiss zone contains a minor amount of mafic gneiss, which occurs in the field in association with biotite migmatite (Unit 1). The rocks are typically well layered (Plate 3). Layering is defined by percentage of mafic minerals and local, thin (<10 cm) pyrite-bearing layers. The rocks are composed of variable amounts of hornblende, clinopyroxene, biotite, plagioclase and minor amounts of quartz; garnet occurs locally. Outcrops contain up to 20 percent tonalitic leucosome, which contains minor amounts of hornblende and biotite.

The mafic gneiss unit contains several occurrences of metamorphosed chert–magnetite iron formation and thin layers of white- to grey-weathering quartzofeldspathic gneiss. Locally, the unit is intruded by metadiorite dykes, which have a distinctive spotted texture defined by coarse-grained hornblende porphyroblasts, which overgrow a clinopyroxene core (Plate 4).

The mafic gneiss is presumed to be derived from mafic volcanic rocks based on their field association with the metasedimentary rocks (i.e., the biotite migmatite), and the occurrences of iron formation. The layers of quartzofeldspathic gneiss are inferred to be derived from felsic volcanic rocks.

Tonalite Gneiss (Unit 3)

The tonalite gneiss unit is a composite unit that includes foliated and variably migmatized metatonalite and metadiorite, and lesser amounts of granitic gneiss. The unit contains common occurrences of deformed and metamorphosed mafic and granitic dykes. The tonalite gneiss unit has been subdivided into three subunits on the basis of field characteristics, although with the unit being so poorly exposed west of the De Pas batholith, and in the complete absence of petrographic, geochemical and geochronological data, the division must be considered tentative.

Subunit 3a consists of grey-weathering, foliated metatonalite and metadiorite containing variable amounts of hornblende, biotite and rare pyroxene. Rocks commonly have a gneissosity defined by the percentage of mafic minerals, and are commonly migmatitic, containing less than 40 percent, white-weathering leucosome (Plate 5).

Subunit 3b occurs in the western part of the study area, west of the De Pas batholith. This subunit is exposed primarily on shoreline outcrops in the Smallwood Reservoir. Outcrops are very sparse in areas north of the reservoir. Subunit 3b is itself heterogeneous, consisting of hornblende

