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Résumé de l'article

Previous work has shown that a major part ofthe Early Archean (>3500 Ma) rocks in Labrador north of Nain were reworked undergranulite-facies conditions between 2800and 2700 Ma. New U-Pb zircon data show that Middle Archean gneisses are more abundant than previously recognized. Their metamorphic histories differ from the historyof the Early Archean rocks. Part of the Middle Archean gneiss suite was emplaced direct lyin granulite faciès between 3250 and 3200Ma and was partly retrogressed at the time of granitoid veining ca. 2990 Ma. Only after ce.2700 Ma do Early and Middle Archean gneisses have similar histories. We suggest that the terrane model proposed for SW Greenland can be applied to Labrador and that terrane intercalation took place ca. 2700Ma. The Middle Archean gneisses north of Nain are likely to be tectonic slivers equivalent to the Maggo gneiss of the Hopedale area to the south. Correlation between the Middle Archean terrane of Labrador and the Akia terrane in SW Greenland is suggested.

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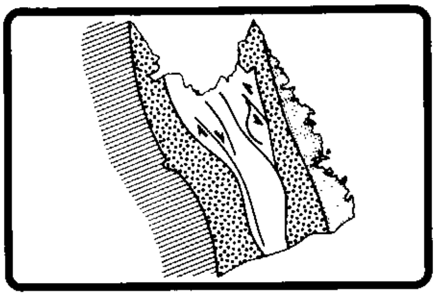

U-Pb mineral ages from northern Labrador: Possible evidence for interlayering of Early and Middle Archean tectonic slices

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Summary
Previous work has shown that a major part of the Early Archean (>3500 Ma) rocks in Labrador north of Nain were reworked under granulite-facies conditions between 2800 and 2700 Ma. New U-Pb zircon data show that Middle Archean gneisses are more abundant than previously recognized. Their metamorphic histories differ from the history of the Early Archean rocks. Part of the Middle Archean gneiss suite was emplaced directly in granulite facies between 3250 and 3200 Ma and was partly retrogressed at the time of granitoid veining *ca.* 2990 Ma. Only after *ca.* 2700 Ma do Early and Middle Archean gneisses have similar histories. We suggest that the terrane model proposed for SW Greenland can be applied to Labrador and that terrane intercalation took place *ca.* 2700 Ma. The Middle Archean gneisses north of Nain are likely to be tectonic slivers equivalent to the Maggo gneiss of the Hopedale area to the south. Correlation between the Middle Archean terrane of Labrador and the Akia terrane in SW Greenland is suggested.

Introduction
The Archean Nain Province of Labrador crops out in the south as the Hopedale block, and in the north as the Saglek block (Figure 1). An understanding of the chronology and geological evolution of these blocks is essential for comparative studies with the reworked Archean rocks being discovered in the interior of the Churchill Province.

A comparative chronology for the Saglek and Hopedale blocks is presented in Table 1. Since whole rock isotopic ages are imprecise and subject to secondary disturbance, only U-Pb zircon ages are quoted (Baadsgaard *et al.*, 1979; Loveridge *et al.*, 1987; Schiøtte, 1988; Schiøtte *et al.*, 1989a,b and the present study).

Hopedale block. The Hopedale block comprises the regional, quartzofeldspathic Maggo gneiss and small intercalations of the Weekes amphibolite and metasedimentary rocks. The field chronology was established by Ermanovics *et al.* (1982). U-poor zircons in a "Weekes metasediment" (Table 1) from the Hopedale block were dated at 3258±24 Ma (2σ) by Schiøtte *et al.* (1989b). The zircons are best interpreted as detrital grains of igneous origin, derived from an early phase of the Maggo gneiss. Most of the Hopedale block is in amphibolite facies, but Ermanovics *et al.* (1982) cite field evidence for a very early granulite-facies event in the western part of the block. If the igneous precursors to some of the Maggo gneiss were emplaced with primary granulite-facies parageneses, the low U contents of the *ca.* 3260 Ma zircons could be a reflection of U depletion under granulite-facies conditions. The Maggo gneiss was reworked during the Hopedalian and Fiordian events (Table 1).

Saglek block. The Saglek block consists largely of the Early Archean quartzofeldspathic Uivak gneiss, derived from a granitoid protolith. The Uivak gneiss is intruded by the cross-cutting, metamorphosed Saglek dykes, and occurs interspersed with narrow belts of supracrustal gneiss (the Nulliak and Upernavik associations). The Middle Archean Lister gneiss was, until recently, thought to be a volumetrically insignificant part of the gneiss complex.

