GEOLOGY OF THE WINOKAPAU LAKE AREA, GRENVILLE PROVINCE, CENTRAL LABRADOR[1]

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Also in Current Research, Part A, Geological Survey of Canada, Paper 83-1A, p. 305-312, 1983.

Abstract

Precambrian crystalline rocks within the northern part of the Grenville Structural Province southeast of Churchill Falls, Labrador, constitute a mixed granitoid-gneiss terrane. A range of hills is underlain by granulite facies quartzofeldspathic paragneiss containing the mineral assemblage hypersthene, sillimanite, quartz and feldspar. Lowlands contain amphibolite facies quartzofeldspathic paragneiss, orthogneiss and deformed porphyritic granite characterized by the assemblage biotite, sillimanite, muscovite, garnet, quartz and feldspar.

Although extensively tectonized during the Grenvillian Orogeny, paragneiss within the area is tentatively correlated with equivalent rocks in and around the Red Wine Mountains massif to the north which have been deformed and metamorphosed during the Paleohelikian sub-era. Orthogneiss is correlated with granitoid rocks of known Paleohelikian age. The protolith of both amphibolite and granulite grade paragneiss may be as old as Aphebian, and probably had its origin in eugeosynclinal facies greywackes and pelitic sandstones of the Hudsonian orogen in western Labrador.

Introduction

Geological studies in Labrador have to date been focused mainly on Aphebian to Paleohelikian sedimentary-volcanic successions of the Labrador Trough and the Central Mineral Belt. By comparison, relatively little has been done on the huge expanse of gneissic and granitoid rocks belonging to the Grenville Structural Province in southern Labrador. This is due to several factors such as lack of exposure, geological complexity, difficulty in access and the resultant logistical problems which arise such as increased cost of field operations. Most previous programs in the Grenville Province have been large scale, regional geological reconnaissance surveys carried out by the Geological Survey of Canada (Eade, 1952, 1962; Wynne-Edwards, 1960; Stevenson, 1967a, b, 1968, 1969, 1970; Jackson, 1974) at 1:500 000, 1:250 000 or 1:125 000 scale. In addition, Brinex has carried out mapping in selected areas of the Grenville Province ranging in scale up to 1:250 000.

In 1978, with the aid of a Federal-Provincial funding agreement to help offset the high cost of field work, the Newfoundland Department of Mines and Energy began a systematic approach aimed at mapping at 1:100 000 scale, a strip at least 2 NTS map sheets deep along the entire Grenville Front Zone from the Labrador Trough in the west to the coast in the east. In central Labrador, this was done originally with the idea of following previously mapped units, some of which had either proven or potential mineralization, from the Central Mineral Belt, south into the Grenville Province in order to define more clearly the nature of the Grenville Front Zone in this part of Canada. The area mapped between 1978 and 1981 is shown in Figure 42.1. Summaries of this work can be found in Thomas and Hibbs (1980), Thomas (1980, 1981), Thomas et al. (1981) and Jackson and Finn (1982). The study of Emslie et al. (1978) was initiated prior to that of the Newfoundland Department of Mines and Energy, and data from this study have since been incorporated.

In 1982 it was decided to extend the mapping southwestward into the Grenville Province (Fig. 42.1) due to some interesting results from the 1978-1981 study. Specifically, it was discovered that gneissic rocks thought originally to have been Grenvillian in age, were older; Rb-Sr isochron ages of

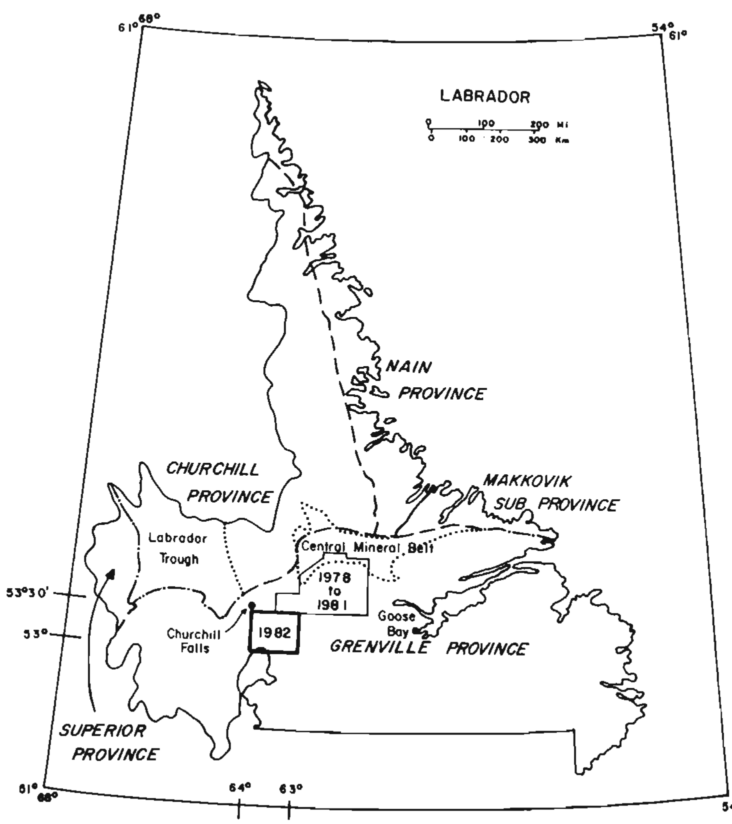

Figure 42.1. *Location of present and previous map areas in central Labrador (structural province divisions after Taylor, 1971).*

[1] Contribution to Canada-Newfoundland co-operative mineral program 1982-84. Project carried by Geological Survey of Canada and Newfoundland Department of Mines and Energy.
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1660 ± 37, 1661 ± 88 and 1666 ± 28 Ma were obtained by Fryer (in Thomas, 1981, and personal communication, 1982). This prompted a renewed search for polydeformed gneisses which would yield Grenvillian ages. The 1982 map area is located southeast of Churchill Falls and encompasses NTS 1:50 000 sheets 13E/3, 4, 5 and 6 (Fig. 42.1). Access is primarily by helicopter from Churchill Falls or by road from the Trans-Labrador Highway.

