GEOLOGY OF THE CHURCHILL FALLS REGION

by

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INTRODUCTION

Three areas were studied in the summer of 1981, designated A, B, and C on Figure 1. Areas A and C were mapped in order to connect previous mapping in the Gabbro Lake and Churchill Falls areas (Rivers, 1981; Wardle and Britton, 1981) with projects in the East Michikamau Lake and Red Wine Mountains areas (Nunn, 1981; this report; Thomas *et al.*, 1981). Area B was the subject of a brief reconnaissance mapping project designed to investigate the nature of an apparently fundamental structural lineament extending through Ossokmanuan and Panchia Lakes.

The Churchill Falls Region lies at the junction of the Churchill and Grenville Provinces and is underlain largely by gneissic and granitoid rocks of Aphebian to Helikian age. All areas form part of an undulating plateau land extensively covered by lakes and a thick mantle of glacial drift. Exposure in all areas is extremely poor and mapping was carried out largely by helicopter, with limited ground traversing.

Previous mapping in areas A and C is limited to the Geological Survey of Canada work by Eade (1952). Although published at 1 inch = 2 mile scale, the mapping was more typical of reconnaissance 1 inch = 4 mile or 8 mile work, and gives only a very superficial account of the region. Area B is covered by 1 inch = 4 miles reconnaissance mapping of Stevenson (1969).

Access to the three areas is possible by unpaved road from the hydroelectric townsite of Churchill Falls. Construction of the Smallwood Reservoir, which includes Ossokmanuan, Gabbro, Lobstick and Michikamau Lakes has resulted in extensive flooding of the plateau. The map for area C has been approximately corrected for this flooding, that for area B, however, has not.

AREA A - SONA LAKE (13E/12, E1/2)

The geology of this area is relatively simple (Figure 2) and consists of a southern unit of Aphebian(?) metasedimentary gneisses (Unit 1), and a northern unit of variably deformed Paleohelikian granitoid rocks (Unit 2). Both units are intruded by scattered gabbroid plutons (Unit 3).

UNIT 1 - APHEBIAN(?) METASEDIMENTARY GNEISSES

These rocks are typically pink, quartz-feldspar-muscovite-kyanite gneisses with accessory garnet, magnetite, and possibly ilmenite. They are usually massive in outcrop; compositional banding where seen is present only on a centimetre scale. The banding is usually isoclinally folded and crosscut by granitic and pegmatitic migmatite leucosome veins developed parallel to fold axial planes. Kyanite in the gneisses characteristically occurs as irregular bluish lenses 2-3 cm long which locally anastamose, imparting a flaser texture to the gneiss. Internally, the lenses consist of microcrystaline kyanite intergrown with biotite, muscovite and opaques. The gneisses also contain pods and boudins of biotite-amphibole schist or amphibolite, apparently the relicts of mafic dikes.

Associated with the kyanite gneisses are outcrops of gray to pink quartz-feldspar-biotite-muscovite gneisses, usually of massive appearance. The origin of these gneisses is not

certain, but the presence of muscovite and the association with kyanite gneisses suggests derivation from quartzofeldspathic sedimentary rocks.

The Unit 1 gneisses are continuous with the similar Disappointment Lake Gneisses described by Thomas *et al.* (1981), and Thomas (1981) from the area to the east. Radiometric dating in this area has indicated a minimum age of 1654 Ma for the gneiss (see Thomas, 1981) suggesting formation in an early Paleohelikian or late Aphebian orogenic event - probably related to the Hudsonian Orogeny. The depositional age of the gneiss protolith could be either Aphebian or Archean.

The contact of Unit 1 with the granitoid suite of Unit 2 has not been observed within Area A. To the west, however, identical gneisses are intruded by sheets of pretectonic aplite and granitoid of the granitoid suite. The Disappointment Lake Gneiss is also clearly intruded by plutonic rocks equivalent to Unit 2.

UNIT 2 - THE GRANITOID SUITE

Unit 2 underlies the northern two-thirds of the area and consists of a variety of tonalitic to granitic plutonic rocks. The earliest intrusive rocks are represented by scattered occurrences of fine grained, equigranular gray tonalite and granodiorite (2a). In one outcrop these have been intruded by aplite and granite dikes of Unit 2b.

Unit 2b is a heterogenous assemblage of pink granite, quartz monzonite, aplite and microgranite, varying in texture from equigranular to porphyritic and probably representing several intrusive phases. Most of these granitoids are biotite bearing with minor hornblende and magnetite. The phenocryst phase is usually microcline. In the northern part of the area they are moderately foliated and preserve igneous textures; however, to the south, they become increasingly foliated and eventually gneissic. Migmatization has affected these gneisses to a varying degree and has produced textures ranging from small isolated patches of granite mobilizate, to lit-par-lit vein systems. Hornblende porphyroblasts are commonly present in the leucosome fraction. Unit 2c extends well to the east of the map area and is correlated with the North Pole Brook Suite described by Thomas *et al.* (1981). This has been dated at *circa* 1650 Ma (Thomas *et al.*, 1981).

Unit 2c is a coarse, pink, megacrystic quartz monzonite restricted to the northeast corner of the area. The unit is characterized by 2-3 cm diameter microcline megacrysts and rare plagioclase phenocrysts set in a coarse groundmass of K-feldspar, plagioclase, biotite and quartz. Magnetite is a common accessory. The unit locally appears gradational with the equigranular granites and quartz monzonites of Unit 2b and is probably genetically related to these rocks. Similar megacrystic monzonite occurs north and east of the map area and is part of an extensive pluton centered on Michikamau Lake (Nunn, 1981). The age of Unit 2c has been established by preliminary Rb-Sr dating at 1715 $\pm$ 100 Ma (Brooks, personal communication). However, this conflicts with a 1525 Ma age on volcanics intruded by the pluton (see Nunn and Noel, this volume).

