NAIN-CHURCHILL PROVINCE CROSS-SECTION, NACHVAK FIORD, NORTHERN LABRADOR

by

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ABSTRACT

The Nain-Churchill boundary is a broad zone of progressive structural reworking in which Archean crust may be traced for at least 25 km into the Churchill Province. The Nachvak Fiord section of the boundary zone is divided into three structural zones: Nain Province, Churchill Border Zone and Churchill Inner Zone.

The Nain Province consists of Archean crust for which the following history is recognized:

1. *Formation of early mafic gneisses, locally associated with supracrustal gneisses;*
2. *Widespread intrusion of granitoid plutons incorporating early mafic gneisses as inclusions;*
3. *Regional deformation, migmatization and granulite grade metamorphism circa 2.8 Ga; formation of Nachvak gneiss;*
4. *Intrusion of Kammarsuit granite circa 2.7 Ga;*
5. *Zonal mylonitization and retrogression circa 2.6 - 2.5 Ga;*
6. *Intrusion of regional post-tectonic mafic dyke swarm circa 2.4 Ga.*

The predominant rock type in the Nain Province is Nachvak gneiss which has been subjected to static amphibolite-greenschist facies retrogression during late Archean and Hudsonian metamorphic events.

The Churchill Border Zone is underlain predominantly by the granitoid Nachvak gneiss but also contains lower Proterozoic sediments of the Ramah Group deformed in the Hudsonian Orogeny. Hudsonian deformation in the gneiss is restricted to zonal reworking in shear zones which change in character from brittle fracture zones in the east to ductile shear zones in the west. The border zone also contains a granulite facies-amphibolite/greenschist facies retrograde isograd, previously thought to be the Nain-Churchill boundary, which marks the western limit of combined late Archean-Hudsonian retrograde alteration. Structural style is that of vertical tectonics and easterly directed overthrusting.

The Churchill Inner Zone contains a westerly extension of the Nachvak gneiss which encloses a linear belt of Archean anorthosite. Nachvak gneiss is bounded to the west by a major belt of quartz + feldspar + garnet mylonitic gneiss (Tasiuyak gneiss) of enigmatic origin. Hudsonian straightening and mylonitic fabrics are pervasive in the inner zone and the late 2.4 Ga dykes have been transposed into the regional fabric. Both western Nachvak and Tasiuyak gneiss have been intensely mylonitized in what may be a major transcurrent shear zone.

INTRODUCTION

Northern Labrador (Figure 1) contains the boundary between Archean gneisses of the Nain Structural Province, stabilized around 2.5 Ga, and lower Proterozoic rocks of the Churchill Structural Province, stabilized following the Hudsonian Orogeny *circa* 1.7 - 1.8 Ga.

As originally defined by Stockwell (1963), on the basis of K-Ar dates, the boundary position lay well west of the position shown on Figure 1. Following regional mapping by Taylor *et al.* (1969, 1970), the boundary was redefined (Taylor, 1971) on structural grounds to the position indicated in Figure 1. Despite occasional criticism (*e.g.* Douglas, 1972), this position of the boundary has been the most commonly accepted since that time (*e.g.* Greene, 1970). Morgan (1975), however, has pointed out that the boundary should lie along the eastern edge of the deformed Ramah Group, a view which has not been recognized in regional maps. On recently published maps for the region (Taylor, 1979), the boundary is shown as a simple line corresponding to the contact between Proterozoic granulite gneisses and Archean amphibolite facies gneisses. Implicit in this work and also in the more local mapping of Morgan (1975) is recognition of the fact that the boundary involves, to at least a limited extent, high grade metamorphic overprinting of Archean crust. Morgan (1975), for example, clearly recognized that Archean gneisses extend into the Churchill Province for several kilometres. Taylor *et al.* (1969, 1970) and Taylor (1979) described a belt of intense mylonitization localized along the eastern margin of the Churchill Province. Bridgwater *et al.* (1973) suggested that it may be a zone of major transcurrent shear, possibly corresponding to a plate boundary.

This paper reports the preliminary results of a study of the boundary zone along the coastal cross-section of Nachvak Fiord. The principal objectives of the study are: (i) to determine the extent to which the boundary zone consists of reworked Archean crust as opposed to new Proterozoic material which may have been added, either by deposition, intrusion or accretion; and (ii) to produce a model for the structural development of the boundary zone.

The work was limited to the shoreline and accessible inland areas around Nachvak Fiord. Work in 1983 will extend the cross-section west to the Quebec-Labrador border.

The study complements an additional project of more regional nature on the boundary zone in the Saglek-Hebron Fiord area (see Figure 1 and Ryan *et al.*, this volume).

REGIONAL SETTING

The principal elements of the Nain-Churchill boundary zone are shown in Figure 1. The northern Nain Province has been investigated in detail only in the region of Saglek Fiord where it has been demonstrated to have a complex crustal history extending from >3.6 Ga to 2.5 Ga and, to have experienced successive reworking at *circa* 3.6, 2.8 and 2.6 Ga (Bridgwater and Collerson, 1976; Collerson *et al.*, 1976; Bridgwater *et al.*, 1978). Elsewhere the northern Nain Province has been defined only as an amphibolite facies gneiss complex which gives undisturbed 'Kenoran' ages (largely K-Ar) of circa 2.5 Ga.

In very early Proterozoic times, *circa* 2.4 Ga, the Nain Province was intruded by a wide-spread post-tectonic mafic dyke swarm (Fahrig, 1970; Taylor, 1974), here referred to as the late dykes.

Nain Province gneisses are overlain unconformably by the lower Proterozoic Ramah Group, a sedimentary succession consisting of a lower, shallow water siliciclastic sequence overlain by a

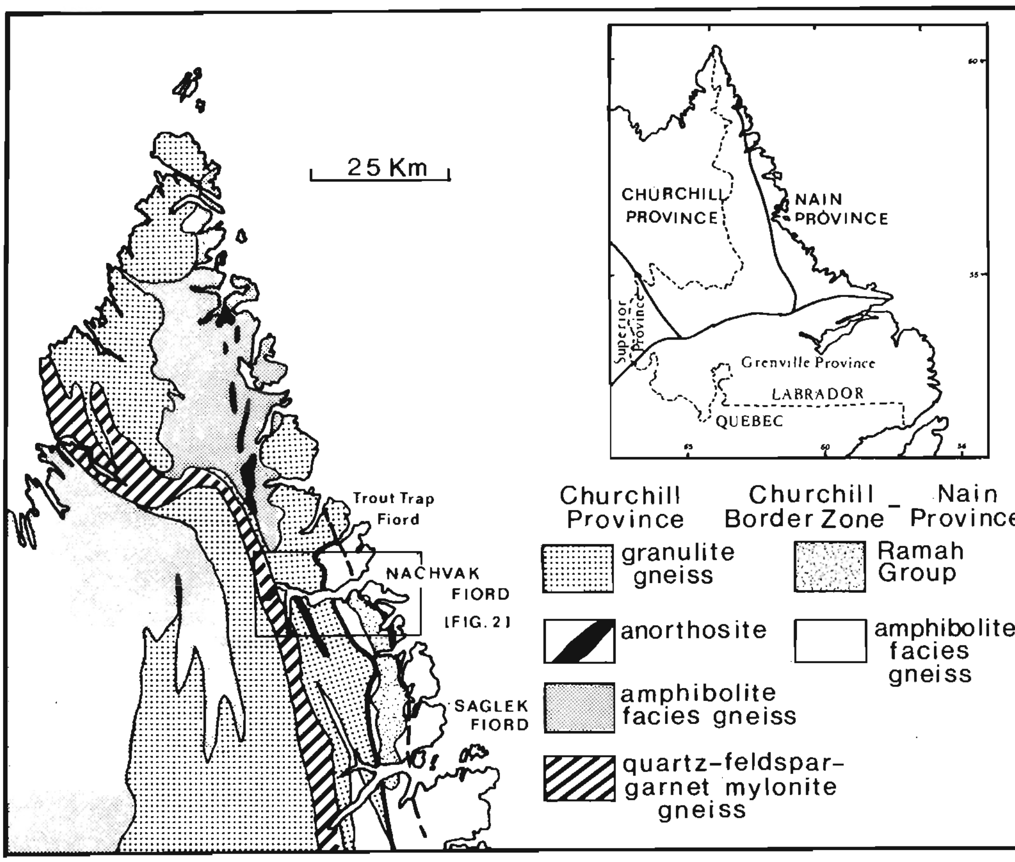

Figure 1 Generalized geology of northernmost Labrador. Simplified after Greene (1970). Position of Nain-Churchill boundary indicated by solid line (Taylor, 1979; Greene, 1970); dashed line, this paper.

deep water argillite-carbonate sequence (Morgan, 1975, 1979; Knight and Morgan, 1981). Morgan (1975) recognized that the Group was extensively affected by cleavage, folding and thrusting during the Hudsonian Orogeny and that the underlying Archean gneisses were also locally reworked and retrogressed in this event; thus, he recognized that the Ramah Group lay within the Churchill Province and that the Nain-Churchill boundary lay along the eastern margin of the group.

