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A TALE OF MORE THAN TEN PLUTONS [GEOLOGY OF THE REGION BETWEEN OKAK BAY AND STAGHORN LAKE, LABRADOR (PARTS OF NTS MAPS 14E/2,7,8)]

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ABSTRACT

The region between Okak Bay and Staghorn Lake is underlain by numerous plutons of granitic and anorthositic rocks. All these plutons had, up to 1996, been assigned to the Mesoproterozoic Nain Plutonic Suite (NPS), but it has since been recognized that they display field characteristics that justify their subdivision into two separate, and unrelated, groups. A bipartite first-order age classification is established for these plutons: those that are Paleoproterozoic and temporally separated from the NPS, and those that are Mesoproterozoic and belong to the NPS. The older group includes anorthositic to gabbroic plutons and monzonitic to granitic plutons that form a northwest-trending swath through Umiakoviarusek Lake, mimicking the grain of the Archean gneisses of the Nain Province. These intrusions are variably altered, locally deformed, and exhibit other secondary characteristics that are interpreted to reflect the influence of the ca. 1.8 Ga Torngat Orogen. The younger group, those that belong to the NPS, occur between the Kingurutik River and Umiakovik Lake, and include overall compositions that closely approximate those of the older group, i.e., anorthositic and granitic. However, the younger intrusions lack the post-crystallization characteristics seen in the older group, and they tend to be larger, have more bulbous outlines, and their shapes are not noticeably influenced by pre-existing structures. Together, the Paleoproterozoic and Mesoproterozoic plutons number at least a dozen separate intrusions, and they represent two pulses of magmatism having likely older and younger time spans of 2124 to 1860 Ma and 1350 to 1318 Ma, respectively.

Sulphide prospects in the Okak Bay–Staghorn Lake region appear to be related to both Paleoproterozoic and Mesoproterozoic mineralizing events. The OKG prospect is proposed as a possible example of the former, whereas the Staghorn Lake prospects are examples of the latter. The recognition of plutonic rocks and sulphide mineralization postulated to be both Paleoproterozoic and Mesoproterozoic in age is a clear indication that magmatic processes, and not the age of the rocks, are the controlling factors in the generation of sulphide magmas in northern Labrador. It is also apparent, that if the postulate of Paleoproterozoic mineralization is verified, then the assumed specific controls on the formation of the Voisey's Bay deposit have no bearing on the formation of the older sulphide magmas.

> *"How many plutons are there? The question has meaning only if criteria can be set up for distinguishing one pluton from another."*
> Konrad Krauskopf, 1968.

INTRODUCTION

The primary title of this contribution is a variation on that of a classic paper written by Konrad Krauskopf thirty years ago (Krauskopf, 1968), the thesis of which is summarized by the quotation above. In the paper, he discussed some of the fundamental problems associated with "stratigraphic" mapping of igneous units within batholiths, using his experience in the Mesozoic Sierra Nevada Batholith of California. These problems confront everyone working within large igneous

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terranes that have evolved through protracted and pulsating magmatism. The Nain Plutonic Suite (NPS) of Labrador is one such igneous terrane, being an anorogenic Mesoproterozoic batholith that has numerous plutons of both similar and contrasting character – anorthosite, granite, diorite, troctolite – and which was constructed during a 60-million year period. Understanding the emplacement order of the plutons within the Mesoproterozoic NPS is fraught with the same or similar obstacles (e.g., the importance of compositional contacts) as understanding the temporal evolution of the Mesozoic Sierra Nevada intrusions.

For the past two summers (1996-1997), the senior author has been dealing with the kind of problems which Krauskopf (1968) addressed, by attempting to divide one part of the NPS on the basis of the relative ages of emplacement of its different subunits. One of the incentives behind this approach is to ascertain if any of the numerous sulphide showings discovered by junior exploration companies in the study area have any spatial or temporal relation to that "stratigraphy". The attempt to define separate intrusions and to determine the age relations between them has had a mixed success (Ryan *et al.*, 1997). In some cases, criteria can be established to "lump" or "split" specific groups of rocks into discrete intrusions, or clear intrusive contacts can be defined to demonstrate the relationship between the different rock units. In other cases, there is little direct evidence to firmly defend or verify surmised relations. In this paper, the results from the 1997 field program within the NPS and within a similar, but older, group of rocks south of Okak Bay are summarized, and evidence or rationale is presented for the postulated divisions discussed here.

A REVISION TO THE AREAL DISTRIBUTION OF THE NORTHERN NPS

Since the early 1940s it has been known that the NPS is dominated by anorthositic and granitic rocks, accompanied by subordinate dioritic and troctolitic compositions (cf. Wheeler, 1942, 1960; Emslie *et al.*, 1972). By the early 1980s, it was apparent that each of the major subdivisions comprised a plethora of individual intrusions, and the field data available at that time allowed Morse (1983) to propose a provisional regional emplacement sequence for the basic rocks. The general relationships established by Morse (*op. cit.*) are supported by regional Ar isotopic systematics (Yu and Morse, 1993), and the U–Pb data clearly demonstrate that several generations of granitic and anorthositic intrusions are present, and attest to pulsating magmatism that lasted for several tens of millions of years (cf. Hamilton *et al.*, 1994).

Compilation maps of the NPS (cf. Wheeler, 1969; Taylor, 1977; Ryan, 1990a; Figure 1a) portray a large area underlain by anorthositic rocks extending northward from Kingurutik Lake to Okak Bay, flanked on the west by the bulbous Umiakovik Lake granite and on the east by smaller, irregular, granitic to syenitic intrusions and by Archean gneisses. This northern lobe underlies a mountainous area to which access is difficult. Reconnaissance work by several junior exploration companies in the area in 1995 resulted in the discovery of numerous gossan zones and sulphide prospects within anorthositic rocks (cf. Kerr and Smith, 1997). These exploration results prompted the Geological Survey of Newfoundland and Labrador (GSNL) to commence a regional mapping survey there in 1996, in order to assess the regional geological setting and possible stratigraphic controls of these sulphide prospects in comparison to those of the syngenetic, troctolite-hosted, Voisey's Bay Ni–Cu–Co ore-body (Ryan *et al.*, 1995; Naldrett *et al.*, 1996). The area chosen for 1:50 000 mapping in 1996 was centred on Puttuaalu Lake, covering NTS map area 14E/1 (Ryan *et al.*, 1997), and was part of a larger area extending toward Okak Bay that was encompassed by a 1:100 000-scale program by the Geological Survey of Canada (GSC) carried out from the same camp (Emslie *et al.*, 1997; Ermanovics *et al.*, 1997). The NTS 14E/1 area was singled out because most of the exploration activity was taking place there.

The 1996 provincial mapping survey across the Puttuaalu Lake area provided very persuasive field evidence to conclude that a large part of the region previously included within the NPS is, in fact, *not* underlain by NPS rocks; rather, many of the rocks there are part of an older, Paleoproterozoic, group of intrusions that display many of the characteristics of the NPS (Ryan *et al.*, 1997; Figure 1b). This first-order subdivision into Paleoproterozoic and Mesoproterozoic units of similar-looking plutonic rocks was based on the recognition that one group of intrusions differed markedly from another group. Those plutons assigned a Paleoproterozoic age show one or more of the following post-emplacement traits: i) intruded by a myriad of melanocratic, granular "granulite" dykes, ii) intruded by altered and deformed metadiabase dykes having a predominant 140° trend, iii) intruded by foliated pink aplitic granite dykes that have a trend similar to the metadiabase dykes, iv) locally characterized by high-temperature subsolidus hydration, v) regionally, although not evenly, altered (metamorphosed at greenschist facies) to the same degree as the crosscutting dykes, and vi) regionally, although inhomogeneously, foliated. Mesoproterozoic plutonic rocks show none of these secondary features, with the exception of minor alteration of the basic rocks adjacent to faults and more pervasive replacement of pyroxene by amphibole in proximity to the granitoid rocks in the western part of the study area. The Paleoproterozoic stratigraphic niche given to the altered group on the basis of field criteria (Ryan *et al.*, 1997) has subsequently been verified by U–Pb age dates from several of those units (Hamilton *et al.*, 1997), demonstrating that they were emplaced before 2.0 Ga. Most of the secondary features noted above can probably be attributed to the influence of the collisional development of

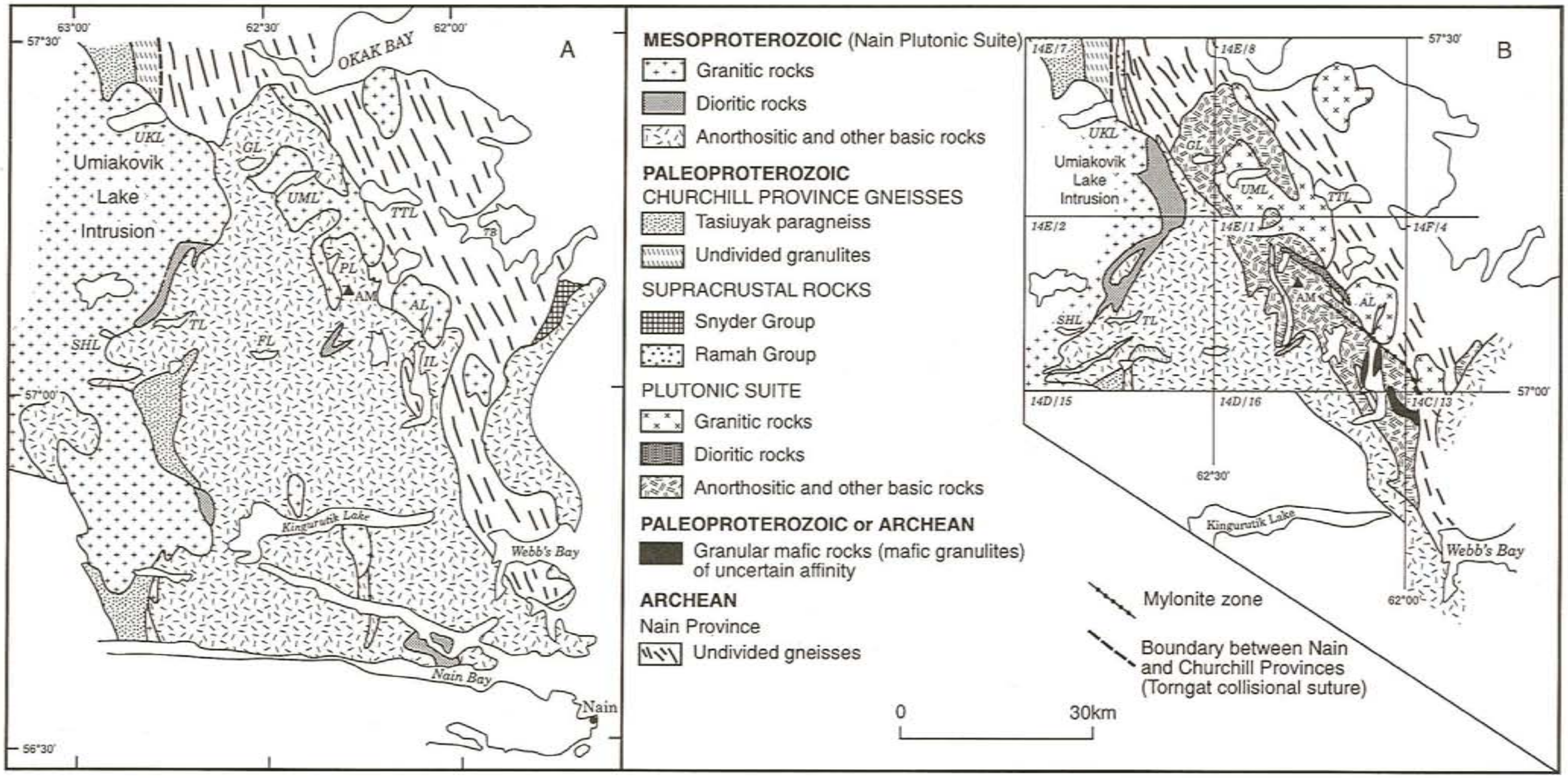

Figure 1. *Sketch maps to show differing interpretations of the age of the plutonic rocks south of Okak Bay. (a) From the regional compilation of Ryan (1990a), which designated all the plutonic rocks as being part of the NPS. (b) The current interpretation of the plutonic terrane based on field work in this area in 1996 and 1997, augmented by earlier mapping of the senior author. The work in 1997 was concentrated within NTS map area 14E/2, 7 and 8. Geographic features are as follows: UKL = Umiakovik Lake,* GL = Goudie Lake, *UML = Umiakoviarusek Lake, TTL = Tasiuyak Tasialua Lake, TB = Tasiuyak Bay, PL = Puttuaalu Lake, AM = Aupalukitak Mountain, SHL = Staghorn Lake,* TL = Tallifer Lake, FL = Frozen Lake, AL = Alliger Lake, *IL = Iglusuataliksuak Lake.*

the ca. 1.8 Ga Torngat Orogen to the west (cf. Van Kranendonk, 1996).

The first-order bipartite regional subdivision of "older" and "younger" groups of anorthositic and granitic intrusions was further subdivided internally into individual plutons or parts of plutons, and more than a dozen different intrusions were outlined between the two groups on NTS map area 14E/1 (Ryan *et al.*, 1997). It was from this starting point that the stratigraphic mapping was conducted in 1997 – on three sheets that abut NTS 14E/1, namely NTS 14E/2, 7, and 8 (Figure 1b) – the field results of which are presented and discussed here.

REGIONAL OVERVIEW

The regional reconnaissance mapping carried out by the GSC in 1996 (Emslie *et al.*, 1997; Ermanovics *et al.*,1997) confirmed previous interpretations that the area between Okak Bay and the Kiglapait Mountains comprises Archean and Paleoproterozoic gneisses, Paleoproterozoic supracrustal rocks, and large tracts of anorthositic and associated granitic rocks. Most of the plutonic rocks have been traditionally considered to be part of the Mesoproterozoic NPS (Figures 1a and 2). However, the 1996 mapping provided field data that significantly modified some of the contemporary thought on the geology of the region. Among the new data were i) the identification of Paleoproterozoic Ramah Group sedimentary rocks as strongly tectonized slivers interleaved with refoliated Archean gneisses northeast of Umiakovik Lake, defining a zone of intense structural reworking of Archean basement and its Paleoproterozoic cover in the proximal foreland east of the Torngat collisional suture, ii) the identification of the Torngat overprint on Archean gneisses and Paleoproterozoic mafic dykes as far as 50 km east of the collisional suture, and iii) the recognition, from the GSNL work (Ryan *et al.*, 1997), that there was a group of anorthositic and granitic rocks in the central part of the region that were related to pre-Torngat intrusive events rather than being part of the younger, post-Torngat NPS.

THE OKAK BAY–STAGHORN LAKE GEOLOGY

The results of the 1996 GSNL mapping and the subsequent age dating (Ryan *et al.*, 1997; Hamilton *et al.*, 1997) in the Puttuaalu Lake area suggested that it would probably be possible to partition all the igneous rocks throughout the whole Okak Bay area into "older" and "younger" groups because it seemed likely that there were more "old" intrusions present than apparent from the GSC reconnaissance work. Indeed, the 1997 mapping seems to confirm this, and, while still lacking geochronological data, it is proposed that all those rocks comprising a northwest-trending swath from Umiakoviarusek Lake to Ikinet Brook (NTS 14E/7,8)* are part of the Paleoproterozoic intrusive assemblage, whereas rocks of similar composition in the western part of the study area belong to the Mesoproterozoic NPS; this interpretation is shown in Figure 3. The rock names used herein are based primarily on field observations, and some of these names may be modified as more data become available. Most of the stratigraphic names for the plutons are informal and provisional. The geographic names used for the intrusions are, where possible, captured from appropriate features named on the NTS map sheets, but in the absence of such NTS nomenclature local names shown on archival maps of E.P. Wheeler II and employed by others in the area are used; these have been italicised in the text (*see* Appendix for details).