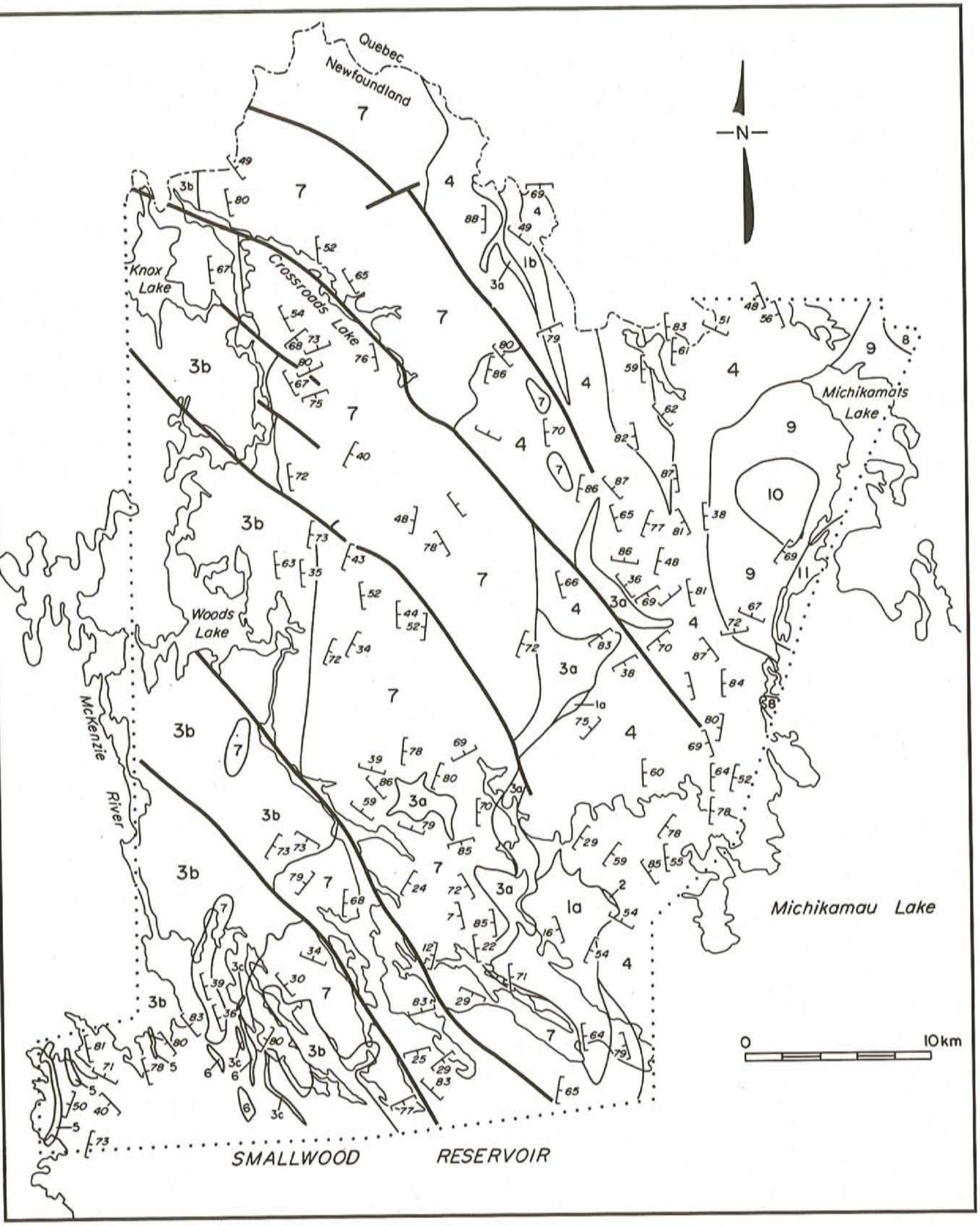


Figure 5. *Geological map of the study area.*

LEGEND (for Figure 5)

MIDDLE PROTEROZOIC

11 *Seal Lake Group*

10 *Syenite*

9 *Michikamats granite*

8 *Michikamau Intrusion*

ARCHEAN and LOWER PROTEROZOIC

7 *De Pas granite*

6 *Gabbro*

5 *Western Supracrustal unit*

4 *Granitoid gneiss and migmatite*

3 *Tonalite gneiss;* **3a**, *tonalite gneiss;* **3b**, *tonalite gneiss and granitoid migmatite, enclaves of biotite migmatite;* **3c**, *xenolithic tonalite gneiss*

2 *Mafic gneiss*

1 *Biotite migmatite;* **1a**, *biotite migmatite;* **1b**, *biotite migmatite, mafic gneiss, orthogneiss, anorthosite pods*

SYMBOLS

Geological contact......................................

Fault..

Principal foliation......................................

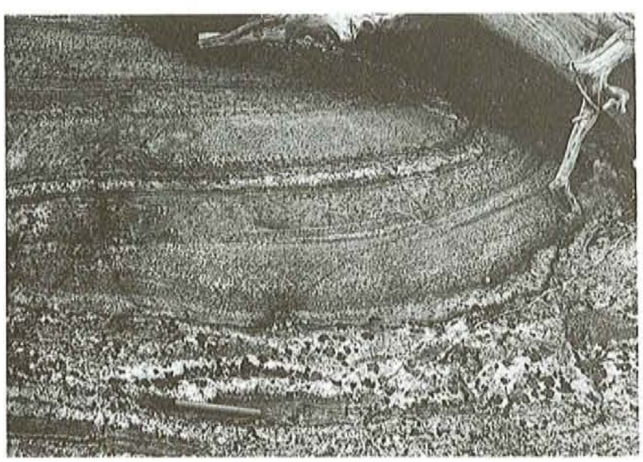


Plate 1. *Typical field aspects of biotite migmatite (Unit 1). Layering in the paleosome, defined by percentage of biotite, is probably relict sedimentary bedding.*

and biotite-bearing tonalite and diorite gneiss and migmatite, granitic gneiss, and minor amounts of biotite migmatite gneiss of uncertain affinity and protolith. Relations between the tonalite gneiss and the granitic gneiss are undefined. The

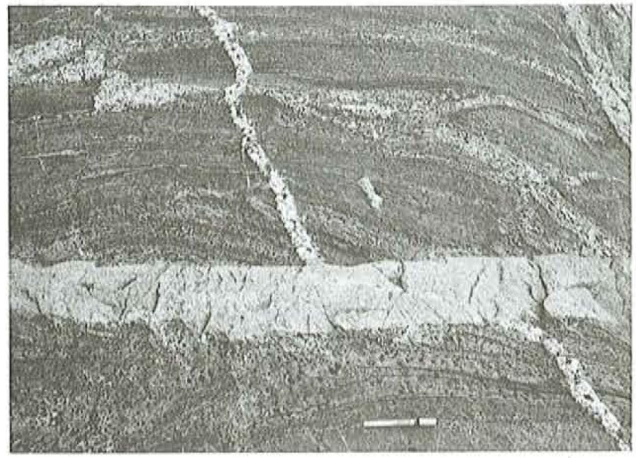


Plate 2. *Outcrop of biotite migmatite, which contains three ages of recrystallized and variably deformed granitic dykes.*

Plate 3. *Typical field aspects of mafic gneiss (Unit 2) containing a minor amount of tonalitic leucosome (top-right) and granitic dykes (left side of the photograph).*

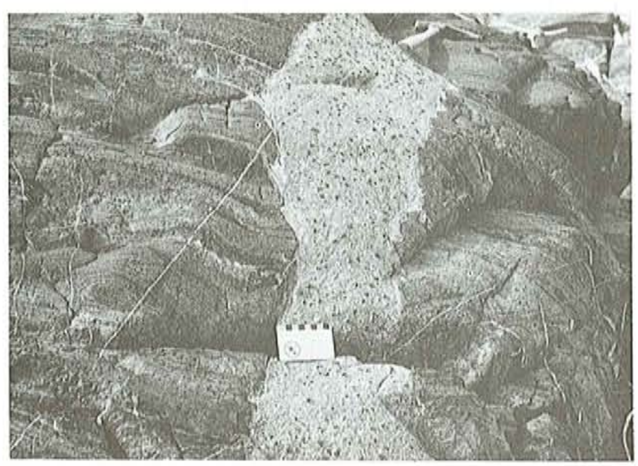


Plate 4. *Spotted tonalite dyke that intrudes mafic gneiss.*

tonalite gneiss in subunit 3b appears to be somewhat less mafic than the tonalite of subunit 3a, but they are similar in most other aspects. Subunit 3b contains inclusions of

