GEOLOGY OF THE LAC GHYVELDE - LAC LONG AREA, GRENVILLE PROVINCE, LABRADOR AND QUEBEC

by

A. Thomas, N. Culshaw[1], G. Mannard[2] and J.G. Whelan
Labrador Mapping Section

Also in *Current Research*, Part A, Geological Survey of Canada, Paper 84-1A.

Abstract

Continuing studies of Precambrian granitoid and gneiss rocks belonging to the Grenville Structural Province in central and south-central Labrador yield evidence of a major Paleohelikian orogenic event. A crustal block in the northern part of the map area comprises mainly polydeformed, granulite facies, quartzofeldspathic paragneiss which contains the mineral assemblage hypersthene, sillimanite, quartz, K-feldspar, sapphirine, and can be traced continuously into equivalent gneiss of known Paleohelikian age. Several gabbronorite and charnockite bodies are also present in the southwest portion of this block.

Granulite facies tonalite to quartz tonalite gneiss having the mineral assemblage orthopyroxene, clinopyroxene, garnet, quartz and feldspar was intruded by a body of porphyritic granodiorite-granite, parts of which were subsequently tectonized to augen gneiss and banded orthogneiss. Together these two units define a distinct crustal block covering much of the southern part of the area. Anorthosite and related gabbronoritic to charnockitic rocks of unknown age intrude both granodiorite-granite of the southern block and gabbronorite-charnockite of the northern block. The two blocks are juxtaposed along a major structure, the Lac Long lineament, which traverses the entire map area from east to west and represents a fundamental lithotectonic break of Grenvillian(?) age.

Introduction

This report summarizes work carried out during the second year of a two-year project focusing on 1:100,000 scale mapping of crystalline rocks within the Grenville Structural Province of south-central Labrador. The project was initiated for three reasons: (1) to continue studies started in 1978, with particular emphasis on age and geological history of gneisses and granitoids in the Grenville Province; (2) to provide a much needed geological and geochemical data base for the sparsely mapped rocks of southern and central Labrador; and (3) to examine the bedrock mineral potential within this part of the Grenville Province.

The area covered encompasses N.T.S. 1:50,000 sheets 13D/11, 12, 13 and 14 contained within the boundaries 63°00' to 64°00' west longitude and 52°30' to 53°00' north latitude (Figure 1). It is a southward extension of the area mapped in 1982 and outlined in Thomas and Wood (1983). Part of the region north and west of Lac Long is in the province of Quebec and was mapped by N. Culshaw of the Geological Survey of Canada. The center of the map area is approximately 100 km south of the town of Churchill Falls, Labrador, and access is by float-equipped fixed wing aircraft or helicopter.

Relatively little previous work has been done in the region besides a 1:250,000 scale reconnaissance project carried out by Stevenson (1969) as well as some regional and detailed mapping by BRINEX (Pyke, 1956). Thomas and Wood (1983) provide references to previous work on adjacent map areas to the north.

Regional Setting

The Lac Ghyvelde - Lac Long area comprises a granulite grade terrain of paragneiss, tonalite gneiss, noritic and charnockitic igneous rocks along with their gneissose equivalents, metamorphosed granitoids and anorthosite. Beyond the map area, to the north and northwest, is a lowland terrain consisting of amphibolite

---

Contribution to Canada-Newfoundland co-operative minerals program 1982-84. Project financed by the Geological Survey of Canada.

1 Geological Survey of Canada, 601 Booth Street, Ottawa, Ontario K1A 0E8.

2 Department of Geology, McGill University, Montreal, P.O.

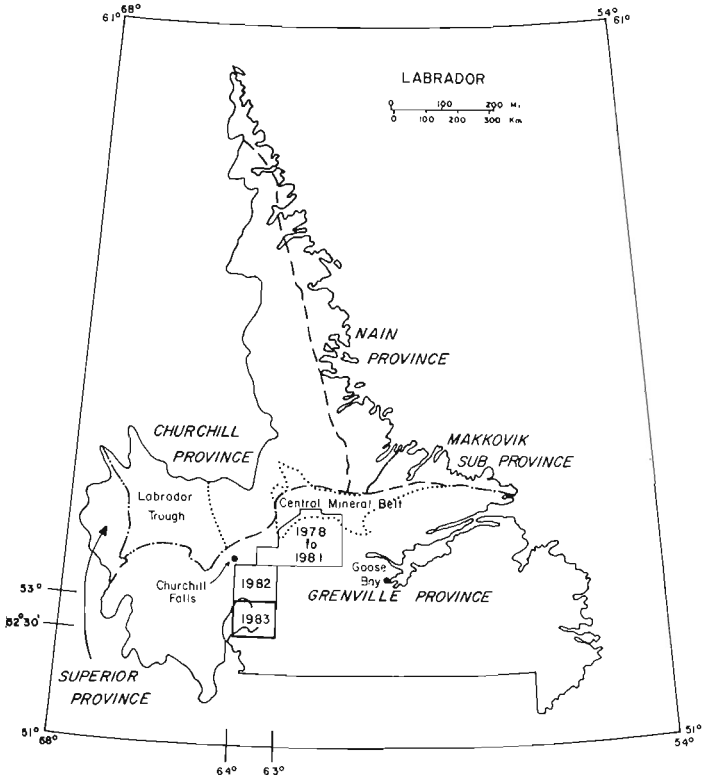

Figure 1: *Location of present and previous map areas in central and south-central Labrador (structural province divisions after Taylor, 1971).*

grade para- and orthogneisses as well as deformed granitoids. Within the northern half of the map area is a highland plateau underlain almost entirely by paragneiss which can be traced north through the southern part of the area mapped in 1982 by Thomas and Wood (1983), and thence continuously northeastward for almost 200 km into the Red Wine Mountains granulite massif. To the west, a poorly exposed, boggy lowland terrain is underlain by a mixed assemblage of paragneiss, anorthositic to gabbroic rocks and metabasics (Nunn et al., 1984).

