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THE DISCOVERY OF PROBABLE ARCHEAN ROCKS WITHIN THE LABRADOR ARM OF THE TRANS-HUDSON OROGEN NEAR THE LABRADOR–QUEBEC BORDER (NTS 14D/3,4,5 and 24A/1,8)

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ABSTRACT

Migmatite gneiss and leucogabbro–anorthosite, intruded by deformed basic dykes, constitute a significant proportion of the lower Proterozoic Trans-Hudson terrane near the Labrador–Quebec border. The predyke rocks are considered to be remnants of Archean crust, and the dykes are correlated with a lower Proterozoic swarm in the North Atlantic craton. Most other gneisses in the area are apparently devoid of the dykes, and may be Proterozoic in age. Following intrusion of the dykes, there was granulite-facies metamorphism and development in much of the area of an intense, north-northwest-trending L–S fabric during Hudsonian thermotectonism. Sheets of late-kinematic biotite granite, a posttectonic dyke of olivine gabbro, and quartz monzonite and peralkaline granite plutons intrude the gneisses of the area.

INTRODUCTION

The Trans-Hudson Orogen represents the largest remnant of an eroded mountain chain in the Canadian Shield (Figure 1). During the past two decades a concentrated effort in the northwestern Trans-Hudson Orogen has been successful in constructing scenarios depicting the evolution of the belt (Lewry, 1987), and this history has been tentatively extended to its northern and easternmost parts (Hoffman, *in press*). Over the past few years several mapping projects in Labrador have begun to examine the evolution of the southeastern arm or 'Labrador segment' of the orogen (Figures 1 and 2) in an attempt to compare and contrast it with the history of the orogen established elsewhere.

The solutions to many of the problems that are apparent within the Trans-Hudson Orogen in Labrador are hampered by the lack of reliable geochronological data. It is thus difficult to ascertain the relative ages of the various zones or subdivisions identified in the orogen (cf. Korstgaard *et al.*, 1987; Wardle *et al.*, 1987, *in press;* Figure 2) and, consequently, to discuss the evolution of the orogen in terms of tectonic elements identified in younger mountain belts (cf. Monger *et al.*, 1972; Williams and Hatcher, 1983; Searle, 1983).

The lack of a firm geochronological foundation has necessitated reliance on lithostratigraphic correlation, a subjective technique that relies on perceived lithological similarities and structural–lithological sequences between areas that may be separated by tens or hundreds of kilometres. Lithostratigraphic correlation in the deeply eroded cores of orogenic belts is also risky because such terranes are remarkably similar, regardless of age. However, certain unique rock associations, with an apparent age restriction to their development, may provide a key to regional correlations in such belts. One such association is the layered leucogabbro–anorthosite complexes of the mid-Archean, a distinctive suite of rocks widely distributed throughout the North Atlantic Craton (Windley, 1973; Myers, 1981). The best known of these complexes is the Fiskenaesset Complex of West Greenland (cf. Myers, 1985), but many others occur worldwide in Archean cratons; e.g., the Sittampundi Complex of India (Ramadurai *et al.*, 1975), and the Nelson River anorthosites of Manitoba (Ermanovics and Davidson, 1976; Bell, 1978). Labrador also has similar Archean layered gabbro–anorthosite complexes: the Okakh Anorthosite and Tessiuyakh Gabbro complexes (Wiener, 1981), the Nachvak Fiord–Ryan's Bay anorthosites and gabbros (Wardle, 1983), and other unnamed bodies near Nain (Hurst *et al.*, 1973; Ryan and Lee, 1986) and Hopedale (Ermanovics *et al.*, 1982; Ryan *et al.*, 1983).

During the 1987 field season, we discovered several dismembered belts of 'Fiskenaesset-type' leucogabbro and anorthosite within gneisses in the Labrador–Quebec border area of the Trans-Hudson Orogen. These layered bodies have, however, been severely metamorphosed and migmatized such that few primary mesoscopic layering variations are preserved. In field aspect, they are virtually identical to Archean leucogabbro–anorthosite bodies north of Hopedale described and illustrated by Ermanovics *et al.* (1982, pages 158-159).

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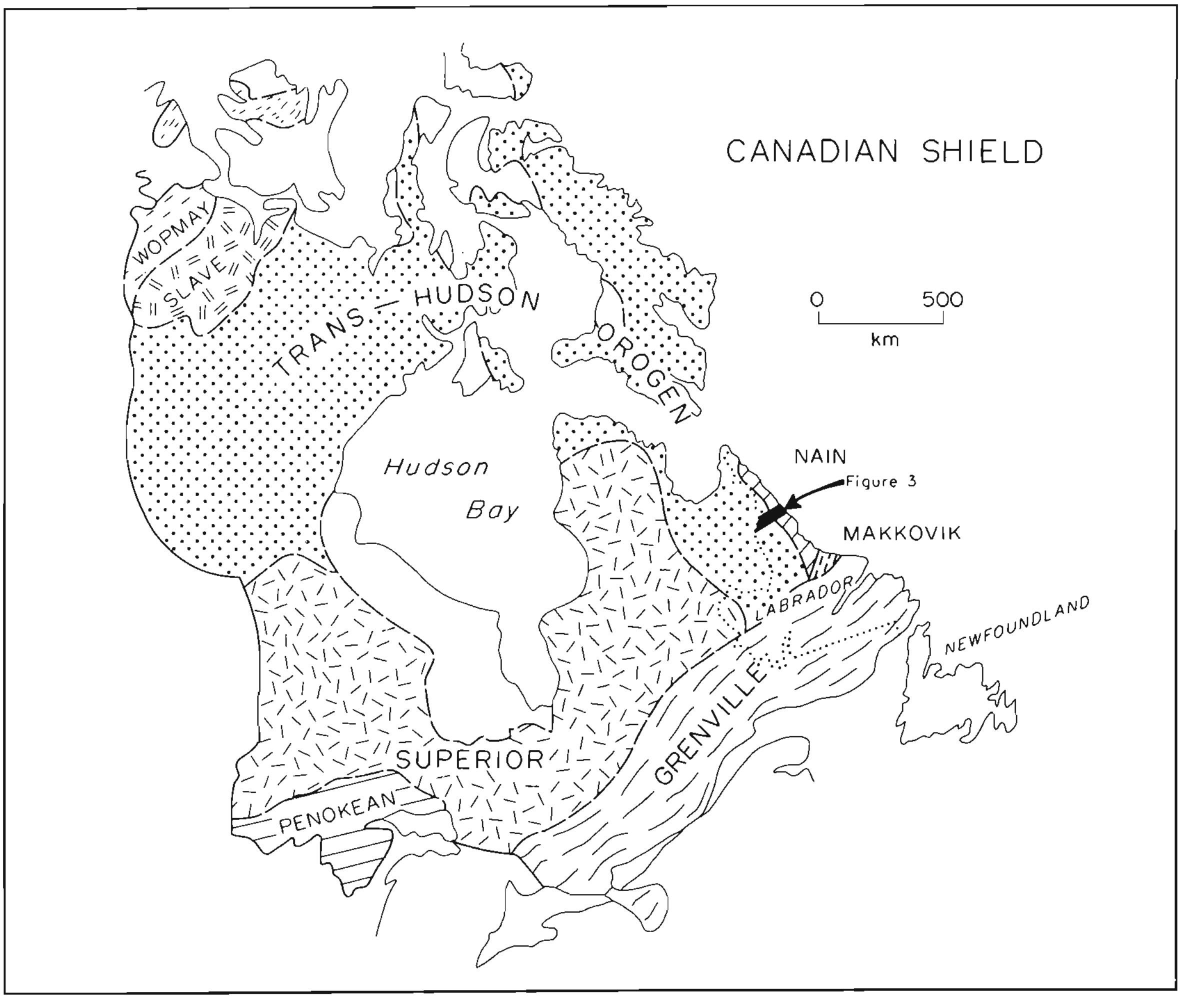