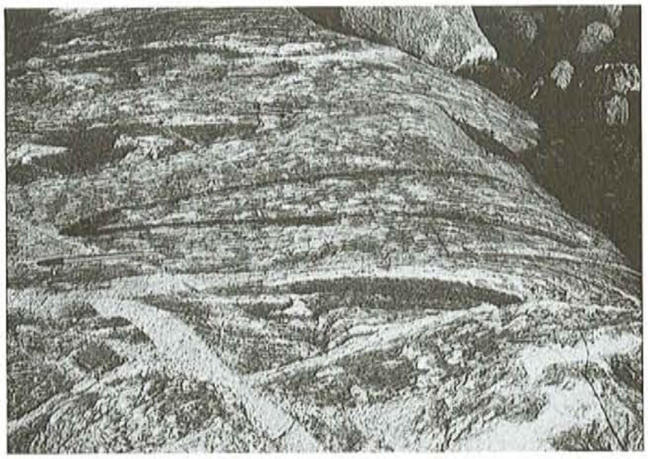


Plate 5. *Typical field aspects of biotite and hornblende-bearing tonalite migmatite (subunit 3a) containing deformed mafic dykes and several ages of granitic intrusions.*

biotite–migmatite gneiss, possibly equivalent to Unit 1, and amphibolite inclusions (boudinaged mafic dykes?; Plate 6). Where the amphibolite inclusions are particularly abundant (>20 percent), the rocks are designated as xenolithic tonalite gneiss (subunit 3c; Plate 7).

Plate 6. *Tonalite gneiss (subunit 3b) containing a deformed amphibolite dyke.*

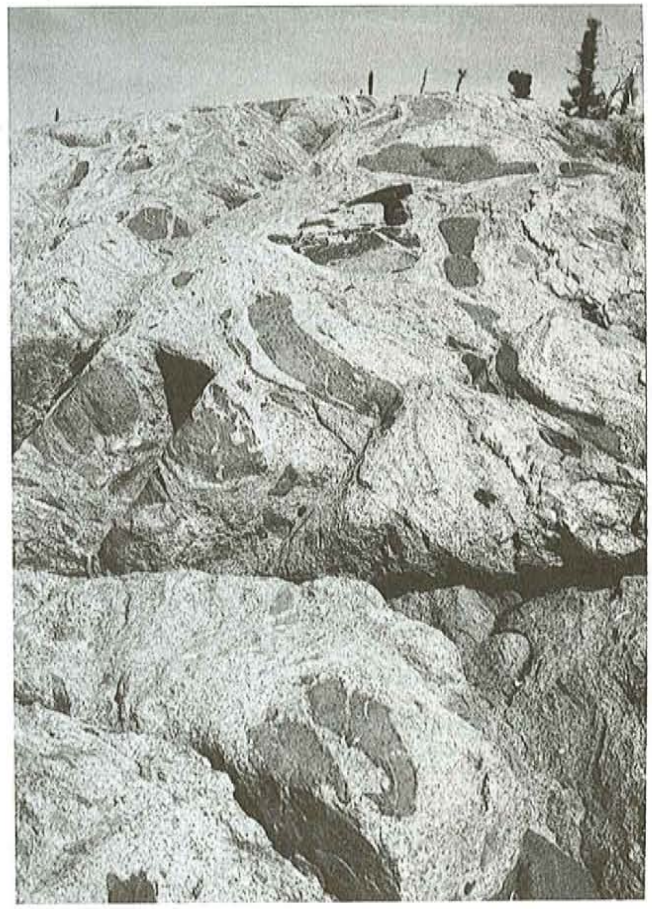


Plate 7. *Xenolithic tonalite (subunit 3c) containing abundant mafic inclusions.*

It is possible that some of the tonalite and granitoid gneisses in the Western gneiss zone that are presently mapped as subunit 3b are Archean gneisses, which can be correlated with gneisses in the Superior Province and that form the Archean basement of the Labrador Trough. In contrast, other parts of subunit 3b in the Western gneiss zone may be correlated with subunit 3a and Unit 4 (granitoid gneiss) in the Central gneiss zone. Isotopic, geochronological and geophysical data will be required to solve this problem and to locate the possible, cryptic suture between Superior Province and Rae Province crust.

Granitoid Gneiss (Unit 4)

The granitoid gneiss unit is a complex, composite unit consisting of several phases of granitic orthogneiss, and younger, variably deformed and recrystallized granitoid bodies, and includes mafic and granitic dykes (Plates 8 and 9). The unit could not be subdivided at this scale of mapping. The most abundant rock type is a foliated and commonly gneissic granitic rock that is derived from a K-feldspar megacrystic granite. The rocks contain biotite and rare hornblende.