To the southwest, a large body of anorthosite forms a range of high, barren hills. Part of this body becomes a narrow, northeasterly trending tongue which protrudes into the southwestern part of the map area. South and southeast of the map area, another poorly exposed lowland region contains a mixture of little metamorphosed gabbroic to granitic rocks as well as amphibolite grade paragneisses.

The region east of and directly adjacent to the map area can be divided into a highland plateau and extensively drift-covered lowlands. The plateau is a continuation of the one found in the northern part of the Lac Ghyvelde - Lac Long area, and is underlain by the same granulite grade paragneiss. The poorly exposed lowlands again comprise a mixed granitoid - amphibolite gneiss terrain, similar to that south of the map area.

All rocks within this part of Labrador are polydeformed and underwent an extensive and complex geological history involving at least two distinct orogenic events at circa 1650 Ma and 1000 Ma.

General Geology

Six major and three minor lithological types have been defined (Figure 2). Granulite grade tonalite to quartz tonalite gneiss (unit 1) is presently thought to be the oldest unit in the area. The gneiss is confined to a rugged highland, which comprises the southern one-third of the map area, and does not outcrop anywhere north of Lac Long. This rock type has not been observed previously in central Labrador, and may represent ancient basement remnants.

The most widespread rock type is quartzofeldspathic paragneiss (unit 2), which is well exposed in a barren upland plateau comprising the entire northern half of the map area. The bulk of the gneiss underwent granulite facies metamorphism (unit 2a), with small local patches having only reached or else been retrograded to amphibolite grade (unit 2b). There are no compositional or structural differences between the two variants of gneiss; subdivision of the unit is based solely on mineralogical contrasts. Quartzofeldspathic paragneiss is correlated with Hope Lake gneiss of Emslie et al. (1978), Thomas (1981), and Thomas et al. (1981). Exposures of the gneiss can be traced continuously from the type locality at Hope Lake into the area of this study.

Strongly foliated to gneissic porphyritic granodiorite and granite (unit 5) outcrop extensively with tonalite gneiss in the southern highland, as well as in and along the southern edge of the fault-controlled glacial spillway within which Lac Long is situated. The granitoids along the spillway form a 5 to 15 km wide east trending belt which completely transects the map area, separating tonalite gneiss in the south from quartzofeldspathic gneiss, gabbroids and charnockitic granitoids in the north. Correlation of these granitoids with those of the North Pole Brook Intrusive Suite (see Thomas, 1981; Thomas et al., 1981) and its equivalents to the north of the map area (see Thomas and Wood, 1983) is being considered at this time.

