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# The Torngat Orogen in the North River-Nutak transect area of Nain and Churchill provinces

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Résumé de l'article

The Archean Nain Province, part of the North Atlantic craton, collided obliquely with the eastern Churchill Province 1900-1800 million years ago. The eastern Churchill Province (Rae Province) and portions of the western Nain Province were deformed by sinistral transcurrent shear at syn- and post-peakgranulite- to amphibolite-facies conditions during the collislonal phase of the Torngatorogeny. Tectonic remnants of the Early Proterozoic Ramah Group were structurally inter-leaved with Nain Province rocks in the tectonic foreland during this orogeny. In the Churchill Province, the orogeny deformed felsic and mafic igneous rocks intruded into sediments deposited on a foredeep shelf of inferred metaplutonic rocks of the eastern Churchill Province. The effects of orogeny extend east of the tectonic foreland as waning metamorphic grade across 85 km of the Nain Province.

### Conclusions

Archean quartzofeldspathic gneisses and the lower Proterozoic Domes dykes contain mineral assemblages that indicate a widespread greenschist- to lower-amphibolite-facies overprint on the Nain craton resulting from collision with the Rae Province. The distribution of unaltered and altered clinopyroxene in the dykes can be used to define two regional zones, the most westerly one showing the greater degree of Hudsonian overprint. The Ramah Group, which originally rested unconformably on the peneplaned Nain craton and its dyke swarm, is now largely disposed as elongate slivers along the reactivated westernmost margin of the craton. The deformational history of the Ramah Group is considered to record early basement-cover translation ($D_1$) followed by upright to overturned folding ($D_2$). Younger overthrusts and steep reverse faults represent events that postdated the above main episodes of Early Proterozoic metamorphism and deformation. All events may be linked to an oblique collision between two Archean continental blocks during Early Proterozoic time (Korstgård *et al.*, 1987).

### Acknowledgements

The work on which this paper is based was carried out as part of a Geological Survey of Canada – Newfoundland Department of Mines and Energy mapping program in northern Labrador in 1982 and 1983. Subsequent discussions with R.J. Wardle, I.F. Ermanovics, M.J. Van Kranendonk and F. Mengel are acknowledged with pleasure. Ingo Ermanovics and Toby Rivers provided thoughtful reviews of the initial draft of this contribution. Published with the permission of B. Greene, Assistant Deputy Minister, Geological Survey Branch. Newfoundland Geological Survey Branch Contribution No. 90-02

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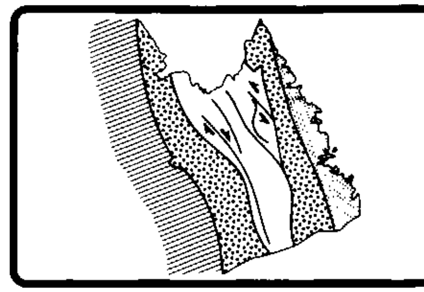

# The Torngat Orogen in the North River–Nutak transect area of Nain and Churchill provinces

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### Summary

The Archean Nain Province, part of the North Atlantic craton, collided obliquely with the eastern Churchill Province 1900-1800 million years ago. The eastern Churchill Province (Rae Province) and portions of the western Nain Province were deformed by sinistral transcurrent shear at syn- and post-peak granulite- to amphibolite-facies conditions during the collisional phase of the Torngat orogeny. Tectonic remnants of the Early Proterozoic Ramah Group were structurally interleaved with Nain Province rocks in the tectonic foreland during this orogeny. In the Churchill Province, the orogeny deformed felsic and mafic igneous rocks intruded into sediments deposited on a foredeep shelf of inferred metaplutonic rocks of the eastern Churchill Province. The effects of orogeny extend east of the tectonic foreland as waning metamorphic grade across 85 km of the Nain Province.