Figure 1. *Sketch map of the Canadian Shield showing the extent of the Trans-Hudson Orogen in relation to other components of the Shield. The Superior, Nain and Slave blocks are Archean, the Wopmay, Penokean, Makkovik and Trans-Hudson are Early Proterozoic, and the Grenville is late Middle Proterozoic.*

The presence of such leucogabbros and anorthosites within the lower Proterozoic Nagssutoqidian and Rinkian mobile belts of Greenland has been one of the lithological criteria used to demonstrate (Nunes *et al.*, 1974; Andersen and Pulvertaft, 1986) or suggest (Pulvertaft, 1973, page 537; Escher and Pulvertaft, 1976; Escher *et al.*, 1976) the presence of reworked Archean rocks within these belts. A similar argument, supported with other evidence, will be presented below.

PREVIOUS WORK AND REGIONAL FRAMEWORK

The interior of the Trans-Hudson Orogen in Labrador and eastern Quebec (Figure 1) is a complex comprising chiefly amphibolite- to granulite-facies rocks, which in terms of their character, can best be described as constituting a regional migmatite terrane. Taylor (1979) was the first to wrestle with separating the orogen in this area into regionally continuous subdivisions; however, the scale of the mapping (1:250,000) was such that many complexities within parts of the region are not apparent from his maps. A tentative subdivision of the northern Labrador segment, delineating several discrete zones (Figure 2), was proposed by Korstgaard *et al.* (1987) and Wardle *et al.* (1987; *in press);* these subdivisions are an attempt to portray the probable origin of the components of the segment in terms of their tectonic history.

The senior author began a 1:100,000-scale transect across the Trans-Hudson Orogen from the Archean Nain Province (or Nain craton) in the vicinity of Voisey Bay on the Labrador coast westward to the Quebec border in 1985. This project was designed to map the Archean–Proterozoic boundary zone across central Labrador, and to survey for mineralized peralkaline granitoid rocks among the Helikian felsic intrusions (Figure 3). Over this same time period Quebec provincial geologists were mapping eastward from the Labrador Trough to the Quebec–Labrador border (van der Leeden *et al.*, 1987). These two surveys have led to an improved understanding of the components that comprise the southeastern arm of the Trans-Hudson Orogen, and will eventually provide a complete cross-section of this part of the orogen, from the Superior Province bounding it in the west, to the Nain Province in the east (Figure 1).

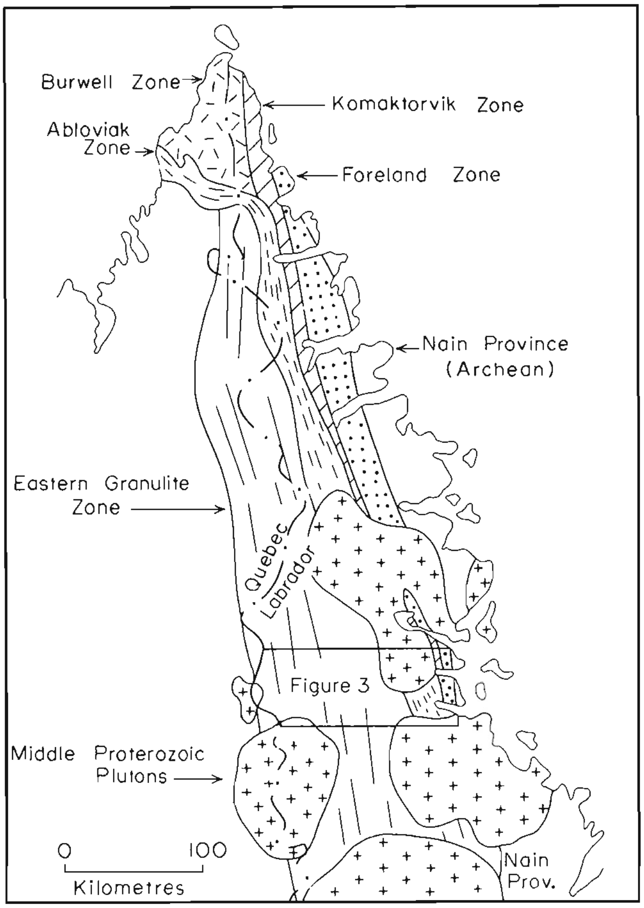


Figure 2. *Tectonic subdivisions of the Trans-Hudson Orogen in Labrador (modified after Wardle* et al., in press*).*

From the survey of the Trans-Hudson Orogen in central Labrador to date (Figure 3; Ryan and Lee, 1986; Ryan *et al.*, 1987), it has been shown that the easternmost part of the mobile belt in the Makavinekh Lake area comprises a 30-km-wide zone of garnet (± sillimanite ± biotite)–quartz–feldspar gneiss. This gneiss is a direct continuation of the Tasiyuak gneiss, a mylonitic, granulite facies diatexite with remnants of paragneiss, which can be traced for 450 km northwards to Ungava Bay, and which constitutes the Abloviak shear zone (Korstgaard *et al.*, 1987; Figure 2). This unit is in fault contact with Archean Nain Province gneisses to the east. It is succeeded westward in the Cabot Lake–Konrad Brook area by granulite- and amphibolite-facies orthogneisses containing numerous intercalated belts of metavolcanic and metasedimentary gneisses. The latter comprise a significant amount of metamorphosed calcareous rocks, metapelitic gneisses, and quartzite of presumed Early Proterozoic (Aphebian) age. One of the granulite-facies metaplutonic units in the northeast corner of the map corridor (Figure 3) has yielded a U–Pb age of 1909 $^{+33}_{-21}$ Ma (Krogh and Scharer, 1987), but it is unclear if this is the magmatic or metamorphic age (or both) of the zircon extracted from it. Although there may be pre-Aphebian rocks in the Trans-Hudson Orogen of the Makavinekh Lake–Cabot Lake area, we have little indication of this, and in fact most of the metaplutonic gneisses intrude and fragment the supracrustals. Unfortunately there are no other geochronological data for this area and we are still unsure of the age of many of the supracrustal rocks. Most are garnet–biotite–sillimanite–graphite gneisses, common in both the Archean and Proterozoic terranes of Labrador. Our only criterion for proposing that some are Aphebian is the preponderence of marble and quartzite, thus making them akin to the shelf sequences that bound the orogen (cf. Wardle and Bailey, 1981). Such belts are not characteristic of Archean terranes, but a recent study by Doig (1987) on the Ungava Peninsula has shown that some paragneiss belts containing pure quartzite and marble in the Trans-Hudson Orogen in that area are Archean. Therefore, it may be necessary to re-evaluate the Labrador occurrences in light of this evidence.

Injected into the layered gneisses are sheets of pink and white granitic pegmatite and medium- to fine-grained pink granite that carry only weakly developed simple planar and linear elements. These are late kinematic with respect to the formation of the gneissic layering. Two of these units are undergoing geochronological study by M.E. Bickford at the University of Kansas.