UNIT 3 - GABBRO, METAGABBRO AND AMPHIBOLITE: MINOR PERIDOTITE

Small, pretectonic elongate stocks and dikes of gabbro have intruded Units 1 and 2. In the northern half of the area, the bodies are generally composed of fairly fresh olivine gabbro with ophitic or subophitic texture. In the southern part of the area, the smaller gabbro bodies and the margins of the larger bodies have been converted to hornblende-plagioclase-garnet amphibolites. The interiors of the larger bodies generally retain their ophitic texture. Recrystallization is

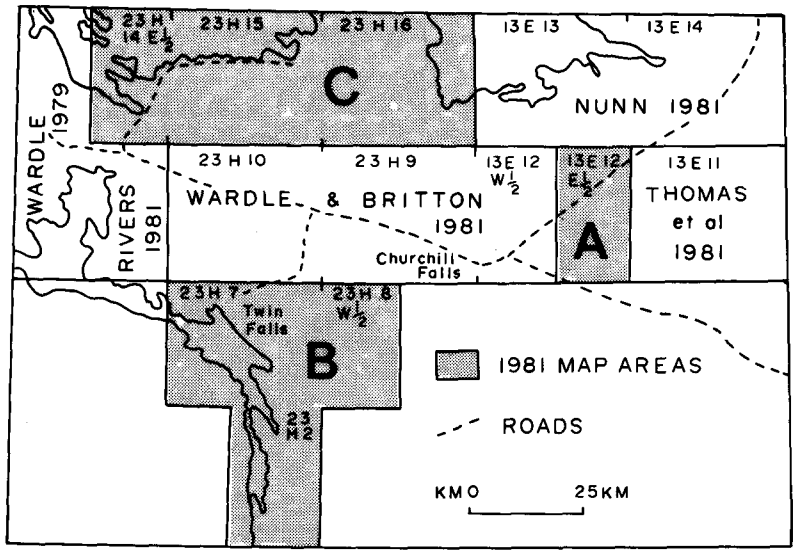


Fig. 1 INDEX TO 1981 MAP AREAS

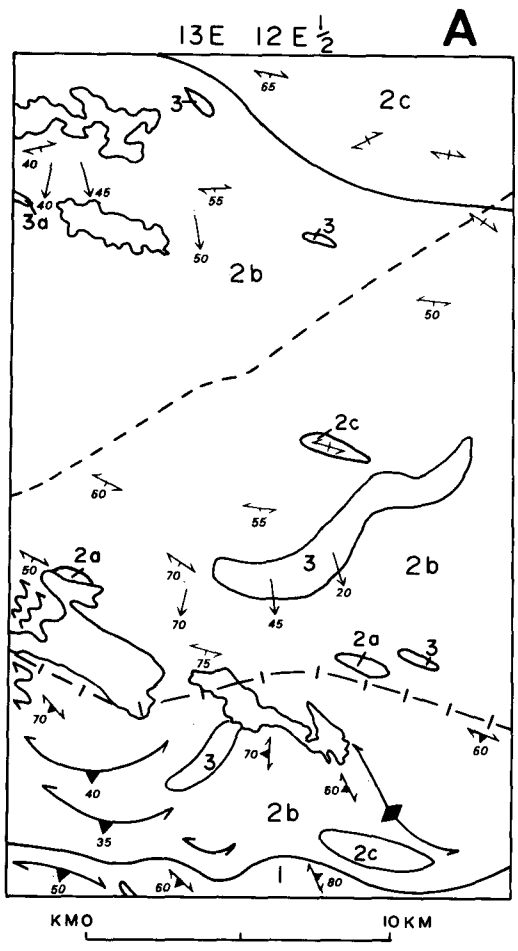


Fig. 2

LEGEND

PALEOHELIKIAN

3 Gabbro, metagabbro and associated amphibolite, minor peridotite

3a - Diorite

2 Granitoid Suite

2c - Pink megacrystic quartz monzonite
2b - Pink equigranular granite, quartz monzonite, aplite and microgranite
2a - Gray tonalite and granodiorite

APHEBIAN - ARCHEAN

1 Kyanite-muscovite bearing quartzofeldspathic gneisses

NOTE: Granitoid units south of line are gneissic and locally migmatitic in texture.

limited to reaction rims of serpentine and actinolite around olivine and pyroxene, and growth of fine garnet in grain interstices. Peridotite has been noted at one locality within Unit 1.

One occurrence has been noted of a fine grained equigranular diorite (Unit 3a) comprising an alteration assemblage of actinolite, saussurite, biotite and opaques. The rock lacks the ophitic texture typical of the gabbros and may have originally contained primary amphibole.

The gabbros of Unit 3 are provisionally correlated with the Shabogamo Intrusive Suite of the Gabbro Lake area, dated at 1385 Ma (Brooks *et al.*, 1981).

STRUCTURE AND METAMORPHISM

The entire area has been affected by the Grenvillian Orogeny. Foliations and gneissosity produced during this event have undulatory east-west trends and steep southerly dips. Cataclastic fabrics present in the northern part of the area may be related to northerly directed, high angle overthrusts. Open folding in the granitoid and Unit 1 gneisses is due to a late period of Grenvillian deformation about north-south axes. This fold generation generally becomes more intense to the south and west of the area (Wardle and Britton, 1981).

Metamorphic grade increases from greenschist facies in the north to middle amphibolite facies in the south.

The gneisses of Unit 1 have clearly been strongly metamorphosed together with the granitoid gneisses of Unit 2, presumably in the Grenvillian Orogeny. Evidence from the area to the east, however (Thomas, 1981), suggests a minimum age of 1650 Ma for the high grade metamorphism in the gneisses. It is possible, therefore, that these gneisses have been through a Hudsonian or early Paleohelikian event prior to granitoid intrusion and subsequent Grenvillian metamorphism. Any fabric evidence of this early event within the Sona Lake map area must have been obliterated during Grenvillian deformation and metamorphism.

AREA B - BAIKIE LAKE-PANCHIA LAKE AREA (23H7, H8W, H2)

Previous reconnaissance mapping (Eade, 1952) indicated a narrow belt of amphibolite, chlorite schist and garnet-biotite gneiss extending through Ossokmanuan and Panchia Lakes. In later compilation work by Greene (1970), this belt was inferred to separate a southwestern terrane of metasedimentary gneisses derived from Aphebian rocks; from a northeasterly terrane of gneisses derived from Helikian rocks. The possibility of a major structural break, or lineament, extending through the Ossokmanuan - Panchia Lake and Atikonak River system was supported by the regional aeromagnetic map (Geological Survey of Canada, 1974) which shows a pronounced contrast in aeromagnetic relief and trend across the lineament.