A field chronology for the Saglek block between Saglek and Hebron fiords was established by Bridgwater *et al.* (1975). Within this largely granulite-facies block, there are small areas where the metamorphic grade

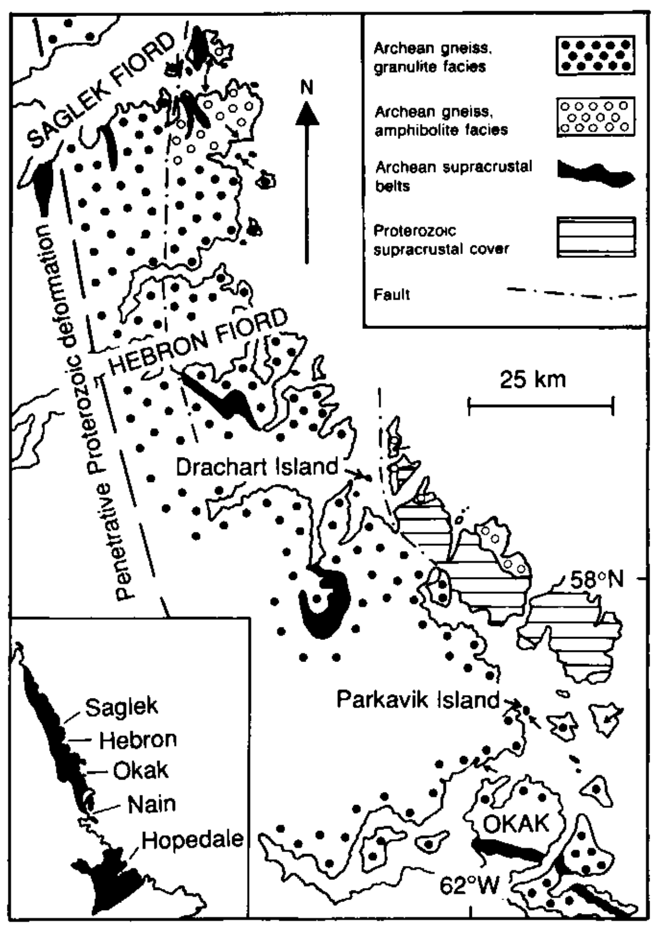

Figure 1 *Simplified geological map of the Saglek Fiord–Okak area. Inset shows the location of the area with respect to the Archean Saglek and Hopedale blocks, coast of Labrador. Arrows denote major occurrences of Middle Archean gneisses in the area.*

Table 1 Geological events in northern Labrador.

Approximate age (Ma)	Saglek block	Hopedale block	Approximate age (Ma)
3730–3860	Age range of rounded inclusions within igneous zircons in Uivak I gneiss. Deposition of Nulliak supracrustals (acid volcanism) dated at 3780 Ma.		
3730	Emplacement of tonalitic Uivak I gneiss.		
3620	Uivak I gneiss veined by leucocratic granitoids.		
	Emplacement of Uivak II augen gneiss.		
	Intrusion of porphyritic Saglek dykes.		
3240	*Emplacement of intermediate to mafic gneisses, partly in granulite facies.*	Age of detrital zircons in metasediment belonging to the Weeke's amphibolite association. Derived from early phase of Maggo gneiss?	3260
	Deposition of supracrustal rocks belonging to the Upernavik association?	Deposition of sediment belonging to the Weeke's amphibolite association?	
		Main phase of Maggo gneiss.	3100
	Intrusion of basic dykes, previously correlated with the main Saglek dykes.	Intrusion of Hopedale dykes.	
2990	*Emplacement of leucocratic granitoids into 3240 Ma gneisses.*	Hopedalian deformation, migmatization and metamorphism in upper amphibolite facies.	
	Tectonic intercalation of some orthogneisses and supracrustals.	Emplacement of the Kanairiktok granitoids followed by Fiordian deformation and metamorphism in lower amphibolite facies.	2840
2700–2800	High-grade metamorphism reaching granulite grade in a major part of the early Archean gneisses, partial melting and emplacement of leucocratic granitoid sheets with mixed crustal and juvenile isotopic signature.		
	Tectonic intercalation of Early and Middle Archean gneisses.		
2685 *	Discrete late-tectonic sheets cutting both Early and Middle Archean gneisses.		
2560	Intrusion of post-tectonic granites.		
	Intrusion of basic dykes.	Intrusion of basic dykes.	
	Early Proterozoic thermal event. Deformation along Proterozoic dykes.	Makkovikian deformation and metamorphism.	