Regional Setting

Regional metamorphic grades and structural trends of rocks in Labrador are shown in Figures 42.2 and 42.3 respectively. The boundaries of the five structural provinces in Labrador (after Taylor, 1971) appear on Figure 42.1 along with those of the Labrador Trough and Central Mineral Belt. The dashed line representing the limit of the Grenville Province indicates the approximate northern extent of recognizable Grenvillian structural deformation. This does not preclude the presence south of this line of rocks exhibiting evidence of older orogenic events.

The Winokapau Lake area encompasses a mixed granitoid, paragneiss terrane metamorphosed primarily to amphibolite and granulite facies (Fig. 42.2). It is located along the southwestern edge of a larger block of crystalline rocks to the east and northeast, the Red Wine Mountains massif, consisting mainly of amphibolite and granulite grade paragneiss intruded by a suite of noritic and charnockitic rocks (see Emslie et al., 1978; Thomas et al., 1981). This block has been thrust northwards over a body of deformed granitoids (termed North Pole Brook Intrusive Suite by Thomas and Hibbs, 1980) of Paleohelikian age. These granitoids are in turn thrust over subgreenschist to greenschist grade sedimentary and volcanic supracrustal rocks belonging to the Nelhelikian Seal Lake Group. To the north of the Winokapau Lake area, a boggy lowland terrane contains scattered exposures of North Pole Brook Suite granitoid rocks and older paragneiss. West of the area, the granitoid gneiss terrane continues into the region presently being investigated by Nunn and Christopher (1983). With the exception of granitoids belonging to the North Pole Brook Intrusive Suite, rocks in the region are polydeformed and polymetamorphosed. The entire area has been affected to some degree by the Grenvillian Orogeny, but abundant evidence exists, especially in granitoids and gneiss to the north, of an earlier, presumably late Hudsonian, orogenic event (Thomas, 1981).

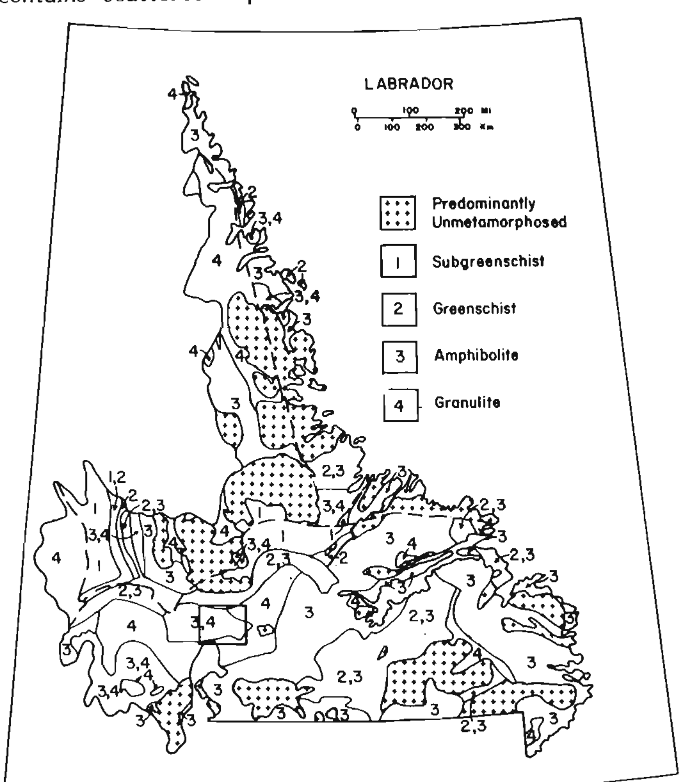

Figure 42.2. Regional metamorphic grades of rocks in Labrador (modified from Fraser and Heywood, 1978).

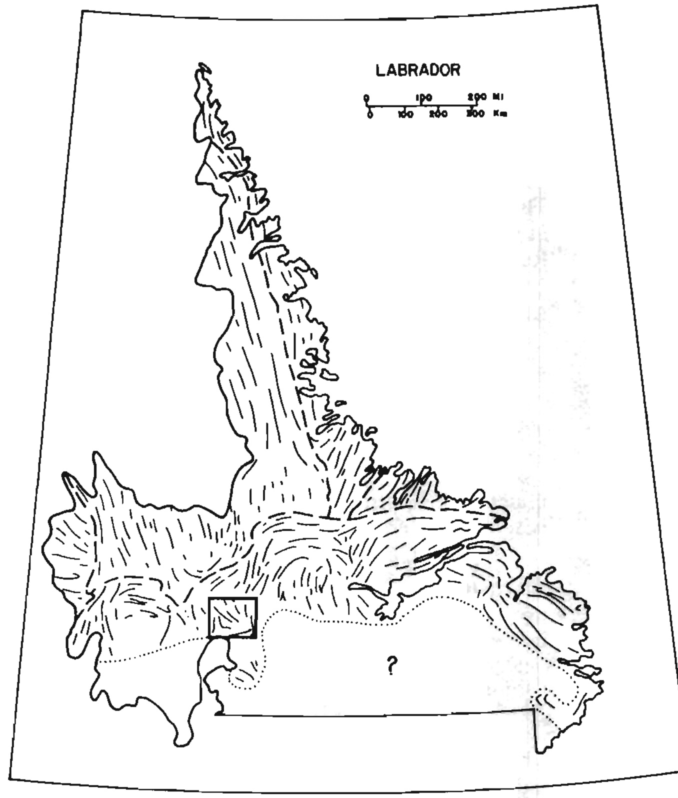

Figure 42.3. Generalized map illustrating regional structural trends in Labrador.