GENERAL GEOLOGY

As a result of the 1981 mapping (Figure 3) it is evident that the major part of the area is underlain by metasedimentary gneisses (Unit 1). These occur in two blocks separated by the Ossokmanuan Lake - Atikonak River lineament, and by a belt of granitoid gneisses (Units 2 and 3). Intrusive into both metasedimentary and granitoid gneisses are a series of gabbroid bodies related to the Shabogamo Intrusive Suite (Unit 4). A later series of granitic intrusions is represented by Units 5, 6 and 7.

The belt of mafic rocks mapped by Eade (1952) along Panchia Lake and Atikonak River could not be substantiated. The scattered exposures of gabbroid rocks which do occur along these waterways belong to small bodies of the Shabogamo Intrusive Suite and the major part of the waterway is apparently underlain by gneissic rocks of Units 1 and 2.

Unit 1 - Metasedimentary gneisses

The gneisses of this unit are similar in general field appearance to those of Unit 1 in Area A, and are connected with that area by a belt of metasedimentary gneisses lying south of the Churchill and Unknown Rivers. Gneisses immediately south of the Unknown River in the northeastern corner of the area are kyanite bearing (1a) and pass southwards into sillimanite gneisses (1b). An approximate isograd has been drawn at the first appearance of sillimanite (Figure 2). However, metastable kyanite persists south of the isograd for several kilometres.

Muscovite bearing gneisses (1c) with minor fibrolite occur immediately south of Ossokmanuan Lake. Muscovite in these rocks is in arrested reaction with quartz to produce sillimanite (fibrolite) and K-feldspar. To the south, muscovite is absent and microcrystalline sillimanite is abundant. A further sillimanite isograd is therefore inferred to exist south of Ossokmanuan Lake.

The gneisses are apparently continuous with similar gneisses exposed to the west in the Labrador City area (Rivers, 1980, 1981). In this area the gneisses have been demonstrated to be equivalent to the Attikamagen Formation of the Aphebian Knob Lake Group (Labrador Trough); therefore, an Aphebian age is proposed for the Unit 1 protolith.

Unit 2 - Quartzofeldspathic gneisses of problematical origin

These rocks occur interspersed with the metasedimentary gneisses, and also as an isolated area of outcrop in the extensive drift covered areas east of Ossokmanuan and Panchia Lakes.

The gneisses are usually pink or gray weathering with the composition quartz-feldspar-biotite $\pm$ hornblende and garnet. Microcline is occasionally present as scattered porphyroblasts. They lack any form of compositional banding and are usually migmatitic. Leucosome development is variable and ranges from small patches of incipient

