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GEOLOGICAL SURVEY OF CANADA — COMMISSION GÉOLOGIQUE DU CANADA

INTRODUCTION

The three map sheets in this open file (N.T.S. sheets 24P, 14M and 25A) show the bedrock geology of the northern part of the Labrador peninsula in Newfoundland (Labrador), Québec and the Northwest Territories, north of latitude 59°15'N. Mapping was completed as part of a Canada-Newfoundland Co-operative Agreement on Mineral Development between the Geological Survey of Canada (GSC) and the Geological Survey Branch of the Newfoundland Department of Natural Resources. The map area was previously included within a 1:250 000 scale reconnaissance mapping project by F.C. Taylor of the GSC (1977a-c, 1979). The geology of the coastal section in the southwestern corner of the map is described by Goulet and Ciesielski (1990), and a gravimetric survey of this area was completed by Seguin and Goulet (1990). Detailed maps at 1:50 000 scale are available for much of N.T.S. map 24P through the Geological Survey of Canada colour Open File series (Van Kranendonk, 1993, 1994a- d; Van Kranendonk and Wardle, 1994, in press a, in press b). Field reports of the area are available from GSC and Newfoundland Current Research reports (Van Kranendonk and Scott, 1992; Van Kranendonk et al., 1993a, 1994; Wardle et al., 1992, 1993, 1994)

The map area contains the rugged Torngat Mountains, which reach a maximum elevation of 4400' (1320m) at Mount Tetragona and the Four Peaks region between Ryans Bay and Komaktorvik Fiord. The highest point in Québec is 4138' (1241m) high Mt. Jacques-Rousseau in the south-central part of the map area. The Torngat Mountains form a NNW-SSE central spine from Mount Tetragona in the south to Killinek (Killiniq) Island in the north which is an alpine terrain dominated by steep slopes, cirques with remnant glaciers, and rock glaciers in cirque floors. West of the mountains, the topography gradually diminishes to Ungava Bay across gently rolling tundra. On Killinek Island and the Button Islands, steep-walled, narrow valleys make traversing difficult. The rugged mountainous terrain is barren, except in the broad U- shaped valleys where grass, willow shrubs and flowers occur together with caribou during the short summer months. Grass and flowers also occur in low relief areas along the Labrador Sea coast, where polar bears are likely to be encountered.

The map area is very well exposed, particularly on wave- and ice-washed coastal exposures and on the slopes and in the valleys of mountains. Inland, mountain tops and ridges are composed entirely of rock which has been heavily fractured and jostled about by the Quaternary glaciers, forming a classical "sea of boulders", or felsenmeer. The mountains are transected by broad river valleys which are filled by Quaternary glacial deposits including gravel and sand. There is almost no bedrock exposure in these valleys. Bedrock exposure in the western half of the map area is good, but generally covered by lichen and moss.

Map coverage was accomplished on foot through helicopter-supported ground traverses and by inflatable boat traverses of the Labrador Sea coast during the summers of 1991-1993. Access was provided by a natural shingle beach located on the southern end of Eclipse Harbour which was used for landing Twin Otter aircraft from Kuujjuaq, Québec. A campsite was established at Iselin Harbour, and a second camp, located inland west of Ryans Bay, was used in 1993 (see Van Kranendonk and Wardle, 1994a).

Geological contacts were divided into those "known" and those "interpreted" (see Legend). Constraints for the known contacts include observed contacts from field traverses, airborne flybys of cliff sections and other unvisited areas, and interpretation of black and white airphotos which reveal contacts between rock units of highly contrasting mafic content (in particular, contacts between the Hutton meta-anorthositic suite and adjacent units). All ages, recorded on the accompanying Figures 2 and 4, are by the U-Pb method on zircon, monazite, or titanite analysed at the GEOTOP Laboratory of the Université du Québec à Montréal (Scott and Machado, 1993, 1994, 1995).

REGIONAL GEOLOGY AND TECTONIC SETTING

The map area is located within the northeastern part of the Laurentian Shield, and is underlain by the northern part of the Archean Nain Province in the east (14M and 25A) and the northern segment of the Paleoproterozoic Torngat Orogen throughout the remainder (24P and 25A). In the southwestern part of the map area, undated gneisses of suspected Archean age, reworked within the Torngat Orogen, are thought to be derived from the southeastern arm of the Rae Province (after Hoffman, 1988).

The Archean Nain Province forms the western margin of the North Atlantic Craton, which is composed of high-grade, polycyclic gneisses that range in age from 3.8-2.5 Ga across a number of lithotectonic terranes (cf. Bridgwater and Schiøtte, 1992; Connelly and Ryan, 1993; Nutman and Collerson, 1991). Prior to this study, no age data were available for Nain Province gneisses north of 59°N, and correlations with terranes identified in West Greenland were unknown.

Torngat Orogen is a Paleoproterozoic belt of highly strained Archean and Paleoproterozoic rocks metamorphosed to amphibolite- and granulite facies, that is thought to represent the deeply exhumed roots of a continent-continent collision zone between the Archean Nain Province and the southeast arm of the Archean Rae Province (Fig. 1: cf. Wardle et al., 1990). The high-grade core of the orogen is underlain by garnet paragneiss and mylonite known as the Tasiuyak gneiss, which extends along the entire strike length of the orogen and reaches a maximum width of 40 km across strike in the map area and in the North River area, 350 km to the south (Ermanovics and Van Kranendonk, 1990). In the southern segment of the orogen (south of Nachvak Fiord, Fig. 1), a calc-alkaline suite of tonalite-granodiorite-granite plutons across the Tasiuyak gneiss-Rae Province (Lac Lomier complex) contact zone (Ermanovics and Van Kranendonk, 1990; Iyer, 1980) has been interpreted as a Paleoproterozoic magmatic arc complex developed at ca. 1880 Ma during westerly subduction under Rae Province (Bertrand et al., 1993).

Previous work in the southern segment of the Torngat Orogen showed that it evolved through three separate deformational episodes: D_{n+1} (ca. 1860 Ma) continent- continent collision and the formation of a doubly-vergent thrust wedge; D_{n+2} (1845- 1822 Ma) sinistral shear deformation, concentrated within the Abloviak shear zone; and D_{n+3} (1794-1773 Ma) uplift of the core of the orogen on east-verging reverse faults (Van Kranendonk and Ermanovics, 1990; Ryan, 1990; Van Kranendonk, 1992: age data from Bertrand et al., 1993).

The model for the southern segment of the orogen is complicated further north by the elliptical Burwell domain, a low-strain structural augen bounded to the south by the Abloviak shear zone and to the east by the Komaktorvik shear zone (Van Kranendonk et al., 1993a, after Korstgård et al., 1987). During the course of the present mapping project, it was found that Burwell domain represents a tilted cross- section through a magmatic arc that was developed, at least in part, on the Nain Province margin at between 1910-1885 Ma (Van Kranendonk and Wardle, 1994b, in press c; age data from Scott and Machado, 1993, 1994). These marginal notes describe the geology of the map area and outline the structural evolution of the northern segment of the Torngat Orogen.

GEOLOGY OF THE MAP AREA

Subdivisions and terminology

The geology of the northern segment of the Torngat Orogen, summarized in Figure 2, has been subdivided into a number of lithotectonic complexes and structural elements as shown in Figure 3 (after Van Kranendonk et al., 1993b). Lithotectonic complexes comprise an assemblage of individual rock units, suites, and groups, and are defined on the basis of restricted associations between some rock units, suites and groups, a restricted geographic distribution, and a continuity of assemblages along strike. Individual rock units may transgress lithotectonic complex boundaries, but suites and groups do not.

The intensity and distribution of Paleoproterozoic structures has been used to subdivide the map area into six structural elements, including three domains of relatively low strain (Four Peaks, Burwell, and North River) separated by the Abloviak, Komaktorvik and Katherine River shear zones (Fig. 3). This structural zonation is superimposed on the lithotectonic complexes, whose rock units, suites and groups, may cross the structural domain boundaries.

Four Peaks domain, coincident with the Nain Province gneiss complex, is unaffected by penetrative Paleoproterozoic strain other than narrow shear zones (cm - dm thick) and discrete faults. Rocks within the domain were deformed and metamorphosed during Late Archean orogeny at granulite facies and, subsequent to Avayalik dyke intrusion, affected by a static Paleoproterozoic overprint of garnet- clinopyroxene assemblages (Van Kranendonk et al., 1994; Wardle et al., 1994).

Burwell domain is an area of tight to open folds and narrow high strain zones bounded to the south by the Abloviak and Katherine River shear zones, and to the east by the splayed western margin of the Komaktorvik shear zone. Metamorphism varies from granulite facies throughout the western half, to amphibolite facies in the eastern half, the latter of which is in part retrograde over the granulite facies, but in part also prograde on rocks that were never at granulite facies.

