Current Research (1997) Newfoundland Department of Mines and Energy, Geological Survey, Report 97-1, pages 29-47

GEOLOGY OF THE NAIN PLUTONIC SUITE AND ITS COUNTRY-ROCK ENVELOPE, ALLIGER LAKE AREA (NTS 14E/1), LABRADOR

B. Ryan, A. Hynes[1] and I. Ermanovics[2]
Labrador Mapping Section

ABSTRACT

The field results and preliminary interpretations of data from the 1996 mapping program in the Alliger Lake area (NTS 14E/1), 50 km northwest of Nain, indicate that the geological evolution of the region may be more complicated than presently appreciated. In particular, the data indicate a long history of anorthositic magmatism. The earliest anorthositic rocks are disposed as parts of dismembered and gneissose layered intrusions within the Archean terrane in the eastern part of the Alliger Lake area. More extensive anorthositic magmatism, represented by altered and deformed intrusions in the central part, may be allied with the Paleoproterozoic granites of the Okak Bay–Webb's Bay region, and imply the emplacement of plagioclase-rich magmas in rifted continental crust during fragmentation of the Archean North Atlantic craton. If these anorthositic rocks are of Paleoproterozoic age, then their presence may indicate a wider distribution of such intrusions. Pristine intrusions of the Mesoproterozoic Nain Plutonic Suite (NPS) occupy the western third of the Alliger Lake map area, and attest to the creation of the NPS via repeated pulses of plagioclase-enriched magmas during the 60-million-year period of anorogenic magmatism that led to the construction of this batholithic igneous terrane. The reasons behind the repetitive anorthositic magmatism, lasting from the Archean to the Mesoproterozoic, within this block of crust are unclear.

The field data imply that the probable Paleoproterozoic anorthositic intrusions were intruded by mafic dykes, and both were deformed prior to emplacement of the NPS. A potential cause for the early tectonism is the development of the collisional Torngat Orogen.

Numerous Ni–Cu sulphide prospects occur in the Alliger Lake area, mostly within the fresh plutons of the NPS, but also within the altered older plutons. The majority of the known prospects are epigenetic with respect to the enclosing rock, yet some of the mineralization seems to be syngenetic, implying multiple episodes of sulphide magma formation.

INTRODUCTION

The northern part of the Nain Plutonic Suite (NPS), the Mesoproterozoic anorthositic–granitic–troctolitic–dioritic igneous terrane of central coastal Labrador (Wheeler, 1969; Ryan, 1990a; Emslie *et al.*, 1994), has been the focus of recent scrutiny by junior mineral exploration companies. This flurry of exploration activity has been prompted by the delineation of numerous small Ni–Cu sulphide prospects during regional exploration and prospecting for Voisey's Bay-type magmatic mineralization (by these companies in 1995), especially in the Alliger Lake–Puttuaalu Lake–Okak Bay sector. The intense exploration in this region over the past year has been carried out with only a rudimentary "snapshot" of the regional geology, and without any previously available data that would illuminate the regional setting or controls of the mineralization. Many questions are ripe for the asking, among which are: Do the new discoveries bear any resemblance to the Voisey's Bay deposit...is there a specific pluton that is hosting the mineralization...and why is this area so endowed with sulphide prospects? Press releases from the exploration companies suggested that much of the mineralization, although mainly confined to plutonic rocks in the area, was epigenetic and occurred within diverse hosts, implying that the genesis and setting of the sulphides in the northern region was different from that of the Voisey's Bay deposit.

[1] Department of Earth Sciences, Memorial University of Newfoundland, St. John's, Newfoundland, Canada, A1B 3X5.

[2] Geological Survey of Canada, 601 Booth Street, Ottawa, Ontario, Canada, K1A 0E8.

The limited understanding of the regional geology of the Alliger Lake–Puttuaalu Brook area, along with the reported number of sulphide occurrences, prompted the provincial Geological Survey to initiate a mapping program in the area in 1996. The project plan ultimately evolved into a provincial–federal initiative, with the objective being to investigate the Alliger–Puttuaalu area at 1:50 000 scale, for integration into a regional 1:100 000-scale compilation map of that part of Labrador from Okak Bay to the Kiglapait Mountains (Emslie *et al.*, 1997; Figure 1). Coupled with the geological mapping was an ancillary program by Kerr (1996; *see* Kerr and Smith, *this volume*) to investigate the sulphide showings from a comparative genetic perspective.

The mapping project plan was co-ordinated as follows: B. Ryan and A. Hynes were responsible for the 1:50 000-scale mapping of the plutonic rocks in the Alliger Lake map area (NTS 14E/1). I. Ermanovics undertook regional examination of the Archean and Paleoproterozoic metamorphic rocks forming the envelope of the NPS. R. Emslie of the Geological Survey of Canada also investigated the Alliger Lake area and carried out reconnaissance work over parts of the NPS elsewhere in the general area (*cf.*, Emslie *et al.*,1997). This report is based primarily on the field work for the project, highlighting some of the established relationships between rock units, noting some of the stratigraphic problems that still remain, and giving an overview of some of the sulphide occurrences in the area.

PREVIOUS GEOLOGICAL MAPPING IN THE ALLIGER LAKE AREA

The northern part of the NPS is exposed in rugged inland terrain to which access is very difficult. Consequently, it has not been investigated to the same extent as similar rocks along the coast, and the database on which the 1996 project was originally designed is meagre. E.P. Wheeler, the first person to undertake serious geological investigations in the region, gained access to parts of the area in the 1940s–50s by canoe and dog-team, but his travel limitations prohibited him from undertaking any systematic investigation of rocks and relationships (*cf.*, Wheeler, 1954). Wheeler's manuscript maps (on file with the Newfoundland provincial Geological Survey), up-to-date as of the early 1970s, show that he gleaned sufficient data from his few trips into the area to arrive at a general compilation of the major gneissic and plutonic rock units, but the mountainous region to the west of the Puttuaalu Lake–Alliger Lake drainage system was largely inaccessible to him. In the mid-1970s Ranson (1976, 1977) undertook an east–west transect of the northern NPS in the context of the Nain Anorthosite Project (Morse, 1971). As part of that survey, Ranson (*op. cit.*) produced the first detailed map of the area directly around Alliger and Iglusuataliksuak lakes. Apart from these sources, the only map of the region pertinent to preparations for the 1996 project is that of Taylor (1977), which incorporated some of the earlier work to portray geological relationships at 1:250 000 scale. All the available data were synthesized in 1989 to produce a 1:500 000-scale compilation of the whole NPS (Ryan, 1990a, 1991a).

GENERAL GEOLOGY, REGIONAL PROBLEMS, AND THE SETTING OF SULPHIDE MINERALIZATION

The compilation maps for the Alliger Lake region (previously cited) portray the distribution of the Archean and Proterozoic rocks as interpreted up to 1990. Generally, Archean gneisses were known to underlie the northeast part of the area, between Iglusuataliksuak Lake and Puttuaalu Brook; the remainder of map area NTS 14E/1 was shown to comprise mainly Mesoproterozoic anorthositic and granitic rocks of the NPS. Recently, however, data have come to light that question this simple geological duality. For example, Emslie and Loveridge (1992) and Connelly and Ryan (1994) presented geochronological evidence that some of the easternmost granitoid plutons assigned to the NPS between Okak Bay and Webb's Bay are Paleoproterozoic. A granitoid pluton located on map area NTS 14E/1, the Alliger Lake intrusion, formerly considered to be of Mesoproterozoic age, has also provided isotopic evidence for Paleoproterozoic crystallization (M. Hamilton and R. Emslie, unpublished data). Adding to the prospects for other pre-NPS intrusions in the region were Ranson's (1976) observations that the contact between the Alliger Lake granite and the abutting anorthosite is "transitional", that plagioclase xenocrysts from the anorthosite can be found in the granite, and that aplitic dykes of Alliger Lake granite intrude the anorthositic rocks. Ranson's observations support the argument that pre-NPS (Neoarchean or Paleoproterozoic) magmatism also included anorthositic intrusions, as suggested by Ryan (1992, 1993) and Ryan and Connelly (1996) on the basis of field observations and age-determinations of rocks from Satok Island and north of Webb's Bay. These latter data suggested that some of the basic plutonic rocks of the Alliger Lake area, instead of being part of the NPS, could represent much earlier magmatism.

Field and laboratory data collected by E.P. Wheeler in the Nain area, led him to erect a lithological category that he referred to as "granulite of uncertain origin". This group is now known to include rocks of diverse age and origin, including Paleoproterozoic layered intrusions (e.g., Bridges intrusion, near Nain) and foliated margins of large NPS anorthosite bodies (cf., Ryan, 1991b, 1993; Royse and Ryan, 1995). In the Alliger Lake area, Wheeler outlined several such "granulite" units. One of these on the west shore of Iglusuataliksuak Lake was investigated by Ranson (1976) who categorized it as NPS leuconorite. Another of Wheeler's such units, at the southeast corner of the map area, seemed to be the continuation of a mafic and ultramafic granulite unit already mapped by Ryan (1993, page 65) on the northern