The unit can be quite variable, over the scale of hundreds of metres, and only on some of the larger and cleaner outcrops

Plate 8. *Granitoid migmatite (Unit 4) and a posttectonic dyke of uncertain age.*

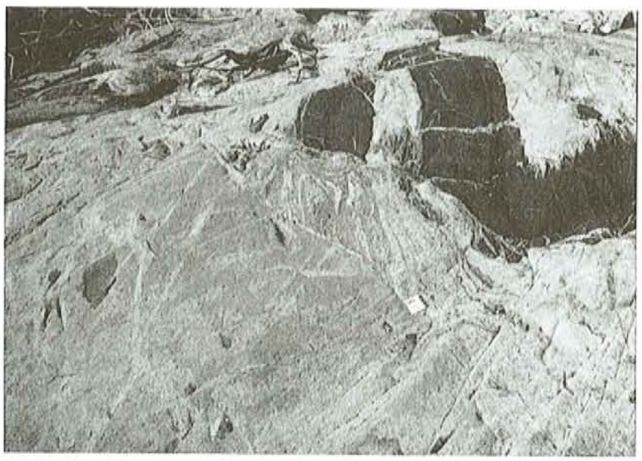


Plate 9. *Photograph showing the composite nature of Unit 4. Granitoid migmatite and included, deformed mafic dyke (top and right-side of the photograph) are intruded by a foliated and variably recrystallized, biotite granite (bottom and left-side of the photograph).*

in the Smallwood Reservoir can the complexity of the unit be appreciated. In one of the better exposures, the unit consists of granitoid migmatite having a paleosome composed of K-feldspar megacrystic granite containing xenoliths of a grey, biotite quartzofeldspathic gneiss of uncertain protolith, the whole of which is intruded by granitic dykes. The outcrop is also intruded by two different sets of mafic dykes that are distinguished on the basis of texture and crosscutting relations. The older dykes are distinctively black-weathering and fine grained, whereas the younger dykes are grey-weathering and contain medium- to coarse-grained hornblende porphyroblasts that give the rocks a 'spotted' texture. The megacrystic granite, includes grey-gneiss xenoliths, and mafic and granitic dykes are deformed and metamorphosed, and the K-feldspar megacrystic granite (paleosome) contains two phases of granitic leucosome that make up less than 20 percent of the outcrop. The outcrop also contains unmigmatized but deformed granitic dykes, which may be related to bodies of medium- to fine-grained, foliated, biotite syenogranite that are observed elsewhere within the unit to be discordant to the gneissosity in the granitic gneiss.

The ages of the different rock types, and the structures and metamorphism in the granitoid gneisses in the Central gneiss zone are uncertain. It is possible that this unit contains Archean and Proterozoic components, and it requires further study.

Western Supracrustal Unit (Unit 5)

The Western Supracrustal unit occurs in the southwestern part of the study area. It is exposed only on shoreline outcrops in the Smallwood Reservoir. Field relations between the unit and the surrounding tonalite gneiss (subunit 3b) were not observed, although it may be significant to note that there were no observed occurrences of xenoliths of the Western Supracrustal unit contained in the tonalite gneiss.

The unit consists of rusty- and brown-weathering biotite $\pm$ muscovite schist, amphibolite gneiss, which is locally interlayered with minor amounts of biotite schist and quartzofeldspathic schist, and mafic schists containing variable amounts of hornblende, biotite, garnet, plagioclase and quartz. The unit also contains several occurrences of marble consisting of calcite, K-feldspar, quartz and tremolite. The marble is inferred to be derived from an impure siliceous carbonate.

The stratigraphic and structural relations between the different rock types that make up the unit are undefined. Based on similarity of rock types, the unit is thought to consist of rocks belonging to the Lower Proterozoic Knob Lake Group. In particular, the biotite $\pm$ muscovite schist and some of the mafic rocks may be equivalent to some members of the Le Fer Formation. The marble (and some of the mafic rocks?) may be correlated with the Denault Formation.

Gabbro (Unit 6)

The southwestern corner of the study area also contains occurrences of variably recrystallized and deformed gabbro. This unit forms dykes up to 10 m thick, which intrude the tonalite gneiss (subunit 3b). Several kilometres west of the study area, the same gabbro forms larger bodies, which underlie a north-trending series of prominent hills that parallel the boundary between the Western gneiss zone and the New Quebec Orogen.

The gabbro is tentatively correlated with the Early Proterozoic Montagnais Intrusive Series.

De Pas Granite (Unit 7)

The De Pas granite, which makes up the De Pas batholith and several small satellite plutons on either side of the batholith, is the best exposed and most abundant unit in the study area. The unit has a remarkably homogeneous composition and texture throughout the study area, although at a larger scale it is a composite unit consisting of variably recrystallized and foliated K-feldspar megacrystic granite and charnockite, isotropic granite and granodiorite, and megacrystic quartz monzonite and monzonite. The unit has not been divided into subunits or individual intrusive bodies.

The De Pas batholith is in intrusive contact with rocks in the Western and Central gneiss zones. The western margin of the batholith has been overprinted by ductile, high-strain zones, which deform De Pas granite and Western zone gneisses (subunit 3b). The age, kinematic sense and significance of the tectonic contact are unknown but may be related to dextral, transcurrent strain on the Lac Tudor shear zone.