### Introduction

The Proterozoic Torngat Orogen of the eastern Churchill Province extends from the northern tip of the Labrador Peninsula (60°N, Figure 1) 550 km southward in rocks in fault contact with the Archean Nain Province. The orogeny deformed Early Proterozoic and older rocks of the Churchill and Nain provinces during Early Proterozoic (1860-1780 Ma, Bertrand *et al.*, 1990) transcurrent shearing at amphibolite- and granulite-facies conditions (Wardle, 1983; Korstgård *et al.*, 1987; Mengel, 1988). The northern and western limits of the Torngat Orogen remain indeterminate, but, based on criteria in the transect area, the western limit is known to extend at least 80 km into the Churchill Province (Van Kranendonk and Ermanovics, 1990; Bertrand *et al.*, 1990). Nain Province rocks adjacent to the Churchill Province were reworked at amphibolite facies in a 3–5 km wide structural foreland of the orogen. East of this foreland, the grade of Proterozoic metamorphism and the intensity of attendant deformation wane eastward across the Nain Province.

Three regional N-S trending lithotectonic units are recognized within a 155 km E-W transect across the Nain–Churchill boundary between 57°30′ and 58°N in the North River–Nutak map area of Labrador (Figure 1). As shown in Figure 2, these units include, from east to west, (a) the Nain Province, *ca.* 85 km wide (Taylor, 1979); (b) the Tasiuyak domain, 32 to 45 km wide (Churchill Province; Taylor, 1979); and (c) the Lac Lomier complex, more than 25 km wide (Churchill Province). The latter two constitute the Proterozoic Torngat Orogen.

**Nain Province**

The Torngat orogeny caused widespread retrogression in the Archean rocks and prograde metamorphism in Early Proterozoic tholeiitic dykes and cover rocks of the Nain Province (see also Ryan, 1990b). The province consists of polydeformed metaplutonic and supracrustal rocks at amphibolite to granulite facies (Ermanovics *et al.*, 1989), ranging in age from the Early to the Late Archean (Schiøtte *et al.*, 1990). These rocks were intruded by tholeiitic, SE- and ENE-striking Napaktok dykes that are probably similar in age to the 2200 Ma Kikkertavak dykes in the Hopedale block (Ermanovics and Ryan, 1990) and the Domes dykes in the Hebron area (Ryan, 1990b) that are characteristic of the North Atlantic craton in general (Bridgwater *et al.*, 1973).

The Nain Province and its Napaktok dykes are overlain unconformably by the Early Proterozoic Mugford and Ramah groups. The Mugford Group, located on the eastern margin of the province (Figure 2), is 1200 m thick and comprises basal, pyritiferous black shale and siltstone succeeded by pillowed flows, sills, breccia and shale (Taylor, 1979; Smyth, 1976). The base of the Mugford Group was locally tightly folded and thrust under lower greenschist-facies conditions. A few unmetamorphosed granitic bodies, less than 6 km in diameter, intruded the basement rocks around the Mugford Group *ca.* 1780 Ma (R. Emslie, personal communication, 1989). The grade of Proterozoic metamorphism in dykes and Nain Province gneisses increases progressively westward from the Mugford Group and attains amphibolite facies in the tectonic foreland of the Torngat Orogen, 80 km to the west.

Quartzite and pelite of the Ramah Group at amphibolite facies are located on the western margin of the Nain Province in the foreland of the Torngat Orogen (Figure 2), where they are intercalated with Nain Province gneiss. The sediments are part of the basal Rowsell Harbour Formation that is more extensively exposed in the Ramah fold and thrust belt north of Saglek Fiord (Figure 2) (Morgan, 1975). Foliations, subhorizontal lineations, and folds (all with a 340° azimuth) resulting from shear deformation during the Torngat orogeny are developed in this foreland and intensify westward, overprinting polydeformed Archean Nain rocks, Napaktok dykes, and earlier structures in the Ramah Group remnants (Van Kranendonk and Ermanovics, 1990). Zones of mylonite and ultramylonite with subvertical elongation lineations (dip-lineated mylonites) are common immediately west of, or within, the Ramah Group remnants and, in general, separate Proterozoic amphibolite-facies Nain Province rocks in the east from Proterozoic granulite-facies Churchill Province rocks in the west. Quartzofeldspathic gneisses devoid of Napaktok dykes occur immediately west of the dip-lineated mylonites. These gneisses may represent Nain Province rocks in which Napaktok dykes were not intruded, but they are assumed to be Churchill Province rocks foreign to the Nain Province. The dip-lineated mylonites may thus represent a late, major structural discontinuity separating the Churchill and Nain provinces. The two provinces are otherwise linked by similar orogenic structures and by progressive changes in metamorphic grade.