* The procedure for U-Pb zircon dating of this rock was not very sophisticated (Schiøtte, 1988), and future work may result in second-order changes of the age.

Italics denotes events within the Saglek block that suggest correlation with the Hopedale block (see text for further explanation).

never exceeded amphibolite facies. The type occurrences of the Early Archean Uivak gneisses and the Middle Archean Lister gneiss are both located within such an area. In the field, the Early Archean rocks (*e.g.*, Uivak gneiss) are distinguished from younger rocks by the presence of the Saglek dykes (Bridgwater *et al.*, 1975). Primary contacts between Early and Middle Archean gneisses are obscured by later tectonism and often also by veins of post-tectonic granite. The granulite-facies metamorphism that affected a major part of the Early Archean Uivak gneisses took place significantly later than the Hopedalian and Fiordian events of the Hopedale block (Table 1).

Gneisses showing field resemblance to the Uivak gneiss extend well into the area between Hebron Fiord and Okak in the southern part of the Saglek block. Mafic granulite gneisses of uncertain affinity have also been identified. Again, primary contacts between contrasting rock types are obscured. Reconnaissance whole rock Pb-Pb and Sm-Nd studies (Schiøtte *et al.*, in press) suggest an Early Archean age for the "Uivak-like" gneisses, whereas the unassigned mafic granulite gneisses have a more juvenile Pb-Nd signature. In the present paper, preliminary conventional single zircon and monazite U-Pb data for representative gneiss samples from the Hebron–Okak area are presented. The data are discussed in the context of the existing data base and recent ideas about crustal evolution.

New zircon and monazite U-Pb data from the Hebron–Okak area

The data were produced at the Royal Ontario Museum. Zircon and monazite were hand-picked and abraded following the techniques of Krogh (1982). Mineral dissolution and extraction of Pb and U followed Krogh (1973) with minor modifications (Corfu and Ayers, 1984). Pb and U were loaded together onto outgassed single Re filaments using a Si-gel and run on a VG354 mass spectrometer in dynamic peak switching mode employing a Daly photomultiplier. U decay constants used are those of Jaffey *et al.* (1971). Total Pb and U blanks were <6 pg (10 pg for monazites) and 0.5 pg respectively. Non-radiogenic Pb in excess of the blank was assumed to have the composition of galena obtained from the Saglek area ($^{206}Pb/^{204}Pb$ = 12.22; $^{207}Pb/^{204}Pb$ = 13.88; $^{208}Pb/^{204}Pb$ = 32.11, G. Hanson, personal communication, 1981). Measured $^{206}Pb/^{204}Pb$ ratio was >2970 Ma for all those zircon grains that are crucial to the chronological arguments.

The Drachart Island sample (Figure 2; for location see Figure 1) belongs to the group of gneisses for which Early Archean whole rock Nd and Pb signatures were obtained. The oldest zircons dated (needle-shaped grains with igneous texture and U contents of a few hundred ppm) confirm the Early Archean age (>3560 Ma). One igneous zircon is concordant at 2780±3 Ma (2σ) and is interpreted as a second generation that grew when the gneiss remelted during granulite-facies metamorphism. There is a second-order difference between this age and the age of partial melting obtained during ion probe zircon dating of Uivak gneisses from further north (2744±4 Ma (2σ), Schiøtte *et al.*, 1989a). Round, chocolate-brown metamorphic zircons have grown both as separate grains and as overgrowths on grains of supposedly igneous origin. Their U contents are high (1000–2500 ppm), and the grains are near-concordant to slightly discordant (2%). Visual inspection of the analyzed grains from this group gave no evidence that would suggest an inherited component. If the highest $^{207}Pb/^{206}Pb$ age (2793±3 Ma (2σ)) is taken as a minimum age for the growth of these zircons, there is again a second-order difference between this age and ages obtained by ion probe zircon dating of Uivak gneisses