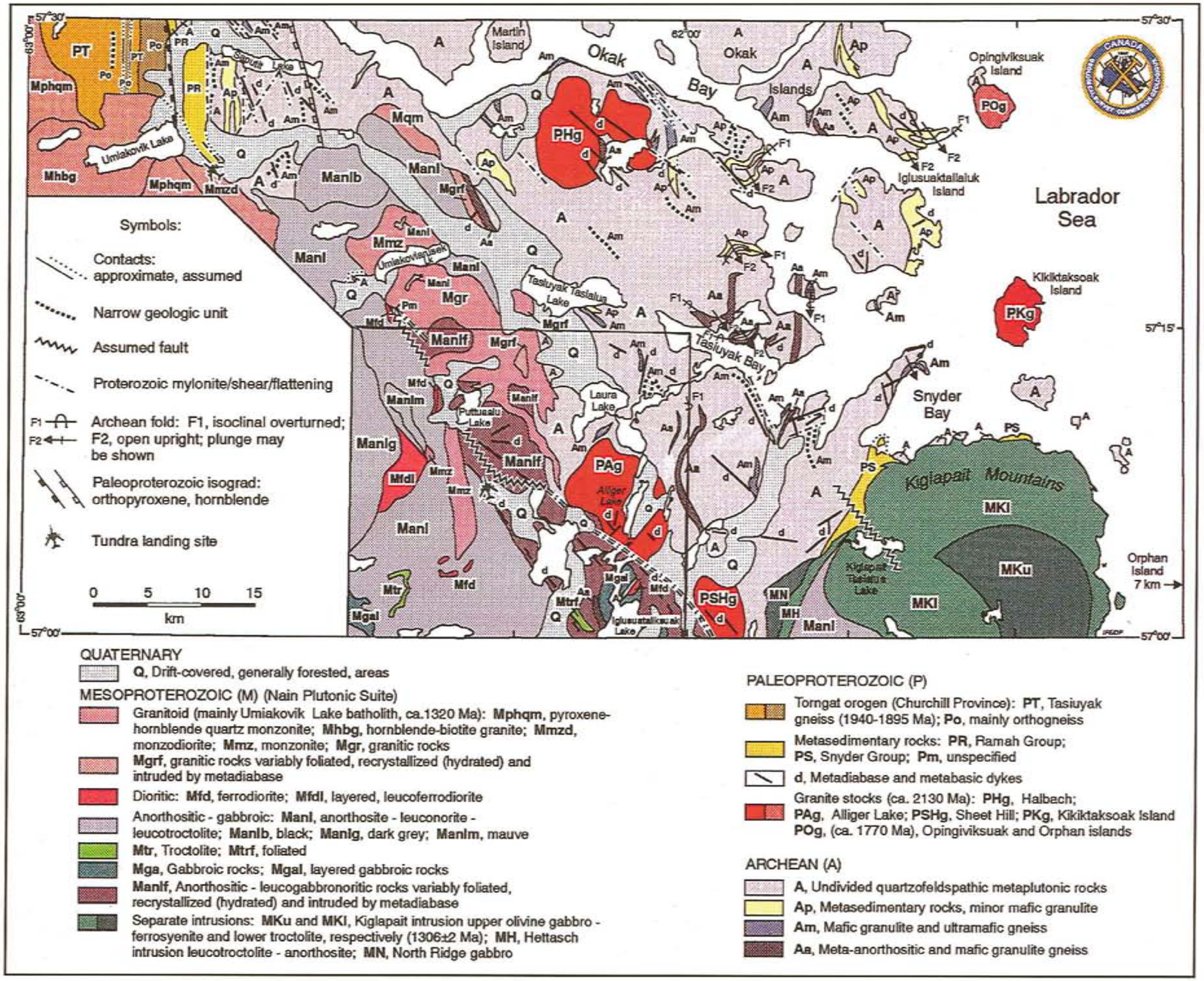

Figure 1. *Sketch map of the Kiglapait Mountains to Okak Bay sector of northern Labrador, showing the distribution of the major igneous and metamorphic rock units in the area (from Emslie* et al., *1997). The Alliger Lake map area is outlined by a box. Note that the designations of some of the plutonic rock units in the Alliger Lake area differ between this map and Figure 2.*

margin of the abutting NTS map area 14C/13 as an Archean or Paleoproterozoic mafic–ultramafic unit. Thus, the nature of the "granulites" was open to query.

In addition to the above regional problems concerning the age of some of the plutonic rocks and the origin of the "granulites", it had become apparent from the press releases by several junior exploration companies that the sulphide discoveries in the area were probably not analogous to the Voisey's Bay deposit. For example, Cartaway Resources reported its "Cirque" property sulphides as "replacement bodies" (press release, September 26, 1995) and Canadian States Resources reported a nearby prospect as "a mineralized structure ... along a northeast–southwest striking fault" (press release, July 20, 1995). Thus, it was necessary to determine how these occurrences compared, and if there was any lithological or structural control on their genesis and distribution.

LOGISTICS AND DATA GATHERING

The field camp for the 1996 survey was positioned by tundra-wheeled Twin Otter to a gravel air-strip northwest of "Miller's Pond" (referred to on Wheeler's manuscript map as "Square Lake" or "Angutausughivik SW Branch 2nd Lake") on July 13. The camp was closed on September 5, and all equipment was transported to Nain by September 6. Field work from the camp was accomplished by daily put-out – pick-up method using a Bell 206L helicopter. The rugged terrain provided a challenge to the mapping teams, restricting examination of many outcrops and impeding the rapid coverage of the area. High winds and inclement weather expended over a week of the season, and further hampered the mapping progress. Surveying has been confined mainly to topographic ridges and the upland "massifs" between the glacial outwash deposits, with limited data from the valley floors and the cliff-faces bordering the valleys. The mapping of the plutonic rocks has been especially frustrating because of the abrupt changes in rock types along the ridges and from hilltop to valley floor. Clear geological contacts indicating the nature of such changes are usually absent, and it is not always possible to determine if the compositional differences reflect intrapluton variations or whether they represent two or more abutting plutons of differing age.

SURVEY RESULTS

The regional geology of the Alliger Lake area (Figure 2) has proven to be superficially simple, yet problematic in detail, especially with respect to the plutonic rocks. As previously noted, there are abrupt changes over small areas, but the significance of such changes is hard to define. However, it is apparent that there is a simple division within the anorthositic and granitoid rocks that points to at least two differing age groups (Ryan and Hynes, 1996). This difference is one that can be outlined across the whole area, and entails use of criteria such as the presence of metamorphosed basic dykes, and the degree of deformation/ recrystallization.

ARCHEAN GNEISSES AND OTHER ROCKS OF PRESUMED ARCHEAN AGE

The predominant rocks of the Archean Nain Province are grey to buff quartzofeldspathic to dioritic gneisses exhibiting amphibolite- to granulite-facies metamorphism (Unit 1). Migmatitic features are particularly well displayed by the grey-weathering gneisses, but the granularity and buff colour of the granulite-facies rocks tend to mask subtle compositional differences between paleosome and neosome. All the quartzofeldspathic gneisses contain numerous small inclusions of older mafic, ultramafic, leucogabbroic, and metasedimentary rocks. Variably metamorphosed basic dykes occur throughout the gneiss complex, and are considered to be intrusions equivalent to the Paleoproterozoic Domes dykes of the Saglek area (Ryan, 1990b) and the Napaktok dykes of the Okak area (Ermanovics and Van Kranendonk, 1990).

Two, 500-m-wide belts of metamorphosed, deformed, and migmatized, pale grey- to white-weathering anorthosite to leucogabbro (subunit 1a) are exposed east of Frank Lake (Figure 2). These are probably dismembered remnants of previously larger layered basic intrusions, and are very distinct rocks, containing discontinuous folia of black hornblende in a white crystalline groundmass. This textural feature has led to the use of "tiger-striped gneiss" as a field-term to describe them. In spite of the deformation that is regionally exhibited by these gneisses, there are local kernels of lower intensity deformation where primary grain shapes and relations can be discerned; in one such zone oval, zoned plagioclase megacrysts are preserved (Plate 1).

Metasedimentary rocks are scarce within the Alliger Lake area, and rarely form belts that can be realistically portrayed at a 1:50 000 scale. Large lensoid rafts, a few tens of metres to a couple of hundred metres in maximum dimension, have been observed northeast of Laura Lake. These are dominated by grey to white quartzite and garnet–sillimanite gneisses.

The mafic and ultramafic rocks (subunit 1b) comprise two distinct groups. The first group is gneissic to migmatitic, and interlayered, on the metre to hundred-metre scale, with quartzofeldspathic gneisses; these also occur as large rafts within the felsic gneisses. They crop out in the northeast part of the study area and, based on field relationships, are older than the enclosing gneisses. Layering is locally prominent (and in small rafts, it may be at a high angle to that of the enclosing gneiss) but the most abundant textural type is a granular or "salt and pepper" one. Ultramafic rocks are locally interlayered with these mafic gneisses, but peridotite also occurs as independent larger bodies and as isolated metre-scale blocks within the quartzofeldspathic gneisses. The second group of mafic rocks is non-migmatized, and generally non-gneissic, and is clearly derived from fine- to medium-grained layered mafic intrusions that included local ultramafic and anorthositic components; no contacts between this type and the quartzofeldspathic gneisses were observed. The rocks of this subdivision are confined mainly to the Iglusuataliksuak Lake area, where they were interpreted to be a "leuconorite" intrusion of the NPS by Ranson (1976, 1979, 1981). Although assigned Archean here, their age is far from certain. They are intruded by the adjacent gabbro and anorthosite (possibly of Paleoproterozoic age), several generations of mafic dykes, and dykes of pink to white granite. There is little doubt about the plutonic parentage of the massive "granulites" because primary igneous textures and layering are common within them. Compositional variations include thin (1 m) layers and thicker (50 m) units of peridotite and leucogabbronorite–anorthosite. The ultramafic rocks are best exposed in the western wedge southeast of Iglusuataliksuak Lake; an anorthositic variant can be seen within the unit west of the lake, where it is intruded by an amphibolitic (metaferrodioritic?) rock prior to its deformation and subsequent injection by at least two different types of metamorphosed basic dykes.

A complex unit (subunit 1c) underlies a northwest-trending ridge on the west side of Iglusuataliksuak Lake, sandwiched between the mafic granulites described above and a leucogabbroic–anorthositic intrusion to the west (Figure 2). This unit is best described as a foliated, polyphase intrusion breccia because it comprises pyroxenitic, anorthositic and metagabbroic lenses hosted by quartzofeldspathic granulite, intruded in turn by an amphibolitic (metadioritic) rock, and locally by a pale-grey foliated tonalite. All are cut by amphibolite (metadiabase) dykes. Furthermore, there are two generations of pink to white granitic aplite present, one set being foliated and part of the migmatizing component that predates the metabasic dykes, the other, a bright pink one, postdating the dykes. This complex assemblage of rocks is peculiar to this one area, and its constituents may encompass a wide age range.

THE ALLIGER LAKE GRANITE

The Alliger Lake granite (Unit 2) is one of several felsic intrusions that form a linear array between Webb's Bay and Okak Bay (Figure 1; Ryan, 1990a), including the Sheet Hill granite, dated at ca. 2110^{+5}_{-2} Ma (Ryan and Connelly, 1996), and the Wheeler Mountain granite, dated at ca. 2135 Ma (Emslie and Loveridge, 1992). The Alliger Lake granite, although assigned to the NPS by Wheeler (1969) and Ranson (1976, 1981), had been postulated by Ryan (1992) to be also of Paleoproterozoic age. This inference is now supported by preliminary U–Pb isotopic data from zircon indicating crystallization during the Paleoproterozoic (R.F. Emslie and M.A. Hamilton, personal communication, 1996).

The Alliger Lake granite forms a prominent mountain northwest of Alliger Lake, and also underlies a more subdued hill to the southeast. The granite is medium grained, grey to pale pink, contains quartz that has an opalescent blue colour, and contains biotite and hornblende as the main mafic minerals. Internally, it is generally massive, although narrow mylonite zones are locally present, but toward its margins it takes on a foliated to gneissose appearance (*cf.*, Ranson, 1976). Its immediate contact with the Archean gneisses was crossed only by a single traverse over its western margin, where it is an "injection-migmatite" in which parallel and discordant blue-quartz-bearing granitic sheets have invaded the older layered rocks (*cf.*, Ranson, 1976, page 41).

A linear zone of fine- to medium-grained, dark-brown-weathering dioritic rocks (Unit 3) along the western side of the Alliger Lake granite was originally figured by Ranson (1976, page 37) as marking a transitional contact between the granite and the anorthositic (gabbroic) rocks to the west. Field examination of the boundary between the granite and the diorite indicates that there is a mingled contact between the two; the diorite also appears to grade westward into dark-grey blue-quartz-bearing gabbro, as concluded by Ranson (1976). If these relations are substantiated by additional field mapping, then it is a strong indication that the diorite and the gabbro are contemporaneous with the Alliger Lake granite, and likewise Paleoproterozoic.

OTHER ROCKS OF POSSIBLE PALEOPROTEROZOIC AGE

Other plutonic rocks in the area are also Paleoproterozoic candidates. This group (Unit 4), mainly comprising leucogabbroic to anorthositic (*s.l.*) compositions, forms a southeast–northwest-trending diagonal swath across the central part of the map area. In addition, foliated granitic rocks northeast of Puttuaalu Lake (Unit 5), and quartzofeldspathic granulites (Unit 6) and mesocratic granulites (Unit 7) in the southwest corner of the map area may also be Paleoproterozoic in age.