In the area of 'Moonbase' Lake, there is a discrete, north-northwest trending, granulite-facies, high-strain zone characterized by mylonitic, laminar-banded gneisses (Figure 3). Similar mylonitic gneisses, with foliated pink granitoid sheets, occur in the vicinity of the Mistastin River, but here the rocks are at amphibolite facies. The 1987 project was primarily concerned with rocks west of these (the same ?) mylonite zones.

MAJOR GEOLOGICAL SUBDIVISIONS OF THE LABRADOR–QUEBEC BORDER MAP AREA

The rocks of the 1987 project area (NTS 14D/3,4,5 and parts of 24A/1 and 8; Figure 4) can be conveniently broken down into three categories:

1) a suite of migmatitic gneisses and leucogabbro–anorthosite intruded by deformed and metamorphosed basic dykes;

2) a suite of gneisses with no unequivocal indication of metamorphosed dykes; these include supracrustal rocks, biotite- and pyroxene-rich gneisses, several granitoid gneisses, and foliated granite; and

3) basic and felsic posttectonic intrusive rocks.

Rocks Intruded by Deformed Basic Dykes

Granulite- and amphibolite-facies quartzofeldspathic migmatite containing intercalated units of gabbro–anorthosite comprise most of the area between 'Esker' Lake and the southeastern part of the project area. A funnel-shaped, foliated tonalite to tonalitic gneiss outcrops in the northeast corner of the 14D/3 map area; this may be younger than the enclosing migmatite. All these rock units are intruded by

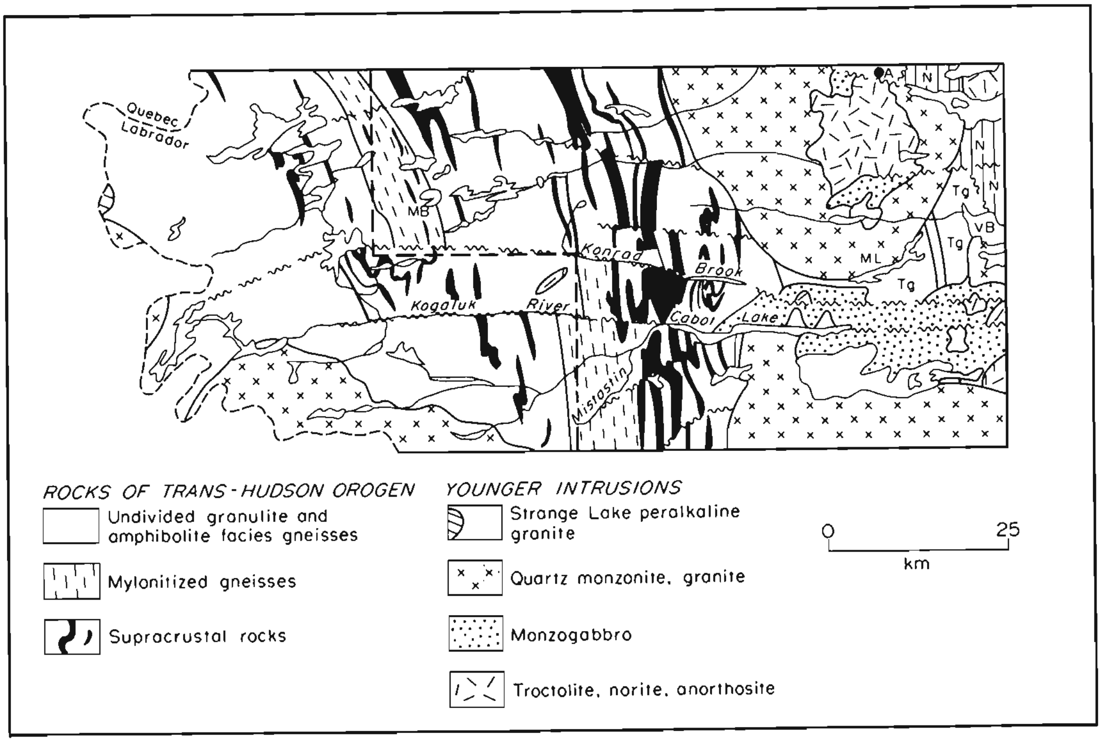


Figure 3. *Generalized geology of the Labrador transect of the Trans-Hudson Orogen examined between 1985 and 1987. Tg=Tasiyuak gneiss; N=Archean gneisses of the Nain Province, VB=Voisey Bay; ML=Makavinekh Lake; MB='Moonbase' Lake. A=location of dated sample referred to in text. The area west of the dashed line is the area mapped in 1987 and shown in more detail in Figure 4.*

variably deformed and metamorphosed basic dykes; the best preserved discordant dykes occur in the area between Long Pond and the Kogaluk River Fault.

The migmatitic gneisses (subunit la and lg) throughout the area are grey-weathering (amphibolite facies) to buff- and yellow-brown-weathering (granulite facies) quartzofeldspathic rocks containing a fabric that varies from a diffuse layering to an anastomosing mylonitic foliation (Plate 1). In some places, the gneisses display a streaky, narrow, grey and white or grey and pink colour banding. This banding results from the deformation of an original biotite (+hornblende± orthopyroxene) granodiorite host that had been transected by a criss-crossing network of more potassic granitic veins and dykes. The more leucocratic network, lenses and bands contain well-developed mafic porphyroblasts, which give an indication of the degree of metamorphism; brown hypersthene at granulite facies and black hornblende at amphibolite facies. The latter is a retrogressive replacement of orthopyroxene. Numerous bands of amphibolite–mafic granulite, are intercalated with the quartzofeldspathic gneisses. In many cases, these bands are undoubtably deformed dykes since they truncate or lack the vein network of the surrounding quartzofeldspathic rocks. However, in other areas, the whole felsic–mafic gneiss assemblage is transected by a variety of younger, subconcordant sheets and veins of granite *(sensu lato).*

The metamorphosed leucogabbro–anorthosite units (shown by small circle pattern on Figure 4) are a varied suite,