**Tasiuyak domain**

This domain comprises Tasiuyak gneiss, homogeneous charnockite gneiss (L>S), and the layered quartzofeldspathic gneiss devoid of Napaktok dykes (S>L) that forms a 500 to 2000 metre wide zone west of the dip-lineated mylonites. The Tasiuyak gneiss is a white and locally rusty, migmatitic, L-S tectonite composed of garnet (10–30%)-quartz-feldspar gneiss with variable and subordinate amounts (<10%) of sillimanite, biotite, graphite, sulphide, rutile and zircon. Concordant and discordant, white, garnetiferous feldspathic mobilizates at centimetre to metre scale are a pervasive feature and compose approximately 65% of the gneiss. Elongate, kilometre-scale bodies of white, garnetiferous perthite granite (S-type granite, diatexite) are prominent in the southwestern part of the domain (Figure 2, area 2). Interpretation of the major element geochemical data of Taylor (personal communication, 1988) suggests that the gneiss was derived from a protolith of psammitic and pelitic rocks.

The Tasiuyak gneiss is intruded by homogeneous, brown, gneissic charnockitic rocks that are most abundant along the eastern and western margins of the domain as units tens of metres to several kilometres wide and tens of kilometres long. The intrusive character of the charnockite is inferred from orthopyroxene-bearing leucosomes or veins

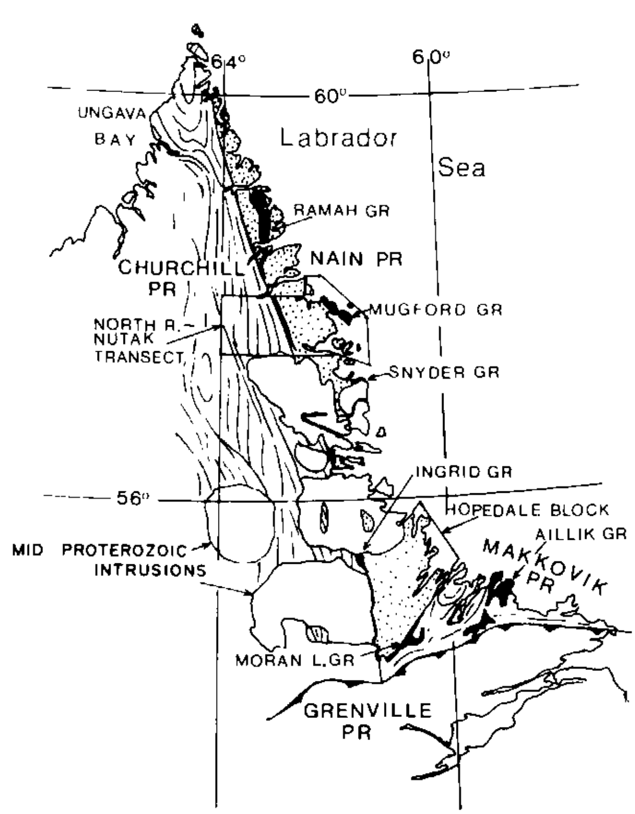


**Figure 1** *Location of North River–Nutak transect area in Labrador.*

that cut the Tasiuyak gneiss. Local, late-kinematic, white perthitic granitoid material, derived from the Tasiuyak gneiss, also intrudes the charnockite. Most contacts, however, are sharp and tectonic.

