GEOLOGY OF THE NORTH WEST RIVER AREA

by

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Abstract

The North West River area is located within the northern part of the Grenville Province 100 km south of the Grenville Front.

The area consists of two major geological components: a pre-Grenville granitoid - metasedimentary gneiss complex believed to have experienced a high grade metamorphic event circa 1650 Ma, and a younger allochthonous gabbro-anorthosite suite of unknown age which was translated northwards as the Cape Caribou River allochthon during the Grenville Orogeny.

The granitoid and metasedimentary gneiss complex is transected by a major northeast trending Grenvillian thrust which to the northeast forms the boundary between Lake Melville and Groswater Bay terranes. In the map area the thrust separates local areas of granulite grade metamorphism in the south from kyanite-, sillimanite- and epidote-bearing assemblages to the north.

Development of the Cape Caribou River allochthon was associated with intense deformation and recrystallization of the basal part of the gabbro-anorthosite suite under largely anhydrous conditions. The basal part of the allochthon comprises an enigmatic unit of mylonitic amphibolite - mafic granulite interlayered with mylonitic orthopyroxene-bearing granite. This may represent the basal contact region of the gabbro-anorthosite suite.

Following the Grenville Orogeny the area was stablized, uplifted and then subjected to a period of late Precambrian-early Paleozoic extensional tectonism associated with development of the Lake Melville graben system. It is speculated that parts of the Lake Melville lowlands near North West River may form part of the graben and be floored at depth by late Precambrian-early Paleozoic sedimentary rocks.

Following deglaciation of the area in the Quaternary, the area around North West River and Lake Melville was covered with extensive glaciofluvial outwash and estuarine deposits of till, sand and clay.

Mineralization in the area is restricted to minor magnetite, illmenite and fluorite showings in the anorthosite, and pegmatite-hosted ilmenite in metasedimentary gneiss.

Introduction

The map area is located in eastern Labrador at the western end of Lake Melville (Figure 1), and includes the community of North West River which is connected by road to the town of Goose Bay 34 km to the south.

The only previous work in the area has been reconnaissance mapping by the British Newfoundland Exploration Company (BRINEX, 1954) and the regional mapping of Stevenson (1969) for the Geological Survey of Canada.

The present project was initiated to link the Newfoundland Department of Mines and Energy 1:100,000 scale mapping by Ryan et al. (1981, 1982) to the west with that by Erdmer (1983) to the north. The area to the south has yet to be mapped at 1:100,000 scale.

General Geology

The map area lies within the Grenville Structural Province of eastern Labrador and is situated 100 km south of the northern limit of Grenvillian deformation as defined by Gower et al. (1980) (Figure 1 inset).

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The area is divisible into two major geological components. A pre-Grenville gneiss complex, believed to have undergone high grade metamorphism circa 1650 Ma, underlies the northeastern half of the area, and has been overthrust from the south by a younger allochthon consisting of amphibolite, gabbro and anorthosite (Figures 1 and 2).

The pre-Grenville complex consists of minor bands of kyanite bearing metasedimentary gneisses (Unit 1) interspersed within a terrane of heterogeneous granitoid gneiss (Unit 2). Following high grade metamorphism at circa 1650 Ma, these were intruded by minor bodies of younger granite (Units 3 and 4).

The allochthon, initially recognized by Ryan et al. (1981) and named the Cape Caribou River allochthon (Figure 1), consists of a basal unit of highly mylonitized and interlayered amphibolite - mafic granulite and white pyroxene-bearing granite. This is overlain by a gabbro-anorthosite suite comprising a lower unit of well layered amphibolite (Unit 6a) followed upward by more massive metagabbro and leucogabbro (Unit 6b), and finally by massive coarse grained anorthosite (Unit 7).

The eastern part of the map area bordering Lake Melville is a low lying plain (Lake Melville lowlands) formed by Pleistocene sand, clay and till deposits. These are probably largely of fluvioglacial outwash origin but the presence of numerous relict strand lines around both Lake Melville and North West River suggests reworking in estuarine or lacustrine environments during postglacial uplift of the Lake Melville region.

It is speculated that much of this lowland area is a down faulted block forming part of the late Precambrian - early Paleozoic Lake Melville graben system. The possibility exists, therefore, that the lowlands are underlain by late Precambrian - early Paleozoic sedimentary rocks.

Unit 1: Kyanite-sillimanite-bearing Metasedimentary Gneisses

These occur principally in a narrow 1 to 2 km wide belt in the northwestern part of the map area (Figure 2) where they separate in part the Cape Caribou River allochthon from the granitoid gneisses of Unit 2. This belt may be connected through a drift-covered area with an outcrop area near the northern margin of the map area. This latter area forms part of a north trending belt of metasedimentary gneiss extending into the area mapped by Erdmer (1983, *his Unit 1a*). A small sliver of gneiss was also been caught up and severely mylonitized within the northeast trending overthrust zone.

The gneisses are generally pink or pale gray in outcrop, the two varieties usually being interbanded. They are strongly migmatitic (Plate 1), with over 25% melt fraction, and display an intricate pattern of small scale isoclinal folds characterized by numerous second and third order parasitic folds. The gneisses also typically possess a fine centimetric scale gneissic banding within which bands of quartz + K-feldspar + plagioclase leucosome alternate with darker melanosome bands of aluminosilicate + muscovite + biotite + magnetite + garnet + quartz + feldspar composition.

Plate 1: *Migmatitic, kyanite-bearing metasedimentary gneisses, Unit 1.*

The metasedimentary gneisses also contain sparse pods and boudinaged bands of garnet + biotite amphibolite which are interpreted as relict pretectonic dikes. Larger bodies of garnetiferous amphibolite also occur within the metasedimentary gneisses and may be genetically related to the dikes. Kyanite is the predominant aluminosilicate polymorph and usually occurs in the assemblage kyanite + K-feldspar + quartz + plagioclase + biotite + magnetite + garnet. It is usually visible on foliation surfaces as 0.5 to 1 mm pale green prismatic grains or grain aggregates.

