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GEOLOGY OF THE SOUTHERN PART OF THE ARCHEAN ASHUANIPI COMPLEX, SHABOGAMO LAKE MAP SHEET (NTS 23G), WESTERN LABRADOR

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ABSTRACT

In western Labrador, the area west of the Proterozoic Labrador Trough is underlain by Archean rocks of the Superior Province. These rocks, which are mainly orthopyroxene ± garnet diatexite, metasedimentary gneiss and metatonalite, and lesser amounts of mafic gneiss and metapyroxenite, make up the southeast corner of a 90,000 km² high-grade gneiss domain named the Ashuanipi Complex. In the study area, field relations indicate that the diatexite intruded the metasedimentary gneiss and metatonalite after these units had already attained peak granulite-facies conditions, as opposed to a model of diatexite petrogenesis involving a progressive migmatization and in situ derivation from the surrounding rocks. Examination of structural, metamorphic and intrusive relations indicates several ages of migmatization and folding, although these events are all inferred to have occurred during one, late Archean tectonothermal event.

Reconnaissance-scale geochemical studies have shown anomalous gold values from lake-sediment and local bedrock samples in the Ashuanipi Complex, and although no specific gold targets were located in 1991, the Ashuanipi Complex has some exploration potential.

INTRODUCTION

PURPOSE

In 1991, a systematic 1:100 000-scale mapping program in the Archean Ashuanipi Complex, which forms the southeastern edge of the exposed Superior Province, was conducted in western Labrador. Mapping occurred in NTS 23G (Figure 1), including NTS 23G/7, 10, 11, 13, 14 and 15. Mapping was accomplished by helicopter-supported traverses and ground traverses; these being mainly conducted from a base camp on the Churchill Falls–Esker road.

Prior to the 1991 field season, this area had only been covered by small-scale, reconnaissance mapping, hence the geology was not known in adequate enough detail to meet current exploration needs. The purpose of the 1991 mapping program was to meet these needs by mapping the distribution of rock units and major structures. The results of this field program will provide a regional geological context for the gold reconnaissance investigation of the Ashuanipi Complex carried out by the Newfoundland Department of Mines and Energy in the 1980's, and earlier, lake-sediment geochemistry programs carried out jointly with the Geological Survey of Canada. Gold mineralization discovered in high-grade supracrustal rocks of the Ashuanipi Complex north of Schefferville, Quebec (Lapointe, 1986), and gold occurrences in other high-grade Archean terranes (e.g., Böhmke and Varndell, 1986; Barnicoat *et al.*, 1991) suggest that this area could have comparable economic potential. This study will also make a contribution to the overall understanding of structural, metamorphic and intrusive relations in this part of the Ashuanipi Complex.

PREVIOUS INVESTIGATIONS

The area has been previously covered by 1":4-mile-scale mapping by Stevenson (1964) and Fahrig (1967). Parts of the area have also been given a cursory examination by Rivers (1985b, c) as part of 1:100 000-scale mapping of the Early Proterozoic Knob Lake Group and younger Proterozoic sedimentary and intrusive rocks, which occur to the east and south of the map area. The area has also been covered by a regional-scale, lake-sediment geochemistry program (Geological Survey of Canada, 1982a, b) and subsequent gold-related studies by Thomas and Butler (1987), Butler (1987), McConnell *et al.* (1987) and McConnell and Newman

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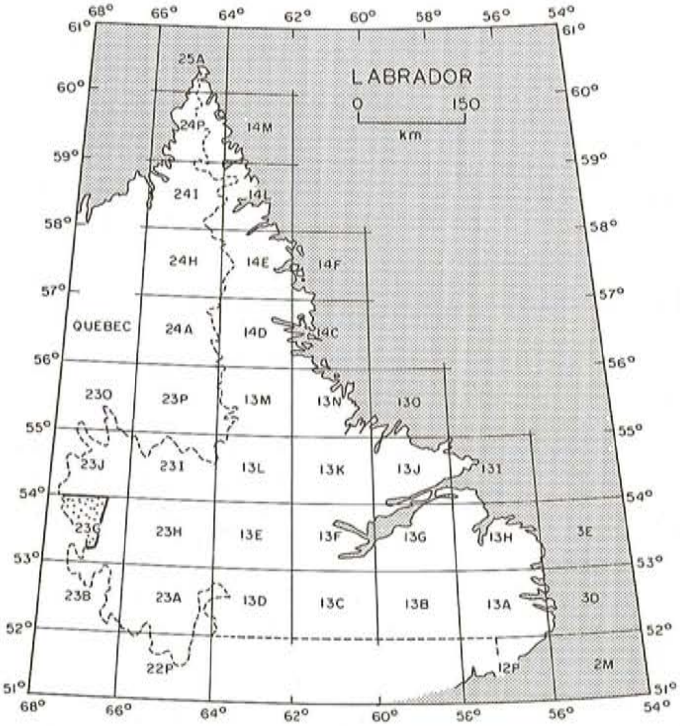

Figure 1. *Index map of Labrador showing the location of the map area (stippled).*

(1988), which concentrated on locating the source of geochemical anomalies discovered during the regional, lake-sediment geochemistry program.

The area mapped in 1991 represents a southward continuation of the 1:125 000-scale mapping of the Ashuanipi Complex in NTS 23J by Percival (1987, 1989) and Percival and Girard (1988). Prior to Percival's work, the Ashuanipi Complex in NTS 23J had been mapped at a scale of 1":4 miles by Frarey (1961) and Stevenson (1963), and farther north, in NTS 23O, by Baragar (1967).

To the southwest of the present study area, parts of the Ashuanipi Complex in Labrador have been mapped by Rivers (1985a).

GENERAL GEOLOGY

REGIONAL SETTING

The Archean rocks mapped in 1991 occur along the southeastern margin of the exposed Archean Superior Province and form part of a 90,000 km² high-grade gneiss domain that is mainly in Quebec (Figure 2). As a result of the initial reconnaissance mapping of this domain in western Labrador in the 1950's and 1960's, which was conducted as part of more detailed investigations of the iron-ore-bearing Lower Proterozoic sedimentary rocks of the Labrador Trough, the Archean metamorphic and intrusive rocks of the Superior Province were collectively named the Ashuanipi Group by Frarey (1961). Subsequently, the rocks were renamed the Ashuanipi Complex by Fahrig (1967). Recently, Card and Ciesielski (1986) have elevated the Ashuanipi Complex to subprovince status, but the term Ashuanipi Complex is still in widespread use (e.g., Percival, 1987, 1989, 1990; 1991a; Percival and Girard, 1988; Machado and Chevé, 1991).

The Ashuanipi Complex is composed of high-grade supracrustal rocks, mainly biotite migmatite derived from greywacke, and metamorphosed plutonic rocks, orthopyroxene-bearing granitoid rocks, and minor, unmetamorphosed tonalite, granodiorite, granite and rare syenite plutons (Eade, 1966; Percival, 1987, 1989, 1990, 1991a, in press; Percival and Girard, 1988; Machado and Chevé, 1991). Most of the complex is composed of granulite-grade rocks, although there are zones of retrogression to amphibolite facies (Herd, 1978).