ARCHEAN GNEISSES

The northeastern and northern parts of the study area comprise amphibolite- to granulite-facies gneisses of the Nain Province, part of a coastal region of Archean-aged rocks that stretches for over 300 km to the north and over 200 km to the south (Wardle *et al.*, 1997). These Archean gneisses were perfunctorily investigated during the 1997 season, mostly between Okak Bay and Tasiuyak Tasialua Lake. The predominant rock is a massive to well-layered, buff-weathering, and locally very friable, migmatitic quartzofeldspathic one probably derived from more than one generation of igneous protolith. It exhibits evidence of a polyphase structural history, and exposures, even over small areas, can vary from regularly layered rocks of apparently simple structure to highly convoluted rocks exhibiting evidence for two or more episodes of deformation, metamorphism and granitic veining. These quartzofeldspathic rocks are rarely free of layers, lozenge-shaped lenses, or angular enclaves of contrasting composition (mafic gneiss, biotite-rich paragneiss, ultramafic rock, and metaleucogabbro and meta-anorthosite) and they are invariably transected by one or more generations of buff, white, or pink granitic veins and large (5- to 10-m-wide) granitoid sheets that hold a variety of emplacement times relative to local deformation.

Mafic gneisses locally form mappable units several hundred metres wide and traceable along strike for several kilometres. The most prominent are mafic granulites that occupy part of a steeply north-plunging antiform on *Illuilik ridge*, between Ikinet Brook and Okak Bay. These are granu-

* Because of the scale and patterning of the figures in this report it is not possible to show some of the geographic names on the figures; the reader is referred to the relevant NTS map sheets.

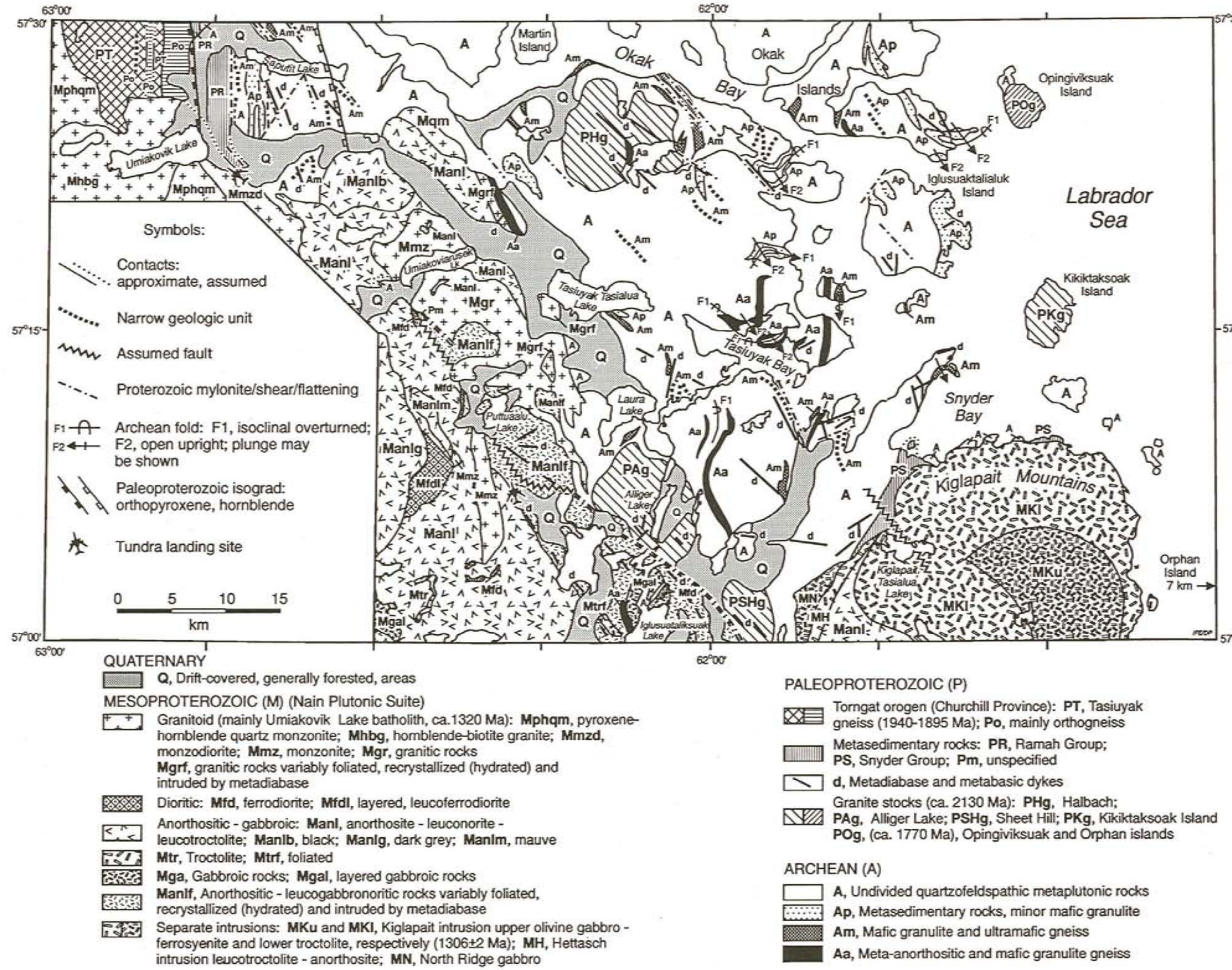

Figure 2. *A general geology map of the Kiglapait Mountains–Okak Bay region, from Emslie* et al. *(1997). The area surveyed by the GSNL during 1997 includes the plutonic rocks between Tasiuyak Tasialua Lake and Saputit Lake, and the region south of Umiakovik Lake that is covered by the "Symbols" box on this sketch map. The age designations and boundaries for some of the plutonic rocks on this map differ from those of Figure 3.*

lar ("salt-and-pepper" textured), fine- to medium-grained rocks having a regionally developed compositional layering and a local mineral foliation. Hornblende, plagioclase, orthopyroxene and clinopyroxene are recognizable as the main mineral components, but garnet is present in many places. The latter mineral locally has well-developed peripheral reaction (decompression?) rims that appear to comprise plagioclase, pyroxene and hornblende; blue-grey "warts" and spots are present in mafic gneisses where garnet has been totally eliminated from the rock at the expense of the reaction minerals.

Metasedimentary rocks are present as units within the Archean gneisses of the Okak Bay–Saputit Lake area and as narrow slivers between younger intrusive rocks southwest and northeast of Umiakoviarusek Lake. Near Okak Bay, they are predominantly rusty-weathering, biotite-rich, garnet±sillimanite paragneisses associated with the mafic granulites or as discontinuous units, tens or a few hundred metres in maximum dimension, within the quartzofeldspathic granulites; these are not shown on Figure 3. Grey quartzite and brown forsterite-bearing marble are rare associated rock-types. Garnet and sillimanite in the aluminous gneisses have been transformed into dull-grey or purplish-grey cordierite-bearing pseudomorphs, due either to a thermal overprint from adjacent intrusions to the west or a post-granulite-facies regional metamorphic event. Paragneisses to the south of Saputit Lake (Figure 3) have been overprinted by Paleoproterozoic amphibolite-facies metamorphism and foliation; these features result from tectonism associated with reworking of the Archean foreland to Torngat Orogen (Ermanovics *et al.*, 1997), and are muscovite-bearing, flaggy rocks. Metasedimentary rocks sandwiched between younger plutons west of Umiakoviarusek Lake comprise, in the southern lens, black calc-silicate rocks, thinly layered quartzite, and psammite; semipelitic rocks that display wisps and clots of a bright mauve cordierite occur among other cordierite-free gneisses of probable sedimentary derivation in the north (too small to illustrate on Figure 3).

Migmatized leucogabbroic and anorthositic rocks (not shown on Figure 3; *see* Ermanovics *et al.*, 1997) occur over a strike-length of several hundred metres northwest of Tasiuyak Tasialua Lake and as small enclaves elsewhere within the gneisses of this area. These are white- to buff-weathering, generally granular rocks, having a foliation defined by streaks of black hornblende.

PALEOPROTEROZOIC MAFIC DYKES IN ARCHEAN GNEISSES

Mafic dykes are not as abundant in the Archean gneisses examined in the 1997 map area as they are in some other parts of the Nain Province. Unlike the coastal zone to the east, where numerous Paleoproterozoic dykes are present (cf. Ermanovics *et al.*, 1997), the inland area seems to be a "dead zone" for dykes. A few have been noted south of Okak Bay, where they are greenschist-facies rocks, up to 3 m in width, some of which exhibit two generations of foliation. There is a paucity of dykes in the gneisses between Ikinet Brook and Saputit Lake, except within the refoliated zone east of Ramah Group where unmigmatized amphibolite layers locally display oblique contacts against relict migmatitic layering of the refoliated Archean gneisses; these amphibolites are interpreted to be transposed basic dykes.

PALEOPROTEROZOIC GNEISSES

Assigning an Archean or Paleoproterozoic age to isolated gneissic septa between the plutons of the study area is difficult without definitive criteria to separate them. However, there is little doubt that those gneisses and variably foliated meta-igneous rocks that form the crescent-shaped septum in the *Ikatsiak Brook* area are Paleoproterozoic because they comprise, in part, the distinctive garnet-rich Tasiuyak paragneiss. The associated gneisses are greenish-grey, granulite-facies, mesocratic rocks that, at least locally, are intrusive into the Tasiuyak gneiss.

The Tasiuyak gneiss in the *Ikatsiak Brook* area is typical of the unit elsewhere in Labrador (cf. Wardle, 1983; Ryan and Lee, 1986; Thériault and Ermanovics, 1997), being a rather monotonous rusty- to white-weathering, garnet- and sillimanite-bearing, migmatitic metasedimentary rock containing variable amounts of garnetiferous granite as narrow veins and foliation-parallel sheets. Mylonitic foliation and lineations are not widely developed here, implying that the influence of the development of the Abloviak shear zone, a transcurrent shear along the eastern side of the Tasiuyak gneiss to the north (cf. Van Kranendonk, 1996), is minimal. Cordierite is a nearly universal replacement of garnet in the present study area, reflecting the thermal overprint of the abutting younger intrusions.

The rocks that bound the Tasiuyak gneiss are predominantly "mesocratic granulites" – greenish-grey-weathering gabbronoritic to enderbitic orthogneisses and more massive rocks that internally differ mainly in the percentage of mafic minerals and the presence or absence of quartz. Some of these orthogneisses are younger than the Tasiuyak gneiss because rafts and schlieren of the paragneiss occur within them. However, it is doubtful that all these enderbitic and gabbronoritic rocks are derived from a common igneous parent. There are, for example, locally well-layered granulites that may be older gneisses, having within them compositions that vary from peridotite to cordierite-bearing semipelitic gneiss. A 20-m-wide opalescent blue quartzite unit has been mapped over a strike length of more than 3 km in granulites that form the east–west-trending septa west of *Frozen Lake*.

RAMAH GROUP

Metasedimentary rocks of the Paleoproterozoic Ramah Group were identified east of Umiakovik Lake in 1996 (Ermanovics *et al.,* 1997). These are supracrustal rocks that originally had an unconformable relationship with the adjacent Archean gneisses, but are now disposed as subvertical belts tectonically interleaved with their mylonitically refoliated basement as a result of thrusting and folding associated with the development of the 1.8 Ga Torngat Orogen. The Ramah Group here comprises mostly grey and white quartzite and dark-brown to black garnet+muscovite+sillimanite schist; amphibolite is a lesser component, and may be derived from gabbroic sills among the sedimentary rocks.

PALEOPROTEROZOIC (AND POSSIBLE PALEOPROTEROZOIC) PLUTONIC ROCKS

The first real indications that some plutonic rocks traditionally assigned to the NPS in the present study area are, in fact, older, came from the GSNL mapping in 1996 (Ryan *et al.*, 1997). The criteria set in 1996 to distinguish the older plutonic rocks from the NPS were applied during the current survey, and, as a result, the distribution of probable pre-NPS igneous rocks has been extended over a significant area south of Okak Bay. This implies that nearly all the anorthositic rocks formerly assigned to the NPS in this northern lobe are Paleoproterozoic in age, as are the granitoid rocks that form the irregular mass centred on Umiakoviarusek Lake (Figures 1b and 3). In addition to the field criteria, the regional aeromagnetic signature derived from GSC data (Figure 4) also helps define the extent of the two suites. Those that have been assigned to the Paleoproterozoic group, on the basis of field observations, correspond with the high magnetic patterns relative to the magnetic lows of the NPS. This reflects the presence of magnetite in the older group and ilmenite in the younger group, which also appears to be a useful field distinction where two similar plutons abut. From the distribution of Paleoproterozoic rocks on Figure 3 and the aeromagnetic signature on Figure 4, a case can be made for concluding that the older plutons have a northwest grain, elongated in the general direction of the regional structures within the Nain Province. Many of the Paleoproterozoic mafic dykes in the Okak Bay–Kiglapait Mountains region also have this preferred orientation (Ermanovics *et al.*, 1997). It is of interest to note that in several of the older plutons there are regional primary magmatic structures, as well as later penetrative deformational fabrics, that may have been influenced by such an ancestral grain in the Nain Province. This elongation pattern of the older plutons is in contrast to that of the Mesoproterozoic plutons, which have more bulbous forms, without any detectable preferred orientation to either their mapped distribution or their magnetic imprint.

On the basis of field relationships and composition it is clear that the Paleoproterozoic group comprises a variety of plutons, and these are separated into nine different intrusions as shown on Figure 3. Unfortunately, there is no outcrop in the broad marshy valley occupied by Umiakoviarusek Brook (NTS 14E/8), so the significance and presence of a boundary line between the basic rocks on either side of the valley is debatable. The following brief descriptions summarize the main characteristics of the Paleoproterozoic plutons. Each descriptive section outlines the age relationship only to proven or assumed older rocks, and notes some of the minor intrusions that may be present. These are treated by geographic location, as the *Illuilik ridge* intrusions and the Umiakoviarusek Lake intrusions (*see* Appendix for origin of the individual names).

ILLUILIK RIDGE INTRUSIONS

At least three different intrusions are exposed along *Illuilik ridge*, the northwest-trending upland south of Okak Bay. They include a foliated monzonitic body, a clinopyroxene ("rapakivi") quartz monzonite to granite, and a gabbronoritic intrusion (Figure 3). Informal names are applied to the latter two in the text below.

Fayalite(?) Quartz Monzonite (FQM)

A quartz monzonite, appearing to be locally olivine-bearing, on the southeast end of the ridge was briefly visited and partially outlined by the first author late in the 1996 field season (Unit M?gr of Ermanovics *et al.*, 1997). At that time, it was apparent that there were features of this unit that implied it was not an NPS intrusion, but was part of the older assemblage identified in the Puttuaalu Lake (NTS 14E/1) area. Samples collected from it yielded zircons from which a U–Pb crystallization age of 2124±1 Ma has been recently obtained (Hamilton *et al.,* 1997), confirming its Paleoproterozoic emplacement. It may be the oldest of all the intrusions in the area.

