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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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Résumé de l'article

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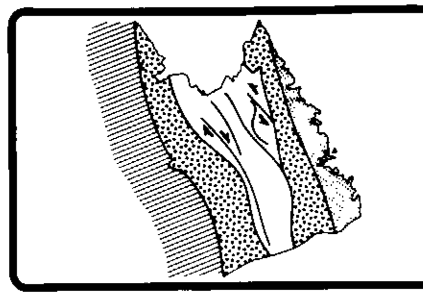

Structural evolution of the Hudsonian Torngat Orogen in the North River map area, Labrador: Evidence for east-west transpressive collision of Nain and Rae continental blocks

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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 structures to have formed through progressive deformation in a sinistral transpressive regime (Wardle, 1983; Korstgård *et al.*, 1987). Alternatively, Mengel (1988) interpreted these structures as resulting from two orogenic events, separated in time by uplift of the high-grade transcurrent shear zone and by deposition of the lower Proterozoic Ramah Group.

This paper describes the structural evolution of the Torngat Orogen in the North River map area of Labrador (NTS map 14E), and develops a geotectonic model for its evolution through E-W transpressive collision of Nain and Rae continental blocks across a 160°-striking margin.

Principal lithologic elements

The Torngat Orogen in the map area comprises five lithologic assemblages from east to west (Figures 1 and 2: see also Ermanovics and Van Kranendonk, 1990):

(1) Re-worked Archean granulite- to amphibolite-facies gneisses and sheared Early Proterozoic Napaktok diabase dykes of the Nain Province (see review by Van Kranendonk and Helmstaedt, 1990);

(2) A previously unknown, discontinuous tectonic sliver of Early Proterozoic Ramah Group supracrustal rocks that is up to 2 km wide and strikes 160°, parallel to the orogenic front and along strike of thicker, more pristine metasediments of the group to the north (Van Kranendonk, 1990). Metamorphosed to upper amphibolite facies, the group in the northern part of the map area retains an unconformable relationship with pinkish-weathering, altered Nain gneisses and Napaktok dykes. Further south, the group is more strongly deformed and all contacts with the basement are tectonic;

(3) A 0–4 km wide strip of mylonitic tonalite gneiss and migmatite that lacks Napaktok diabase dykes, has been affected by Hudsonian granulite-facies metamorphism, and contains many meta-anorthositic boudins. These rocks form the southernmost extension of a 350 km long strip of such rocks found along the eastern part of the orogen (Taylor, 1979; Figure 1). They are interpreted as an uplifted basal section of the Nain crust into which dykes were not emplaced;

(4) Mylonitic, migmatitic Tasiuyak paragneiss, derived S-type granitic rocks, and homogeneous, L-S charnockitic rocks of the Tasiuyak gneiss complex; and

(5) Polycyclic tonalitic orthogneiss and migmatite, mafic granulite, metasedimentary gneiss that is interpreted as the southern extension of the lower Proterozoic Lake Harbour Group (Figure 1), and homogeneous, L-S charnockitic rocks (identical to those in the Tasiuyak gneiss complex) of the Lac Lomier complex.

Hudsonian deformation

The Torngat Orogen in the transect area (Figure 2) can be structurally divided from east to west across lithologic boundaries into: the ***Foreland***, the eastern margin of which is defined as the eastern limit of penetrative Hudsonian foliation and which coincides roughly with the transition from Hudsonian greenschist to amphibolite facies; the ***Abloviak*** and ***Falcoz*** zones, which are 160°-striking zones of intense shear deformation; and the ***North River*** domain, located west of the Abloviak zone and characterized by N-S deformation fabrics (Figure 1).

Within the Foreland, three sets of Early Proterozoic structures have been recognized (Table 1)(Van Kranendonk, 1990). An S_1 foliation that cuts Archean gneissosity (S_n) strikes 160° parallel to the orogenic front, and is also present in Napaktok dykes, parallel to dyke margins. This foliation increases in intensity from east to west across the Foreland into the Ramah Group, where it forms a strong schistosity that is axial planar to rootless isoclinal folds of bedding. A set of easterly verging thrusts that imbricated the supracrustal rocks and basement gneisses is interpreted to have formed contemporaneously with folding and fabric development during tectonic thickening, as all these structures are folded by subsequent events (Van Kranendonk, 1990).