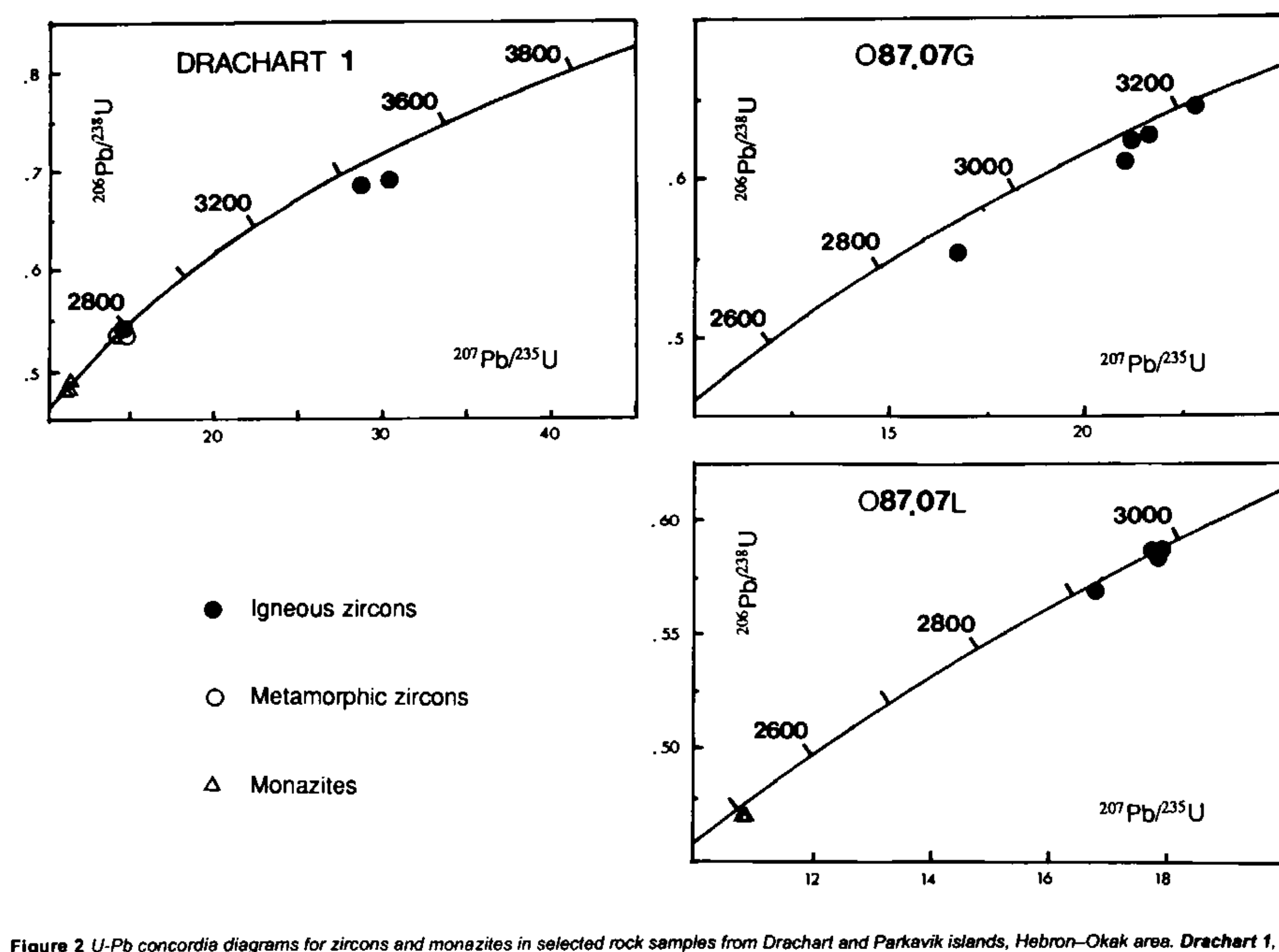

Figure 2 *U-Pb concordia diagrams for zircons and monazites in selected rock samples from Drachart and Parkavik islands, Hebron–Okak area.* ***Drachart 1****, Uivak gneiss melted at granulite facies on Drachart Island;* ***O87.07G****, granulite-facies gneiss on Parkavik Island;* ***O87.07L****, cross-cutting granitoid on Parkavik Island.*

from further north. We do not regard this difference as a bias arising from the use of two different analytical methods. A sequence of separate, but closely spaced, events (recrystallization, partial melting and further recrystallization) was suggested by the ion probe work and thus, the events recorded at Drachart Island could be particularly early ones. The possibility that the presently proposed ages are slightly too old due to the presence of a subtle inherited component should also be considered, in particular for the 2793±3 Ma chocolate-brown zircon which is about 2% discordant and thus could be on the lower part of a mixing line between 2780 Ma and a poorly constrained Early Archean age.