The intrusion is elongated within the general northwest grain of the Archean gneisses bounding the eastern side of the ridge, and, on the basis of several outcrops of similar rock west of Tasiuyak Tasialua Lake (Figure 3), is projected at least as far south as Puttuaalu Brook (NTS 14E/8). Foliated granitoid rocks northeast of Puttuaalu Lake (Unit 5 of Ryan *et al.,* 1997) may also be part of this intrusion. The rock on *Illuilik ridge* is generally medium grained and buff- to white-coloured on weathered surface, but has a distinct green cast on fresh surfaces. A foliation is generally present, but in places is so weak that original porphyritic texture in the monzonite can be easily discerned; at the other extreme are zones of strongly deformed rock that could be termed "augen schist". Examination of two thin sections from the rock on the ridge, perhaps best classified as a quartz syenite, indicates that

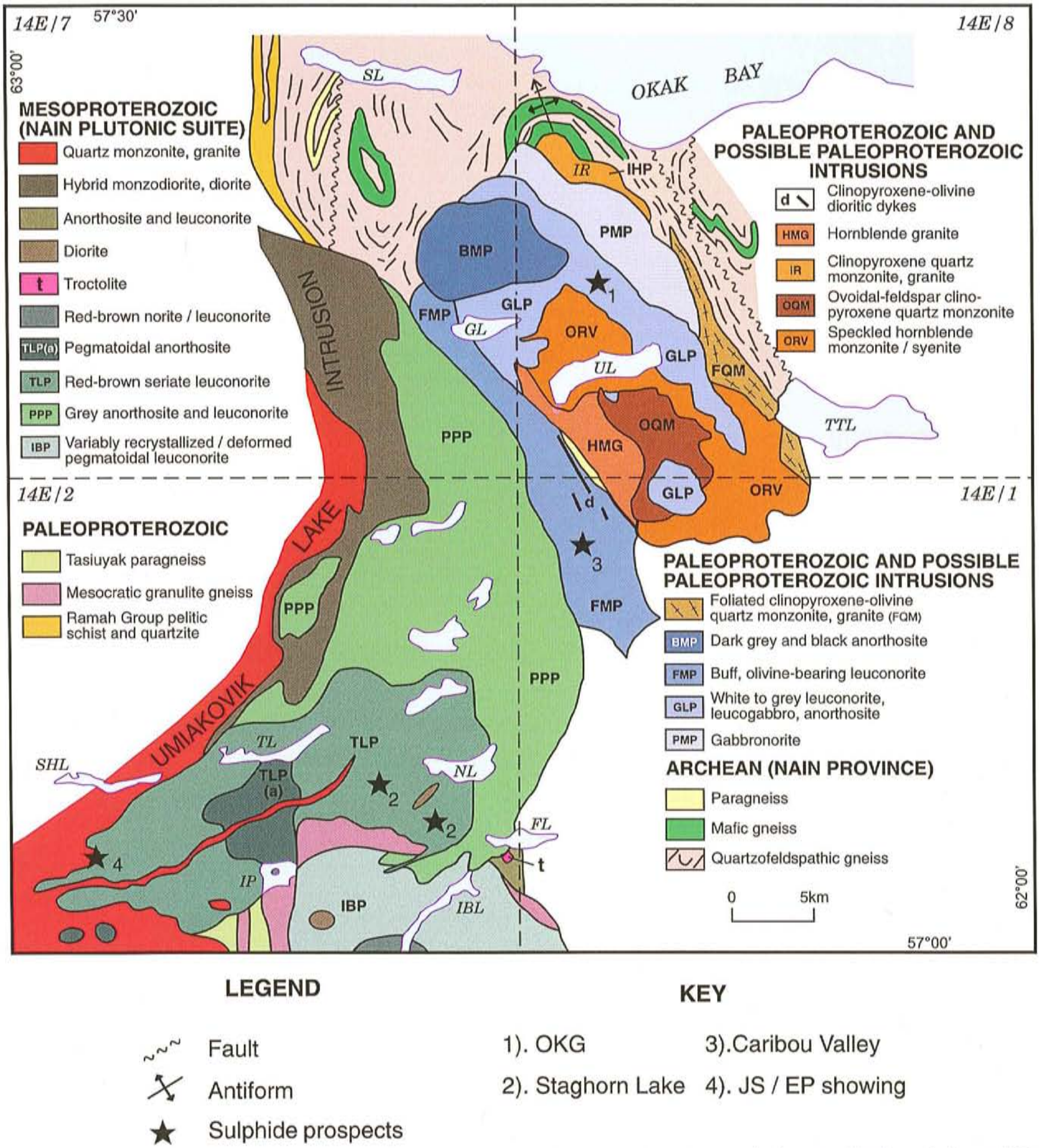

Figure 3. *Sketch map showing the major subdivisions within the plutonic and gneissic rocks between Staghorn Lake and Okak Bay. Acronyms for geographic features are as follows: SL = Saputit Lake, IR =* Illuilik ridge, *UL = Umiakoviarusek Lake, NL =* Norma Lake, *FL =* Frozen Lake, *SHL = Staghorn Lake, IBL =* Ikatsiak Brook chain landing lake, *IP =* Island Pond. Acronyms for plutons named in the text are as follows: FMQ = fayalite(?) quartz monzonite, PMP = Pripet Marshes *pluton, IHP = Illuilik Hill pluton, GLP =* Goudie Lake *pluton, FMP =* Faceted Mountain *pluton, BMP =* Black Mountain *pluton, HMG = hornblende quartz-monzonite to granite pluton, ORV =* Owl Rock valley *pluton, OQM = ovoidal-feldspar quartz monzonite, IBP =* Ikatsiak Brook *pluton, PPP =* Pyramid Pass *pluton, TLP =* Tallifer Lake *pluton. (Note that the stacking order of units within the subdivisions of the map legend does not necessarily relate to stratigraphic order, and that the legend refers to the whole map, not just the sheet within which it is composed.)*

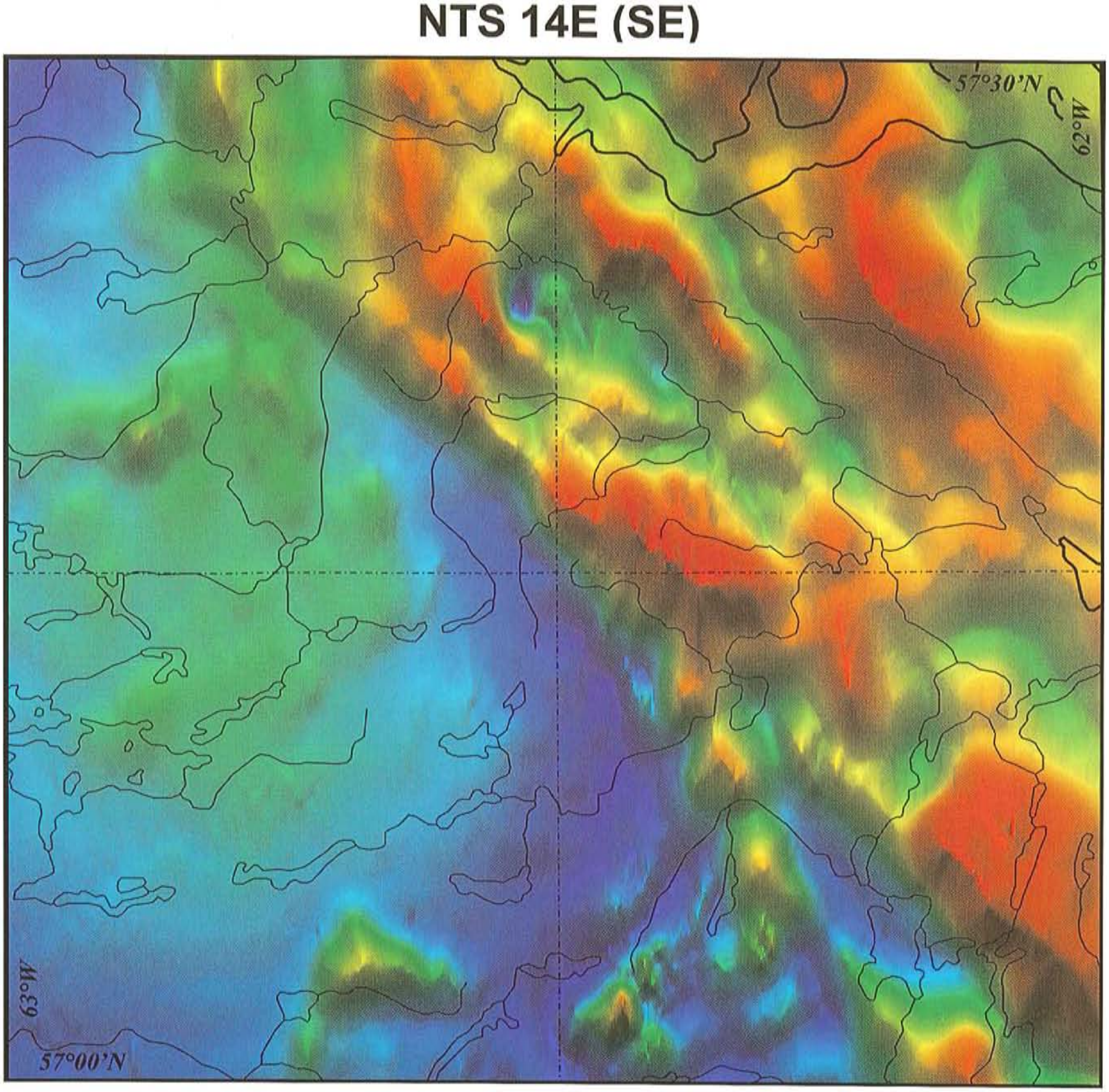

Figure 4. *Colour-contoured (blue = low; red = high) regional aeromagnetic map of the southeast corner of NTS map area 14E, covering the area surveyed in 1996 and 1997, produced by G. Kilfoil (Geochemistry, Geophysics and Terrain Sciences Section) from data derived from GSC map 07453G (GSC, 1983). Geographic features and geological units can be identified by cross-referencing to Figures 1, 2 and 3.*

the main minerals are quartz, perthitic feldspar, microcline, altered clinopyroxene, and clots of opaque oxide+carbonate that could be derived from the alteration of olivine or orthopyroxene.

Intrusive relations are not well established for this elongate pluton. Inclusions of Archean gneiss are present locally at the south end of *Illuilik ridge*, but a clear peripheral intrusive contact with the gneisses nearby was not observed.

Its relation to the basic pluton to the west has not been determined from field exposures, but the latter is assumed to be younger (*see* below). The quartz monzonite is intruded by a 15-m-wide, northeast-striking, (olivine-bearing) metagabbro dyke at the south end of *Illuilik ridge*. This dyke postdates the foliation, a relation that is somewhat of an enigma because presently it is assumed that deformation and metamorphism here are products of the Torngat Orogen. However, this dyke postdates deformation presumably caused by the imprint of Torngat Orogen, yet displays a greenschist overprint attributed to the same event! Either this dyke is synorogenic, or it postdates the Torngat Orogen and has been overprinted by a younger alteration, or there has been pre-Torngat deformation of some of the Paleoproterozoic intrusions through this area.

Gabbronorite and Leuconorite (Pripet Marshes Pluton, PMP)

The western side of *Illuilik ridge* is underlain by massive, medium- to coarse-grained basic rocks that are dominantly grey leuconorite and gabbronorite (Unit Manl of Ermanovics *et al.*, 1997). The outermost part of this leuconoritic intrusion against the gneisses is a fine-grained, granular melanocratic rock that comprises cloudy tabular plagioclase and actinolitic amphibole pseudomorphs of pyroxene. The main part of the intrusion, through the central part of the ridge, is a dark-grey to pale-grey to brownish-weathering leuconorite or leucogabbronorite, having abundant magnetite throughout, and displaying variable replacement of mafic minerals by amphibole. Generally, it is medium-grained, and the texture is distinctly subophitic. The plagioclase is tabular to equant, and the former type locally displays a well-developed lamination. Dark-grey plagioclase megacrysts occur throughout the pluton.

The Pripet Marshes pluton intrudes the Archean gneisses and locally contains inclusions of these. Its relation to the foliated monzonite described above has not been established, but is assumed to be younger because it lacks the deformation of the nearby granitoid.

Clinopyroxene Quartz Monzonite (Illuilik Hill Pluton, IHP)

This intrusion (Unit Mqm of Ermanovics *et al.*, 1997) is a northwest-trending tadpole-shaped body sandwiched between the Pripet Marshes pluton and Archean gneisses at the northern end of *Illuilik ridge*. It is an ovoidal-feldspar monzonite to hornblende–quartz monzonite and granite (Plate 1a) that exhibits a mingled and transitional contact against the Pripet Marshes pluton. This granitic rock is predominantly medium grained, having feldspar (plagioclase intergrown with potassium feldspar) ovoids up to 4 cm in diameter and ovoidal grey quartz "eyes" surrounded by a granular network of clinopyroxene; streaks of the latter mineral define a primary late magmatic crystallization foliation in places. Dark plagioclase xenocrysts are locally abundant along the contact with the gabbronorite, and poikilitic black hornblende is widely distributed through the interior of the intrusion.

The Illuilik Hill pluton intrudes the core of a steeply north-plunging antiform of Archean gneisses at the northern end of *Illuilik ridge*. It is in gradational contact, and apparently coeval, with the Pripet Marshes pluton to the west, via a texturally diverse rock that varies from a monzogabbro to a quartz diorite in composition. The former is texturally similar to the gabbroic rock to the west, but it contains quartz and potassium feldspar; the diorite is a finer grained rock that is locally characterized by abundant grey quartz "eyes".

UMIAKOVIARUSEK LAKE INTRUSIONS

The rugged area southeast of Umiakoviarusek Lake is underlain by a variety of granitic rocks that in map-plan view are nearly completely encircled by anorthositic rocks (Emslie and Russell, 1988; Emslie *et al.*, 1997; Ermanovics *et al.*, 1997). Mapping of the contact between the granitoid rocks has resulted in the establishment of unequivocal relative age relationships between some intrusions, but the nature and extent of other contacts is still open to confirmation. However, it is clear that all the granitoid rocks postdate the gabbroic to anorthositic intrusions in this area.

Gabbroic to Anorthositic Intrusion (Goudie Lake Pluton, GLP)

This gabbroic pluton (Unit Manl of Ermanovics *et al.*, 1997), may include more than one intrusion. As defined, it encompasses all the medium-grained, grey- to white-weathering gabbroic and anorthositic rocks extending from Tasiuyak Tasialua Lake northwest to beyond *Goudie Lake*. It has been perfunctorily examined because its eastern side is generally exposed only on the near vertical cliff on the western side of the Umiakoviarusek Brook valley (NTS 14E/8) and it is just sporadically exposed on the lower ridges west of an extensive sand plain southeast of Umiakoviarusek Lake. The northern part of the pluton underlies rugged country around *Goudie Lake*. It is unclear if the circular area of gabbro capping the hills southeast of Umiakoviarusek Lake, and representing a remnant of the original roof to the underlying felsic plutons of this area, is part of the Goudie Lake pluton, but it is equated with it at this time. Most of the rocks within the Goudie Lake pluton are medium- to coarse-grained, dark grey to pale grey to white, leucogabbroic, leuconoritic and anorthositic rocks. These basic rocks exhibit a regional, although not universally developed, secondary alteration, interpreted to be a product of a greenschist-facies metamorphic overprint; this alteration is also apparent in drill core from the OKG prospect (*see* later section; Kerr and Smith,

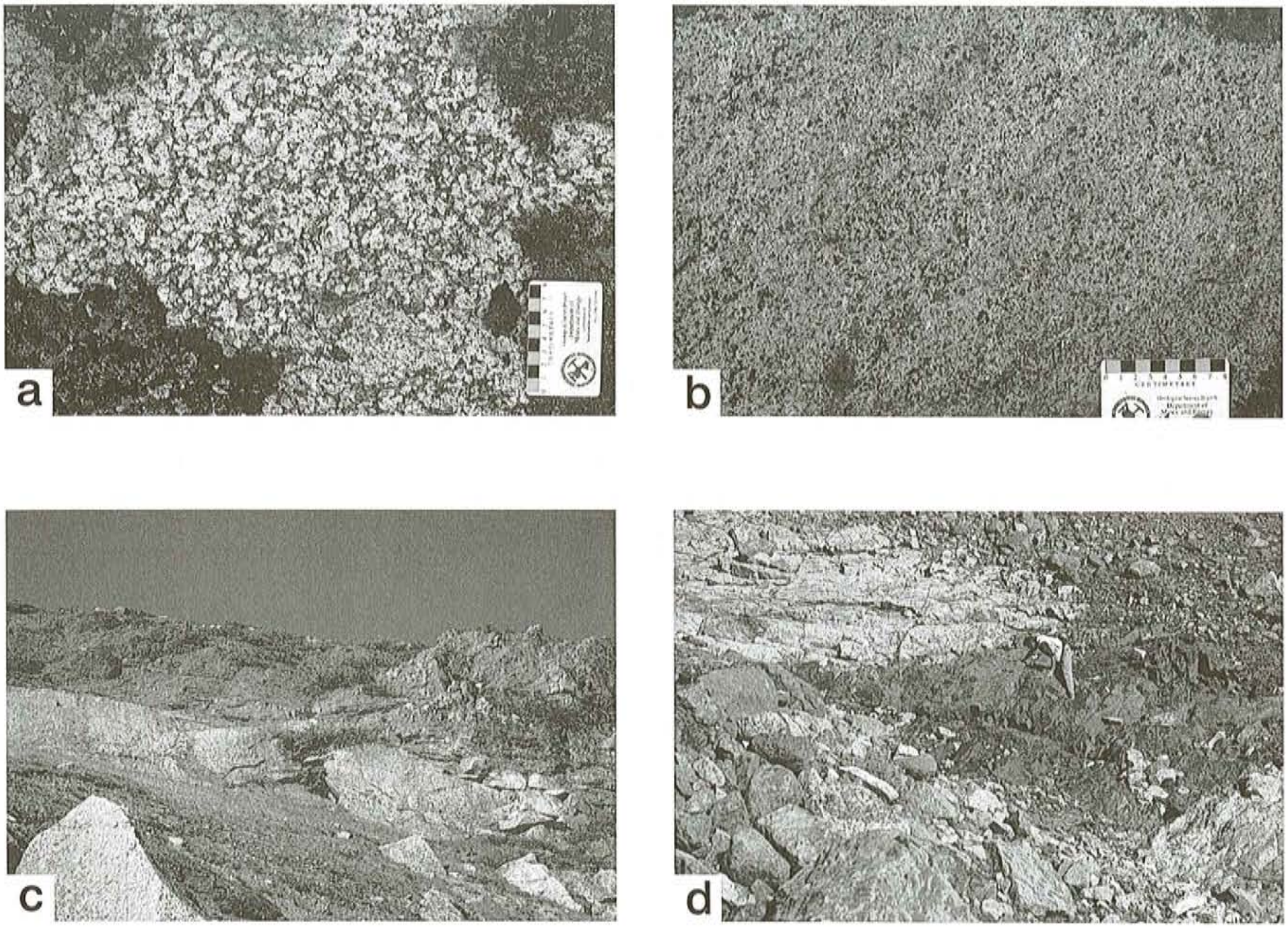

Plate 1. *Textures and intrusive relations of the Paleoproterozoic rocks. a) Ovoidal feldspars within clinopyroxene-bearing quartz monzonite of the Illuilik Hill pluton. Ovoids here are coarse intergrowths of plagioclase and potassium feldspar. b) Granular texture of leuconorite of the Faceted Mountain pluton northwest of Umiakoviarusek Lake. Note hint of tabular morphology to some of the plagioclase, but these feldspars are multigrain aggregates; pyroxene here is an aggregate of monoclinic and orthorhombic types. c) Intrusive contact between the Owl Rock valley hornblende monzonite and the Goudie Lake (leuconorite) pluton southeast of Umiakoviarusek Lake. Dark-grey leuconorite overlies pale speckled monzonite. d) Metagabbro (amphibolite) dyke, having strongly foliated margins, within white leuconorite of the Goudie Lake pluton, south slope of* Black Mountain.