**Lac Lomier complex**
The Lac Lomier complex comprises homogeneous charnockitic rocks (as above), leuco- and mesocratic layered metaplutonic gneiss, amphibolite (derived from a volcanic protolith?), and layered metasedimentary rocks, possibly representing shallow water rock types, comprising paragneiss, marble, calcsilicate, rusty metapelitic rocks, rare iron-formation, and minor Tasiuyak-type gneiss. The supracrustal rocks form 10–15% of the complex, are concordantly deformed with the metaplutonic gneisses, and are intruded by and deformed together with the charnockitic rocks. Large elongate masses of the homogeneous charnockite are confined mainly to the transitional zone between the Lac Lomier complex and the Tasiuyak domain. Smaller, elongate charnockitic bodies in the central parts of the complex intrude migmatitic, layered, quartzofeldspathic rocks, and occur concordantly with enderbitic, dioritic and gabbroic orthogneiss. Locally complex, pre-granulite-facies migmatitic fabrics (early Early Proterozoic or Archean, *e.g.*, Ryan, 1990a) in the gneisses are tentatively interpreted as predating Torngat deformation, which suggests that the supracrustal rocks and intrusive charnockites may be the sole, late Early Proterozoic additions (about 40%) to the crust in the Lac Lomier complex. Tasiuyak gneiss occurs as a minor, infolded component of the Lac Lomier supracrustal rocks, which is in contrast to its extensive distribution in the Tasiuyak domain. The difference in the composition of metasedimentary rocks between the Lac Lomier complex and Tasiuyak domain may represent a preserved west to east facies change across a platform to rise, continental margin.

**Tectonic variation in the orogen**
Proterozoic sinistral shear fabrics occur throughout an 80 km wide belt of the transect area. Fabrics consist of a pervasive, shallowly N-plunging, mineral elongation lineation generally on subvertical schistosity. The regional fabric strikes N-S in a central structural area which is bordered by the 340°-trending Abloviak zone (20 km wide) in the east, and is transected by the Falcoz zone (10 km wide) in the west (Figure 2). Mylonitic and shear fabrics transpose an earlier metamorphic layering in almost all rocks except the homogeneous charnockitic intrusions, in which a single-phase syn-peak metamorphic mineral extension lineation (common to all rocks) is the only fabric (L>S).

Rocks oriented N-S in the Lac Lomier complex and the western Tasiuyak domain are deformed in rootless open folds (generally 1 to 2 km wide by up to 2 km long, and distributed in zones 55 km long) in which fold axes are subhorizontal and collinear with a N-S extension lineation defined by quartz, sillimanite, and orthopyroxene, ±biotite. These tracts of folded rocks are separated by, and are cut by, anastomosing subparallel zones of straightened gneiss, 3–7 km wide. In the Lac Lomier complex, granulite-facies mylonite forms some straight zones, but most zones of intense straightening are composed of granulite-facies gneiss injected by syn- and late-kinematic granitic material in amphibolite facies. Late brittle faults (shatter zones) with pseudotachylite injections and indications of oxidation and hydration commonly lace or border some of the intensely straightened zones.

In the Tasiuyak domain, the N-S fabrics intensify eastward from the area of open rootless folds (area 1, Figure 2) to an area in which moderate to steep opposing dips suggest folds having wavelengths of tens to hundreds of metres, but in which fold closures are absent (area 3, Figure 2). In the southern Tasiuyak domain, these areas are separated by a number of small, domal intrusions of lineated, white, garnet (±biotite), perthite megacrystic S-type granite (area 2, Figure 2) that appear to have oriented shear layering to shallow dips in domal portions of the intrusion (S. Hanmer, personal communication, 1989). The trend of these intrusions and attendant areas of migmatite strikes 340°, parallel with the Abloviak and Falcoz zones.