The gneiss on Parkavik Island (Figure 2; for location see Figure 1) belongs to the group of granulite-facies gneisses from which juvenile whole rock Pb and Nd compositions were measured. The oldest $^{207}Pb/^{206}Pb$ age (3219±3 Ma (2σ)) was obtained on the least discordant grain (barely on concordia within error). A broad correlation with the 3235±8 Ma (2σ) Lister gneiss further north (Schiøtte *et al.*, 1989a) is suggested. There is no indication that Parkavik Island ever experienced the granulite-facies metamorphism that affected the Early Archean gneisses between 2800 Ma and 2700 Ma. It is possible that the igneous body originally crystallized with granulite-facies parageneses. U contents as low as 30 ppm in the zircons may be a reflection of U depletion in the granulites. High U (370–1270 ppm) pink zircons from a cross-cutting, leucocratic granitoid sheet (Figure 2) suggest an emplacement age of *ca.* 2990 Ma (the oldest $^{207}Pb/^{206}Pb$ age is 2991±3 Ma (2σ)). Partial retrogression of the main Parkavik Island gneiss took place in intimate association with this event and predated the granulite-facies event affecting the Early Archean rocks by about 200 Ma.

Monazites from the Drachart Island gneiss and the discordant granitoid on Parkavik Island have yielded $^{207}Pb/^{206}Pb$ ages in the 2510–2570 Ma range and grew at the time of emplacement of a post-tectonic granite in the area (Baadsgaard *et al.*, 1979). From this time onward, the Early and Middle Archean gneisses shared similar geological histories.

Implications for the Saglek block

Orthogneisses of Lister gneiss age are volumetrically more important than previously thought in the gneiss complex north of Nain. More work on both Early and Middle Archean gneisses is needed to confirm that the pattern of contrasting metamorphic histories is consistent throughout the area, but, on the present evidence, we tentatively suggest that the Middle Archean gneisses are tectonically juxtaposed against (rather than intrusive into) an Early Archean "Uivak continent". The monazite ages from Drachart and Parkavik islands are minimum ages for the time of juxtaposition, but both Early and Middle Archean gneisses are cut by discrete pink granite sheets similar to sheets from the Saglek–Hebron area for which a preliminary age of 2685 Ma has been obtained (Schiøtte, 1988). Thus, juxtaposition is likely to have taken place *ca.* 2.7 Ga. The concentration of post-tectonic granites close to the lithological boundaries suggests that the emplacement of these granites could be controlled by suturing.

Inherited zircons of Uivak age have not been reported from the Middle Archean gneisses (neither the type Lister gneiss nor the presently studied gneisses), in accordance with our contention that the latter did not penetrate the old continent. However, it remains a puzzling fact that whole rock Nd and Pb data for the type (amphibolite-facies) Lister gneiss (Schiøtte, 1988, 1989) suggest a source that was already mildly U depleted and LREE enriched relative to the mantle at the time of emplacement (μ_1 as low as 7.38, ε_{Nd}= −0.66). Slight secondary changes of LREE/HREE ratios could have perturbed the initial ε_{Nd}, but small amounts of foreign unradiogenic Pb would have to have been introduced from outside to explain the low μ_1. Thus, the possibility that the Middle Archean gneisses in the amphibolite-facies area around Saglek Fiord were contaminated with Early Archean crust at the time of emplacement cannot be dismissed.

Comparisons between the Saglek and Hopedale blocks

The 3258±24 Ma age of the detrital zircons from the "Weekes metasedimentary unit" suggests that an early phase of the Maggo gneiss in the Hopedale block was contemporaneous with the Lister gneiss and the mafic gneiss of Parkavik Island. The low-U state of the zircons makes the similarity to Parkavik Island particularly striking. The Hopedalian and Fiordian events of the Hopedale block are substantially older than the granulite-facies event recorded by the Uivak gneisses in the Saglek block. Future high-precision zircon studies in the Hopedale block are needed in order to determine whether the Hopedalian event correlates with the *ca.* 2990 Ma event recorded on Parkavik Island. We tentatively suggest that it does, and that the Middle Archean gneisses in the Saglek block are tectonic slivers of a separate terrane represented by the Maggo gneiss in the Hopedale block. If our proposal is correct, the main structural trends in the two Archean blocks (although superficially similar) cannot be correlated.