A sequence of events in the eastern part of the Ashuanipi Complex established by conventional and ion-probe U–Pb geochronology suggests the following Archean history:

1) deposition of sedimentary rocks at approximately 2.7 Ga (Mortensen and Percival, 1987; Chevé and Brouillette, 1991; Percival *et al.*, 1991);

2) intrusion of tonalite plutons and sills into the supracrustal rocks at 2.7–2.69 Ga (Chevé and Brouillette, 1991; Machado and Chevé, 1991; Percival, 1991a; Percival *et al.*, 1991);

3) granulite-facies metamorphism and voluminous, syn- to late syn-metamorphic orthopyroxene-bearing granodiorite (diatexite) intrusions; these are approximately constrained to the interval 2.685 to 2.650 Ga (Mortensen and Percival, 1987; Percival *et al.*, 1988; Percival *et al.*, 1991; Chevé and Brouillette, 1991);

4) initiation of cooling following peak metamorphism at 2.67–2.64 Ga (this is based on U–Pb monazite ages; Mortensen and Percival, 1987; Percival *et al.*, 1988; Percival *et al.*, 1991); the monazite ages suggest rapid cooling following the metamorphic peak (Percival, 1990);

5) intrusion of late pegmatites; one of which is dated by U–Pb monazite to be 2654 ± 5 Ma (Mortensen and Percival; 1987), and leucogranite dated at 2.65 Ga (Percival *et al.*, 1991);

6) post-metamorphic peak thermal events; these are dated by growth of new zircon in a diatexite at 2642 Ma (Mortensen and Percival, 1987), and monazite at 2619 ± 6 Ma (Chevé and Brouillette, 1991; Machado and Chevé, 1991), and

7) intrusion of nepheline syenite at 2625 ±3 Ma (Chevé and Brouillette, 1991; Machado and Chevé, 1991).

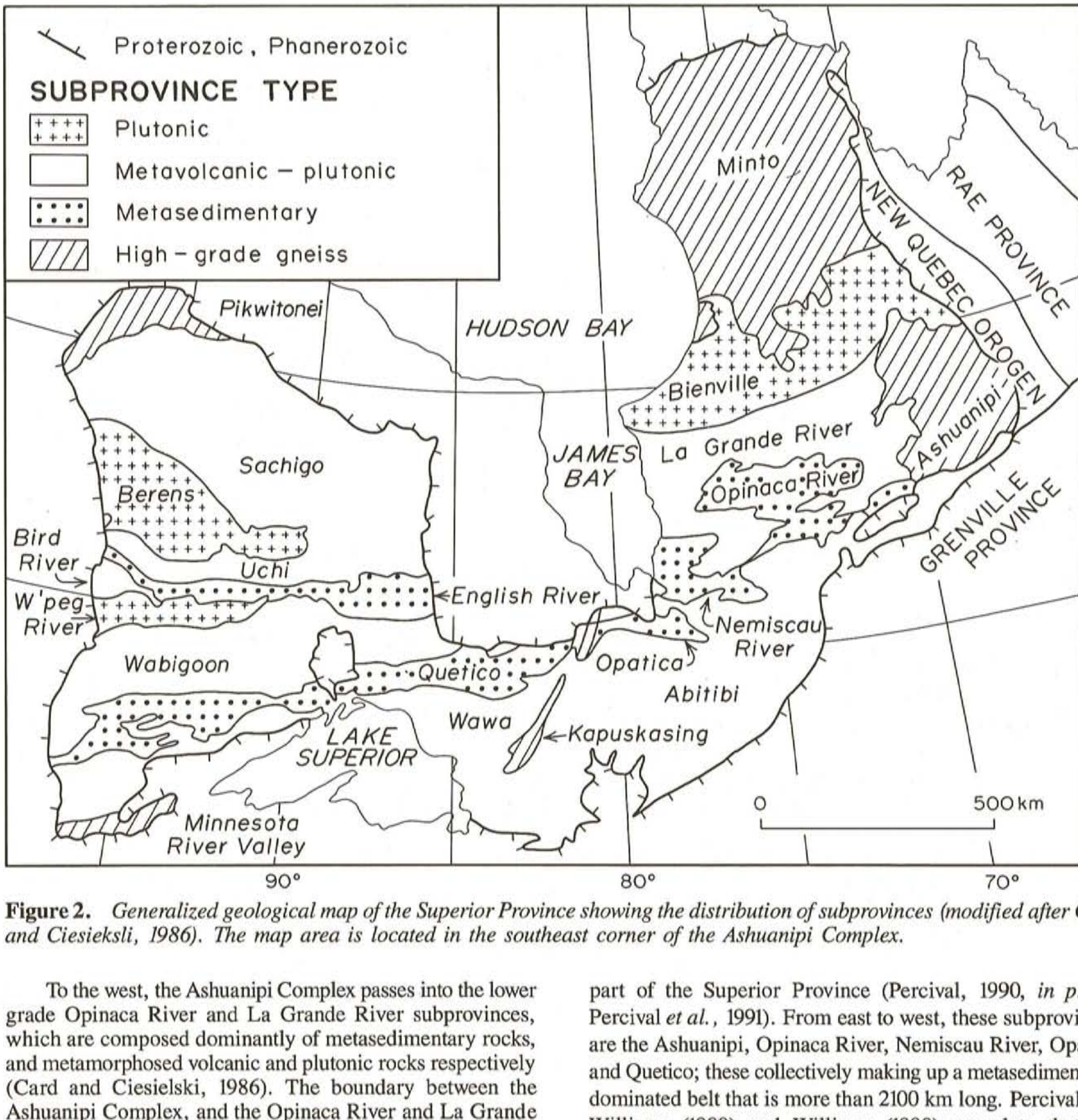

Figure 2. *Generalized geological map of the Superior Province showing the distribution of subprovinces (modified after Card and Ciesieksli, 1986). The map area is located in the southeast corner of the Ashuanipi Complex.*

To the west, the Ashuanipi Complex passes into the lower grade Opinaca River and La Grande River subprovinces, which are composed dominantly of metasedimentary rocks, and metamorphosed volcanic and plutonic rocks respectively (Card and Ciesielski, 1986). The boundary between the Ashuanipi Complex, and the Opinaca River and La Grande River subprovinces is a gradational amphibolite–granulite transition zone that has both, prograde and retrograde components (Percival, 1990). To the north, the Ashuanipi Complex is bound by the Bienville Subprovince (Card and Ciesielski, 1986), which is composed mainly of orthogneiss, but has a minor amount of supracrustal rocks (Ciesielski, 1991).