At the southern end of the paragneiss belt, and in the small sliver located along

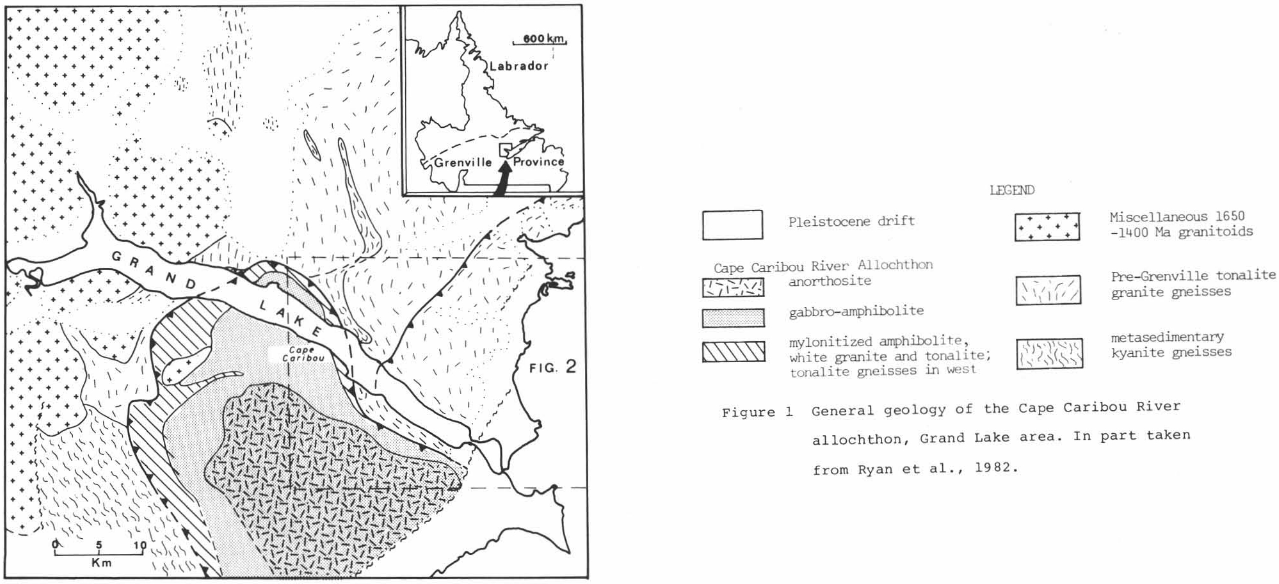

Figure 1: *General geology of the Cape Caribou River allochthon, Grand Lake area. In part taken from Ryan et al., 1982.*

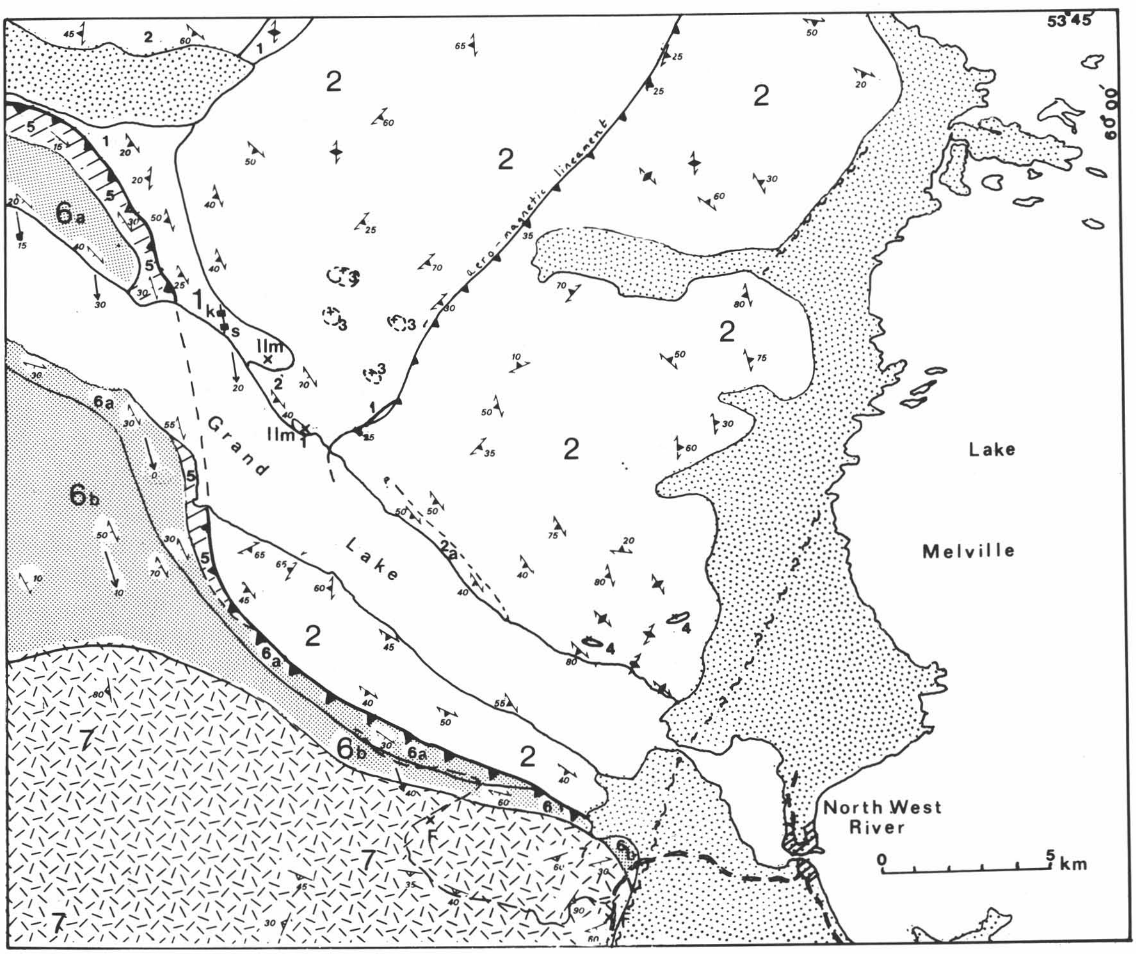

Figure 2: *Geology of the North West River area (13F/9), Labrador.*

the major northeast trending thrust, sillimanite is the representative aluminosilicate and occurs as fine fibrolite aggregates within the same mineral assemblage as kyanite. An approximate isograd has been drawn to separate the kyanite and sillimanite fields (Figure 2). The two minerals have not been observed together and their mutual time relationships are uncertain.

An exposure of the metasedimentary gneisses on the north shore of Grand Lake (Figure 2) contains 1 to 3 m wide interbands of a green banded gneiss with the composition biotite + hornblende + epidote + diopside (?), and contains irregular segregations of coarse intergrown garnet, quartz and plagioclase. These rocks are apparently of calc-silicate composition and resemble rocks found in association with other metasedimentary gneisses in more easterly parts of the Grenville Province (Gower, personal communication, 1983).

Legend for Figure 2

Pleistocene drift

HELIKIAN

Cape Caribou River Allochthon

7 *Massive, coarse grained anorthosite.*

6b *Interlayered gabbro, leucogabbro and minor anorthosite, passing structurally downwards into metagabbroic equivalents.*

6a *Amphibolite and leucoamphibolite.*

5 *Interlayered, mylonitized amphibolite, mafic granulite and white granite.*

Thrust Contact

Granitoids

4 *Coarse grained, megacrystic biotite granite.*

3 *Fine grained tonalite and microgranite.*

Pre-Grenville Gneisses

2 *Granitoid gneisses: generally gray, migmatitic granodiorite gneisses with abundant amphibolite bands.*

2a *Gray quartz diorite to tonalite gneiss.*

APHEBIAN (?)