The unit chiefly consists of pink- to orange-weathering, K-feldspar megacrystic syenogranite and monzogranite containing less than 10 percent biotite and hornblende. The rocks contain up to 25 percent, subhedral to anhedral, prismatic K-feldspar megacrysts, which are typically around 5 cm long, and have a fine- to coarse-grained groundmass (Plate 10). Magnetite is a common accessory mineral. In outcrops where recrystallization is extensive, rocks develop a weak gneissic or augenitic texture defined by aggregates of recrystallized and elongated K-feldspar megacrysts. Where rocks preserve a phaneritic texture, they locally contain a foliation defined by alignment of the megacrysts, which may be a relict or accentuated igneous lamination.

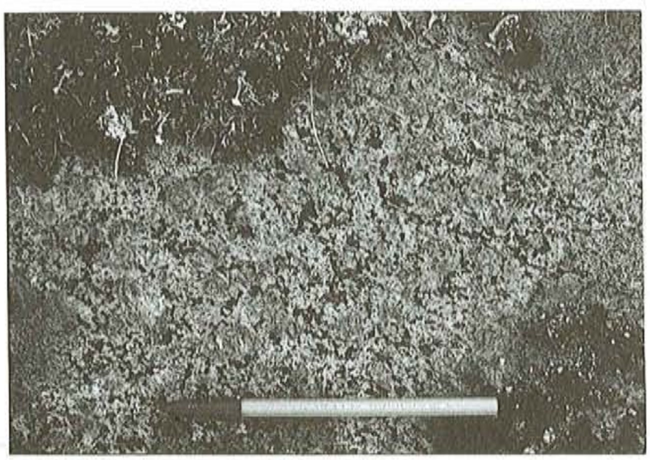


Plate 10. *Typical field aspects of De Pas granite (Unit 7) containing abundant K-feldspar megacrysts.*

Charnockitic rocks occur throughout the main batholith but they appear to be most common in its central and eastern parts. Petrographic studies and re-examination of the hand specimens will be required to delineate the areas underlain by charnockite, and by other rock types, with greater confidence.

MIDDLE PROTEROZOIC UNITS

Michikamau Intrusion (Unit 8)

Only a few outcrops belonging to the Michikamau Intrusion were examined in a very cursory manner in 1992. The outcrops occur along the west and north shores of Michikamau and Michikamats lakes. The Michikamau Intrusion is not a focus of study in this project; it has been studied in detail by Emslie (1963, 1970, 1978). The outcrops examined in 1992 consisted of undeformed, layered gabbroic anorthosite.

Michikamats Granite (Unit 9)

A granite pluton, which occurs in the northeastern part of the study area, consists of K-feldspar megacrystic granite herein informally named the Michikamats granite. The Michikamats granite is thought to intrude the Michikamau Intrusion, although the intrusive relation has yet to be decisively demonstrated in the field. The contacts between the surrounding granite and the granitoid gneiss (Unit 4) appear to be sharp; the granite does not contain accidental inclusions of the country rocks. The granite does contain a few small inclusions of isotropic, fine-grained granite, which is somewhat more mafic than the host Michikamats granite. The granite inclusions are interpreted to be cognate xenoliths.

The unit has a consistent texture and composition. It consists of massive, white- and pink-weathering, K-feldspar megacrystic monzogranite. The K-feldspar megacrysts are elongate to spherical (5 cm in diameter) and commonly are concentrically zoned (Plate 11). The zoning is defined by colour variations in the K-feldspar and by very fine-grained mafic inclusions. Rocks contain approximately 10 percent biotite, hornblende and accessory magnetite.

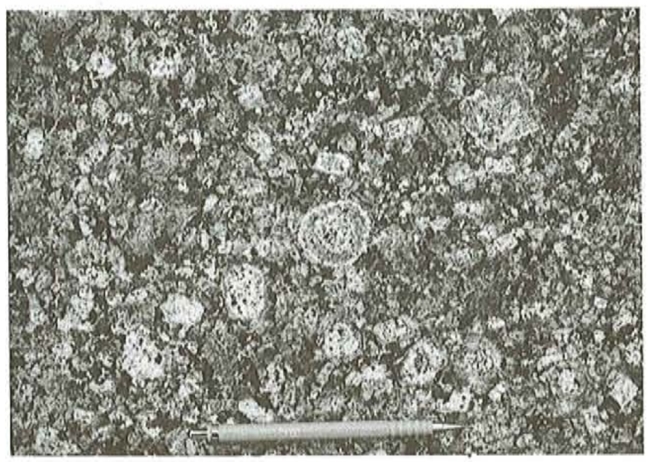


Plate 11. *Photograph of Michikamats granite (Unit 9) containing abundant, prismatic to spherical, and concentrically zoned K-feldspar megacrysts, and showing massive structure.*

The absence of foliation and the presence of concentrically zoned K-feldspar megacrysts distinguish the Michikamats granite from the De Pas granite (Unit 7).

Syenite (Unit 10)

The central part of the Michikamats pluton is underlain by syenite and quartz syenite. The rocks are pink- to white-weathering and medium to coarse grained; commonly they contain K-feldspar megacrysts. The rocks contain approximately 10 percent hornblende that commonly contains a core of clinopyroxene. Occurrences of syenite, which contain clinopyroxene (5 percent), but do not contain hornblende, are less common. Minor amounts of biotite and magnetite are common. The syenite is massive.