Leucocratic Gabbroic Metaplutonic Rocks

The gabbroic metaplutonic rocks are the predominant rocks in the region between Iglusuataliksuak and Puttuaalu lakes, and comprise mainly, dark-grey (non-recrystallized) to white-weathering (recrystallized) leucogabbro, leuconorite and anorthosite (Unit 4). They are intruded by a plethora of premetamorphic to postmetamorphic dykes, varying in composition from black hornblendite (metalamprophyres?), green to dark-grey metagabbro–metadiabase, buff to brown monzonite and diorite, pink to white aplitic to pegmatitic granite, and olivine diabase (*see* later section, page 40). The main mesoscopic variants within the anorthositic plutons can be summarized as follows.

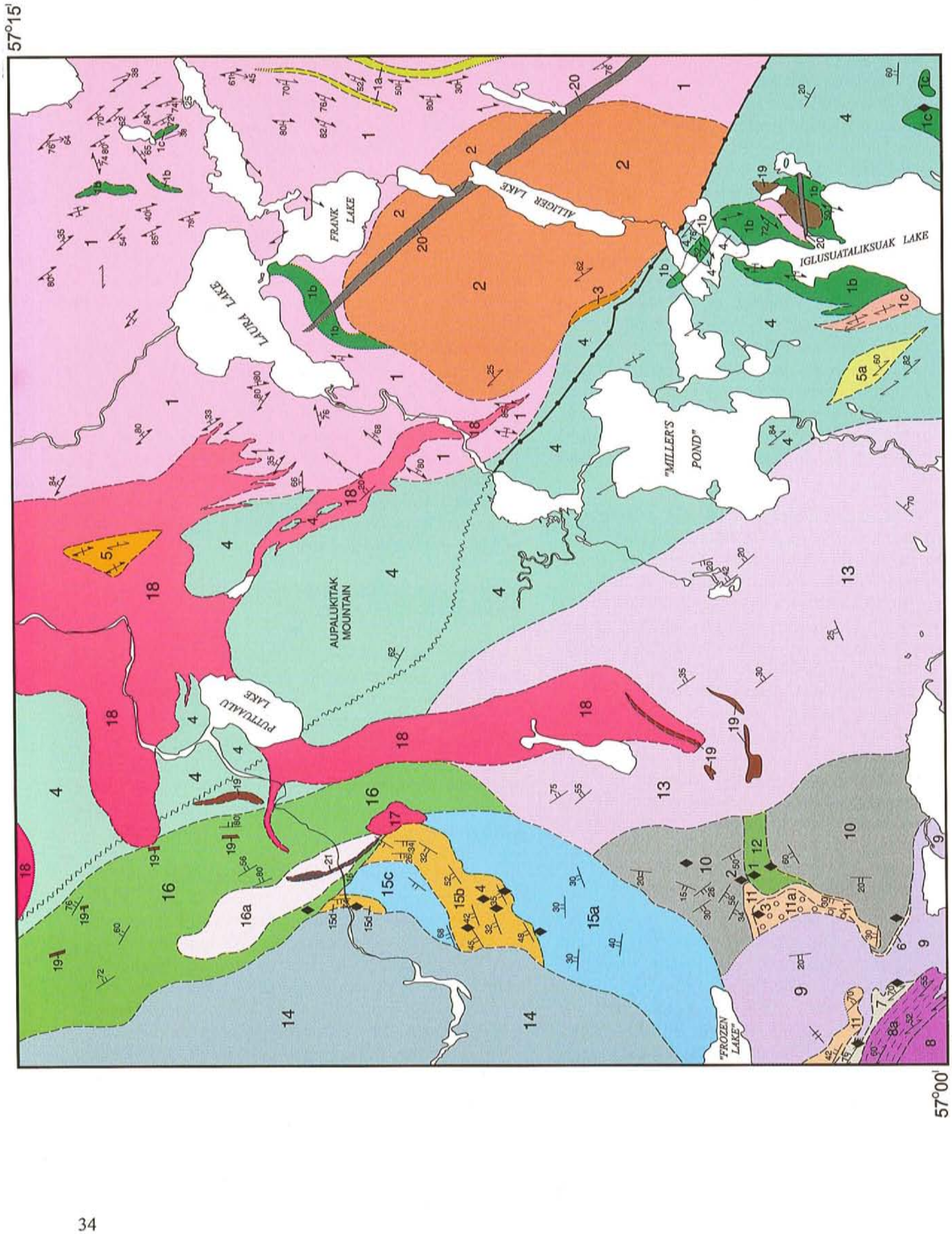

Figure 2. *Geological map of the Alliger Lake area. The Quaternary drift cover has been omitted to show the interpreted distribution and relationships of the rock units.*

LEGEND

MESOPROTEROZOIC

21	Porphyritic pyroxene diorite
20	Olivine gabbro
19	Diorite, ferrodiorite
18	Clinopyroxene fayalite ± hornblende monzonite and quartz monzonite; diorite
17	Clinopyroxene fayalite monzonite
16a	Pink to grey anorthosite
16	Buff (olivine-bearing?) leuconorite
15b,d	Well-layered gabbronoritic (dioritic) rocks
15a,c	Massive leuconoritic to anorthositic rocks
14	Massive dark-grey leuconorite
13	Grey to brown leuconorite and anorthosite
12	Pale-mauve to grey anorthosite
11a	Pale-grey anorthosite
11	Reddish-brown troctolite and leucotroctolite
10	Dark grey to buff anorthosite and leuconorite
9	Grey to brown norite and anorthosite
8a	Strongly foliated leuconorite
8	Massive coarse-grained leuconorite

PALEOPROTEROZOIC (?)

7	Mesocratic granulites
6	Quartzofeldspathic granulites
5a	Foliated monzonitic(?) to gabbronoritic dyke
5	Foliated hornblende quartz monzonite
4	Undivided leucogabbroic to anorthositic rocks exhibiting variable secondary alteration and deformation
3	Brown diorite to ferrodiorite
2	Alliger Lake granite

ARCHEAN

1c	Complex unit comprising quartzofeldspathic gneiss, meta-anorthosite, pink aplitic granite, and tonalite
1b	Migmatized to massive mafic and ultramafic rocks
1a	Leucogabbro and anorthosite gneiss
1	Undivided quartzofeldspathic gneiss

SYMBOLS

Geological boundary (approximate, assumed)

Gneissic layering (vertical, inclined, dip unknown)

Foliation (vertical, inclined, dip unknown)

Mineral lineation or fold axis

Igneous layering/lamination (inclined, vertical)

Mylonite zone

Fault zone (approximate, assumed)

Sulphide showing

Codes for sulphide showings:

1. Cartaway's Cirque area;
2. Canadian States showing;
3. Hill-top showing;
4. Krinor area.

Figure 2. *Continued.*

Plate 1. *Oval plagioclase megacrysts in metamorphosed leucogabbro east of Frank Lake. These rocks are normally foliated and display a streaky texture, but this outcrop is from a zone of low deformation where primary features have been retained.*

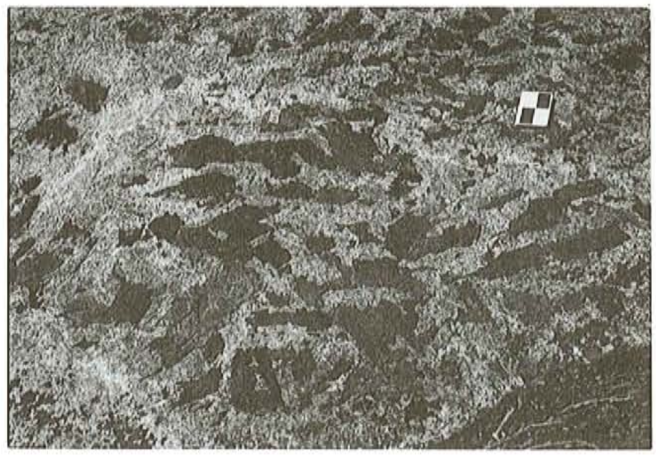

Plate 2. *Pegmatoidal zone in leucogabbro and anorthosite east of Iglusuataliksuak Lake. Dark (green) minerals here appear to be clinopyroxene, but could be amphibole pseudomorphs of orthopyroxene. Scale-bars on notebook are 10 cm.*

East of Iglusuataliksuak Lake, medium-grained to pegmatoidal dark-grey to pale-grey leucogabbro and anorthosite predominate (Plate 2). Original clinopyroxene is mainly replaced by pale-green amphibole throughout this area. West of the lake, coarse-grained, pale-grey to white, leucogabbronoritic to anorthositic rocks are found, locally containing layers displaying very coarse variably recrystallized pyroxenes and having irregular mafic dykes that appear synplutonic with the host. Narrow pyroxenite lenses are locally present south of Miller's Pond.

Secondary amphibole is variably developed in the Aupalukitak Mountain area. There, some rocks clearly contain black hornblende as the only mafic mineral, yet some of the coarser grained rocks exhibit either fresh brown orthopyroxene or else orthopyroxene having a black hornblende halo. In the far northern part of this unit, the rock is a pale- to dark-grey, medium- to coarse-grained leuconorite, in which pyroxene is replaced by pale-green amphibole.

Foliated Granitic and Monzonitic(?) Rocks

A triangular wedge of foliated, pink- to grey-weathering, hornblende quartz–monzonite and granite (Unit 5) occurs within younger hornblende (–pyroxene) monzonite northeast of Puttuaalu Lake. These are medium-grained rocks, containing faintly blue elongate quartz and augen of potassium feldspar.

A lozenge-shaped unit of pale-brown- to grey-green-weathering foliated "mesogranulite" of possible monzonitic or dioritic composition (subunit 5a) intrudes white leucogabbronorite and anorthosite west of Iglusuataliksuak Lake. In turn, the mesogranulite is intruded by pink aplitic granitic dykes. Olivine gabbro along the northeastern edge of this body appears to be gradational into the "granulite" and is presently considered to be part of this unit, but could represent a completely different intrusion.

Quartzofeldspathic Granulite-Facies Gneiss

This is a group of buff-weathering diffusely layered rocks (Unit 6) sandwiched between two anorthositic plutons in the southwest corner of the map area. Mafic gneisses are a subordinate component where these rocks were examined.

Mesocratic Granulite Rocks

This enigmatic group of rocks (Unit 7), occurring in the southwest corner of the area, is one that E.P. Wheeler had placed in his "granulite of uncertain origin" category. In the field these mesocratic, diffusely layered rocks enclose narrow rusty red-brown-weathering units that appear to have been derived both from peridotitic and sedimentary protoliths.

MESOPROTEROZOIC INTRUSIVE ROCKS – THE NAIN PLUTONIC SUITE

These rocks underlie the western one-third of the map area. Regional-scale compositional differences, variations in layering attitude, and discrete intrusive contacts have all been used to outline the separate bodies on the accompanying map (Figure 2). Using the boundaries thus defined, it is clear that at least a dozen separate intrusions are represented here, dominated by anorthositic (*s.l.*) rocks, but also including monzonite and diorite. Some of the boundary lines of specific plutons are speculative; their positions are dictated in part by assumptions in lieu of outcrop, the failure to recognize the elusive contacts during field work, and the interpretation of specific map patterns during post-season compilation.