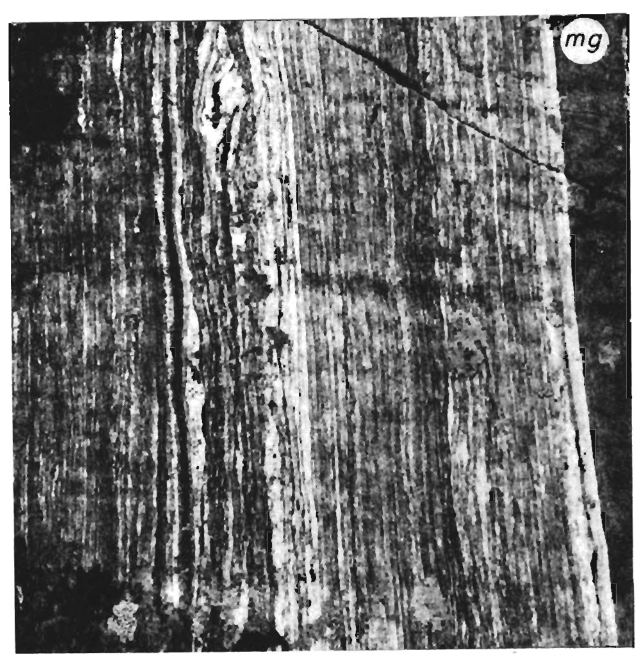
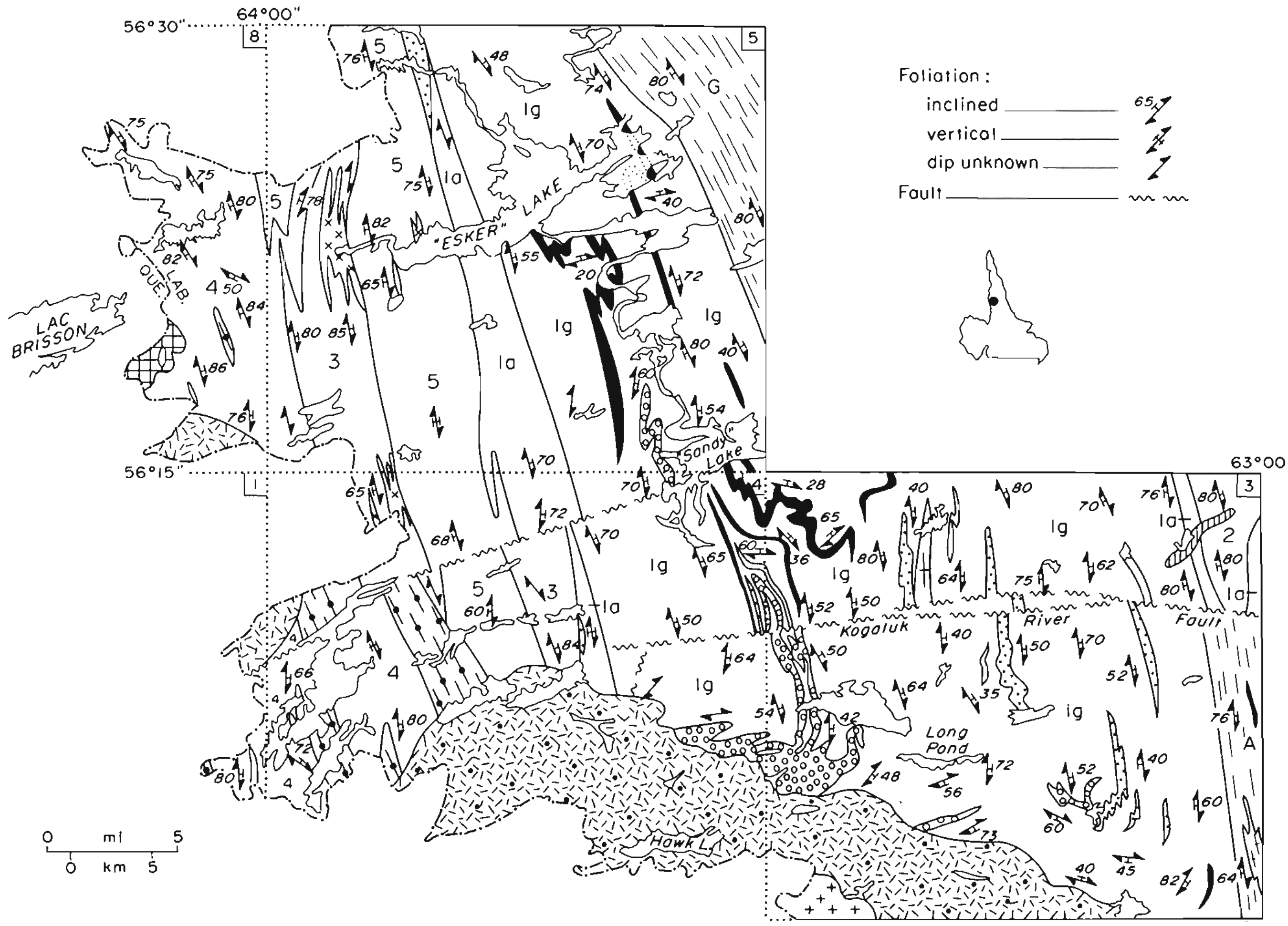


Plate 1. *Granulite-facies gneiss north of Kogaluk River. Note the large orthopyroxene crystal in felsic welt to the right of the lens cap (upper left). Rocks here have a mylonitic foliation. Mafic granulite (mg) layer on right side of photo may be deformed and metamorphosed dyke.*



Middle Proterozoic

- Strange Lake peralkaline granite
- Rapakivi granite (Mistastin batholith)
- Hornblende quartz monzonite
- Olivine gabbro
- Anorthosite and leuconorite

Archean and Lower Proterozoic

- Pink biotite granite
- Mylonitized gneiss: A=amphibolite facies; G=granulite facies
- Foliated pink potassic granitic gneiss
- Garnetiferous granite and related gneiss

Archean and Lower Proterozoic (Continued)

- 5 Pegmatoidal white granitic gneiss
- 4 Gabbronorite gneiss
- 3 Biotite-rich gneiss and augen gneiss
- Paragneiss
- Mafic gneiss

(Rocks intruded by subseqently metamorphosed mafic dykes)

- 2 Tonalite and tonalitic gneiss
- Migmatized leucogabbro and anorthosite
- 1 Quartzofeldspathic migmatite g=granulite facies; a=amphibolite facies

Figure 4. *Generalized geological map of the interior of the Trans-Hudson Orogen near the Labrador–Quebec border. Much of the area south of "Esker" Lake and east of Long Pond is covered by a thick veneer of glacial debris; the extent of map units in these areas is extrapolated or interpreted from aeromagnetic data (Geological Survey of Canada, 1983). The outline of the poorly exposed Strange Lake peralkaline granite is taken from an unpubished map by R. Miller and from Miller (1986). Numbers in boxes denote NTS 1:50,000 scale map sheets 14D/3,4,5 and 24A/1,8.*

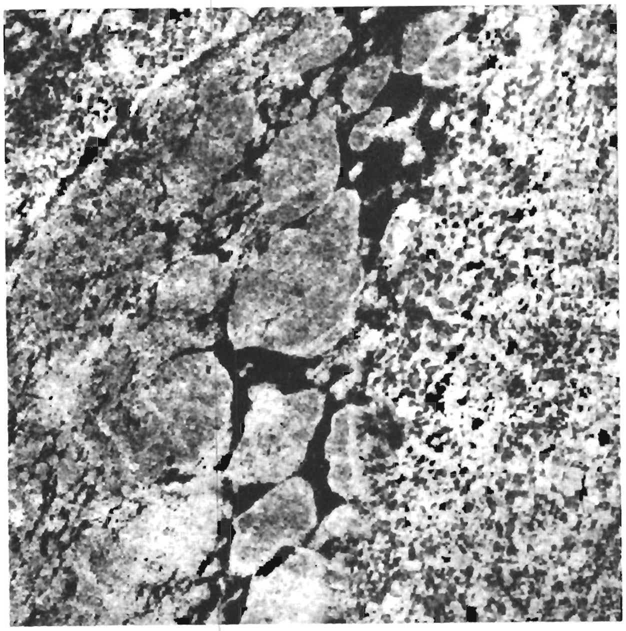


Plate 2. *Snowball-textured gabbro, injected by granitic material exhibiting granulite facies mineralogy, west of Long Pond. Largest plagioclase "ball" is 10 cm in maximum dimension.*

ranging from pure white, granular, quartz-bearing anorthosite, to streaky hornblende-bearing anorthosite and leucogabbro. A very distinctive morphological type among the leucogabbros and gabbros is a 'snowball' or 'tennis-ball' texture, in which white, ovoidal, plagioclase up to 15 cm in diameter is surrounded by a black, hornblende-rich matrix (Plate 2). Fragments of such leucogabbroic–anorthositic rocks occur widely distributed within the quartzofeldspathic gneisses, and are not shown on Figure 4. In fact, the gabbro–anorthosite units that are shown on the map are not all coherent monolithologic bodies, but in many cases are zones in which the amount of gabbro–anorthosite relative to the younger quartzofeldspathic gneisses varies from 20 to 90 percent; only one unit of fairly massive metaigneous rocks of this type has been delineated (about 3 km south of Long Pond).