Seal Lake Group (Unit 11)

Rocks in the northeastern part of the study area are unconformably overlain by clastic sedimentary rocks belonging to the Seal Lake Group. The Seal Lake Group rocks are unmetamorphosed and do not contain penetrative structures. The rocks are very recessive and the unit is poorly exposed; all of the outcrops observed in 1992 are low, flat outcrops that occur along the shores of Michikamau and Michikamats lakes.

Outcrops along the west shore of Michikamau Lake consist of pink- to white-weathering quartz arenite and polymictic conglomerate. The arenite is medium grained and medium bedded (2 to 20 cm), and contains local crossbeds and ripple structures. The conglomerate is immature, containing poorly sorted and variably rounded clasts of Michikamats granite and granite gneiss (Unit 4) that are up to 10 cm in diameter.

There are several outcrops of Seal Lake Group conglomerate occurring on islands in the north end of Michikamats Lake. The polymictic conglomerate is a completely unsorted, framework supported conglomerate containing variably rounded, spherical to elongate clasts, locally up to 35 cm (Plate 12). Clasts are mainly foliated granite and granite gneiss derived from Unit 4. Clasts of mylonitic granitoid gneiss, presumed to be derived from the George River shear zone, are common.

Plate 12. *Polymictic conglomerate belonging to the Seal Lake Group (Unit 11).*

STRUCTURE AND METAMORPHISM

In the absence of detailed geochronological and petrographic studies, determining the ages of structures and metamorphic assemblages in the study area is difficult. Rocks in the area may record the effects of Archean, Early Proterozoic (Hudsonian), Labradorian, and Grenvillian tectonothermal events. Hence, the following discussion concerning structural relations, and correlation of structures and metamorphic features must be considered provisional.

CENTRAL GNEISS ZONE

In the Central gneiss zone, the oldest structures, apart from rare occurrences of bedding in metasedimentary rocks, are the principal foliation defined by the metamorphic minerals and recrystallized mineral aggregates, and the metamorphic layering. The rocks in the Central gneiss zone (Units 1 to 4) are metamorphosed to upper amphibolite facies, and there are a few, sporadic occurrences of orthopyroxene.

The principal foliation and gneissosity in Units 1 to 4 are approximately north- to northeast-trending. Several sets of superposed folds, inferred to be syn-metamorphic structures, deform the foliation and gneissosity; the youngest set is consistently southeast-trending and moderately plunging.

Intrusive relations observed in the study area demonstrate that the gneissic rocks in the Central gneiss zone had attained their syn-metamorphic fabrics prior to the intrusion of the De Pas batholith. At present, this is the only relation that constrains the age of the syn-metamorphic structures in this zone. These structures could be Archean or Hudsonian.

Postdating the intrusion of the De Pas batholith, Central gneiss zone rocks and their intrusive contact with the De Pas batholith are folded by east- to southeast-trending, open to tight folds. Similar folds are also recognized in the main part of the Central gneiss zone where they deform small granitic bodies and granitic dykes which have discordant relations to the syn-metamorphic structures in the host gneisses. These folds, which are apparently unaccompanied by foliation development, are presumed to be Hudsonian structures.

From west to east, across the Central gneiss zone, the syn-metamorphic structures are progressively overprinted by a zone of approximately north-striking ductile, high-strain structures (Figure 6 and Plate 13) which are inferred to be related to the regionally extensive, dextral transcurrent, George River shear zone. Strain across the high-strain domain is heterogeneous and there are numerous examples of rocks, which occur east of the domain boundary shown in Figure 6, that are not highly strained.

There were no examples of unequivocal kinematic indicators observed in the study area. Mineral elongation lineations in highly strained rocks have shallow to steep plunges. Based on field examinations, upper amphibolite-facies assemblages, which are recognized in lesser strained Central zone gneisses to the west, are not retrogressed in the high-strain zones. This relation suggests that the high strain was concomitant with upper amphibolite-facies