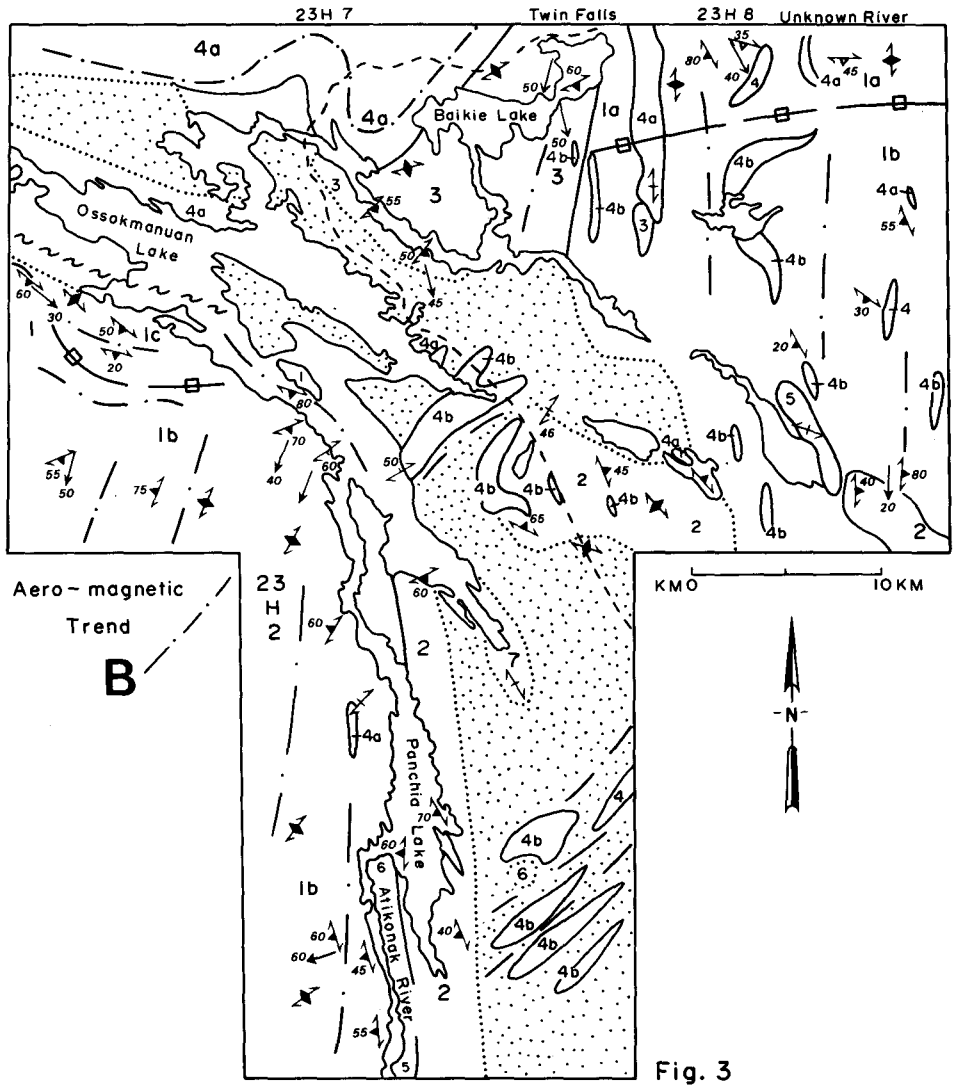


Fig. 3

LEGEND

NEO or PALEOHELIKIAN

7 Pink foliated granite

6 Foliated quartz diorite - quartz monzodiorite

PALEOHELIKIAN

5 Pyroxene bearing quartz diorite (enderbite)

4 Shabogamo Intrusive Suite

4a - metagabbro - gabbro
4b - anorthositic gabbro

3 Granodiorite - quartz monzonite granitoid gneisses

2 Quartz-feldspar-biotite gneiss of problematical origin

APHEBIAN

1a Kyanite gneiss; 1b, sillimanite gneiss; 1c, muscovite gneiss

isograd

melt to lit-par-lit vein systems. Hornblende and biotite porphyroblasts are common in the leucosome veins. In thin section, the plagioclase is characteristically strongly anti-perthitic; a feature that otherwise has only been noted in the pyroxene bearing granitoid of Unit 5. This feature, together with the massive nature of the gneisses, may indicate a plutonic origin for Unit 2. However, some of the pink quartzofeldspathic gneisses look identical in field appearance to the matrix of the sillimanite bearing gneisses and it is also conceivable that they may represent alumina deficient quartzofeldspathic gneisses of meta-sedimentary origin.

Unit 3 - Granodiorite - quartz monzonite granitoid gneisses

This is a uniform suite of gray weathering, quartz-feldspar-biotite gneisses exposed around Baikie Lake and the southern part of the Unknown River. These rocks have a predominantly granodioritic composition, ranging to quartz monzonite. Outcrop sections seen normal to lineation usually preserve relict feldspar porphyritic and seriate igneous textures. The gneisses are again variably migmatitic and commonly show two generations of leucosome; an early lit-par-lit banding developed parallel to gneissic foliation, and a later crosscutting banding parallel to axial planes of F_2 folds. Both generations are spotted with euhedral porphyroblasts of hornblende. Local merging of the two leucosome generations suggests that both were formed during one prolonged period of metamorphism, rather than two separate events.

In the vicinity of the south Unknown River the gray gneisses have been intruded by abundant pretectonic sheets of pink aplite and quartz monzonite gneiss. Some of these are possibly related to anatexis; however, the potassic intrusives are also very similar in appearance to a late granitic suite noted in previous work to the north (Unit 9 of Wardle and Britton, 1981).

The contact between Units 2 and 1 follows the course of the Unknown River north of Baikie Lake. The contact has been the locus for considerable ductile shearing and flattening, but sheets of pink aplite and augen granite gneiss in Unit 1 suggest an original intrusive relationship.

Unit 4 - Shabogamo Intrusive Suite

The major intrusion belonging to this suite is located north of Ossokmanuan Lake and consists of fresh olivine gabbro (4a) with well developed ophitic texture. Pods of coarse grained pyroxene-plagioclase gabbro are common within this subunit and weak igneous layering is also locally present. The body forms a thick folded lacolith extending 25 km west of the area to Gabbro Lake (Wardle, 1979b; Rivers, 1981). Near its margins the gabbro has been converted to hornblende-plagioclase amphibolite.

In the remainder of the area, anorthositic gabbros are the predominant representative of the Shabogamo Intrusive Suite. These are distinctive, medium to coarse grained gabbros generally of pale gray appearance. Plagioclase forms euhedral 1-2 cm long laths and is intergrown in ophitic or subophitic texture with orthopyroxene, clinopyroxene and olivine. In most cases subsolidus cooling reactions have produced coronas of garnet and clinopyroxene around mafic grains. Coronas of serpentine around olivine have also been observed and are probably the result of metamorphic hydration.

Around the margins of these bodies the ophitic and corona textures have been destroyed and the rocks hydrated to coarse plagioclase-garnet-hornblende schists.

Unit 5 - Pyroxene bearing quartz diorite (enderbite)

This unit occurs as a single elongate body in the northeastern part of the area. In outcrop the rock is a gray weathering, moderately foliated, equigranular rock of medium grain size. Neither gneissic nor relict igneous textures have been seen. In thin section the rock is composed of clinopyroxene and hypersthene intergrown with interstitial quartz and antiperthitic plagioclase. The unit appears to be of plutonic origin; however, its relationship to other intrusive rocks in the area is not clear.

Unit 6 - Foliated quartz diorite-monzodiorite

This unit forms a single intrusive body located along the Atikonak River. The unit is typically medium grained and has a brown or gray hue due to feldspar coloration, and locally contains microcline megacrysts. Plagioclase and orthoclase feldspar occur intergrown with interstitial quartz and felted aggregates of biotite, opaque and garnet. These aggregates can locally be seen to be replacing orthopyroxene and the unit may be genetically related to Unit 5. Shearing along the Atikonak River has locally converted the rock to augen schist.

Approximately 2 km south of the map area rocks similar to Unit 6 contain numerous xenoliths of sillimanite gneiss, indicating an intrusive relationship with Unit 1. This is consistent with the lack of high grade metamorphic fabrics in Unit 6.

Unit 7 - Pink foliated granite

An outcrop area east of the north end of Panchia Lake consists of pink, fine grained leucocratic granite. The major part of these outcrops are only moderately foliated; locally, however, the foliation takes on a convoluted gneissic character associated with thin pegmatitic leucosome veins. A third outcrop east of the south end of Panchia Lake consists of pink gneissic granite which may be a more strongly metamorphosed variety of the above rock types.

The moderately foliated granites appear structurally younger than the Unit 1-3 gneisses. The local appearance of gneissic texture suggests that they may be anatectic granites produced from these gneisses.

STRUCTURAL HISTORY

The gneisses of Units 1-3 are characterized by regional north- south structural trends, also apparent on the aeromagnetic map of the area (Geological Survey of Canada, 1974). In outcrop, this structural trend can usually be seen to be a vertical composite fabric which has been produced by tight to isoclinal folding of gneissic banding. Ductile shearing associated with this folding has locally imparted a flaggy, schistose texture to the gneisses, a feature which is particularly apparent along the Atikonak River.