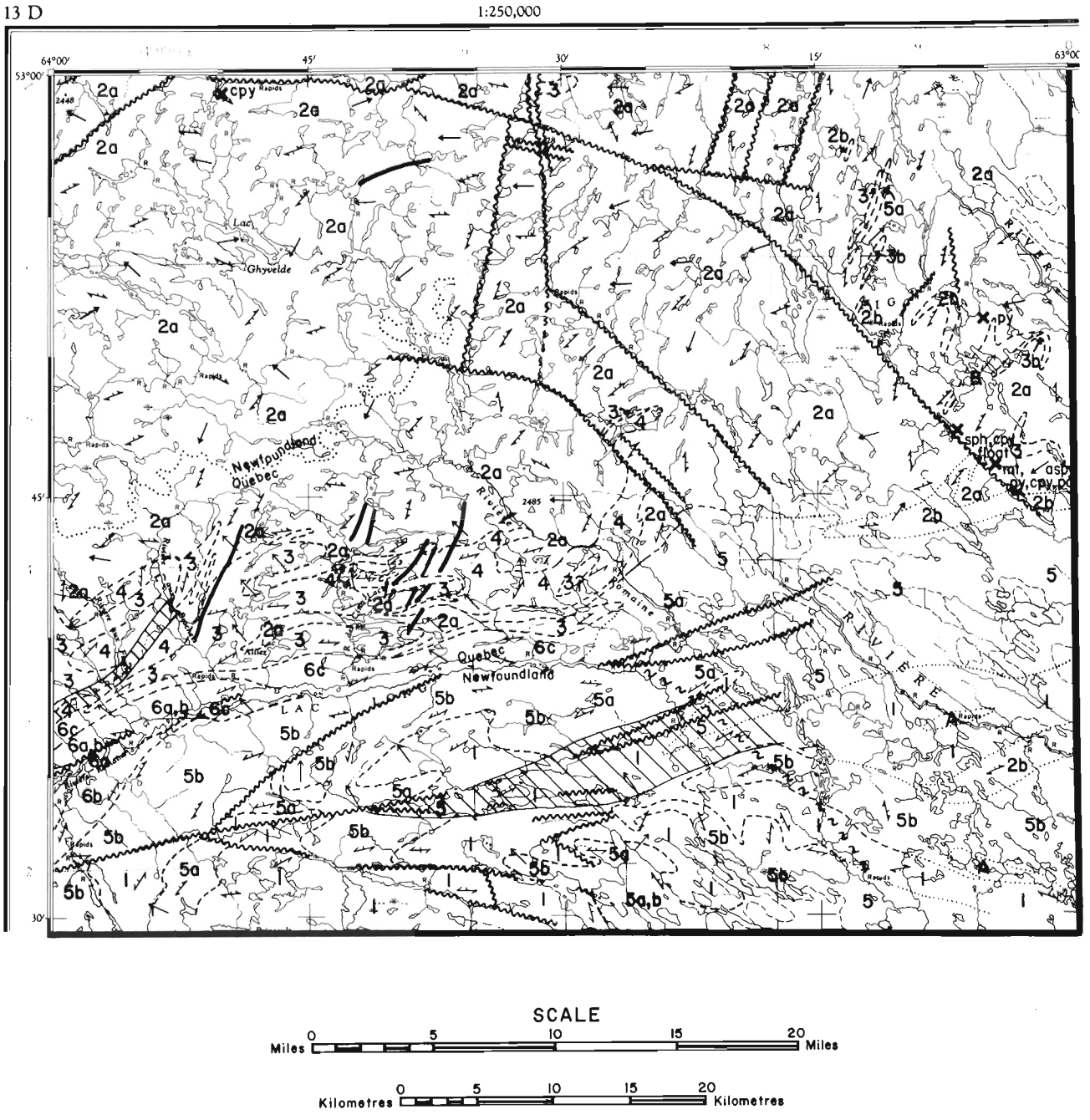

Figure 2: *Geology of the Lac Ghyvelde - Lac Long area, Labrador and Quebec.*

LEGEND

GRENVILLIAN OROGENY

LATE HUDSONIAN TO PRE-ELSONIAN OROGENY

NEOHELIKIAN?

DIABASE.

AGE RELATIONSHIP AND AFFINITY UNCERTAIN

B — DIORITE/QUARTZ DIORITE: Equigranular, moderately to strongly recrystallized, exhibiting relict igneous texture.

A — GABBRONORITE: Fresh, ophitic igneous texture predominates (possible Shabogamo Gabbro).

PALEOHELIKIAN

6 — ANORTHOSITE SUITE: 6a, Anorthosite, leucogabbro, monzogabbro; 6b, leuconorite/gabbronorite; 6c, charnockitic monzonite.

PALEOHELIKIAN and/or EARLIER

5 — GRANODIORITE/GRANITE: 5a, Strongly foliated to augen textured porphyritic granodiorite/granite; 5b, granodiorite/granite orthogneiss.

4 — MEGACRYSTIC CHARNOCKITIC GRANITE.

3 — GABBRONORITE, includes several small pyroxene-rich ultramafic and ultramafic gneiss bodies (3b).

2 — PARAGNEISS: 2a, Pink to grey, banded hypersthene-sillimanite-biotite ± sapphirine granulite grade quartzofeldspathic gneiss; 2b, pink to white, banded sillimanite-biotite ± muscovite ± garnet amphibolite grade quartzofeldspathic gneiss.

1 — TONALITE/QUARTZ TONALITE: Massive to gneissic, granulite grade.

SYMBOLS

GEOLOGICAL BOUNDARY (approximate, assumed)

GNEISSIC BANDING - FOLIATION (inclined, vertical, horizontal)

FOLIATION (inclined, vertical, horizontal)

Plunging minor fold axes and mineral stretching lineations associated with earlier fold structures confined to the granulite grade paragneiss terrain

Plunging quartz ribbon, mineral stretching and intersection lineations associated with later fault structures, shearing, mylonitization and gneiss straightened zones along the Lac Long lineament

FAULT (defined, assumed)

SHEAR ZONE

MINERAL OCCURRENCE py - pyrite, cpy - chalcopyrite, sph - sphalerite po - pyrrhotite, aspy - arsenopyrite, mt - magnetite.

A small recrystallized body of dioritic to quartz dioritic composition (unit B) is exposed near the east-central margin of the map area. It intrudes the surrounding paragneiss, but has no apparent relationship to the other granitoids, so that its age and origin are at present unknown.

Bodies of charnockitic granite (unit 4) occur with gabbronorite, as well as anorthosite and related rocks, in a 10 km wide tongue which protrudes into the west-central part of the area, along the contact zone between quartzofeldspathic gneiss of unit 2 and granitoid gneiss of unit 5. North and northwest of Lac Long, the granite both intrudes and is intertongued with gabbronorite and paragneiss. Due to similarities in lithology and geological relationships with host rocks, charnockitic granite is correlated with the monzodiorite / quartz monzonite unit of Emslie et al. (1978) as well as unit 3 of Thomas and Wood (1983).

Gabbronorite (unit 3) is present within granulite grade paragneiss as deformed and/or boudined intrusive bodies. All but two of these, located northeast of Lac Ghyvelde and near the east-central edge of the map area, are confined to the previously mentioned 10 km wide tongue. Due to similarities in mineralogy, several small, deformed, lenticular ultramafic and ultramafic gneiss bodies (unit 3b) of unknown age and origin are also included within the unit. Gabbronorite is correlated with unit 2 of Thomas and Wood (1983) and the gabbro, leuconorite, anorthosite unit of Emslie et al. (1978).

Two exposures of fresh, unmetamorphosed gabbronorite (unit A) occur in sand- and bog-covered ground in the southeastern part of the map area. These may belong to the circa 1380 Ma Shabogamo Intrusive Suite, but at present their origin is uncertain.

Anorthositic rocks (unit 6) in the southwest corner of the area have been subdivided into anorthosite and related gabbros (unit 6a), norites (unit 6b) and charnockitic monzonite (unit 6c). These rocks are part of a much larger anorthosite suite (presumably of Paleohelikian age?) which extends from the map area southwestward to Lac Fournier in eastern Quebec. They have a close spacial relationship with gabbronorite and charnockitic granite northwest of Lac Long, and are presently thought to be Paleohelikian in age.