General Geology of the Winokapau Lake Area

Although structurally and metamorphically complex, there is little lithological variation of rocks within the map area. Eight units were defined (Fig. 42.4), with two of them, quartzofeldspathic paragneiss and granodioritic to granitic orthogneiss, constituting approximately 80 per cent of exposed bedrock. A range of hills in the northeastern and southern segments of the area is underlain by granulite grade paragneiss (unit 1a), tentatively correlated with the Hope Lake gneiss of Emslie et al. (1978), Thomas (1981) and Thomas et al. (1981). The northeastern hills are actually a physical extension of the Red Wine Mountains massif in which granulite grade paragneiss was first recognized by Emslie et al. (1978). Till or sand covered lowland terrane in the northern, south-central and southeastern parts of the area is dominated by poorly exposed amphibolite grade paragneiss (unit 1b), similar in lithological character and style of deformation to Disappointment Lake gneiss of Thomas (1981) and Thomas et al. (1981) to the northeast. Although granulite and amphibolite grade paragneisses in the vicinity of Winokapau Lake are mineralogically distinct from one another, they exhibit lithological and compositional similarities. It is, therefore, presently assumed that the two are metamorphic variants of the same unit.

Orthogneiss (unit 4b) is poorly to moderately well exposed, primarily in a 16 km wide band passing diagonally from northwest to southeast, through the central part of the area. Porphyritic granite to granodiorite protolith (unit 4a) is identifiable in places within this band. A small body of orthogneiss is also exposed near the northeastern corner of the area. Granodiorite to quartz diorite (unit 5), recrystallized and foliated but with a recognizable relict igneous texture, occurs in the north-central part of the area. It is correlated with less deformed granodiorite to the north, belonging to the North Pole Brook Intrusive Suite of Thomas (1981) and Thomas et al. (1981). Three small, recrystallized and foliated quartz dioritic to dioritic bodies (unit 6) of unknown age and origin are present within the gneisses south of the Churchill River. In addition, a small, plutonic body of foliated to massive granite (unit 8) occurs just south of Winokapau Lake in the southeastern part of the area. Its predominantly massive nature suggests that the body is a late syn- to post-kinematic intrusion associated with the Grenvillian Orogeny.

Gabbronorite, gabbro, diabase and parts of a charnockitic suite more widely exposed to the northeast of the map area (see Emslie et al., 1978), constitute the remaining lithologies. Folded bodies of norite (unit 2) are confined to granulite grade paragneiss in the southern hills. Paleohelikian Shabogamo gabbro and gabbronorite (unit 7) occur as deformed sills and bodies within the amphibolite grade paragneiss and orthogneiss; two late syntectonic diabase dykes of unknown affinity cut orthogneiss and paragneiss near the eastern boundary of the area. The charnockitic rocks (unit 3) are minor in occurrence, confined to several small outcrops north of the west end of Winokapau Lake and in the central part of the southern granulite paragneiss.

All rocks within the Winokapau Lake area have been extensively deformed during the Grenvillian Orogeny; but at least some of the earlier folds and possibly faults are probably pre-Grenvillian. No radiometric age data are presently available on rocks of the Winokapau Lake area, but geological relationships between units and tentative correlations with less tectonized equivalent rocks to the north and northeast, suggest a Paleohelikian or earlier age protolith for the gneisses. They most probably originated within a eugeosynclinal succession of greywackes, sandstones and mudstones similar to that exposed along the western margin of the Labrador Trough.

Paragneiss (unit 1)

Granulite grade paragneiss (unit 1a) is rusty pink to buff, fine- to medium-grained, dense and extremely resistant to weathering. It is banded, with prismatic to fibrous sillimanite, fine grained hypersthene, magnetite and minor biotite confined to mafic layers which pinch and swell, imparting an anastomosed appearance to the rock. Mafic bands vary in width up to 2 cm and commonly contain lenticular clots of densely packed aggregates of fibrolitic sillimanite, pyroxene and magnetite. Ubiquitous fine grained magnetite within these bands results in the granulite paragneiss having a unique, intense aeromagnetic "signature". The anomaly patterns reflect bedrock structural trends and can be used to delineate the limits of the gneiss in drift covered areas. Felsic bands consist of very dense, fine- to medium-grained granoblastic polygonal aggregates of quartz, K-feldspar and plagioclase. These bands are tightly folded, also 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 mafic bands; pseudotachylyte veinlets in the same size range also crosscut felsic bands. Abundant evidence of partial melting is present in the granulite paragneiss. Both layer parallel and crosscutting quartz-feldspar sweats are common, as are localized zones of incipient melting within felsic bands. This melting took place under dry conditions at high temperatures as evidenced by subhedral to euhedral hypersthene crystals up to 1 cm long within some of the sweats.

Granulite grade paragneiss is highly deformed with tight isoclinal, chevron and hook folds well developed on a centimetre scale. Shear and cataclastic zones occur locally near faults and along the contact with amphibolite grade paragneiss in the lowlands. The polydeformed nature, high metamorphic grade and predominance of a quartz, feldspar, sillimanite assemblage suggest that granulite paragneiss is derived from an old sedimentary protolith.