1997; Kerr, *this volume*). The secondary overprint is manifested in blue-green amphibole and biotite after primary pyroxenes. Field identification suggests that clinopyroxene prevails over orthopyroxene; grey to blue-grey quartz is present locally.

It has not been possible to establish the relationship between the Goudie Lake pluton and any other unit to the northeast of it, but it is clearly intruded by the hornblende-rich monzonitic pluton that straddles Umiakoviarusek Lake (*see* below). Deformed and greenschist-metamorphosed diabase and gabbro dykes, and foliated "granulite" dykes, occur throughout the Goudie Lake pluton, varying from less than a metre to over 5 m in width; these dykes are also prevalent in the OKG drill core (A. Kerr, personal communication, 1997). The Goudie Lake pluton is also transected by white and pink aplitic granitic dykes and allanite-bearing hornblende granite pegmatites. The relationship between these minor granitic and mafic intrusions has not been regionally verified and is ambiguous – at one outcrop north of *Goudie Lake* a pegmatitic granitic dyke intrudes a mafic dyke, yet south of the lake the opposite relation has been observed.

Buff-Weathering Leuconorite (Faceted Mountain Pluton, FMP)

This elongate pluton was mapped on NTS map area 14E/1 in 1996 as a part of the NPS (Unit 16 of Ryan *et al.*, 1997; Unit Manl10 of Ermanovics *et al.*, 1997) but additional observations in 1997 suggest that it is one of the "older" group. It is well exposed in the high peaks along the west side of the *Caribou valley* and on a ridge between the west ends of Umiakoviarusek and *Goudie* lakes. This unit has a core of pure anorthosite (subunit 16a of Ryan *et al.*, 1997; Unit

Manl9 of Ermanovics *et al.*, 1997), different from that of the NPS because it has a very distinctive pink hue (R.F. Emslie, personal communication, 1996).

In the 1997 project area, the Faceted Mountain pluton comprises predominantly a granular, buff-weathering, medium- to coarse-grained leuconoritic rock. Individual tabular feldspars and single pyroxene crystals are rarely observed, rather, the feldspars and the pyroxenes have a granular aspect (Plate 1b), and the latter locally occurs as elongate segregations. However, in some places dark-grey feldspar crysts can be recognized within the otherwise granular buff aggregates, and those rocks assigned to the pluton northwest of *Goudie Lake* display more typical cumulate textures of tabular feldspar and intercumulus pyroxene.

On a low hill in the valley west of Umiakoviarusek Lake the Faceted Mountain pluton encloses a fairly extensive elongate unit of brownish-grey- to dark green-grey-weathering, foliated, medium- to fine-grained "mafic granulite" or gabbronorite (not shown on Figure 3). This mafic rock displays vestiges of gabbroic texture, is layered in places, locally contains tabular crysts of dark-grey plagioclase, and has isolated inclusions of red–brown peridotite and coarse-grained anorthosite. The rock is texturally distinct from the Archean mafic gneisses and is clearly igneous in origin. It could conceivably be a foundered fragment of the original magma chamber roof to the enclosing leuconorite pluton.

Thin section examination of specimens of granular-textured leuconoritic rock from the Faceted Mountain pluton in the 1996 map area (NTS 14E/1) indicates that the mafic component comprises several phases, being varying volumes of orthopyroxene, clinopyroxene, brownish-green hornblende and olivine; coarse-grained mafic clots and segregations are composed of all the foregoing minerals.

Intrusive relations with abutting rocks are not always demonstrable. It does intrude the metasedimentary gneisses on its northeast margin south of Umiakoviarusek Lake, and the same margin contains rafts of white to pale-grey anorthosite northwest of the lake implying that it intrudes the Goudie Lake pluton. One fine-grained granular "mafic granulite" dyke was observed at the northern end of the intrusion, just west of *Goudie Lake*. This dyke is similar to those that intrude Paleoproterozoic plutons, such as the one underlying Aupalukitak Mountain (Ryan *et al.*, 1997; Figure 1b), and is thus circumstantial evidence in support of the Faceted Mountain pluton being of this age as well. The Faceted Mountain pluton is also intruded by northwest-trending dykes of dark-brown, hornblende-rich olivine+clinopyroxene diorite, the most prominent of which is a strongly foliated one, several tens of metres wide, south of the west end of Umiakoviarusek Lake.

Contact relations between the Faceted Mountain pluton and the granitoid rocks are addressed in appropriate sections below.

Dark-Grey to Black Leuconorite to Anorthosite (Black Mountain Pluton, BMP)

This intrusion (Unit Manlb of Ermanovics *et al.*, 1997) underlies a prominent, dark, jagged, mountain north of *Goudie Lake*. It is a unique rock unit in the area because of its persistent black colour. Although small areas of similar black anorthositic rock are known from the NPS of the study area, no large bodies of such rock have been documented, and this property of the Black Mountain pluton, along with some of the more reliable criteria cited earlier, have been used to advocate a pre-NPS age for it. The pluton seems to be composed completely of very dark grey to black leucogabbro, leuconorite and anorthosite, generally exhibiting coarse to pegmatoidal grain size. Bronze orthopyroxene locally forms oikocrystic clots over 20 cm in diameter. These poikilitic patches are generally irregular in outline, but in parts of the intrusion exhibit a preferred elongation, probably a result of late settling and compressing of the crystal cumulate. Widely developed is a network of white feldspar enclosing the darker one; the white one is interpreted to represent recrystallization of the original dark plagioclase. There is a very widespread secondary alteration of these rocks, the usual manifestation being the transformation of the primary pyroxenes to green amphibole. Locally there are discrete zones of "bleaching", areas where the black plagioclase has been altered to a creamy-white one and all pyroxene is replaced by a green amphibole. These alteration zones are somewhat reminiscent of silicification or albitization; although alteration of this type occurs peripheral to aplitic and coarser granitic veins in places, there is little accompanying indication of silica flooding (e.g., quartz veins) or that all the alteration can be related to granitoid veins. Foliation is locally preferentially developed in some of these pale zones relative to the darker rock outside.

The northern half of the *Black Mountain* pluton is surrounded by sand-filled river valleys that have little, if any, exposure, so relations with surrounding rocks have not been observed. The pluton must be intrusive into the granulite-facies Archean gneisses along its northwestern side, but other contacts are debatable. The distribution of rocks assigned to the pluton produces a map pattern that is amenable to an interpretation of it crosscutting the Goudie Lake pluton and the Faceted Mountain pluton. There is quite a sharply defined colour contrast contact on the south slope of *Black Mountain* between this dark unit and the light grey leuconorite assigned to the Goudie Lake pluton, but in the one place where the contact was examined on the ground the exact relation (intrusive? gradational?) between the two is not readily apparent.

Hornblende Quartz Monzonite and Granite Pluton (HMG)

This unnamed intrusion (southwestern part of Unit Mgr of Ermanovics *et al.*, 1997) underlies a northwest-trending ridge on the east side of the *Caribou valley* southeast of the west end of Umiakoviarusek Lake. Pale-grey quartz monzonite and granite appear to be the dominant rock types of this intrusion, but in places potassium feldspar seems to be absent and the composition could be hornblende tonalite. On its western side, west of Umiakoviarusek Lake, there is a buff-weathering charnockitic rock – a pyroxene–fayalite-bearing quartz monzonite – that is presently assigned to this pluton, but may be a separate intrusion.

The most widely distributed rock of this pluton is generally a pale grey- to white-weathering, rarely pale-pink-weathering, medium-grained granite. The main mafic mineral apparent in the field is a black hornblende, but biotite is locally present. In places, rusty cores to the amphibole may be remnants of pyroxene or olivine. Minute bronze grains in some outcrops and hand specimens suggest that titanite may be present, a mineral generally absent from rocks of the NPS (Emslie and Loveridge, 1992, p. 106) and thus implying this intrusion is not part of the NPS.

The marginal rock west of Umiakoviarusek Lake is olivine bearing, and in places resembles the foliated (fayalite-bearing?) rock at the south end of *Illuilik ridge*. The most widespread rock in this marginal setting is pink- to buff-weathering, and locally has ovoidal feldspars. Two thin sections from this rock have been examined, and indicate a variable assemblage of quartz, plagioclase, potassium feldspar, orthopyroxene, clinopyroxene, olivine and dark-green hornblende; not all the mafic phases are present in one sample.

This pluton is variably foliated. For example, there is a weak foliation present in the interior of this unit, in part appearing to be a late magmatic alignment of the hornblende; centimetre-scale ductile shear zones are locally developed, but in general there is no pervasive penetrative fabric. This lack of internal foliation is in strong contrast to the marginal rocks, which, although locally massive, are rarely without a fabric in most outcrops. This marginal foliation is best defined by elongate felsic minerals, especially quartz, the latter standing out in relief on some surfaces and giving the rock the appearance of a deformed grit.

Contacts between the grey hornblende granitoid rocks of this pluton and other abutting rocks are not well established, but are addressed in the sections on the other granitoid rocks described later. The relation between the western (marginal) olivine-bearing rocks and the more widespread grey granite to the east has not been resolved, but contacts between the marginal fayalite-bearing phase and the rocks to the west of the pluton are fairly well-established. The foliated marginal rocks are clearly intrusive into calc-silicate and other metasedimentary rocks south of Umiakoviarusek Lake. The olivine-bearing rocks also intrude the Faceted Mountain leuconoritic pluton in this area, but better evidence for the relation between the two occurs northwest of the lake where rafts of the buff-weathering basic rock are enclosed by the fayalite- and pyroxene-bearing quartz-monzonite. Several foliated mafic dykes, composed of biotite+clinopyroxene "amphibolite", have intruded the pink charnockitic rock west of Umiakoviarusek Lake. A few deformed mafic dykes have also been observed within the grey granite to the east; the grey rock is also regionally intruded by dykes and veins of pink aplitic granite, but the relative ages of these minor intrusions are unknown.

Speckled Hornblende Monzonite (Owl Rock Valley Pluton, ORV)

This intrusion (Unit Mmz of Ermanovics *et al.*, 1997) is the largest and second oldest of the granitoid intrusions in the Umiakoviarusek Lake region. This pluton differs from all the other felsic rocks in the area in that it is practically devoid of quartz and has an abundance of stubby black hornblende that gives it a distinctive spotted or speckled appearance. The hornblende locally exhibits a primary magmatic alignment, and variations in its volume produce a diffuse layering. However, in addition to these magmatic features the monzonite also locally displays a penetrative deformational foliation.

The distinctiveness of this unit relative to normal granitoid rocks of the NPS has been noted by Emslie *et al.* (1997, p. 228); it was also apparent to Taylor (1979) who termed it a syenite. It comprises at least two different phases, one of which is white- or pale-brown-weathering, the other being maple-sugar brown to deep reddish-brown. The latter variety tends to have much larger hornblende than the paler one, in places as poikilitic grains up to 8 cm in size. In several places southeast of Umiakoviarusek Lake the darker one is in sharp contact with the lighter one atop several small knolls. The pale one contains large rafts of leuconorite and anorthosite but the darker one is devoid of them. The geometry of the contact indicates that the darker is a gently dipping sheet atop the lighter in this area. The darker rock may thus represent a separate influx of magma that was injected across a substrate or floor of paler rock supporting spalled blocks of anorthosite and leuconorite. However, the emplacement of both the light and the dark monzonites is considered to be part of the same episode of magmatism, because elsewhere in the pluton there are well-layered rocks where the light and dark phases form alternating units on the scale of tens of centimetres, perhaps representing repetitive accumulation in a more distal part of the chamber (or at a different time) than the thicker units near Umiakoviarusek Lake.

Compositional variations based on plagioclase to potassium feldspar ratios within this pluton are difficult to establish in field exposure because of the uniform creamy-brown colour of the feldspar. Several thin sections from the area southeast of Umiakoviarusek Lake are available and these indicate that the rock is generally monzonitic, having remnants of clinopyroxene and olivine preserved in the core of some of the green hornblende.

Intrusive contacts against the Goudie Lake pluton are apparent at several locations, and rafts of leuconorite and anorthosite are locally present within the monzonite, as noted above. The Owl Rock valley pluton occupies the higher elevations atop anorthositic rocks north of Umiakoviarusek Lake, but southeast of the lake several exposed contacts indicate that it dips below the anorthositic rocks (Plate 1c). The irregular map pattern in the rugged terrane northwest of Umiakoviarusek Lake, augmented with observations of gently dipping contacts against the leuconoritic rocks, indicate that here too there is a gently inclined interface between the two plutons. Taken together, these data indicate that the Owl Rock valley pluton is disposed as one or more shallowly inclined sheets against the Goudie Lake pluton. In two small outcrops, sharp contacts have been observed between the grey hornblende granite (HMG) and fine-grained, hornblende-spotted, melanocratic rocks that are interpreted as being related to the speckled hornblende-rich monzonite of the Owl Rock valley pluton; the relation between the two is equivocal, but the melanocratic rock is interpreted as the marginal phase or dykes of the hornblende monzonite and thus the grey granite is considered as being older. Several north-trending, altered olivine-bearing metagabbroic dykes, similar to that which cuts the Illuilik ridge monzonite, have been noted in the southern part of the pluton.

Ovoidal-Feldspar Clinopyroxene Quartz Monzonite (OQM)

This pluton (northeastern part of Unit Mgr of Ermanovics *et al.*, 1997) underlies a northeast-trending ridge and the valley to the west of it directly south of Umiakoviarusek Lake. It is divisible into several subunits, but their areal distribution has not been defined. The most widespread rock is a greenish-brown- to buff-weathering, medium-grained one, similar to the Illuilik Hill pluton, that appears to be dominantly of quartz monzonitic to granitic composition, and which displays rapakivi characteristics – plagioclase-mantled ovoidal potassium feldspar megacrysts, grey to blue-grey "drop quartz", and a locally deeply indurated surface. Clinopyroxene (+orthopyroxene+olivine?) forms a groundmass component to the quartz and feldspars, and is distributed among the felsic constituents as mesh-like aggregates. Hornblende is generally apparent, and in some parts of the pluton seems to be the dominant, if not only, mafic mineral. Locally, along its southern contact with an overlying cap of leucogabbro there is a finer grained rock that is quartz poor, has crystals of dark plagioclase, and appears to be dioritic or monzodioritic in composition. This variety exhibits isolated grains and irregular stringers of perthitic ovoids, suggesting magma mingling with the coarser ovoidal-feldspar-bearing quartz monzonite that it borders.