Rare, late northeasterly trending diabase dikes cut quartzofeldspathic paragneiss, gabbroids and granitoids north of Lac Long. Their absolute age is unknown, but they are not strongly tectonized and may be late syn- or post-tectonic intrusives associated with the Grenvillian Orogeny.

Rocks within the Lac Ghyvelde - Lac Long area underwent two distinct orogenies. An earlier high grade event resulted in extensive complex folding accompanied by up to granulite grade metamorphism. A later, lower grade event is responsible for further tectonism, including folding and ductile and brittle faulting.

Tonalite - Quartz Tonalite Gneiss (Unit 1)

Rocks belonging to this unit are predominantly gneissic in character, although massive homogeneous zones of greater than outcrop scale were observed. Tonalite gneiss weathers gray to buff-white, is gray-green on fresh surface and banded in an irregular discontinuous manner. It consists of approximately 40% plagioclase, 30% pyroxene (augite and hypersthene), less than 10% quartz and garnet ± magnetite ± biotite ± minor hornblende. The rock exhibits an equigranular polygonal granoblastic texture with an average grain size of 1 to 2 mm. Garnet occurs both as subhedral to anhedral porphyroblasts or crystal aggregates up to 2 cm and as fine grained polygonal groundmass crystals. The gneiss is also characterized by particularly plagioclase-garnet-rich zones, containing abundant coarse aggregates of subhedral pyroxene crystals, possibly representative of meta-anorthositic rocks. Rounded garnet porphyroblasts ranging in size up to 10 or 12 cm are common to these meta-anorthositic rocks. Numerous relict mafic or ultramafic dikes and boudins, now consisting almost entirely of polygonal aggregates of hornblende and/or pyroxene, are present throughout the tonalite unit. Extensive reaction rims and bleached zones in the host tonalite occur at the rims of the dike relicts.

These dikes have been folded, flattened and boudinaged. Even where the tonalite is massive, the selvedge zones at their margins show complex fold interference patterns, indicating that the unit underwent pervasive deformation. In addition, cataclasis and shearing occurs sporadically along contact zones between tonalite and gneissic granodiorite of unit 5.

The mineralogy, nature and partly massive character of the tonalite gneiss suggest an igneous protolith. The gneiss has apparently had a complicated structural-metamorphic history, and its protolith may have been as old as Archean (?).

Paragneiss (Unit 2)

Granulite grade quartzofeldspathic paragneiss (unit 2a) is rusty pink to buff, with an average grain size of 1 to 4 mm, dense and extremely resistant to weathering. It is well banded, with prismatic to fibrous sillimanite, fine grained hypersthene, magnetite, minor biotite and rare sapphirine confined to melanocratic layers which pinch and swell, imparting an anastomosed appearance to the rock. Melanocratic bands vary in width up to 2 cm and commonly contain lenticular clots of densely packed aggregates of fibrolitic sillimanite, pyroxene and magnetite. Leucosome bands consist of very dense, fine to medium grained granoblastic polygonal aggregates of quartz, K-feldspar and plagioclase. These bands are tightly folded; they pinch and swell, and may be up to 5 cm wide. Black pseudotachylyte lenticles and discontinuous layers up to 1 cm wide are commonly found parallel or subparallel to melanocratic bands; pseudotachylyte veinlets in the same size range also crosscut leucosome bands. Abundant evidence of partial melting is present in the granulite paragneiss, with both layer-parallel and crosscutting quartz-feldspar sweats being common. This melting took place under dry conditions at high temperatures as evidenced by subhedral to euhedral hypersthene crystals up to 1 cm long in some of the sweats.

Amphibolite grade quartzofeldspathic paragneiss (unit 2b) is relatively uncommon, being confined to several small (less than 5 km), narrow lenses in granulite grade paragneiss and two narrow belts in tonalite - granitoid gneiss within the eastern part of the map area. It is buff-white to pink on weathered surface and consists of quartz, K-feldspar, plagioclase, sillimanite, biotite, muscovite, garnet and magnetite-ilmenite. Metamorphic differentiation is well developed with mafic minerals segregated into bands up to 0.5 cm wide, separated by 2 to 3 cm wide quartz-feldspar bands. Due to the abundance of biotite and muscovite, amphibolite grade paragneiss is less dense and more fissile than its granulite grade counterpart. Granoblastic polygonal texture predominates within the quartz-feldspar bands and is in most places medium grained.

Paragneiss is extensively tectonized, with granulite facies gneiss in particular exhibiting complex minor fold patterns including mushroom and dome and basin structures plus centimetre scale, tight, isoclinal, chevron and hook folds. The small scale fold patterns in the gneiss are identical in style to and mimic the regional scale structures. As previously mentioned (Thomas and Wood, 1983), mineralogy and chemical composition of this paragneiss unit suggest derivation from a sedimentary protolith. A U-Pb age on zircon (Krogh, written communication, 1983) from a sample of granulite grade paragneiss collected during the course of the Thomas and Wood (1983) study, although discordant, has yielded a lower intercept age of 1676 Ma. This date probably represents the age of granulite grade metamorphism of the gneiss and therefore gives a minimum age for deposition of the protolith.

Gabbronorite (Unit 3)

The bulk of the gabbronorite unit comprises norite, two-pyroxene gabbro and two-pyroxene metagabbroic gneiss to metabasite. Additional but less voluminous associated lithotypes included within this unit are noritic gneiss, pyroxene-magnetite gabbro, pyroxene-olivine gabbro, ultramafics and ultramafic gneiss.