1 *Kyanite-sillimanite-bearing, gray to pink, migmatitic metasedimentary gneisses.*

Late crosscutting quartz + feldspar pegmatites are abundant within the metasedimentary gneisses, and locally contain between 10 and 35% of a metallic mineral preliminarily identified as ilmenite. On the north shore of Grand Lake the gneisses are intruded by a single late mafic dike which crosscuts gneissic banding but was folded and recrystallized during a later deformation.

The gneisses of Unit 1 are generally similar in composition and structural style to extensive belts of metasedimentary gneiss in the Grenville Province of central Labrador (see Ryan et al., 1982; Thomas, 1981; Thomas et al., 1981). These gneisses, generally termed Disappointment Lake gneiss (Thomas, 1981), have been dated at circa 1650 Ma by Rb-Sr method (Fryer *in* Thomas, 1981), an age interpreted to represent the timing of high grade metamorphism in the unit. The protolith of these gneisses, as with those of the present map area, is believed to have been a predominantly pelitic-psammitic sequence, probably of early Proterozoic age.

Unit 2: Granitoid Gneisses

This is a heterogeneous unit underlying much of the northeastern half of the map area (Figure 2).

The predominant lithology is a gray gneiss of overall granodiorite composition which is usually strongly migmatitic with a tonalite paleosome and a granodiorite to granite leucosome. The overall mineral composition is quartz + feldspar + biotite + magnetite ± hornblende ± garnet ± epidote. Garnet occurs only in minor amounts and hornblende is largely found in the leucosome fraction. Epidote is a common constituent in the northwestern part of the unit. Scapolite has been found locally in mylonitized equivalents of the gray gneisses. Typical accessory minerals are monazite, apatite, allanite, zircon and sphene; monazite being unusually abundant at some localities.

South of Grand Lake, isolated localities of granodiorite gneiss have been found containing orthopyroxene in association with the above mentioned assemblage.

The gray granodioritic gneisses are interbanded on a variety of scales with pink granite gneisses which have the monotonous assemblage quartz + feldspar + biotite ± garnet.

A subunit of gray, quartz diorite to tonalite gneiss (2a) has also been recognized along the northern shore of Grand Lake. This subunit is generally less migmatitic and gneissic than the neighboring granodiorite gneisses, and contains recognizable relict igneous features such as attenuated amphibolite xenoliths, augened plagioclase megacrysts and amphibolite dikes which locally retain angular apophyses and recrystallized chilled margins. The inland extension of this unit is poorly defined. These gneisses have the assemblage quartz + feldspar + hornblende + biotite + magnetite ± garnet ± clinopyroxene ± orthopyroxene. They are typically hornblende-rich and locally contain abundant garnet porphyroblasts. Clinopyroxene is well preserved but orthopyroxene is highly altered and partially replaced by biotite.

All gneisses of Unit 2 contain abundant bands and boudins of amphibolite, locally forming up to forty percent of outcrops. In low strain zones these have rectilinear shape and are recognizable as relict dikes (Plate 2). Larger, outcrop scale bodies of amphibolite, locally preserving a vague compositional banding, are also present within all Unit 2 gneisses and may be genetically related to the dikes. The amphibolites have the general assemblage plagioclase + hornblende + biotite + Fe Ti oxides ± clinopyroxene ± minor orthopyroxene. Pyroxene, largely clinopyroxene, but including orthopyroxene has been observed only in rocks south of Grand Lake. The mafic rocks of Unit 2 in this area are, therefore, more correctly referred to as mafic granulite.

Plate 2: *Relic amphibolite dikes in granitoid gneisses of Unit 2.*

The granodiorite gneisses exposed along the north shore of Grand Lake have been intruded by scattered late mafic dikes generally similar to the example noted from the metasedimentary gneisses. These are characteristically dark green in color, and consist of a recrystallized intergrowth of amphibole, plagioclase and garnet. They crosscut the gneissic and migmatite fabrics of the host rocks at acute angles (Plate 3) but were later cleaved, folded and recrystallized.

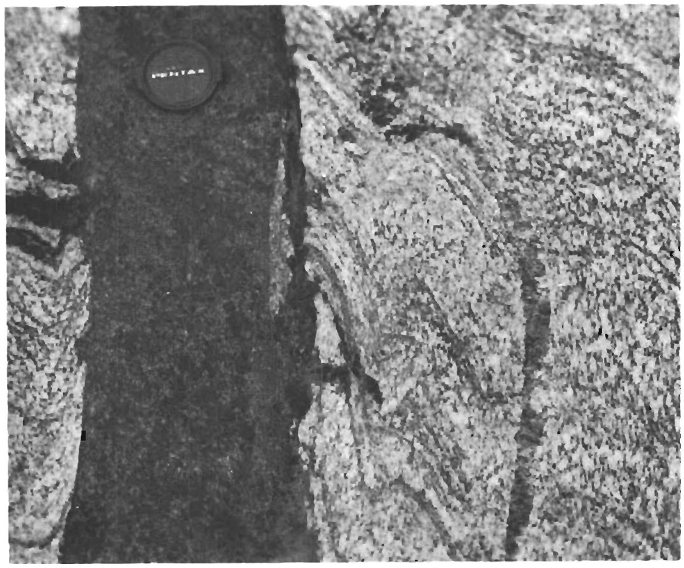

Plate 3: *Late amphibolite dike crosscutting gneissic banding in Unit 2 granitoid gneiss.*

The contact between Units 1 and 2 is exposed on the north shore of Grand Lake, where granodiorite gneisses of Unit 2 are interlayered with the metasedimentary gneisses on a scale of 1 to 2 m. However, the evidence is ambiguous as to whether this is a tectonic effect or reflects an original intrusive relationship.

The granitoid gneisses of Unit 2 extend to the north where they have been described by Erdmer (1983, *his unit 2)* and dated at 1680 Ma (U-Pb zircon, Krogh, written communication, 1983) an age which is presumed to approximate the timing of high grade metamorphism and migmatization in the unit. This is consistent with other circa 1650 Ma metamorphic ages obtained from the Disappointment Lake gneiss of central Labrador and indicates a major early Proterozoic metamorphic event within the central and eastern Grenville Province. This is referred to by Nunn et al. (1984) as the Labradorian orogeny.

Unit 3: Fine Grained Tonalite-microgranite

Four small, separate outcrops consisting of fine grained, weakly foliated granitoid rocks occur north of Grand Lake in the central part of the area (Figure 2). One outcrop comprises a fine grained gray tonalite or granodiorite; the others are pink leucocratic microgranites. The outcrops may belong to one large composite pluton, but more probably represent small isolated intrusions. The weakly foliated state suggests that intrusion followed the main metamorphic episode in the host gneisses.