Archean structures in Nain gneisses and foliated Napaktok dykes have been deflected anti-clockwise into NNW strikes by D_2 sinistral simple shear. These rocks, and the S_1 schistosity and F_1 folds in Ramah Group rocks, are folded by F_2 folds that have a consistent S-sense of asymmetry. Westward within the Foreland, F_2 fold axes change from steeply to shallowly plunging and are subparallel to an increasingly more intense mineral elongation lineation (L_2).

D_2 structures in the Foreland pass westward into the 20 km wide Abloviak zone. There, transposed compositional layering in paragneiss and migmatite (S_1) is strongly sheared at granulite to amphibolite facies. The zone is characterized by a penetrative, shallowly NNW-plunging mineral lineation (L_2) and a subvertical, 160°-striking mylonitic schistosity (S_2) that contains abundant indicators of sinistral simple shear (*i.e.*, asymmetric extensional shears, rotated metamorphic porphyroblasts) and approximately E-W pure shear (*i.e.*, L-S shear fabrics, upright buckle folds) that formed between 1845 to 1830 Ma (Bertrand *et al.*, 1990).

In the southern part of the map area, the Abloviak zone transgresses the Ramah Group at amphibolite facies and affects Nain gneisses and Napaktok dykes for up to 4 km east of the group (Figure 2). The Ramah Group is folded into a 2 km wide antiform whose eastern limb contains abundant indicators of sinistral transcurrent shear. Folding occurs about subhorizontal, but variably plunging, axes. The western margin is bounded by a 400 m wide, subvertical zone of porphyroclastic ultramylonite and tectonic breccia (S_3; see below and Table 1), in which dominantly west-side-up movement also included a component of sinistral translation (S. Hanmer, personal communication, 1990). Alternating pelite and metaquartzite layers display subhorizontal and subvertical mineral elongation lineations, respectively. No overprinting relationships of these lineations or differences in metamorphic grade between the dip-lineated and transcurrent deformation zones were observed, suggesting that these fabrics may have formed contemporaneously within a transpressional deformation regime (Van Kranendonk, 1990).

Abloviak fabrics, striking 160°, grade into less intense N-S trending shear fabrics (S_2) and tight to open folds (F_2) of granulite-facies gneissic layering (S_1) in the North River domain. F_2 folds have moderately N-plunging axes that are parallel to a granulite-facies mineral elongation lineation (L_2). Fold limbs are commonly transposed (S_2). Pre-granulite, westward-verging thrusts are locally preserved in supracrustal remnants of the Lac Lomier complex. Charnockitic rocks intruded already partly migmatized rocks (S_1) of the Tasiuyak gneiss and Lac Lomier complexes at *ca.* 1860 Ma and contain D_2 L-S fabrics that developed during high-grade shearing between 1845 and 1830 Ma (see Bertrand *et al.*, 1990).

The Falcoz zone, which strikes 160° in the western part of the map area, is parallel to the Abloviak zone and deflects the N-S fabric of the North River domain at granulite to amphibolite facies (Figure 1). The Falcoz zone and the Moonbase zone farther south (see Ryan, 1990), are interpreted as crustal-scale, sinistral extensional shears within the regional N-S fabric domain.

The third set of structures comprises steeply dipping zones of ultramylonite and pseudotachylyte that are up to 200 m wide and show west-side-up, dip-slip movement. These ultramylonites are concentrated along the Foreland/Abloviak zone boundary, where they telescope the E-W metamorphic gradient associated with the sinistral shear deformation (*cf.* Mengel, 1988) and separate the Ramah Group from rocks to the west. The age of this deformation is bracketed by the emplacement ages of pre- to syn-kinematic granitoid rocks between 1805 and 1780 Ma, the same age as post-kinematic veins in the Abloviak zone (see Bertrand *et al.*, 1990).