The geology of the Churchill Province is known only from the regional mapping of Taylor *et al.* (1969, 1970) and Taylor (1979). The eastern margin of the province in the Nachvak Fiord region is underlain by granulite facies gneisses believed by Taylor (*op. cit.*) to be of Proterozoic age which pass north into amphibolite facies gneisses (Figure 1). To the west these pass into a distinctive quartz+feldspar+garnet mylonite gneiss and then into a further belt of Proterozoic granulite gneisses. Both granulite and amphibolite facies gneisses contain linear belts of anorthosite, also proposed to be of probable Proterozoic age. Anorthosite is not found west of the quartz + feldspar + garnet mylonite gneiss.

As a result of the past season's work, it is evident that as in the case of other structural province boundaries, for example the Grenville Front (Gower *et al.*, 1980), the Nain-Churchill boundary is not a single, simple tectonic feature but rather a broad zone of progressive crustal reworking. In order to describe the effects of this reworking, the Nachvak Fiord region (Figure 2) is divided into three structural zones: the Nain Province, characterized by Archean gneisses with only minimal Hudsonian effects; the Churchill Border Zone in which the Ramah Group has been homogeneously deformed and the Archean basement zonally sheared; and the Churchill Inner Zone in which Archean gneisses have been pervasively deformed and mylonitized during the Hudsonian. Implicit in this division is the recognition that the Churchill Province boundary lies east of the Ramah Group as proposed by Morgan (1975). It is impossible, however, to define a precise eastern limit of the effects of Hudsonian deformation and the boundary between the Churchill Border Zone and Nain Province is necessarily a broad gradational zone.

A key element in recognition of the effects of Hudsonian orogenesis in this region is the behaviour of the late dyke swarm. The structural state of the dykes varies from undeformed, rectiplanar in the Nain Province, to zonally sheared in the Churchill Border Zone, to completely transposed in the Churchill Inner Zone.

The stratigraphy and disposition of rock units within the region are summarized schematically in Figure 3.

NAIN PROVINCE

This is underlain largely by granitoid gneiss of plutonic derivation, referred to here as the Nachvak gneiss, which includes numerous relicts of early mafic and supracrustal gneiss, and which has been subsequently intruded by a late pluton known as the Kammarsuit granite.

Early Mafic Gneisses

These occur as linear inclusions varying from metres to tens of kilometres in length. They vary considerably in composition and texture but generally fall into four types:

(i) Fine grained, massive to weakly banded mafic gneiss with granoblastic texture. These are often intimately associated with supracrustal gneisses and may likewise be of supracrustal or high level intrusive origin.

(ii) Coarse to medium grained mafic gneiss with a compositional variation from ultramafic to leucogabbro, which may locally be recognized as relict igneous layering. This rock type forms the map scale units shown in Figure 2.

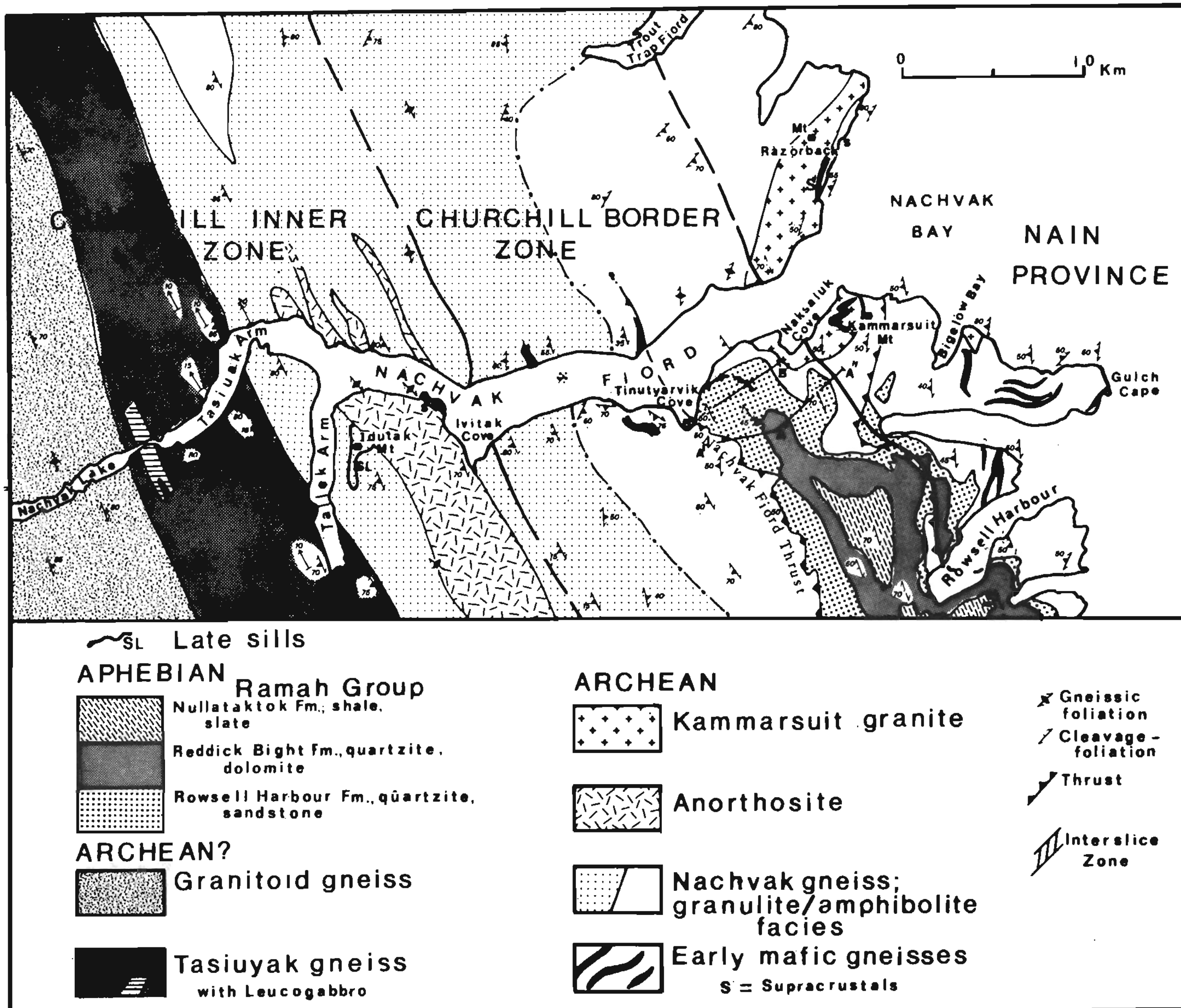

Figure 2 Geology of Nachvak Fiord area. Modified in part from Taylor (1979) and Morgan (1979).

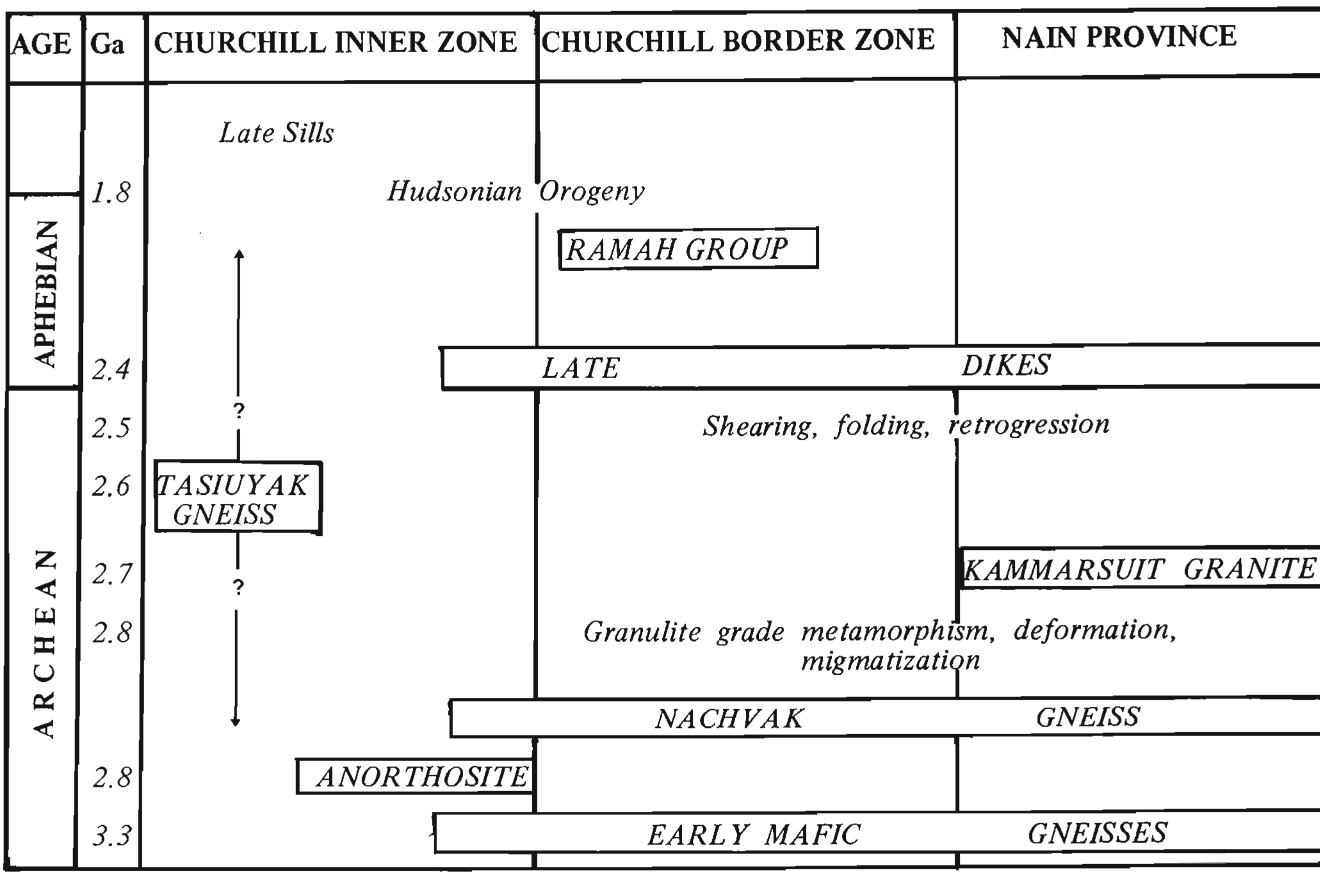

Figure 3 Summary of tectonic development, Nachvak Fiord area.