Unit 4: Megacrystic Granite

Two small bodies of biotite megacrystic granite intruded Unit 2 gneisses near the southeastern end of Grand Lake (Figure 2). The westernmost body is in reality a network of granite dikes rather than a homogeneous pluton. The granites contain K-feldspar megacrysts 2 to 3 cm diameter set in a matrix of quartz, plagioclase and coarse biotite. They are weakly foliated and clearly crosscut gneissic fabrics in the Unit 2 host rocks.

Unit 5: Interlayered, Strongly Mylonitized Amphibolite - Mafic Granulite, Leucoamphibolite and white Granite

This forms the strongly tectonized basal unit of the Cape Caribou River allochthon (Figure 2). The unit typically is a well layered sequence (layers 2 to 30 cm thick) of dark, garnetiferous amphibolite - mafic granulite, varying to garnetiferous leucoamphibolite with concordant layers of white granite. The white appearance is deceptively suggestive of tonalite, and it is only after staining that the relatively K-feldspar-rich nature of these sheets is apparent. The granite sheets typically range between 0.5 cm and 30 cm in thickness and more rarely up to a metre. They are all parallel and interspersed with amphibolite layers of similar thickness (Plate 4). The highly concordant nature of the layering is undoubtedly in large part a tectonic effect and reflects the extremely high strain developed at the base of the Cape Caribou River allochthon. Locally granite veins have been observed to be isoclinally folded and also to crosscut amphibolite layers at shallow angles.

The mafic layers contain the assemblage green hornblende + plagioclase + magnetite + clinopyroxene ± orthopyroxene ± garnet. Garnet is usually abundant in these rocks, forming poikilitic porphyroblasts from 0.5 to 3 cm in diameter, but is not always present. Green clinopyroxene, probably diopside, is the dominant pyroxene and is locally overgrown by green hornblende.

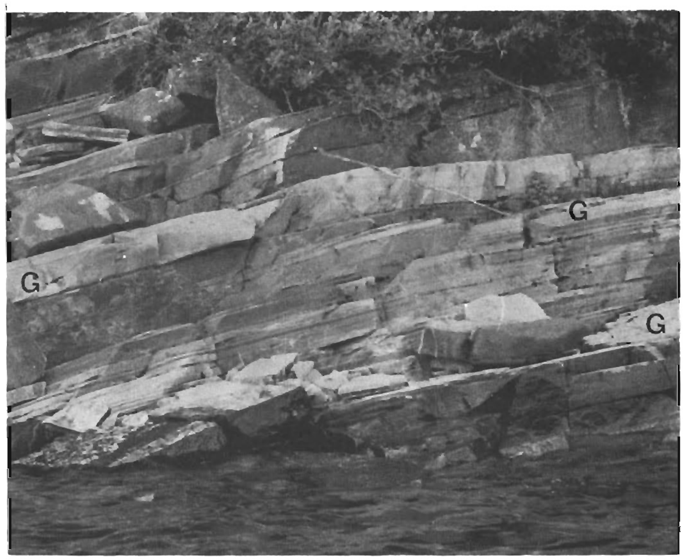

Plate 4: *Interlayered, strongly mylonitized amphibolite - mafic granulite, and white granite of Unit 5. (G = granite).*

Orthopyroxene is relatively rare in the mafic layers. The mafic rocks are commonly medium grained, with strong schistose fabrics wrapped around garnet porphyroblasts. The latter locally preserve helicitic inclusion trails indicative of rotation during growth.

The granitoid layers vary locally to tonalite, and contain the assemblage quartz + feldspar + magnetite ± clinopyroxene ± orthopyroxene ± garnet ± biotite. They show well developed mylonite texture with thin ribbon quartz grains enclosing elongate augen of feldspar, pyroxene and garnet. On the microscopic scale this cataclastic texture has been recrystallized to a polygonal granular texture.

The origin of Unit 5 and its relationships to the overlying metagabbroic and anorthosite rocks of the Cape Caribou River allochthon are uncertain. The amphibolite - mafic granulite component of Unit 5 is practically identical in appearance to the amphibolite component of the structurally overlying layered amphibolites (Unit 6a) of the gabbro-anorthosite suite. However, nowhere is it possible to trace a continuous section from one unit to the other and there is only permissive evidence for a gradational contact. On the other hand the interlayering of amphibolite and granite is also broadly similar to highly straightened and mylonitized amphibolite-rich parts of the Unit 2 granitoid gneiss complex. Thus the question arises as to whether Unit 5 forms the tectonized base of the gabbro-anorthosite suite, or is an allochthonous slice of basement.

Crucial to the resolution of this question is the origin of the granitic sheets within Unit 5. Significantly these sheets do not show any indication of having had gneissic texture prior to mylonitization and appear to be derived from mylonitization of granites rather than thin slices of basement gneiss. They also locally show crosscutting relationships with amphibolite bands indicating an original intrusive relationship. This is further supported by the local presence of irregular sheets of white granite in the overlying amphibolites (Unit 6a) of the gabbro-anorthosite suite (see below).

We suggest, therefore, that the granite sheets were intruded into an amphibolite - mafic granulite sequence presumed to form the base of the gabbro-anorthosite suite. The origin of the granites is unknown. It is possible that they represent a transposed stockwork system produced at the contact zone of a deep level granite pluton. Alternatively they could be interpreted as the products of rheomorphic injection following melting of granitoid host rock by intrusion of the gabbro-anorthosite suite; or possibly the products of frictional melting related to thrusting. In each case it is likely that they mark the basal contact zone of the gabbro-anorthosite suite.

As a final point it is worth noting that for the western part of the Cape Caribou River allochthon, (Figure 1) Ryan et al. (1982) demonstrated the lowest part of the allochthon to consist of gray granite to granodioritic gneisses. Most of these rocks are extensively mylonitized but usually they retain vestiges of gneissic fabric and as such are distinct from the rocks of Unit 5.

Unit 6: Gabbro-amphibolite

Unit 6 represents a variably deformed and recrystallized gabbroid body, the lower part of which consists of amphibolite (Unit 6a) and the upper part gabbro-metagabbro (Unit 6b).

Unit 6a: Amphibolite-leucoamphibolite

Unit 6a consists of banded amphibolite and leucoamphibolite interpreted to form the metamorphosed and recrystallized base of the layered gabbros and metagabbros of Unit 6 (Figure 2). The rocks generally appear as dark to buff amphibolites in which layering is often strikingly well preserved (Plate 5), and show variation in composition from ultramafic to leucoamphibolite and meta-anorthosite. Layering is invariably concordant with foliation and dips at shallow angles to the south and southwest. Well developed and clearly exposed layering is present on the shores of Grand Lake. To the south, and presumably upward in the structural pile, the amphibolites are more massive and pass gradationally into the metagabbros of Unit 6b.