On the larger scale, Mortensen and Percival (1987) have recognized a similarity in rock types, structural style and orientation, and a synchroneity in intrusive and metamorphic events between the Ashuanipi Complex and the Quetico Subprovince of northwestern Ontario. On this basis, the Ashuanipi Complex is considered to be a continuation of the major metasedimentary subprovinces that occur in the central part of the Superior Province (Percival, 1990, *in press;* Percival *et al.*, 1991). From east to west, these subprovinces are the Ashuanipi, Opinaca River, Nemiscau River, Opatica and Quetico; these collectively making up a metasedimentary-dominated belt that is more than 2100 km long. Percival and Williams (1989) and Williams (1990) speculate that the Quetico Subprovince developed as a sedimentary prism between accreting volcanic arcs.

To the east, the Ashuanipi Complex is unconformably overlain by the Early Proterozoic Knob Lake Group (Frarey and Duffell, 1964) of the Labrador Trough. Along the southeastern and southern boundary of the Ashuanipi Complex, the Ashuanipi Complex–Knob Lake Group contact is a Grenvillian-age thrust fault, along which the Knob Lake Group rocks are thrust over the Ashuanipi Complex (see Rivers, 1983, 1985a, c; van Gool *et al.*, 1987, 1988; Brown, 1988; Brown *et al.*, 1991). Locally, the thrusting also involves the Ashuanipi Complex rocks.

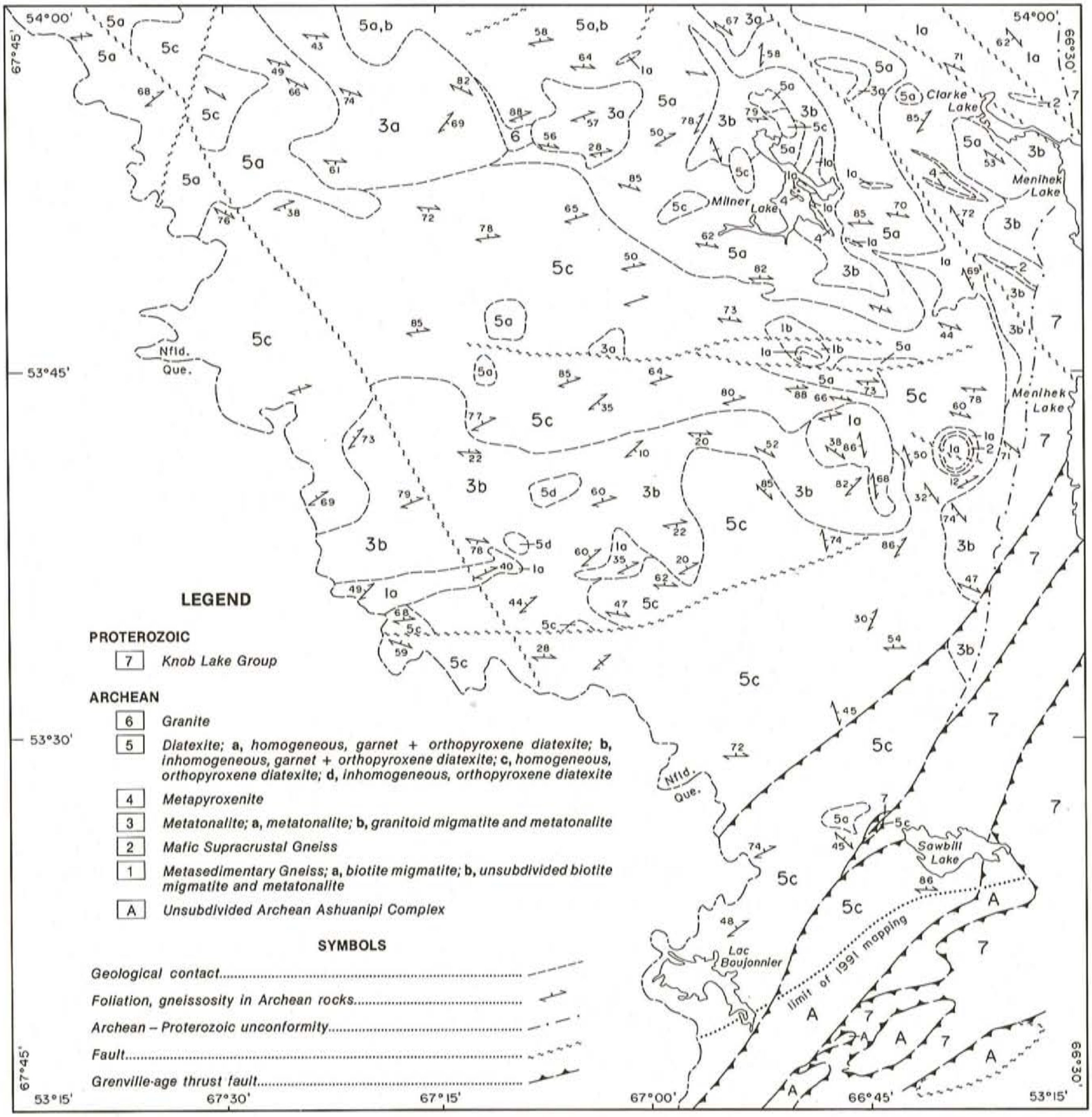

Figure 3. *Geological map of the Ashuanipi Complex in part of NTS 23G.*

UNIT DESCRIPTIONS

Metasedimentary Gneiss (Unit 1)

On the basis of intrusive relations observed in the field, the metasedimentary gneiss unit is determined to be the oldest unit in the map area (Figure 3). The unit has been subdivided into two subunits; these are biotite migmatite (subunit 1a), and unsubdivided biotite migmatite and metatonalite (subunit 1b). The biotite migmatite in the two subunits is the same rock type.

The biotite migmatite is composed of grey-, brown- or rusty-weathering restite, and white-weathering leucosome that is present in variable amounts. Locally, the unit consists of greater than 40 percent leucosome. The restite is a fine- to medium-grained, biotite quartzofeldspathic rock that commonly has both garnet and orthopyroxene porphyroblasts (Plate 1). Locally, garnet makes up more than 15 percent of the restite but it is not ubiquitous.

The biotite migmatite has two phases of white-weathering, K-feldspar-bearing leucosome that are

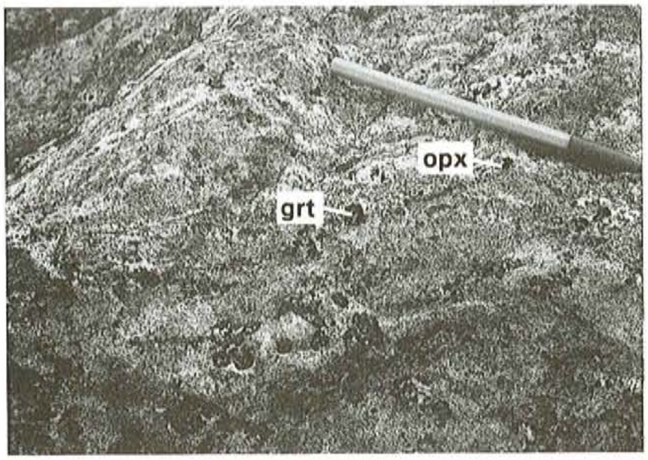

Plate 1. *Metasedimentary gneiss that has garnet (grt) and orthopyroxene (opx) porphyroblasts.*

distinguished on the basis of crosscutting relations and texture. The oldest phase occurs in closely spaced (1 to 10 cm), thin (1 to 2 cm) layers that are oriented parallel to the biotite foliation in the restite; the leucosome imparting a streaky appearance to outcrops. This phase commonly contains garnet and orthopyroxene and makes up less than 15 percent of the unit. The second phase, discordant to both the first leucosome and the biotite foliation in the restite, occurs in layers that are up to 1 m thick and widely spaced relative to the first phase. The second-phase leucosome is fine- to coarse-grained, commonly having coarse-grained feldspars, garnet and orthopyroxene. Outcrops of biotite migmatite may have up to 40 percent of the second-phase leucosome. Layers of second-phase leucosome are deformed.