Tonalite and tonalitic gneiss (Unit 2) is a distinctive unit in the northeast corner of map area 14D/3. It is a pale- to dark-grey-weathering, hornblende- and biotite-bearing rock, which locally displays only a slight fabric. Textural features, which locally characterize the unit, are remnant dark grey, primary (igneous), plagioclase and clots of black hornblende; these stand out especially in the lighter-weathering areas. It locally contains a predeformational vein network similar to that described above for parts of the migmatite complex.

All of the rock units mentioned above are either plainly intruded by variably deformed and metamorphosed basic dykes or contain layer parallel units of amphibolite–mafic granulite that can be interpreted as having been derived from such dykes. The best examples of the relationship between the dykes and other rocks can be seen in the granulite-facies terrane of the Long Pond–'Sandy' Lake area, where numerous dykes occur. These dykes vary from a few centimetres to 25 m in width and are largely recrystallized, usually exhibiting granulite-facies mineralogy (i.e., hypersthene–diopside–hornblende–plagioclase). Not all dykes are massive and undeformed; most are folded, lineated and foliated on their margins, and in zones of high strain are concordant to gneissosity, attenuated and/or boudinaged and carry a pronounced planar fabric. Unlike the gneisses they intrude, and older fragmented mafic units within them, the dykes are not migmatized (Plate 3). The only veining noted in the dykes consists of irregular, synmetamorphic, hypersthene-bearing 'sweats' and late-kinematic granitic pegmatites with a weak or nonexistant foliation. Where best preserved, the dykes exhibit relict primary subophitic and locally porphyritic textures. Large phenocrysts of blue labradorite feldspar have been noted in several dykes, but this is uncommon; typically, the feldspar 'phenocryst' is a white polycrystalline aggregate that is elongate where the dykes are deformed.

Plate 3. *Migmatite intruded by dyke that is metamorphosed to granulite facies. Lens cap for scale.*

The leucogabbroic–anorthositic rocks were deformed and migmatized prior to dyke intrusion, a conclusion that arises from (1) the observation of randomly oriented, foliated, leucogabbroic fragments within a granitic host containing a more singularly oriented fabric, both of which are truncated by the metamorphosed dykes, and (2) that of areas of foliated leucogabbro intruded by highly discordant, nonfoliated, recrystallized dykes.

Rocks Generally Without Unequivocal Metamorphosed Dykes.

Most of the other gneisses in the map area generally lack convincing evidence of having been intruded by mafic dykes. The presence of metamorphosed and deformed dykes cannot be entirely ruled out since narrow homogeneous mafic units do occur in these gneisses. Usually, these mafic bands exhibit the same neosome network as their hosts. We have, however, observed two outcrops of migmatized mafic gneisses that are crosscut by nonmigmatized metamorphosed dykes (see below). Gneisses that fall into this category range in composition from migmatitic supracrustal and granitic orthogneisses to a deformed, two-pyroxene, basic pluton.

Mafic gneisses, presumed to be largely of supracrustal origin (shown as solid black on Figure 4) and metasedimentary rocks (shown as closely spaced dotted pattern on Figure 4) occur throughout the area. The mafic gneisses range from less than a metre in length and width to several hundred metres in width and several kilometres in length. They show varying degrees of migmatiztion by younger granitoid veins and dykes; some of these younger granitoids clearly emanate from the surrounding quartzofeldspathic gneisses. The mafic units are generally clinopyroxene–amphibolite and hornblende-rich mafic granulite in which the layering is defined by variations in colour index. Locally, these mafic units are characterized by almandine garnet, which may occur as clusters up to several centimetres in diameter. Coronal overgrowths or complete pseudomorphs of symplectic plagioclase and hornblende have been observed after garnet in some mafic granulites, a reaction attributed to hydration following granulite-facies metamorphism (cf. Wells, 1979). We have observed two outcrops in which a metamorphosed mafic dyke crosscuts these migmatized mafic units; such relationships suggest that perhaps many, if not all, of these mafic gneisses may predate dyke emplacement.

Also interlayered with the quartzofeldspathic gneisses are units of migmatized garnet–sillimanite–biotite paragneiss, white sillimanite–muscovite quartzite and rare garnet–clinopyroxene–quartz rock. Dark-grey to brown, impure marble and clinopyroxene-rich calc-silicate rock also occur locally as inclusions; these are rare and are generally less than 10 m in width and less than 100 m in length. The problem of assigning an absolute or relative age to these paragneisses has been noted earlier; even though they are migmatized, they do not appear to be intruded by the metamorphosed dykes.

Dark-grey-weathering, biotite- and hornblende-rich quartzofeldspathic gneiss and intercalated mafic gneiss (Unit 3), characterized by pinch-and-swell, *lit-par-lit,* medium grained to pegmatoidal granitoid layers of at least three generations, outcrops west of 'Esker' Lake and southwest of 'Sandy' Lake (Plate 4). The internal mineral fabric in this gneiss is well developed because of the abundance of biotite, but in some areas there are elongate streaks of granular feldspar and discrete feldspar augen that suggest derivation, in part, from an originally porphyritic granitoid protolith.

Plate 4. *Biotite–hornblende migmatite gneiss south of 'Esker' Lake. Pinch-and-swell structure of leucosome is not uncommon in this unit.*

This migmatite unit is bounded to the west in the 'Esker' Lake–Lac Brisson area by a massive to gneissic unit varying from melagabbronorite to quartz-bearing gabbronorite and garnetiferous leuconorite (Unit 4). Though mostly a granulite-facies rock, it was locally retrogressed under amphibolite-facies conditions (giving rise to quartz diorite gneiss and leucoamphibolite), especially within the contact aureoles of younger felsic plutons south of Lac Brisson. The mesoscopic texture of the unit varies from fine- to medium-grained, massive, equigranular (with 'salt and pepper' appearance), to coarsely porphyritic (augen texture where highly deformed) and coarse grained gabbroic displaying relict subophitic textures (Plate 5). The finer grained, melacratic portions are identical in their field appearance and mineralogy to the metamorphosed basic dykes described previously, suggesting that this unit may have been the deeper plutonic feeder to the dykes. This metaplutonic unit is intruded by numerous sheets of white to pink, garnetiferous granite and its gneissic equivalents in the southwest corner of the map area (Figure 4), and gives rise to a mixed, migmatitic, unit. The gabbronorite is variably affected by Hudsonian deformation. In many areas, there is no obvious planar fabric but a linear one is present. In other areas, a planar fabric is detected only in narrow felsic crosscutting veins. Yet, in other areas, the unit has a well-developed augen texture, a gneissic layering, or it shows indications of polydeformation. We attribute the variety of features to primary heterogeneities within the intrusion and its inhomogeneous response to subsequent deformation.

A very distinctive white-weathering granitoid gneiss (Unit 5) trends north-northwest through the western part of 'Esker' Lake. This unit is medium grained to pegmatoidal.