Tectonic model and regional implications

Observations in the map area show three principal sets of structures associated with Torngat orogenesis: (1) S_1 metamorphic foliation in all rock units of the orogen, and oppositely verging thrusts and folds in the Ramah Group and metasedimentary remnants of the Lake Harbour Group; (2) regional N- and 160°-striking shear fabrics; and

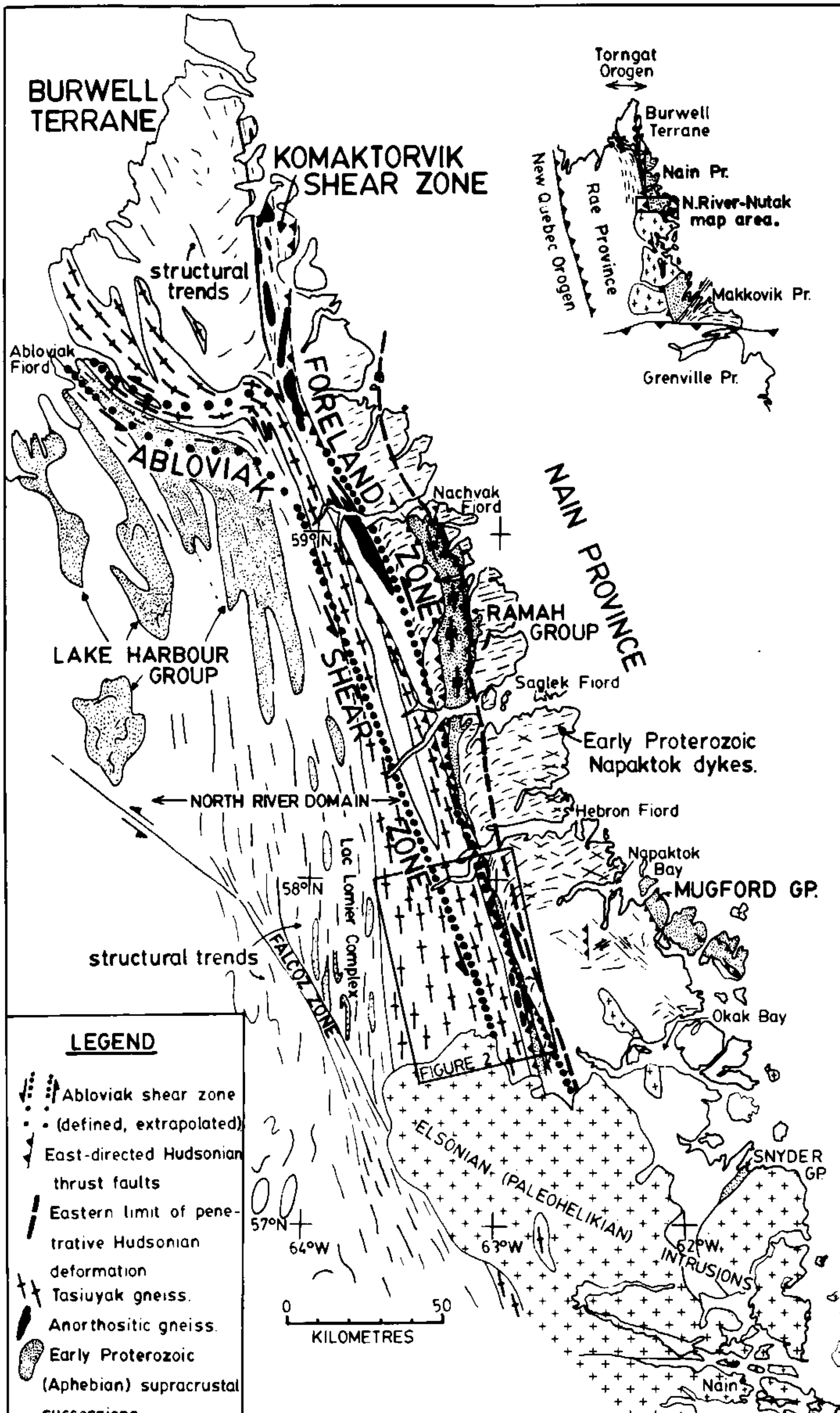

Figure 1 *Geology of the Hudsonian Torngat Orogen in eastern Québec and northern Labrador, showing the major lithologic units and structural subdivisions discussed in the text.*