***Abloviak and Falcoz zones.*** The N-S structural fabric is bounded in the east by the Abloviak zone and is interrupted in the west by the Falcoz zone (Figure 2). Transposition of layering in the Tasiuyak domain of area 3 (Figure 2) intensifies eastward and the layers are progressively re-oriented into the Abloviak zone (area 4, Figure 2). In this zone, all layering is transposed to discontinuous centimetre- to millimetre-scale shear layers producing mylonitic fabrics; sparse, rootless isoclines occur at the metre scale. The transposition fabric and shallow, north-plunging, stretching lineation strike 340° and affect both the eastern Tasiuyak domain and the Nain Province, including its Ramah Group cover rocks in the tectonic foreland. The Abloviak zone is 20 km wide and extends at least 180 km to the NNW, overstepping the Tasiuyak gneiss to affect not only the Nain Province, but also rocks of the Lac Lomier complex (see Ryan, 1990b). The Abloviak

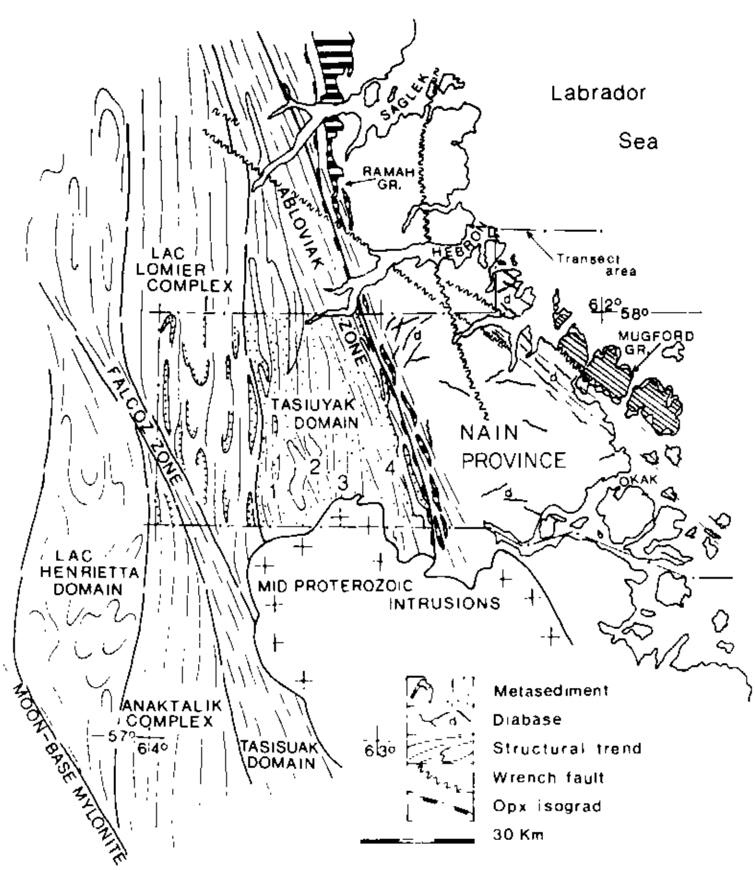


**Figure 2** *Nain Province and lithotectonic divisions of the Torngat Orogen. Lithologic detail shown in the transect area; numerals refer to areas discussed in text. Geology and structural trends in part after Taylor (1979) and from total-field aeromagnetic, shadowgram graphics, map 1MW NO20, Geophysics Division, Geological Survey of Canada. Terminology south of Falcoz zone after B. Ryan (personal communication, 1990).*

zone characterizes the deformational style of the eastern Torngat Orogen in the transect area (see Van Kranendonk and Ermanovics, 1990).

In the southwestern Lac Lomier complex, the regional N-S sinistral shear fabric rotates progressively to a 340° azimuth in granulite- to amphibolite-facies rocks of the 10 km wide Falcoz zone. The central part of this zone consists of mylonite derived from amphibolite-facies granitic rocks (5 km wide), which are injected by abundant syn-shear pegmatitic mobilizate. This zone, like the parallel Abloviak zone, may represent crustal-scale, sinistral extensional shears (see Girard, 1990), probably coeval with the N-S shear fabrics. The Falcoz zone is interpreted from aeromagnetic maps to extend into the Tasisuak domain 155 km to the SSE (Figure 2) (Ryan, 1990a).