North River domain is named after the region west of the Abloviak shear zone in the Okak Bay area (Fig. 1: Van Kranendonk and Ermanovics, 1990). It is characterized by NW-SE trending, tight to open D_{n+2} folds of amphibolite- to granulite-facies rocks of the Rae Province gneiss complex. The dominant structures in this domain are related to the formation of the Abloviak shear zone (D_{n+2}), into which it grades. A southern limit for this domain was not mapped.

Lithology

Nain Province gneiss complex

Archean gneisses

The granulite-facies Nain Province comprises ≤80% of brown to buff coloured, leucocratic, tonalitic orthogneiss [**Agl**], generally strongly migmatitic and characterized by numerous disrupted layers and pods of ultramafic and mafic gneiss. These occur intermixed with pelitic to psammitic metasedimentary rocks and are probably of supracrustal origin. A U-Pb zircon determination of 2834 ± 4 Ma has been obtained from migmatitic orthogneiss from the Avayalik Islands (Scott and Machado, 1994).

Mafic gneisses, including layered to massive mafic granulites [**Amf**] and thin pods and layers of massive to layered pyroxenite [**Aum**], range from metres to kilometres in extent and are only locally large enough to be mapped as individual units. These rocks generally have gradational contacts with metasediment-dominated supracrustal belts and probably represent a mixture of supracrustal (metavolcanic?) rocks and mafic intrusions. Belts of rusty-weathering supracrustal gneiss [**Ams**] occur interspersed with the orthogneisses throughout the area but are most prevalent west of Komaktorvik Fiord, where the principal rock type is a thinly layered, white and rusty brown, strongly migmatitic gneiss consisting of white leucogranite and garnet quartzite intercalated with layers of rusty, pelitic sillimanite gneiss and garnet psammite gneiss. Also present are layers and lenses of the various mafic and ultramafic rocks described above. The mafic gneisses are generally characterized by prominent development of red garnet and bright green clinopyroxene; the ultramafic rocks generally preserve orthopyroxene as the principal mafic phase but this may be recrystallized to garnet and clinopyroxene around the periphery of ultramafic lenses. A distinctive supracrustal assemblage is preserved as layers within orthogneiss near Abate Point east of Komaktorvik Fiord. These rocks consist of interlayered marble, clinopyroxene-calc-silicate, clinopyroxene-magnetite-quartz iron formation and garnet-clinopyroxene quartzite.

The orthogneisses also contain podiform enclaves of pale grey meta-anorthosite [**Aan**] that vary from metres to kilometres in size. These units are usually associated with layered leucogabbroic rocks and probably represent the more differentiated parts of dismembered layered mafic intrusions. Compositional layering is the only primary feature that is preserved in these rocks; primary igneous texture has been totally recrystallized to granoblastic assemblages of grey to purple plagioclase, garnet, clinopyroxene and minor hornblende. Garnet occurs intergrown with quartz in prominent symplectites up to several centimetres across. The anorthosite pods are intruded by veins of pegmatite and leucotonalite apparently generated during granulite-facies melting of the ambient tonalitic gneisses. The relationship of the anorthosites to the protolith of these gneisses prior to migmatization is not clear.

Orthogneisses and their inclusions are cut by veins and sheets of homogeneous, foliated to gneissic tonalite/granodiorite. In the southeast, linear bodies of coarse grained granodiorite/granite [**Agd**] emplaced into the migmatitic gneisses may represent larger bodies of this suite (Van Kranendonk, 1994a). All rocks were then deformed under granulite-facies metamorphic conditions, which is interpreted to have occurred at 2769 ± 5 Ma, the age of metamorphic zircon overgrowths. Collectively, all Archean structures in the Nain Province are referred to as the D_n set of structures. These rocks are in turn cut by white, biotite-allanite pegmatite sheets [**Apg**], which are undated.

Paleoproterozoic Avayalik dykes

Archean gneisses and structures are cut by Paleoproterozoic mafic dykes of the Avayalik swarm (Wardle et al., 1992, 1994). Dykes and their host rocks were affected by Paleoproterozoic metamorphism which varies in grade across the map area. In the southeast, orthopyroxene-bearing Archean gneisses host E-W trending, subvertical Avayalik dykes with chilled margins and black feldspar megacrysts. Locally these undeformed and unmetamorphosed dykes have irregular, branching, or en echelon intrusion forms and shallow dips. Toward Kangalaksiorvik Fiord, these dykes are cut by garnet-clinopyroxene-quartz veins. Further west, dykes trend NE-SW and dip moderately to the SE but are still undeformed, indicating that the change in orientation is a primary feature of intrusion.

Both Archean gneisses and Avayalik dykes in the Four Peaks domain are recrystallized to garnet-clinopyroxene assemblages in the absence of associated deformation features, indicating a period of high-pressure, static Paleoproterozoic metamorphism (Van Kranendonk et al., 1994; Wardle et al., 1994; as initially noted by Morgan and Taylor, 1972). Metamorphic assemblages in the Archean gneisses and Avayalik dykes show systematic variations across the map area (Fig. 3). The gneisses east of Komaktorvik Fiord are characterized by orthopyroxene-clinopyroxene granulite facies assemblages that are clearly associated with Late Archean migmatization of these rocks prior to folding and dyke intrusion. Avayalik dykes east of Komaktorvik Fiord are generally fresh, apart from the development of fine garnet in pegmatitic pods and within thin fractures at dyke margins.

West of Komaktorvik Fiord, the orthopyroxene in felsic orthogneisses becomes rimmed and, in places, totally replaced by aggregates of fine red garnet and green clinopyroxene (Van Kranendonk et al., 1994; Wardle et al., 1994). Further to the west, the orthopyroxene-bearing assemblages in all but ultramafic rocks have been totally replaced by garnet-clinopyroxene assemblages. Dykes in this area also show pervasive development of garnet, clinopyroxene and quartz, both in the form of reticulate vein systems, and as blotchy overgrowths. The development of these textures is generally accompanied by a whitening of the black plagioclase phenocrysts and a recrystallization of the dyke matrix to a granoblastic texture. The garnet-clinopyroxene assemblages probably formed by the general reaction: orthopyroxene + plagioclase = garnet + clinopyroxene + quartz which is indicative of granulite-facies metamorphism at pressures in excess of 8 kbars (cf. Wells, 1979). Preliminary geothermobarometric data on a garnet-clinopyroxene- plagioclase-quartz bearing sample from inner Kangalaksiorvik Fiord suggest P-T conditions of between 10-13 kbars, and 800°C (unpublished data, Geological Survey of Canada). Garnet-clinopyroxene bearing Avayalik dykes in orthopyroxene bearing country rocks from Avayalik and Home Island have yielded P-T estimates in the range of 7-10 kbars, 700 ± 50°C (Mengel and Rivers, 1994; unpublished data, Geological Survey of Canada). Garnet in these rocks is typically rimmed by thin bands of white plagioclase, a texture that may be due to reversal of the above reaction during uplift and decompression (see below).

A 25 m wide, N-S striking, garnetiferous Avayalik(?) dyke in the Four Peaks domain has yielded an U-Pb zircon upper intercept age of 1834 +7/-3 Ma, which Scott and Machado (1994) regard as the time of crystallization of the dyke (see Fig. 2 for location). However, regional mapping has shown that the Avayalik dykes do not occur in any Paleoproterozoic supracrustal or metaplutonic units within Nain Province or in Burwell domain, thereby indicating an age of >1910 Ma - the age of the oldest dated metaplutonic rock (see below) - for the main swarm of the Avayalik dykes. The age data therefore suggests that either; 1) there are two ages of dykes lumped together in the Avayalik swarm, or 2) the dated dyke contains zircon which grew during formation of the Paleoproterozoic garnet-clinopyroxene assemblages within the Four Peaks domain (Van Kranendonk et al., 1994). The main set of dykes in the Avayalik swarm may be correlated with the Domes and Napaktok dykes identified further south, that have been dated by the K-Ar and Rb-Sr whole rock methods as ca. 2450 Ma (Fahrig, 1970; Taylor, 1974).

Rae Province gneiss complex

Gneisses of suspected Archean age

In the southwestern corner of the map area, Rae Province orthogneisses of suspected Archean age [**ARtn**] vary from white-weathering, homogeneous, tonalitic gneiss to agmatitic and schlieric textured migmatites in which 40-50% of the rock consists of inclusions of grey gneiss and mafic - or less commonly anorthositic - rocks floating in a granitic neosome. Rare mafic dykes have also been observed. Rae Province orthogneisses differ from their Nain Province counterparts and those in the Tasiuyak gneiss complex by having abundant granite and a paucity of ultramafic inclusions. No age data is available for the orthogneisses in the map area, but similar gneissic migmatites located 150 km to the southwest, on the south coast of Ungava Bay, have yielded a complex Archean population of zircon that ranges from 2922- 2688 Ma (Machado et al., 1989).