Buff-white to pink, amphibolite grade paragneiss (unit 1b) is similar in lithology to granulite grade paragneiss, consisting of quartz, K-feldspar, plagioclase, sillimanite, biotite, muscovite, garnet and magnetite-ilmenite. Hornblende is present in local amphibolite layers within the quartzofeldspathic gneiss and metamorphic differentiation is well developed with mafic minerals segregated into bands up to 0.5 cm wide, separated by 2-3 cm wide quartz-feldspar bands.

Unlike granulite grade paragneiss, amphibolite paragneiss is less dense and more fissile due to its richness in biotite and muscovite. Strong linear and planar fabrics are developed respectively within and parallel or subparallel to the gneissic banding. Sillimanite may be prismatic or fibrolitic and tends to form radiating clusters along the contact between mafic and quartzofeldspathic bands. Lenticular fibrolite clots are also common within the mafic bands as are euhedral to subhedral garnet porphyroblasts which overgrow the foliation. Granoblastic polygonal texture predominates within the quartz-feldspar bands and is in most places medium- to coarse-grained. At least three generations of pegmatite sweats indicate that partial melting was an ongoing process during formation of the paragneiss. Early melt bands, parallel to the gneissic banding, are abundant throughout the amphibolite paragneiss terrane and commonly result in a migmatitic structure. These bands are ptygmatically folded and cut by a later set of veinlets which are also deformed. The most recent sweats are associated with deformed, coarse grained tourmaline pegmatite dykes; together with these dykes, they crosscut all previous structures, melt bands and veinlets.

Amphibolite grade paragneiss is highly tectonized, exhibiting complex minor fold patterns including mushroom and dome and basin structures. The structural style, mineralogy and overall lithology of this unit compares favourably with that of the Disappointment Lake gneiss of Thomas (1981) dated by B. Fryer (personal communication, 1982) by Rb-Sr at 1666 ± 88 Ma. Although amphibolite grade paragneiss around Winokapau Lake has undergone a more complex deformational history, it is tentatively correlated with Disappointment Lake gneiss to the northeast.

Gabbronorite (unit 2)

Bodies of noritic to gabbroic composition intrude granulite grade paragneiss in the south. They consist of plagioclase, hypersthene, diopside, magnetite, and minor biotite and hornblende. Igneous textures are preserved in the centres of the bodies whereas the margins are recrystallized to granoblastic polygonal aggregates. Sharp, intrusive, chilled marginal contacts of gabbronorite against granulite gneiss are well exposed. These rocks are similar in composition and intrusive style to gabbronoritic rocks to the northeast, described by Emslie et al. (1978) and Thomas et al. (1981).