Field evidence suggests that NPS anorthositic and noritic rocks form nested or coalesced plutons. Older plutons in the southeast part of the terrane, which have moderately inclined layering, have been truncated by a younger, more steeply layered group in the northwest part. However, the intermediate and silicic rocks, have predominantly dyke-like map patterns. The elongate monzonite south of Puttuaalu Lake seems to be a steeply dipping dyke-like body, whereas the smaller body west of it is confined to high-elevations and appears to be remnants of a sheet. A sheet-like geometry seems to be applicable to the northwest-trending diorite to monzonite southwest of Laura Lake as well, where it is predominantly exposed in topographic lows and displays shallowly inclined layering. Local, flat-lying contacts between the large mass of hornblende monzonite and older rocks north of Puttuaalu Lake also implies it is, in part, disposed as an undulating sheet.

Basic Plutons

With the exception of a well-layered series of rocks just south of Puttuaalu Brook, the majority of the NPS basic plutons in the western part of the map area can be loosely called "anorthositic". Anorthosite (*s.s.*), although occupying significant areas of outcrop locally, is, however, subordinate to leuconorite as a major component in most plutons. Layering can be locally detected in many of these intrusions; for the most part it is diffuse, controlled by subtle changes in mineral volumes rather than being sharply defined. The following comments summarize the general aspects of each subdivision.

The southwesternmost corner of the map area is occupied by a dark-grey to pale-grey, mildly recrystallized anorthosite to leuconorite (Unit 8), abutting a strongly foliated, northeast-dipping, zone of leuconorite to norite (subunit 8a) up to 1 km wide. There seems to be a gradational contact from the massive rocks through to the foliated zone, and the latter is interpreted to be the solid-state deformed border to the pluton; similar relationships are present along the eastern side of the Mount Lister intrusion and the Pearly Gates intrusion (Ryan, 1992, 1993). The grey leuconorite to anorthosite is locally very coarse grained, displays finer grained white zones where recrystallized, has disseminated clots of opaque oxides, orthopyroxene that is kinked, and plagioclase showing a labradorite schiller. The buff-weathering layered border zone is characterized by a strong foliation, outlined by lozenges of variably recrystallized orthopyroxene in a granular feldspar matrix. Massive pyroxene pods up to 5 m in maximum dimension are present in this zone. Grey to pink, granular anorthositic dykes oriented at a low angle to the foliation are present in the border zone, discordant to compositional layering, yet appearing to be pre-deformation intrusions that have experienced the same degree of recrystallization as the host norite.

The foliated border zone described above is intruded by a medium-grained to very coarse-grained, grey to purplish-brown, subophitic-textured norite to anorthosite (Unit 9), the extent and internal characteristics of which have not been firmly established. This pluton also intrudes "mesocratic granulite" and a grey anorthosite to leucotroctolite on its southwestern margin, and is considered to be intrusive into plutons that abut its eastern side as well. Orthopyroxene forms spongy clots within a plagioclase-rich host, and many outcrops of this intrusion display scattered megacrysts of dark-purple to blue-grey plagioclase that locally have a deep blue labradoresence. Also included within this pluton are fine-grained, granular rusty-brown diffusely layered gabbro-noritic(?) rocks along its northeastern and southwestern margins that may represent a border phase, but their relationship to the coarser and more leucocratic rocks has not been established.

Directly northeast of the leuconoritic pluton described above is a large area of dark-grey- to buff-weathering leuconorite and anorthosite that has within it at least two smaller intrusions. The main body (Unit 10) is internally diverse, and may itself include more than one intrusion. It varies from a medium- to coarse-grained dark-grey to purplish-grey anorthosite to leuconorite to a buff-, crumbly weathering leuconorite to norite, both phases containing conspicuous black plagioclase megacrysts. Pale-grey to dark-grey anorthosite and leuconorite inclusions are readily identified in the buff-weathering member because of the colour contrast; such inclusions are not easily seen in the grey parts of the pluton. The buff-weathering member is also locally prone to develop shallow (5 to 10 cm) rounded pits or potholes 20 to 50 cm in diameter, and also to weather into bulbous outcrops. Inclusions of older, but possibly cognate, layered "granulites" are present in the northern part of this unit; these tend to be rusty-brown-weathering and contain irregular rafts of older white anorthosite. The "granulites" are particularly well displayed east of Frozen Lake, on property currently under licence to Canadian States Resources.

A reddish-brown troctolite and a distinctive reddish-brown mottled leucotroctolite (Unit 11) form an arcuate body that intrudes and sits atop the western part of the pluton described above. The troctolitic rocks are overlain by grey olivine anorthosite and anorthosite (subunit 11a) that are well exposed on the Noranda Exploration claim group, and the whole is considered to be remnants of a larger intrusion truncated by the noritic pluton to the west. The mottled troctolite exhibits a streaky colour variation of red-brown mafic minerals in a grey anorthositic groundmass (Plate 3). This streaky alignment of the mafic and felsic constituents is attributed to compaction prior to final solidification, and is a planar feature that permits the definition of several folds in the unit. These folds are unique to the troctolitic unit, and may be a consequence of local deformation above the roof of the younger noritic intrusion, which is exposed to the west. Mottled leucotroctolite and grey anorthosite that outcrop 3 km south of Frozen Lake may be an extension of the above units, but continuity has not been demonstrated.

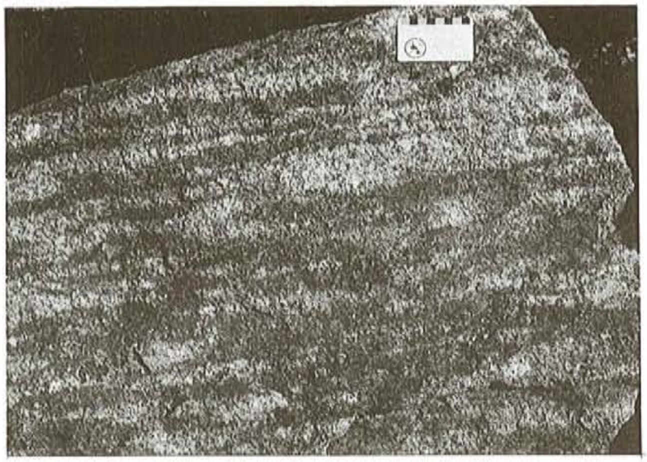

Plate 3. *Streaky planar fabric near the base of the leucotroctolite unit southeast of Frozen Lake, interpreted to be a magmatic compaction feature. Dark areas are elongate concentrations of red-brown olivine; pale areas are plagioclase.*

The troctolite–anorthosite and the older buff-grey norite to anorthosite plutons described above are themselves intruded by a fine- to medium-grained pale-mauve to pale-pink to grey anorthosite (Unit 12) that forms a dyke-like body in the Cartaway Resources' "Cirque" area. Small dykes of this anorthosite intrude the buff rock at the contact, but the contact with the mottled troctolitic rocks is diffuse rather than sharp, implying that the latter intrusion may still have been an unconsolidated crystal mush when the massive anorthositic dyke was emplaced. Even though a sharp contact cannot be defined, the discordance between the orientation of the compaction fabric in the troctolite and the mapped distribution of the anorthosite clearly indicates a transgressive relationship between the two units.

A wide variety of rocks has been grouped into the large unit (Unit 13) west of Miller's Pond, so it is very unlikely that it represents a single pluton. It includes poikilitic-textured, pale-grey to dark-grey leuconorite, medium- to fine-grained pale-grey to mauve anorthosite, brown–red olivine-bearing(?) leuconorite and norite, and a pale-buff leuconorite. A prominent northeast-trending cliff face west of Miller's Pond displays an intimate interdigitating contact between the grey and brown facies of this unit, but relative ages have not been defined. The eastern margin of this intrusion, where it abuts the older, white-weathering, recrystallized anorthosite and leuconorite, is a dark-brown, fine- to medium-grained, subophitic-textured leuconorite and norite, locally well layered. The interior and western parts of the pluton comprise predominantly grey- to brown-weathering, medium- to coarse-grained anorthosite to norite. Spongy (poikilitic) orthopyroxene is widely distributed throughout the intrusion. Dark-grey to black plagioclase xenocrysts are nearly a universal feature of the body, and locally there are discrete angular (cognate?) inclusions of black anorthosite from which the nearby broken black plagioclases were derived (Plate 4). Most of the layering measurements obtained from this body indicate a northeast-dipping attitude, in contrast to the overall westerly dip of layering in the unit to the west; this differing layering orientation is the main criterion used for defining the map boundary between the two.

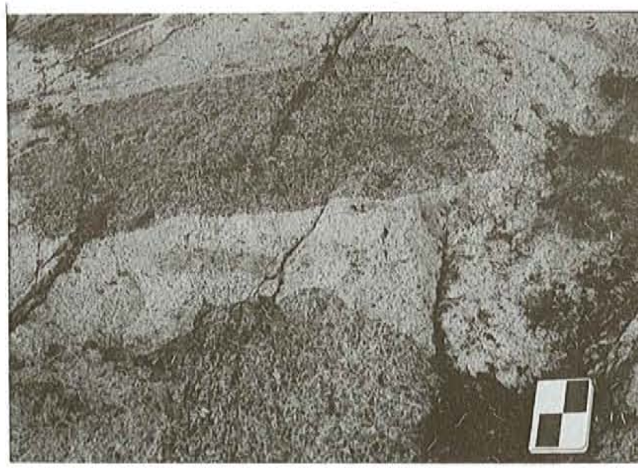

Plate 4. *Blocks of dark-grey to black anorthosite within a matrix of pale-grey leuconorite. Note scattered black plagioclase xenocrysts that have been dislocated from the inclusions.*

The northwestern part of the map area is underlain by rocks that appear to represent several nested intrusions having variably inclined walls. As elsewhere, definitive evidence of intrusive contacts are sadly lacking, and many of the map boundaries are based on contrasting texture, lithotypes, and layering.

The marginal westernmost (and youngest?) unit (Unit 14) of the map is a coarse-grained to pegmatoidal, dark-grey, leuconorite to anorthosite characterized by disseminated plagioclase grains displaying a dark to pale-blue labradorite schiller. Older pale-grey anorthosite inclusions are present locally, and, along the central part of its eastern contact, as outlined on Figure 2, there is an extensive intrusion-breccia unit, in which angular blocks of pale-grey to white anorthosite are abundant. The source of these blocks is uncertain: they could be exotic, they could be cognate, or they could be derived from the massive mauve to grey anorthosite unit to the northeast.