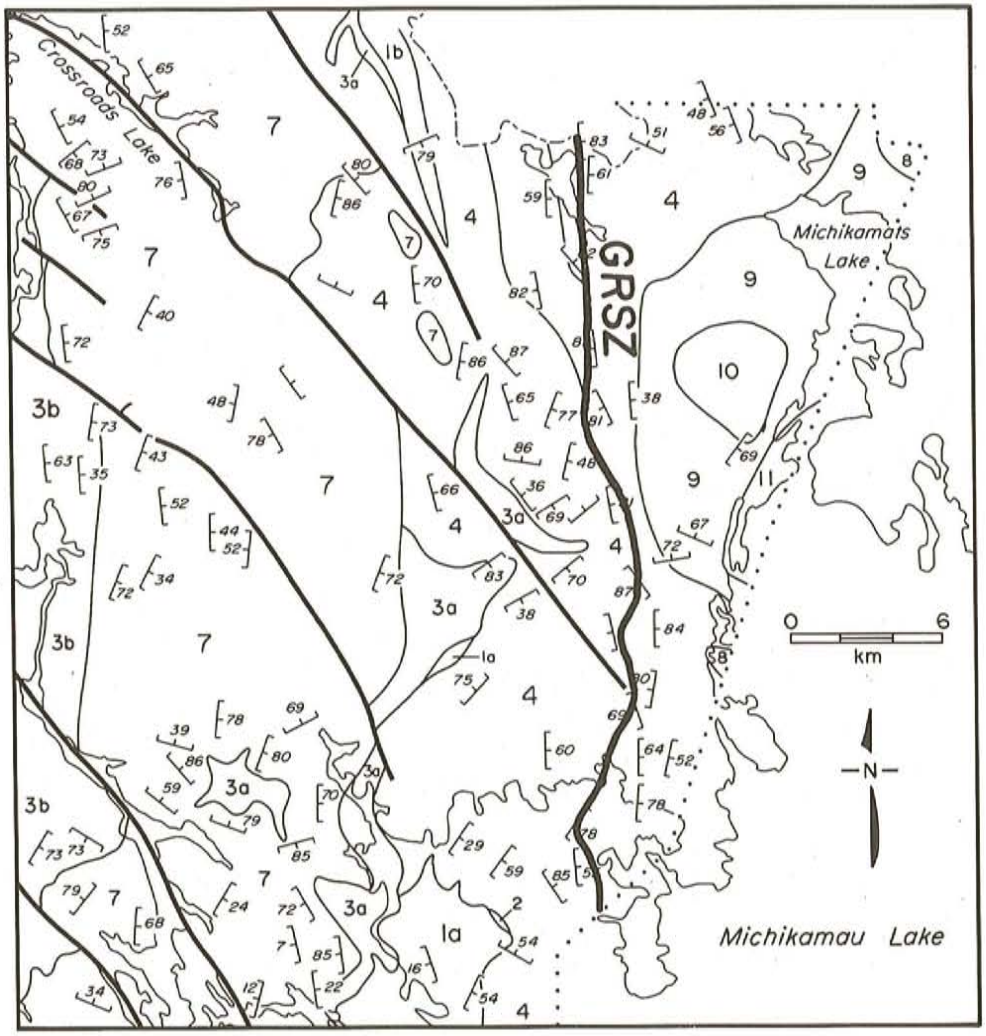


Figure 6. *The line marked GRSZ defines the approximate western limit of George River shear zone structures.*

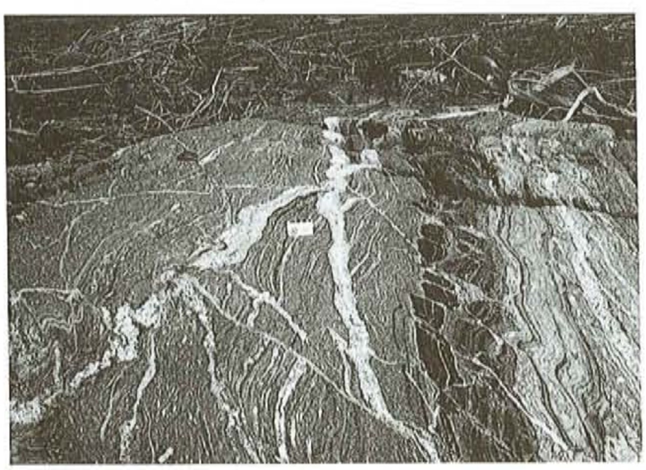


Plate 13. *Recrystallized mylonite derived from granitoid migmatite (Unit 4) and included mafic dykes, George River shear zone.*

metamorphism. The highly strained rocks are extensively recrystallized and many of the high-strain fabrics are obliterated.

If the correlation with the George River shear zone is correct, then the highly strained structures in the eastern part of the Central gneiss zone are Hudsonian and related to ca. 1880 to 1840 Ma dextral transpressive deformation between the New Quebec Orogen and the eastern Churchill Province hinterland. The field relations suggest that deformation was synchronous with upper amphibolite-facies metamorphism, and by extension, may suggest that the age of regional metamorphism in the Central gneiss zone is also Hudsonian. However, the Central gneiss zone may also have an Archean history of high-grade metamorphism and penetrative deformation.

DE PAS BATHOLITH

In the De Pas batholith, granitic and charnockitic rocks are variably foliated and recrystallized. The foliation is interpreted to be Hudsonian. Foliation is mainly north-striking, although in the southern part of the study area there is a gradual deflection in foliation attitude from north- to northwest- to, locally, west-striking. The deflection in structural orientation is also manifested by a swing in the

LEGEND (for Figure 6)

MIDDLE PROTEROZOIC

11 *Seal Lake Group*

10 *Syenite*

9 *Michikamats granite*

8 *Michikamau Intrusion*

ARCHEAN and LOWER PROTEROZOIC

7 *De Pas granite*

6 *Gabbro*

5 *Western Supracrustal unit*

4 *Granitoid gneiss and migmatite*

3 *Tonalite gneiss;* **3a,** *tonalite gneiss;* **3b,** *tonalite gneiss and granitoid migmatite, enclaves of biotite migmatite;* **3c,** *xenolithic tonalite gneiss*

2 *Mafic gneiss*

1 *Biotite migmatite;* **1a,** *biotite migmatite;* **1b,** *biotite migmatite, mafic gneiss, orthogneiss, anorthosite pods*

SYMBOLS

Geological contact....................................

Fault..