The style of migmatization seen in the Unit 1 gneisses is very similar to that described from Area A, with migmatite veins occurring parallel to F_2 fold axial planes and the composite fabric. This is also similar to the structural style seen in the Unit 1 and 2 gneisses, and there is, as yet, no reason to suppose that all gneiss units were not formed in the same event. The Shabogamo Intrusive Suite also appears to have undergone the same deformational and structural history, although this is by no means confirmed. The *circa* 1400 Ma age for this suite (Brooks *et al.*, 1981) implies a Grenvillian age for the metamorphism and deformation of Units 1-4 (and possibly Unit 5). This conflicts, however, with the pre-1650 Ma age established for the metasedimentary gneisses (Disappointment Lake Gneiss) similar to Unit 1 in the Red Wine Mountains area (Thomas *et al.*, 1981).

The most obvious explanation for this discrepancy is that the pre-Grenvillian event of the Red Wine Mountains area dies out to the west and was not recorded in the Churchill Falls Region. It is also conceivable that Grenvillian orogenesis has been more intense in this region and that earlier fabrics have simply been obliterated. At present, the former hypothesis seems more logical since the southerly extrapolation of the 'Hudsonian Front' of the Churchill Province lies between the Churchill Falls and Red Wine Mountains regions. In this case, Hudsonian metamorphism would be expected to increase in intensity from west to east.

Intrusion of Unit 6 apparently occurred after metamorphism of Unit 1, but prior to shearing along the Atikonak River. Unit 6 would therefore appear to be a late Grenvillian intrusion. Unit 7 may have been produced by anatexis during the climatic stage of Grenvillian metamorphism.

METAMORPHISM

Metamorphic conditions during formation of the Unit 1 gneisses varied from middle amphibolite facies conditions in the north of the area, to upper amphibolite facies south of the sillimanite isograds. The presence of textures indicative of partial melting in the kyanite gneisses suggest that this occurred at pressures of over 6 kb (*i.e.*, over 22 km depth) and at temperatures of over 650^{o}C (Winkler, 1974).

Gneisses of Units 2 and 3 lack metamorphic index minerals, but on the basis of structural similarity to Unit 1, they were probably metamorphosed under the same conditions.

The corona textures seen in the anorthositic gabbros of Unit 4 are probably premetamorphic and related to subsolidus reaction of plagioclase with pyroxene or olivine during cooling at pressures of over 6 kb (Griffin and Heir, 1974). The corona assemblages were later converted to hornblende-garnet-sodic plagioclase amphibolite facies assemblages during regional metaorphism.

Unit 5, although strongly recrystallized, appears to preserve original igneous mineralogy, including orthopyroxene. Unit 6 appears to have been metamorphosed at lower amphibolite or possibly greenschist facies conditions during late shearing.

THE ORIGIN OF THE OSSOKMANUAN LAKE - ATIKONAK RIVER LINEAMENT

From the preceeding description, it is evident that the metasedimentary gneisses of Unit 1 are similar in both lithology and structural style either side of this lineament. It follows, therefore, that this is not a particularly profound structure. The strong aeromagnetic contrast across the lineament is probably in part a function of differential exposure: the gneisses west of the lineament are well exposed and have high magnetic relief, whereas the ground to the east is deeply buried under glacial drift and has low magnetic relief. The contrast may also be enhanced by the appreciably higher magnetite content of the metasedimentary gneisses, in comparison with that of the granitoid gneisses east of the lineament.

Previous mapping to the west of the area, along Ossokmanuan Lake (Rivers, 1981), has indicated the existence of a major thrust, or high angle reverse fault, along the lake. This fault has juxtaposed kyanite bearing gneisses, similar to those of Unit 1, against greenschist grade metasediments of the Labrador Trough. The fault is believed to extend east into the map area and to separate the sillimanite gneisses south of Ossokmanuan Lake from gabbro to the north. The fault also probably accounts for the deflection of gneissic and aeromagnetic trends into east-west orientations south of the lake. East of Ossokmanuan Lake the fault is inferred

to swing south through Panchia Lake and Atikonak River where it becomes a ductile shear zone.

A provisional tectonic model for the area is proposed in which the area is divided into two thrust blocks separated by the Ossokmanuan Lake thrust and Atikonak River shear. The northern block was translated north along a series of ductile shear zones described from the Churchill Falls area to the north (Wardle and Britton, 1981). The southwestern block is only the eastern portion of a much larger lobate thrust block that is inferred to have overridden the northern block. Movement was accommodated by overthrusting along the Ossokmanuan fault and by a combination of lateral and vertical motion along the Panchia Lake - Atikonak River shear.

Thrusting clearly occurred late in the structural history of the area, following formation of the gneissic fabrics. It is possible that the predominant north-south trend of gneissic fabrics in both thrust blocks is due to lateral east-west directed constrictive stresses set up during northward movement of the thrust blocks.

AREA C - SANDGIRT - LOBSTICK - HOOK BAY AREA (23H/14E, H/15, H/16)

This area lies at the junction of the Churchill and Grenville structural provinces. The northern limit of Grenvillian deformation trends east-west across the northern part of the area (Figure 4).

The oldest rocks present are various granitic and minor metasedimentary gneisses of the Churchill Province which extend into the area from the north and northwest. These have been intruded by a variety of gabbroid and granitoid plutons ranging in age from very late Aphebian to early Paleohelikian. These are locally overlain with probable unconformity by Neohelikian red beds and conglomerates.

The area is particularly significant because it lies at the junction of two extensive batholith belts (Figure 5). One of these lies along the axis of the Churchill Province (Taylor, 1979), the other along the northern margin of the Grenville Province (Nunn, 1981; Thomas *et al.*, 1981; Ryan *et al.*, 1981).

ARCHEAN - APHEBIAN

Unit 1a - Tonalitic-granitic gneisses

Scattered outcrops of this heterogeneous unit occur throughout the central part of the area. In general, the rocks are white to gray weathering migmatitic gneisses of tonalitic to granodioritic composition, associated with strongly foliated to gneissic tonalites and granites. Many of the outcrops demonstrate complex structural histories in which migmatite gneiss has been intruded by several generations of pretectonic leucotonalite, granite and pegmatite dikes. Many of the gneisses also contain amphibolite pods and layers, which may occasionally be recognized as pretectonic dike remnants.

The more complex migmatitic gneisses bear general resemblance to gneisses of the Eastern Basement Complex (Wardle, 1979a), which form basement to the Labrador Trough. These are gneisses of Archean age structurally reworked during the Hudsonian Orogeny. The foliated granitoid material in Unit 1a could be either late Archean or Aphebian in age.