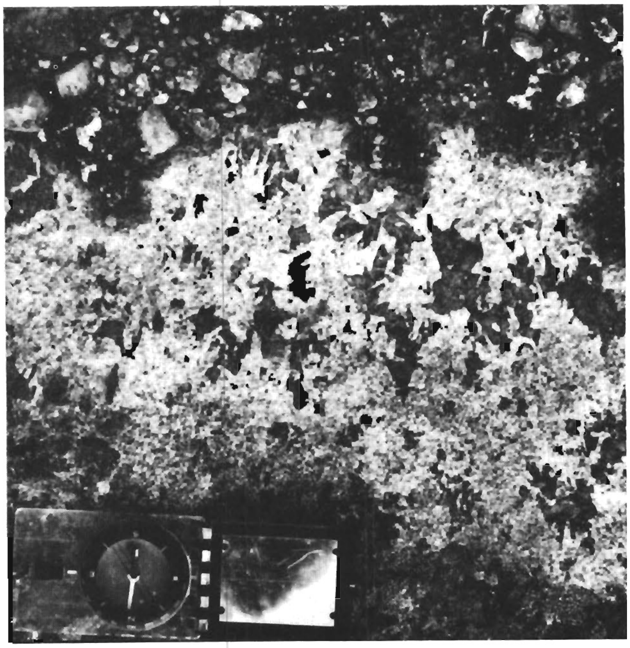


Plate 5. *Primary igneous texture in a coarse grained, mildly recrystallized part of the gabbronorite gneiss unit east of Lac Brisson. Such preservation of primary features is rare.*

In places, it lacks a well-defined layering, but generally it exhibits a schlieric foliation defined by discontinuous subparallel seams of biotite. It contains numerous screens of older gneiss, especially the migmatite of Unit 3. This unit is poorly exposed, except northwest of 'Esker' Lake. It is noteworthy for its local zones of radioactivity, a feature that makes it readily identifiable on airborne gamma-ray spectrometer maps of the area (Geological Survey of Canada, 1986). It is manifested in an aeromagnetic low (Geological Survey of Canada, 1983), which we have used to interpret its distribution in the drift-covered parts of map areas 14D/4 and 14D/5. This unit displays an intense mylonitic fabric in exposures along a string of small lakes at its southern end. This reflects an increase in the deformation from north to south.

Variably foliated biotite–garnet granite gneiss forms a poorly exposed unit in the southwest corner of the map area and occurs as a migmatizing agent within Unit 4. Sheets of foliated garnet granite believed to be related to this unit also locally crosscut the gneisses of Unit 5. The gneiss ranges from an equigranular white, leucocratic, garnetiferous granitoid rock (similar to the mylonitic diatexites of the Abloviak shear zone near Voisey Bay referred to earlier) to a porphyritic medium grained, pink- to grey-weathering rock containing abundant pink feldspar augen, in which garnet is concentrated in the biotite-rich parts of the matrix.

Pink foliated potassic granite and related gneiss occur throughout the area as narrow sheets interlayered with the other rocks. They are no doubt of several generations, and only a few of the larger ones are shown (as crosses) on Figure 4. All such rocks are salmon pink in colour, vary texturally from aplitic to medium grained, and commonly exhibit a shiny glacial polish.

Massive to weakly foliated, white- to pink-weathering, equigranular, fine grained biotite granite (shown by x pattern on Figure 4) forms an elongate body interdigitating with gneisses of Unit 3 west of 'Esker' Lake and also near the Quebec border on 14D/3. The generally undeformed nature of these rocks led Taylor (1979) to interpret the northernmost body as a continuation of a quartz monzonite pluton that occurs to the south-southwest (see below). However, the texture of the granite and morphology of the contact between the granite and its country rocks differ from that of the quartz monzonite, and it is considered instead to be a late-kinematic Hudsonian intrusion.

Basic and Felsic Posttectonic Intrusions

A large dyke of undeformed olivine gabbro and three felsic plutons constitute intrusions that postdate the regional metamorphism and deformation of the surrounding gneisses. The gabbro dyke (shown by parallel cross-hatching on Figure 4) is a 5 by 1 km intrusion outcropping in the northeast corner of 14D/3. It is a coarse grained, leucocratic to melacratic rock in which plagioclase locally forms radiating clusters. It is considered to be contemporaneous with similar mafic rocks of the Nain Plutonic Suite in the Voisey Bay area (Ryan and Lee, 1986).

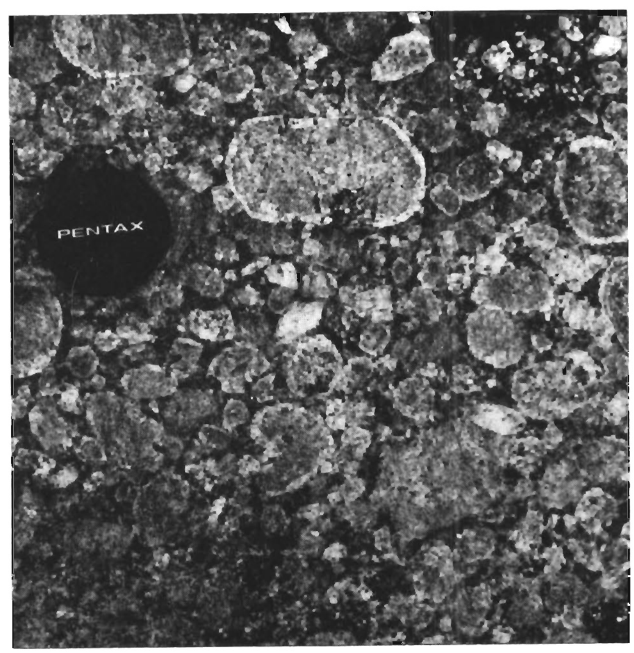


Plate 6. *Densely packed, mantled, ovoidal, feldspar megacrysts, typical of the Mistastin batholith.*

The most extensive felsic unit occurs along the southwest corner of the map area encompassing the northern part of the Mistastin batholith, a generally rusty-weathering rapakivi quartz monzonite to granite (Emslie *et al.*, 1980). It is characterized by abundant, ovoidal, mantled potassium feldspar megacrysts in a medium grained hornblende-bearing matrix (Plate 6). A large raft of anorthosite and leuconorite, with blue chatoyant feldspar, is enveloped by the granite batholith along the southern perimeter of the map area