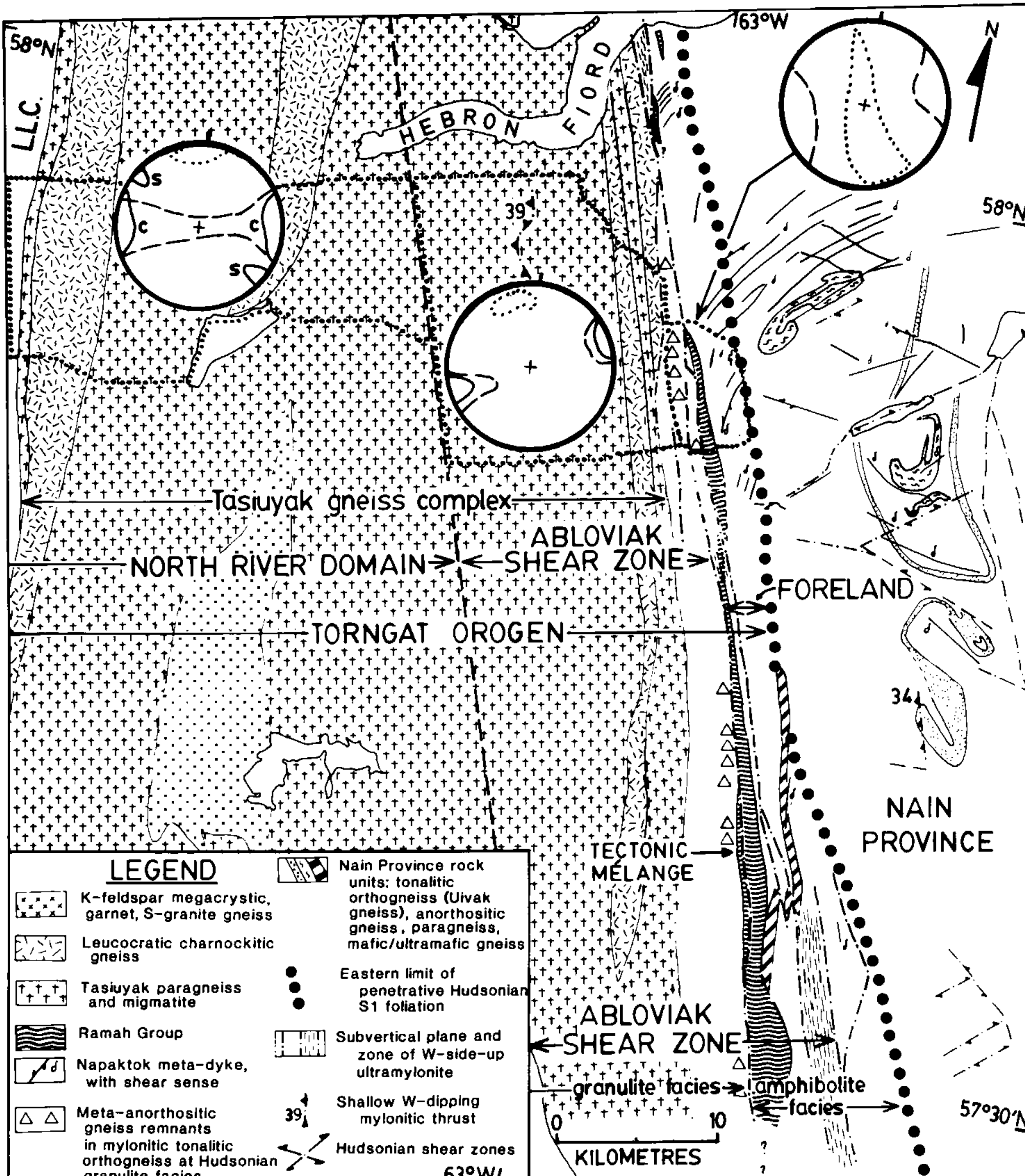

Figure 2 *Geology of the eastern Torngat Orogen in the North River–Nutak map area. Lambert equal-area stereoplots are of Hudsonian fabric elements from the regions outlined by small dots: dashed lines outline areas of poles to compositional layering (S_1); solid lines outline areas of poles to metamorphic foliation (S_2); dots outline areas of L_2 extension lineation and F_2 axes. C and S shear planes in the North River domain are marked on the net. L.L.C., Lac Lomier complex.*

(3) west-side-up zones of down-dip lineated ultramylonite and pseudotachylyte that are concentrated along the orogenic front. These structures are summarized in Table 1; each set may have been diachronous across the orogen. The Ramah Group contains all three sets of structures and was therefore deposited prior to all Hudsonian deformation.