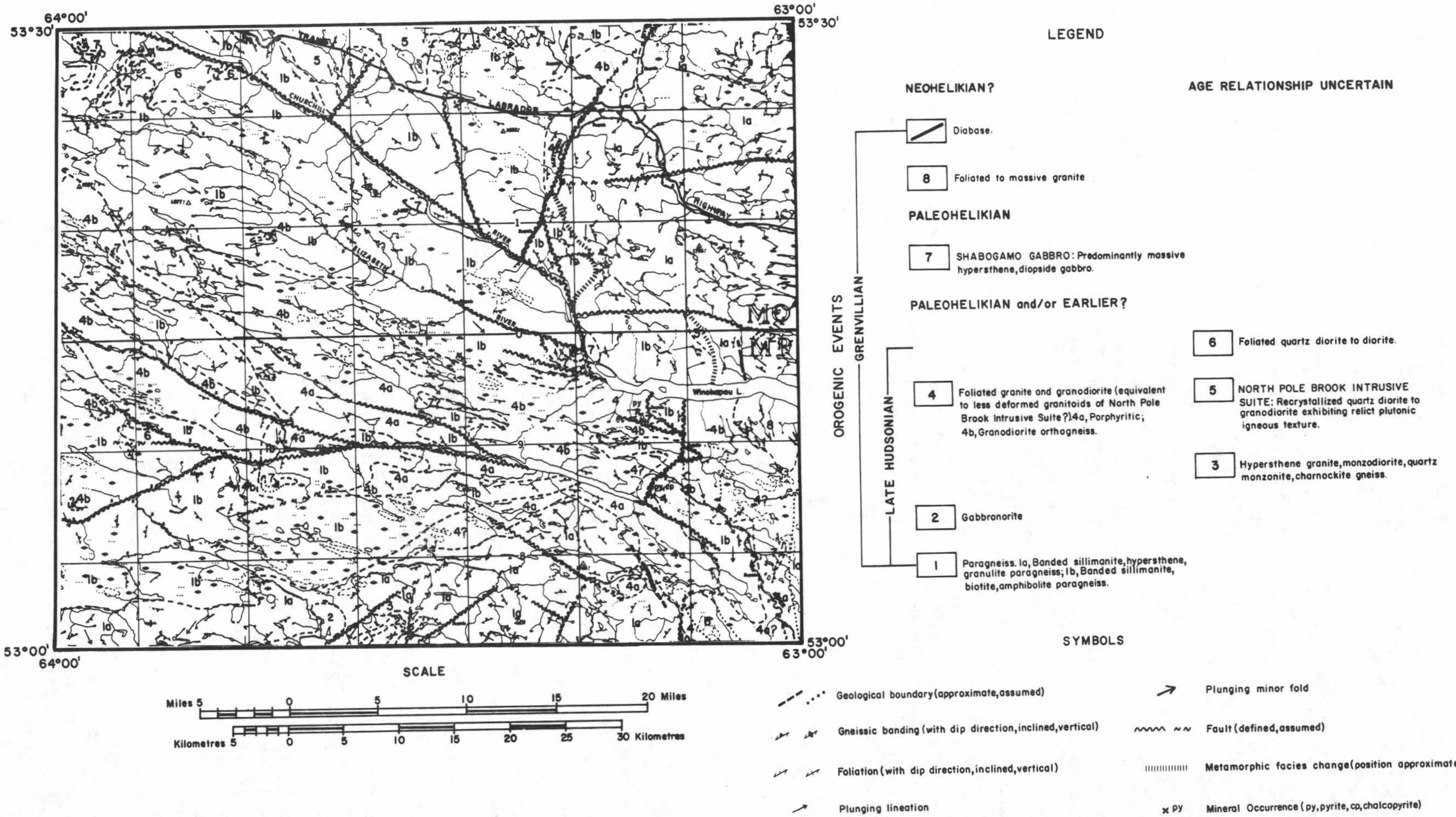

Figure 42.4. *Geology of the Winokapau Lake area, central Labrador.*

Hypersthene Granitoids (unit 3)

Several outcrops define a small body of hypersthene-bearing granite-granodiorite north of Winokapau Lake. A body of similar size also occurs in the central part of the granulite paragneiss. Quartz, K-feldspar, plagioclase, hypersthene and minor biotite are the main constituents. The body north of Winokapau Lake is highly deformed with a cataclastic texture. It is fault bounded on the north and its eastern margin runs close to a presumed metamorphic facies change from amphibolite to granulite grade. The southern body is approximately rectangular, bounded on two sides by faults and on the remaining two sides forming an intrusive contact within host gneiss.

Foliated Granite and Orthogneiss (unit 4)

The metamorphosed granitoid rocks are divided into two main subunits. Porphyritic granite to granodiorite (unit 4a) is most common in the central and southeastern parts of the area. It consists of abundant megacrysts of microcline up to 2 cm set in a medium grained groundmass of quartz, plagioclase, orthoclase, biotite and hornblende. A variety of metamorphic and structural characteristics are displayed. Porphyritic granite-granodiorite may be moderately to strongly foliated, lineated or banded. Where lineated, primary igneous texture is preserved on outcrop faces normal to the plunge of the lineation, and megacrysts are attenuated on faces parallel to the lineation. With increased deformation and metamorphism, total recrystallization takes place resulting in formation of orthogneiss (unit 4b). The mineralogy remains the same except for the addition of euhedral garnets up to several millimetres in size. Igneous texture is completely altered to coarse, granoblastic polygonal texture although megacrysts remain as lenticular augen. With extreme deformation, the megacrysts are strung out to form quartzofeldspathic bands. Since intense deformation is widespread throughout the area and low strain zones are present only locally in fold noses, banded or augen orthogneiss predominates over its megacrystic protolith.

No contacts between paragneiss of unit 1 and rocks of unit 4 were observed, but sillimanite-bearing paragneiss xenoliths are present within porphyritic granodiorite and orthogneiss in the adjoining map area (see Nunn and Christopher, 1983). Indications are that the granitoids intruded the paragneiss terrane prior to at least the last major period of deformation.

North Pole Brook Intrusive Suite (unit 5)

Quartz diorite to granodiorite, present in the northern part of the area, exhibits relict equigranular igneous texture and is much less deformed than the orthogneiss. It consists of quartz, K-feldspar, biotite, hornblende and magnetite. Although strongly foliated in the map area, it can be traced northwards into almost undeformed equivalents, which have been collectively termed North Pole Brook Intrusive Suite by Thomas and Hibbs (1980). This unit is intrusive into older polydeformed amphibolite grade paragneiss north of the Churchill River, but could not be traced south of the river into orthogneiss which is thought to represent its higher grade equivalent.

Foliated Quartz Diorite to Diorite (unit 6)

Confined to three small bodies south of the Churchill River and Winokapau Lake, quartz diorite-diorite consists of quartz, K-feldspar, plagioclase, hornblende, minor biotite and magnetite. The rock is dark green, almost black on weathered and fresh surfaces, and in places approaches gabbroic composition. No contacts were observed, but the bodies probably represent younger intrusives within the amphibolite grade paragneiss.

Shabogamo Gabbro (unit 7)

Gabbro is present within the amphibolite grade paragneiss terrane as narrow, elliptical bodies, probably representing disjointed and boudinaged sills. Although the bodies are metamorphosed, relict igneous textures are preserved within their centres; corona textures are present locally. Orthopyroxene, clinopyroxene, abundant magnetite-ilmenite and plagioclase are the main constituents. The bodies tend to be extremely coarse grained in their centres, and fine grained and recrystallized along their margins. They intrude amphibolite grade paragneiss and orthogneiss and are correlated with the Shabogamo Intrusive Suite, widely exposed throughout western Labrador.

Foliated to Massive Granite (unit 8)

This is the least tectonized rock in the area and is thought to be quite young. Granite characterized by coarse, equigranular grain size and plutonic, igneous texture occurs in a small body south of Winokapau Lake. It consists of quartz, orthoclase, plagioclase and biotite with minor magnetite or ilmenite. Xenoliths of mafic to quartzofeldspathic paragneiss are abundant within the granite which is bleached along the xenolith contacts. The body has intruded a previously deformed gneiss terrane and may have had its origin in the partial melt fraction derived during the metamorphism of those same gneisses.

Structure

No major regional structures were observed due to a combination of poor exposure, especially along contacts between different rock types, and lack of continuous passive marker horizons within individual units. Therefore, all fold closures and axes are inferred from variations in trends of gneissic banding, foliation and approximated contacts between contrasting rock types. Figure 42.5 shows the major structural elements within the Winokapau Lake map area. It is emphasized that the structural inferences made are preliminary and have to undergo more rigorous testing by the data which have not yet been fully compiled. Four major periods of deformation are postulated, with evidence for four phases of folding and as many faulting events. Figure 42.6 pictorially illustrates a possible theoretical structural interpretation for rocks within the map area.