Several relative age relationships are apparent for this "rapakivi" intrusion and the bounding rocks. Metre-sized inclusions of anorthositic and leucogabbroic rock have been observed throughout the pluton, and it clearly abuts and intrudes larger areas of basic rocks belonging to the Goudie Lake pluton on its northern and eastern margins. Monzodioritic rocks along the southern part of the pluton intrude the overlying leucogabbroic roof. On its eastern side it clearly intrudes the hornblende monzonite of the Owl Rock valley pluton. This is obvious from the 1:50 000-scale regional map pattern because the contact between the two plutons is transgressive to layering trends in the hornblende monzonite. It is also demonstrable from field relations that several large dykes of quartz-bearing "rapakivi granite" project eastward and intrude layered monzonite highly oblique to the layering attitude. Along these contacts the quartz-bearing rock also contains abundant poikilitic hornblende, interpreted to be a result of local hydration, making the interface between the two intrusions difficult to discern. The contact with the grey hornblende granite to the west lies mainly within a drift-filled valley or along the side of a steep mountain wall and is thus not well established. However, along the south slope of the mountain underlain by the grey hornblende granite (HMG) there is a junction between that granite and a brown-weathering quartz-eye porphyry. The porphyry is interpreted to be the chilled margin of the rapakivi pluton. The sum of all the aforementioned relationships implies that this pluton is the youngest granitoid intrusion in the Umiakoviarusek Lake area. As with many other plutons, there are local aplitic and pegmatitic granitic dykes within it, and at least two metagabbro dykes cut it.

Minor Intrusions of Assumed Paleoproterozoic Age

This category includes basic and granitic rocks alluded to in the foregoing sections, the attributes of some of which are expanded here. These include the brown dioritic dykes, the metagabbro and metadiabase dykes, and a "quartz-eye" monzonitic dyke, the latter forming a northwest-trending unit southwest of Umiakoviarusek Lake. Most of these minor intrusions are not shown on Figure 3.

The dioritic dykes, herein named the Caribou valley dykes because of their abundance in the valley, are quite distinct in the field due to their black- to deep red-brown-weathering colour. Small dykes of this type were noted during the 1996 field season as being widely distributed within, and mainly confined to, the Faceted Mountain pluton, but they were assigned a Mesoproterozoic age (Unit 19 of Ryan *et al.*, 1997) and equated with other dioritic and ferrodioritic rocks present within the NPS plutons (Unit Mfd of Ermanovics *et al.*, 1997). Subsequent petrographic study has indicated mineralogical and textural distinctions between the units considered here and those that intrude the NPS plutons, and the former are now considered to be an older group. The largest of these dioritic bodies occurs just west of Puttuaalu Lake (NTS 14E/1), where it intrudes and contains inclusions of Paleoproterozoic white anorthosite (Ryan *et al.*, 1997). Two large dioritic dykes were mapped within the present study area. The largest one is several tens of metres in maximum width and is traceable for over 2 km within anorthositic rocks of the Faceted Mountain pluton at the northern end of the *Caribou valley* south of Umiakoviarusek Lake (cf. Emslie and Russell, 1988; Figure 3); several smaller north-trending dykes are present in the poorly exposed valley floor to the southeast. A diorite dyke also intrudes the Faceted Mountain pluton and a sliver of gneisses northwest of Umiakoviarusek Lake. These dioritic intrusions are dense, hornblende+olivine+opaque oxide-rich rocks that are foliated parallel to their margins. Emslie and Russell (1988) noted that scree blocks from one of these dykes along the west wall of the *Caribou valley* on NTS map area 14E/1 contain opaque oxide and sulphide mineralization.

A southeast-trending, widening-southwards, dyke of monzonite or diorite (not shown on Figure 3) intrudes gneisses and the Faceted Mountain pluton west of Umiakoviarusek Lake. It has been traced along strike for over 3 km and has a maximum width of approximately 500 m. Generally, it is fine grained and brown-weathering, but where more leucocratic, it is pale pink to pale grey. Smoky to opal-blue quartz "eyes" are a sparse constituent through most of the intrusion, but there are local zones where it stands out conspicuously among the other minerals. The dyke pinches out northward, interpreted to be a result of excision by a younger pluton of the NPS. The southern extent and possible links between this dyke and the granitoid rocks of the immediate region are unknown because the dyke disappears southward underneath a sand-floored valley west of Umiakoviarusek Lake.

Basic dykes (metadiabase, metagabbro, and biotite "amphibolite") intrude most of the rocks assigned a Paleoproterozoic age as noted in the foregoing pluton descriptions. The largest of these is a 5- to 15-m-wide north-trending, grey, olivine-bearing, metagabbro dyke that has been traced intermittently for over 2 km west of Tasiuyak Tasialua Lake, where it is oblique to layering trends in the Owl Rock valley monzonite and where it crosscuts the contact between that pluton and the younger "rapakivi" quartz monzonite (OQM). Other dykes of this type occur in the same general area, and a northeast-trending one intrudes the foliated monzonite on *Illuilik ridge*. Olivine-free gabbros and finer grained metadiabase dykes are not as abundant in the plutons of the present study area as they are on the map area examined in 1996. However, several have been noted at widely spaced localities, the greatest concentration being in the Goudie Lake pluton north of *Goudie Lake* (Plate 1d). Here, they have acted as rheologically incompetent layers in otherwise massive metaleucogabbro and leuconorite, and some have been transformed to mylonitic actinolite schist during later deformation. Several thin sections from the best preserved dykes are available at this time, and they indicate that the plagioclase is typically clouded with fine oxide dust, and clinopyroxene is variably replaced by green amphibole and biotite. Some of the coarser grained rocks contain remnants of olivine, as noted above, a mineral not widely recorded in the typical Paleoproterozoic mafic dykes of the Nain Province to the north (cf. Ryan, 1990b; Van Kranendonk, 1992); this brings a direct correlation with these dykes into question.

Several sheets of diffusely layered, fine-grained, altered, greenish-brown gabbro occur within the Goudie Lake pluton in the vicinity of the OKG prospect of Castle Rock Exploration (Figure 3; *see* later section) and are interpreted to intrude that pluton. These sheets are moderately dipping bodies, but examination of them is hampered by their occurrence in a vertical cliff face. One is exposed in a small brook at the top of the cliff where it strikes north and dips about 45° to the west. This gabbroic sheet and another examined at the top of the cliff above the OKG prospect contain irregular segregations and dykelets of brown pyroxenite that carry disseminated sulphide minerals. These gabbroic bodies do not seem to intrude the speckled hornblende monzonitic rocks of the Owl Rock valley pluton, postulated to be Paleoproterozoic in age, that overlie the Goudie Lake pluton in this area. This observation, coupled with the fact that granitic dykes cut the sheets, imply the layered gabbros and the (genetically associated?) pyroxenites predate emplacement of the monzonite, and are therefore Paleoproterozoic in age.

Foliated biotite+clinopyroxene "amphibolite" dykes are widely distributed within the olivine-bearing quartz monzonite that forms the border phase of the hornblende granite (HMG) near Umiakoviarusek Lake. A swarm of such dykes, generally less than a metre in width and trending northwest, is well exposed in and near the river that flows into Umiakoviarusek Lake from the west.

Pink to grey aplitic to pegmatitic granitic dykes, generally on the centimetre to metre scale, transect all the Paleoproterozoic plutons, and probably attest several periods of emplacement for such minor intrusions. They are mineralogically variable, and range from pink potassic biotite–leucogranite to hornblende+biotite granite in composition. Correlation between these dykes and immediately adjacent granitoid units is not always readily apparent. One particular variety of such dykes is characterized by subhedral and euhedral allanite crystals that locally reach several centimetres in length. In otherwise massive host-rocks, many of the narrow granitoid dykes commonly show a foliation because they acted as sites of local shear during deformation.

MESOPROTEROZOIC PLUTONIC ROCKS (NAIN PLUTONIC SUITE)

Intrusions that are likely all of Mesoproterozoic age, and thus belong to the NPS, underlie the western part of the map-area, stretching from the Kingurutik River (NTS 14E/2) to *Goudie Lake* (Figure 3). These rocks have more compositional integrity over larger areas than the Paleoproterozoic plutons described above, which may imply that, in general, these younger plutons are larger than their Paleoproterozoic counterparts. In addition, these younger plutons tend to have more bulbous outlines than the Paleoproterozoic ones as noted in an earlier part of this paper.

The NPS plutons of the map area are predominantly anorthosite and leuconorite, but the western half of the region is underlain by granitoid and dioritic rocks of the Umiakovik Lake intrusion. The vast majority of these Mesoproterozoic rocks are fresh. One notable exception is the basic rocks peripheral to the Umiakovik Lake intrusion, which are recrystallized, show some growth of secondary amphibole and biotite, and display a pallid weathering, all assumed to be due to the thermal imprint from the younger intrusion.

The significance and importance of internal subdivisions within the terrane of basic rocks assigned to the NPS are open for discussion. In some cases, rock units have been "lumped" that may, in fact, represent different intrusions. At the other extreme, large tracts have been "split" because they are underlain by differing rocks that may, in fact, be all part of the same intrusion. This inherent uncertainty in subdividing the NPS stems both from the lack of clear strike-continuous intrusive contacts and from the degree of regional importance placed on those contacts that have been documented. It also stems from the lack of coherency between scattered outcrops in poorly exposed zones. The southeast corner of NTS map area 14E/2 has been a particularly difficult area to decipher because there appears to be several different intrusions here, the borders of which have not been satisfactorily resolved. Some of these problems are addressed below.

Within the NTS 14E/1,2,7,8 region there is only one age-date from the NTS basic plutons, namely a crystallization age of 1322±1 Ma for a pegmatitic leuconoritic rock of the Puttuaalu Brook area (Hamilton *et al.*, 1997), now considered to be part of an intrusion referred to in this report as the Pyramid Pass pluton (*see* below). This age agrees with field relations that indicate the Pyramid Pass pluton is transected by the dioritic rocks belonging to the border of the ca. 1318 Ma Umiakovik Lake intrusion (Emslie and Loveridge, 1992). No other geochronological data are available to substantiate the conclusions drawn from the field relations given below.

Pegmatoidal Leuconorite and Anorthosite (Ikatsiak Brook Pluton, IBP)

This intrusion occupies most of the southeast corner of NTS map area 14E/2 (Figure 3), and is considered to be the oldest NPS pluton in the study area. It is composed primarily of coarse-grained to pegmatoidal, pale-grey- to white-weathering leuconorite and anorthosite, but the periphery is a foliated to gneissic buff-weathering leuconorite; it corresponds with units 8 and 8a of Ryan *et al.* (1997) for NTS map area 14E/1. One of the outstanding field characteristics of this intrusion is the presence of anhedral to subhedral orthopyroxene megacrysts, and granular aggregates derived from recrystallized megacrysts, in places exceeding a metre in maximum dimension (Plate 2a).

Internally, this intrusion varies from undeformed to mildly deformed and recrystallized. There is local labradorite schiller to the plagioclase, and ilmenite clots are sparsely present. The orthopyroxene megacrysts exhibit kinked cleavage in many parts of the pluton. Part of the intrusion along its southwest side is a finer grained leuconorite in which elongate poikilitic spots of orthopyroxene define a gently north-dipping feature; this could be a younger sheet.

The Ikatsiak Brook pluton is bordered on its northeastern margin against granulite-facies Paleoproterozoic gneisses by a strongly foliated and recrystallized outer zone of buff-weathering leuconorite and anorthosite. In these rocks, most of the primary igneous plagioclase and orthopyroxene are recrystallized to granular aggregates of the same minerals, the foliation being defined by streaks and lozenges of pyroxene granules and by similarly oriented augen of plagioclase. The foliated rocks appear to be less well developed or entirely absent from its northwestern and western margins against the gneisses, but a sand-covered valley floor obscures part of this contact. The high-temperature deformed border zone of the Ikatsiak Brook pluton is morphologically identical to that which separates the Mount Lister intrusion and the Pearly Gates intrusion from their gneissic envelope (cf. Ryan, 1993), and is interpreted to be an indication that this "tectonic" interface developed by solid-state emplacement and recrystallization of the igneous rocks against the gneisses.

There are north-dipping foliated rocks like those of the northern border zone also on the southern margin of the intrusion at the very southwest limit of the pluton as mapped in this area, but a younger mafic intrusion has excised most of them so that their former extent has not been determined. If they are part of the Ikatsiak Brook pluton, then this pluton is a (folded?) sheet having an upper and lower "tectonic" contact with its host. If they are the border zone of another pluton,

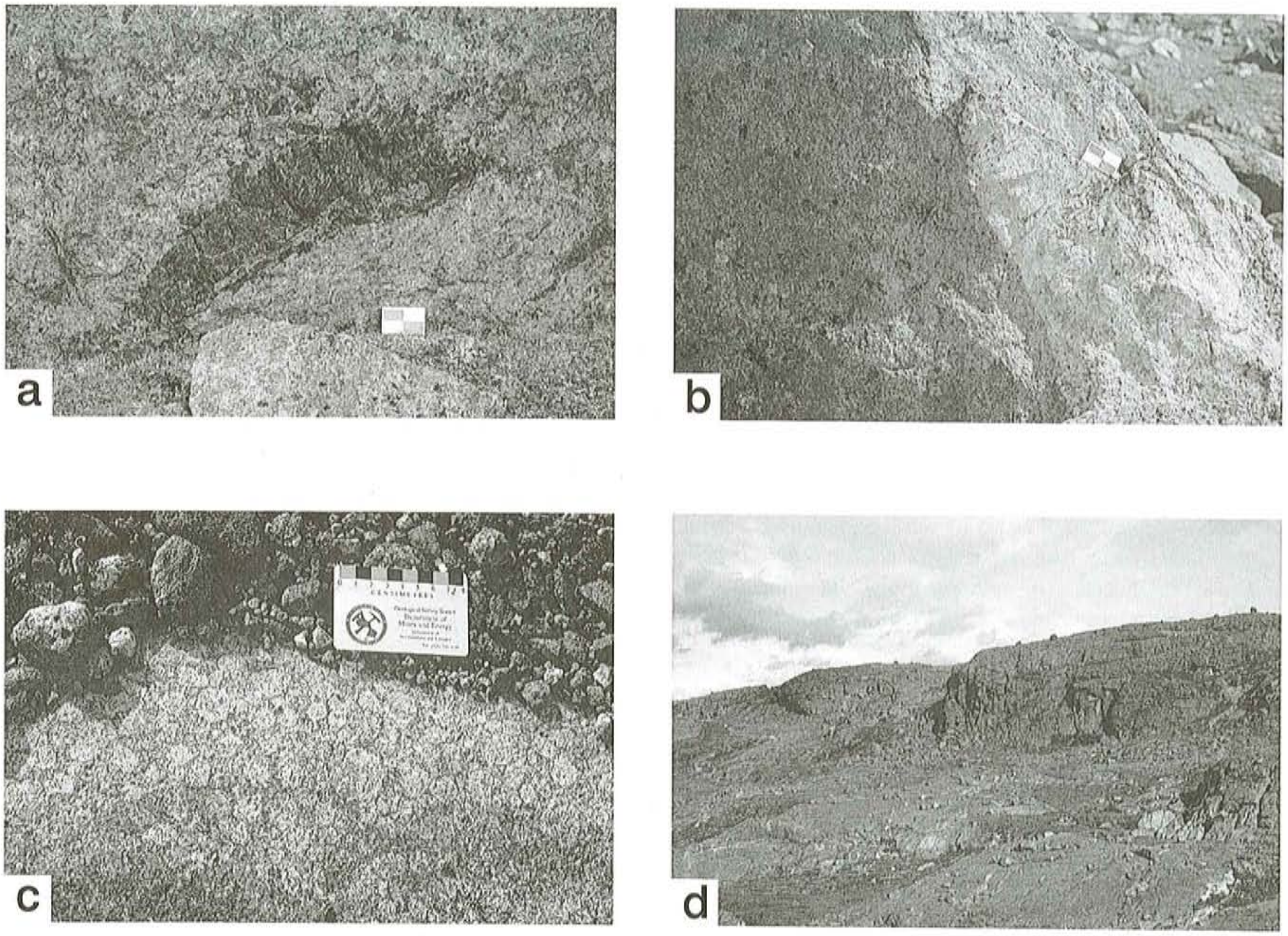

Plate 2. *Textures and intrusive relations of the NPS plutons. a) Large, partially recrystallized, orthopyroxene megacryst, Ikatsiak Brook pluton. b) Sharp contact between white anorthosite (at right) and brown seriate textured leuconorite, interior part of Tallifer Lake pluton. c) Ovoidal feldspar in hybrid dioritic rock along border of the Umiakovik Lake intrusion. Ovoids here are composed of numerous equant plagioclase grains, orthoclase, and clinopyroxene all "glued" together by quartz; quartz is absent from the groundmass. d) Dark-brown quartz monzonite of the Umiakovik Lake intrusion (cliff in background) sitting atop pale-grey leuconorite of the Tallifer Lake pluton, north of Kingurutik River.*

then the greater part of that intrusion lies south of the study area. The determination of the affinity of these southern foliated rocks must await further work.