Norite is generally massive, and ranges from a medium grained variety with well developed subophitic texture, to a rock with cumulophyric orthopyroxene. These may reach sizes of 5 cm and be spectacularly kinked. Patches of coarse gabbroic pegmatite are also commonly found in norite. Plagioclase and orthopyroxene are subequal, with Fe-Ti oxides as accessories. Although primary igneous textures are discernible in this rock, plagioclase may be partly or wholly recrystallized into polygonal aggregates.

Two-pyroxene gabbro is medium grained and equigranular, with plagioclase partly recrystallized. With increased orthopyroxene content, this rock grades into norite.

Two-pyroxene metagabbroic gneiss / metabasite is the most common of the gabbroic rocks. In general it is uniform, massive and exhibits a very fine grained, equigranular, polygonal, granoblastic metamorphic texture. In some localities there is a sparsely developed granitic veining which on erosion surfaces appears to be smeared out into the regional stretching direction. Also present are charnockitic granite dikes.

Noritic gneiss is derived from the norite and is found interspersed with gabbroic gneiss. It is equigranular, medium to fine grained with a polygonal metamorphic texture. Compositional heterogeneities locally form a discontinuous layering, in some places deformed into intrafolial isoclinal folds.

Pyroxene-magnetite gabbro is found only in association with norites along the

northern margin of the aforementioned 10 km wide tongue, and consists of medium to fine grained equigranular rocks in which Fe-Ti oxides are of greater or equal abundance to clinopyroxene.

Pyroxene-olivine gabbro underlies several small hills to the west of the lower reaches of Riviere aux Brochets. It is a uniform massive rock of high color index, containing medium to coarse pyroxene and olivine(?).

Rocks within the ultramafic and ultramafic gneiss bodies (unit 3b) are similar in character to the gabbronoritic rocks, but are composed almost completely of pyroxene with little or no plagioclase.

The lithotypes in the gabbronorite unit are correlated with identical rocks found in the Red Wine Mountains, northeast of the Lac Ghyvelde - Lac Long area by Emslie et al. (1978) and Thomas et al. (1981).

Megacrystic Charnockitic Granite (Unit 4)

Charnockitic granite is a weakly foliated megacrystic rock which weathers a rusty buff color. Large (up to 4 cm) unrecrystallized K-feldspar megacrysts are set in a matrix of medium grained plagioclase. Quartz content averages between 15 and 20%, but may be as high as 30%. Mafic minerals, which comprise no more than 10% of the rock, include orthopyroxene, Fe-Ti oxides and a fine felted biotite which is thought to have replaced orthopyroxene. Non-megacrystic granite, as well as pink and gray amphibolite facies metagranitoids, are found locally within charnockitic granite. The amphibolite facies granitoids exhibit a strong LS fabric associated with the development of a straight belt north and northeast of Lac Long which is discussed in more detail later.

Granodiorite - Granite (Unit 5)

Rocks of granodioritic to granitic composition have a much greater areal extent than the charnockitic granitoids, with two textural varieties evident. Porphyritic granodiorite to granite (unit 5a) is strongly foliated, and commonly, though not everywhere, phenocrysts are deformed into lenticular augen. Well developed porphyritic texture is preserved within these rocks south of both the east and west ends of Lac Long. Unit 5a rocks consist of abundant phenocrysts of microcline ranging in size from 2 to 4 cm, set in a medium grained groundmass of quartz, plagioclase, orthoclase, biotite, hornblende and minor garnet. Extremely mafic-deficient zones may be found throughout this unit. With progressive deformation, partial groundmass recrystallization and stretching of feldspar phenocrysts into lenticular augen of preferred shape orientation occurred. In the most highly deformed rocks, total recrystallization took place, resulting in the formation of orthogneiss (unit 5b) in which feldspar phenocrysts were either obliterated or combined with groundmass quartz to form quartzofeldspathic bands. Granodiorite - granite orthogneiss consists of quartz, plagioclase, orthoclase, hornblende, ubiquitous red garnet and minor amounts of biotite. Igneous texture is completely altered to medium to coarse granoblastic polygonal texture.

The granitoid rocks of unit 5 are found as dikes in unit 1 tonalite gneiss south of Lac Long. Their relationship to quartzofeldspathic paragneiss of unit 2 is unknown as no contacts were observed between the two rock types.

Anorthosite Suite (Unit 6)

Anorthosite, leucogabbro and monzogabbro (unit 6a) constitute approximately one-third of the mass of the anorthosite suite which protrudes into the map area. These rocks are massive to foliated, locally extremely flaggy and very coarse grained. The main mineral constituent is plagioclase, usually partially or wholly recrystallized to a fine, white equigranular aggregate. Coarse (1 to 10 cm) reddish brown phenocrysts of iron-stained plagioclase are confined to monzogabbro. Mafic minerals orthopyroxene, clinopyroxene and Fe-Ti oxides, ranging in size up to 15 cm, commonly form less than 20% of the rock and usually exhibit subophitic texture with the pyroxene being coronitic. Rarely, deformed and kinked pyroxene and Fe-Ti oxide crystals in excess of 0.5 m have been observed in pegmatitic zones within some of the more leucocratic rocks.

Leuconorite and gabbronorite (unit 6b) occur along the northwest shore of Lac Long as well as west and southwest of the lake. They are igneous textured rocks that vary in weathered appearance from black to a rusty cream color. Leuconorite is coarse, leucocratic and contains 20 to 30% subequal Fe-Ti oxides and orthopyroxene. Its texture is subophitic, with the two mafic minerals being commonly segregated into a crude layering, and locally the rock being strongly deformed and recrystallized. Gabbronorite is medium grained and consists of 30 to 50% orthopyroxene, clinopyroxene and Fe-Ti oxides in a buff-white to gray plagioclase groundmass. Plagioclase laths show varying degrees of recrystallization.