Unit 1b - Metasedimentary, metavolcanic gneisses

Interspersed with the granitoid gneisses are several outcrops of probable supracrustal gneiss. The only outcrop of undoubted metasedimentary origin is located in the Churchill River (H15) and consists of well banded biotite gneiss with a 1 m thick band of orthoquartzite. Other outcrops located near the western edge of H16 consist of finely banded felsic and mafic gneisses of possible metavolcanic origin. The age of these rocks could be either Archean or Aphebian.

Unit 1c - Metagabbro, amphibolite, amphibolite gneiss

These lithologies are found interspersed with and intrusive into outcrops of the granitoid gneisses. Rock types encountered vary from metagabbro with relict igneous texture and layering, to hornblende amphibolite and amphibolite gneiss. All types are usually intruded by pegmatite and foliated granite. Amphibolite gneisses are commonly migmatitic. This unit probably includes a variety of protolith ages. Metagabbros exposed on an island in Sandgirt Lake intrude the metaarkoses of Unit 1e and are clearly of Aphebian age. As such they probably represent a southern extension of the Montagnais Group gabbro sills of the Labrador Trough (Wardle, 1979a). Similar metagabbros elsewhere in the map area may be of the same age. The amphibolites and amphibolite gneisses may be more

highly metamorphosed varieties of these rocks or alternatively could be derived from Archean intrusives.

Unit 1d - Ultramafic

One occurrence of deformed ultramafic, probably pyroxenite was found in H16. Peridotite is also locally seen as cumulate bands in metagabbros of Unit 1c.

Unit 1e - Meta-arkose and minor biotite gneiss

This unit is restricted to an island in Sandgirt Lake where it consists of pink, recrystallized meta-arkoses with sparse interbands of quartz pebble conglomerate. Bedding and crossbedding are well preserved, albeit in a highly opressed state. With the exception of these features, metamorphic recrystallization has destroyed all sedimentary textures and imparted a granitic appearance to the rock. Bedding is tightly folded with a strong axial planar muscovite foliation. Small patches of granitic mobilizate apparently indicate incipient partial melting.

Along the south shore of the island the meta-arkoses grade locally into banded biotite gneisses, probably developed from pelitic intervals within the arkose sequence.

The meta-arkoses are correlated with the Aphebian Seward Formation arkoses and granule conglomerates of the Labrador Trough, which occur 25 km northwest of the map area. The unit is intruded by folded metagabbro sills and dikes of Unit 1c which, as noted previously, are believed to correlate with the Montagnais Group sills of the Labrador Trough.

LATE APHEBIAN - PALEOHELIKIAN. THE GRANITOID SUITE

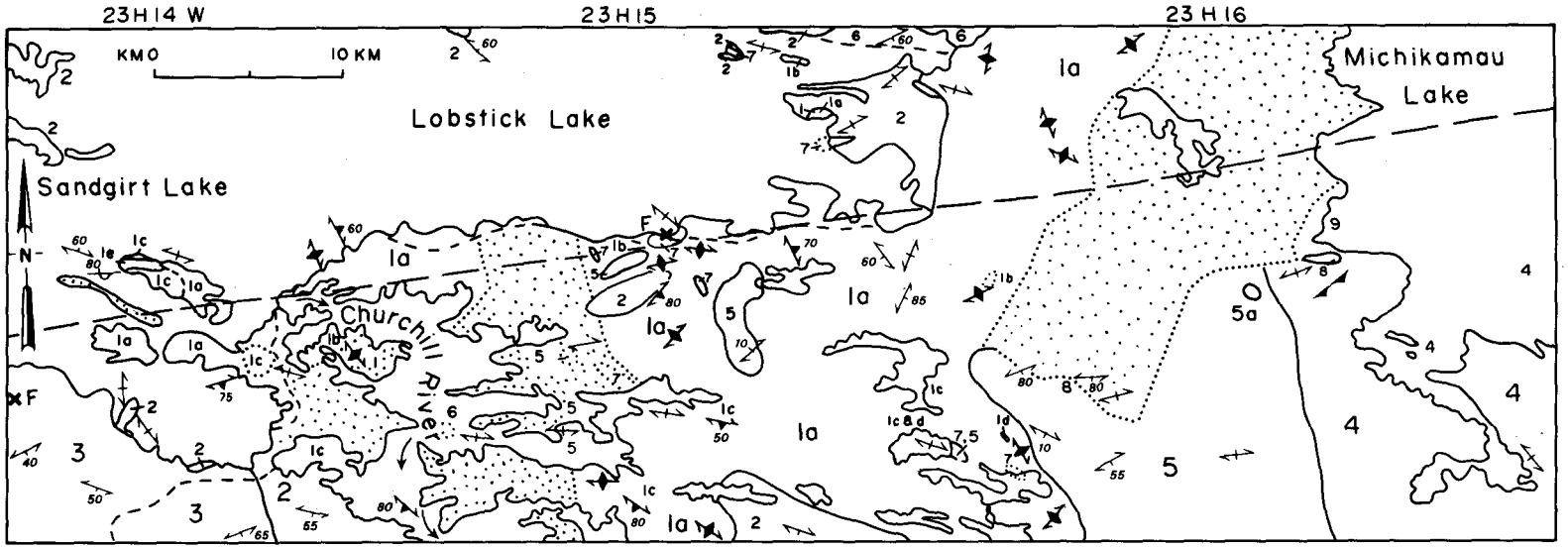
Unit 2 - Megacrystic granite

This unit is sparsely exposed around the south shore of Sandgirt Lake, and on the east side of Lobstick Lake. A megacrystic granite located on the southern margin of H15 is also provisionally included in Unit 2.

In outcrop, the unit is a gray weathering, coarse grained, megacrystic rock generally of granite composition. Variation in the K-feldspar megacryst content produces local compositional changes to quartz monzonite and granodiorite. Where deformed the unit becomes reddened and may be difficult to distinguish from Unit 4. The megacrysts, which vary in size from 2 to 4 cm, are generally orthoclase and are set in a coarse groundmass of plagioclase and interstitial quartz. Mafic mineralogy within the map area consists of biotite, with or without hornblende, intergrown with epidote and secondary chlorite. North of the area the unit contains primary orthopyroxene partly altered to amphibole.