Lake Harbour Group

Orthogneisses of suspected Archean age are infolded with metasedimentary rocks of the Paleoproterozoic Lake Harbour Group (Jackson and Taylor, 1972; Taylor, 1979), including white-weathering, coarse grained calcite marble [**PLmb**], white quartzite [**PLqz**], hornblende-biotite-plagioclase-quartz dioritic gneiss [**PLdg**], rusty brown-weathering garnet-graphite-biotite ± sillimanite paragneiss [**PLrg**], coarse grained garnet-sillimanite metapelite [**PLpg**], and rare sheets of hornblende-plagioclase ± garnet ± orthopyroxene metagabbro. Contact relationships between the group and orthogneisses are sharp and strongly sheared near the Abloviak shear zone, but unsheared away from the zone, where they may represent stratigraphic contacts or the trace of premetamorphic thrust faults (Goulet and Ciesielski, 1990).

Charnockitic rocks

Orthopyroxene-bearing granitoid rocks [**Pigd**] with a single set of planar and linear fabric elements are interlayered with Rae orthogneisses and Lake Harbour Group metasedimentary rocks. The charnockitic rocks are similar to those of the Killinek charnockite suite (see below) and are distinct from the migmatitic, heterogeneous gneisses of suspected Archean age by virtue of their single fabric, the presence of coarse orthopyroxene crystals, and a buff weathering appearance.

Noodleook complex

Noodleook complex is composed of five principal rock suites, including: reworked Archean gneisses with metamorphosed and deformed Avayalik dykes of Nain Province parentage, the Hutton meta-anorthositic suite, metagabbroic rocksof the Murray Head igneous complex; a Paleoproterozoic diorite-tonalite-granite (**DTG**) suite of metaplutonic rocks, and orthopyroxene-bearing granitoid rocks of the Killinek charnockite suite (Figs. 2, 3). A younger suite of Paleoproterozoic metaplutonic rocks, a set of amphibolite dykes, and a set of syntectonic metadiorite dykes comprise the remainder of the complex.

Reworked Archean gneiss and deformed mafic dykes

Reworked Archean gneisses of the Noodleook complex [**Agn, Argn**] are identical in appearance to those of the Nain Province gneiss complex in terms of textural heterogeneity and structural complexity. One sample of migmatitic orthogneiss, without dykes, yielded an U-Pb zircon age of 2803 ± 3 Ma (Fig. 2). In the eastern part of the complex, migmatitic tonalite/granodiorite orthogneisses at granulite facies are cut by schlieric pink and grey granite and granitoid gneiss of the Duck Island granitoid suite [**Agg**] (Van Kranendonk et al., 1994). The suite contains a penetrative, amphibolite-facies foliation which formed prior to intrusion of the Avayalik dykes. This observation suggests a period of late Archean deformation which is estimated to have occurred at ca. 2660 Ma, the average U-Pb age of two monazite grains from a sample of the suite (Fig. 4).

Migmatitic and schlieric granitoid gneisses contain deformed, metamorphosed and folded mafic dyke remnants [**Pdb**] that are interpreted to represent the western continuation of the Avayalik dyke swarm. These rocks are partly to completely recrystallized as a result of Paleoproterozoic amphibolite-facies metamorphism across the Komaktorvik shear zone and eastern half of the Burwell domain.

In the central-west part of the map area and on Killinek Island are two small areas of migmatitic orthogneiss of suspected Archean age at transitional amphibolite- to granulite facies [**APgl**]. These areas, like their Nain Province counterparts, contain numerous inclusions of mafic, ultramafic and anorthositic rocks in a migmatitic, leucocratic tonalite gneiss host. Interlayered with the gneisses on Killinek Island are thin slivers of mafic gneiss of uncertain Archean or Paleoproterozoic age [**APmf**]. The migmatitic gneisses of suspected Archean age have gradational margins with adjacent Paleoproterozoic tonalite-granodiorite rocks.

Hutton meta-anorthositic suite

Reworked Archean gneisses in the eastern part of the complex are host to a continuous body, up to 3 km wide by over 110 km long, of meta-anorthositic and associated rocks of the Hutton meta-anorthositic suite (Fig. 2: Van Kranendonk and Scott, 1992; Wardle et al., 1992, 1993). Similar rocks occur as a disaggregated train of lenses and rafts for over 325 km along strike, south to Okak Bay (Fig. 1: Ermanovics and Van Kranendonk, 1990). Pristine, coarse grained anorthosite with subophitic textures of blue igneous labradorite and igneous orthopyroxene (up to 60 cm in diameter), variably recrystallized to hornblende-biotite-epidote, is common throughout the southern part of the suite, where igneous layering is locally preserved in low strained areas. Low-strained rocks grade into medium grained, granoblastic gneisses and mylonites [**APanl**]. Gabbroic anorthosite compositions dominate the suite, but anorthosite (colour index < 10), leucogabbro [**APanm**], rare ultramafic rocks, and rusty sulphide gossans also occur.

Contact relationships between anorthositic rocks and Archean gneisses are sharp and deformed, so that a relative age relationship between these units is indeterminable. However, the occurrence of a thin sheet of gabbroic anorthosite and leucogabbro within Archean rocks just north of Saglarsuk Bay (Fig. 2) suggests the anorthositic suite may have been emplaced as a sill complex within the Archean host rocks (cf. Van Kranendonk, 1991). This interpretation is consistent with a much simpler set of structures within anorthositic rocks than in their migmatitic, polycyclic host rocks (see below).

Direct attempts at dating the Hutton meta-anorthositic suite have so far yielded only metamorphic zircons (1795-1779 Ma: Scott and Machado, 1993), but there is good field evidence for an older age of the suite because it is crosscut by: 1) a granite dyke, dated as 1804 +3/-2 Ma, which cuts migmatitic gneissosity in the suite; 2) equivalents of megacrystic metagranite sheets, dated outside of the Hutton meta-anorthositic suite as ≥1864 Ma; 3) Paleoproterozoic metaplutonic rocks of the DTG suite, the equivalents of which have been dated outside of the Hutton meta-anorthositic suite as 1910-1885 Ma; and 4) Avayalik dykes, which are considered to be >1910 Ma (see discussion above, and Fig. 4 for age locations).

Metagabbroic rocks

Murray Head and the islands immediately to the east expose the Murray Head igneous complex [**APgb**]. Primarily composed of coarse grained, 2-pyroxene gabbros, this complex also contains thin layers of leucogabbro, anorthosite and syenite (Van Kranendonk and Scott, 1992). Igneous features and textures are commonly preserved, including metre-scale layering, local cross-bedding, and cognate xenoliths of more mafic phases in mesocratic gabbro. The age of the complex is unknown, but its low state of strain and lack of migmatitic textures are used to infer an age younger than the Late Archean deformation which strongly affects adjacent orthogneisses. A minimum age is provided by cross-cutting Avayalik dykes interpreted to be older than 1910 Ma (see below).

A similar occurrence of low-strained metagabbroic rocks occurs on the islands just west of Home Island and at Jolliet Harbour. This massive, medium- to coarse-grained gabbro contains well preserved ophitic texture of tabular plagioclase laths set in a matrix of clinopyroxene, garnet and hornblende. The gabbro is locally strongly foliated and becomes weakly gneissic with the development of white pegmatitic sweats containing coarse symplectites of garnet, clinopyroxene and (?)quartz. The unit truncates the gneissic fabrics in the surrounding gneisses, locally incorporating large rafts of gneiss; numerous layers also contain xenoliths of mafic gabbro in layered leucogabbro. The Jolliet Harbour gabbro is cut by metadiabase Avayalik dykes containing garnet-clinopyroxene-hornblende assemblages. The dykes are locally deformed by the same fabric elements that affect the gabbro.

Paleoproterozoic supracrustal rocks

Elongate inclusions and rafts of Paleoproterozoic supracrustal rocks occur throughout that part of the Noodleook complex located within the Burwell domain (Fig. 2). Rusty-weathering garnet-biotite pelitic and psammitic gneiss [**Pspg**] occurs as layers and rafts within the DTG and Killinek charnockitic suites, to about 60°N (Wardle et al., 1992, 1993). The widest and most extensive belt of paragneiss trends E-W through the Ikkudliayuk Lake area and then swings north, crossing the strike of the DTG suite at an acute angle, to Grenfell Sound and north across Killinek Island, where it forms the boundary between Paleoproterozoic metaplutonic rocks and Archean gneisses within the Komaktorvik shear zone (Fig. 2). The paragneisses consist of alternating white, garnetiferous granite and rusty, biotite-garnet-graphite ± sillimanite pelitic gneiss. Metasedimentary gneiss south of Shungmiyuk Inlet are strongly migmatitic (20-50% granitic and pegmatitic veins) and contain layers of garnetiferous amphibolite and distinctive green garnetiferous quartzite (Wardle et al., 1993). Some layers contain thin bands of plagioclase-porphyritic amphibolite that locally preserves relict grading and may have originated as volcanic layers in the gneiss protolith. On the north shore of Tellialuk Arm, grey quartzofeldspathic gneisses of interpreted sedimentary origin also contain interlayers of porphyritic amphibolite.