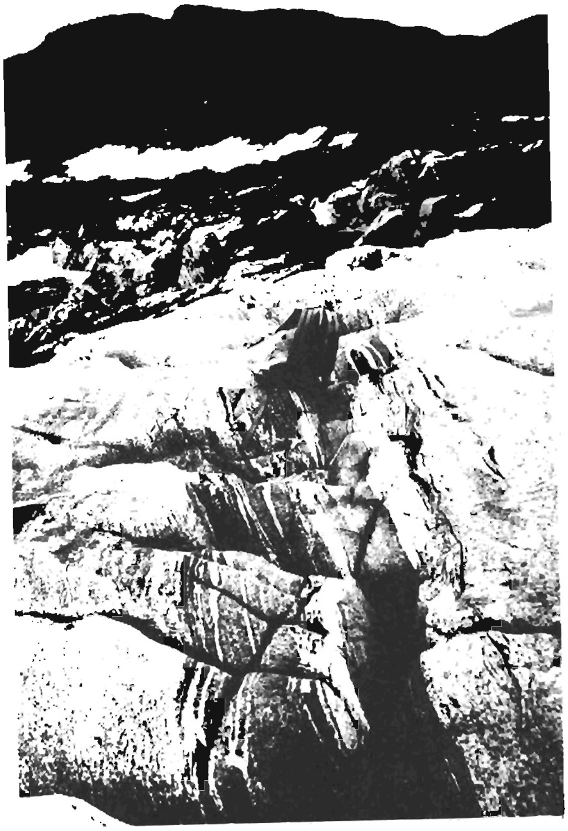

Plate 1

Plate 2

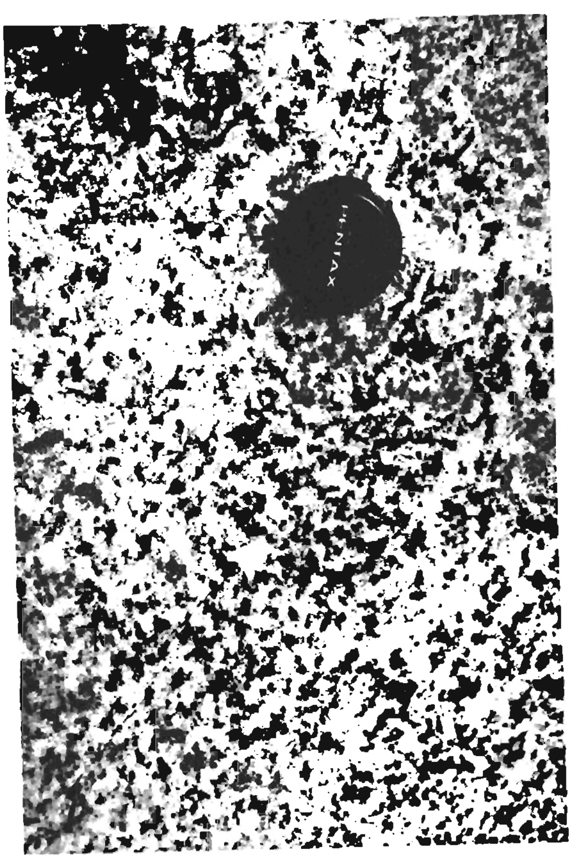

Plate 3

Plate 1 - Early mafic gneiss: screen of migmatitic (type iii) mafic granulite (retrogressed) in non-migmatitic Nachvak gneiss, Gulch Cape. Scale - packsack, 40 cm high.

Plate 2 - Early mafic gneiss: inclusion of massive, black amphibolite (type iv), possibly a pre-tectonic mafic dyke, in migmatitic Nachvak gneiss, north shore Nachvak Fiord, 3 km west of Tinutyarvik Cove. Scale - notebook, 19 cm long.

Plate 3 - Nachvak gneiss: relict igneous texture seen normal to lineation in non-migmatitic granodiorite gneiss, Gulch Cape. Scale - lens cap, 5 cm diameter.

(iii) Highly migmatitic, grey, mafic to intermediate gneiss of dioritic to gabbroic composition. These are found only as small inclusions in Nachvak gneiss (Plate 1).

(iv) Dense, black, granoblastic mafic gneiss found only as small slab-like bodies, apparently the remnants of deformed mafic dykes (Plate 2) intrusive into the Nachvak gneiss protolith.

All types show evidence of granulite grade metamorphism (two pyroxene assemblages), but have been partially retrogressed, together with the host Nachvak gneiss, to amphibolite and greenschist facies assemblages comprising hornblende, secondary brown and green biotite, actinolite, orthoamphibole, and locally chlorite, epidote and calcite.

Some of the migmatitic mafic gneisses (type iii) were clearly migmatized prior to incorporation in the Nachvak gneisses (Plate 1). The type (iv) mafic dyke remnants (Plate 2) were only deformed following incorporation in the Nachvak gneiss. The contacts of other inclusions are usually obscured by partial melting and deformation, and structural relationships with the Nachvak gneiss are uncertain.

The parentage of the mafic gneisses is undoubtedly mixed. The type (i) fine grained and type (ii) metagabbroic gneisses resemble those associated with the pre-2.8 Ga Upernavik supracrustals of the Saglek area (Bridgwater *et al.*, 1975; Collerson *et al.*, 1976), although it is not inconceivable that some could be derived from the pre-3.6 Ga Nulliak assemblage (Collerson *et al.*, *op. cit.*) of the same area.

The origin of the type (iii) migmatic mafic gneisses is uncertain; some are obviously derived from an early gneiss terrane, others may simply be highly metamorphosed and migmatized equivalents of types (i) and (ii). The most obvious candidate for the type (iv) dyke remnants are the *circa* 3.3 Ga Saglek dykes (Collerson *et al.*, *op. cit.*). They do not, however, contain the relict plagioclase phenocrysts typical of Saglek dykes and it is equally possible that they are derived from a younger dyke suite not represented in the Saglek area.

Supracrustal Gneiss

Gneiss of definite supracrustal origin is rare in the area and confined to several narrow screens exposed on the sea cliffs of Mount Razorback and the south coast of Nachvak Bay (Figure 2). These are finely banded, rusty weathering, garnet rich psammitic and semi-pelitic gneisses with thin interbands of metaquartzite or metachert. They closely resemble parts of the *circa* 3.3 - 2.8 Ga Upernavik supracrustal sequence of the Saglek area (Bridgwater *et al.*, 1975; Collerson *et al.*, 1976) and also the equivalent Malene supracrustals of West Greenland (Bridgwater *et al.*, 1976).

Nachvak Gneiss

This is a new term informally applied to the granitoid gneisses which form the predominant rock type in the Nachvak Fiord area. In the Nain Province zone, these are typically gray-green weathering gneisses of granodioritic to tonalitic composition containing numerous inclusions and screens of early mafic gneiss. Near the margins of the larger screens the Nachvak gneiss is characteristically crowded with mafic gneiss inclusions.

The unit is seen in its least metamorphosed state between Bigelow Bay and Gulch Cape where it is locally a strongly foliated to gneissic granodiorite (Plate 3) with augen texture. Elsewhere in the area the granodiorite-tonalite gneiss has been heterogeneously migmatized with production of a fine grained, white, granitic melt fraction (Plate 4).