Charnockitic monzonite (unit 6c) is characterized by large K-feldspar megacrysts and an abundance of Fe-Ti oxides. As a consequence of the high oxide content, the rock has a very rusty appearance and a deeply weathered, friable nature. Quartz was not found in hand sample, and the freshest feldspar megacrysts have a greenish hue suggesting charnockitic mineralogy.

Gabbronorite (Unit A)

This lithology is similar in mineralogy to the other gabbronoritic rocks but differs in two respects: (1) grain size is generally finer, and (2) igneous texture is extremely fresh with no recrystallization of plagioclase or mafic minerals apparent in the two small exposures examined.

Diorite - Quartz Diorite (Unit B)

Diorite to quartz diorite is minor in occurrence and consists of medium grained recrystallized quartz, plagioclase, hornblende, biotite and rare garnet. Although it contains relicts of the "salt and pepper" igneous texture common to diorites, the rock is thoroughly overprinted with a polygonal granoblastic texture. Patchy zones appear to approach gabbroic composition. This rock may correlate with unit 6 of Thomas and Wood (1983).

Structure

Structural data support the division into two major crustal blocks, north and south of an east-west line passing through the center of the Lac Ghyvelde - Lac Long map area (Figure 3). This line is drawn along the northern edge of a locus of faults and shear zones in the vicinity of Lac Long, informally referred to as the Lac Long lineament. The northern crustal block can be further subdivided, on the basis of changes in structural trends and fold geometry, into eastern and western parts. In this way the map area is conveniently partitioned into three domains, within each of which the style and orientation of structures is internally consistent (Figure 3). There is evidence on the scale of mapping for at least three major deformation events involving folding and for three fault sets. No attempt is made to correlate faults with deformation responsible for folding.

The Lac Long northeast domain is characterized by isoclinal folds overturned to the southeast, of which the axial planes dip steeply to the northwest. A lower hemisphere stereographic projection (Figure 3) indicates that gneissic layering and foliation, coplanar with these axial planes, strike northeast and dip predominantly northwest. F_1, F_2, and F_3 fold axes plunge at moderate angles to the southwest, F_1 and F_2 being for the most part coaxial.

Although folds within the Lac Long northwest domain do not differ in style significantly from those in the northeast domain (i.e. 3 periods of deformation with refolding of earlier folds), some differences in geometry occur. F_1 and F_2 folds are isoclinal; however F_3 folds are open. F_1 and F_2 axial planes coincident with the orientation of gneissic layering and foliation dip steeply north-northwest and south-southeast (Figure 3) on either side of vertical F_3 axial planes which strike east-northeast. There is a significant rotation of these planes with respect to their counterparts from the northeast domain, into a more westerly trend. F_1 and F_2 minor fold axes in this domain retain moderate plunges but their trends are also rotated into a predominantly westerly orientation. Note in Figure 3 that a small percentage of lineations including F_1 and F_2 minor fold axes plunge to the east.

The Lac Long south domain is characterized by isoclinal folds overturned to the south. Axial planes trend east-northeast to east and dip north-northwest. Lower hemisphere stereographic projection of gneissic banding and foliation planes indicates a northeasterly to east-northeasterly trend and steep northwest dips, with development of a fairly intense maximum (Figure 3). F_1, F_2 and F_3 minor fold axes and associated lineations are rare, but those observed suggest a westerly plunge. Most lineations present in this domain represent mineral stretching and quartz ribbons associated with the formation of the Lac Long lineament. These have moderate northwest plunges that cluster into a strong maximum (Figure 3) which contrasts sharply with that of Figure 42.7 of Thomas and Wood (1983) for rocks north of the Lac Long northern domains.

The oldest faults trend north-south and are in rocks belonging to the northeast and northwest Lac Long domains. These are terminated by arcuate, southeasterly trending faults which exhibit some degree of left-lateral offset movement and could not be traced across the Lac Long lineament. The most recent faulting recognized occurs in association with the Lac Long lineament. This is a major structure that transects the map area from east to west, and has associated with it faults, shear zones and a strong aeromagnetic expression. Faults within the southern Lac Long domain are either parallel to or occur as subparallel splays off of the lineament.