**Geophysical interpretation of the Tasiuyak gneiss**

A gravity survey was conducted along the transect to interpret the configuration of the Tasiuyak domain at depth (T. Feininger and I. Ermanovics, unpublished data). Ninety stations were established with an average spacing of two kilometres. Rock samples were taken at 85 stations and 144 densities were measured. Densities of metaplutonic rocks of the Nain Province (2.72 g•cm$^{-3}$) and of the Lac Lomier complex (2.73 g•cm$^{-3}$) are statistically indistinguishable. The Tasiuyak gneiss is denser (density contrast = +0.065 g•cm$^{-3}$) than the average of the enclosing rocks, and distinct at the 85% confidence interval.

The residual positive gravity anomaly over the Tasiuyak domain has an amplitude of 19.3 mGal and is strongly asymmetrical, with a gentle western flank (~1 mGal•km$^{-1}$), and a steep eastern flank (~3.5 mGal•km$^{-1}$). Total-field aeromagnetic intensities, on the other hand, have relatively more gentle gradients to the east than to the west of a featureless low that corresponds with the Tasiuyak gneiss.

An interpretation based on two-dimensional gravity modelling of the Tasiuyak domain along 57°50'N suggests a prismatic body, about 13 km thick along the eastern side, tapering to a feather edge at the west. The hypothetical base of an upper crust overlying a denser lower crust with an assumed density contrast of +0.275 g•cm$^{-3}$ was calculated using the smoothed regional gravity profile.

**Discussion**

Our work has established that a part of the eastern Churchill Province, at least 80 km wide, was pervasively deformed by transcurrent sinistral shear under granulite- to amphibolite-facies conditions during the Torngat orogeny. Similar deformation, at amphibolite facies, is apparent in the tectonic foreland of the Nain Province up to 5 km east of the late mylonite faults. These steep, west-side up faults separate Churchill Province rocks from recognizable Nain Province rocks. Greenschist-facies metamorphism and localized mylonite formation, probably co-extensive with Torngat orogenesis, affected all of the Nain Province.

Protoliths of the Tasiuyak gneiss and supracrustal rocks of the Lac Lomier complex may be correlative continental shelf facies of Early Proterozoic age. The age of the Ramah and Mugford groups and their relationship to the Early Proterozoic supracrustal rocks of Churchill Province remain unknown.

High strain and metamorphism mask much of the pre-Torngat orogenic history of Churchill Province. The pre-shear history may be evident in the less strained, amphibolite-facies rocks west of the Lac Lomier complex (Ryan *et al.*, 1988; Ryan, 1990a). The rootless open folds of the central structural area can be interpreted as due to either early E-W crustal shortening extant throughout the Torngat Orogen prior to pervasive simple shear deformation, or to syn-shear buckling resulting from extreme extension (S. Hanmer, personal communication, 1989) (Figure 3). P-T vectors (decompression paths) from Abloviak zone rocks north of Saglek indicate that tectonic burial to at least 33 km (assuming 3.3 km per kbar) preceded, or less likely accompanied, transcurrent shear (Mengel and Rivers, 1989).

The residual, positive Tasiuyak gravity anomaly of about 20 mGal, located over the Tasiuyak domain, is explained by the relatively high density of the Tasiuyak gneiss. Aside from slight downwarping of the base of a hypothetical "upper crust" beneath the domain, no crustal discontinuity is evident at depth in the transect area. The thickened, 13 km deep portion of Tasiuyak gneiss along the eastern Abloviak zone may be a primary depositional feature of a "Tasiuyak basin", due to structural thickening, or both.

