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U-Pb geochronological evidence for Archean crust in the continuation of the Rae Province (eastern Churchill Province), Grenville Front Tectonic Zone, Labrador

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Article abstract

In Labrador, the northerly-trending zonesof the Churchill Province are truncated at their southern margin by rocks of the Labrador Orogen within the Grenville Province. Churchill Province rocks locally extend into the Grenville Province where they are grada-tionally reworked. This paper describes thegeology of the central part of the Churchill Province (the Rae Province) in a 3700 km2 area lying astride the Grenville Front.

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References

Ashwal, L.D., Wooden, J.L., Wiebe, R.A. and Emslie, R.F., 1988, Isotopic signatures of Proterozoic intrusives in the eastern Canadian Shield as probes of older basement types: Geological Association of Canada — Mineralogical Association of Canada — Canadian Society of Petroleum Geologists, Program with Abstracts, v. 13, p. A3.

Bertrand, J.-M., Van Kranendonk, M.J., Hanmer, S., Roddick, C. and Ermanovics, I., 1990, Structural and metamorphic geochronology of the Torngat Orogen in the North River–Nutak transect area, Labrador: Preliminary results of U-Pb dating: Geoscience Canada, v. 17, p. 297-301.

Ermanovics, I., Korstgård, J. and Bridgwater, D., 1982, Structural and lithological chronology of the Archean Hopedale Block and adjacent Makkovik Subprovince, Labrador: Geological Survey of Canada, Paper 82-1B, p. 153-165.

Ermanovics, I.F., Van Kranendonk, M., Corriveau, L., Bridgwater, D., Mengel, F. and Schiøtte, L., 1988, Geology of North River – Nutak map-areas, Nain–Churchill provinces, Labrador: Geological Survey of Canada, Report 88-1C, p. 19-26.

Ermanovics, I.F. and Van Kranendonk, M.J., 1990, The Torngat Orogen in the North River – Nutak transect area of Nain and Churchill Provinces: Geoscience Canada, v. 17, p. 279-283.

GSC (Geological Survey of Canada), 1983, Tasisuak Lake, Newfoundland — Québec, 1:250,000 aeromagnetic map: Geological Survey of Canada, Map 35001G.

Girard, R., 1990, Evidence d'un magmatisme d'arc Protérozoïque inférieur (2.3 Ga) sur le plateau de la rivière George: Geoscience Canada, v. 17, p. 265-268.

Girard, R., Van Kranendonk, M.J. and Bealieu, R., 1990, The Falcoz Zone: map-scale shear bands in the Torngat Orogen: Geological Association of Canada — Mineralogical Association of Canada, Program with Abstracts, v. 16, p. A47.

Girard, R., Woussen, G., Bélanger, M. and Bowring, S., 1988, The Ntshukian magmatic event and its implications on the Labrador Trough tectonic evolution: Geological Association of Canada — Mineralogical Association of Canada — Canadian Society of Petroleum Geologists, Abstracts with Program, v. 13, p. A45.

Goulet, N. and Ciesielski, A., 1990, The Abloviak shear zone and the NW Torngat Orogen, eastern Ungava Bay, Québec: Geoscience Canada, v. 17, p. 269-272.

Hoffman, P.F., 1988, United plates of America, the birth of a craton: Early Proterozoic assembly and growth of Laurentia: Annual Reviews of Earth and Planetary Sciences, v. 16, p. 543-603.

Hoffman, P.F., 1990, Dynamics of the tectonic assembly of northeast Laurentia in geon 18 (1.9–1.8 Ga): Geoscience Canada, v. 17, p. 222-226.

Kalsbeek, F., Taylor, P.N. and Pidgeon, R.T., 1988, Unreworked Archean basement and Proterozoic supracrustal rocks from northeastern Disko Bugt, West Greenland: implications for the nature of Proterozoic mobile belts in Greenland: Canadian Journal of Earth Sciences, v. 25, p. 773-782.

Korstgård, J., Ryan, B. and Wardle, R., 1987, The boundary between Proterozoic and Archean crustal blocks in central West Greenland and northern Labrador, *in* Park, R.G., and Tarney, J., eds., Evolution of the Lewisian and Comparable Precambrian High-Grade Terrains: Geological Society of London, Special Publication No. 27, p. 247-259.