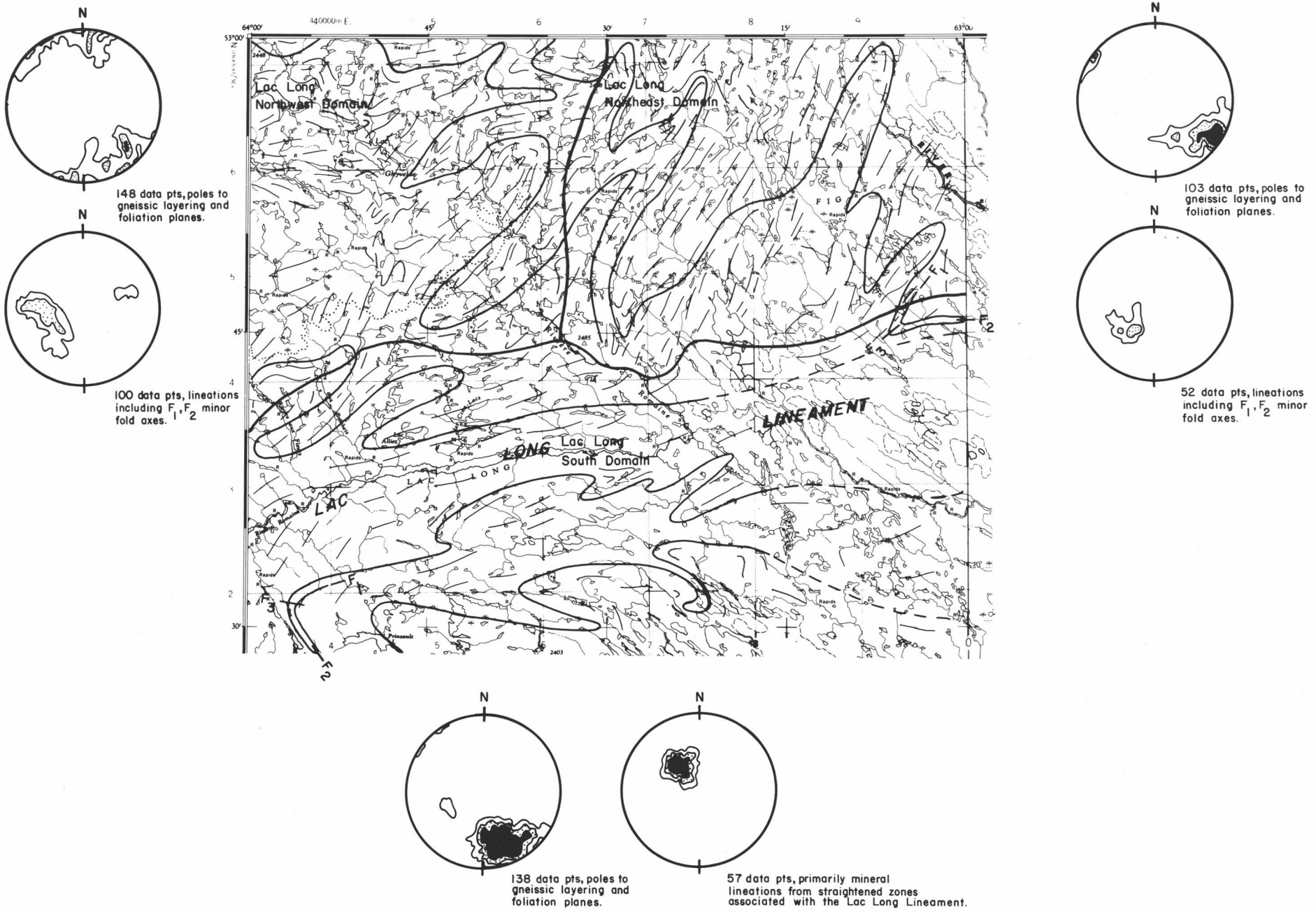

Figure 3: *Bedrock structural trends within the three domains of the Lac Ghyvelde - Lac Long map area; stereonet contour intervals 3, 6, 9 percent of points per 1 percent area of the net.*

Structures in the northern Lac Long domains are confined to quartzofeldspathic gneiss of known 1600-1700 Ma age. Structures within the Lac Long south domain occur in widely differing lithologies of unknown age. The contrasts in both lithology and structural trends between the northern and southern crustal blocks suggest that different deformational events are represented. This conclusion is supported by the presence of a straightened belt within the northwest part of the Lac Long lineament, containing strongly developed LS fabrics which postdate those in the northern block, and transposed and flattened quartzofeldspathic granulite grade gneiss. It is suggested that structures within the northern crustal block are part of an old, circa 1650 Ma, orogeny and those in the southern block represent an even older orogeny, a second pulse of the 1650 event, or a younger (Grenvillian?) orogenic event. Geochronological study of the tonalite gneiss should solve this problem.

Metamorphism

With the exception of scattered areas of the quartzofeldspathic paragneiss, local zones in charnockitic granite, diorite - quartz diorite (unit 8) and granodiorite-granite (unit 5), all rocks within the Lac Ghyvelde - Lac Long region have stable metamorphic mineral assemblages characteristic of the granulite facies.

The K-feldspar - orthopyroxene - sillimanite ± sapphirine assemblage in quartzofeldspathic paragneiss of unit 2 requires formation under dry conditions at high temperatures and pressures, as does the plagioclase - pyroxene - garnet - magnetite assemblage of the unit 1 tonalite gneiss.

Anorthositic, gabbronoritic and charnockitic rocks may have been emplaced in their host rocks during a regional granulite facies event as evidenced by their stable high grade mineralogy and degrees of polygonal recrystallization. The grade of the granodioritic and dioritic units is difficult to ascertain due to a lack of suitable index minerals; however, the presence of hornblende, biotite and ubiquitous garnet as well as relict igneous texture suggest that they reached a metamorphic grade of no higher than amphibolite. It is possible that granulite facies metamorphism in the Lac Long south domain was overprinted by no greater than amphibolite facies metamorphism accompanying the younger orogenic event thought to have affected that domain. If so, this metamorphism may have caused only patchy amphibolite retrogression of the rocks north of the Lac Long lineament.

Economic Geology

Sparse sulfide mineralization is found in bedrock and float mainly in the northeast part of the map area. Pyrite and magnetite with minor chalcopyrite, arsenopyrite and pyrrhotite occur in a narrow local lens of possible metamorphosed iron formation in granulite grade quartzofeldspathic paragneiss. A 20 m wide gossan within the same paragneiss unit close to a small body of gabbronorite contains pyrite mineralization.

Chalcopyrite-, sphalerite(?)- and pyrite-bearing float is also found in the general region of the bedrock mineralization, but it is emphasized that the source of this float could be distant since glaciation from the northeast was extensive. A small occurrence consisting of stringers of an unknown Cu-bearing mineral is located in paragneiss 5 km north of Lac Ghyvelde, but was not examined during the course of this study.

Fe-Ti oxides are abundant in the anorthosite suite rocks examined previously by BRINEX for Ti potential. Well sorted, almost pure magnetite-ilmenite sand occurs on a small beach midway along the north shore of Lac Long suggesting that this body of rocks warrants additional study.