Structures across the orogen are consistent with the indenter model of Watterson (1978), whereby the Archean North Atlantic craton was indented northward into, and overridden by, the Proterozoic Nagssugtoqidian mobile belt in Greenland. This NW relative motion was accompanied by sinistral transcurrent shear along the western margin of the craton during oblique collision with the eastern Churchill Province during the Torngat orogeny *ca.* 1860-1780 Ma.

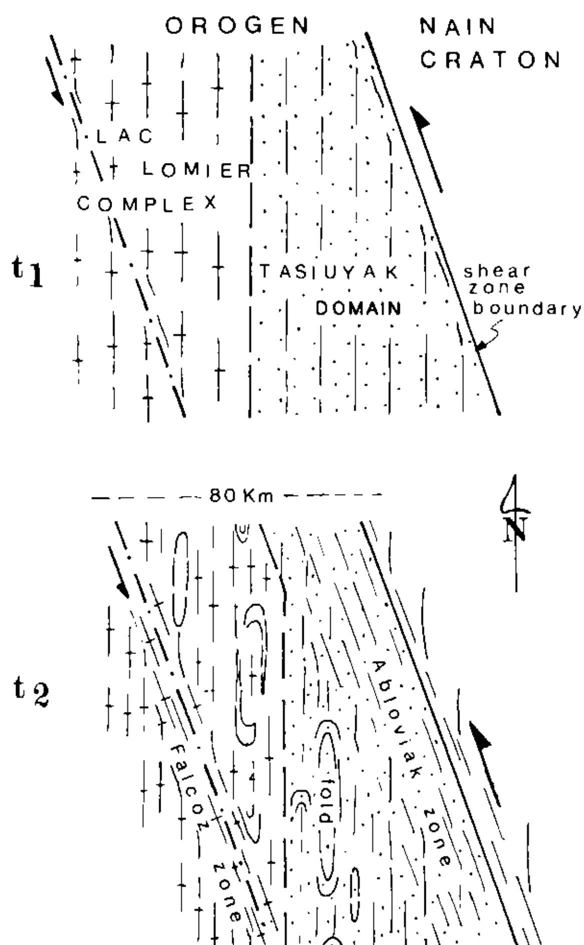


**Figure 3** *The shear regime in the Torngat Orogen at time 1 and 2. In this model, kilometre-scale, open, rootless folds result from syn-shear buckling during N-S extension of metamorphic layers.*

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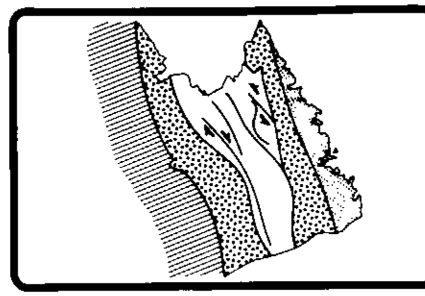

# Structural evolution of the Hudsonian Torngat Orogen in the North River map area, Labrador: Evidence for east-west transpressive collision of Nain and Rae continental blocks

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**Summary**

The Hudsonian Torngat Orogen in the North River map area, Labrador, evolved through: (1) early thrusting and associated isoclinal folding in lower Proterozoic supracrustal cover rocks, and the development of a regional tectonic fabric at peak metamorphic grade; (2) folding and intense shearing on subvertical planes, characterized by a subhorizontal NNW-plunging extension lineation during sinistral transpression; and (3) E-directed thrusting during uplift of the orogen. These structures are interpreted as progressive features that resulted from E-W oblique collision of the Archean Nain and Rae continental blocks across a 160°-striking boundary.

**Introduction**

The Hudsonian Torngat Orogen of the Laurentian Shield is located between, and deforms the margins of, the sialic nuclei of the Archean Nain and Rae provinces (Figure 1). Previous workers identified characteristic NNW-trending, subhorizontally lineated sinistral shear fabrics that formed under high-grade metamorphic conditions, and E-directed thrusts along the eastern orogenic front that telescoped the gradational E-W metamorphic gradient associated with the earlier shearing (Morgan, 1975; Ryan *et al.*, 1983; Mengel, 1988). Some authors considered these struc-