The unit also characteristically contains numerous xenoliths of various types of diabase, gabbro and amphibolite. Some of the xenoliths are entrained and may be the boudinaged remains of synplutonic dikes.

Around the south shore of Lobstick Lake, the granite contains small diffuse screens of Unit 1 granitoid gneiss. The granite must intrude these rocks but contacts are blurred by the metasomatic overgrowth of K-feldspar megacrysts in the gneisses. All variations may be recognized between granite gneiss and a megacrystic 'granite' with a gneissic



C

Fig. 4

3 Pink, plagioclase porphyritic monzonite and microgranite

2 Gray megacrystic granite
2a - pink granite

ARCHEAN-APHEBIAN

1 1a - Tonalitic-granitic gneisses, foliated granitoid

1b - Metasedimentary, meta-volcanic gneiss

1c - Metagabbro, amphibolite, amphibolite gneiss

1d - Ultramafic

1e - Meta-arkose and minor biotite gneiss

NEOHELIKIAN

9 Pink sandstone and siltstone

8 Polymictic conglomerate

PALEOHELIKIAN-LATE APHEBIAN

7 Diabase-gabbro-diorite, commonly net veined and amphibolitized

6 Fine grained gray grano-diorite-tonalite

5 Pink, equigranular granite, quartz monzonite, micro-granite; 5a, felsite

4 Pink megacrystic quartz monzonite

F Fluorite occurrence

Northern limit of Grenvillian deformation

matrix. Similar metasomatic effects have been observed west of the map area along the Atikonak River (Wardle, 1979b). Alignment and augening of the megacrysts in contact regions indicates synkinematic intrusion of Unit 2.

Intrusive into the megacrystic granite are late phases of pink, medium grained, granite and associated aplite (2a). These have also locally been intruded by synplutonic mafic dikes.

The granodiorite and associated granites form the southern tip of an extensive batholith extending along the axis of the Churchill Province. On the geological map of Labrador (Greene, 1970), this is shown as a Paleohelikian body belonging to the Elsonian adamellite suite (*circa* 1460 Ma). However, K-Ar dates by Taylor (1979) indicate a late Hudsonian age of *circa* 1620 Ma. This is supported by the presence of biotite and megacryst alignment fabrics indicative of syntectonic emplacement.

Unit 3 - Porphyritic quartz monzonite and microgranite

This unit is confined to the southwest corner of the map area where it comprises a distinctive pink weathering, plagioclase phyric, quartz monzonite. Plagioclase phenocrysts vary from 0.5 - 2 cm and are usually saussuritized to a pale green colour. The phenocrysts are set in a groundmass of K-feldspar, minor quartz and biotite. Associated with the unit are areas of pink microgranite, probably forming late intrusive phases.

Rb-Sr whole rock dating of the unit has been attempted and yielded a very poorly defined errorchron of *circa* 1700 Ma (C. Brooks, personal communication).

Unit 4 - Megacrystic quartz monzonite

This unit is found south of Lake Michikamau in H16 and forms part of a large pluton centered on the area east of the lake (see Nunn and Noel, this volume). The unit is also equivalent to Unit 2a of Area A. The quartz monzonite, varying locally to quartz syenite and granite, is generally pink weathering and megacrystic with 1-3 cm diameter K-feldspars. The megacrysts are set in a coarse grained matrix of plagioclase, interstitial quartz, biotite and hornblende. Sphene, magnetite, apatite and epidote form common accessory phases, usually intergrown with biotite or hornblende. The unit is distinguished from the similar lithology of Unit 2 by its pink colouration, smaller megacryst size, and paucity of mafic inclusions.

Preliminary Rb-Sr dating of this unit in the east Lake Michikamau area (Nunn and Noel, this report) has yielded an errorchron age of 1715 $\pm$ 100 Ma (Brooks, personal communication). As noted previously, this age conflicts with a 1525 determination on volcanics intruded by the pluton (see Nunn and Noel, this volume).

Unit 5 - Granite-microgranite-quartz monzonite

This heterogeneous unit occurs as a belt adjacent to Unit 4, where it is contiguous with Unit 2b of Area A; and as an isolated sequence of outcrops south of Lobstick Lake. Typical lithologies are pink, fine to medium grained granites, microgranites and aplites with minor amounts of quartz monzonite. Textures are usually equigranular but may locally be porphyritic, or even megacrystic, with K-feldspar.

One example of felsite (5c), probably a hypabyssal intrusion, was noted approximately 5 km west of Hook Bay.

Unit 6 - Granodiorite and tonalite

These are chiefly exposed along the north shore of Lobstick Lake. An isolated foliated tonalite also occurs in the Churchill River on H15. The rocks

are typically gray weathering, fine grained granodiorites, containing hornblende and poikilitic biotite. Inclusions of amphibolite and cognate xenoliths of granodiorite are also found. Medium grained hornblende-biotite tonalite exhibiting a weak, northeast trending primary fabric forms two minor components of this unit in north Lobstick Lake. The age of these rocks relative to other granitoid units is unknown.

Unit 7 - Diabase, gabbro, diorite

These rocks occur as small bodies in close spatial association with the granitoid lithologies. The predominant rock type is a pale to medium gray, biotite gabbro (or diorite) varying in texture from coarse diabase to medium grained gabbro. The rock is generally fresh or weakly foliated and contains stubby plagioclase laths enclosing clinopyroxene which is partially or almost completely altered to amphibole (hornblende?). Dark reddish biotite forms distinctive poikilitic plates 1-2 mm long. Quartz occurs as a minor interstitial phase. The pyroxene-amphibole reaction appears magmatic rather than metamorphic and indicates a dioritic affinity for the unit. The gabbroids intrude the megacrystic granite of Unit 2 post- tectonically (*i.e.*, post-primary fabric). In other units, however, the gabbro-diorites are usually net-veined by aplite and pegmatite, and are locally amphibolitized and partially assimilated by their hosts. They appear, therefore, to have been intruded synplutonically with the major part of the granitoid suite.