South of 60°N, paragneisses give way to layered mafic gneisses characterized by units with centimetre-scale compositional layering [**Psmg**] (Van Kranendonk et al., 1993a, 1994). Homogeneous, unlayered units in these sequences, ≤20 m thick, are interpreted to represent massive volcanic flows or sills, whereas the occurrence of layers and discordant sheets of hornblende diorite and rare units of quartz-feldspar porphyry suggest that subvolcanic intrusions are also present. Possible evidence for pillows was identified in one locality, and rare interlayers of paragneiss, calc-silicate and possible fragmental andesites suggest a dominantly supracrustal origin for these rocks. Leucogabbro and anorthositic rocks [**Panm**] occur in one unit in the central part of the map area. The typical centimetre-scale layering of mafic gneisses is interpreted to represent highly strained volcanic pillow texture (cf. Myers, 1978). Westward within the Noodleook complex, mafic gneisses lose their textural heterogeneity with increasing metamorphic grade and recrystallization to garnet-hornblende ± pyroxene mafic amphibolite/granulite [**Pab**].

Geochemical analyses of the layered mafic gneisses show them to be subalkaline, N-type MORB tholeiites with slightly depleted LREE patterns (Van Kranendonk and Wardle, in press c). An absolute age for the supracrustal rocks is unknown, but a Paleoproterozoic age is indicated by the fact that they do not contain Avayalik dykes and are in fault contact with Archean rocks (Van Kranendonk et al., 1994). A younger limit is provided by the cross-cutting, 1910 Ma DTG suite.

Diorite-tonalite-granite (DTG) suite

Archean gneisses and Paleoproterozoic supracrustal rocks of the Noodleook complex were intruded by a polyphase intrusive suite of Paleoproterozoic metaplutonic rocks that varies from older gabbro and diorite, through tonalite, to youngest granite [**PiDTG**] (Van Kranendonk et al., 1993a). Tonalite is the most voluminous component west of the Hutton anorthositic suite, but diorite [**Pid**] and granite [**Pigr**] are more common further east, where outcrops commonly show multiple intrusive phases.

In the eastern half of Burwell domain and across the KSZ, DTG suite rocks are heterogeneously deformed at middle amphibolite facies and retain igneous texture in areas of low strain where the rocks contain an insignificant volume of leucosome veins. In the western half of the complex, however, rocks of the DTG suite are at transitional amphibolite- to granulite-facies, where they are composed of gneissic tonalitic rocks [**Pign**] with abundant inclusions of mafic amphibolite-granulite [**Pitq**]. In these areas, the gneissic tonalitic rocks are difficult to discern from Archean gneisses [**Agn**].

The DTG suite displays a broad calc-alkaline trend, leading to an interpretation that it represents a subduction-generated magmatic arc suite (Van Kranendonk and Wardle, in press c). Zircon dates from a variety of compositions in the suite fall in the range 1910-1885 Ma (Fig. 2). Sm-Nd results from two tonalite samples plot just below the depleted mantle curve at 1.91 Ga (εNd of 0.2 and -2), suggesting the minor involvement of some Archean crustal material (Archean crust or Proterozoic sediments with an Archean detrital component) in plutonic rocks with an otherwise relatively juvenile signature (Campbell, 1994). Contamination by an Archean source is supported by the presence of inherited Archean zircons in these rocks (Scott and Machado, 1995).

Killinek charnockitic suite

The northwestern part of the map area is dominated by homogeneous, medium- to coarse-grained, orthopyroxene-bearing granitoid rocks of the Killinek charnockitic suite [**Pigd**] (Figs. 2, 3). The suite shows a range in composition from tonalite-granodiorite- granite, but is dominated by granodiorite (Wardle et al., 1993). Granoblastic textures are common throughout the suite and orthopyroxene in these rocks is of metamorphic, rather than igneous origin. These rocks contain rare xenoliths of ultramafic, anorthositic and mafic rocks, large rafts of Tasiuyak-like metasedimentary gneisses [**PsTg, Pspg**], and locally, orthogneiss inclusions with complex structures suggestive of an Archean protolith. In the northern part of the map area, the Killinek charnockitic suite is separated from Archean Nain gneisses and associated Paleoproterozoic rocks of the DTG suite by thin belts of metasediment. In the west-central part of the area, however, the relationship between the charnockitic and DTG suites is less clear and occurs across a complex zone of heterogeneous metaplutonic gneisses with abundant mafic supracrustal enclaves [**Pitq, Pign**] (Van Kranendonk and Wardle, in press b). The transition in part coincides with the change from granulite facies in the west to retrogressed granulite-facies in the east, and there is no evidence that the two suites are separate in age or origin (cf. Scott and Machado, 1995).

Two samples of this suite were dated by the U-Pb method on zircon, and yielded ages of 1895 ± 3 Ma and 1886 ± 4 Ma (Fig. 2). Some samples of the suite show highly radiogenic Pb isotopic signatures, suggestive of either derivation from partial melting, or assimilation of, sedimentary protoliths. Other samples with less radiogenic Pb may be derived from melting of Archean crust (D. Bridgwater, pers. comm., 1993).

Younger metaplutonic suite

Plagioclase-porphyritic, mesocratic metatonalites (1869 +3/-2 Ma: colour index = 30-40) and K-feldspar megacrystic, biotite metagranites (minimum age of 1864 ± 2 Ma) within the northern part of the Komaktorvik shear zone represent a younger suite of Paleoproterozoic metaplutonic rocks than either the DTG or Killinek charnockitic suites (Fig. 2: age data from Scott and Machado, 1993, 1994). The mesocratic metatonalites cut Nain gneisses and DTG suite rocks and straddle the boundary with the Killinek charnockitic suite. On one island on the southeast end of Killinek Island (NTS 25A), sheets of mesocratic plagioclase-phyric tonalite are interlayered with Archean gneisses. Sm-Nd results from the mesocratic tonalite suggest a strong component of contamination by Archean crust (Campbell, 1994).

Megacrystic metagranites crosscut rocks of both the Killinek charnockitic suite and the Nain Province/DTG suite association, and locally retrogress the charnockitic rocks. Similar granites, though undated, occur as linear bodies south of Eclipse Channel (Fig. 2: Van Kranendonk and Wardle, 1994, in press a). A steeply east-dipping protomylonitic schistosity within granites located in the Komaktorvik shear zone contains a steeply east-plunging lineation and shows kinematic indicators of east-side-up displacement.

Amphibolite and syntectonic metadiorite dykes

Along the eastern margin of the Noodleook complex, within, or immediately adjacent to the Komaktorvik shear zone, are two younger sets of mafic dykes. One set comprises straight-margined, black-weathering amphibolites with equigranular hornblende-plagioclase ± garnet ± clinopyroxene assemblages. These dykes have a maximum age of 1804 +3/-2 Ma, the age of a granite dyke which is host to an amphibolite dyke (age from D. Scott, GEOTOP, pers. comm., 1994).

A second set of dykes, which cut the Avayalik dykes, is characterized by a distinctive olive green-weathering appearance and composed of an equigranular, to weakly diabasic matrix of hornblende-plagioclase within which is found occasional garnet porphyroblasts and black plagioclase megacrysts. These metadiorite dykes have highly irregular intrusion forms, are restricted to within the Komaktorvik shear zone and are considered to be syntectonic with Komaktorvik shear deformation (Van Kranendonk et al., 1994).

Tasiuyak gneiss complex

Tasiuyak gneiss and other paragneisses

Granulite-facies rocks of the Tasiuyak gneiss complex (after Van Kranendonk and Ermanovics, 1990) crop out in the southern and southwestern parts of the map area and are dominated by white and rusty weathering garnet ± sillimanite ± graphite paragneiss and associated diatexite collectively known as the Tasiuyak gneiss. Characterized by lilac-coloured garnets, the Tasiuyak gneiss is predominantly a homogeneous unit of mylonite within the Abloviak shear zone, where it contains a subvertical schistosity and subhorizontal mineral elongation lineations. At Abloviak Fiord, however, the Tasiuyak gneiss displays a subhorizontal compositional layering in a low strain domain, that varies between garnet quartzites and quartz arenites, through garnet-biotite-graphite quartzo-feldspathic gneiss (semipelite and diatexitic granite), to garnet-sillimanite-biotite-graphite metapelite. This layering contains a component of relict bedding in rocks that also contain a strong straightening/flattening component developed prior to Abloviak shear deformation. The composition of the layers in the low strain domains is used to suggest that the Tasiuyak gneiss was originally derived from a thick, monotonous sequence of turbiditic metasediments.