Locally, the biotite migmatite has a third phase of leucosome that is also distinguished on the basis of crosscutting relations. The third phase is texturally similar to the second-phase leucosome but it does not have garnet or orthopyroxene. The third-phase leucosome is a minor component of the biotite migmatite.

Apart from variations in the amount of leucosome and minor variations in the percentages of garnet and orthopyroxene, the biotite migmatite has a homogeneous composition. These rocks are presumed to be derived from greywacke. Occurrences of mafic boudins, inferred to be derived from pre-metamorphic mafic dykes, are common in the biotite migmatite. Locally, the biotite migmatite unit has thin (1 m), pyrite-bearing zones.

Sheet-like intrusions and small bodies of metatonalite (Unit 3) occur at all scales (up to several hundred metres wide) throughout the biotite migmatite unit. In areas where the metatonalite is particularly abundant and the two rock types cannot be separated at the present scale of mapping, the rocks are mapped as subunit 1b. The contacts between subunits 1a and 1b are gradational.

Mafic Supracrustal Gneiss (Unit 2)

Interlayered locally with the metasedimentary gneiss unit are occurrences of mafic gneiss. Two areas in the northeast corner of NTS 23G/15 have mappable occurrences of these rocks.

The mafic gneiss is black-, black and white-, or rusty-weathering. Outcrops are typically very well layered, consisting of 2- to 5-cm-thick layers that are distinguished on the basis of percentage of mafic minerals, and locally, by thin layers of tonalitic leucosome. The rocks are composed of variable amounts of orthopyroxene, clinopyroxene, hornblende, biotite and plagioclase. Garnet is rare. The leucosome has biotite and orthopyroxene, and makes up less than 15 percent of the unit.

The unit contains local occurrences of sulphide-bearing rocks; these forming 1-m-thick zones that are laterally continuous for several metres in outcrop. Locally, the sulphide zones are strongly magnetic.

The mafic gneiss is presumed to be derived from mafic volcanic rocks. This interpretation is based on the field association with the metasedimentary unit. Relict volcanic features were not observed.

Metatonalite (Unit 3)

The metatonalite unit is subdivided into two subunits designated as 3a and 3b. These are composed of metatonalite (subunit 3a), and a heterogeneous subunit (3b) consisting of granitoid migmatite and metatonalite.

Metatonalite (Subunit 3a)

The metatonalite subunit occurs as sub-mappable, structurally concordant, sheet-like intrusions in the metasedimentary gneiss (Unit 1) and as larger plutons that are surrounded by diatexite (Unit 5). Contacts between the metatonalite and the metasedimentary units are sharp. The metatonalite contains few metasedimentary xenoliths. In contrast, the metatonalite–diatexite contacts are locally gradational, and the diatexite contains abundant metatonalite inclusions in areas adjacent to the contacts.

Metatonalite is structurally and texturally varied. It occurs as variably deformed, metatonalite foliate, which has coarse-grained orthopyroxene and relict igneous textures, and as variably recrystallized, orthopyroxene-bearing metatonalite migmatite.

Most of the occurrences of metatonalite that are within the metasedimentary gneiss unit are metatonalite foliate. These are not shown on the map because of their small size. The metatonalite foliate is white to grey-weathering and fine- to medium-grained having medium- to coarse-grained (to 2 cm), elliptical, inclusion-rich orthopyroxene grains (Plate 2). Based on detailed petrography and mineral chemistry of similar metatonalite from the contiguous Schefferville map sheet (NTS 23J), Percival (1991a) has concluded that the plagioclase- and quartz-inclusion-rich orthopyroxene grains are relict igneous oikocrysts. The rocks also contain minor

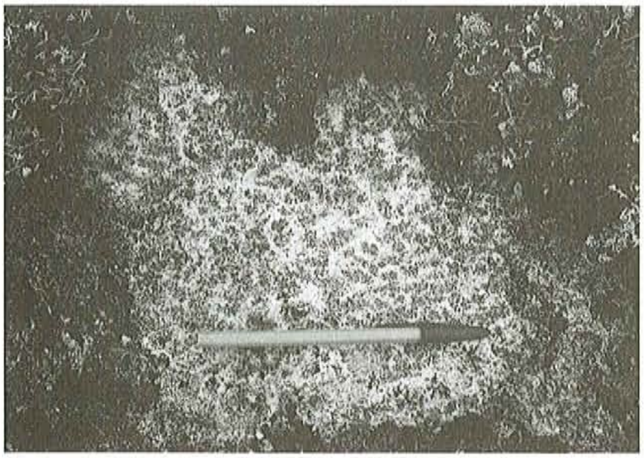

Plate 2. *Typical field aspect of metatonalite (subunit 3a) having coarse-grained orthopyroxene oikocrysts.*

biotite and local garnet. In rare occurrences, the orthopyroxene oikocrysts define layering in the metatonalite that is inferred to be relict igneous layering. The presence of igneous orthopyroxene in these rocks suggests that the tonalite was fractionated from relatively anhydrous magma, possibly in an environment analogous to a Phanerozoic magmatic-arc (Percival, 1991a).

Occurrences of subunit 3a that form the larger metatonalite bodies in the map area are composed of metatonalite foliate, identical to the rocks described above, and as tonalite migmatite. The migmatitic rocks are highly varied in texture and composition. They are variably deformed and recrystallized, and composed of orthopyroxene, common clinopyroxene, plagioclase, biotite, and have up to 30 percent orthopyroxene- and biotite-bearing leucosome. Locally, rocks have two phases of deformed, orthopyroxene-bearing leucosome; these being distinguished on the basis of crosscutting relations. Orthopyroxene occurs in the restite and the leucosome mainly as blocky, equant grains that are inferred to be metamorphic orthopyroxene, and less commonly in the restite as coarse-grained igneous oikocrysts. The rocks contain local garnet. The subunit also contains minor, migmatitic metadiorite and metagabbro. Locally, in the mafic rocks, mafic minerals define compositional layering that may represent relict igneous layering.