Abutting the southeast edge of the massive grey leuconorite above is a group of four units (subunits 15a to 15d) that together are interpreted to represent an older, layered to massive intrusion; rafts of the layered rock are enclosed by marginal leuconorite of the pluton to the west, but other evidence for intrusive relations have not been observed. The four-part division of the pluton is based on the apparent transitional nature of the contacts between each subunit and the consistency of layering across all these subdivisions. The following four subdivisions are indicated: a lower unit (subunit 15a) of massive, purplish-grey leuconorite, anorthosite, and mottled leucotroctolite; a central unit (subunit 15b) of well-layered granular gabbronorite (or pyroxene diorite); a massive (olivine-bearing?) norite (subunit 15c), and an overlying unit (subunit 15d) of layered rocks. The lowermost unit is a massive rock, and is leuconorite to anorthosite in composition; a diffuse layering is locally recognizable, as is a preferred planar orientation to compacted oikocrystic olivine clots. The overlying "layered series" is unique in the map area, inasmuch as it is the only NPS intrusion to display fine-scale (centimetre to metre thickness) consistent planar compositional variations. The rock is granular; subophitic textures are generally absent from the layered rocks and the mineral grains form a random interlocking array, reminiscent of metamorphic rocks. However, classic features of magma-current deposition are widespread, including mineral-graded layering and low-angle cross-lamination. Older plutonic fragments within the layered group include black anorthosite and white- to pale-grey leuconorite; some of these fragments clearly represent roof or wall rocks that fell into the magma chamber, settled through the magma, and depressed the underlying layered cumulate substrate. Petrographic examination of a limited number of samples from this layered group of rocks by AH indicates that the minerals are dominated by plagioclase and inverted pigeonite or plagioclase and two discrete pyroxenes. Mineralogically, the rocks could be classified as gabbros and gabbronorites. However, this assemblage of minerals appears in the group of rocks within the NPS that has been referred to as Fe-rich diorites (*cf.*, Wiebe, 1990). Indeed, the mineral compositions determined by microprobe analyses (andesine plagioclase and Fe-rich pyroxenes; R.F. Emslie, personal communication, 1997) are like those of the diorites as well, so that the layered rocks could be referred to as diorite and leucodiorite (Emslie *et al.*, 1997). Overlying the lowest layered group is a reddish-brown to grey (olivine?) leuconorite to norite, which is locally diffusely layered; it, too, has scattered inclusions of older white anorthosite. The norite is overlain by a second layered group, but the latter seems to have been excised by the younger intrusion to the west.

An elongate north-northwest-trending unit of dominantly buff-coloured and weakly friable (olivine-bearing?) leuconorite (Unit 16), having a core of pale-grey to mauve to pale pink anorthosite (subunit 16a), underlies the mountains west of Puttuaalu Lake. The brownish yellow weathering of this leuconorite is fairly distinctive, and the disposition of the pyroxenes as aggregates of roughly equant grains is also peculiar to this unit. Elongate segregations of pyroxene and diffuse compositional variations define a planar feature that dips moderately to steeply to the east. The core of anorthosite is generally medium grained and equigranular and is unique in its pink colour; it is one of the few anorthosite-dominant areas of plutonic rocks that form a coherent mappable unit at 1:50 000 scale.

Intermediate to Silicic Intrusions

Iron-rich diorite, monzonite, and quartz monzonite intrusions are subordinate to the basic plutonic rocks of the Alliger Lake map area. Generally, this group of rocks is poorly exposed and many of the outcrops are deeply weathered and friable. In some cases, the dioritic and monzonitic rocks are combined into a single unit (Figure 2) because all variations may occur over a small outcrop area and no intrusive contacts were observed, or because insufficient work has been done to draw reliable boundaries between them. However, there are outcrop examples of oxide-rich diorite dykes cutting the monzonites in several areas, and this is exemplified at map scale by a north-northeast-trending dyke west of Miller's Pond (Figure 2). As previously noted, the margins of the largest intrusions tend to be stockwork zones, in which a plethora of variably oriented intersecting dykes transect older rock. These stockwork zones locally cover a significant area distal from the more coherent bodies, something that is particularly well displayed by the diorite–monzonite–gneiss contacts west of Laura Lake. In some cases, the complexities of the contacts appear to be a function of the generally subhorizontal attitude of the intrusions.

The smallest unit of this subdivision shown on Figure 2 is an oval body of medium-grained, buff-weathering, pyroxene-? fayalite monzonite (Unit 17) that has been outlined at the 2500 ft. (800 m) elevation southwest of Puttuaalu Lake. Its north–south extent has not been ascertained; in fact, it could extend southward and connect to the large dyke-like body to the east. Some notable features about this body are the conspicuous dark-grey plagioclase xenocrysts(?) and euhedral potassium feldspar phenocrysts. On its southern margin it grades into a fine-grained monzodiorite (R.F. Emslie, personal communication, 1997).

The dyke-like body (Unit 18) to the east is similar to the rock described above, except that it is locally quartz bearing. In places, aligned potassium feldspar phenocrysts impart an igneous fabric and biotite is conspicuous in some outcrops. Inclusions of anorthositic rocks occur along contacts with the older basic plutons. The extension of this body to the northeast to join the larger body north of Puttuaalu Lake is interpretative because of a blanket of Pleistocene sand and gravel.

However, subhorizontal brown monzonite dykes appear to be present in the inaccessible high cliff walls west of Puttuaalu Lake, and networks of brown monzonite dykes can be seen in the hillsides both to the northwest and southeast, which, together, suggest continuity of this easily eroded rock beneath the cover. The distribution of the monzonitic to dioritic rocks to the north, northeast and southeast of Puttuaalu Lake is somewhat conjectural because outcrop is rather sparse. Fine- to medium-grained, speckled to hornblende–poikilitic, monzonite and quartz–monzonite, locally having grey quartz "eyes", are exposed on the eastern side of a ridge of leuconorite north of Puttuaalu Brook. The extension of this unit to the west is based only on several isolated outcrops of brown-weathering monzonite or diorite poking through the glacial cover; anorthositic rocks are also present, but there is insufficient exposure to ascertain which is areally the more abundant rock type.

The elongate southeast-trending body crossing the river between Laura Lake and Miller's Pond is a composite of several rock types, including coarse-grained monzonite and finer grained pyroxene diorite. The valley-floor exposures have a gentle dip to measured layering, which, combined with abundant shallowly to moderately inclined dykes in cliffside exposures, suggest that the map pattern is a consequence of erosion exposing part of a subhorizontal sheet. A similar case for a subhorizontal sheet-like aspect to monzonite–diorite intrusions can be made west of Laura Lake, where the interdigitating pattern shown on Figure 2 is an attempt to portray the observations of subhorizontal sheets on the hillside and alternating gneiss–monzonite outcrops in the irregular topography of the hilltop.

Distinct hornblende-rich and oxide-rich, friable, dioritic rocks (Unit 19) are widely distributed as narrow (1 to 2 m) dykes throughout the area, but several larger bodies are shown on the accompanying sketch map (Figure 2). West of Puttuaalu Lake, a dark-brown-weathering intrusion contains many inclusions of the surrounding white recrystallized Paleoproterozoic(?) anorthosite. Several podiform, brown, diffusely banded, pyroxene-rich dioritic dykes occur in monzonite and leuconorite forming the walls of two mountains west of Miller's Pond. The geometry of these intrusions has not been established, but indications are that they represent two subparallel sheets that dip to the southeast. A single isolated monzonite–diorite body has been outlined north of Iglusuataliksuak Lake, but may be a composite of two intrusions. At its northeastern end, it sits upon leucogabbro and is a hornblende-bearing rock that contains inclusions of foliated Alliger Lake granite. At its southwestern end, it is a blue-quartz-bearing rock reminiscent of the brown Paleoproterozoic(?) dioritic rock that borders, and appears transitional with, the western side of the Alliger Lake granite.

DYKES OF VARIOUS TYPES AND AGES

The region is transected by numerous small (cm to 20 m scale) dykes ranging in composition from hornblendite to granite pegmatite. These exhibit a variety of morphological and deformational features. A few examples of such dykes are given below.

Metagabbroic and metadiabase dykes, with a dominant southeast (140°) trend, are scattered through the Archean gneisses and are considered to be Paleoproterozoic intrusions equivalent to the Domes dykes (Ryan, 1990b) and the Napaktok dykes (Ermanovics and Van Kranendonk, 1990) farther north as noted previously. Most of these dykes are planar intrusions, up to 15 m wide that are traceable along strike for hundreds of metres. Primary igneous textures are widely preserved, but in many dykes, pyroxene(s), and to a lesser degree plagioclase, are replaced by secondary minerals, giving the dykes a dark-green cast. Foliation is heterogeneous, and is best seen on the dyke margins. The metamorphism and foliation are interpreted to result from thermotectonism accompanying the 1.86 to 1.74 Ga collisional Torngat Orogen. Dykes of similar character within the Alliger Lake granite support a Paleoproterozoic age for this intrusion, just as such deformed and metamorphosed dykes were used to argue for a Paleoproterozoic rather than Mesoproterozoic age for the Sheet Hill granite (Ryan, 1993).

Black-weathering dykes of hornblendite (metalamprophyre?), black- to dark-green-weathering dykes of metadiabase and metagabbro (Plate 5), yellow-brown-weathering dykes of magnetite-bearing monzonite or diorite, and brown to bright-pink-weathering dykes of aplitic to pegmatitic granite are widely distributed in the swath of generally coarse-grained Paleoproterozoic(?) basic intrusions between Iglusuataliksuak and Puttuaalu lakes. These dykes have a strong southeast (average 140°) preferred orientation, although other less common orientations have also been recorded. Most of these dykes exhibit clear field evidence of secondary (metamorphic) alteration of the primary igneous minerals, and many such dykes were the loci of shear-type deformation. Diabase dykes, for example, are converted to amphibole-rich paper schists proximal to the northwest-trending mylonite zone that passes through leucogabbroic rocks northeast of Miller's Pond, and many of the aplitic granitic dykes that occur within the basic plutons between Iglusuataliksuak and Puttuaalu lakes also display strong deformational fabrics. Although Ranson (1976) noted the presence of numerous basaltic and aplitic granitic dykes in the Iglusuataliksuak Lake area, he did not mention their metamorphic and structural state. Even though the compositions of these dykes, with the exception of the hornblendites, are matched by the compositional spectrum of the NPS, there is

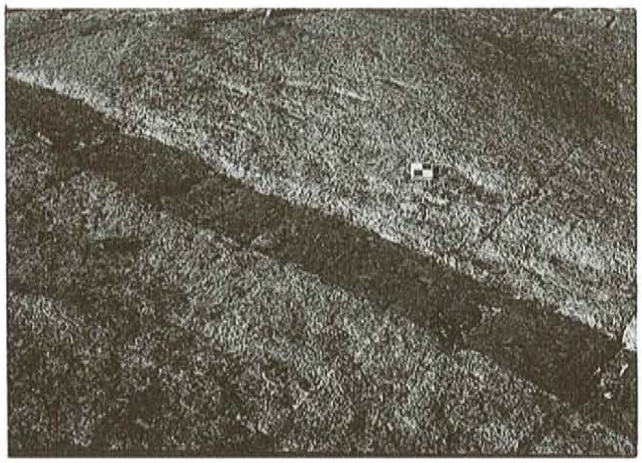

Plate 5. *A 140°-trending black amphibolite (metagabbro) dyke within white anorthosite on the southeast slope of Aupalukitak Mountain.*

no adequate reason to advocate a Mesoproterozoic age. Their dominant 140° trend (comparable with that of the Napaktok(?) dykes in the Archean terrane), their metamorphism and their deformation, and their exclusive concentration in the altered group of anorthositic and leucogabbroic rocks are sufficient evidence to entertain the notion that they and their NPS-like host-rocks are all Paleoproterozoic in age. Other aspects to be considered as pointing to a pre-NPS age for the dykes are that the hornblendites resemble the ca. 2000 Ma (A.C. Cadman, personal communication, 1995) lamprophyric intrusions within the Paleoproterozoic Satok Island monzonite, and the pink granitic aplite dykes are mesoscopically identical to the 1871 $^{+5}_{-2}$ Ma aplites that intrude deformed leucogabbro and anorthosite south of Iglusuataliksuak Lake (Connelly and Ryan, 1994; Ryan and Connelly, 1996).