Plate 4

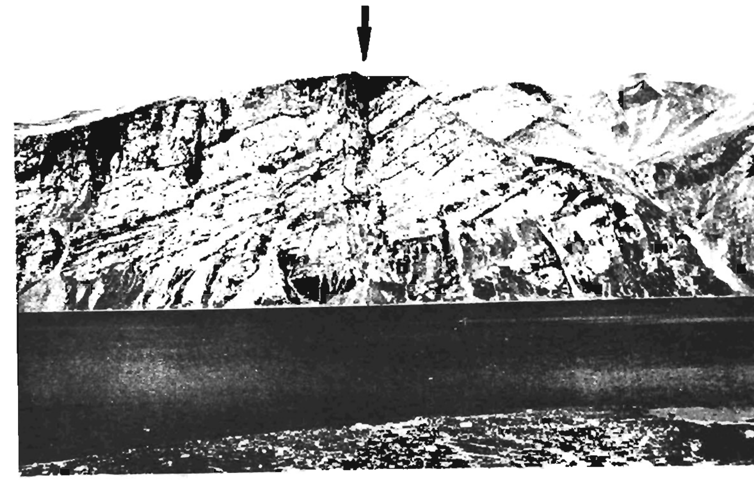

Plate 5

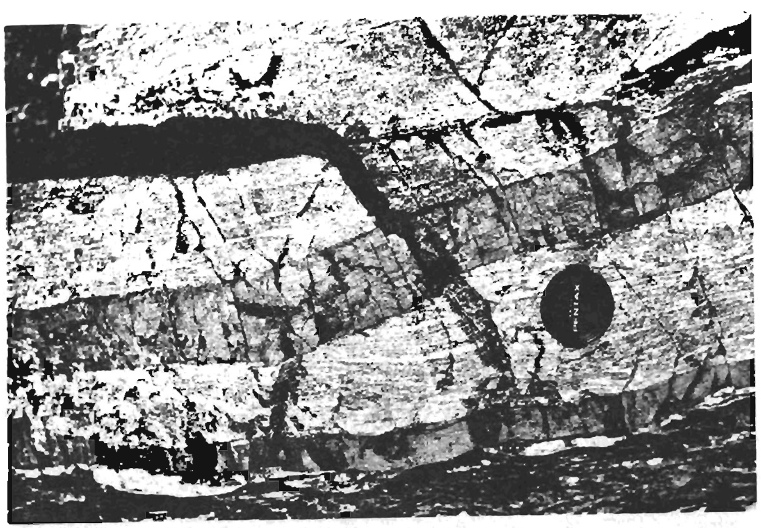

Plate 6

Plate 4 - Nachvak gneiss: migmatitic granodiorite to quartz monzonite gneiss, Bigelow Bay. Scale - hammer, 43 cm long.

Plate 5 - Late dyke swarm. Dykes are largely undeformed with strike 045 - 055° and dip 40 - 55° NW, and cross-cut granulite grade fabrics in Nachvak gneiss. Dyke swarm is cut by Hudsonian shear zone (arrow) in which dykes are rotated to vertical, boudinaged and sheared. Dyke remnants preserved in internal shear augen retain cross-cutting relationships with pre-dyke mylonitic fabrics (cf. plate 6), thereby demonstrating that Hudsonian shearing has occurred by reactivation of late Archean shear zone. Scale - height of fiord wall is 650 m.

Plate 6 - Late dykes cross-cutting mylonitized Nachvak granulite facies gneiss in Churchill Border Zone. Dykes have been recrystallized, foliated and partially transposed during Hudsonian deformation. Location is north shore, Nachvak Fiord, 5 km west of Tinutyarvik Cove. Scale - lens cap, 5 cm diameter.

Textures vary from agmatitic to lit-par-lit. These have been zonally flattened during subsequent deformation into banded gray and white quartzofeldspathic gneiss.

The Nachvak gneiss preserves abundant evidence of early granulite facies metamorphism, associated with migmatization and deformation. Relict assemblages comprise quartz + feldspar + hypersthene + clinopyroxene + hornblende ± biotite. Retrogression of this assemblage is visible in outcrop as diffuse green haloes around pyroxene grains and a green coloration of plagioclase. In thin section pyroxene has been internally pseudomorphed by uralitic aggregates of tremolite and orthoamphibole (anthophyllite?) and rimmed by microcrystalline haloes of green biotite intergrown with minor chlorite. Plagioclase is also severely altered to epidote-calcite assemblages.

Structures in the Nachvak gneiss have a general north-south trend, swinging to northeast north of Nachvak Fiord, with steep to moderate westerly dips. Zones of fabric straightening are present but ductile shear zones are absent. A large reclined isocline of migmatitic granite exposed on the the sea cliffs of Mount Razorback represents the only evidence of megascopic folding.

The age of the Nachvak gneiss has not been determined directly; however, a U-Pb zircon age of 2.825 Ga (Morgan, 1979) from Bell Inlet, 23 km south of Gulch Cape, probably approximates the timing of granulite facies metamorphism and represents a minimum age for the unit.

Collerson *et al.* (1982) have proposed most of the granitoid gneisses occurring between Saglek and Nachvak Fiords to be equivalents of the Kiyuktok gneiss of the Saglek area which was formed circa 2.8 Ga by reworking and migmatization of the 3.6 Ga Uivak gneisses.

From this summer's work it is evident that where the protolith of the Nachvak gneiss can be recognized *i.e.* in the eastern part of the area, it was a relatively simple granodiorite-quartz monzonite plutonic rock (Plate 3), very different to the complex banded Uivak gneiss protolith of the Kiyuktok gneiss (see Ryan *et al.*, this volume). Furthermore, the Nachvak gneiss lacks the abundant Saglek dyke remnants which characterize the Uivak and Kiyuktok gneisses. The Nachvak gneiss does contain isolated dyke-like inclusions (type iv) but these are nowhere as abundant as in the Saglek area.

Alternatively (D. Bridgwater, personal communication), it is possible that the Nachvak gneiss, at least in part, is equivalent to the *circa* 2.8 Ga Nuk gneisses of western Greenland (McGregor, 1973; Bridgwater *et al.*, 1976) which are derived from a series of calc-alkaline granitoid plutons intruded *circa* 3.05 Ga (Baddsgard and McGregor, 1981) into older crust represented by equivalents of the Uivak gneiss.

It is conceivable, however, that the more completely deformed and migmatized parts of the Nachvak gneiss, where protolith type is difficult to recognise, may include an Uivak component deficient in Saglek dykes. This would certainly be compatible with the numerous mafic inclusions in the gneiss which suggest derivation by reworking of earlier crustal material.

Further mapping and isotopic work is clearly needed before correlations of the Nachvak gneiss can be confirmed. In particular the critical area between Nachvak and Saglek Fiords needs detailed mapping.

Kammarsuit Granite

This unit was initially recognized by Morgan (1975, 1979) as a distinctive orthogneiss unit on the south side of Nachvak Bay and subsequently named

Kammarsuit gneiss by Collerson *et al.* (1982). It is now recognized that the unit extends well to the north of Nachvak Bay (Figure 2) and that for the most part it is simply a strongly foliated megacrystic granite. In its least deformed state, in exposures around Mount Razorback, the unit is a dark, green-gray megacrystic granite with white weathering K-feldspar megacrysts 2-4 cm long, and bluish quartz. This was locally intruded by later phases of pale gray, coarse grained, more quartz-rich granite and by sheets of pink or white leucogranite. The pluton also includes abundant sheet-like inclusions of early mafic gneiss. A small satellite pluton of equigranular granite, probably related to the Kammarsuit granite, occurs east of Bigelow Bay (Figure 2). Dykes of Kammarsuit granite also intruded Nachvak gneiss along the south shore of Nachvak Bay.

The primary mafic mineral phase of the Kammarsuit granite was evidently pyroxene, possibly in association with hornblende; however, subsequent retrograde metamorphism largely replaced this with pseudomorphic aggregates of green and brown biotite, uralitic tremolite and green-brown hornblende.

Over most of its exposed area the granite is pervasively foliated, with pronounced megacryst alignment, but is neither gneissic nor migmatitic. West of Naksaluk Cove a strong ductile shear fabric was superimposed on the granite to produce a coarse augen gneiss. This deformation predates intrusion of late Archean dykes.

The contacts of the Kammarsuit granite are well exposed on all sides. The eastern contact of the granite, most clearly seen on the north coast of Nachvak Bay, is steep and clearly cross-cuts earlier gneiss and migmatite fabrics of the Nachvak gneiss at a slight angle. The western contact is concordant with structures in the Nachvak gneiss, largely as the result of superimposed late Archean deformation.

Collerson *et al.* (1982) have obtained an Rb-Sr age of 2.693 Ga (+ 148 - 120) for the granite which they believe approximates time of intrusion. They also proposed the granite to be chronologically equivalent to the Nuk gneisses of West Greenland, a correlation which now seems untenable. It is more likely that the Kammarsuit granite is equivalent to late porphyritic granites such as the Ilivertalik granite of West Greenland (Bridgwater *et al.*, 1976) emplaced during or immediately following the main high grade metamorphic event of 2.8 Ga, but prior to the latest phase of regional deformation.

Green Dykes

Several scattered examples have been found of thin, mafic to intermediate dykes with irregular trends and greenish colouration. The dykes cross-cut the gneissic and migmatitic fabrics of the Nachvak gneiss at moderate to shallow angles, but have been recrystallized and partially transposed into the gneissic fabrics during subsequent late Archean deformation. The dykes are composed of fine grained, green hornblende intergrown in granoblastic texture with plagioclase. In terms of their structure the dykes appear to be of similar age to the Kammarsuit granite.

Late Dykes

The late dyke swarm in the Nain Province has an overall east-west trend but local trends may be irregular (Morgan, 1975). Individual dykes are not shown in Figure 2 but their distribution has been mapped by Morgan (1979). In size they vary from less than 1 m to over 100 m in width and vary from basalt to medium grained gabbro. Most of the basalt dykes are aphanitic but plagioclase phyric varieties are common. The great majority of dykes are undeformed and clearly truncate structures in the host Nachvak gneiss and Kammarsuit granite. However, some have suffered minor shearing along their contacts, presumably as a result of

Hudsonian deformation. In thin section, even undeformed dykes show a pervasive static alteration which has partially to completely replaced pyroxene and plagioclase with fine intergrowths of actinolite + chlorite + epidote ± biotite, and calcite ± epidote respectively. The effects of this alteration become more pronounced towards the Churchill Border Zone where many of the dykes are fine grained 'greenstones'. These usually lack penetrative fabrics but may locally display crude shear fabrics.