The subunit also has a few occurrences of massive to weakly foliated, clinopyroxene-bearing metatonalite. Contact relations between these rocks and the other rocks in subunit 3a were not observed. The clinopyroxene-bearing metatonalite has been correlated with subunit 3a on the basis of rock type, although preservation of a phaneritic texture and the absence of a strong foliation suggests that it may be younger than other Unit 3 rocks.

On the basis of similarity of both rock types and relative age relations, the metatonalite is correlated with the metatonalite that occurs in the contiguous Schefferville map sheet (NTS 23J) mapped by Percival (1989). The U–Pb geochronological studies of the metatonalite in the Schefferville map sheet area indicates igneous crystallization at approximately 2690 Ma; this predates the regional granulite-facies metamorphism by approximately 20 Ma (Percival, 1991a).

Granitoid Migmatite and Metatonalite (Subunit 3b)

Occurrences of granitoid migmatite and metatonalite make up a heterogeneous unit that is designated as subunit 3b. This subunit is distinguished from the metatonalite (subunit 3a) in that it consists of several rock types that have a compositional range from granite to tonalite; the composition being varied down to the metre-scale within subunit 3b. The metatonalite component of subunit 3b is identical to the migmatitic tonalite in subunit 3a, and makes up at least 50 percent of subunit 3b. Contact relations between the different rock types in subunit 3b are equivocal, and they could not be separated at this scale of mapping. Subunit 3b also has common occurrences of leucogranite sheets (Plate 3) and local inclusions of both metasedimentary gneiss (Unit 1) and mafic supracrustal gneiss (Unit 2). The diatexite (Unit 5) has xenoliths of subunit 3b rocks.

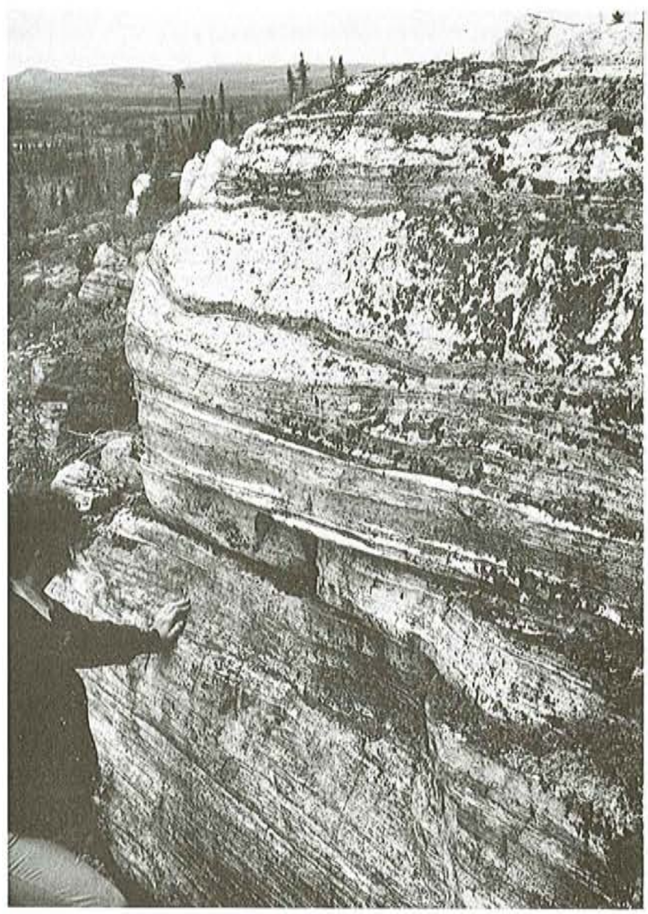

Plate 3. *Granitoid migmatite (subunit 3b) having sheet-like intrusions of deformed and recrystallized leucogranite.*

The granitoid migmatite rocks are varied from pink- to grey- to rusty-weathering. They are composed of fine- to medium-grained restite and one or two phases of leucosome, which make up less than 40 percent of the unit. Restite is commonly orthopyroxene-bearing and biotite is ubiquitous. The first phase of leucosome is fine grained and occurs as thin (1 to 5 cm), biotite- or biotite and orthopyroxene-bearing layers. The second phase of leucosome is coarser grained and occurs in layers that are up to 1 m thick; these being discordant to the first phase of leucosome. The second phase of leucosome commonly contains orthopyroxene and biotite, and local magnetite. Both phases of the leucosome are deformed.

Sheet-like intrusions of pink- and white-weathering leucogranite are a common occurrence in the granitoid migmatite subunit; locally, these make up to 20 percent of the subunit. The 1- to 3-m-thick intrusions are discordant to both phases of the leucosome and to the foliation in the restite but are themselves recrystallized and deformed.

Metapyroxenite (Unit 4)

Deformed metapyroxenite dykes and pods occur within both the metasedimentary gneiss (Unit 1) and the metatonalite (Unit 3). They are most common in the northeast corner of NTS 23G/15, where the unit forms dykes in the metasedimentary gneiss. The maximum thickness of a metapyroxenite dyke is postulated to be approximately 250 m although contacts with the surrounding metasedimentary gneiss could not everywhere be precisely located in the field. Local occurrences of small, metapyroxenite inclusions also occur in both the metasedimentary gneiss (Unit 1) and the diatexite (Unit 5) throughout the map area. In the metasedimentary gneiss, the inclusions are interpreted to be relicts of deformed pyroxenite dykes, whereas in the diatexite, the inclusions are inferred to be deformed xenoliths.

The rocks are black-, dark green-, or dung brown-weathering. They are varied from fine to coarse grained, and from massive to foliated. Locally, the rocks are gneissic having fine-scale (less than 1 cm thick) metamorphic layering that is defined by variations in percentage of mafic minerals. The rocks are composed dominantly of coarse-grained clinopyroxene and orthopyroxene, and lesser plagioclase, biotite and possible amphibole. Local olivine is suspected.

These rocks are interpreted to be derived from pre-metamorphic pyroxenite dykes that intruded both the supracrustal rocks and the metatonalite (Unit 3).

The metatonalite (Unit 3) and the metapyroxenite (Unit 4) are correlated with Percival's (1991a) Desliens igneous suite on the basis of similarity of rock types and relative age relations.

Diatexite (Unit 5)

Coarse-grained, orthopyroxene-bearing igneous rocks, which have compositions from granodiorite to monzogranite, are the most abundant rock type in the map area. These rocks are termed diatexites following the definition of Brown (1973), and have been subdivided in the field using the scheme of Percival (1989, *in press*), this being based on the presence or absence of garnet, and the abundance of gneissic inclusions. The subunits are: 1) homogeneous, garnet and orthopyroxene diatexite (subunit 5a), 2) inhomogeneous, garnet and orthopyroxene diatexite (subunit 5b), 3) homogeneous, orthopyroxene diatexite (subunit 5c), and 4) inhomogeneous, orthopyroxene diatexite (subunit 5d). Gneissic enclaves make up to 25 percent of homogeneous diatexite, and from 25 to 50 percent of inhomogeneous diatexite. The gneissic enclaves that are included in diatexite are dominantly metasedimentary gneiss (Unit 1) and metatonalite (Unit 3). Inclusions of mafic gneiss (Unit 2) and metapyroxenite (Unit 4) are less common. The diatexite is intruded by variably deformed, pink- or white-weathering orthopyroxene-bearing pegmatite veins, and minor, leucogranite intrusions (Plate 4).