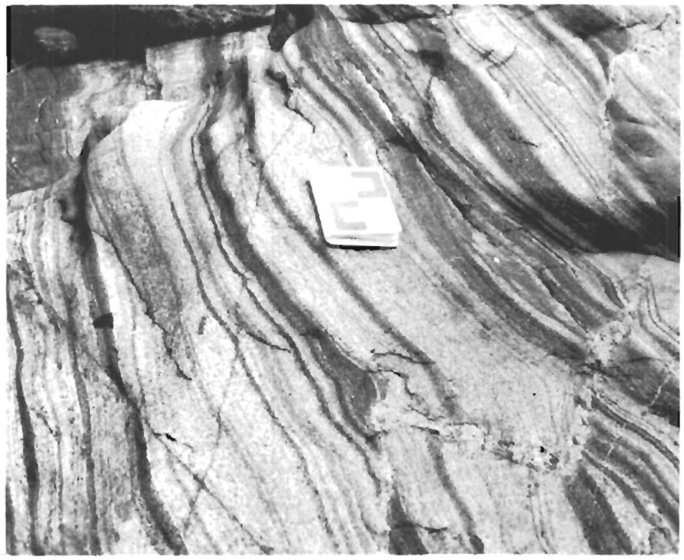

Plate 5: *Layered amphibolite - leucoamphibolite of Unit 6a.*

Unit 6a comprises the general assemblage plagioclase + clinopyroxene + magnetite + hornblende ± garnet ± biotite ± quartz. Orthopyroxene has not been observed in any part of the unit, in contrast to the amphibolite - mafic granulite rocks of Unit 5. Clinopyroxene, probably diopsidic, is clearly of metamorphic origin and is unstable with respect to hornblende.

Contact relationships with underlying Unit 5 are, as discussed above, unexposed. Ryan et al. (1982) described thick dikes of metagabbro-amphibolite which intrude the allochthonous granitoid gneisses at the base of the western part of the allochthon. The metagabbros are apparently related to the gabbro-anorthosite suite and crosscut gneissic banding within the gneisses, indicating that intrusion of this suite followed the principal period of deformation and metamorphism in the basement (Unit 2) gneisses.

Unit 6b: Interlayered gabbro, leucogabbro and minor anorthosite

This unit structurally overlies Unit 6a. The metagabbros are distinguished from the amphibolites of 6a on the basis of preservation of relict igneous texture and lack of the strong foliation characteristic of the amphibolites.

The metagabbros show a considerable compositional range from coarse grained leucogabbros and very rare anorthosite, to medium grained gabbros and more rarely to thin ultramafic bands. The most prevalent rock type is dark, massive to weakly foliated, medium grained gabbro. Layering, generally dipping shallowly to the southwest, is usually developed on a scale of metres and is less striking than in the amphibolites of Unit 6a. The metagabbros generally retain partial igneous mineral assemblages, *viz.* plagioclase + orthopyroxene + clinopyroxene. These have been largely recrystallized on the microscopic scale, with development of green hornblende rims around pyroxene, and growth of minor garnet in grain interstices.

The metagabbros at one locality on the Cape Caribou River are intruded by an irregular system of white granite sheets which predate the single Grenvillian(?) fabric present in these rocks. They may be genetically related to the granite sheets of Unit 5.

Unit 7: Massive, coarse grained anorthosite

The anorthosite forms the core and the highest structural level of the Cape Caribou River allochthon (Figures 1 and 2). The unit is largely composed of coarse grained, white to gray anorthosite-leucogabbro with a mafic content of less than 35 percent. Large labradorite crystals (1 to 4 cm long) are typical and locally range up to 50 cm in length. Orthopyroxene forms interstitial plates, usually intergrown with magnetite and/or ilmenite, but also occurs as discrete giant crystals which range up to 50 cm in diameter. These giant crystals usually interfinger at their margins with tabular plagioclase crystals of the host anorthosite, and appear to be intercumulus.

The anorthosite is largely homogeneous and layering is usually seen only as a local ribbing produced by differential weathering. Rhythmic compositional layering is locally found around the margins of the anorthosite (Plate 6) where it grades into gabbro of Unit 6b. Where sufficiently well exposed, layering indicates the unit to be right way up.

A pervasive plagioclase-pyroxene mineral lamination is found in many parts of the anorthosite and is of primary origin. The lamination is parallel to layering and dips moderately to the west and southwest.

In thin section the anorthosite is seen to largely retain igneous texture in the form of cumulate plagioclase with interstitial intergrowths of orthopyroxene, clinopyroxene and Fe Ti oxides. Pyroxene is partly rimmed by green hornblende and in some samples has also developed partial garnet coronas.

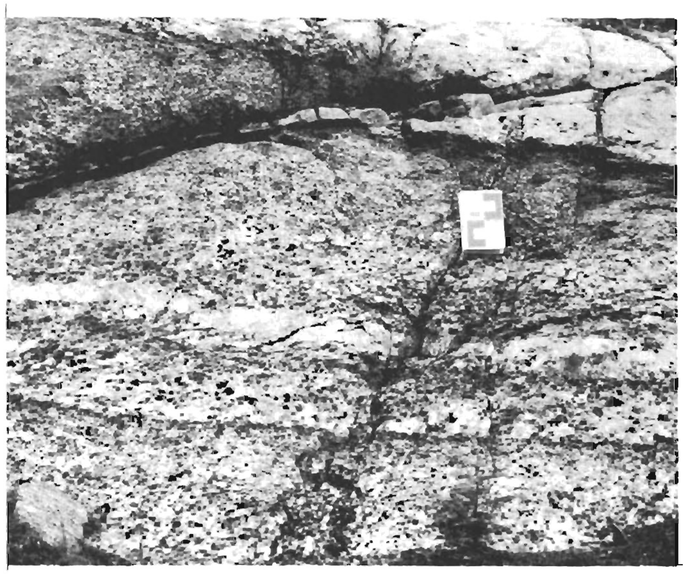

Plate 6: *Rhythmic leucogabbro-anorthosite layering in Unit 7 anorthosite.*

The pyroxenes are also internally recrystallized, and clinopyroxenes typically contain internal trains of hypersthene grains which probably developed by recrystallization of exsolution lamellae in a primary augitic pyroxene.

The anorthosite is intruded by several rectilinear mafic dikes which may be far more numerous than indicated by available outcrop. These have predominant northwest strikes, although it is evident in some outcrops that at least two dike sets are present. The dikes locally retain chilled margins but have been internally recrystallized to microcrystalline aggregates of plagioclase, garnet, green hornblende, magnetite and clinopyroxene. An oblique or wall-parallel fabric is locally developed within the dikes, but otherwise mineral fabrics are isotropic.

A variety of pretectonic granitoid dikes and sheets ranging from white tonalite to pink granite, monzonite and pegmatite intrude the anorthosite and the mafic dikes. These may be related to a suite of granites which intrude the western part of the Cape Caribou River allochthon (Ryan et al., 1982) (Figure 1).