CHURCHILL BORDER ZONE

This zone is underlain by Nachvak gneiss intruded by late Archean dykes and overlain by Ramah Group sedimentary rocks.

Nachvak Gneiss

Nachvak gneiss in this zone is subdivided by an isograd which separates a western belt of granulite facies gneisses from retrograde amphibolite to greenschist facies gneisses in the east (Figure 2). The retrograde isograd corresponds to the Nain - Churchill boundary as defined by Taylor (1979). The granulite grade gneisses are characterized by ortho and clinopyroxene + hornblende + biotite assemblages in both mafic and quartzofeldspathic gneisses, with garnet as an additional phase in mafic granulites. Granulite fabrics in the Nachvak gneiss clearly predate intrusion of late dykes and are therefore of Archean rather than Hudsonian age as implied by Taylor (1979).

The retrogressed gneisses are gray and are contiguous with similar Nachvak gneiss in the Nain Province. Retrograde assemblages indicate a range of metamorphic conditions from amphibolite to greenschist facies and probably result from a combination of late Archean and Hudsonian effects.

The Nachvak gneiss of the Churchill Border Zone differs from that of the Nain Province in the greater development of sheared, straightened and mylonitic gneiss which occurs in zones 3 to 30 m wide. These are characterized by border zones of straightened or protomylonitic gneiss and cores of fine grained mylonite and ultramylonite gneiss. Where migmatitic mafic gneisses have been involved in these zones distinctive black and white or black and pink striped mylonites have been produced by attenuation and transposition of felsic and mafic components. Fabric trends in the Churchill Border Zone are generally northwest with steep to moderate westerly dips. Megascopic and mesoscopic F_2 folds associated with shear zones have strong easterly vergence and shallowly plunging hinge lines.

Contrary to expectation the majority of shear zones in the eastern part of the border zone are cut by undeformed or only mildly brecciated late dykes and are therefore of late Archean rather than Hudsonian age. In some instances the late dykes preserve discordant chilled margins against the Archean mylonites but have been internally sheared and brecciated during Hudsonian reactivation of the shear zones. Hudsonian structures outside of the shear zones are represented by thin reverse faults associated with thin breccia zones and low grade alteration. Bridgwater *et al.* (1975) have mentioned similar late Archean mylonite zones from the Saglek area; equivalent structures of this age are also well known from the southern margin of the Nagssugtoqidian Mobile Belt in Greenland.

In the western part of the Churchill Border Zone the late dykes are more extensively involved in shearing (see below) and it is difficult to distinguish late Archean from Hudsonian effects. Nevertheless within shear augen in these zones the late dykes locally preserve discordant relationships to earlier mylonitic fabrics.

Late Dykes

The dykes in the border zone increase markedly in abundance from east to west and also develop a very regular northeast trend with moderate westerly dips. This is well displayed on the north side of Nachvak Fiord, opposite Ivitak Cove, where approximately thirty percent of the fiord wall is composed of dyke material locally cut by Hudsonian shear zones (Plate 5). In this area, the northeast trending dykes are cut by local sets of vertical north-south dykes. The majority of dykes in the border zone are undeformed but have been internally recrystallized, pyroxene being pseudomorphed by aggregates of green and brown biotite. Shearing of dykes is more abundant in the Churchill Border Zone than in the Nain Province and its effects vary from the production of crude, low grade chlorite + biotite + epidote + actinolite fabrics in the eastern part of the border zone to biotite + amphibole + plagioclase schistosities in the west. Plate 6 illustrates an example of late dykes which have intruded a late Archean shear zone, and then been foliated and partially transposed during Hudsonian reactivation of this zone.

Ramah Group

Only the lower part of the Ramah Group, consisting of the Rowsell Harbour, Reddick Bight and Nullataktok Formations, is present in the Nachvak Fiord area (Morgan, 1975; 1979). The stratigraphy and sedimentology of the group have been well established by Morgan (1975) and Knight and Morgan (1981) and were not re-examined in this study which instead concentrated on the structural aspects of the group.

The structure style of the Ramah Group is illustrated in the cross-sections of Figure 4. The basal unconformity of the Ramah Group dips gently west and overlies a zone of paleo-weathered gneiss and regolith. Above the unconformity in the east, the group is gently west-dipping with a weak sericitic cleavage developed in fine grained rock types. To the west the group becomes increasingly deformed in close folds slightly overturned to the east. These are associated with a strong axial planar cleavage formed by sericite and fine biotite in sedimentary rocks, and actinolite in metadiabase sills.

The western boundary of the Ramah Group is formed by the Nachvak Fiord thrust (Morgan, 1975), a major structure which has transported Nachvak gneiss eastward over Rowsell Harbour Formation. Both gneiss and metasediments are intensely phyllonitized for several metres adjacent to the thrust. The thrust is also locally overlain by a small sliver of Rowsell Harbour quartzite which is either a secondary thrust slice, or more likely a folded invagination of the thrust surface. An unnamed thrust has juxtaposed the basal Ramah Group, together with its unconformity and underlying basement, and the eastern Ramah Group near Rowsell Harbour (Figure 3). Significantly this thrust is located within the basement rather than along the basement-cover interface. A further thrust, here named the Tinutyarvik thrust, is exposed on the south side of Nachvak Fiord where it has duplicated the basal Rowsell Harbour Formation together with its unconformity and underlying paleoweathered basement (Figure 3; Plate 7). For most of its extent, the thrust must lie within the basement and only locally does it cut into the basal Ramah Group. Its geometry (see Figure 4) requires a considerable part of the eastern Ramah Group to be allochthonous. Dolomite breccias of slump or collapse origin have been found at sea level 100 m below the lower Ramah unconformity and indicate that the pre-Ramah erosion surface must have had relief on the order of 100 m or more. This is taken to suggest that the lens of Ramah quartzite preserved below the Tinutyarvik thrust may have originated as a depression fill (possibly a channel) which was sliced off by the thrust (Figure 4). The Tinutyarvik thrust is a blind one in the sense that it never penetrates the overlying sedimentary pile and is a model for similar thrusts which may well underlie the remainder of the western Ramah Group.

CHURCHILL INNER ZONE

The Nachvak gneiss extends into the Churchill Inner Zone where it contains an extensive belt of anorthosite. The western limit of the Nachvak gneiss is formed by a sheared contact with quartz + plagioclase + garnet mylonitic gneiss termed the Tasiuyak gneiss. More granitoid gneisses are present west of this unit but were not examined during this study.

Nachvak Gneiss

The Nachvak gneiss of this zone differs from that of the Churchill Border Zone in that it has been pervasively straightened and mylonitized. Late dykes have been partially to completely transposed into the mylonitic fabrics demonstrating that the fabrics are largely of Hudsonian age.

Hudsonian deformation increased in intensity from east to west towards the contact with the Tasiuyak gneiss and most of the unit west of the anorthosite was converted to mylonite and ultramylonite gneiss locally veined with pseudotachylyte. The mylonitic zones are generally brown weathering with darker brown or black bands representing attenuated bands of mafic granulite. Internally the mylonite fabric comprises a quartz + feldspar + ortho and clinopyroxene + hornblende + biotite assemblage recrystallized into a fine granoblastic-polygonal texture. Mafic mylonites contain red (almandine?) garnet as an additional phase. In a 60 m wide zone adjacent to the Tasiuyak gneiss both felsic and mafic mylonites become markedly garnetiferous.

Hudsonian deformation in the Churchill Inner Zone evidently occurred under largely anhydrous conditions. Intense Hudsonian shearing obscured any evidence of pre-existing Archean mylonitic fabrics in this zone.

Anorthosite

The presence of linear bodies of deformed anorthosite in the eastern Churchill Province was first recognized by Taylor (1979) who assigned them a probable Aphebian age.

The anorthosite at Nachvak Fiord forms a 5 km wide body which divides into several smaller units north of the fiord, an effect which is thought to be due to interfolding with Nachvak gneiss and the northerly plunge of anorthosite under the gneiss.

Strictly speaking, the anorthosite is largely a leucogabbro (mafic content 10-35%), using the terminology of Myers (1973), but varies to ultramafic, layered gabbro and true anorthosite. Much of the unit has been strongly deformed and recrystallized and these terms are used only to indicate composition. The most pristine exposures of the unit are found on its eastern side where cummulate layered gabbro displaying 15-30 cm alternation of graded ultramafic, gabbro and anorthositic layers, is locally preserved. Dark bands of intergrown garnet, orthopyroxene, diopside and hornblende with symmetrical garnet rims are also found concordant with layering and may be either late intrusive or segregation features. Layering is the only primary feature preserved in the gabbro, all igneous textures having been recrystallized to granoblastic polygonal forms.