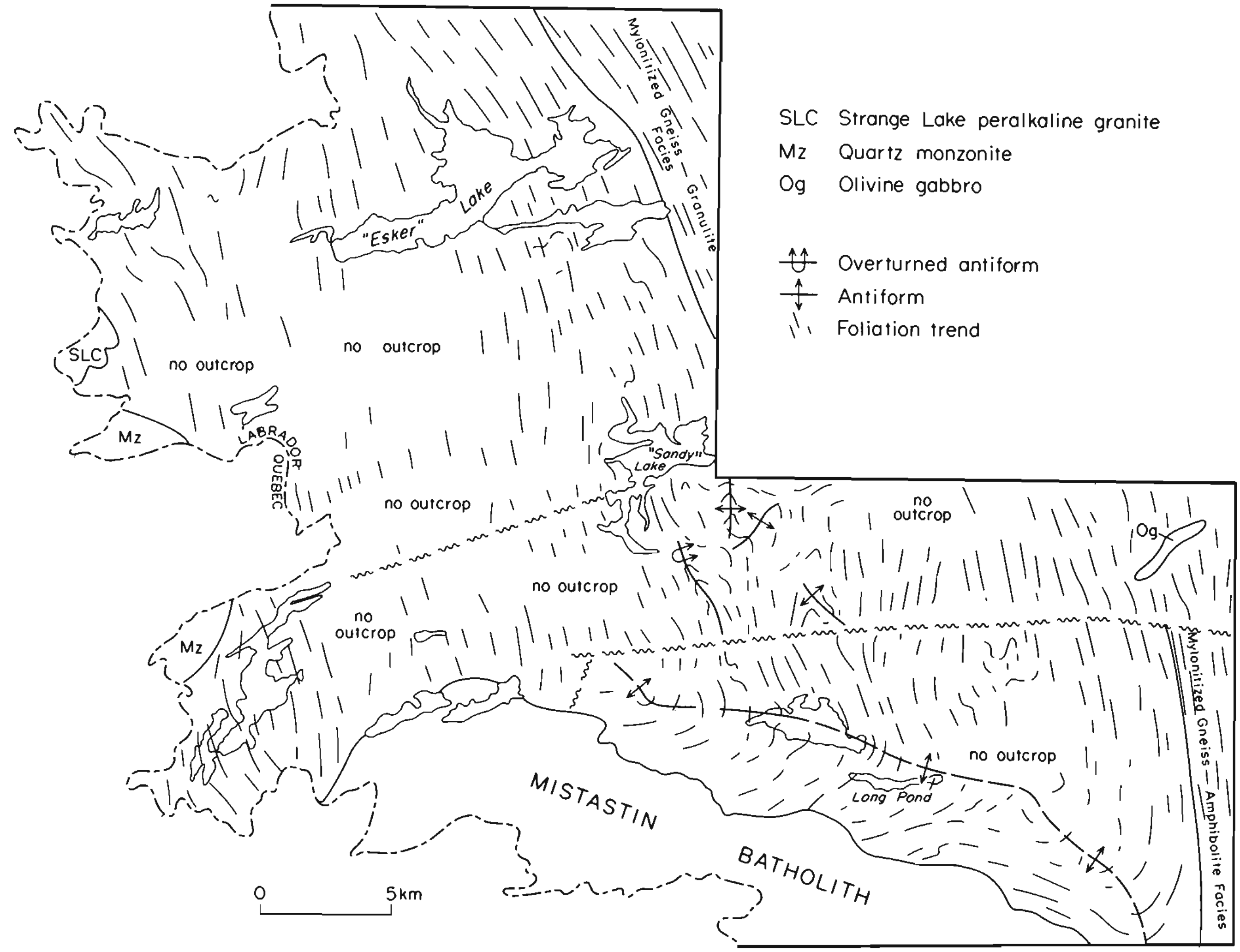


Figure 5. *Generalized trend-line map for area shown in Figure 4. Note that this map does not differentiate foliations of differing ages.*

(Figure 4). The Mistastin batholith has a pyroxene- and hornblende-hornfels contact aureole up to 2 km wide. One of the most distinctive features of the aureole is the growth of large, randomly oriented, skeletal biotite porphyroblasts in the migmatitic gneissic matrix to the anorthosite unit west of Long Pond. It is worthy of note that foliations in the country-rock gneisses are oriented roughly parallel to the contact with the batholith southeast of Long Pond; however, this appears to be a pre-intrusion orientation (see below), since the trend is in fact truncated by the batholith on a regional scale (Figures 4 and 5). The continuity of country-rock aeromagnetic signatures into areas underlain by granite (Geological Survey of Canada, 1983) suggests that the Mistastin batholith in this area is a relatively thin subhorizontal sheet.

The westernmost pluton, composed of hypidiomorphic-textured, pink-weathering quartz monzonite forms scattered outcrops along the western periphyry of the area. It is distinguished from the Mistastin batholith by the lack of mantled, ovoid, feldspar megacrysts. Currie (1985) has noted such textures in the extension of this pluton west of the Labrador–Quebec border, but this has not been confirmed either by the writers or by Quebec geologists (e.g., Bélanger, 1984).

The Strange Lake Alkalic Complex (Currie, 1985; Miller, 1986) with its REE–zirconium–yttrium deposit, straddles the Labrador–Quebec border. It is drift-covered in the study area, and is exposed in only a few outcrops southeast of Lac Brisson, where it comprises a grey-weathering, 'spotted' riebekite granite. The spotted appearance is caused by conspicuous black riebekite crystals. The complex has been the subject of intense exploration and study since its discovery by the Iron Ore Company of Canada in 1979 (cf. Hlava and Krishnan, 1980; Miller, 1985, 1986; Currie, 1985). Radiometric dating of the complex has yielded a K–Ar age of 1271 ± 30 Ma (Currie, 1985) and a Rb–Sr age of 1189 ± 32 Ma (Duthou *et al.*, 1986).

Undeformed, fresh to slightly altered, rectilinear diabase dykes (not shown in Figure 4), varying from a few centimetres to tens of metres in width, are widely distributed within the gneissic terrane. Their absolute age is unknown, but in the eastern part of the project corridor near Makavinekh Lake (Ryan and Lee, 1986), they crosscut Helikian rapakivi plutons. This shows that they postdate the youngest plutonic activity associated with the Nain Plutonic Suite.

STRUCTURAL GEOLOGY AND METAMORPHISM

A cursory examination of the map patterns (Figure 4) indicates that the study area is dominated by a north-northwest-trending, generally steeply dipping assemblage of gneisses. Tight folds, defined and postulated on the basis of the distribution of a few marker units and the aeromagnetic patterns, have axial plane trends parallel to the overall gneissosity. Deviations, however, are apparent south of 'Sandy' Lake and in the area of Long Pond where units, folds and foliations trend roughly east-west. These variations, shown on a foliation trend map (Figure 5), indicate a history of multiple deformation, but the correlation of this history with regional tectonic events in the Trans-Hudsonian Orogen elsewhere in Labrador (cf. Korstgaard *et al.*, 1987; Wardle *et al.*, *in press)* is not yet established. A few salient features of the deformation seen in this area are outlined below.

The generally north-northwest-trending gneissic layering, the gneissic foliation and the tight to isoclinal folds that dominate the map pattern are considered the chief manifestation of Hudsonian deformation. The gneissosity is usually steeply dipping, but is locally subhorizontal. Shallow dips are especially common south of 'Esker' Lake where numerous isoclinal folds, shallowly plunging to the north, are present. A prominent shallowly plunging mineral-rodding lineation (not shown on Figures 4 and 5) associated with the folds is also conspicuous in the 'Esker' Lake area. This lineation is the chief fabric orientation that can be detected in many horizontal exposures; only on appropriate subvertical outcrop surfaces can the gneissic layering attitude be seen. A subhorizontal lineation and shallowly plunging folds are also common in other parts of the area, but steeply plunging structures are present as well. In fact, mesoscopic structures with varying style and attitude can occur over small areas. The relationships between these mesoscopic fold structures are not yet understood.

As noted above, east-west-trending structures are present in the 'Sandy' Lake and Long Pond area. The former area appears to reflect the effects of superposed folding (Figure 5), a notion supported by the common occurrence of closed interference structures (Type 1 of Ramsay, 1967; Plate 7). The distribution of the leucogabbro—anorthosite units west of Long Pond also suggests elongate closed interference patterns, but these appear to be older than those of the 'Sandy' Lake area.

The gneissic foliation attitudes near Long Pond outline a large open antiform, plunging moderately to the southeast. The southern limb of this fold is truncated by the Mistastin batholith (Figure 5) so the antiform is not considered to be related to batholith intrusion, but to be an older structure in the gneiss terrane, possibly equivalent to similar open folds outlined by Taylor (1979) west of the batholith in Quebec.