The contact of the anorthosite with the structurally underlying metagabbros is gradational and interlayered over a distance of about 1 km.

The age of the anorthosite and its associated gabbros is constrained only by the 1650 Ma of deformation in the Unit 2 gneisses and the 1000 Ma age of the Grenvillian Orogeny. The typical anorthosite event in Labrador, termed the Elsonian event (Emslie, 1978), occurred around 1450 Ma. However, Emslie (1978) established a minimum age for the nearby Mealy Mountains anorthosite of 1640 Ma (based on Rb-Sr and U-Pb zircon ages for monzonites intruding the anorthosite).

Structural Development

The dominant structural feature of the area is the Cape Caribou River thrust which conveniently divides the area into two major structural domains: a northeastern gneiss domain, which may again be internally subdivided by the northeast trending thrust; and a southeastern domain represented by the Cape Caribou River allochthon.

Northeastern Gneiss Domain

This comprises the metasedimentary gneisses of Unit 1, the extensive granitoid gneisses of Unit 2 and the minor granitoid intrusives of Units 3 and 4. Structural trends within the domain are variable with dips varying from steep to shallow to the south, southeast and southwest. Superimposed upon the gneissic and migmatitic fabrics are a number of ductile shear zones of northeast trend. The most important of these follows a major negative aeromagnetic lineament (Figure 2) and is interpreted to form the southwestern extension of a major thrust - ductile shear zone which has been mapped in the area to the northeast by Erdmer (1983). The thrust is only locally exposed within the map area, and is characterized by flaggy schistose and mylonitic gneisses with shallow southeasterly dips and southeast plunging mineral lineations. Based on comparisons with other areas of thrusting in the northern Grenville Province (e.g. Thomas, 1981) the age of the thrust is assumed to be Grenvillian, although this is by no means certain. It was apparently overridden by the Cape Caribou River allochthon (Figure 2).

In the southwestern part of the domain, the gneissic fabrics were reoriented into the northwesterly structural trends associated with the basal thrust zone of the Cape Caribou River allochthon. Adjacent to this thrust, the gneisses were strongly straightened and overprinted by mylonitic ductile shear zone fabrics (Plate 7). In general, however, the degree of mylonitization is far less than that present in the upper thrust plate. Both reoriented gneissic fabrics and superimposed shear fabrics dip at shallow to moderate angles to the southwest. Fabrics in the southeastern part of thrust generally have steeper attitudes (40 to 60°) than those in the northwest near the nose of the lobate thrust (10 to 20°).

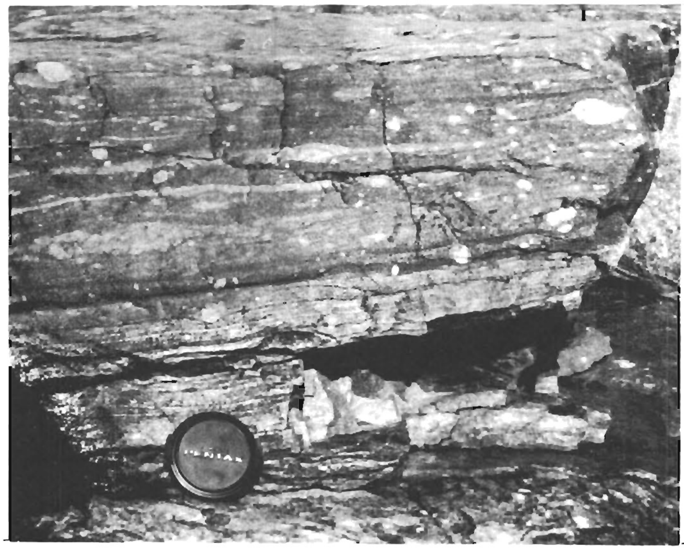

Plate 7: *Augen mylonite derived from granitoid gneisses, Unit 1. Associated with Cape Caribou River thrust zone.*

The foliation geometry of the northeast domain is summarized in the stereonet plot (Figure 3a). The diagram shows two maxima which indicate northeast structural trends, with moderate to shallow southeasterly and northwesterly dips. The opposing dips are probably related to folding about gently northeast plunging folds with northeast trending axial traces. The spread of points in the northeast quadrant of the diagram is attributed to refolding of these foliations into southwesterly dipping attitudes. This occurred primarily in association with development of the Cape Caribou River allochthon.

Also associated with structural reorientation are zones of second phase (F_2) folding. In general these folds are tight to isoclinal in style, are reclined to the northeast, and plunge moderately to the southeast or west. Their axial planes are generally coplanar with reoriented gneissic fabrics and are locally associated with second phase (S_2) biotite fabrics. These minor structures are not shown on the Figure 2.

A pervasive feature of the overthrust zone is the development of a strong mineral lineation (Figure 2), plunging southeast between 0° and 40°. The lineation and fold vergence, taken together, indicate tectonic transport on the Cape Caribou River thrust to have been to the northwest at 320°. Lineations for the northeast domain are summarized in Figure 3c. The predominant southeasterly plunging lineations were partly refolded by F_3 folding into shallow northwest plunging lineations.

A late period of open folding about north-south subhorizontal axes affected the rocks in the vicinity of the Cape Caribou River thrust. These folds (not shown in Figure 2), which are generally only discernible in the Grand Lake shoreline exposure, have variable shallow plunge directions to both north and south, and produced periclinal undulations of earlier fabrics. This period of folding is probably responsible for the local north dipping attitude of foliations and north plunging lineations seen north of Grand Lake.

Cape Caribou River Allochthon Domain

Much of the deformation associated with the development and translation of the allochthon was taken up within the amphibolites and granites of Unit 5. These rocks are highly straightened, thoroughly mylonitic with pronounced ribbon quartz fabrics, and possess strong southeast plunging mineral lineations. Isolated, rootless isoclinal fold closures have been noted indicating that the regular layered appearance of Unit 5 probably represents an extremely high strain state.

The amphibolites of Unit 6a are strongly foliated and deformed into numerous tight to isoclinal folds reclined to the north. These are readily seen from the air on the cliffs of Cape Caribou.

Penetrative deformation dies out upward into the gabbro-anorthosite suite rocks and, in the upper levels of the allochthon, is restricted to thin isolated brittle shear zones of irregular trend, and pervasive fracturing and granulation.

Foliation attitudes within the allochthon are summarized in Figure 3b. The diagram shows a partial girdle of northwest-southeast strike which is consistent with the shallow to moderate easterly, southerly and southwesterly dips seen in the allochthon. The easterly dips are due to readings taken from the nose region of the allochthon west of the map area. Two subsidiary girdles have been superimposed upon the principal girdle; a well defined northeast-southwest one, and a less well defined north-south one. Both are interpreted as the result of late periclinal refolding, largely about northwest-southeast trending axes. This fold episode is correlated with the similar F_3 folds seen in the northeastern domain.