A set of granular, black, "hornblende–granulite" dykes occurs locally in the layered "mafic granulite" and the anorthositic plutons in the Iglusuataliksuak Lake–Aupalukitak Mountain area. At least four generations of such dykes are exposed in layered mafic rocks on one small hill on the west side of Iglusuataliksuak Lake. Some of these dykes are bordered by narrow selvedges of leucogabbro, reminiscent of an older dyke being split by a younger intrusion that exploited the same fracture.

A 10 m-wide, east–west-oriented, hornblende-rich diorite dyke occurs on the summit of Aupalukitak Mountain. This dyke has a fine-grained margin, but is coarser (5 mm grain size) in the core. The plagioclase is distinctly pink, and is strongly normally zoned (R.F. Emslie, personal communication, 1997).

The types of dykes described above are absent from the Mesoproterozoic intrusions that constitute the western one-third of the map area. Fresh diabase dykes, having a predominant northeast trend have been recognized in a few places, but they are rare when compared to the abundance of altered, dominantly southeast-trending basic dykes to the east. Pink to red aplitic to pegmatitic granitic dykes, also with a predominant northeast trend, are more common than the diabasic dykes in the NPS plutons. These are undeformed, except adjacent to minor faults. Both the fresh diabase and the pink granite dykes occur in the Paleoproterozoic(?) intrusions to the east as well, but there they postdate the deformation exhibited by the older dyke group and its hosts.

Several large, medium- to coarse-grained, subophitic-textured, black-weathering, olivine gabbro dykes (Unit 20) have been partially outlined. The continuity of the east–west dyke along the northeast shore of Iglusuataliksuak Lake is probably representative of its extent, but the continuity of the northwest-oriented dyke trending through Alliger Lake is more speculative. The latter dyke forms a prominent yellowish brown zone of residual gravel on a ridge northwest of Alliger Lake, and continues northwest into the adjacent valley; its southward extrapolation is based on several small outcrops on a hillside 4 km east of Alliger Lake. Similar black olivine gabbros have been noted in isolated outcrops in meta-anorthosite west of Iglusuataliksuak Lake and in the Alliger granite south of Alliger Lake; in both cases, lateral continuity for significant distance cannot be demonstrated.

A plagioclase phyric, grey- to brown-weathering diorite or pyroxene monzonite dyke (Unit 21) trends northwest across Puttuaalu Brook. The extent of this dyke is based on three outcrops in the immediate area but a texturally similar rock also occurs within the monzonitic unit 5 km southeast of the presently assumed dyke termination (R.F. Emslie, personal communication, 1996), and the whole unit may be related to the monzonite intrusions. This rock is generally fine grained, but contains numerous dark-grey plagiclase phenocrysts or xenocrysts that are up to several centimetres in maximum dimension.

SELECTED FEATURES OF STRUCTURE AND TECTONICS

The development of the Archean gneiss complex in this part of Nain Province involved multiple plutonic episodes and polyphase deformation as early as ca. 3.6 Ga (e.g., Ermanovics and Van Kranendonk, *in press*; Schiøtte *et al.*, 1992). The bulk of the complex derives from multiphase granodioritic, tonalitic and dioritic igneous precursers that intruded and dispersed a sequence of metasedimentary rocks, mafic–ultramafic-layered rocks, and inferred mafic metavolcanic rocks. This early assemblage was isoclinally folded at granulite grade generally about north–south axes. A final, major tectonic event (ca. 2.7 to 2.56 Ga?) involved intrusion of quartz monzonitic–granodioritc rocks and open folding about northwest–southeast axes at amphibolite grade, dispersing and migmatizing the earlier granulites. This overprinting event is marked by rocks exhibiting pronounced southeast-trending foliations and by moderate- to shallow-plunging southeast-trending mineral lineations. The whole gneiss complex was folded about broad warps on east–west-trending axes to produce the present map pattern, prior to emplacement of a group of generally 140°-trending diabase dykes equated with the Paleoproterozoic Domes and Napaktok dykes. Both the dykes and the gneisses were subsequently affected by upper greenschist- to lower amphibolite-facies metamorphism and local deformation, events postulated to be the manifestation of the development of Torngat Orogen at 1.86 to 1.74 Ga.

The recognition of a group of deformed and hydrated basic intrusions and remnants of foliated granitoid rocks (along with the Alliger Lake granite) through the central part of the area, with evidence of metamorphism comparable to that seen in the diabase dykes in the Archean gneisses, suggest that these plutonic rocks represent pre-Torngat Orogen igneous activity and that their subsequent tectonic overprint is a consequence of the tectonism related to the Torngat Orogen. The dykes within these intrusions have, in many cases, preferentially absorbed the deformation and have been converted to actinolitic and hornblendic schists, likewise comparable to the reaction of Paleoproterozoic dykes in the Archean gneisses in the Okak and Saglek regions to the imposed Paleoproterozoic deformation and metamorphism (Ermanovics and Van Kranendonk, 1990; Ryan, 1990b).

A major ductile shear zone, exemplified by amphibolite-facies protomylonite to ribbon ultramylonite, transgresses the anorthositic rocks in the Miller's Pond–Iglusuataliksuak Lake area. Partly, it marks the contact between the Alliger Lake granite and the white anorthositic rocks to the southwest. It passes northward into a brittle fault south of Puttuaalu Lake, the continuity of which is lost in the drift-covered valley northwest of the lake, but it appears again as a ductile mylonite zone marking a contact between strongly foliated and recrystallized anorthosite and weakly foliated gabbronorite (R.F. Emslie, personal communication, 1997) just off the Alliger Lake map area to the north. The mylonite also disappears under drift cover east of Iglusuataliksuak Lake, but emerges in outcrop again to the southeast and off the map area along the western side of the Sheet Hill granite (Emslie *et al.*, 1997; Figure 1). From there it continues southward, where it is truncated by the Hettasch Lake troctolite of the NPS (Ryan, 1993). Limited structural indicators suggest that the movement on this shear was west-over-east.

There are profound implications for regional geology if, in fact, the group of intrusions addressed above is pre-NPS and their secondary metamorphic–structural characteristics are Paleoproterozoic in age. There have been no indications from previous work in this area that such rocks may exist here, perhaps because lithotype mapping has clouded the fact that there are other features of the rocks that bring into question a correlation with the NPS. Pre-NPS anorthositic intrusions allied with the 2.1 Ga granites in this area would support earlier suggestions by Ryan and Connelly (1996) that anorogenic magmatism of the NPS type occurred long before onset of the main NPS event. This would be the first clear recognition that pre-NPS "massif anorthosites" exist in Labrador, and give unequivocal evidence of the repetitive nature of this type of plutonism in the Nain area (*cf.,* Ryan and Connelly, 1996). The tectonic setting of this plutonism is unclear, but first-order considerations would link it with continental rifting that fractured the North Atlantic Archean craton in the Paleoproterozoic. If the deformation and metamorphism of these intrusions is of Paleoproterozoic age, it provides evidence that the effects of Torngat Orogen extend across the Nain Province foreland in this area. The overall character of the tectonism in this region is comparable with that seen in an analogous geographic position relative to the Torngat collisional suture in the Okak–Saglek region as noted above (cf. Ermanovics and Van Kranendonk, 1990; Ryan, 1990b). If this link can be substantiated, it provides the first firm evidence for ca. 1.8 to 1.7 Ga tectonic affects in this area. (It is possible to go one step further in this line of thought, and suggest that the folding of the Snyder Group, east of the map area, traditionally considered to be related to emplacement of the nearby Kiglapait layered intrusion, is due to Paleoproterozoic deformation as well. One feature that suggests this possibility is that the contact metamorphic isograds mapped by Speer (1973) plainly truncate the open-fold structures in the Snyder Group, indicating that the folding pre-dated imposition of the static metamorphism.)

Deformation fabrics are rarely present in the NPS plutons that underlie the western part of the area, aside from the foliated leuconorite in the southwest corner of the map area. The rare fabrics that have been observed in these plutons are confined to centimetre-scale hot-shear zones within otherwise subophitic igneous rocks, and to protomylonitic foliations associated with late brittle faults. The exception to this is the northwest-trending belt of strongly foliated and recrystallized leuconoritic rocks at the southwest corner of the study area, interpreted to be the preserved outer margin of a pluton that was deformed during emplacement essentially as a solid state body. This belt of foliated rocks, in which high temperature deformation and annealing have occurred, is identical to the foliated margins of such large and early (ca. 1350 Ma) anorthosite–leuconorite bodies as the Pearly Gates and Mount Lister intrusions. Therefore, it is probably continuous along strike and marginal to the abutting leuconorite–anorthosite outside the current map area, and could be used to outline the extent of this particular intrusion. It is certainly continuous to the northwest, but the excision by a younger leuconoritic intrusion at its southeast end in the current map area suggests that this older foliated intrusion may not extend much farther. Regardless, the identification of foliated, and quite likely very early, intrusions in this area substantiate earlier speculations on the presence of such rocks within the northern lobe of the NPS (Ryan, 1991b). The significance of the foliated rocks to the evolution of the NPS is still a matter of debate. Even though such rocks are confined to the perimeter of the Pearly Gates and Mount Lister intrusions, and can be postulated to be directly related to the emplacement of the plutons, there is insufficient evidence to fully discard notions that some regional-scale, but zonal, deformation overlapped the construction of the NPS.

GEOCHRONOLOGICAL STUDIES

It became obvious during the mapping of the Alliger Lake map area that certain fundamental problems needed to be resolved, especially the age of plutonic rocks crossing the area north-northwest from Iglusuataliksuak Lake. To this end, samples were collected by M.A. Hamilton for U–Pb geochronological studies at the Geological Survey of Canada. One of the samples to be investigated is a foliated pink aplitic granite that has intruded a monzonitic(?) "mesogranulite", the latter itself being foliated and having intruded, and incorporated inclusions of, recrystallized white anorthosite. It has already been shown by Connelly and Ryan (1994) that mesoscopically similar aplites south of the present map area are Paleoproterozoic, giving a crystallization age of ca. 1871 Ma. A sample of the "mesogranulite" was also collected to further investigate the age of the anorthositic and monzonitic magmatism in this area. As another test of the antiquity of the leucogabbroic rocks in the map area, an 11-m-wide, southeast-trending metagabbroic dyke was sampled on a hilltop east of Iglusuataliksuak Lake. A primary crystallization age would help ascertain the validity of correlating the metamorphosed dykes in this area with the Paleoproterozoic dykes of the area to the north, and at the same time provide a limit on the lower age of the gabbroic intrusions. Collectively, the results from the aplite, the monzonitic granulite and the metagabbro will enable constraints to be placed upon the minimum age of the anorthositic and leucogabbroic rocks around Iglusuataliksuak Lake. If these samples confirm the data of Connelly and Ryan (1994), then there can be little doubt that Paleoproterozoic (or Neoarchean) NPS-like anorthosites are present. This raises questions as to how much of the region between Puttuaalu Lake and Okak Bay is underlain by such rocks. Preliminary observations suggest to one of us (BR) that they may be more widespread than presently appreciated, especially in the area northeast of Umiakoviarusek Lake.