North of the Abloviak shear zone, the Tasiuyak gneiss grades into grey, migmatitic paragneiss with red garnet and no sillimanite [**Pspg**]. This second paragneiss unit is similar to paragneisses of the Noodleook complex at Ikkudliayuk Lake (described above) and locally contains a ≤15 m thick unit of calc-silicate and marble (Van Kranendonk, 1994b). Paleoproterozoic paragneisses are separated from panels of suspected Archean gneiss in the Tasiuyak gneiss complex by a 1-500 m thick contact zone in which are found discontinuous units of ultramafic rock (hornblendite), rusty, graphitic paragneisses [**Psrg**], blue-grey graphitic and/or red Fe-rich quartzites [**Psqz**], and rare layers of calc-silicate and/or impure marble [**Pscs**]. These contact zones are interpreted to represent thrust faults, as individual units within them are discontinuous and truncated against adjacent units.

Tonalite orthogneiss of suspected Archean age

Migmatitic tonalite/granodiorite orthogneisses with abundant thin leucosome veins and evidence of a complex structural and metamorphic history prior to Paleoproterozoic deformation events, occur within large fault-bounded panels within the Tasiuyak gneiss complex (Van Kranendonk, 1994d; Van Kranendonk et al., 1994). These polycyclic gneisses [**APgl**] contain layers and rafts of mafic gneiss, anorthositic gneiss, and paragneiss, and contain folded and disrupted remnants of discordant mafic dykes. The absence of such dykes in the adjacent paragneisses and the more complex structural history in the orthogneisses suggest an Archean age for the latter.

Migmatitic orthogneisses of suspected Archean age are locally to extensively homogenized to an equigranular, wispy-textured orthopyroxene-bearing tonalite/granodiorite with numerous mafic layers and lenses derived from remnant mafic dykes and mafic granulite gneisses [**Pigm**]. The homogeneous rocks have an identical appearance to those of the Killinek charnockitic suite further north, except that those in the Tasiuyak gneiss complex contain a greater proportion of mafic inclusions. Homogenization may have occurred either through assimilation of the older rocks by widespread intrusion of younger magmas, or through in situ partial fusion of the Archean gneisses.

Paleoproterozoic metaplutonic rocks

Charnockitic rocks [**Pigd**] in the Tasiuyak gneiss complex have a similar appearance to those of the Killinek charnockitic suite, but commonly contain xenoliths of mafic granulite and tonalitic orthogneiss, and were extensively mapped as diatexite [**Pigm**] (Van Kranendonk, 1994c). These rocks grade into the previously described areas of lithologically and structurally more complex orthogneiss of suspected Archean age. A Sm-Nd result from a sample of homogeneous, orthopyroxene tonalite from this area yielded an εNd (@ 1.86 Ga) of -6.7, consistent with a large amount of contamination by Archean crust, and is significantly more negative than for samples of the DTG suite (Campbell, 1994).

In the bend of the Abloviak shear zone, an orthopyroxene tonalite with one set of planar fabric elements (D_{n+2}: see below) and a preserved (though transposed) intrusive vein network into the Tasiuyak gneiss, has yielded an U-Pb zircon age of 1839 ± 3 Ma. This rock therefore represents a syntectonic intrusion during formation of the Abloviak shear zone, and it is not certain how extensive such young plutons are within the unit mapped as **Pigd**.

In the northern part of the complex, largely confined to within the second paragneiss assemblage, are dark grey to black weathering, mesocratic quartz diorites [**Piqd**] with 20-30% of hornblende + orthopyroxene and a weak plagioclase-porphyritic texture (see Van Kranendonk et al., 1993a). In contrast with the schlieric charnockitic rocks (described above) which appear to be derived through melting of Archean crust, the quartz diorites are homogeneous, weakly-strained bodies (outside of the Abloviak shear zone) which commonly show intrusive relationships with surrounding paragneisses and contain cognate xenoliths of finer-grained diorite. A sample of quartz diorite was dated as 1896 ± 2 Ma (Fig. 2).

STRUCTURAL AND METAMORPHIC GEOLOGY

Three sets of Archean structures in the Nain Province gneiss complex, and four regionally-developed sets of Paleoproterozoic structures across the rest of the map area have been identified (Van Kranendonk et al., 1993a). The Archean history of the Nain Province gneiss complex is described above and by Wardle et al. (1994) and Van Kranendonk and Wardle (in press a) and will not be dealt with herein. For the purposes of this paper, the Archean structures are collectively referred to as D_n. The progressive sets of Paleoproterozoic structures are referred to as D_{n+1}, etc., and each was accompanied by metamorphism (M_{n+1}, etc.). A more detailed description of Paleoproterozoic deformational events is presented in Van Kranendonk and Wardle (in press c).

First phase structures

D_{n+1} structures include a migmatitic gneissosity developed in the granulite-facies rocks of the Tasiuyak gneiss complex and Killinek charnockitic suite, and a foliation or gneissic layering in some rocks of the DTG suite. High strain zones with local development of sheath folds occur along the contacts between layered mafic gneisses and reworked Archean rocks of the Noodleook complex and are interpreted to reflect a phase of D_{n+1} thrusting that was responsible for the tectonic intercalation of rock units in this area (Van Kranendonk et al., 1993a). A sense of vergence off the thrusting is unknown due to the intensity of subsequent deformational events in this area. These structures die out to the east across the Komaktorvik shear zone and were not recognized within the "Younger magmatic suite" of the Noodleook complex. In the North River domain, SW-verging thrust faults were recognized by Goulet and Ciesielski (1990: D1 structures) between Lake Harbour Group metasedimentary rocks and Archean basement of the Rae Province gneiss complex.

D_{n+1} deformation in the western part of Burwell domain occurred under granulite- facies conditions, as indicated by the observation that a set of migmatitic structures and associated granulite-facies mineral assemblages have been deformed by D_{n+2} structures (also at granulite facies). In some areas, mafic enclaves in granitoid gneiss have orthopyroxene-bearing rims on amphibole cores, suggesting arrested prograde granulite-facies metamorphism. In the eastern part of Burwell domain, some amphibolite-facies rocks have never been to granulite facies, suggesting that M_{n+1} metamorphism decreased from west to east. The state of M_{n+1} metamorphism in the North River domain is not known, due to subsequent granulite-facies metamorphism during D_{n+2}.

D_{n+1} structures are related in that they predate the younger, better-defined sets of structures, but they have not been directly dated in most parts of the map area so that the possibility exists that they are of different age in different parts of the map. Available U-Pb age constraints suggest that the D_{n+1} deformation occurred at between 1870 ± 3 Ma - the age of monazite in a sample of Tasiuyak gneiss - and ca. 1860 Ma - the age of metamorphic zircon overgrowths in metasediment from the central part of the map area (see Fig. 4).

Second phase structures

D_{n+1} planar fabric elements are deformed within NW-trending D_{n+2} folds and sinistral shear zones across the western half of the map area, including the 8-10 km wide Abloviak shear zone (ASZ), which straddles the boundary between the Nain and Rae provinces along the entire strike length of the orogen and is developed primarily within the Tasiuyak gneiss (Figs. 1-3). The ASZ is characterized by subvertical mylonitic schistosities, subhorizontal mineral elongation lineations defined by quartz, sillimanite and orthopyroxene, and isoclinal folds on subhorizontal axes parallel to the lineations. Kinematic indicators within the zone are everywhere sinistral (Van Kranendonk et al., 1993a). West of the bend in the ASZ, the northern margin of the zone splays into several arms of high strain that wrap around low-strain augen in which D_{n+2} structures are restricted to open, upright folds and a weak axial-planar quartz foliation. The ASZ passes north into the Burwell domain where upright, NW-SE striking D_{n+2} folds on moderately NW- plunging axes contain a penetrative, subvertical axial planar foliation and granulite- facies mineral elongation lineations. Two zones of high D_{n+2} strain along the eastern margin of the Killinek charnockitic suite (Fig. 3) are characterized by moderately- plunging L_{n+2} elongation lineations and are responsible for SE-directed uplift of the suite. These zones are rotated into parallelism with the western margin of the D_{n+3} Komaktorvik shear zone, which is characterized by south-plunging amphibolite-facies mineral elongation lineations.

Eastward within the southern part of the Burwell domain (in the Noodleook complex), D_{n+2} structures die out rapidly across a zone of interference between NW-trending D_{n+2} and SW-trending D_{n+3} folds, and were not recognized very far east of the granulite- to amphibolite-facies transition (Fig. 3). South of the ASZ, the North River domain is characterized by upright, tight doubly-plunging folds which form large- scale dome and basin structures (cf. Taylor, 1977a).

M_{n+2} granulite-facies metamorphism accompanied D_{n+2} deformation across the Tasiuyak gneiss complex and northwestern part of the Noodleook complex underlain by the Killinek charnockitic suite. P-T estimates of ≤10 kbars, 800°C have been obtained for this area by Mengel and Rivers (1994). As with the M_{n+1} metamorphism, M_{n+2} metamorphism dies out rapidly to the east in the southern part of Burwell domain, and was not recognized in the eastern half of the Noodleook complex. The timing of D_{n+2} deformation in this area is estimated to have occurred at 1843 ± 3 Ma, the age of a metamorphic zircon overgrowth in a sample of the Killinek charnockitic suite (Fig. 4). A post-D_{n+2}, pre-D_{n+3} pegmatite in the Tasiuyak gneiss, dated as 1824 ± 2 Ma, provides a minimum estimate for the age of the D_{n+2} deformation (Scott and Machado, 1994).