Elsewhere, the unit is dominated by fine to medium grained, pale gray to brown weathering leucogabbro and anorthosite characterized by folded and boudinaged lenticles of orthopyroxene rimmed by hornblende. In local low strain zones it can be demonstrated that these are derived by attenuation of

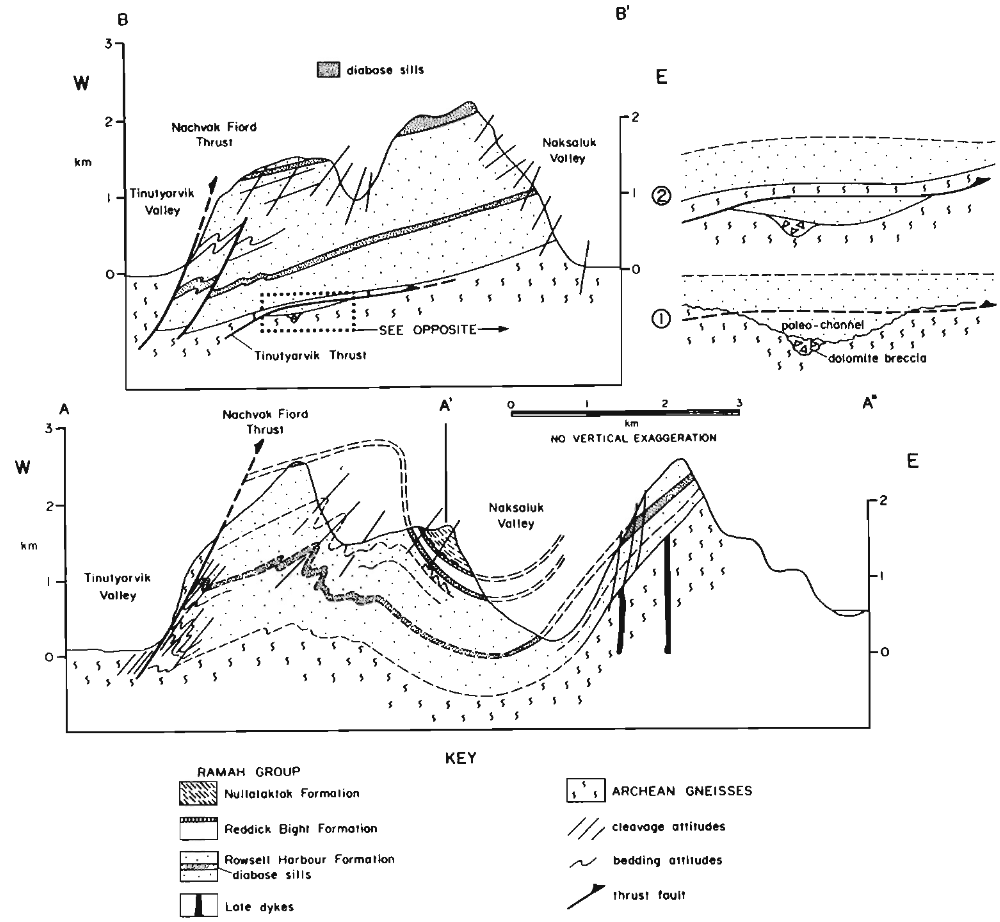

Figure 4 Structural cross-sections of northern Ramah Group, Nachvak Fiord. Sketches 1 and 2 illustrate schematic development of Tinutyarvik thrust (see below).

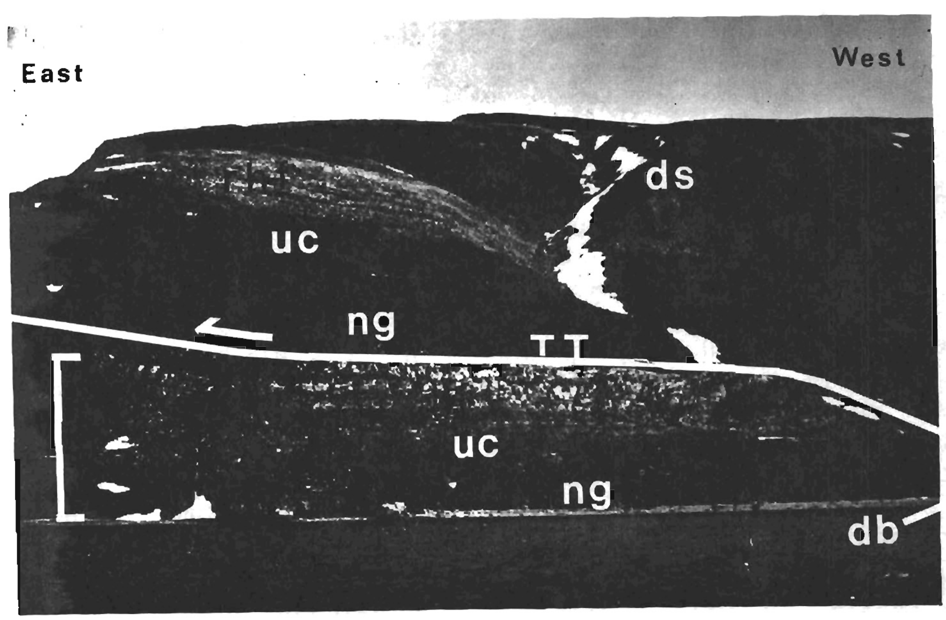

Plate 7 - Tinutyarvik thrust viewed from northwest. ng = Nachvak gneiss; uc - unconformity; rhf = Rowsell Harbour Formation quartzite; TT = Tinutyarvik thrust; ds = diabase sill; db = dolomite breccias found just to right of photo at sea level. Scale - height of section bar is 50 m. Note veiw in photograph is reversed in comparison with that illustrated in Figure 4.

large, 4-5 cm diameter, primary pyroxene megacrysts. Plagioclase usually forms an equigranular polygonal texture with a 0.5 - 1.5 cm grain size, but can also be shown to have formed by recrystallization of much larger igneous feldspars.

Layering in the main body of the anorthosite is uncommon but the unit does contain 1-10 m bands of metagabbro (now mafic granulite) and rare 1 m or less bands of pyroxenite which may be derived from ultramafic layers.

Mafic granulites of metagabbro and leucogabbro derivation are noticeably abundant along the contacts of the anorthosite where they alternate with bands of anorthosite and with sheets of granite gneiss emanating from the Nachvak gneiss. The mafic granulites locally contain a compositional variation possibly derived from igneous layering and are indistinguishable from the type (i) and (ii) mafic gneiss inclusions in the Nachvak gneiss. It is difficult to say at present whether they are differentiates of the anorthosite suite or whether they represent part of the country rock complex into which anorthosite intruded.

The structure of the anorthosite is characterized by a pervasive foliation or gneissosity, associated with flattening and recrystallization of original igneous textures. The unit is generally free, however, of the mylonitic foliations which characterize the surrounding granitoid gneisses. This is in large part probably due to its quartz-free nature and consequent resistance to ductile shearing.

The anorthosite predates granulite grade metamorphism and is intruded post-tectonically by late dykes. There is little doubt therefore that it is Archean. The timing of anorthosite intrusion with respect to the Nachvak gneiss is uncertain since original intrusive relationships have been obscured by migmatization of the anorthosite margins. If it is assumed that the inclusions of mafic granulite (metagabbro - leucogabbro) form part of the anorthosite suite then anorthosite must predate Nachvak gneiss. A corollary to this assumption is that the anorthosite is probably of similar age, possibly genetically related, to the metagabbroic component (type ii) of the early mafic gneisses.

Anorthosite intrusions have long been recognized as a characteristic feature of the Archean of West Greenland, *e.g.* the Fiskenaesset complex (Myers, 1975; Windley *et al.*, 1973)), where they were intruded in the period 3.3 to 2.8 Ga (Bridgwater *et al.*, 1976), and have recently also been recognized in the Nain Province (Collerson *et al.*, 1976; Wiener, 1981; Ermanovics *et al.*, 1982). The Churchill Province anorthosites represent the most extensive development of Archean anorthosite yet found in Labrador.

Tasiuyak Gneiss

This is a new term applied to the Nachvak Fiord sector of a 6-10 km wide belt of quartz+plagioclase+garnet gneiss recognized by Taylor (1979) as forming a major component of the eastern Churchill Province.

The unit is typically a leucocratic gneiss with an approximate average percent composition: quartz (40), plagioclase (20), garnet (30), biotite (10) + variable amounts of sillimanite, graphite and K-feldspar.

On washed surfaces the gneiss is highly distinctive, being finely banded with mauve, garnet rich, bands alternating on a 2-10 cm scale with white, quartz-plagioclase bands containing scattered 1-3 cm garnet porphyroblasts. On weathered surface the gneiss is rusty brown, largely due to an iron-rich (pyrope rich?) garnet content, and appears similar to the nearby granulite facies Nachvak gneiss. Fine grained, red biotite is present in the garnet-rich melanocratic bands, often in association with prismatic sillimanite and graphite. Acicular sillimanite also occurs enclosed within garnet porphyroblasts. Orthopyroxene is suspected to occur in western exposures of the unit, but to date has not been confirmed in thin section. Quartz-rich bands, possibly of metaquartzite origin, and tonalitic bands are common in the more leucocratic gneiss components.