Field and geochronological evidence indicate that these structures are related through progressive deformation caused by E-W transpressive collision of the Nain and Rae provinces across a 160°-striking boundary. In this model (Figure 3), the shelf facies Lake Harbour Group (west) and the flyschoid Tasiuyak gneiss sequence (east), and the Ramah Group were deposited on the opposing flanks of Rae and Nain continents, respectively, and were deformed by thrusting during tectonic thickening associated with the onset of orogeny. The N-S D_2 fabric of the North River domain is interpreted as the regional deep-level response to oblique collision with components of E-W pure shear and sinistral transcurrent shear (*i.e.*, buckle folds with transposed limbs). Oblique collision of the Nain and Rae provinces probably included a component of underthrusting of the Nain province, as indicated by east-directed thrusting along the orogenic front and by the exposure of deeper crust in the west. The homogeneous charnockitic rocks of the Tasiuyak gneiss and Lac Lomier complexes may

Table 1 **Sequences of structures across the Torngat Orogen.**

North River domain	*Abloviak zone*	*Ramah Group*	*Foreland*
S_1 = gneissic layering in all lithologic units and formation of west-verging thrusts in paragneiss	S_1 = transposed compositional and migmatitic layering	S_1 = schistosity axial planar to rootless isoclinal folds (F_1), and thrusts	S_1 = shear foliation in Napaktok metadykes
S_2 = weak axial planar fabric and transposed fold limbs	S_2 = subvertical mylonitic schistosity	S_2 = weak, upright foliation	S_2 = 160°-striking vertical quartz foliation in Nain gneisses
L_2 = metamorphic mineral elongation lineation parallel to F_2 axes	L_2 = shallow N- plunging mineral elongation parallel to F_2 axes	L_2 = strong mineral extension: in south, sub-horizontal in incompetent units, subvertical in competent units	L_2 = weak to moderately strong mineral elongation, parallel to F_2
F_2 = tight, upright folds of S_1 on shallow N-plunging axes	F_2 = rootless, isoclinal folds of S_1	F_2 = dominantly S-asymmetric folding parallel to L_2	F_2 = S-asymmetric folds of reworked Nain gneisses and foliated Napaktok dykes
S_3 = subvertical zones of cataclastic rock	S_3 = shallow W-dipping thrusts, and E-W tear faults	S_3 = steep, W-side-up zones of ultramylonite	S_3 = moderately W-dipping thrust zones of mylonite and pseudotachylyte
L_3 = downdip slickenside lineation	L_3 = downdip mineral elongation on thrusts	L_3 = subvertical mineral elongation	L_3 = downdip mineral elongation lineation