The first period of deformation resulted in the creation of a well developed gneissic and primary melt banding. The banding has a moderate to steep dip and is parallel to F_1 isoclinal fold axes about which it has been folded by D_1. The original trend of these axes has been changed by later deformations, but may have been east-west. During D_2, F_1 isoclinal structures were folded about closed to tight northwest-southeast F_2 fold axes. A second melt banding consisting of quartz-feldspar veinlets which crosscut the primary gneissic banding also formed at this time. Under the effects of D_3, F_1 and F_2 regional structures were deformed about east-trending F_3 fold axes into isoclinal mushroom and dome and basin fold patterns. The D_2 melt banding was ptygmatically folded and a third system of crosscutting partial melt veinlets formed, as well as associated tourmaline pegmatite dykes.

Stretched augen, mineral elongation and mineral streaking define a consistent pattern of strongly developed lineations (Fig. 42.7) presently thought to be associated with F_3 structures within the amphibolite grade paragneiss and orthogneiss. The lineations plunge at an angle of approximately 40° on a bearing of 155° and indicate a probable northwesterly transport direction for bulk rock movement during D_3. The trend of these lineations is strikingly similar to those within the Red Wine Mountains massif to the northeast (see Emslie et al., 1978, Fig. 27.3).

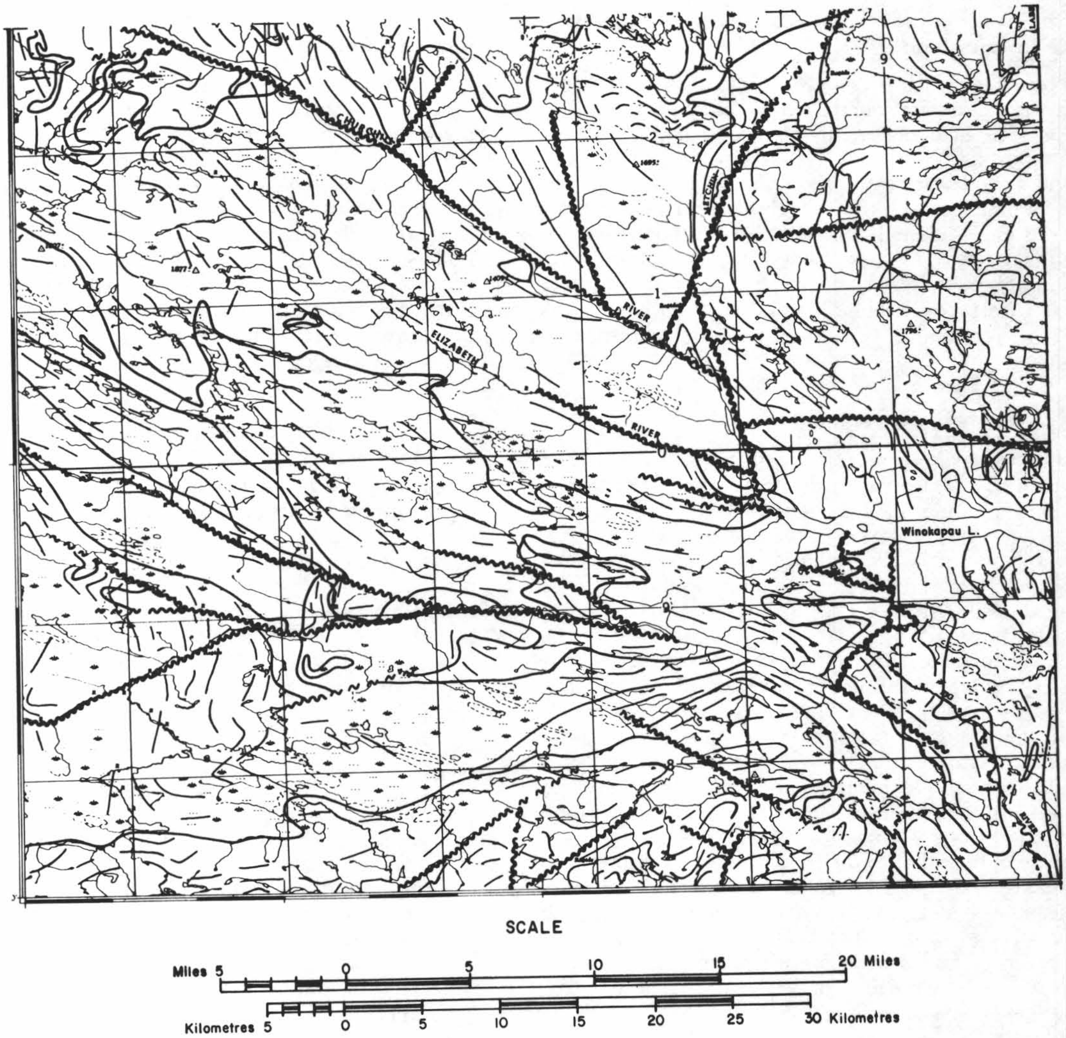

Figure 42.5. *Structural grain in the Winokapau Lake area, based on trends of gneissic banding and foliation.*