Fine-grained ferrodioritic rocks along the western margin of the Alliger Lake granite, in apparent mingled and gradational contact with the granite to the east (Ranson, 1976) and seemingly gradational to blue-quartz-bearing gabbroic rocks to the west, were collected to determine if these form part of the NPS or are related to the postulated Paleoproterozoic magmatism.

Only one of the western nested group of anorthositic and leuconoritic plutons proved to contain a compositional variant readily amenable to age-determination studies. The eastern border of the westernmost dark-grey anorthosite–leuconorite pluton is locally characterized by a zone of megabreccia, in which pale-grey to white angular anorthositic blocks reside in a dark-grey pegmatoidal leuconorite matrix. Within one such interblock zone, the leuconorite has intergranular pockets in which trapped magma has fractionated to a silicic composition, yielding a quartz–potash feldspar–biotite assemblage in which prismatic and stubby, pink to dark-brown zircons are developed. This pluton is probably one of the youngest in the area, so the zircon age determination will provide an indication of the timing of NPS magmatism here.

SULPHIDE MINERALIZATION

The NPS in the map area is presently the focus of exploration for Ni–Cu sulphide mineralization by several companies, arising from the 1995 staking frenzy that followed the recognition of the geological setting and the economic significance of the sulphide discovery in the Reid Brook troctolite near Voisey's Bay (cf., Ryan *et al.*, 1995; Emslie, 1996; Naldrett *et al.*, 1996). Many gossan zones and surface mineralization of a metre to hundreds-of-metres in dimension were found (Figure 2; *see,* press releases of Ace Developments, August 21, 1995; Canadian States Gas Ltd. [Resources], July 20, 1995; Cartaway Container [Resources] Corporation, August 31, 1995; NDT [– Aranlee, Project 15-1], August 15, 1995). The most extensive exploration programs in the map area during the summer of 1996 were those of Cartaway Resources, Canadian States Resources and Noranda Exploration, all of which hold contiguous claim blocks in the western part of the area. Several airborne magnetic anomalies, gossan zones and pockets of massive sulphide mineralization were outlined in this rugged country in 1995, of which the Cartaway "Cirque", and the Noranda "Hill-top" properties are illustrative topographic examples (*cf.,* Kerr and Smith, *this volume*). The "Cirque" gossans are exposed on the nearly vertical and inaccessible 300-m-high walls of a large cirque, and the Noranda area of interest is near the wind-swept summit of a 1000 m mountain. The Canadian States Resources prospects are in a setting that is less rugged, but still not well-protected from the vagaries of the weather. Targets of exploration interest and drill testing outside the western part of the map sheet included the "Krinor" occurrence of Castle Rock Exploration, which comprises a gossan zone and sulphide mineralization located on, and at the base of, a 200-m precipitous cliff south of Puttuaalu Brook, and the LB-J property of Cartaway Resources, situated in a drift-covered valley northwest of Puttuaalu Lake. These sulphide prospects, and others to be described below, are discussed here in their geological context. They are treated in more detail by Kerr and Smith (*this volume*).

There are several gossans in the Cirque area that are very conspicuous from many kilometres distance, particularly those on the Cartaway and Canadian States claim blocks. The distribution of the sulphide zones, implies that the mineralization is hosted by at least two differing rock units, namely the dark-grey- to buff-weathering leuconorite pluton and the pale-grey to mauve massive dyke-like anorthosite. The sulphide occurrences examined on the ground and in drill-core at the respective exploration camps (*see* also Kerr, 1996; Kerr and Smith, *this volume*) do not have a clear genetic relationship to the enclosing rock. These sulphides occupy centimetre to several metre scale irregular pockets and sharp-walled veins within otherwise barren host rocks, and appear to represent localized injections of sulphide liquid emplaced after the host rock had already been significantly or totally crystallized. There is textural evidence for intergrain migration of the sulphides into the immediate silicate host (net-texture), and a case can be made in a few examples that the sulphides may be indigenous to the enclosing rock (*see* Kerr and Smith, *this volume*), but evidence for appreciable sulphide liquid being present at time of cumulate formation is missing. This is in sharp contrast to the Voisey's Bay deposit, where the sulphide magma was quite clearly an integral and significant component within the silicate magma that produced the troctolitic rocks of the Reid Brook intrusion. Data from company press releases indicate that the sulphide mineralization encountered in drillholes by both Canadian States and Cartaway is subeconomic. The grades of both Ni and Cu from the most thoroughly tested surface and drill prospects are generally less than 2% and Co is less than 0.2%. For a summary of results from both properties, see Kerr and Smith (*this volume*).

The Noranda Exploration site, termed the "Hill-top" property, occurs within massive anorthosite and mottled olivine anorthosite that lies stratigraphically above the mottled leucotroctolite in this area. The intermittently exposed surface mineralization is confined to a granular gabbronoritic rock ("granulite") of unclear relationship to the anorthosite. It resembles the layered gabbronoritic rocks that occur on the margin of the pluton to the west, so that it could be a mineralized dyke of this latter rock. In fact, drilling has intersected a mineralized dyke-like gabbroic body within the immediate area (G. Squires, personal communication, 1996). Although a direct link between this dyke and the scattered mineralized surface outcrops is equivocal, the outcrops fall within a geophysical anomaly that is interpreted to correspond with the subsurface strike of the dyke (G. Squires, written communication, 1997). Noranda has not released any geological data nor assay results from its Hill-top drilling program.

The Krinor showing (Castle Rock Exploration) is within the crescent-shaped layered gabbronoritic (dioritic) intrusion that underlies a highland area south of Puttuaalu Brook, and is one of several gossanous sulphide concentrations in this area. Castle Rock Exploration reported that grab samples from surface mineralization indicated maximum values of 1.31% Ni, 0.52% Cu and 0.21% Co. The distribution of the cliff stain and the massive sulphide minerals in outcrop at the base of the cliff indicate that the mineralization is restricted in distribution, is discontinuous along strike, and cuts across the layering in the host rocks. These features are consistent with post-cumulate processes, suggesting that here, too, the mineralizing event is separated from the genesis of the layered sequence itself. Other occurrences have irregular and limited distribution as well, and similarly cannot be tied genetically to their hosts. Conversely, a gossan zone southeast of the Krinor (on the Columbia Yukon 1506M claim block) is developed over sulphide mineralization that seems to be confined to the interstices of pyroxenes in a dark pyroxenite unit within the layered rocks, indicating that some sulphide deposition was contemporaneous with silicate magma crystallization. Results from 7 drillholes from this zone (Columbia Yukon press releases, June 7 and 20, 1996) indicated maximum assays of 1% Ni, 0.9% Cu and 0.14% Co. Kerr and Smith (*this volume*) provide more data from these properties.

There are several other sulphide gossans in the area:

1) A prominent notch within a mountain face of Unit 10 in the southwest part of the area, the trace of a minor fault, is the site of a rusty sulphide-bearing zone that is under licence to NDT (– Layfield, project 14-4). Binocular examination of this occurrence suggests that the limited mineralization may be related to a ferrodiorite dyke that forms the hill at this location.

2) A rusty cliff wall is developed within grey or buff leuconorite on the north side of Puttuaalu Brook (Canadian States, 1558M), but is inaccessible from the valley floor.

3) Rusty layered gabbronoritic (dioritic) rocks and an associated gossanous ferrodiorite dyke outcrop on the south side of the brook in the same area (also Canadian States, 1558M). This zone has been drilled, and sulphide mineralization was reported by Canadian States Resources in press releases on July 10 and 15, 1996. No systematic drilling results have been released, but grades of up to 1.29% Ni, 0.58% Cu, and 0.12% Co were reported in a press release on September 11, 1996.

4) Several gossanous zones are obvious within the mesocratic granulite (Unit 7) at the southwest corner of the sheet (NDT–Aranlee, Project 15-1). Grab samples from the gossans yielded up to 1.06% Ni, 0.88% Cu and 0.16% Co (Aranlee Resources, press release, May 14, 1996).

5) Absolut Resources discovered several small sulphide gossan zones east of Iglusuataliksuak Lake in 1995. One zone is developed in mildly deformed and metamorphosed,

possibly Paleoproterozoic-aged, leucogabbro, cut by metamorphosed mafic dykes, where the leucogabbro has intruded a sequence of layered mafic and ultramafic "granulite" at the southeast corner of the area. The distribution of the sulphide minerals is not easily discerned because of the surface rust, but a company press release in July of 1995 indicated that both massive and disseminated mineralization could be recognized within the "anorthosite" of the region. If this mineralization is indigeneous to the leucogabbro, and if the leucogabbro is Paleoproterozoic, then it is obvious that pre-NPS intrusions have the potential to host larger concentrations of sulphide.

Some of the recent exploratory drilling in the Alliger Lake area has been carried out on the basis of geophysical anomalies both in areas of good bedrock exposure and in areas where no bedrock is exposed. An example of the latter is the Cartaway Resources LB-J project, where an EM target was outlined in a broad drift-covered valley northwest of Puttuaalu Lake. Here, two holes intersected a flat-lying troctolitic intrusion having layers of subeconomic mineralization in which the sulphides have a network texture and are apparently coeval with the host (Cartaway Resources, press releases of April 24 and 29, and June 20, 1996).

To summarize, it is clear that the recent surface exploration and drilling in the Alliger Lake region has not been successful in discovering "another Voisey's Bay". However, the distribution of massive and disseminated sulphide mineralization indicates that magmatic sulphide liquids were associated with the genesis of the rocks here, but the most promising sulphide prospects apparently do not represent accumulations that were contemporaneous with the intrusions that now enclose them. There are two critical questions that need to be answered, with respect to the genesis of, the mineralization: Where did the sulphide liquid come from and what is it related to...and do the podiform sulphide accumulations represent upward migration of sulphide magma from an underlying 'leaky' reservoir, or downward migration from a now eroded higher magma chamber? It seems that the current thought among some of the industry personnel (cf., Cartaway Resources, press release, June 20, 1996) is that the sulphide mineralization was generated by the former process, and deep drilling will be undertaken in order to test the existence of such a hidden source.

CONCLUSIONS

Several major results can be claimed from the mapping of the Alliger Lake map sheet area. These have implications for further studies in this area and adjacent map areas. At the same time, new problems have been highlighted.

1. Massive to layered "granulites" of the Iglusuataliksuak Lake area are derived from an igneous precursor, but the age of these metaigneous rocks is debatable. Ranson (1976, 1981) favoured a link to NPS plutonism, but if the gabbroic pluton that intrudes these granulites is Paleoproterozoic, then this link is obviously invalid. The fact that the leucogabbroic–anorthositic rocks associated with the mafic granulite rocks were foliated prior to the injection of a suite of probable Paleoproterozoic basic dykes implies a Neoarchean age.