A Greenlandic connection?

Our proposed model is inspired by the pattern of tectonically intercalated terranes that has been deduced in SW Greenland (summarized by Nutman *et al.*, 1989). Close similarities between the Early Archean rocks in northern Labrador and the similarly old Amîtsoq gneisses and associated rocks in SW Greenland were previously noted by Bridgwater *et al.* (1978). The emplacement ages of the Middle Archean orthogneisses in Labrador are not directly correlative with any published age from gneisses in SW Greenland. However, in terms of emplacement processes and metamorphic history, there are similarities between the Middle Archean Labrador gneisses and the Nûk gneisses of the Akia terrane (Nutman *et al.*, 1989) in SW Greenland. Both around Hopedale and in the Akia terrane, there are several orthogneiss phases, only a few of which have been dated. In both places, there are indications that some of these orthogneisses initially crystallized with granulite-facies parageneses and were retrogressed between 2.95 and 3.0 Ga in close association with the generation of anatectic granitoids (Garde, 1989).

Although no Nûk gneiss quite as old as the Lister gneiss has yet been identified, it is interesting that two detrital zircons from a metasedimentary rock belonging to the composite group called Malene supracrustals in SW Greenland have $^{207}Pb/^{206}Pb$ ages that agree, within error, with the age of the Lister gneiss. The weighted average for four of five $^{207}Pb/^{206}Pb$ measurements (analyses 3-2, 3-3, 11-1 and 11-2; Schiøtte *et al.*, 1988, table 3) suggests an age of 3227±8 Ma (2σ). The fifth analysis (3-4) was obtained close to the rim of a grain and was slightly younger. Schiøtte *et al.* (1988) regarded these zircons as Early Archean (Amîtsoq) grains that had suffered large amounts of early Pb loss. Emphasis was placed on their relatively high discordance. Since that publication, the standardization procedure for U/Pb ratios measured on the ion probe (SHRIMP) has been revised, and the grains now appear near concordant. We now suggest that they were derived from a Greenlandic equivalent to the Lister gneiss and that the Maggo gneiss, Lister gneiss, Parkavik Island gneiss and the type Nûk gneiss of the Akia terrane represent one and the same terrane.

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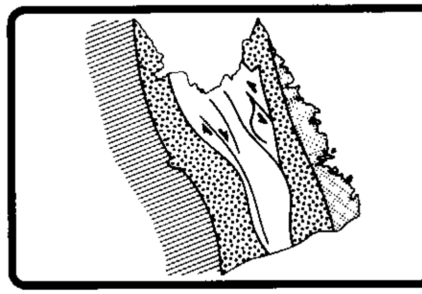

Late Archean geologic history of the Nain Province, North River–Nutak map area, Labrador, and its tectonic significance

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Summary
The high-grade gneisses of the Archean Nain Province were formed through Early and Late Archean orogenic cycles. Late Archean structural development consisted of pre-thermal-peak isoclinal folding and thrusting in allochthonous Upernavik supracrustal rocks, followed by regional, recumbent, isoclinal folding and upright refolding of the Upernavik suite and reworked Early Archean gneisses under amphibolite- to granulite-facies conditions. Style and sequence of the Late Archean structures closely resemble those described by previous workers from the Early Archean gneiss complex of the North Atlantic craton, from Precambrian greenstone belts, and from Phanerozoic orogenic belts, suggesting that no principal differences exist in the structural evolution of these types of terrain.

Introduction
The Archean Nain Province of the Laurentian Shield is a typical high-grade gneiss terrane that consists of 70–80% tonalitic orthogneiss and migmatite and up to 30% tectonic remnants of supracrustal rocks. The province has a complicated geologic history that involved both Early and Late Archean orogenic cycles, separated by the emplacement of the Saglek mafic dykes *ca.* 3.4–3.2 Ga (Bridgwater and Collerson, 1976; Collerson *et al.*, 1981).

The purpose of this paper is to describe the Late Archean structural and metamorphic evolution of the Nain Province in the North River–Nutak map area of northern Labrador (NTS maps 14E and 14F), located south of the Saglek–Hebron area described by Collerson *et al.* (1981).