Minor intrusions within the Ikatsiak Brook pluton include dioritic dykes, granitic pegmatite dykes and fine-grained, pale-brown, granular "gabbronoritic" dykes. These and other younger intrusive rocks are addressed in appropriate sections below.

Massive, Coarse-grained, Grey Leuconorite (Pyramid Pass Pluton, PPP)

This large intrusion underlies all the eastern side of the NPS from *Frozen Lake* north to *Goudie Lake*, and forms part of the country rock to the Umiakovik Lake intrusion. It is considered to be the western continuation of Unit 14 of Ryan *et al.* (1997); the U–Pb age of ca. 1322 Ma derived by Hamilton *et al.* (1997) from leuconorite along Puttuaalu Brook (NTS 14E/1) is interpreted to represent the time of crystallization of this pluton.

The Pyramid Pass pluton is composed nearly entirely of monotonous, coarse-grained, grey- to slightly brown-weathering anorthosite and leuconorite. However, it can be internally subdivided into generally north-trending, east-dipping and strike continuous "mega-units" having compositions such as coarse grey anorthosite, oxide-bearing medium-grained anorthosite, and layered leuconorite. These compositional variations give rise to a crude regional stratification, and could represent the products of prolonged crystal accumulation within a large magma chamber.

The most widespread rock of the Pyramid Pass pluton is a coarse-grained to pegmatoidal leuconorite. Labradorite schiller is sporadic, but regionally persistent, within the plagioclase feldspar, some of which shows a colour zonation in shades of blue and green. Even in rocks where the average grain size is 2 to 3 cm there are megacrystic plagioclase crystals exceeding 15 cm in maximum dimension. Subophitic textures are well developed throughout the extent of this intrusion, and in many places tabular plagioclase exhibits a preferred orientation. There are places in the intrusion where the normally grey feldspar is recrystallized to a finer grained pale-grey to white aggregate. One of the most persistent zones of such recrystallization is proximal to the Tallifer Lake pluton (*see* below) in the *Norma Lake–Tallifer Lake* area, and may be a product of thermal metamorphism from this younger intrusion.

South and east of *Norma Lake* there is a massive coarse- to medium-grained, variably recrystallized, pale-grey- to dark-grey-weathering anorthosite and leuconorite that is characterized by abundant large crysts of subhedral to euhedral black plagioclase. The relationship of this anorthositic rock to the main part of the Pyramid Pass pluton to the north is not known, so it is considered to be a phase of the Pyramid Pass pluton at this stage of investigation. The extent of this anorthosite west of *Frozen Lake* is not well defined because here it is difficult to separate the leuconoritic compositions from those of the superficially similar Ikatsiak Brook pluton. However, it appears to be bordered, at least locally, in this latter area by fine-grained granular rocks having diffuse layering and elongate pyroxene segregations, so additional work using this criterion may be successful in better delineating its extent.

Intrusive relations between the Pyramid Pass pluton and abutting plutonic rocks are equivocal, and will be revisited in appropriate sections below. With respect to older rocks, it was discovered in 1996 that the eastern margin of the Pyramid Pass pluton in the Puttuaalu Brook area (NTS 14E/1) is a breccia zone, in which it supports large blocks of grey to white anorthosite probably derived from the Faceted Mountain pluton to the east (Ryan *et al.,* 1997), but such breccias are absent from the northeastern contact area mapped this year. The junction between the Faceted Mountain pluton and the Pyramid Pass pluton in the present study area was examined only southwest of *Goudie Lake.* Here, buff-weathering, foliated, granular, magnetite-bearing leuconorite of the (Paleoproterozoic?) Faceted Mountain pluton is succeeded westward by grey, subophitic, ilmenite-bearing leuconorite having 5 cm to 20 cm equant and tabular plagioclase in a finer groundmass. A contact between these two units was not observed, but the differing textural attributes are interpreted to indicate that the massive Pyramid Pass pluton is younger than, and intrusive into, the foliated Faceted Mountain leuconorite. It is also assumed to intrude Paleoproterozoic (?) quartz-bearing dioritic rocks in the same area.

The age of this intrusion relative to several small intrusions defined south of *Frozen Lake* is not known. On the basis of contact projections in this complicated area, the anorthositic lobe of the *Pyramid Pass* pluton is interpreted to crosscut a small troctolitic intrusion and a mauve anorthositic unit.

Internal minor intrusions include granitic and basic dykes, and these will be addressed in another part of this report.

Brown, Subophitic Leuconorite
(Tallifer Lake Pluton, TLP)

This pluton can be fairly reliably defined on a regional basis on the southern half of NTS map area 14E/2. It is subdivided into two units, a leuconorite (TLP) and a smaller anorthosite (TLPa), but the relation between the two has not been established. The leuconoritic part is distinct from surrounding rocks of similar overall composition in that it has a very pronounced brown-weathering color, a function of a higher (Fe-rich ?) orthopyroxene content than most of the other leuconorites. This higher pyroxene content also contributes to enhancing the differences in grain size of the plagioclase, such that the intrusion can be seen to be regionally marked by a seriate texture.

The seriate leuconorite of the Tallifer Lake pluton displays equant and tabular, light-grey to dark-grey plagioclase, surrounded by a bronze- to dark brown-coloured orthopyroxene. Ilmenite is a widespread and conspicuous phase in parts of this intrusion, and at the "mouth" of the appendage south of *Norma Lake* (Figure 3) it is particularly abundant. The plagioclase size throughout most of the intrusion generally ranges from <1 cm to 10 cm, but zones having consistent coarser grain size (>10 cm) are also present; labradorite schiller is locally well developed. Near some contacts with the older gneisses, the seriate texture gives way to a porphyritic one, in which 10 cm feldspars are supported by a subophitic matrix having 2 to 3 cm feldspars. Orthopyroxene in this intrusion is locally poikilitic. Layering is locally present, and a well defined, generally east- to northeast-trending, (current-induced?) alignment of plagioclase is sparsely, but regionally, recognized. This unit has a pallid weathering surface along its western side where affected by the thermal overprint of adjacent dioritic and granitic rocks of the Umiakovik Lake intrusion.

Anorthosite (TLPa) south of *Tallifer Lake* is presently included as part of the Tallifer Lake pluton, but its actual relationship to the leuconorite is not firmly established. In contrast to the generally brown-weathering of the leuconoritic rocks, the anorthosite is pale grey to dark grey, and in places the plagioclase reaches more than 20 cm in size and displays a blue-green labradorite schiller.

Intrusive contacts between the Tallifer Lake pluton and the gneisses along its southern boundary are fairly reliably located and defined. However, contacts with abutting plutons are not as easy to establish. The northern contact against the Pyramid Pass pluton on Figure 3, corresponds mainly to a colour change from grey rocks to brown rocks, with little evidence in the field for a continuous sharp contact between them. However, the contact probably represents a discrete pluton boundary for the following reasons. First, the textural contrast between the northern pale leuconorite and the seriate-textured brown rocks is so pronounced that it is highly unlikely that they are related. Second, the presence of inclusions of pale rocks in the darker one at several places along this contact implies that the brown rock is younger. Third, the north-trending "stratigraphy" of the Pyramid Pass pluton is regionally truncated by this contact. Together, these observations imply that the northern boundary as depicted in Figure 3 is an intrusive junction between one pluton to the north and another pluton to the south. The eastern contact is defined by the change from seriate-textured brown rocks to grey massive anorthosite having black plagioclase crysts. The southern appendage is clearly a dyke that crosscuts coarse-grained pale-grey anorthosite and leuconorite, but whether all these latter rocks belong to the Pyramid Pass pluton or to the Ikatsiak Brook pluton is a problem that must persist until further work can be done. There is certainly a lobe of the Tallifer Lake intrusion that punctures the western border of the Ikatsiak Brook pluton at Island Pond, disrupting the sheath of gneisses surrounding the older intrusion in that area.

The nature of the contact and the age relationship between the seriate leuconorite and the internal massive anorthosite of the Tallifer Lake pluton is, as note above, somewhat equivocal. There are isolated inclusions of anorthosite within the leuconorite, providing field evidence that the anorthositic part is older; one exposure shows a sharp junction between the two (Plate 2b) along which the feldspars in the seriate rock are oriented parallel to the contact. These are tempting pieces of evidence to argue for two different intrusions, but the possibility that the anorthositic rocks are a core zone to the leuconorite pluton cannot be ruled out, and thus the inclusions and sharp contacts reflect a cognate relationship rather than a geologically significant difference in their ages.

Among the minor intrusions within the Tallifer Lake pluton are pink to white granitoid dykes and pale-brown "gabbronoritic" dykes. In addition, south of *Norma Lake* it is intruded by several melanocratic dioritic dykes.

Red–Brown Leuconorite

This intrusion, located along the southern margin of the map area and assumed to be the northern edge of a larger pluton (that continues on NTS 14D/15 to the south), was only briefly examined. The predominant rock of this intrusion is a red–brown-weathering, medium-grained, leuconorite, perhaps olivine-bearing, generally having evenly distributed orthopyroxene but locally having the pyroxene as "spongy" clots.

This pluton is interpreted to intrude the grey leuconorite of the Ikatsiak Brook pluton at its eastern end and intrude layered and foliated rocks that may, or may not, be part of that older intrusion at its western end. The interpretation is based on the following criteria. First, it appears from the limited traversing that, in map view at 1:50 000 scale, the trace of the contact between the red–brown massive rock transgresses an older boundary between foliated and massive rocks at its western contact. Second, at the eastern contact, sheets of finer grained red–brown norite crosscut coarse-grained grey leuconorite that display megacrysts of orthopyroxene; the textural difference implies a temporal difference. Third, irregular and slab-shaped inclusions of grey anorthosite and leuconorite are locally present within the dark rock; some of these inclusions are foliated but the host is not.

Umiakovik Lake Intrusion

This intrusion occurs along the western margin of the study area (Figure 3), and was not examined in any systematic manner because of time constraints imposed by inclement weather and the desire to unravel the internal architecture of the basic plutons. Its lithotypes within the map area are predominantly dioritic rocks in the north and quartz monzonitic rocks in the south, but these are merely the border members of an enormous, polyphase, ca. 1318 Ma intrusion of batholithic proportions that forms the northwestern lobe of the NPS (Emslie and Russell, 1988; Ryan, 1990a; Emslie and Stirling, 1993; Figure 1a).

The northern half of the Umiakovik Lake intrusion in the study area is a narrowing-southward unit of hybrid rocks, of which a brown- to grey–brown-coloured, fine- to medium-grained, granular pyroxene diorite and monzodiorite are the most widespread types. Diffuse layering is locally present, but of insufficient continuity to ascertain the internal geometry of the unit. Textural variations within the hybrid unit include abrupt grain-size changes, anastomosing and bifurcating streamers of ovoidal feldspar-bearing granitoid, local ovoid feldspar "clots" (Plate 2c) comprising aggregates of equant plagioclase cemented by quartz and potassium feldspar, dark-grey plagioclase xenocrysts, black hornblende oikocrysts, and grey quartz "eyes".

Quartz monzonite, having characteristics of rapakivi granitoids, occurs west of the hybrid rocks in the north and abuts leuconoritic rocks of the Tallifer Lake pluton in the south. These rocks are red–brown-weathering, friable and deeply indurated. The dominant rock is a coarse-grained pyroxene–olivine (±hornblende) quartz monzonite, having ovoid potassium feldspar megacrysts several centimetres in diameter, and grey "drop quartz" several millimetres in diameter. Parts of the unit seem devoid of quartz and are more monzonitic in composition.

The Umiakovik Lake intrusion is clearly younger than the Pyramid Pass pluton and the Tallifer Lake pluton, a relationship implied from the truncation of the contact between these two basic plutons by the mapped trace of the outer boundary of the Umiakovik Lake intrusion (Figure 3), and in agreement with the crystallization ages of the Pyramid Pass and Umiakovik Lake bodies quoted earlier. In the northern area, there is a clearly defined intrusive contact between the eastern margin of the pyroxene diorite of the Umiakovik Lake intrusion and leuconoritic rocks of the *Pyramid Pass* intrusion. The western margin of the diorite is transitional to coarse "rapakivi" (quartz–) monzonite, and the boundary corresponds to the consistent presence of ovoidal feldspar megacrysts and/or quartz "eyes" in the western rocks. In the southern part of the map area a large northeast-trending "rapakivi" dyke has pierced the Tallifer Lake pluton. This may be the exposed feeder to the eroded base of the Umiakovik Lake intrusion; the Umiakovik Lake intrusion in this area has an irregular outline because topography intersects it where it sits atop a moderately northwestern-dipping floor formed by leuconorite of the Tallifer Lake pluton (Plate 2d) and it infills "valleys" at the top of that basic intrusion. A small outlier of quartz-monzonite, in places a feldspar porphyry, capping a prominent hill north of the Kingurutik River (the river follows the contact between the Tallifer Lake pluton and the Umiakovik intrusion in this part of NTS 14E/2) may be the only preserved remnant of the original base of the Umiakovik Lake intrusion in that area.

Other NPS Rocks of Limited or Unknown Extent

This group includes those NPS rocks that i) are suspect as to being confined within the boundaries proposed, ii) are of limited extent within the map area, or iii) are too small to portray at the scale of Figure 3.

The first category of rocks listed above refers mostly to those within the lithologically complex and drift-covered region south of *Frozen Lake*. Here, sparse outcrop and abrupt changes in rock-types encountered during a few traverses combine to make delineation and significance of the designated intrusions very suspect. Our preliminary map-pattern for this region as shown on Figure 3 incorporates the following rock types and relationships.

A composite unit of red–brown-weathering noritic (and troctolitic ?) rocks overlain by mauve to pink-tinged anorthosite seems to sit "unconformably" astride granulite-facies gneisses and the foliated margin of the Ikatsiak Brook pluton on the southwest slope of a pyramid-shaped mountain south of *Frozen Lake*. The mapped distribution of the rocks included in this intrusion implies that it is a sheet-like body that dips moderately to the north, and it appears to be intruded by massive grey anorthosite of the Pyramid Pass pluton and by a buff leuconorite of unknown affinity (*see* below).

Several outcrops of medium- to coarse-grained mottled leucotroctolite were used to delimit a small body along a ridge directly south of *Frozen Lake*. In one outcrop, there are olivine grains in excess of 30 cm in size, and in another there is a northeast-striking, southeast-dipping layering. Relative age relations with surrounding rocks have not been observed, but it is interpreted to be older than buff leuconorite to the southeast.

The buff leuconorite noted above was observed at only 3 locations. It appears to define a small lobe-shaped unit south of *Frozen Lake*, not differentiated from other anorthositic rocks in this area on Figure 3. It varies from being pale-brown, medium-grained and having oikocrystic orthopyroxene clots to being fine-grained, red-brown and having orthopyroxene (and olivine ?) evenly scattered through it. In one outcrop, it contains rafts of mauve anorthosite like that which forms part of the composite pluton nearby, and on this basis is interpreted to be younger than that pluton. In map view at 1:50 000 scale its distribution truncates the foliated margin of the Ikatsiak Brook pluton, implying an intrusive contact against that pluton as well.

Rocks that fall under the second category to be addressed in this section are dark-brown- to black-weathering, fine- to medium-grained, olivine-bearing, pyroxene diorite dykes and irregular stocks that are present between *Ikatsiak Brook* and *Norma Lake* (Figure 3). The narrowest units (not shown on Figure 3) are clearly moderately dipping dykes, but some of the wider units appear to represent subhorizontal bodies whose mapped shape represents the intersection of irregular topography and shallowly dipping contacts. The largest of the latter type occurs in a boulder-strewn broad valley southeast of *Island Pond*, where it is quartz-bearing and contains inclusions of gneiss and anorthositic rocks. Similar pyroxene-rich dioritic units form floors to linears and narrow valleys southwest of *Norma Lake*. This group of dioritic intrusions appears to be restricted in distribution to the Ikatsiak Brook pluton and the Tallifer Lake pluton, and may be related to the dioritic rocks of the Umiakovik Lake intrusion.