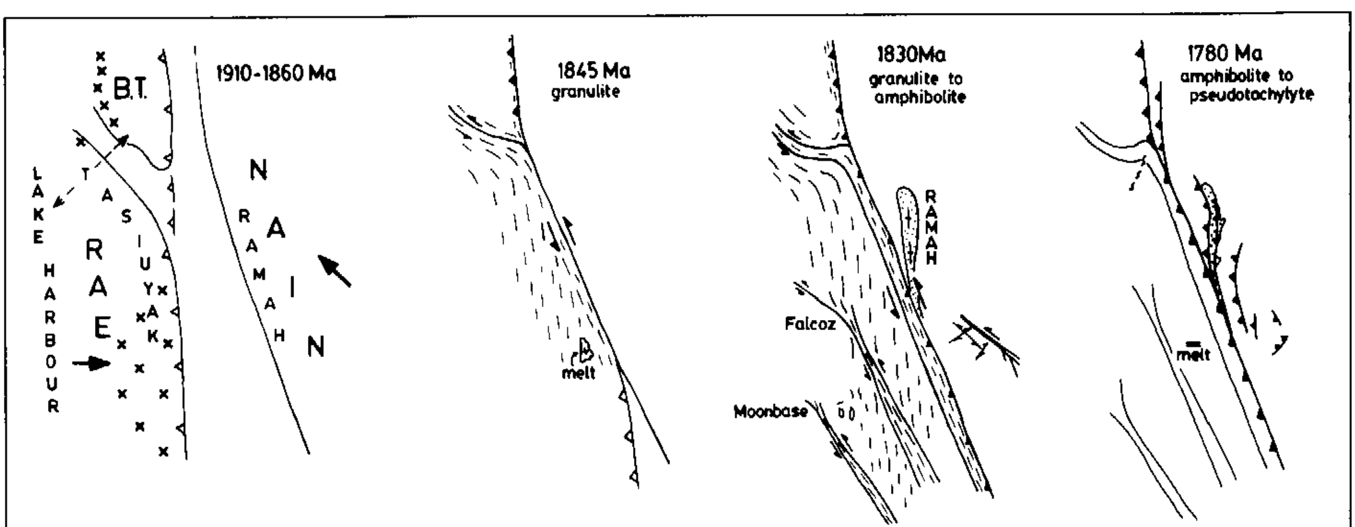

Figure 3 *Cartoon showing the conceptual development of the Torngat Orogen through east-west collision of Nain and Rae continental blocks across a 160°-striking margin.*

represent deep-level magmatic products of this subduction.

D_2 deformation was concentrated along the Abloviak zone, which followed the 160° strike of the Nain continental margin. Crustal-scale sinistral extensional shear bands (Falcoz and Moonbase zones) developed in order to compensate for the obliquity of the colliding margins and may have continued to slip late in the N-S shear regime (*i.e.*, amphibolite-facies mylonite in the Falcoz zone). In the northern part of the orogen, the presence of symmetrical, upright D_2 folds in the Ramah Group (Mengel, 1988; Figure 1) indicates that the group lay beyond the eastern limit of transcurrent shearing and was only affected by the shortening component of the deformation.

The dip-lineated mylonites along the orogenic front are interpreted to have been the loci for continued shortening across the orogen as it was exhumed from amphibolite facies. These mylonites outlived the bulk of the transcurrent component of the deformation. Dip-slip shearing apparently nucleated near the cryptic suture between the Nain and Rae provinces, and was subsequently concentrated along the Hudsonian granulite-amphibolite facies transition, probably due to competency and density contrasts between these metamorphic blocks.

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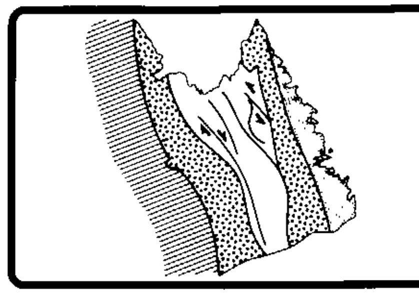

The synmetamorphic P-T-*t* path of granulite-facies gneisses from Torngat Orogen, and its bearing on their tectonic history

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Summary
Granulite-facies gneisses in the Abloviak shear zone in the internides of the Torngat Orogen are characterized by subvertical shear fabrics and associated subhorizontal stretching lineations. P-T vectors, derived from individual samples of these gneisses by conventional geothermobarometry of equilibrium core, rim and replacement symplectite assemblages, yield evidence of over 3 kbars decompression associated with cooling of approximately 150°C. When the sample population is considered together, a P-T-*t* path involving over 5 kbars decompression and 250°C cooling is defined. Such paths are compatible with theoretical models of synmetamorphic uplift following doubling of crustal thickness during thrusting, and imply that transcurrent motion took place in tectonically thickened crust, and was coeval with uplift. In a regional context, the Torngat Orogen preserves evidence of the oblique collision of two Archean cratonic blocks, the Nain and Rae provinces, during the Early Proterozoic and their amalgamation with Laurentia.

Introduction
There are several ways in which P-T-*t* paths can be evaluated in metamorphic rocks. In this study, we have opted to make quantitative estimates of P and T using geothermobarometry, and to couple these with relative estimates of *t* that can be determined from metamorphic microstructures. This