2. It has been shown that some of the basic plutonic rocks, through the central part of the map area, are mineralogically and structurally separable from the plutonic rocks that occupy the western third of the area. In addition to their mesoscopic differences, the former group is also transected by a suite of variably metamorphosed and deformed basic dykes. It is possible that this group of anorthositic, leucogabbroic, and leuconoritic intrusions is not part of the Mesoproterozoic NPS, but represents, instead, Paleoproterozoic intrusions that are allied to the Paleoproterozoic Alliger Lake granite and Sheet Hill granite. The secondary minerals and deformation displayed by these basic intrusions could be the direct result of tectonism accompanying the formation of Torngat Orogen. Sulphide mineralization in these gabbroic rocks points to an additional exploration target in this region.

3. In spite of the failure to recognize clear intrusive relations in all cases, we have demonstrated that the NPS basic plutonic rocks in the western part of the map area can be subdivided into many distinct intrusions. This corroborates findings from elsewhere in the NPS that the igneous terrane comprises nested intrusions that represent many pulses of similar magmatism rather than a singular "instantaneous" event.

4. The recognition of high-temperature foliated and annealed zones proximal to variably recrystallized anorthosite and leuconorite in this area extends the known distribution of plutons assumed to be emplaced as solid state bodies early in the evolution of the NPS. Hence, it is clear that the pluton in the southeast corner of the map area is one such intrusion, and that it has been subsequently intruded and stoped by at least one younger pluton that was derived from a crystal-laden magma. The recognition of this high-temperature recrystallized border, and its peripheral gneisses, confirms the notion expressed elsewhere (Ryan, 1991b) that such solid-state deformed rocks are more widespread than currently appreciated from reading the available literature. It may be the eastern continuity of a foliated margin to a similar pluton previously outlined in the Kingurutik River area (cf. Brand, 1976; Ryan, 1991b); if so, it could be used as a marker unit to define the extent of that pluton.

5. Sulphide mineralization in the area clearly occurs in several differing NPS intrusions and, in at least most of the examples with which we are familiar, is disposed as podiform concentrations having limited continuity. It is apparent that

few, if any, of the more promising prospects in the Alliger Lake map area represent sulphide magma which was contemporaneous with the enclosing plutonic rock. Rather, the mineralization has features that are better interpreted in terms of emplacement within brittle fractures following near or total solidification of the hosting plutonic rocks. Although the relative timing of sulphide injection can be ascertained on a local scale, its absolute age is unknown. Certainly, the similarity of the mineralization in the major prospects indicates a similar process operating in all of them, but this does not imply that they are all of the same age. The source of the sulphide magma remains a mystery, and leaves open prospects for the future discovery of a larger and economic concentration of sulphide minerals.

ACKNOWLEDGMENTS

The field season's surveying went smoothly because of the helicopter flying of expert pilots John Danby and Steve Howe. Ron Emslie, Mike Hamilton and Dick Wardle provided sounding boards for some of the discussions regarding regional geology, and Ron is thanked for his contributions to the mapping and to this paper. We appreciate the field and office discussions with Andy Kerr, regarding his impressions of the style and nature of the sulphide mineralization in the project area. Andy is thanked for his constructive comments on an early draft of this paper. We thank the mineral exploration companies who allowed us to examine their drill core, and we acknowledge their openess in camp discussions and for allowing us to use some data not yet in the public domain; they may not necessarily agree with all our interpretations.

REFERENCES

Brand, S.
1976: Geology, petrology and geochemistry of the Lower Kingurutik River area, Labrador, Canada. Unpublished Ph.D. thesis, Purdue University, W. Lafayette, Indiana, 265 pages.

Connelly, J. N. and Ryan, B.
1994: Late Archean and Proterozoic events in the central Nain craton. *In* Eastern Canadian Onshore-Offshore Transect (ECSOOT), Report of Transect Meeting (December 10-11, 1993). *Edited by* R.J. Wardle and J. Hall, University of British Columbia, LITHOPROBE Secretariat, Report 36, pages 53-61.

Emslie, R.F.
1996: Troctolitic rocks of the Reid Brook intrusion, Nain Plutonic Suite, Voisey Bay area, Labrador. *In* Current Research, Part C. Geological Survey of Canada, Paper 96-1C, pages 183-196.

Emslie, R.F., Ermanovics, I.F. and Ryan. A.B.
1997: Geology of the northern Nain Plutonic Suite and its envelope rocks, Labrador. Geological Survey of Canada, Current Research, Report 1997-C, pages 223-234.

Emslie, R.F., Hamilton, M.A. and Thériault, R.J.
1994: Petrogenesis of a mid-Proterozoic anorthosite-mangerite-charnockite-granite (AMCG) complex: Isotopic and chemical evidence from the Nain Plutonic Suite. Journal of Geology, Volume 102, pages 539-558.

Emslie, R.F. and Loveridge, W.D.
1992: Fluorite-bearing Early and Middle Proterozoic granites, Okak Bay area, Labrador: Geochronology, geochemistry and petrogenesis. Lithos, Volume 28, pages 87-109.

Ermanovics, I.F. and Van Kranendonk, M.
1990: The Torngat Orogen in the North River - Nutak transect area of Nain and Churchill provinces. Geoscience Canada, Volume 17, pages 279-283.

In press: Geology of the Archean Nain Province and Paleoproterozoic Torngat Orogen in a transect of the North River–Nutak map area, Newfoundland and Quebec. Geological Survey of Canada, Bulletin 497.

Kerr, A.
1996: Searching for the siblings of Voisey's Bay: diverse Ni–Cu–Co sulphide mineralization in northern Labrador. *In* Report of Activities, 1996. Newfoundland Department of Mines and Energy, Geological Survey, pages 44-46.

Kerr, A. and Smith, J.L.
This volume: The search for magmatic Ni–Cu–Co mineralization in northern Labrador: A summary of active exploration programs.

Morse, S.A.
1971: Introduction. *In* The Nain Anorthosite Project, Labrador: Field Report 1971. *Edited by* S.A. Morse, Department of Geology, University of Massachusetts, Amherst, Massachusetts, USA, Contribution 9, pages 1-7.

Naldrett, A.J., Keats, H., Sparkes, K. and Moore, R.
1996: Geology of the Voisey's Bay Ni-Cu-Co deposit, Labrador, Canada. Exploration and Mining Geology, Volume 5, pages 169-179

Ranson, W.A.
1976: Geology of the Ighlokhsoakhtaliksoakh Lake area. *In* The Nain Anorthosite Project, Labrador: Field Report 1975. *Edited by* S.A. Morse, Department of Geology,

University of Massachusetts, Amherst, Massachusetts, USA, Contribution 26, pages 33-45.

1977: Anorthositic and monzonitic rocks near Puttuaaluk Lake, Labrador. *In* The Nain Anorthosite Project, Labrador: Field Report 1976. *Edited by* S.A. Morse, Department of Geology, University of Massachusetts, Amherst, Massachusetts, USA, Contribution 29, pages 21-32.

1979: Anorthosites of diverse magma types in the Puttuaaluk Lake area, Nain Complex, Labrador. Unpublished Ph.D. Thesis, University of Massachusetts, Amherst, Massachussetts, USA.

1981: Anorthosites of diverse magma types in the Puttuaaluk Lake area, Nain Complex, Labrador. Canadian Journal of Earth Sciences, Volume 18, pages 26-41.

Royse, K.R. and Ryan, B.
1995: Structural evolution and emplacement of the Nain Plutonic Suite in the Dog Island area. *In* Current Research. Geological Survey Branch, Department of Natural Resources, Report 95-1, pages 37-46.

Ryan, B.
1990a: Preliminary geological map of the Nain Plutonic Suite and surrounding rocks (Nain-Nutak, NTS 14SW). Newfoundland Department of Mines and Energy, Geological Survey Branch, Map 90-44, Scale 1:500 000.

1990b: Basement-cover relationships and metamorphic patterns in the foreland of the Torngat Orogen in the Saglek-Hebron area, Labrador. Geoscience Canada, Volume 17, pages 276-279.

1991a: Nain - Nutak area: a new 1:500 000-scale colour compilation. *In* Current Research. Geological Survey Branch, Department of Mines and Energy, Report 91-1, pages 229-230.

1991b: New perspectives on the Nain Plutonic Suite and its country rocks. *In* Current Research. Geological Survey Branch, Department of Mines and Energy, Report 91-1, pages 231-255.

1992: Nain area geology: observations on selected islands, and the area south of Nain Bay (NTS 14C/6, 14; 14D/9). *In* Current Research. Newfoundland Department of Mines and Energy, Geological Survey Branch, Report 92-1, pages 381-398.

1993: Further results of mapping gneissic and plutonic rocks of the Nain area, Labrador. *In* Current Research. Newfoundland Department of Mines and Energy, Geological Survey Branch, Report 92-1, pages 61-75.

Ryan, B. and Connelly, J.N.
1996: Paleoproterozoic plutonism in the Nain area: similar rocks (but differing origins?) to the Mesoproterozoic Nain Plutonic Suite. *In* Proterozoic Evolution in the North Atlantic Realm. *Compiled by* C.F. Gower. COPENA-ECSOOT-IBTA conference, Goose Bay, Labrador, July 29-August 2, 1996, Program and Abstracts, pages 156-157.

Ryan, B. and Hynes, A.
1996: Geology of the Alliger Lake area (NTS 14E/1). *In* Report of Activities, 1996. Newfoundland Department of Mines and Energy, Geological Survey, pages 65-7.

Ryan, B, Wardle, R.J, Gower, C. F. and Nunn, G.A.G.
1995: Nickel-copper-sulphide mineralization in Labrador: the Voisey Bay discovery and its exploration implications. *In* Current Research. Newfoundland Department of Natural Resources, Geological Survey, Report 95-1, pages 177-204.

Schiøtte, L., Nutman, A.P. and Bridgwater, D.
1992: U-Pb ages of single zircons within "Upernavik" metasedimentary rocks and regional implications for the tectonic evolution of the Archean Nain Province, Labrador. Canadian Journal of Earth Sciences, Volume 29, pages 260-276.

Speer, J. A.
1973: Stratigraphy, structure and metamorphism of the Snyder Group. *In* Nain Anorthosite Report, Labrador, Field Report 1972. *Edited by* S.A. Morse. University of Massachusetts, Department of Geology, Contribution 11, pages 21-29.

Taylor, F.C.
1977: Geology, North River-Nutak. Geological Survey of Canada, Map 1436A, 1:250 000 scale.

Wheeler, E.P.
1954: Report on Field Work done in 1953 and 1954. Unpublished BRINEX report on file with the Department of Mines and Energy, Geological Survey, 7 pages.

1969: Minor intrusives associated with the Nain anorthosite. *In* Origin of Anorthosite and Related Rocks. *Edited by* Y.W. Isachsen. New York State Museum Science Service, Memoir 18, Albany, New York, pages 189-206.

Wiebe, R.A.
1990: Dioritic rocks in the Nain Complex, Labrador. Schweizerische Mineralogische und Petrographische Mitteilungen, Volume 70, pages 199-208.