NPS rocks that are too small to portray on Figure 3 include granitic and basic dykes. Most of the granitic dykes are northeast trending, nondescript, aplitic to medium grained, pale pink to white, and generally less than 2 m in width. Wider dykes south of *Norma Lake* locally display ovoidal feldspar and "drop" quartz, implying a relationship to the Umiakovik Lake intrusion. The regionally widespread basic dykes within NPS plutons are pale-brown-weathering, fine- to medium-grained, granular-textured rocks, appearing to be noritic or gabbronoritic in composition. They have no obvious preferred strike orientation, are vertical to gently dipping, and are from a few centimetres to more than 2 m thick. Though normally even grained, they locally have phenocrysts (or xenocrysts) of plagioclase.

No diabase dykes were noted within the NPS plutons of the project area, which emphasizes the difference between these plutons and the Paleoproterozoic (and possible Paleoproterozoic) ones described in the previous section.

OKAK BAY–STAGHORN LAKE SULPHIDE MINERALIZATION

The Okak Bay–Staghorn Lake area has been the focus of sulphide exploration by several junior exploration companies since 1995 (cf. Kerr and Smith, 1997; Kerr, *this volume*). Numerous gossan zones were pin-pointed during preliminary regional reconnaissance surveys by these companies in 1995, surveys sparked by the announcement, in late 1994, of the discovery Ni–Cu–Co mineralization within a troctolite intrusion of the NPS at Voisey's Bay, 120 km to the south. Castle Rock Exploration Corporation and NDT Ventures have been the most active companies in the region covered by this report, having conducted extensive geophysical and drilling programs over several summers. Cartaway Resources Corporation has been drill-testing geophysical targets south of Umiakoviarusek Lake, and these are addressed here because they fall within the domain of Figure 3 but are located within the 1996 survey area (NTS 14E/1; Figure 3). In addition, Gallery Resources drilled a geophysical target south of Umiakovik Lake (Figure 1b). The following summaries of the most noteworthy of the exploration projects are derived from information in the public domain (press releases, company prospectuses) augmented by comments on the regional setting as derived from information presented in this paper. The reader is referred to Kerr and Smith (1997) and Kerr (*this volume*) for additional data about some of the sulphide prospects.

OKAK BAY AREA

Castle Rock Exploration Corporation discovered sulphide mineralization on one of its claim blocks (joint venture with United Compass Resources Limited) south of Okak Bay in the summer of 1995, and the claim area was eventually designated as the OKG prospect (Figure 3). The discovery gossan is exposed on a near-vertical valley wall of altered leuconoritic and anorthositic rocks west of Umiakoviarusek Brook (NTS 14E/8; Kerr and Smith, 1997, Figure 4). Initial grab samples from the gossan zone returned assay values up to 1.76% Ni, 1.34% Co and 0.21% Co. Several geophysical targets were subsequently outlined in the valley, and drilling was conducted in late 1995, in 1996, and early 1997.

The cliff-side gossan is developed over disseminated and massive sulphide within altered and locally foliated grey leuconorite to anorthosite. Massive sulphides are pod-like, but the relationship between mineralized and unmineralized rock is not clear everywhere because of the heavy rust stain (cf. Kerr and Smith, 1997). Sulphide-bearing pyroxenite float occurs at the base of the cliff, and similar pyroxenite-rich rock is present within the gossanous cliff (Kerr and Smith, 1997). A drilling program in late 1995 failed to intersect the subsurface extent of the cliff showing (United Compass Resources Limited, annual report for 1995). The senior author briefly visited the cliff-side discovery zone in 1996 as part of a reconnaissance examination of the surrounding plutonic rocks. Observations made at the time indicate that the leuconoritic and anorthositic rocks on the precipitous cliff above the gossan are transected by a sheet of greenish-brown gabbroic rock, dipping about 20^0 to the west into the cliff, and both the anorthositic and younger gabbroic rocks are cut by several several-metre-thick pale pink granitic dykes. The presence of gently dipping gabbroic sheets, younger granitic dykes, and the indications of pyroxenite in the showing area suggest that there is a correlation between the geology of the sulphide prospect and that of the immediately surrounding area, because the same rock types have been recorded in the stream bed 1.5 km northwest of the showing (*see* earlier section on Paleoproterozoic minor intrusions).

Drilling of geophysical targets (electromagnetic anomalies) beneath the valley floor in the fall of 1995 and summer of 1996 intersected disseminated to massive pyrrhotite, chalcopyrite, and pentlandite, hosted by several steeply inclined "layers of pyroxenite" (Castle Rock Exploration Corporation, press release, December 18, 1995; United Compass Resources Limited, press release, July 3, 1996). Assays from the 1995 mineralized intersections failed to produce the same metal contents as the initial surface samples, but drill core indicated that in places the mineralized zones are up to 14 m wide. The authors are not aware of any published results from the 1996 program. Castle Rock Exploration Corporation undertook a two-hole drilling program over two magnetic anomalies in the valley in early summer of 1997, but results were not sufficiently encouraging to maintain the exploration program, and in September the company indicated that a planned survey using deep-sensing geophysics over the OKG prospect had been postponed.

Golden Trump Resources and Noront Resources conducted a 1996 summer ground and drill exploration program on a claim block (2381; "NOT-3") adjoining the OKG prospect (Kerr and Smith, 1997, Figure 4). The claims are located at the ridge top, above the OKG cliff-face showing. The Golden Trump drilling program tested airborne and ground EM conductors over and near a small gossanous outcrop. Company press releases indicate that at least two drillholes penetrated "massive and net-textured" pyrrhotite and chalcopyrite, some of which is reported as being hosted by pyroxenite. This agrees with the authors' brief examination of the surface showing, which, like some of the Castle Rock sulphide mineralization, is associated with pyroxenite and surrounded by grey leucogabbro. Drill-core assay values from the differing styles of mineralization reported by the Golden Trump–Noront partners indicate variable metal content, with individual samples from some massive sulphide intersections yielding contents as high as 2.1% Ni, 1.5% Cu and 0.14% Co. These grades are significantly better than any encountered during the OKG drilling.

The sulphide prospects in the "OKG Cluster" (Kerr and Smith, 1997) are enigmatic because they are associated with "pyroxenite", which is not a widespread rock type in either the Paleoproterozoic intrusions or the younger NPS. The age of these ultramafic rocks is not immediately obvious from their setting. Kerr (*this volume*) favours a Mesoproterozoic age, but they may be Paleoproterozoic for the following reasons. First, they are locally altered in the same way as the surrounding anorthositic rocks of the Paleoproterozoic(?) Goudie Lake pluton, implying both have been overprinted by the effects of Torngat Orogen. Second, the pyroxenitic rocks, and the gabbroic sheets with which they are locally associated, do not appear to penetrate the Owl Rock valley monzonite pluton, an intrusion that is interpreted as being Paleoproterozoic in age. It was pointed out earlier that where these ultramafic rocks were examined on surface, they form centimetre-scale dykes or monomineralic segregations within diffusely layered gabbroic sheets that are interpreted to intrude the leuconorites of the Goudie Lake pluton of the OKG area, suggesting a genetic link between the two. The intrusive nature of the pyroxenites is also supported by data from Castle Rock Exploration (Castle Rock press release, April 17, 1997), by Piercey and Wilton (1998) and by Kerr (*this volume*). However, there are no indications that the pyroxenites intersected at depth are enclosed by layered gabbros. Nevertheless, it is interesting to note that the drill data on the mineralized pyroxenite zones presented by Castle Rock / United Compass and by Golden Trump / Noront indicate that these zones strike northerly and dip to the west, in agreement with the surface observations of the attitude of the gabbroic sheets and the pyroxenite "dykes" within them.

The west side of the *Caribou valley*, south of Umiakoviarusek Lake, has been an area of interest to Cartaway Resources since 1995, encompassing the company's LB-J,K, H and CAN-12 claim blocks. This area is geographically within NTS map area 14E/1 surveyed in 1996 (Ryan *et al.*, 1997), but falls within part of the re-interpreted northwestern margin of that sheet as shown on Figure 3. Initial interest in the area was prompted by a time-domain EM anomaly, interpreted to represent a flat-lying conductor, within the LB-J block. A 254 m drillhole penetrated the anomaly in early 1996, and encountered "a differentiated succession of alternating layers of anorthosite and pyrrhotite-bearing troctolite" of the "NPS" within which "one 8-m-thick troctolite layer.....contained 5 to 20% sulphides" of "magmatic origin", locally exhibiting a "networked" texture (press release, April 24, 1996). A second hole intersected a flat-lying "troctolite with 10 to 20% network sulphide, pyrrhotite with minor chalcopyrite" within a 2 m interval over 200 m below the surface (Cartaway Resources , press release, April 29, 1996). Results from the metal assays of the sulphides (Cartaway Resources, press release on June 20, 1996) proved disappointing from an economic perspective, with maximum values reaching 0.084% Ni, 0.125% Cu and 0.029% Co. A large magnetic and conductive geophysical anomaly on the LB-H block did not yield drill information to explain its presence (Cartaway Resources, press release, October 22, 1996). During the summer of 1997, a vertical 215 m hole was drilled into a "flat conductor" on the CAN-12 property, adjoining the west side of the LB-J block. The hole intersected "lenses of disseminated to massive sulphides within an anorthositic host" between 112 and 121 m below the surface, from which maximum metal values were reported (Cartaway Resources, press release, October 17, 1997) as follows: 0.50% Ni, 0.58% Cu, and 0.11% Co over 0.58 m.

Based on evaluation and re-interpretation of the geology of the *Caribou valley* arising from the 1997 mapping, it is proposed here that the Cartaway properties cover Paleoproterozoic intrusions (Figure 3), not those of the NPS. The claim blocks fall within the southern part of the Faceted Mountain leuconorite–anorthosite pluton, where there are numerous north-trending magnetite-rich vertically dipping dykes of olivine–hornblende diorite (the Caribou valley dykes). Comments on the setting of the Cartaway geophysical anomalies and the resultant drill data are only preliminary because these have not been investigated in their field setting. However, a couple of interpretations can be placed on the data relative to the regional geological relationships. For example, the senior author has observed moderately dipping layered sections up to 10 m thick in parts of the Faceted Mountain pluton on the west side of the *Caribou valley*, the darker coloured members of which, may contain olivine and which may be the mineralized "troctolite" noted in the core. Alternatively, it is tempting to speculate that the alternating units of "anorthosite and troctolite" on the LB-J property represent leuconorite–anorthosite intruded by olivine-rich diorite dykes, and the sulphide-bearing "troctolite" intersected by the drilling is likewise part of the (Paleoproterozoic?) dioritic suite, which in this area is known to locally carry oxide and sulphide minerals in surface exposures (cf. Emslie and Russell, 1988). The anorthosite-hosted mineralization on the CAN-12 may be sulphides that have migrated from such smaller mafic intrusions.

STAGHORN LAKE–UMIAKOVIK LAKE AREA

The southwestern part of the study area, in the *Ikatsiak Brook–Norma Lake* region about 12 to 20 km east of Staghorn Lake (NTS 14E/2), has been the site of an exhaustive exploration program of mapping, prospecting, geophysical surveys, and drilling by NDT Ventures and its joint-venture partners (Aranlee Resources Ltd., Layfield Resources Ltd., Birchwood Ventures Ltd., Essex Resource Corp., Lumina Investment Corp.) over the past two summers. There are several prominent sulphide gossans in the area southwest of *Norma Lake*, and other smaller gossans in the same general area. Some gossan zones, along with geophysical (magnetic-EM) targets, were drilled. Exploration of the sulphide gossan zones on the Staghorn Lake properties (Figure 3) began in 1995, when initial reconnaissance sampling returned assay values up to 0.69% Ni, 1.27% Cu and 0.17% Co; some of the showings have been described by Kerr and Smith (1997).

A press release from NDT Ventures in late September 1995 indicated that the joint venture areas of the Staghorn Lake area are underlain by "norites and leuconorites" within which the company noted "multiple stratiform subhorizontal zones of disseminated to massive sulphides composed of pyrite, pyrrhotite, chalcopyrite, minor bornite and native copper". Grab samples of fresh sulphide from several of these zones returned metal assays as high as 1.86% Ni, 0.95% Cu and 0.17% Co. A year later the company reported that olivine-bearing mafic rocks had been identified in parts of the Staghorn Lake area, and grab samples from newly discovered zones of pyrrhotite, chalcopyrite, and pentlandite had returned assay values of 1.13% Ni, 2.44% Cu and 0.189% Co. Kerr and Smith (1997) have presented a summary of some of the other assay results reported by NDT Ventures and its joint venture partners, and given a reconnaissance view of the geology of several of the Staghorn Lake properties as known in 1996. They note that one prospect (Project 10-1, joint venture with Aranlee Resources Ltd.) west of *Norma Lake*, comprises massive sulphide pods within otherwise barren anorthosite, adjacent to a 250 m^2 area that has numerous small rusty zones. Aranlee Resources (Aranlee Resources, press release, May 14, 1996) reported that four shallow holes were drilled on this property in 1995; the one assay result released by the company is 0.29% Ni, 0.28% Cu and 0.067% Co over 0.8 m. In 1997 NDT drilled several of the more promising sulphide gossans and geophysical anomalies, especially in zones known to be underlain by olivine-bearing rocks. Aranlee Resources Ltd. (Aranlee Resources, press release, July 25) reported that one drillhole on its property (Project 15-1) south of *Frozen Lake* had intersected very small volumes of sulphide minerals (host rock not indicated). A July 24 press release from NDT announced the drill intersection of "foliated/layered leuconorite and sections of layered troctolite" on a joint venture property (Project 11-3, Essex Resources) west of *Frozen Lake*, within which were several zones of "massive and near massive sulphides"; the best zone, about 6 m thick, gave an average of 0.16% Ni, 0.34% Cu and 0.06% Co. Later in the fall (NDT, press release, September 16, 1997) NDT announced that another drillhole on the same property had penetrated "layered to foliated, medium-grained leuconorite and anorthosite" within which there are "vein-zones and narrow patches of massive pyrrhotite with minor chalcopyrite". Ni, Cu and Co values reported are 0.44%, 0.30%, and 0.097%, respectively. At the same time the company also announced that a drillhole on a joint venture (Project 13-2, Birchwood Ventures) property south of *Frozen Lake* penetrated about 330 m of troctolite atop a "foliated leuconorite to norite and massive anorthosite"; although sulphides were encountered, the mineralization was not of sufficient economic interest to warrant further testing. NDT curtailed its exploration program of the Staghorn Lake area in the late summer of 1997; future plans for the claim blocks in the area have not been announced.

Gallery Resources drilled areas of magnetic anomalies located within quartz monzonite of the Umiakovik Lake intrusion about 8 km south of Umiakovik Lake on NTS map area 14E/7 (Figure 1b; just to the west of the study area and not shown on Figure 3). These positive anomalies are apparent within the regional aeromagnetic database for this region (Figure 4), but more detailed surveys carried out for Gallery Resources refined their shape and distribution. Initially, the anomalies were promoted by the company as possible kimberlite intrusions because their circular shapes resembled those commonly associated with kimberlite pipes (cf. October and November, 1996, issues of the Voisey's Bay News). On October 16, 1997, the company announced that drilling of the anomalies had intersected over 50 m of "significant sulphide mineralization" at 486 m, the mineralized interval being composed of disseminated to semimassive pyrrhotite and chalcopyrite. The company has given no indication in the press release of the host to the mineralization, but our knowledge of the regional geology would indicate that granitic or dioritic rocks of the Umiakovik intrusion are the likely hosts. A week later, the company reported that the hole had penetrated "anorthositic rocks" at 535 m, below the previously reported main mineralized (granitic ?) interval, and that these anorthositic rocks were also mineralized. Assay results from the mineralized zone, reported on November 5, 1997 indicated that the mineralization is "uneconomical" (0.2% Cu, 0.05% Ni, 0.1 g/t Au, 3.4 g/t Ag, and 0.01% Co). Further testing of a deep geophysical anomaly on the property was planned for late 1997, but results have not yet been released.

A new sulphide showing in the study area was discovered at the eastern margin of the Umiakovik Lake intrusion by JS and EP during helicopter mapping north of the Kingurutik River near the end of the field season (Figure 3). The sulphide showing is within fine-grained, dense, mafic pods hosted by friable and orange-red-weathering monzonite, and the sulphide mineralization is visible over areas of several square metres. Hand specimens of the fine-grained rock are dark and difficult to categorize mineralogically, but they appear to be an olivine+oxide rich (ferrodioritic?) rock in which the sulphide (tarnished pyrrhotite and chalcopyrite?) occurs as stringers. The extent, affinity and origin of this mineralization has not been determined. Assays of samples from the showing are in progress.