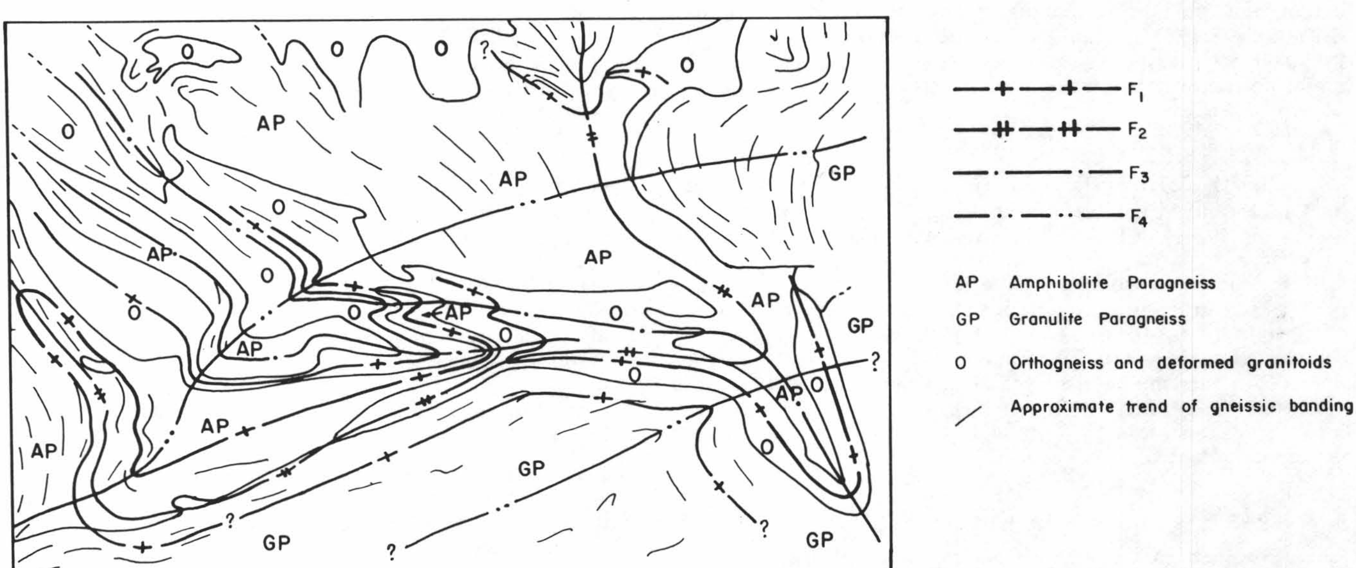

Figure 42.6. *Pictorial diagram (not to scale and neglecting effects of faulting) illustrating possible structural interpretation of rocks around Winokapau Lake.*

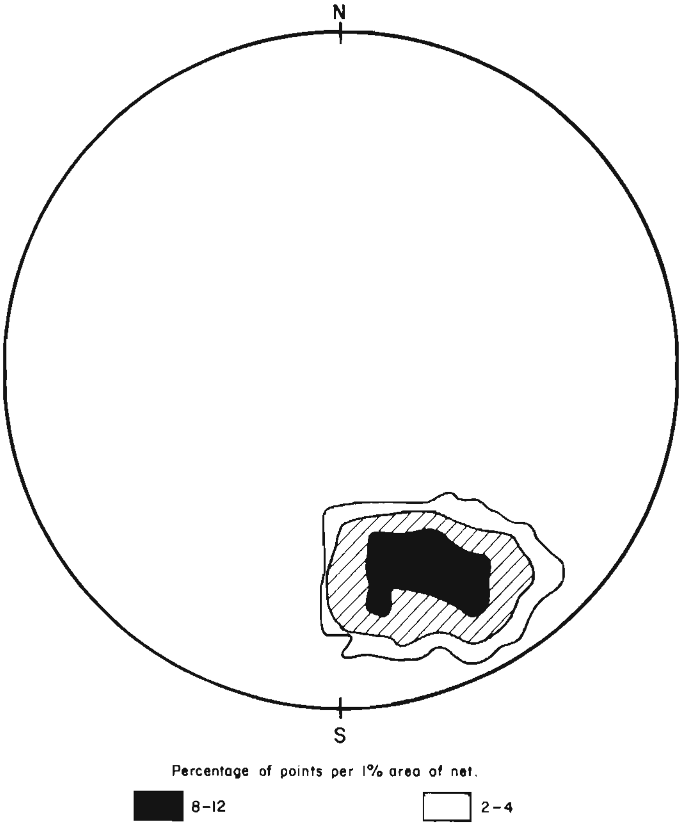

Figure 42.7. Contoured lower hemisphere stereographic plot of lineations from the amphibolite paragneiss, orthogneiss and granitoids (based on 56 data points).

The most recent deformation (D_4) has resulted in open folding of all previous structures about east-northeast-trending F_4 fold axes. This has caused F_3 fold structures to open up and F_2 fold structures simultaneously to become more attenuated. The D_3 melt veinlets have been strongly deformed whereas the associated pegmatite dykes were more gently deformed into open minor folds.

In Figure 42.6, structures have been tentatively extended from the amphibolite grade paragneiss and orthogneiss into the granulite grade paragneiss terrane. In the adjoining area to the west, there is limited evidence to suggest that the granulite gneiss constitutes a separate structural block which acted as a buttress against some of the deformation within the amphibolite grade rocks. If this turns out also to be the case in the Winokapau Lake area, the above structural extension may be invalid.

No attempt is made to correlate faults within the map area with deformation events responsible for folding. All faults are based on one or more of the following criteria: (1) presence of fault breccia; (2) shear and/or mylonite zones; (3) slickensided surfaces associated with shearing; (4) mismatch of lithological units across lineaments; (5) scarps associated with shearing and lineaments; (6) well defined lineaments alone.