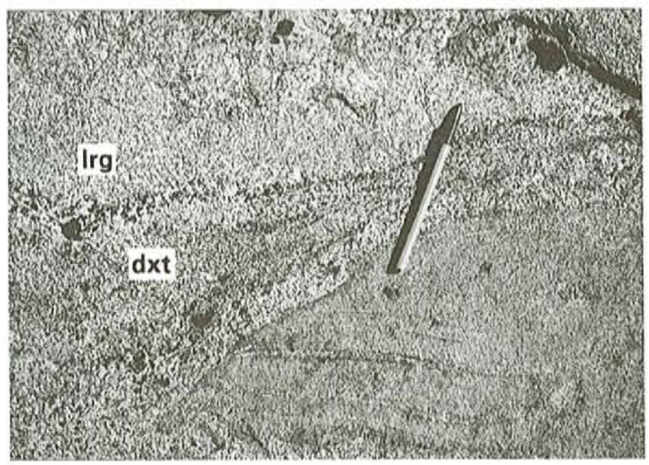

Plate 4. *Typical aspect of homogeneous orthopyroxene ± garnet diatexite (subunits 5a and 5c). Photograph shows diatexite phase (dxt) that surrounds gneissic inclusion and is itself cut by leucogranite phase (lgr).*

The contacts between the diatexite and the older rocks (Units 1 to 4) are narrow zones, at this scale of mapping, but in the field they can be somewhat gradational, consisting of zones up to several-hundred-metres wide, which have older gneiss units and abundant diatexite intrusions. However, the contacts are not transitional contacts that are suggestive of a progressive, *in situ* migmatization of the surrounding rocks. Moreover, the intrusions of diatexite are discordant to the migmatitic structure in the gneissic enclaves (Plate 5), the leucosomes of which are commonly orthopyroxene-bearing; this demonstrates that the surrounding rocks attained granulite-facies conditions prior to the intrusion of the diatexite.

Within the diatexite unit, the quantity of gneissic inclusions is locally quite variable, hence the contacts between the homogeneous and inhomogeneous diatexite subunits are commonly gradational, and the contacts shown on the map are approximate. In contrast, the contacts between the garnet-bearing and garnet-absent homogeneous diatexite appear to be sharp. In the northern part of the map area, where the

Plate 5. *Inclusion of metasedimentary gneiss in diatexite. The gneissic inclusion has an orthopyroxene-bearing metamorphic leucosome that predates the intrusion of the diatexite.*

garnet-bearing variety (subunit 5a) is most common, the garnet-absent diatexite (subunit 5c) occurs in small, discrete bodies within subunit 5a. In the central and southern parts of the map area, the orthopyroxene (garnet-absent) diatexite is dominant; there are only very minor occurrences of diatexite that have garnet.

In individual subunits, there is also local evidence of multiple phases of diatexite that can be distinguished on the basis of grain size and inclusion content. These local, outcrop-scale variations do not form mappable units at the present scale of mapping.

Homogeneous, garnet diatexite (subunit 5a) is white- to rusty-weathering having coarse-grained, K-feldspar phenocrysts and variable amounts of medium- to coarse-grained garnet (up to 15 percent) and blocky, equant orthopyroxene (Plate 6). Locally, both garnet and orthopyroxene have spongy textures that are defined by abundant quartz and feldspar inclusions. Biotite is ubiquitous, and the rocks contain local magnetite. The rocks are variably foliated but commonly the diatexite is massive, the unit having a planar fabric that is defined by flattened, elongate gneissic inclusions (Plate 7). Where the inclusions are abundant, the diatexite has a pseudo-gneissosity having a compositional layering that is defined by the inclusions.

Homogeneous, orthopyroxene diatexite (subunit 5c) is structurally and texturally similar to the garnet diatexite (subunit 5a). Subunit 5c contains up to 15 percent medium- to coarse-grained, blocky orthopyroxene, and lesser biotite and local magnetite. In the central and southern parts of the map area, this rock type has a homogeneous composition and texture over several-hundred square kilometres (Plate 8). The presence of orthopyroxene ± garnet-bearing assemblages in the diatexite indicates granulite-facies, regional metamorphism during formation of the diatexite.

Plate 6. *Typical homogeneous, garnet diatexite (subunit 5a) showing massive structure and coarse-grained texture.*

Plate 7. *Outcrop of diatexite having a foliation that is defined by flattened, elongate inclusions.*

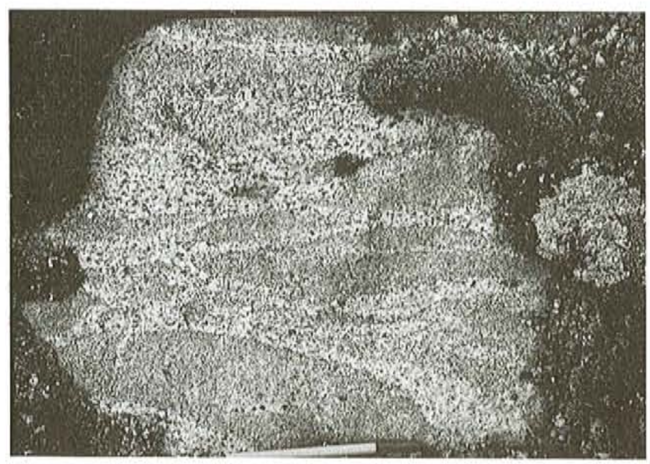

Plate 8. *Typical outcrop of inhomogeneous, orthopyroxene diatexite (subunit 5d) showing coarse-grained orthopyroxene and inclusions of orthopyroxene-bearing metatonalite.*

The non-transitional nature of contacts between the diatexite and the metasedimentary gneiss and metatonalite