None of the sulphide mineralization of the Staghorn Lake area dealt with in the above section of this report is easily associated genetically with any particular intrusion. The mineralization encountered by both NDT Ventures and Gallery Resources, from the descriptions in the companies' press releases (and from our own limited observations), seems to be all of epigenetic origin. The part of the region that has been of interest to NDT Ventures and its partners, the southeast corner of NTS 14E/2, is an area underlain by several different rock types, interpreted by us to indicate several intrusions, and it is thus likely that the gossans, geophysical targets and the mineralization reported by NDT reflects sulphide within more than one of the plutons from this area. These plutons include the Ikatsiak Brook pluton, the Pyramid Pass pluton, the Tallifer Lake pluton and several smaller intrusions. Gossan zones located within the boundaries of Project 10-1 and Project 11-3, southwest of *Norma Lake*, for example, are related to disseminated and more massive pods of vein-type sulphides (Kerr and Smith, 1997) within leuconorite and anorthosite of the *Tallifer Lake* pluton, some of which are spatially associated with diffusely layered fayalite-bearing (?) dioritic sheets; the latter may be equivalent to the "layered troctolite" recorded in drill core. It is clear from exposed local relationships and from a consideration of the regional geology that some of the plutons enclosed by the NDT claim blocks have punctured Tasiuyak gneiss. Using the present model for the origin of the Voisey's Bay deposit (cf. Ryan *et al.*, 1995; Naldrett *et al.*, 1996; Ripley *et al.*, 1997), assimilation of this gneiss could have been the catalyst that promoted the formation of the sulphide magma that gave rise to the veins and discordant podiform bodies of mineralization present on the NDT properties in this area.

The sulphides encountered by Gallery Resources seem to be present in both granitic rocks of the Umiakovik Lake intrusion and within anorthositic rocks that reside over 500 m in the subsurface. Mineralization within the granitic rocks may be like that which this survey has revealed along the eastern margin of the Umiakovik Lake intrusion near Staghorn Lake, where the sulphide-laced host rock appears to be podiform melanocratic (ferrodioritic?) enclaves within rapakivi monzonite. The intersection of anorthositic rocks within the Gallery Resources drill area may indicate the existence of a raft of anorthosite within the Umiakovik granite here, or else it is the floor to the Umiakovik Lake intrusion as evidenced by relationships documented in this report from near the Kingurutik River. The sulphides reported by Gallery Resources from the granitic and anorthositic rocks of the Umiakovik Lake area would thus seem to be epigenetic, having an external source and having impregnated both anorthosite and the surrounding granite.

OTHER MINERALIZATION

Cartaway Resources Corporation (Cartaway Resources, press release, June 20, 1996) discovered gold- and silver-bearing quartz veins on the northwest shore of Umiakoviarusek Lake during its 1996 exploration program. The veins are described as being within a 7-m-wide "sulphide-bearing alteration zone on a cliff face". The altered host rock to the veins is "Archean gneiss in a window through Nain Plutonic Suite rocks", but the press release also notes the presence of "magnetite–silicate iron formation" in talus below the showing. The authors have not seen this showing, but the predominant rock in the region is the speckled monzonite of the Owl Rock valley intrusion, so the presence of "Archean gneiss" would imply that the latter is an inclusion within this Paleoproterozoic (?) plutonic rock. One assay of a quartz vein from the showing is reported to have yielded 3493 ppb gold, 117 ppm silver, 1.6% copper, 0.5% bismuth, and "anomalous amounts of arsenic, antimony, and cobalt".

GENERAL DISCUSSION AND SUMMARY

The 1997 season was the second year that the GSNL has conducted mapping in the northern part of the NPS. The approach to the 1997 work in the Okak Bay–Staghorn Lake part of the region was influenced, in large part, by the results of the previous year's work in the Puttuaalu Lake area (NTS 14E/1), which had demonstrated that both Paleoproterozoic and Mesoproterozoic plutonic rocks were present in this part of Labrador. The 1997 work sought to better define the extent of these two plutonic terranes and to ascertain the regional setting of the sulphide mineralization within them.

The separation of Paleoproterozoic and Mesoproterozoic plutons during the 1996 field season was facilitated by the application of criteria summarized in an earlier section of this paper, and, along with subsequent age dating, demonstrated beyond doubt that many of the anorthositic and granitic rocks in the Okak Bay area attest to a period of Paleoproterozoic magmatism of similar character to the Mesoproterozoic NPS (Ryan *et al.*, 1997; Hamilton *et al.*, 1997). This verified earlier suspicions voiced by Ryan and Connelly (1996) that such rocks must be (or must have been) present in the area, based on field work and age determinations of rocks in the Webb's Bay–Nain area to the south. The separation of the two groups during the 1997 field season has been more difficult because some of the criteria are not present to justify the subdivision. One of the main criteria employed to previously demarcate the older rocks has been the presence of a swarm of metamorphosed Paleoproterozoic diabase dykes within them but, as noted, these dykes are scarce within the Archean gneisses and the plutonic rocks of the present study area. The paucity of dykes has made it difficult to confidently assign a general age to some of the plutons which are suspected as being Paleoproterozoic. For example, the apparent absence of such dykes from the Pripet Marshes pluton and the Illuilik Hill pluton could be cited as evidence that these plutons are of Mesoproterozoic age. Similarly, one could advocate that the secondary alteration seen in the Goudie Lake pluton can be attributed to contact metamorphism from the younger granitoid rocks that abut it. This paper argues that features such as the locally developed, yet regionally distributed, foliation and the region-wide imprint of the secondary (greenschist-facies) alteration can be better reconciled with a blanket of low-intensity deformation and metamorphism during the development of the 1.8 Ga Torngat Orogen, and therefore the plutons are Paleoproterozoic in age.

The two summers (1996, 1997) of field work in the Okak Bay area have clearly demonstrated that it is possible to establish intrusive contacts within the "amorphous" region of similar plutonic rocks and to roughly demarcate the outlines of individual plutons that make up this terrane. It has shown that a regional bipartite subdivision based on "older" and "younger" plutons can be further broken down into internal components that demonstrate coalescence of many small intrusions to produce the current anatomy of the terrane. Therefore, the distribution of plutons that has emerged from the 1996 and 1997 field work has radically altered existing maps for the region, and has revised thinking on the uniqueness of the NPS anorthositic and granitic magmatism within the context of the geological evolution of northern Labrador. From the map perspective, the current interpretation of the regional geology is that most of the rocks formerly assigned to the northeastern part of the NPS are, in fact, part of a series of intrusions of nearly identical character that predate the development of the NPS by some 800 million years. This fact must be borne in mind by those who may be active in mapping and exploration in this area in the future. From the geological evolution perspective, the presence of Paleoproterozoic anorthositic and granitic rocks makes it apparent that the processes that contributed to the formation of the Mesoproterozoic NPS were active at an earlier time. The repetitive nature of "anorogenic" and "bimodal" plutonism in the Nain region is now an established fact, and this fact brings into question the singularity of the NPS in the region, and has wider implications for the tectonic setting and genesis of anorthositic rocks (cf. Ryan *et al.*, 1997; Hamilton *et al.*, 1997)). For example, the NPS has a temporal and geological setting that is compatible with its development above an extensive ponded subcrustal magma reservoir in an anorogenic environment (Emslie *et al.*, 1994), some 400 million years after the waning of tectonism associated with the development of the Torngat Orogen. The Paleoproterozoic anorthositic and granitic magmatism, on the other hand, seems more compatible with a pre-orogenic setting, associated with extension during fragmentation of the North Atlantic Archean craton (cf. Ryan and Connelly, 1996; J. Connelly and B. Ryan, unpublished data). The presence of two nearly identical rock suites, separated by some 800 million years, raises an intriguing question as to why this region of crust has been subjected to pulses of this type of "anorogenic" magmatism over such a protracted period.

The 1997 field results reported here for NTS map areas 14E/2, 7, and 8, suggest that, like NTS map area 14E/1, these cover an area that is underlain by two different groups of plutonic rocks. It would seem that the emplacement of the Paleoproterozoic group of plutons, and their subsequent deformation, have been influenced by ancestral structures in the Archean crust of the Nain Province. These plutons number at least nine separate intrusions, and they are regionally marked by a higher magnetic signature than the NPS. The older intrusions encompass a range of rock types that includes anorthosite, leucogabbro, leuconorite, monzonite, quartz monzonite and granite; regionally less voluminous intrusions include dioritic and gabbroic/diabasic dykes. There is good field evidence to conclude that a hornblende-rich monzonitic member of these intrusions, the Owl Rock valley pluton, is disposed as one or more subhorizontal sheets. The varying attributes of those plutons assigned a Paleoproterozoic age would imply that one of the monzonitic intrusions, that at the south end of *Illuilik ridge* which has been dated ca. 2124 Ma, may have been deformed before others were emplaced. An alternative explanation is that the younger plutons are all part of the NPS, making the foliated monzonite at the south end of *Illuilik ridge* the only true Paleoproterozoic intrusion in the area. The presence of foliated and metamorphosed dykes in some of the presumed younger intrusions would, however, seem to indicate that these intrusions similarly predate the imprint of the 1860 Ma Torngat Orogen, so the former explanation is currently favoured.

The Mesoproterozoic rocks of the NPS, like the earlier intrusions, can be partitioned into several plutons. These differ from their older counterparts in being ilmenite-bearing rocks that have little magnetic expression. Their emplacement was not governed by any obvious local pre-existing structure, and some of the plutons are much larger and have more bulbous form than the older intrusions. The nature of the contacts between each of the many intrusions that appear to be present have not all been satisfactorily established, nor has the extent of each of the subdivisions been firmly delineated. Nevertheless, the rationale used for separation of the area into many plutons has produced a map pattern that is in keeping with that expected in igneous terranes which have been constructed by coalescence of multiple intrusions. It would appear that the oldest intrusion within the NPS is the Ikatsiak Brook intrusion, which may have ascended to its final site of residence in the crust in the solid, or near-solid, state. If the Ikatsiak Brook pluton was coeval with similar plutons 60 km to the south, then it may have crystallized ca. 1350 to 1340 Ma (cf. Connelly and Ryan, 1994). The younger limit on major igneous activity in the Okak Bay–Staghorn Lake region is indicated by the 1318 Ma crystallization age of the Umiakovik Lake intrusion (Emslie and Loveridge, 1992), which is interpreted to have intruded all other major plutons of the NPS within the study area. Thus the multiplicity of intrusions within the study area represents just the first half of the currently accepted life of NPS magmatism (viz. 1350 to 1290 Ma), adding credence to postulates that plutonism began and ended earlier in the western part of the terrane than in the coastal part of the NPS of the Nain area.

Sulphide mineralization in the study area is found within rocks that are interpreted as being both Paleoproterozoic and Mesoproterozoic in age. Although it is possible that the mineralization in both groups of rocks is due solely to Mesoproterozoic processes, it is advocated here that some of the mineralization in the Paleoproterozoic rocks reflects processes active at that earlier time. Thus whether a given rock is part of the NPS should not be used as a criterion for exploration. It is also clear that if the Mesoproterozoic mineralization of the Staghorn Lake area is related to the same assumed structural and source controls as the Voisey's Bay deposit – viz., the presence of the Nain–Churchill boundary as a passageway to allow metal-rich NPS magmas to rise from the mantle, and the Tasiuyak gneiss as the sulphur contaminant needed for ore formation (Ryan *et al.*, 1995) – then the older (Paleoproterozoic) mineralization cannot be attributed to these because that mineralization was formed prior to the development of the Nain–Churchill boundary and the juxtaposition of the Tasiuyak gneiss against the Nain Province. That is not to say that *similar* controls did not exist - the plutonism was taking place in an extensional environment and the intrusions passed through Archean crust that locally contains extensive units of pelitic paragneiss.

So, in conclusion, turning again to the words of Konrad Krauskopf: "What we set out to do is to build up, in effect, a "stratigraphy" of [intrusive] bodies.............that were formed at an intermediate level in the earth's crust, just as a stratigrapher seeks to establish sequences of layered rocks deposited at the surface." By demarcating the boundaries of the plutons and erecting an intrusive order it was hoped to ascertain the validity of spatially and temporally linking sulphide mineralization to a specific intrusion. The latter objective proved, in most cases, to be as difficult as firmly defining the extent of the plutons - the mineralization is epigenetic with respect to the large intrusions, yet some of it seems confined within, or is proximal to, smaller intrusions to which it may be genetically related. The conclusions reached are not set in stone, but rather are notions to be discussed and debated through ongoing mapping and exploration in northern Labrador in the years ahead.

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APPENDIX

SOURCES OF GEOGRAPHIC NOMENCLATURE USED FOR THE INFORMAL NAMES OF PLUTONS IN THE 1997 MAP AREA

There are very few formally named geographic features on the NTS maps for this area, as is the case in most of northern Labrador, from which stratigraphic names for rock units can be extracted. In the absence of such nomenclature, many provisional names have been proposed within this report that are, in small part of our own usage, but most are drawn from archival place name maps and an unpublished manuscript compiled prior to 1974 by E.P. Wheeler II (cf. Wheeler, 1953). Some of the names are clearly of Inuit origin and refer to a particular trait of the feature, yet others may have been coined by Wheeler himself based on some peculiar geological or topographic observation. Many of the geographic features cannot be shown at the scale of Figure 3, so the NTS 1:50 000-scale map sheets numbers and approximate central UTM location co-ordinates are given.

Black Mountain (NTS 14E/7; 528300E, 6359000N): The named used by R.F. Emslie (personal communication, 1996) to refer to the prominent, dark, jagged mountain north of *Goudie Lake*.

Caribou valley (NTS 14E/1; 536000E, 6342000N): This name was coined by Wheeler for the broad gravel-floored valley running northwest from Puttuaalu Lake.

Faceted Mountain (NTS 14E/1; 532500E, 6342500N): The name used by Wheeler for the southern of two prominent 1000-m mountain peaks at the north end of the *Caribou valley*. He named the northern one, along the boundary with NTS 14E/8, Breaker Mountain.

Frozen Lake (NTS 14E/2; 530000E, 6324000N): A name from Wheeler's manuscript geological maps, for the lake straddling the boundary of NTS map areas 14E/1 and 14E/2.

Goudie Lake (NTS 14E/7; 528000E, 6354000N): The name used by Wheeler for the lake northwest of Umiakoviarusek Lake. The name may have been inspired in some way by the Goudie family, long-time residents of Labrador.

Ikatsiak Brook: (NTS 14E/2; 516000E, 6318200N): This name was used by Wheeler to refer to the brook along the southern edge of NTS 14E/2 that flows westward through several irregular and elongate lakes on this sheet and on NTS 14D/15 to empty into the Kingurutik River. In an unpublished report he referred to the lake at the southeast corner of NTS 14E/2 as "Ikatsiak Brook chain landing lake".

Illuilik ridge (NTS 14E/8; 535000E, 6363000N): The name we have applied to the elongate northwest-trending upland south of Okak Bay, on which Illuilik Hill is the formal name shown on the NTS sheet for one of the most prominent points. The name Illuilik may be a modification of Illuerlik, meaning "the place [along the shoreline] having an island outside it" (Wheeler, 1953).

Muskrat Brook (NTS 14E/8; 540000E, 6354000N): Wheeler used this name for the small brook east of Umiakoviarusek Lake that flows northwest into Umiakoviarusek Brook. The name may have been inspired by a local population of muskrats (*Ondatra zibethica*).

Norma Lake (NTS 14E/2; 527000E, 6328000N): Source of name is Wheeler's manuscript geological maps. The lake is located east of Tallifer Lake.

Owl Rock valley (NTS 14E/8; 539000E, 6347000N): Wheeler's manuscript map shows this name for the west- to northwest-trending valley between the mountains west of Tasiuyak Tasialua Lake, the southern entrance to which is marked by a small knoll called Owl Rock, perhaps referring to a perch or nest for some of the owl population of the area.

Pripet Marshes (NTS 14E/8; 536000E, 6356000N): This name seems to have been applied in jest by Wheeler as a designator for the expanse of swamps in the northwest-trending broad valley occupied by Umiakoviarusek Brook. He probably felt they were the local equivalent of the famous Pripet Marshes, the largest in Europe, located in Belarus and the Ukraine.

Pyramid Pass (NTS 14E/7; 526600E, 6350000N): This informal name is taken from Wheeler's place-names map, and seems to refer to a valley near a small ridge having the profile of a pyramid, at the eastern margin of the map sheet.

Tallifer Lake (NTS 14E/2; 516000E, 6328600N): This name was used by Wheeler for the large lake east of Staghorn Lake.