Discussion

From the outset, in 1978, of recent studies into the nature and extent of the Grenvillian Orogeny in south-central Labrador, a number of unexpected findings have ensued. Before that time, it was concluded that amphibolite to granulite grade metamorphic events recorded in large expanses of paragneiss and orthogneiss within the region were of Grenvillian age. Similarly, it was thought that most if not all of the major structural deformation was due to the Grenvillian Orogeny.

Grenvillian structural effects have been documented in the Seal Lake Group along with subgreenschist to greenschist facies metamorphism, as far as 230 km north of the present map area. In addition there are numerous examples of circa 1000 Ma potassium-argon dates from the Seal Lake Group south into the region of this study. During the recent studies, however, a number of uranium-lead (Krogh, written communication, 1983) and rubidium-strontium (Fryer, 1983) ages of circa 1600-1700 Ma have been obtained for high grade crystalline rocks from well within the present boundary of the Grenville Province (Figure 4). These record metamorphic events in both para- and orthogneisses varying in grade from amphibolite to granulite, as well as

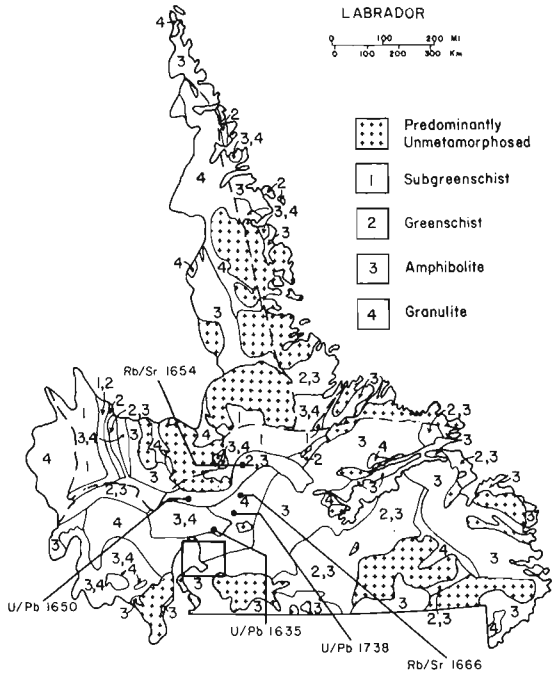

Figure 4: *Regional metamorphic zones in Labrador, with recent geochronological data superimposed (modified from Fraser and Heywood, 1978).*

several cooling ages of little deformed granitoids. Rubidium-strontium isochrons which yield these dates are largely undisturbed. Uranium-lead results giving these dates are nearly concordant, with minor lead loss attributable to a circa 1000 Ma event. The dates therefore suggest that many of the presumed high grade Grenvillian gneisses in this part of Labrador belong to a much older crystalline terrain which underwent a Grenvillian metamorphic event of much lower intensity than previously assumed. In summary, the geochronological, structural and metamorphic data as well as to some extent contrasting lithologies, record a previously unsuspected intense Paleohelikian orogenic event at circa 1600-1700 Ma which affected the rocks in central and south-central Labrador. This event has been informally termed the Labradorian Orogeny by Nunn et al., 1984.

Acknowledgements

Lakeland Helicopters Limited and pilot J. Crawford provided air transport in the field. R. Nugent, C. O'Flaherty and G. Wong ably assisted the field survey, and cook G. Lynch is thanked for a nourishing and varied menu. The manuscript was critically reviewed by D. Wardle and J. Murray of the Newfoundland Department of Mines and Energy.

References

Emslie, R.F., Hulbert, L.J., Brett, C.P., and Garson, D.F.
1978: Geology of the Red Wine Mountains, Labrador: the Ptarmigan Complex. *In* Current Research, Part A, Geological Survey of Canada, Paper 78-1A, pages 129-134.

Fraser, J.A., and Heywood, W.W., *editors*
1978: Metamorphism in the Canadian Shield. Geological Survey of Canada, Paper 78-10, 367 pages.

Fryer, B.J.
1983: Report on geochronology, Labrador mapping. Unpublished summary of geochronological results obtained on samples collected from central Labrador between 1978 and 1980, 35 pages.

Nunn, G.A.G., Noel, N. and Culshaw, N.G.
1984: Geology of the Atikonak Lake area, Grenville Province, western Labrador. *In* Current Research. Newfoundland Department of Mines and Energy, Mineral Development Division, Report 84-1 *(this volume)*.

Pyke, M.W.
1956: Report on exploration in areas G and K, Labrador. BRINEX confidential company report.

Stevenson, I.M.
1969: Lac Brule and Winokapau Lake map areas, Newfoundland and Quebec. Geological Survey of Canada, Paper 67-69, 16 pages.

Taylor, F.C.
1971: A revision of Precambrian structural provinces in northeastern Quebec and northern Labrador. Canadian Journal of Earth Sciences, Volume 8, pages 579-584.

Thomas, A.
1981: Geology along the southwestern margin of the Central Mineral Belt. Newfoundland Department of Mines and Energy, Mineral Development Division, Report 81-4, 40 pages.

Thomas, A., Jackson, V. and Finn, G.
1981: Geology of the Red Wine Mountains area, central Labrador (13E/9, 10, 11, 15, 16; 13F/12, 13). Newfoundland Department of Mines and Energy, Mineral Development Division, Open File Report Lab. (573).

Thomas, A. and Wood, D.
1983: Geology of the Winokapau Lake area, Grenville Province, central Labrador. *In* Current Research, Part A, Geological Survey of Canada, Paper 83-1A, pages 305-312.