The earliest generation faults are found within the granulite grade paragneiss. In the eastern granulite terrane, east-west faults have a poorly documented but apparent sinistral component to their movement. In the southern granulite terrane, a conjugate set of northeast and southwest faults are associated with intense mylonitization and shearing.

Second generation northeast- to north-trending faults terminate the east-west faults in the eastern granulite terrane, and at least one is an extremely deep-seated reverse fault. It separates granulite grade paragneiss from the lower grade rocks to the west, and is continuous north of the map area with the major fault that defines the Red Wine Mountains granulite massif. It has also been folded during D_3 and cut by Shabogamo gabbro. In addition, sometime during its history, the fault underwent ductile movement during a high grade metamorphic event. Evidence for this is the presence of syntectonic sillimanite, having a preferred orientation within the plane of the fault.

A single fault running south from the west end of Winokapau Lake constitutes evidence for third generation faulting.

The numerous fourth and last generation faults are reflected in the northwest- to west-trending drainage pattern. They are fundamental structures along which preglacial and postglacial erosion has taken place to produce spectacular deep gorges. These gorges normally contain abundant glaciofluvial deposits and it is obvious that the fourth generation faults have influenced the orientation of postglacial spillways and more recently regenerated drainage. Erosion along one of these faults has created the Churchill River gorge through which the entire runoff of the Smallwood Reservoir (formerly Michikamau Lake) catchment area flows. The fourth generation faults terminate or impart a sizeable left lateral offset component to second generation faults, and the Churchill River fault which continues through Winokapau Lake terminates the third generation fault.

First and second generation faults are thought to be extremely old structures which may date back to the Hudsonian Orogeny. The previously mentioned, deep seated reverse fault is probably an ancient structure which has been reactivated several times, the last being during the Grenvillian Orogeny. Third and fourth generation faults are most likely Grenvillian in age and may incorporate significant reverse movement as well as repeated cycles of activation.

Metamorphism

The metamorphic grade of rocks within the Winokapau Lake area varies from amphibolite in the northwest to granulite in the south and east. The division between amphibolite grade and granulite grade rocks is for the most part abrupt. In the east, it runs partly along the reverse fault which juxtaposes rocks of the two facies, and in part constitutes a metamorphic transition. In the south, the nature of the division is unknown. There is no evidence to indicate a gradual increase in metamorphic grade from north to south throughout the area.

Granitoid rocks in the northern and northwestern part of the area exhibit static recrystallization textures and incipient melt zones resulting from a single amphibolite grade metamorphic event. The stable mineral assemblage present is plagioclase, quartz, biotite and hornblende. Paragneiss in contact with these granitoids has been metamorphosed at least once to amphibolite grade. A prograde plagioclase, K-feldspar, quartz, biotite, sillimanite, garnet assemblage is overprinted by retrograde muscovite. Plates up to 1 cm can be found within and discordant to the foliation, but the retrogression is patchy and muscovite-free zones are common.

Both paragneiss and orthogneiss in the central part of the map area have been metamorphosed to amphibolite grade, at least once by the same event which affected granitoids in the northern part of the area. Plagioclase, K-feldspar, quartz, biotite, sillimanite, garnet and muscovite are present in paragneiss; plagioclase, K-feldspar, quartz, biotite, hornblende and garnet in orthogneiss. The development of muscovite is patchy within the central paragneiss terrane, but much more voluminous than in the north and northwest.

Granulite grade paragneiss and gabbronorite in the south and east, chiefly have the assemblages plagioclase, K-feldspar, quartz, hypersthene, sillimanite, minor biotite, and plagioclase, hypersthene, diopside, magnetite-ilmenite respectively. Sapphirine was also tentatively identified. Temperature, total pressure and water pressure constraints on these rocks, require formation near the base of the crust; therefore it is probable that granulite and amphibolite grade paragneisses are respectively deeper and shallower crustal level equivalents of the same unit.

Discussion

Granitoids and orthogneiss are tentatively correlated with less deformed, lower grade equivalent rocks belonging to the North Pole Brook Intrusive Suite, which yield a Rb-Sr isochron cooling age of 1654 ± 22 Ma (Fryer in Thomas, 1981). The amphibolite grade event recorded in both granitoids and orthogneiss at Winokapau Lake must therefore be younger and is probably Grenvillian.

Amphibolite grade paragneiss is correlated with equivalent grade Disappointment Lake gneiss, which is intruded by North Pole Brook granitoids (Thomas, 1981) and was determined by Fryer (personal communication, 1982) to have a preliminary Rb-Sr age of 1666 ± 28 Ma. If this correlation is valid, paragneiss at Winokapau Lake must have been deformed and metamorphosed to amphibolite grade at least twice; once during the Hudsonian Orogeny or an early Paleohelikian event, and again during the presumed Grenvillian event recorded in the granitoids and orthogneiss. The development of three generations of melt-banding within the paragneiss also suggests a history of more than one metamorphic event.

Granulite grade paragneiss is correlated with Hope Lake gneiss (see Emslie et al., 1978; Thomas, 1981; Thomas et al., 1981) which gives a preliminary Rb-Sr errorchron age of 1675 Ma (Emslie in Thomas, 1981). The granulite grade paragneiss at Winokapau Lake has probably experienced a similar metamorphic history to that of the amphibolite grade paragneiss, but due to the anhydrous condition of the rocks no evidence of lower grade metamorphic events remains.

Therefore, although all rocks within the Winokapau Lake area have undergone amphibolite facies metamorphism during the Grenvillian Orogeny, it is possible that granulite grade and in part amphibolite grade events recorded in the paragneiss terrane may be as old as late Hudsonian. At present no thin sections have been examined and the identification of specific assemblages and textures which might enable the separation of earlier and later metamorphic events awaits further work.

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