Compositional banding seen in the interior of the gneiss is isoclinally folded in shallow, north plunging folds with a strong, colinear quartz lineation and mylonitic axial planar fabric. Towards the eastern boundary of the gneiss the compositional banding is completely transposed into the mylonitic fabric and the unit becomes a fissile, flaggy gneiss with a thin compositional striping and an intense L>S (*cf.* Flinn, 1965) mylonitic fabric defined by ribbon quartz.

In thin section, textures are generally granoblastic polygonal, and little evidence is preserved of the intense grain size reduction suffered by the unit. Garnet does not appear markedly affected by mylonitization and appears to have recrystallized during deformation.

Pseudotachylyte veins from 10 cm to 3 m in width are present throughout the Tasiuyak gneiss. Veins are typically crowded with angular fragments of mylonite gneiss set in a black vitreous matrix, are discordant to mylonitic foliation, and clearly postdate the main period of cataclasis. Veins seen in the walls of Tasiuyak Arm have a general westerly dip and may be related to a late period of brittle reverse faulting or thrust movement. The eastern contact of the Tasiuyak gneiss is a 1 km wide zone of interleaving with the Nachvak gneiss, in which 1-50 m wide slices of white, mylonitic Tasiuyak gneiss are interleaved with similar size slices of brown, garnetiferous mylonitized Nachvak gneiss. The degree of interleaving decreases to the west; however, one small, 7 m wide, fault-bounded sliver of brown granulite gneiss was found in the center of the Tasiuyak gneiss north of Tasiuyak Arm. A small, 1 m wide, sliver of calc-silicate with the assemblage diopside + calcite + phlogophite + tremolite + plagioclase was found enclosed in Nachvak gneiss within the interslice zone east of Tallek Arm. It is uncertain whether this is derived from the Tasiuyak gneiss or is an original Nachvak gneiss inclusion.

At the west end of Nachvak Fiord, the gneiss is intruded by sheets of pale gray, garnet + orthopyroxene + diopside + plagioclase rock with granoblastic texture, corresponding in composition to leucogabbro. These are unlike other metagabbroic rocks in the area and their significance is, at present, uncertain. The western contact of the Tasiuyak gneiss was not seen during this season's work.

In previous work by Taylor (1979) and Morgan (1975), the Tasiuyak gneiss has been interpreted as a paragneiss formed by metamorphism of Aphebian sedimentary rocks. Given the mineral composition of the unit, this must be correct and it is difficult to propose any protolith other than an arenaceous clastic sediment. The gneiss, however, is remarkably uniform in composition and remarkably poor in potash for a typical metasedimentary gneiss. The compositional banding may have a primary origin but it more likely represents a metamorphic segregation fabric, possibly developed during intense partial melting, with the garnet-rich melanocratic bands representing refractory melanosome material. Ryan *et al.* (this volume), working on the southerly extension of this unit, have described localities where the gneiss has apparently intruded mafic granulite gneiss, suggesting that the unit was sufficiently mobile to act as a granitoid melt. This may account for the homogeneous nature of the gneiss. The low potash content of the gneiss may reflect an unusual protolith composition, *e.g.* a clastic rock derived from a tonalitic terrane; alternatively, it may be due to stripping of K^+ during intense anatexis.

The age of the Tasiuyak gneiss is also uncertain; the unit is suspected to have undergone granulite facies metamorphism, most likely during the 2.8 Ga Archean event, however, an Aphebian age cannot as yet be ruled out.

Granulite Gneisses West of Tasiuyak Gneiss

These were not examined during this season's work, but according to Taylor (1979), they represent a westerly continuation of the granulite granitoid gneisses (Nachvak gneiss of this paper).

Late Dykes

West of Ivitak Cove, the abundance of dykes decreases markedly, and no dykes have been found in the Tasiuyak gneiss. The few dykes that are present in the Nachvak gneiss and anorthosite have been partially to completely transposed into the Hudsonian regional fabric. Dykes are also generally thin (<1 m thick) and do not stand out on aerial photographs as they do in the other zones.

Some dykes retain a vestige of diabasic texture but most have been recrystallized to schists with the assemblage hornblende + ortho and clinopyroxene + plagioclase. Various stages of recrystallization have been recognized from those preserving primary pyroxene, to those in which primary pyroxene has recrystallized into lenticular grain aggregates or islands, to the final stage in which pyroxene, hornblende and plagioclase are intergrown in an equigranular granoblastic texture. Although the mineral assemblages are those of the granulite facies, it is felt that they reflect anhydrous recrystallization rather than very high grade metamorphism.

Post-tectonic Sills

Several sills were observed at about the 1000 m level on cliff faces of Idyutak Mountain and mountains south of Tasiuyak Arm. These could not be examined in outcrop but appear to be of mafic composition and entirely post-tectonic. In all probability, they are Helikian, belonging to either the *circa* 1.4 Ga Elsonian event, or the 1.2 Ga Gardar event.

TECTONIC DEVELOPMENT

The tectonic development of the Nachvak Fiord region is summarized in Figure 3. The earliest events are recorded in the mafic gneiss inclusions in the Nachvak gneiss. These inclusions may represent remnants of an early Archean terrane equivalent to the 3.3 - 2.8 Ga Upernavik supracrustals, and associated gabbroic intrusives, of the Saglek area, and to the Malene supracrustals of West Greenland. Anorthosite intrusion, probably as layered sheets, may also belong to this period.

The area was flooded by granodiorite-tonalite magma in a widespread plutonic event prior to 2.8 Ga, possibly equivalent to the Nuk event of West Greenland. Plutonism was followed by regional, granulite grade metamorphism associated with migmatization and deformation *circa* 2.8 Ga, and was succeeded by intrusion of the charnockitic Kammarsuit granite as part of a widespread, late Archean plutonic event. There then followed a period of late shearing and folding which appears to have increased in intensity to the west. Fold vergence indicates tectonic transport to the east. This event may also have been responsible for retrogression of the Archean granulites in eastern Nachvak Fiord, although this is probably also in part a Hudsonian effect. The full significance of the late Archean shearing is difficult to assess since much of it has been masked by Hudsonian deformation. It appears likely, however, that the event was at least partly responsible for the north-south linear grain and steep attitude of Archean structures in the Nachvak Fiord area. The late Archean shear zones also acted as structural inhomogeneites which localized Hudsonian shear zone deformation.

Late Archean shearing was followed by uplift, cooling and closure of the rock system to argon loss at around 2.5 - 2.4 Ga, based on the numerous K-Ar dates of this age from the northern Nain Province (Taylor, 1979). Following cratonization, the Archean crust was intruded by a basaltic dyke swarm which is a regional feature of both Labrador and Greenland and which probably heralded crustal rupture prior to development of lower Proterozoic mobile belts. The manner in which the dyke swarm reached a peak of intensity at the west end of Nachvak Fiord, and then suddenly died out, is intriguing but has no ready explanation.

Following an interval of subsidence on the margin of the developing Hudsonian Orogen, during which time the Ramah Group was deposited, the area was deformed again during the Hudsonian Orogeny *circa* 1.8 - 1.75 Ga. The marginal effects of this event are most clearly seen in the Ramah Group which was folded, cleaved and overthrust to the east. The basement underlying the Ramah Group lacks any Hudsonian structures other than brittle reverse fault zones and clearly did not undergo the shortening represented by folding and cleavage formation in the Ramah Group. The degree of deformation in the Ramah Group appears to have been at least partially accommodated by decollement along structures such as the Tinutyarvik thrust and the unnamed thrust at Rowsell Harbour. Deformation may also have resulted partly from transmission of stress across the Nachvak Fiord thrust, particularly if a large mass of basement was emplaced over the Ramah Group.

Within the remainder of the Churchill Border Zone Hudsonian deformation was concentrated in discrete shear zones which change in character from zones of brittle brecciation in the east to ductile shear in the west. Fold vergence within the zones indicates overthrusting to the east.

Hudsonian deformation in the Churchill Inner Zone is dominated by straightening and mylonitization in shear zones which increase in width and abundance towards the west, where they merge into a continuous mylonite zone in the Tasiuyak gneiss. From the behaviour of the late Archean dykes it is evident that the crust in the Churchill Inner Zone was considerably more ductile than in the border zone and that deformation occurred at high temperatures.

The most interesting feature of the zone, however, is the manner in which fold and lineation style changes from east to west into the Tasiuyak gneiss. In the Nachvak gneiss folds have 30 - 50° plunges to both north and south with vergance to the east. Lineation is not well developed, but where present it is usually an intersection lineation related to F_2 folds, and the fabric is S>L (Flinn, 1965). Within the interslice zone and the Tasiuyak gneiss, folds are upright, isoclinal and have a 10-15° northerly plunge colinear with an intense quartz lineation. The most probable origin for the lineation and mylonitic L>S fabric is a lateral simple shear environment, the most likely environment for which would be a major transcurrent fault zone. The colinearity of lineation and fold hinge lines is not unusual in a high shear strain environment and probably developed by progressive rotation of fold hinge lines into the lineation (*i.e.* the principal axis of the strain ellipsoid) at advanced strain states.

If the transcurrent model is correct, it indicates an abrupt change from an environment of vertical tectonics associated with overthrusting in the Churchill Border Zone, to lateral movements in the interior zone. Further work may show that this zone of lateral shear marks the edge of recognizable Archean crust in the Churchill Province. This would in turn lend considerable weight to the proposal by Bridgwater *et al.* (1973) that the eastern Churchill mylonites represent a major transcurrent shear zone boundary between Nain and Churchill plates.