In the southern part of the area where all rock types have been strongly deformed and metamorphosed, this unit is difficult to distinguish from some of the metagabbros of Unit 1c, particularly in small, poorly exposed outcrops. It is possible, therefore, that some of the Unit 1c lithologies belong to Unit 7 and vise versa.

NEOHELIKIAN

Unit 8

Polymictic conglomerate is exposed at two localities; in the central part of H16, and near the west shore of Lake Michikamau. The conglomerates are generally massive and strongly cleaved. Clasts, usually of pebble size, but ranging up to boulder size, are well rounded and set in an epidotized, gray sandstone matrix. The clasts are composed largely of aplite, epidotized gray felsic porphyry, pink felsic porphyry and microgranite, with lesser amounts of vein quartz and altered basalt. Rare clasts of red, feldspar-phyric rhyolite and foliated tonalite have also been noted. The microgranites, aplites and porphyries are lithologically similar and appear to have been derived from a hypabyssal volcano-plutonic source. No units of this nature, with the possible exception of the Unit 5a felsite, have been observed in the area, and it appears that the source must have been higher levels of the granitoid suite, now removed by erosion.

Identical rocks have been mapped by Nunn (1981) in the east Lake Michikamau area where they are interbedded with pink sandstones equivalent to Unit 9 of this report (see below). Both lithologies are interpreted to unconformably overlie quartz monzonite equivalent to Unit 4 of this report, and to be of Neohelikian age. Nunn (1981) has further suggested a correlation with the Seal Lake Group exposed east of Lake Michikamau.

Unit 9 - Pink sandstone and siltstone

This unit is poorly exposed on the west shoreline of Lake Michikamau, where it consists of maroon to pale pink and yellow, finely crossbedded sandstone. Bedding attitudes are shallow and a moderate vertical cleavage is present. The belt of sandstones extends under the lake and is exposed on islands immediately east of the map area (Nunn,

1981) where the sandstones are interbedded with thin, red siltstone horizons. The unit may also have a considerable extent under the broad expanse of drift west of Lake Michikamau.

Late Dikes

Several fresh basalt dikes have been observed to intrude Units 1e and 7. Their trends are variable and their age is unknown.

STRUCTURE AND METAMORPHISM

The gneisses, amphibolites and metasediments of Unit 1 have been strongly deformed and metamorphosed in the Hudsonian Orogeny. Structures developed during this event are subvertical with north-south or northeast-southwest trends in the eastern part of the area, and northwest-southeast trends in the west. Folds in Unit 1e are reclined to the southwest.

Unit 2 of the granitoid suite appears to have been intruded during the late stages of the Hudsonian Orogeny. Some of the primary fabric development in Units 4 and 6 (see also Nunn and Noel, this volume) may also be related to late stage, syntectonic emplacement.

The granitoid suite is inferred to have been uplifted and deeply eroded sometime towards the end of the Paleohelikian, an event that elsewhere in Labrador coincided approximately with the close of the Elsonian intrusive event of *circa* 1450 Ma. This event does not appear to have been associated with any penetrative deformation.

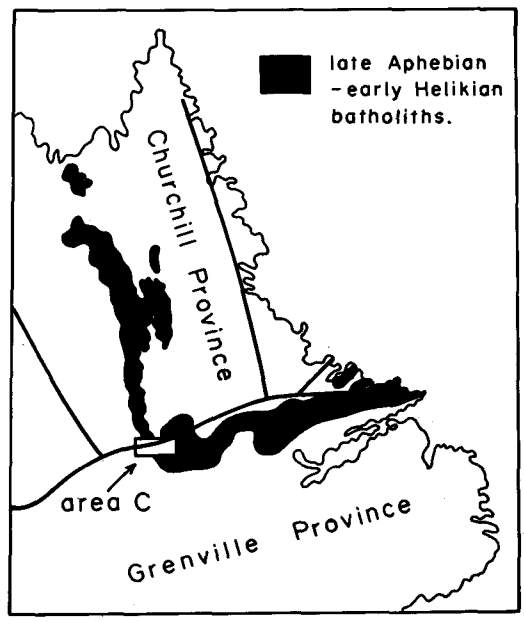
Rocks in the area south of Lobstick and Sandgirt Lakes were variably deformed during the Grenvillian Orogeny *circa* 1000 Ma. The approximate northern limit of Grenvillian foliation and cleavage is shown in Figure 4. The only effects of deformation north of this line are isolated narrow shear zones. Grenvillian structures consist of cataclastic or low grade penetrative foliations of undulatory east-west trend and steep southerly dip. Fabric trends in the gneisses are irregular, a feature which is probably due to partial reorientation of earlier structures.

Metamorphism associated with the Grenvillian deformation produced largely greenschist facies assemblages. North of the deformation limit, the metamorphism is seen as a static retrogression. South of the limit it is associated with both penetrative and cataclastic fabric development and increases from chlorite grade (chlorite-actinolite-epidote-albite assemblages) to biotite grade near the southern boundary of the map area.

DISCUSSION

As shown in Figure 5, the area lies at the junction of two batholith belts. The megacrystic granites of Unit 2 form the southern margin of the Churchill Province batholith. These rocks were apparently emplaced at fairly deep crustal levels during the waning stages of the Hudsonian Orogeny. The other granitoid units of the area represent

Fig 5



the western extremity of the northern Grenville Province batholith. These rocks generally lack the primary fabrics seen in Unit 2 and may have been emplaced immediately after the Hudsonian Orogeny in the period 1700-1600 Ma. Age dating is still in progress on many of these units. It is apparent, however, that many of the plutonic rocks in the area, previously regarded as Elsonian (in particular Unit 4; Greene, 1970, 1974) are probably early Paleohelikian or late Aphebian.

The significance of the two batholiths is not completely understood. They represent syn to post-Hudsonian batholiths and could be either the root zones of volcanic arcs or be related to crustal suturing and accretion during the terminal stages of the Hudsonian Orogeny.

MINERALIZATION

No significant mineralization has been previously recorded from the area. The only mineralization encountered during this work were minor fluorite showings in the quartz monzonites of Unit 3 and in granite intermixed with gabbro-diorite of Unit 7. However, the abundance of granitoid rocks in the area has not previously been recognized and it is possible that some of these may be worth further investigation.

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