Principal foliation.......................................

regional-scale aeromagnetic anomaly pattern. The change in orientation of structures in the De Pas batholith could be explained by passive reorientation of Hudsonian foliation into an east–west attitude during either the Labradorian or Grenvillian orogenies. Mapping in 1993 may reveal if a similar deflection of structures occurs in rocks of the Central and Western gneiss zones.

WESTERN GNEISS ZONE

Middle to upper amphibolite-facies tonalite gneiss in the Western gneiss zone contains a foliation defined by the metamorphic minerals and recrystallized mineral aggregates, and the metamorphic layering. The foliation is mainly north- to northwest-trending.

The age of the metamorphism and the syn-metamorphic foliation in the tonalite gneiss could be Archean or Hudsonian. The latter interpretation is favoured because of the similarities in structural orientation and metamorphic grade between the tonalite gneiss and the Western Supracrustal unit. The latter is correlated with the Lower Proterozoic Knob Lake Group. This conclusion does not discredit a model that predicts that the tonalite gneiss unit has an Archean emplacement age and cryptic Archean structures.

Structures in tonalite gneiss, in the Western gneiss zone, are locally overprinted by approximately north-trending, ductile high-strain zones (Plate 14). The most prominent of these zones is exposed along islands in the Smallwood Reservoir, south-southeast of the McKenzie River. Similar, minor shear zones have been found in rocks on both sides of the contact between the Western gneiss zone and the De Pas batholith. No reliable kinematic indicators were observed in any of the shear zones, although the strain is interpreted to be coeval and related to deformation in the Early Proterozoic, dextral transpressive Lac Tudor shear zone.

Plate 14. *Typical field aspects of mylonitic ('straight') gneisses, which are derived from tonalite gneiss (subunit 3b) and included mafic dykes, and inferred to be related to the Lac Tudor shear zone. The outcrop includes minor dextral displacement of a little-deformed pegmatite dyke.*

GRENVILLIAN STRUCTURES

Apart from the deflection in attitude of Hudsonian foliation in the De Pas batholith, the study area contains two sets of structures of possible Grenvillian age. One set are the regionally persistent, northwest-striking sinistral faults, which have displacements of up to several kilometres and deform rocks throughout the study area. Outcrops along fault traces have not been observed; their position is inferred from offsets of the De Pas batholith contacts and from topographic lineaments. The faults are tentatively interpreted to be Grenvillian structures based on a correlation with Grenvillian faults that have similar attitudes, and which occur farther south in the Grenville Province (e.g., in the Lac Joseph terrane) and in the Superior Province (Ashuanipi Complex).

The second set of structures are minor, greenschist-facies, brittle to ductile faults that occur in the southern part of the study area (Plate 15). The character of these structures suggests that they are late, and probably Grenvillian.

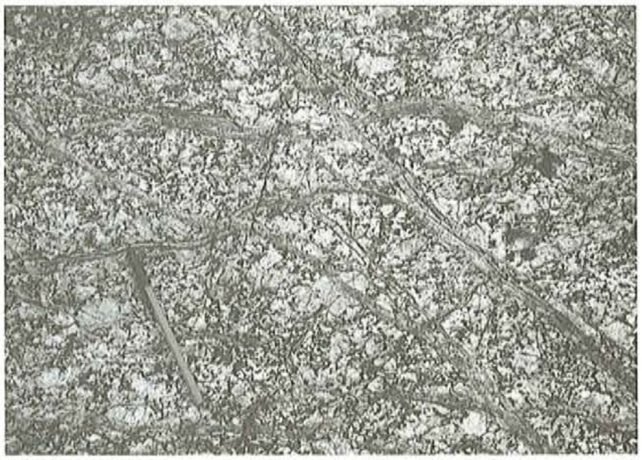


Plate 15. *Minor, brittle to ductile, greenschist-facies faults developed in De Pas granite. The outcrop is in the southern part of the study area.*

The Grenville Front, which might be represented in the study area by a single structure, or a line marking the northern limit of penetrative Grenvillian strain, was not located during the mapping in 1992. Determining the position and nature of the Grenville Front will be one of the objectives in 1993.

ECONOMIC GEOLOGY

High-grade supracrustal rocks in the Central gneiss zone contain several, minor sulphide occurrences. The most extensive zones of sulphide staining are associated with iron formation, which is interlayered with biotite (metasedimentary) migmatite (Unit 1) in several places. Chemical analysis of samples from several sulphide-stained zones in iron formation has not revealed significant amounts of gold. High-grade metamorphic terranes are not normally associated with gold mineralization, although there are examples of gold associated with iron formation and high-grade metasedimentary rocks in the Archean Ashuanipi Complex in Quebec (e.g., Lapointe, 1986). The metasedimentary rocks might also have some potential for SEDEX base-metal deposits.

Mapping in 1992 did not uncover large areas underlain by mafic metavolcanic rocks (Unit 2), although further mapping might reveal more extensive occurrences of these rocks, which have the potential to host base-metal sulphide deposits.

The Michikamats granite (Unit 9), and the body of syenite and quartz syenite (Unit 10) that intrudes it, are interpreted to be Middle Proterozoic anorogenic intrusions. Although the mineralogy and chemistry of these units are currently unknown, they may have potential for rare-metal and rare-earth mineralization.

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