Plate 7. *Interference patterns in gneisses southeast of 'Sandy' Lake. Such structures are not uncommon in the 'Sandy' Lake—Long Pond sector of the area.*

Two extensive zones of mylonitized rocks occur in the area (Figures 4 and 5) together with more commonly occurring localized narrow mylonite zones. The southern mylonite zone comprises predominantly grey, hornblende-blastic, amphibolite-facies gneisses containing numerous intercalated pink granite sheets. An anastomosing foliation and prominent shallowly plunging mineral lineation characterize this zone. The granulite-facies northern zone also displays a shallowly plunging mineral-rodding lineation and related small-scale isoclinal folds within a steeply dipping, mylonitic, laminar, gneissic banding. The northern zone contains rocks that are plainly derived from the predyke terrane. The lineation in both these high-strain zones has the same character and orientation as that found in the Abloviak and Komaktorvik zones on the western margin of the orogen (Figure 2), implying an origin in a similar transcurrent shear regime (Korstgaard *et al.*, 1987; Wardle *et al.*, 1987; *in press).*

The metamorphic mineral assemblages in the gneisses reflect upper-amphibolite- and granulite-facies conditions as outlined in the previous sections. The amphibolite-facies rocks appear to be a result of retrogression from granulite facies since relict hypersthene is locally present in some parts of the lower-grade terrane. A 2-km-wide pyroxene- and hornblende-hornfels contact aureole around the Mistastin batholith is characterized by dark-brown, friable quartzofeldspathic gneisses, and metasedimentary gneisses in which garnet and sillimanite are replaced by hypersthene, cordierite and spinel. These features are identical to those observed around plutons in the Nain Plutonic Suite to the east (Ryan and Lee, 1986).

THE EVIDENCE FOR ARCHEAN ROCKS IN THE PROJECT AREA

The lack of a firm geochronological data base has been a major obstacle to deciphering the geological evolution of the Trans-Hudson Orogen in Labrador. Taylor (1979) considered that all of the rocks in this area were Early Proterozoic (Aphebian). Korstgaard *et al.* (1987) and Wardle *et al. (in press)*, on the other hand, have postulated that the interior gneisses probably comprise significant volumes of reworked Archean crust. It is proposed here that the Labrador–Quebec border area contains remnants of such older crust that have not been thoroughly structurally reconstituted during the Hudsonian Orogeny. The proposal is based on two main premises, viz. (1) that the leucogabbroic–anorthositic rocks of the map area are time equivalents of similar layered complexes in the Archean gneiss terranes of Labrador and Greenland, and (2) that the metamorphosed diabase dykes are the time equivalents of the lower Proterozoic (2300-2400 Ma) swarm intruded into the Archean Nain Province, and therefore all rocks intruded by such dykes in the present study area are also Archean.

It is not possible to fully define the extent of this predyke (Archean) gneiss terrane because throughout most of the area, any discordance between an earlier layering and the dykes has been destroyed by the high strain and transposition associated with Hudsonian deformation. However, where the gneiss–dyke assemblage appears to have been simply reoriented into a parallel layered complex, the veined character of the gneisses contrasts with the massive metamorphosed dykes. Unfortunately, Hudsonian migmatization has also affected most of these (transposed) gneisses so that the recognition of 'early' migmatite within such rocks is tenuous.

Although the trend of the gneisses in the 'Esker' Lake–Long Pond area is parallel to that of Hudsonian fabrics throughout the Trans-Hudson Orogen of this region, these gneisses appear to have preserved pre-Hudsonian features. These gneisses have been metamorphosed under granulite facies conditions during the Hudsonian Orogeny, but they have not been affected by the same intensity of structural overprint as other gneisses in this area. A sharp boundary between 'gneisses with discordant dykes' and 'gneisses with transposed dykes' cannot be easily drawn due to variations in strain intensity across the area, but the least amount of transposition is seen in the area south and west of Long Pond. This area also contains the 'older' elongate interference patterns (outlined by the leucogabbro–anorthosite units), perhaps an indication that the map pattern in this area (Figure 4) is a function of the reorientation of pre-Hudsonian (predyke?) gneissic structures by Hudsonian deformation. It is apparent in the field that the dykes crosscut mesoscopic (Archean?) fold structures in the gneisses (Plate 8), but insufficient data are available to unequivocally define any predyke macroscopic folds. Even in the area near Sandy Lake, where most dykes and their hosts have been transposed into parallelism, there are strain shadows adjacent to some of the thickest dykes in which the predyke migmatized and folded character of the complex can be seen.

Plate 8. *Mesoscopic open fold structure truncated by granulite-facies metamorphosed dyke south of Long Pond. Dark lens at top of photo is one of a number of older migmatized mafic pods in the gneiss at this locality. Field of view is 50 cm wide.*

Interestingly, the area in which the dykes have been recognized occurs west of major zones of mylonitized gneisses, suggesting that these zones may represent major structural junctions between the rocks of this area and those examined previously to the east. There are, however, isolated exposures in the Cabot Lake–'Moonbase' Lake area (Figure 3) in which nonmigmatized, massive amphibolite–mafic granulite units show slight discordance to layering of the enclosing quartzofeldspathic gneiss (Ryan *et al.*, 1987, page 157). In addition, there are isolated occurrences of snowball-textured metaleucogabbro and meta-anorthosite in the gneisses of the same area, one of which forms a mappable unit at 1:100,000 scale (Ryan *et al.*, *op. cit.*). The mylonite zones, therefore, do not seem to represent major junctions between crustal blocks with widely differing lithostratigraphic components. Instead, they are local high-strain zones within the same crustal block, which may in part bound regions with pre-Hudsonian features still preserved.

CONCLUSIONS

Leucogabbro–anorthosite complexes and migmatitic gneisses transected by metamorphosed diabase dykes have been discovered within the Trans-Hudson Orogen near the Labrador–Quebec border. It is proposed that the predyke complex represents Archean crustal components, which, in part, have escaped the greatest imprint of Hudsonian deformation, but which have been metamorphosed under the prevailing granulite-facies regional metamorphism. These Archean rocks may constitute either a westward extension of the Nain crust, which has escaped wholesale reworking, or an exotic terrane that has been incorporated into the

Trans-Hudson Orogen through accretion. If our conclusion, which is based on field relationships, is correct, then this represents the first concrete field evidence of Archean rocks within the Trans-Hudson Orogen of this region. Archean components have been identified by zircon dating within the southern Labrador sector of the Trans-Hudson Orogen near Churchill Falls (Krogh, 1986), and have been postulated elsewhere on the basis of Nd–Sm signatures from younger plutons (Ashwal *et al.*, 1986). In addition, there are radiometric indications of pre-Hudsonian crustal components in the Trans-Hudson terrane of Quebec west of the study area (van der Leeden, personal communication, 1987). The existence of preserved remnants of recognizable Archean crust in the interior of the Trans-Hudson Orogen in Labrador–Quebec, supports the contention of Korstgaard *et al.* (1987) that this region largely comprises a reworked Archean terrane with infolded and metamorphosed Aphebian cover. The extent of the Archean crust is not readily obvious because of the intensity of the Hudsonian overprint, and the paucity of radiometric ages. Dr. U. Scharer (at Université du Québec, Montréal) has recently begun a geochronological investigation of samples from several units in the predyke terrane of the map area in an attempt to test the hypothesis outlined above.

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