In the Four Peaks domain, the prograde southeast to northwest development of static garnet-clinopyroxene assemblages is interpreted to have occurred during D_{n+2} deformation, as suggested by the 1834 +7/-3 Ma age of zircon from a garnet-clinopyroxene bearing Avayalik dyke in this region, as previously discussed. P-T estimates from this area range from 7.3 kbars, 650°C in the north, to 10-13 kbars, 700-800°C in the south (Mengel and Rivers, 1994; unpublished data, Geological Survey of Canada). In the southeastern part of the Four Peaks domain, pressures were found to increase from core to rim of mineral grains, suggesting that the M_{n+2} assemblages record progressive burial during D_{n+2} deformation (unpublished data, Geological Survey of Canada).

Third phase structures

D_{n+3} structures at amphibolite facies include the Komaktorvik shear zone, the Katherine River shear zone, and large-scale, N-S trending folds of the Abloviak shear zone and rock units within the Burwell domain. The Komaktorvik shear zone (KSZ) is a broad (up to 12 km wide), NNW-SSE striking belt of D_{n+3} amphibolite-facies ductile shear concentrated across the Hutton anorthositic suite along the boundary between the Nain Province gneiss complex and the Noodleook complex (Fig. 3: Van Kranendonk et al., 1993a, b; Van Kranendonk and Wardle, 1994b, in press c). The KSZ has splayed, saw-toothed margins with adjacent Burwell and Four Peaks domains and is characterized by steeply-dipping protomylonitic to mylonitic schistosities, southerly-plunging mineral elongation lineations, and meso- to macro-scale, tight to open folds. Garnet-hornblende bearing amphibolite dykes within the zone are tightly folded or transposed into parallelism with the gneissosity. High strain is concentrated within unattached, 1-5 km wide, straight segments of porphyroclastic protomylonite, including: a 30 km long segment from the southeastern corner of the map area to Ryans Bay; another from the bottom of Eclipse Harbour to 60°N; and a third, to the west of the Hutton anorthositic suite, from 60°N to the top of Killinek Island. S_{n+3} foliations change across the KSZ from steeply east-dipping in the east, through the vertical, to steep westerly and northwesterly dips in the west. L_{n+3} linear fabric elements also vary in orientation across the map area, from steeply east-plunging in the east, through moderately south-plunging across the central part of the map area, to shallow southwest-plunging in the west (Van Kranendonk and Wardle, 1994a, in press a). Kinematic indicators of east-side-up, sinistral oblique displacement characterize the eastern part of the zone (Van Kranendonk and Scott, 1992), and rare kinematic indicators of oblique dextral, west-side-up displacement were observed in SW-striking splays of the KSZ into the Burwell domain (Van Kranendonk and Wardle, in press b).

The Katherine River shear zone (KRSZ) is an amphibolite-facies zone of dextral shear (D_{n+3}) located across the boundary between the Noodleook and Tasiuyak gneiss complexes along the northern margin of the ASZ (Fig. 3: Van Kranendonk et al., 1993a). Deformation states within the zone vary from protomylonite and mylonite in the northwest, to mylonite and ultramylonite in the southeast. Mylonitic foliations are steeply dipping, whereas mineral elongation lineations vary from moderately W- to SW-plunging in the west, through subhorizontal WNW-ESE plunging around the central-eastern portion, to moderately NW-plunging along the NW-SE striking segment of the shear zone (Van Kranendonk, 1994a; Van Kranendonk et al., 1993a). At the northwestern corner of the zone, mylonite passes into brittle, NW-SE striking faults that link up with a major fault zone which separates the Noodleook and Tasiuyak gneiss complexes.

M_{n+3} metamorphism involved the widespread retrogression of granulite-facies mineral assemblages to garnet-hornblende bearing assemblages. This occurred under P-T conditions of surprisingly high metamorphic grade, however, as determined from a number of samples within and immediately to the east of the KSZ which record conditions of up to 12 kbars, 800°C in garnet-hornblende mylonites (Mengel and Rivers, 1994). In some samples, pressure is seen to rise from core to rim of mineral grains (unpublished data, Geological Survey of Canada), which is consistent with a model of reverse sense of uplift of the Four Peaks domain over Burwell domain and progressive burial of the steeply east-dipping shear zone margin. Amphibolite-facies recrystallization occurred to lower P-T conditions during cooling and uplift (Mengel and Rivers, 1994).

Dating of syntectonic pegmatites and of metamorphic zircons from rocks within the D_{n+3} KSZ and KRSZ has shown that the main phase of amphibolite-facies deformation occurred at between ca. 1798-1779 Ma, while titanite dates and a zircon age from a younger syntectonic pegmatite indicate prolonged cooling and localized deformation between 1776-1673 Ma (Fig. 4).

Fourth phase structures

Narrow zones of ultramylonite and fault breccia, commonly with pseudotachylite veins, constitute the youngest set of Paleoproterozoic structures in the map area (D_{n+4}). In the KSZ, NNW-SSE striking faults, oriented subparallel to D_{n+3} shear fabrics with east-side-up kinematics, show west-side-up displacement. Further west, NW-SE striking faults contain a component of sinistral strike-slip displacement, and may be related to late-stage tightening of the bend in the Abloviak shear zone. This deformation occurred under amphibolite- to greenschist-facies conditions, and continued to shallow crustal levels, where pseudotachylite formed.

ECONOMIC GEOLOGY

Graphite and base metal (Ni, Zn, ± Cu) showings in sulphidic and graphitic horizons within the Tasiuyak gneiss around Abloviak Fiord have been described by Bodycomb (1993) and interpreted by her to represent Ni-rich black shale horizons within the Tasiuyak gneiss.

Gossan zones of rusty-weathering, sulphide-rich material within, or adjacent to metasedimentary rocks were found in charnockite on the south shore of Killinek Island (see sheet 3). Assay results from one sample revealed 450 ppm Ni and 330 ppm Cu: values of Pt, Pd and Au were <15 ppb.

An assay sample of rusty Archean paragneiss from a thin unit (<200 m) east of the meta-anorthositic body and south of Saglarsuk Bay showed 600 ppm Ni and 250 ppm Zn: values of Pt, Pd and Au were <15 ppb. Such small, rusty zones are commonly found in association with Archean metasediments, but are never more extensive than a few metres. Rusty-weathering sulphide gossans within the Hutton anorthositic suite (see maps) are described in Wardle et al. (1992, 1993): Ni values range up to 474 ppm, Cr values up to 1590 ppm (samples of layered gabbro and ultramafite). No mineralization was seen in the layered amphibolite gneisses [**Psmg**], but units of ultramafite [**Aum, Pumf**] yielded Ni contents up to 1046 ppm.

TECTONIC EVOLUTION

The Archean Nain Province in the map area has undergone a long and complex tectonic history that has not been studied in detail. Three major deformational events have been recognized, however, interspersed with magmatism and accompanied by high-grade metamorphism. Early supracrustal rocks were intruded by tonalite orthogneisses and strongly deformed under granulite-facies conditions. Subsequently, a set of mafic dykes was emplaced and a second generation of tonalite sheets. These rocks were all deformed in a second granulite-facies event at ca. 2770 Ma, that produced upright, open folds and subvertical straight gneiss belts trending NNW-SSE (D_n). Along the eastern margin of the Noodleook complex, Nain gneisses were intruded by the Duck Islands granitoid suite, and deformed under amphibolite-facies conditions at ca. 2660 Ma.

After cratonization of the Nain Province, the Hutton meta-anorthositic suite was emplaced into the western margin of the Nain Province, probably during a period of earliest Proterozoic rifting (see Van Kranendonk and Wardle, in press c). Diabase dykes of the Avayalik swarm were then emplaced, probably also during rifting. The change from extensional to contractional geology occurred at, or before ca. 1910, the age of the oldest dated Paleoproterozoic metaplutonic rock in the map area.

The northern segment of the Torngat Orogen is dominated by the emplacement of a magmatic arc (DTG and Killinek charnockitic suites) that resulted from easterly subduction beneath the Nain Province at between 1910-1885 Ma. This large volume of plutons formed a continental promontory on Nain Province (Van Kranendonk and Wardle, 1994c). Slivers of mafic supracrustal rocks within the plutons are interpreted on the basis of their field characteristics, tectonic setting and geochemistry to represent the remnants of a marginal (back arc?) basin which developed along the thinned western margin of the Nain Province during the early stages of subduction. Arc plutons and associated supracrustal rocks do not occur on Nain Province margin in the southern segment of the Torngat Orogen. Instead, the suite of 1880 Ma plutons in the Rae Province margin and Tasiuyak gneiss is interpreted to reflect a period of westerly subduction at this time (Van Kranendonk, 1992; Bertrand et al., 1993).