Lineation directions within the allochthon are summarized in Figure 3d. Again these have been affected by F_3 refolding. Overall lineation directions are very similar to those of the northeastern structural domain, as shown by the combined lineation plot (3e) for the two domains.

The development of the Cape Caribou River allochthon and its associated structures is, at present, assumed to be a Grenvillian event, by analogy with most of the other north directed thrusting along the northern margin of the Grenville Province.

Post-Grenvillian Structures

A series of northeast trending lineaments is apparent on aerial photographs of the North West River area (see also Figure 2). Some of these may be associated with development of the northeast trending thrust and ductile shear zone structures; however, the majority appear to crosscut these earlier structures. Significantly the bluffs which mark the abutment of bedrock against the Pleistocene drift of the Lake Melville lowlands also follow a partial northeast topographic trend (Figure 2) and may be locally fault-controlled. The general trend of both lineaments and interpreted faults is parallel to that of the late Precambrian - early Paleozoic Lake Melville graben system (Kindle, 1924; Erdmer, 1983) which is locally floored by the Upper Precambrian - lower Paleozoic Double Mer Formation sandstones. By inference it is proposed that the prominent lineaments of the map area are fracture-controlled and related to this period of crustal extension. It is also conceivable that the faults (which are interpreted to control the eastern exposures of Precambrian crystalline bedrock against the Lake Melville lowlands) are graben boundary faults which dropped Upper Precambrian - lower Paleozoic sedimentary rocks down against the crystalline rocks. In this model, the Pleistocene-covered Lake Melville lowlands around North West River and Lake Melville could be underlain at depth by rocks broadly equivalent to the Double Mer Formation.

Metamorphic Development

Northeastern Gneiss Domain

Metamorphic assemblages in the metasedimentary gneisses of Unit 1 show a transition from the assemblage kyanite + K-feldspar + quartz + plagioclase + biotite + magnetite ± garnet in the north to one similar, but with sillimanite rather than kyanite, near the northeast trending thrust which transects the domain. Kyanite + K-feldspar are present in stable association with melt phases indicated by the

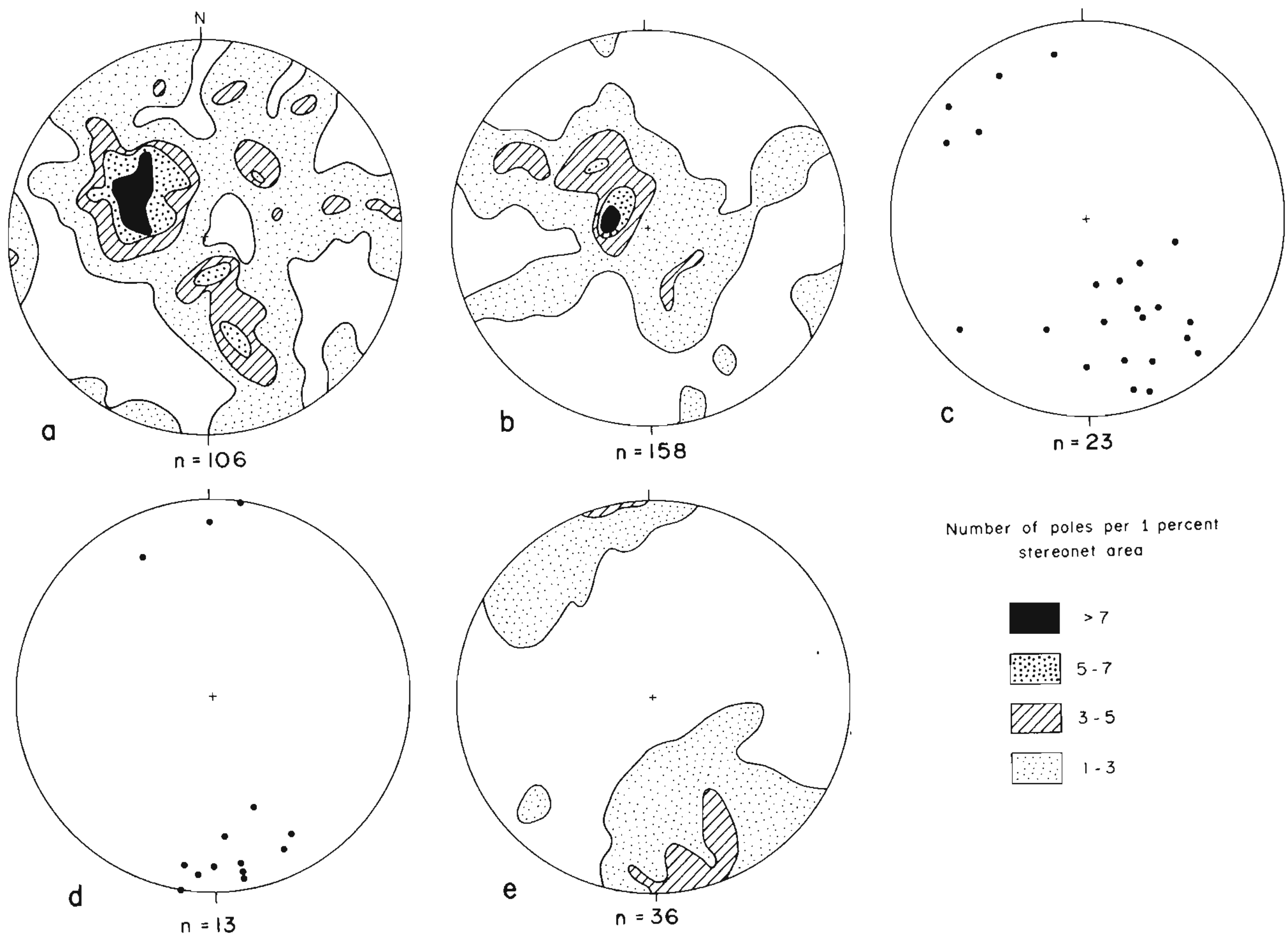

Figure 3: *Stereonet plots, poles to foliation: lineations*
3a - *northeastern (autochthonous) structural domain;*
3b - *Cape Caribou River allochthon;*
3c - *lineations, northeastern (autochthonous) structural domain;*
3d - *lineations, Cape Caribou River allochthon;*
3e - *combined lineations, Cape Caribou River allochthon and northeastern structural domain.*

migmatite textures and represent an extremely high pressure - high temperature assemblage of approximately 7 kb, 650°C (Carmichael, 1978). Erdmer *(in preparation)* has determined PT conditions of 8.5 - 9.0 kb at 700°C for rocks similar to these northeast of the map area. The southerly transition to a sillimanite-bearing assemblage may reflect either an isobaric increase in temperature, or a transition to lower pressures. Erdmer *(in preparation)* has calculated higher metamorphic temperatures (660° - 890°C) for rocks south of the thrust in the region to the northeast of the map area. There are no independent pressure estimates available.