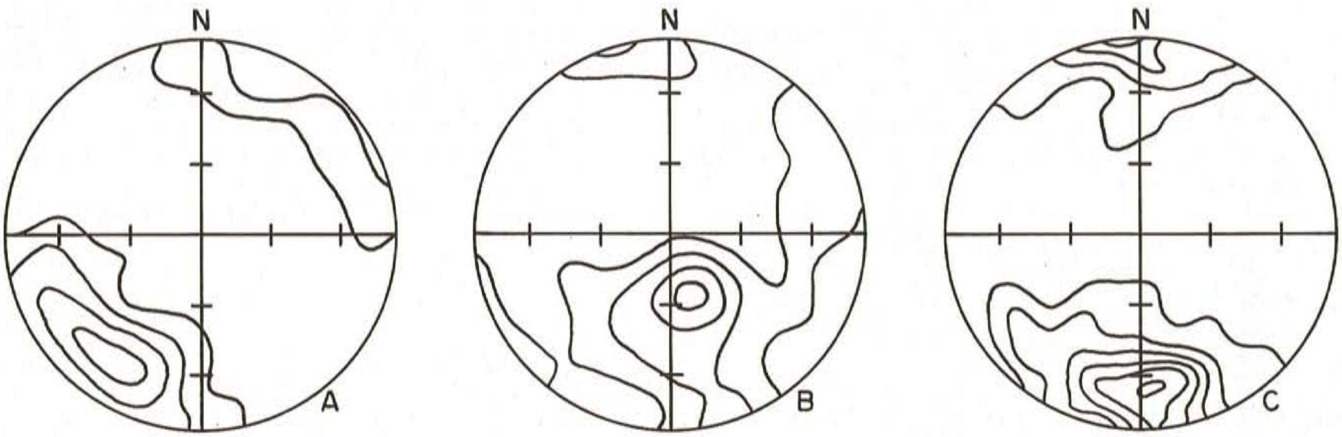

Figure 4. *Contoured, lower-hemisphere, equal area projections of poles to foliation and gneissosity. Contours are in increments of 2σ; A—Poles to foliation and gneissosity (S_1) in metasedimentary gneiss, mafic gneiss, metatonalite and metapyroxenite (Units 1 to 4) in the northern part of the map area (north of 53°45′N). n=147, σ=1.41; B—Poles to foliation and gneissosity (S_1) in metasedimentary gneiss, mafic gneiss, metatonalite and metapyroxenite (Units 1 to 4) in the southern part of the map area (south of 53°45′N). n=98, σ=1.37; C—Poles to foliation in diatexite (Unit 5) in the map area (all diatexite occurrences), n=264, σ=1.45.*

units, and the fact that the diatexite has inclusions which themselves have their own granulite-facies minerals and metamorphic textures, indicate that the diatexite was not derived from *in situ* melting of either the metasedimentary gneiss or the metatonalite. Comparative geochemistry by Percival *(in press)* has shown, however, that the peraluminous, garnet-bearing diatexite has a composition that is identical to the metasedimentary gneiss (i.e., Unit 1), suggesting that melting of metasedimentary gneiss, in a structural level that was lower than the present erosion surface, was the source of the diatexite. Less amounts of melting of the same metasedimentary gneiss source, leaving residual garnet, may account for the garnet-absent diatexite (Percival, *in press*).

The U–Pb zircon dating of diatexite plutons from the Ashuanipi Complex has yielded igneous ages of 2667 ± 1 Ma (Mortensen and Percival, 1987), 2653 ± 3 Ma (Machado and Chevé, 1991), and ages in the range 2685–2670 Ma (Percival *et al.*, 1991).

Granite (Unit 6)

All of the Archean rocks (Units 1 to 5) are intruded by isotropic to weakly foliated and variably recrystallized bodies of leucogranite. Most commonly, these rocks occur as sub-mappable, sheet-like intrusions, although they locally form elongate bodies that can be traced for several kilometres. The larger, map-scale intrusions commonly occur along prominent valleys within the diatexite unit.

The rocks are pink-weathering, typically fine- to medium-grained syenogranite to monzogranite having minor biotite and local magnetite. The massive structure and phaneritic texture suggest that these leucogranite bodies are posttectonic with respect to the main, ca. 2670 Ma metamorphism and deformation in the Ashuanipi Complex.

MAFIC DYKES

The Archean rocks are intruded by three sets of unmetamorphosed and undeformed mafic dykes of presumed Proterozoic age. The dykes are not shown on the map because of their small size. The dykes strike at approximately 055°, 270° and 355°. Occurrences of these rocks are not common in the map area.

STRUCTURE AND METAMORPHISM

A relative chronology of structural, metamorphic and intrusive events can be established for the Archean rocks in the map area based on relations observed in the field. These are summarized in this section.

Local occurrences of compositional layering in the restite of both metasedimentary gneiss and metatonalite units are the oldest structures in the map area. The layering, possibly representing relict bedding and igneous layering, respectively, is completely transposed about the principal foliation (S_1); this being defined by the peak, granulite-facies minerals, orthopyroxene and biotite, in both units. Locally, isoclinal closures of the pre-S_1 compositional layering are observed. In both units, formation of the first phase of leucosome is presumed to be approximately synchronous with the development of S_1 based on the observation that first phase of leucosome is oriented parallel to S_1, and that it contains the peak, granulite-facies assemblage of orthopyroxene, biotite, and local garnet. The principal foliation in the mafic gneiss and metapyroxenite units is also defined by granulite-facies minerals; thus it is correlated with S_1 in the metasedimentary gneiss and metatonalite units. In the northern part of the map area, S_1 in the metasedimentary gneiss, mafic gneiss, metapyroxenite, and metatonalite units is mainly northwest-striking (Figure 4a). In the southern part of the area, the S_1 attitude is varied due to the more pervasive effects of later folding (Figure 4b).

The metasedimentary gneiss commonly contains a second phase of leucosome that is discordant to both the first leucosome and S_1 but also has the peak metamorphic assemblage. In the metasedimentary rocks, the first leucosome and S_1, and to a variable extent, the second leucosome, are folded by tight to isoclinal, northwest-trending folds (Plate 9).

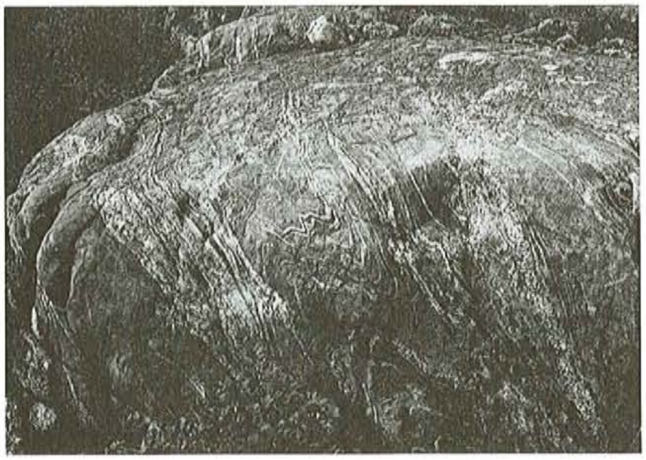

Plate 9. *Northwest-trending fold of S_1 in metasedimentary gneiss that is defined by the biotite foliation and the first phase of the metamorphic leucosome. The fold is transected by lesser deformed second-phase leucosome that is also orthopyroxene-bearing.*

Northwest-trending folds also deform S_1 and the first leucosome in the metatonalite, although the relation between the second leucosome and the folding is unresolved. The second leucosome in the metatonalite is variably deformed and contains orthopyroxene, biotite and local garnet, and has a texture and composition that is similar to the homogeneous, orthopyroxene diatexite (subunit 5c). The northwest-trending folds also deform the metapyroxenite unit.