The structural evolution of the northern segment of the Torngat Orogen occurred in three distinct episodes (Van Kranendonk et al., 1993a; Van Kranendonk and Wardle, in press c). The D_{n+1} phase of deformation, at ca. 1870-1860 Ma, was responsible for the development of gneissic fabrics in Paleoproterozoic units across the map area, thrust intercalation of units, and high-grade metamorphism. These structures are interpreted to have formed in a doubly-vergent thrust wedge during Nain-Rae continental collision. Accretion of the magmatic arc onto the Nain Province margin was accompanied by the emplacement of the "Younger magmatic suite" and by burial of the western half of the arc to depths of up to 35 km. Indentation by the continental promontory on Nain Province caused a deflection in Rae Province margin.

D_{n+2} sinistral shear deformation, still at granulite facies, occurred at between ca. 1843-1824 Ma. This deformation was concentrated within the Abloviak shear zone, but formed folds and smaller-scale shear zones throughout the western half of the Burwell domain. Shear deformation splayed to the northwest off the bend in the Rae Province margin. Northward translation of the Nain Province at this time is interpreted to have resulted in the oblique burial of the Nain lithosphere to depths of ≤40 km beneath the still hot and buoyant Paleoproterozoic arc and the formation of high- pressure garnet-clinopyroxene assemblages in the southern part of the Four Peaks domain.

The broad KSZ, with its irregular geometry and splayed margins, does not mark the site of a fundamental plate boundary, as rocks of similar age and provenance occur on either side of it. Instead, the KSZ is interpreted to represent the site of concentrated deformation on the limbs of a crustal-scale fold, centred on the Hutton meta-anorthositic complex, that formed during crustal-scale disharmonic folding of the Abloviak shear zone across the D_{n+1} flexure in Rae Province margin (Van Kranendonk et al., 1993a). The Katherine River shear zone is interpreted to represent the principal slip plane of the disharmonic fold. Formation of the Komaktorvik shear zone probably involved a component of dislocation along its eastern margin in addition to the strain resulting from folding. During folding and shear zone development, east-directed reverse shear along the western margin of the KSZ and west-directed reverse shear along the eastern margin of the KSZ resulted in simultaneous uplift of both the granulite-facies Four Peaks domain and the Killinek charnockitic suite, respectively. Uplift of these granulite-facies domains was not fast enough to cause recrystallization of the lower-grade rocks in the core of Burwell domain to higher P-T conditions (Van Kranendonk and Wardle, in press, b, c; Van Kranendonk et al., 1993b). D_{n+4} deformation represents in part a continuation of the D_{n+3} deformation, and in part the result of rebound of the internal parts of the orogen after burial during D_{n+3}.

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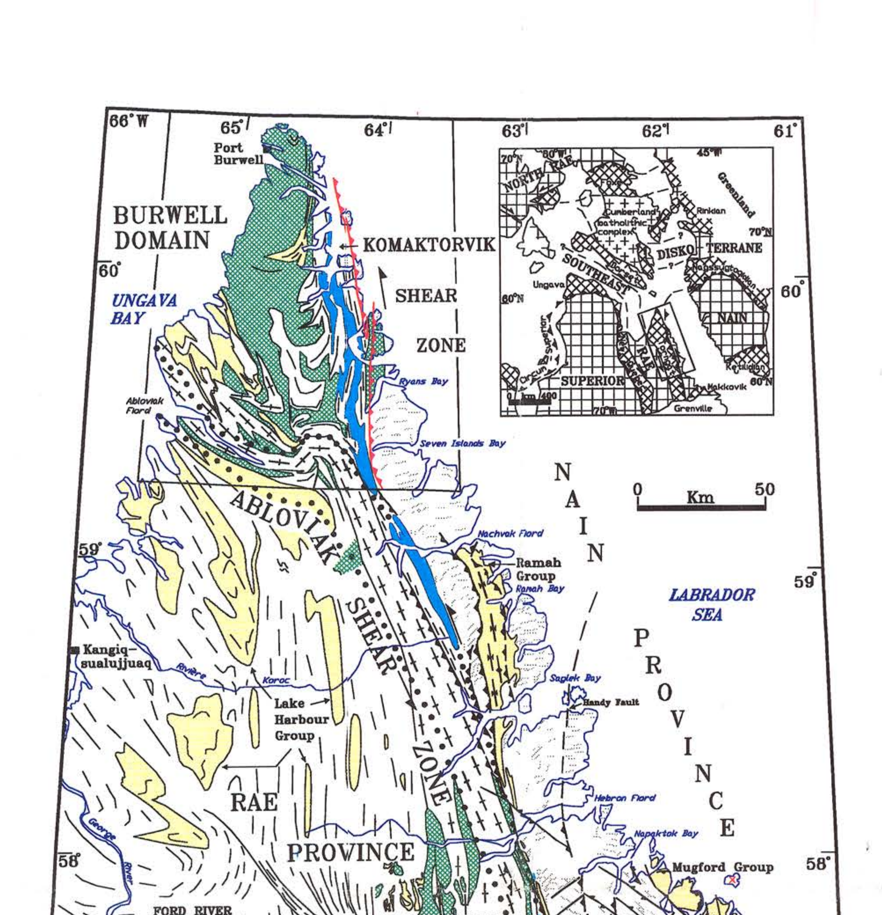


Fig. 1: Geology of the Paleoproterozoic Torngat Orogen in northeastern Canada. Inset figure shows pre-Mesozoic drift reconstruction of Archean cratons and Paleoproterozoic orogens in northeast Laurentia (after Van Kranendonk et al., 1993c and Hoffman, 1989). Location of present map area and Figure 2 indicated by square outline

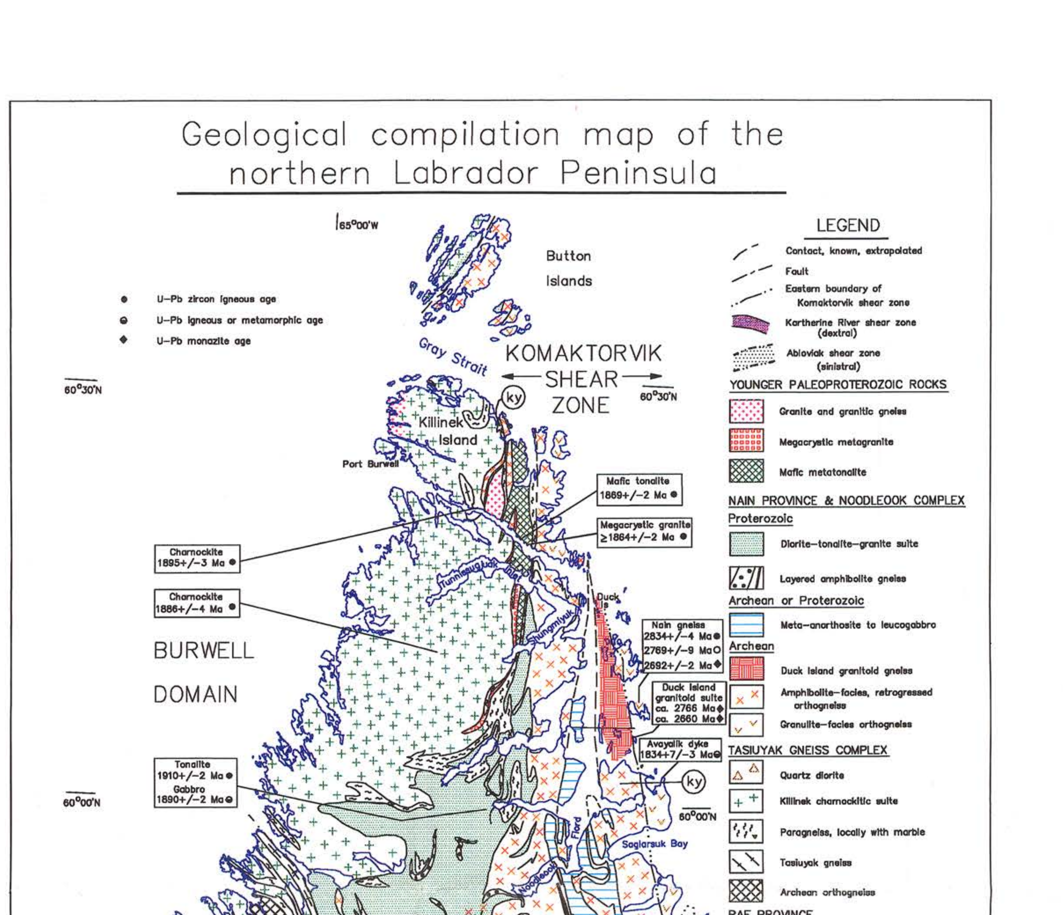


Fig. 2: Geological compilation map of the northern segment of the Torngat Orogen. Magmatic U-Pb zircon and monazite age data from Scott and Machado (1993, 1994). ky = kyanite localities