Metamorphism associated with the Hudsonian Orogeny rises from greenschist facies in the Churchill Border Zone to amphibolite facies in the inner zone. The retrogression of Archean granulite assemblages seen in the eastern part of the border zone is in part a result of late Archean metamorphism but is also largely a Hudsonian feature, an assumption which is based on the similarity of alteration assemblages in the granulite gneisses and late dykes. The area of retrogression also corresponds fairly closely to the area occupied, or at one time probably occupied, by the Ramah Group, a unit which may have supplied the water necessary for hydrous alteration of the granulite assemblages. The remainder of the Churchill Border Zone and the inner zone were reworked under anhydrous conditions and presumably represent deeper crustal levels out of range of Ramah water. Metamorphic assemblages and textures in late dykes of the Churchill Inner Zone indicate that Hudsonian metamorphic grade rose to at least amphibolite facies but did not reach the stage of partial melting. Anhydrous recrystallization of granulite facies minerals occurred in this zone but may well have taken place at temperatures much lower than these normally associated with granulite grade metamorphism.

SUMMARY

As is usual with studies in areas of complex crustal history, as many problems have been raised as have been answered. The most significant aspect of the season's work is recognition of the extent to which Archean crust extends into the Churchill Province. This has ramifications for the geology north of Nachvak Fiord and suggests that much of the ground east of the quartz + feldspar + garnet mylonite (Tasiuyak gneiss) on Figure 1 may be reworked Archean crust, including all of the northern Labrador anorthosites. Also implicit is the suggestion that much of the granulite metamorphism in this area is of Archean rather than Hudsonian age.

Further work will be needed, however, to determine whether the Tasiuyak gneiss marks the western edge of Archean crust or if it is simply an intra-Archean feature. Related problems involve determination of the origins of the Tasiuyak gneiss and of the mylonite zone which it contains. Further work in 1983 will extend the cross-section examined in this study west to the Quebec border and may help to shed further light on these problems.

MINERALIZATION

Reported mineral occurrences in the area are limited to graphite in the Tasiuyak gneiss and pyrite in the Ramah Group (Douglas, 1976).

Graphite occurs as disseminated flakes on foliation surfaces and is usually concentrated in the more garnet rich bands of the gneiss.

Pyrite in the Ramah Group occurs within an approximately 0.5 m thick bed near the base of the Nullataktok Formation. The bed is composed of massive to bedded pyrite-pyrrhotite with pebbles of quartz, chert and shale (Knight and Morgan, 1981).

'Opal' has also been reported from the area (Douglas, 1976), but is in fact the ubiquitous blue quartz characteristic of the Kammarsuit granite and granulite facies gneisses.

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REFERENCES

Badsgaard, H. and McGregor, U.R.
1981: The U-Th-Pb systematics of zircons from the type Nuk gneisses, Godthabsfjord, west Greenland. Geochemica et Cosmochimicha, volume 45, pages 1099-1109.

Bridgwater, D. and Collerson, K.D.
1976: The major petrological and geochemical characteristics of the 3600 m.y. Uivak gneisses from Labrador. Contributions to Mineralogy and Petrology, volume 54, pages 43-45.

Bridgwater, D., Escher, A. and Watterson, J.
1973: Tectonic displacements and thermal activity in two contrasting Proterozoic mobile belts from Greenland. Royal Society of London, Philosophical Transactions, Series A, volume 273, pages 493,512.

Bridgwater, D., Collerson, K.D., Hurst, R.W. and Jesseau, C.W.
1975: Field characteristics of early Precambrian rocks from Saglek, coast of Labrador. Geological Survey of Canada, Paper 75-1, part A, pages 287-296.

Bridgwater, D., Keto, L., McGregor, V.R. and Myers, J.S.
1976: Archean gneiss complex of Greenland. *In* The Geology of Greenland. *Edited by* A. Escher and W.S. Watt. Grønlands Geologiske Undersøgelse, Copenhagen, Denmark, pages 18-75.

Bridgwater, D., Collerson, K.D. and Myers, J.S.
1978: The development of the Archean gneiss complex of the North Atlantic region. *In* Evolution of the Earth's Crust. *Edited by* D.H. Tarling, London Academic Press, pages 19-69.

Collerson, K.D., Jesseau, C.W. and Bridgwater, D.
1976: Crustal development of the Archean gneiss complex, eastern Labrador. *In* The Early History of the Earth. *Edited by* B.F. Windley. New York, John Wiley and Sons, pages 237-253.

Collerson, K.D., Kerr, A., Vocke, R.D. and Hanson, G.N.
1982: Reworking of sialic crust as represented in late Archean-age gneisses, northern Labrador. Geology, volume 10, pages 202-208.

Douglas, R.J.W.
1972: A revision of Precambrian structural provinces in northeastern Quebec and northern Labrador: Discussion. Canadian Journal of Earth Sciences, volume 9, pages 925-929.

Douglas, C.
1976: Mineral occurrence tables, Labrador. Mineral Development Division, Newfoundland Department of Mines and Energy, Open File Lab. 326.

Ermanovics, I.F., Korstgaard, J.A. and Bridgwater, D.
1982: Structure and lithological chronology of the Archean Hopedale block and the adjacent Proterozoic Makkovik Subprovince, Labrador,

Report 4. Geological Survey of Canada, Paper 82-1, part B, pages 153-165.

Fahrig, W.F.
1970: *In* Age determinations and geological studies, K-Ar isotopic ages, Report 9. Geological Survey of Canada, Paper 69-2A, pages 75-76.

Flinn, D.
1965: On the symmetry principle and the deformation ellipsoid. Geological Magazine, volume 102, pages 36-45.

Gower, C.F., Ryan, A.B., Bailey, D.G. and Thomas, A.
1980: The position of the Grenville Front in eastern and central Labrador. Canadian Journal of Earth Sciences, volume 17, pages 784-788.

Greene, B.A.
1970: Geological map of Labrador. Mineral Development Division, Newfoundland Department of Mines and Energy.

Knight, I. and Morgan, W.C.
1981: The Aphebian Ramah Group, northern Labrador. *In* Proterozoic Basins of Canada. *Edited by* F.H.A. Campbell. Geological Survey of Canada, Paper 81-10, pages 313-330.

McGregor, V.R.
1973: The Precambrian gneisses of the Godthaab district, West Greenland. Royal Society of London, Philosophical Transactions, Series A, volume 273, pages 343-358.

Morgan, W.C.
1975: Geology of the Precambrian Ramah Group and basement rocks in the Nachvak Fiord - Saglek Fiord area, north Labrador. Geological Survey of Canada, Paper 74-54, 42 pages.

1979: Geology Nachvak Fiord - Ramah Bay, Newfoundland - Quebec. Geological Survey of Canada, Map 1469A.

Myers, J.S.
1973: Igneous structures and textures in the Majorqap qava outcrop of the Fiskenaesset anorthosite complex. Rapport Grønlands geologiske Undersøgelse, volume 51, pages 47-53.

1975: Igneous stratigraphy of Archean anorthosite at Majorqap qava near Fiskenaesset, south-west Greenland. Rapport Grønlands geologiske Undersøgelse, volume 74, page 27.

Ryan, B., Martineau, Y., Bridgwater, D., Schiøtte, L. and Lewry, J.
1983: The Archean - Proterozoic boundary in the Saglek Fiord area - Report 1. Duplicate publication in Newfoundland Department of Mines and Energy, Mineral Development Division, Current Research, Report 83-1 (this volume); and in Geological Survey of Canada Paper 83-1, part A (in press.).

Stockwell, C.H.
1963: Third report on structural provinces, orogenies and time-classification of rocks of the Canadian Precambrian Shield. Geological Survey of Canada, Paper 63-17, pages 125-131.

Taylor, F.C.
1971: A revision of Precambrian Structural Provinces in northeastern Quebec and northern Labrador. Canadian Journal of Earth Sciences, volume 8, pages 579-583.

1974: *In* Age Determinations and Geological Studies, K-Ar isotopic ages, Report 12. Geological Survey of Canada, Paper 74-2, page 56.

1979: Reconnaissance geology of a part of the Precambrian Shield, northeastern Quebec, northern Labrador and Northwest Territories. Geological Survey of Canada, Memoir 393.

Taylor, F.C., Bell, C.K., Reinhardt, E.W. and Skinner, R.
1969: Northeastern Quebec and northern Labrador, Quebec - Newfoundland. Geological Survey of Canada, Map 13-1968.

Taylor, F.C., Reinhardt, E.W., Froese, E. and Morgan, W.C.
1970: Northeastern Quebec and northern Labrador, Quebec - Newfoundland. Geological Survey of Canada, Map 8-1970.

Wiener, R.W.
1981: Tectonic setting, rock chemistry and metamorphism of an Archean gabbro-anorthosite complex, Tessiuyakh Bay, Labrador. Canadian Journal of Earth Sciences, volume 18, pages 1409-1421.

Windley, B.F., Herd, R.K. and Bowden, A.A.
1973: The Fiskenaesset Complex, West Greenland, Part 1: A preliminary study of the stratigraphy, petrology and whole rock chemistry from Qeqertarssuatsiaq. Grønlands geologiske Undersøgelse, Bulletin 106.