Intrusion of diatexite postdates both S_1 and the first leucosome in the metasedimentary gneiss, mafic gneiss, metatonalite and metapyroxenite units. This relation is based on observations of inclusions in diatexite that contain both deformed S_1 and the first leucosome. The northwest trend of contacts between diatexite and older rock units in the area suggests that diatexite intrusion may have been approximately late-synchronous with respect to the formation of the northwest-trending structures (i.e., late-syn S_1).

The relation between the diatexite and the second leucosome in the metasedimentary gneiss is unresolved because there were no observed occurrences of metasedimentary gneiss inclusions within the diatexite that contained two phases of leucosome. In contrast, the second leucosome in the metatonalite may be related to the intrusion of diatexite; this based on the aforementioned similarity of rock types and textures.

The diatexite is variably foliated. It has a foliation that is most commonly defined by flattened, elongate inclusions, but also by biotite, and locally by trails of orthopyroxene in the diatexite phase itself. Throughout the map area, the foliation in the diatexite is mainly west-striking (Figure 4c). The discordance in attitude between the west-striking foliation in the diatexite and the northwest-trending structures in the older units suggests that the foliation in the diatexite postdates the northwest-trending folds of S_1 and the first leucosome in the older units. Development of the foliation in the diatexite is inferred to be approximately synchronous with formation of a set of east- to northeast-trending folds that also deform the older rock units and structures. These folds also deform minor intrusions of recrystallized and variably foliated leucogranite that occur mainly within the metatonalite and diatexite units. (These deformed leucogranite intrusions are inferred to predate the undeformed bodies of Unit 6 granite.) The superposition of these folds on the earlier northwest-trending folds has produced map-scale dome and basin structures that are most evident in the southern part of the map area, and has resulted in the preservation of metasedimentary gneiss and metatonalite in structural basins bound by diatexite.

The fact that granulite-facies minerals define an S_1 foliation that predates the intrusion of the diatexite, as well as the foliation in the diatexite itself, and that the deformed leucosomes in the supracrustal rocks and the metatonalite have orthopyroxene and garnet, indicate that the several ages of foliation development, folding and leucosome formation, and intrusion of diatexite occurred during one, granulite-facies event. The U–Pb geochronology by Mortensen and Percival (1987), Percival *et al.* (1988) and Percival *et al.* (1991) of Ashuanipi Complex rocks from north of the map area, approximately constrains the peak of this tectonothermal event to the period 2.69–2.65 Ga.

All of the Archean rock units are deformed by north-northeast-, northwest-, east-, and southeast-striking faults. These faults are consistently marked by prominent topographic lineaments but occurrences of fault rocks are rare. In the map area, the southeast-striking faults are inferred to cut the Ashuanipi Complex–Knob Lake Group contact and have a sinistral transcurrent component of displacement. North of the map area, Percival (1989) has shown that the east-striking faults also cut the Ashuanipi Complex–Knob Lake Group contact. The age of the north-northeast-striking faults is uncertain.

The northeast-striking faults are confined to the southern part of the map area. These faults are Grenville-age thrust faults that extend from the folded and thrusted Knob Lake Group rocks, a pre-Grenvillian autochthonous cover sequence, into the Ashuanipi Complex, the pre-Grenvillian autochthonous basement (see Rivers, 1983, 1985a, c; van Gool *et al.*, 1987, 1988; Brown, 1988; Brown *et al.*, 1991). Exposures of Ashuanipi Complex rocks that are deformed by these faults indicate that faulting occurred under ductile to brittle, greenschist-facies conditions. In the Ashuanipi Complex, the faults are inferred to be steep-dipping reverse faults.

ECONOMIC GEOLOGY

Gold mineralization is not commonly associated with high-grade supracrustal terranes although reported occurrences of gold by Böhmke and Varndell (1986) and Barnicoat *et al.* (1991) from Archean high-grade supracrustal terranes in Zimbabwe and Australia, respectively, suggest that the Ashuanipi Complex may be an exploration target for gold. This is supported by regional geochemical studies in the Ashuanipi Complex by the Geological Survey of Canada (1982a, b) and Hornbrook and Friske (1989), and combined geochemical and geological studies by Thomas and Butler (1987), Butler (1987), McConnell *et al.* (1987) and McConnell and Newman (1988), which showed anomalous concentrations of gold in lake-sediment and local bedrock samples. These results, combined with the reported occurrence of gold associated with metamorphosed iron formation in the Ashuanipi Complex in Quebec by Lapointe (1986), demonstrates that the Ashuanipi Complex has exploration potential.

Mapping in 1991 revealed common occurrences of minor, pyrite-bearing zones within the metasedimentary gneiss and mafic supracrustal gneiss units. Gold analyses of several of these zones yielded results that did not exceed the lower detection limit of 5ppb (approximately). There were no observed occurrences of metamorphosed iron formation in the map area.

SUMMARY

The 1991 field season involved 1:100 000-scale mapping of the Archean Ashuanipi Complex in the northern part of the Shabogamo Lake map sheet (NTS 23G). The area is composed dominantly of orthopyroxene- and garnet-orthopyroxene-bearing diatexite plutons. Field relations suggest that the diatexite is intrusive and not formed as the result of *in situ* migmatization of the surrounding gneisses. The diatexite plutons intrude metasedimentary and mafic gneisses, inferred to be derived from greywacke and mafic volcanic rocks, respectively, and metatonalite and metapyroxenite that are derived from igneous rocks that intruded the supracrustal rocks prior to the high-grade event.

A relative structural, metamorphic and intrusive chronology can be established based on relations observed in the field. The metasedimentary gneiss, mafic gneiss, metatonalite and metapyroxenite units all attained granulite-facies conditions prior to the intrusion of the diatexite plutons. Pre-diatexite structures include the principal, northwest-striking foliation (S_1) in the pre-diatexite rock units, which is defined by both high-grade minerals and metamorphic leucosome, and northwest-trending folds of the foliation and the leucosome. Diatexite, intruded into the surrounding high-grade rocks in bodies that were approximately concordant with the northwest-trending structures (i.e., late syn-S_1) in the supracrustal rocks and metatonalite, have a dominantly west-striking foliation that is defined by both deformed inclusions of the high-grade gneisses and by high-grade minerals in the diatexite itself. The foliation in the diatexite, as well as the older structures, are overprinted by a set of east- to east-northeast-trending folds. The superposition of these folds on the earlier structures has formed dome and basin structures; the supracrustal rocks and metatonalite commonly occurring in structural basins.

Lake-sediment and bedrock geochemical studies by the Geological Survey of Canada (1982a, b), Hornbrook and Friske (1989), Thomas and Butler (1987), and McConnell *et al.* (1987) have shown that there are areas in the Ashuanipi Complex in Labrador of anomalously high gold and gold-sympathetic elements. Mapping in 1991 failed to locate occurrences of bedrock having anomalous gold concentrations; nevertheless, the Ashuanipi Complex has some exploration potential.

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