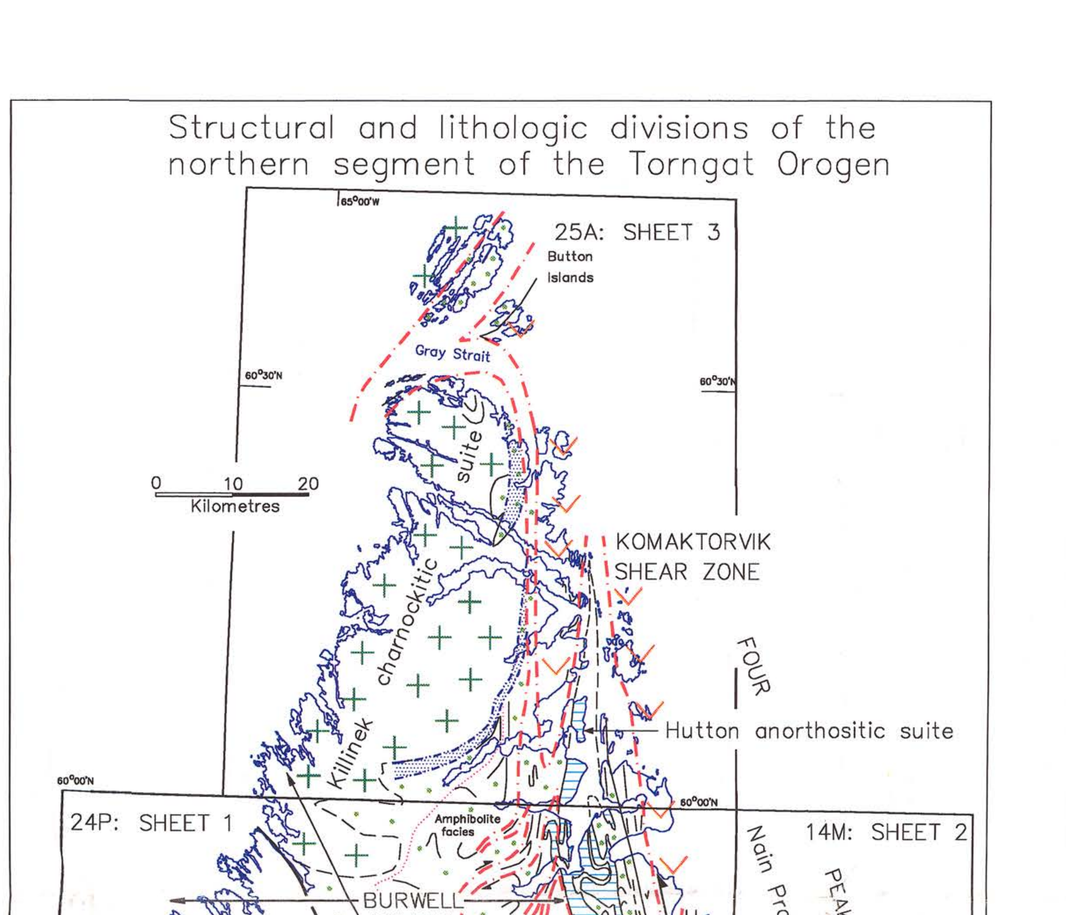


Fig. 3: Lithotectonic elements (complexes and suites) and structural divisions (DOMAINS, ZONES) of the northern segment of the Torngat Orogen (modified after Van Kranendonk et al., 1993b). Four Peaks domain and Nain Province gneiss complex are coincident. Metamorphic zones are represented by dotted lines. Komaktorvik shear zone outlined by heavy dash-dot line, and Dn+2 shear zones by light stipple. Areas of map sheets 1-3 are indicated by heavy black outlines

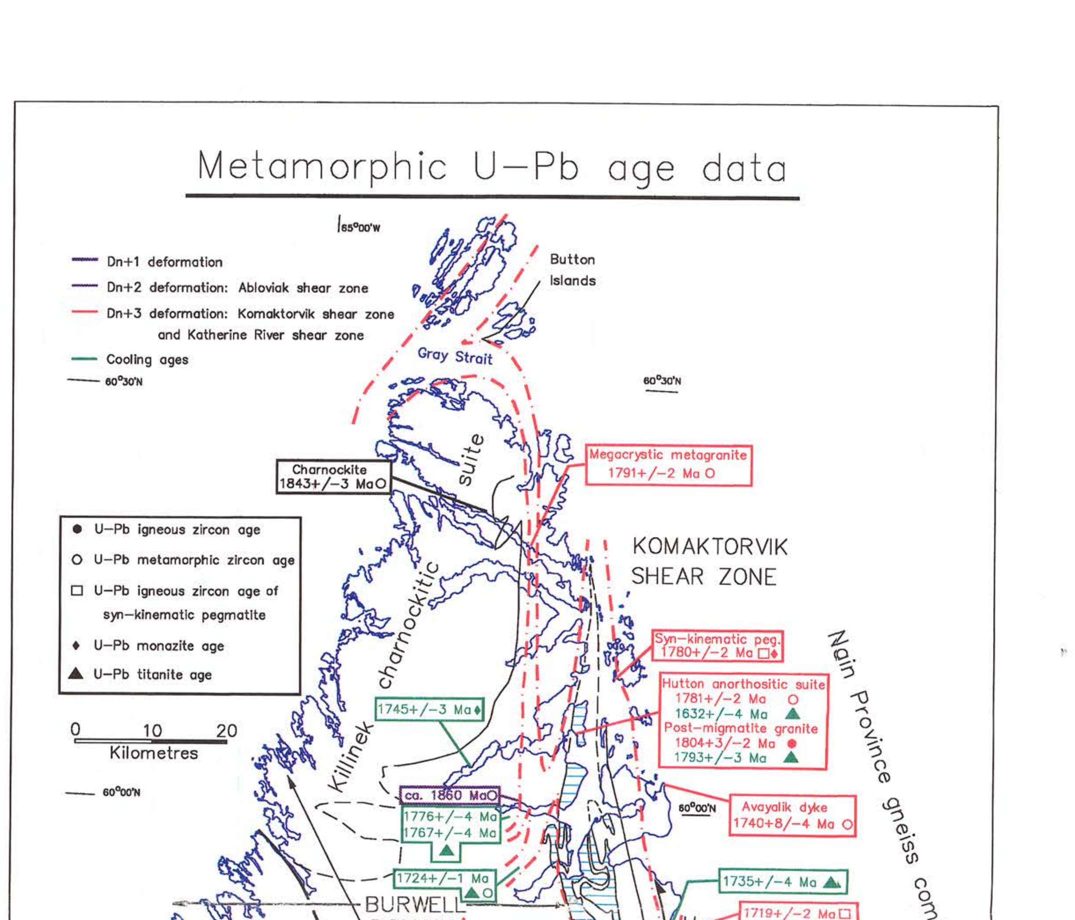
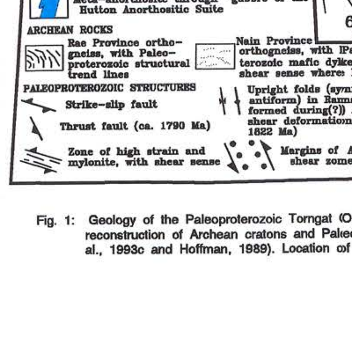
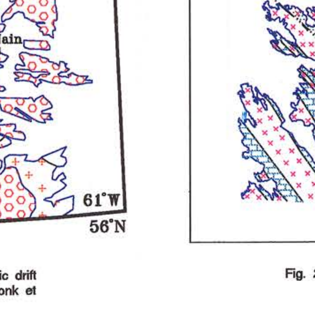


Fig. 4: Metamorphic U-Pb age data on zircon, monazite and titanite in the northern segment of the Torngat Orogen (data from Scott and Machado, 1993, 1994)



LOCATION MAP - LOCALISATION DE LA CARTE



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SHEET 4

GEOLOGY

LABRADOR PENINSULA AND OFFSHORE ISLANDS NORTH OF 59°15'N

NEWFOUNDLAND (LABRADOR) - QUÉBEC - NORTHWEST TERRITORIES

COOPERATION

COOPERATION AGREEMENT MINERAL DEVELOPMENT — ENTENTE DE COOPÉRATION SUR L'EXPLOITATION MINÉRALE

Contribution to Canada-Newfoundland Cooperation Agreement on Mineral Development (1990-1994), a subsidiary agreement under the Economic and Regional Development Agreement.

Contribution à l'Entente de coopération Canada-Terre-Neuve sur l'exploitation minérale (1990-1994), entente auxiliaire négociée en vertu de l'Entente Canada/Terre-Neuve de développement économique et régional.

Canada — Newfoundland Terre-Neuve

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