Metamorphic assemblages in the granitoid gneisses generally indicate amphibolite facies conditions. However relict orthopyroxene in rocks south of Grand Lake and in Unit 2a indicates that at least the southern part of the granitoid gneisses were subject to granulite grade metamorphism. In the northeastern part of the granitoid gneisses, epidote is a stable component of the paragenesis in association with hornblende, garnet and biotite.

Peak metamorphic conditions in both metasedimentary and granitoid gneisses are believed to have been attained in the circa 1650 Ma event. This is indicated by both the U-Pb zircon date of Krogh (written communication, 1983) which shows very little evidence of a post-1650 Ma disturbance, and by the late mafic dikes (described under Unit 2) which crosscut a gneissic banding that must be pre-Grenvillian in age. Ductile shearing associated with development of the Cape Caribou River allochthon was associated with the development of second biotite fabrics in granitoid gneisses, and hornblende-garnet fabrics in mafic rocks. Ductile shearing also produced widespread late muscovite growth in the metasedimentary gneisses.

<u>Cape Caribou River Allochthon</u>

Metamorphism associated with development of this structure was concentrated in the basal part of the allochthon, in Unit 5. The presence of orthopyroxene + clinopyroxene + hornblende + garnet assemblages in this unit, in both mafic and granitic components, is diagnostic of granulite facies conditions. It is possible that the granulite mineralogy was developed prior to thrusting, possibly as a contact aureole effect under the gabbro-anorthosite suite. However it is also apparent that these granulite assemblages remained stable during what must have been a largely anhydrous thrust - ductile shear regime. Ryan et al. (1982) also described granulite facies assemblages from mylonitic granitoid gneisses at the base of the western part of the allochthon.

Metamorphic assemblages in the amphibolites of Unit 6a and the metagabbros of Unit 6 are characterized by plagioclase + clinopyroxene (diopside) + hornblende assemblages. Clinopyroxene, probably derived by recrystallization of igneous pyroxene, was only locally hydrated to hornblende, also suggesting a largely anhydrous deformation and recrystallization. Primary orthopyroxene is only found in the less deformed gabbros; elsewhere it recrystallized to clinopyroxene + hornblende.

The anorthosite of Unit 7 has largely retained its igneous mineralogy. Pyroxene developed thin partial garnet coronas in what may have been either a cooling or a metamorphic reaction with plagioclase. However, the dominant metamorphic effect was the development of thin hornblende and biotite rims around pyroxene grains.

The lack of well developed clinopyroxene, garnet or spinel corona textures in the gabbro-anorthosite suite is very noticeable and contrasts with other gabbroid suites present in the northern part of the Grenville Province (see Emslie, 1983; Wardle, in preparation; Rivers, 1983). This probably indicates that the gabbro-anorthosite rocks of the Cape Caribou River allochthon never experienced the very deep burial conditions (greater than 6-9.5 kb), generally considered necessary to produce these assemblages (e.g. Griffin and Heier, 1969).

It is presumed that development of peak metamorphic assemblages within the Cape Caribou River allochthon was a Grenvillian event, although as noted above some of the granulite mineralogy within the base of the allochthon may be pre-Grenville.

Brittle movement along both the Cape Caribou River thrust and the northeast trending thrust followed the main period of ductile shearing and was associated with low grade chlorite-epidote-muscovite retrogressive alteration.

Mineralization

The anorthosite (Unit 7) contains abundant magnetite and some ilmenite, usually intergrown with pyroxene; however, large concentrations have not been seen. The interior parts of the anorthosite locally contain iridescent labradorite (Figure 2) and may have potential for building or facing stone. However the pervasive fracturing and granulation probably detract from this potential.

Small showings of fluorite have also been found associated with sheared granite veins within the anorthosite (Figure 2). Fluorite occurs largely as a thin veneer on joint and fracture surfaces.

Pegmatites within the metasedimentary gneisses of Unit 2 locally contain concentrations (10 to 30 percent) of a gray metallic mineral tentatively identified as ilmenite. In the best locality, a small tongue of gneiss south of the main metasedimentary gneiss belt (Figure 2), the mineralization extends over an area of at least 40 m^2.

Summary and Discussion

The early history of the map area is recorded in the northeastern part of the area where a gneiss terrane composed of metasedimentary and granitoid gneisses experienced a major pre-Grenvillian event of high grade metamorphism and deformation. The available isotopic data suggest that this occurred circa 1650 Ma. The possibility must also be considered that the terrane has an even older crustal history, although this has yet to be confirmed by isotopic dating.

The northeastern domain is dissected by a thrust which continues for over 50 km to the northeast to where it is hidden under Lake Melville. Gower (1983, 1984) and Erdmer (1983) have noted that this thrust separates a southern terrane (Lake Melville terrane), characterized by an abundance of megacrystic granites, sillimanite-bearing metasedimentary gneisses, and local granulite facies domains, from a northern terrane (Groswater Bay terrane) characterized by a prevalence of epidote-bearing granitoid gneisses, and kyanite-bearing metasedimentary gneisses.

To a limited extent these differences are also recognized within the North West River area. Small amounts of megacrystic granitoid and granulite facies rocks are found south of the northeast trending thrust, termed the Rigolet thrust zone by Gower and Owen *(in preparation)*, whereas kyanite-bearing metasedimentary gneisses and epidote-bearing granitoid assemblages are found north of it. There is also a transition from kyanite- to sillimanite-bearing assemblages towards the thrust suggesting that, if metasedimentary gneiss were exposed, sillimanite-bearing assemblages might also be found south of the thrust. In other respects, however, the granitoid gneiss shows very little compositional or structural change across the thrust and it appears that the main effect of thrusting has been to juxtapose high temperature (Erdmer, *in preparation)* assemblages in the south against lower temperature - high pressure assemblages in the north.

The thrust is presumed to have developed during the Grenville Orogeny and was associated with north-northwesterly directed structural translation. It was then overridden by another Grenvillian thrust structure, the lobate Cape Caribou River allochthon, which was translated in a similar direction.

The upper part of the allochthon comprises anorthosite which passes down through gabbros into layered metagabbros and amphibolites. The basal part of the allochthon is an enigmatic unit consisting of mylonitized amphibolite and mafic granulite, proposed to be a basal part of the gabbro-anorthosite suite sheeted by granite. The unit is thought to represent the basal contact zone of the gabbro-anorthosite suite but the possibility cannot be ignored that it forms part of the basement.

Granulite facies assemblages in the basal part of the allochthon remained stable during overthrusting and mylonitization, indicating largely anhydrous conditions of metamorphism.

Following the Grenvillian Orogeny the area was stabilized and, in the late Precambrian, subject to an episode of extensional tectonism associated with development of the Lake Melville graben. It is speculated that the Pleistocene-covered expanse of the Lake Melville lowlands may represent a part of the graben floor and be underlain at depth by Upper Precambrian - lower Paleozoic sedimentary rocks.

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