Krogh, T.E. and Heaman, L.M., 1989, Report on U-Pb results for the 1988/89 Labrador geochronology contract: unpublished report on file with Mineral Development Division, Newfoundland Department of Mines and Energy, St. John's.

Krogh, T.E., 1990, 1989–1990 Geochronology Report: unpublished report on file with Geological Survey Branch, Newfoundland Department of Mines and Energy, Open File 14D/40.

Myers, J.S., 1985, Stratigraphy and structure of the Fiskenaesset Complex, southern West Greenland: Grønlands Geologiske Undersøgelse, Bulletin 150, 72 p.

Nunn, G.A.G., Heaman, L.M. and Krogh, T.E., 1990, U-Pb geochronological evidence for Archean crust in the continuation of the Rae Province (eastern Churchill Province), Grenville Front Tectonic Zone, Labrador: Geoscience Canada, v. 17, p. 259-265.

Ryan, B., 1990, Basement-cover relationships and metamorphic patterns in the foreland of Torngat Orogen in the Saglek–Hebron area, Labrador: Geoscience Canada, v. 17, p. 276-279.

Ryan, B., Lee, D. and Corriveau, L., 1987, Geology of the eastern Churchill Province between Anaktalik Brook and Cabot Lake (NTS 14D/2,6,7), Labrador: Newfoundland Department of Mines and Energy, Mineral Development Division, Report 87-1, p. 155-159.

Ryan, B., Lee, D. and Dunphy, D., 1988, The discovery of probable Archean rocks within the Labrador arm of the Trans-Hudson Orogen near the Labrador-Québec border (NTS 14D/3,4,5 and 24A/1,8): Newfoundland Department of Mines and Energy, Mineral Development Division, Report 88-1, p. 1-14.

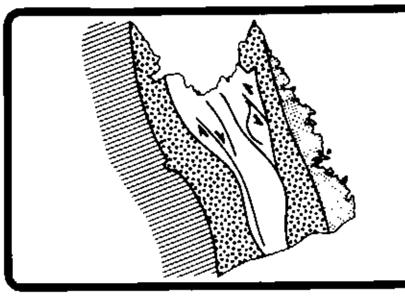
Taylor, F.C., 1979, Reconnaissance geology of a part of the Precambrian Shield, northeastern Québec, northern Labrador and Northwest Territories: Geological Survey of Canada, Memoir 393, 99 p.

van der Leeden, J., Bélanger, M., Danis, D., Girard, R. and Martelain, J., 1990, Lithotectonic domains in the high-grade terrain east of the Labrador Trough, *in* Lewry, J.F. and Stauffer, M.R., eds., Trans-Hudson Orogen of North America: Geological Association of Canada, Special Paper 37, p. 371-386.

Wardle, R.J. and Bailey, D.G., 1981, Early Proterozoic sequences in Labrador, *in* Campbell, F.H.A., ed., Proterozoic Basins of Canada: Geological Survey of Canada, Paper 81-10, p. 331-359, supplement.

Wardle, R.J., Ryan, B., Nunn, G.A.G. and Mengel, F.C., 1990, Labrador segment of the Trans-Hudson Orogen: crustal development through oblique convergence and collision, *in* Lewry, J.F., and Stauffer, M.R., eds., The Early Proterozoic Trans-Hudson Orogen of North America: Geological Association of Canada, Special Paper 37, p. 353-370.

Wiener, R.W., 1981, Tectonic setting, rock chemistry and metamorphism of an Archean gabbro-anorthosite complex, Tessiuyakh Bay, Labrador: Canadian Journal of Earth Sciences, v. 18, p. 1409-1422.



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Summary

In Labrador, the northerly-trending zones of the Churchill Province are truncated at their southern margin by rocks of the Labrador Orogen within the Grenville Province. Churchill Province rocks locally extend into the Grenville Province where they are gradationally reworked. This paper describes the geology of the central part of the Churchill Province (the Rae Province) in a 3700 km² area lying astride the Grenville Front.

The eastern part of the area, the Orma domain, consists of supracrustal rocks intruded by, and infolded into, orthogneiss. The supracrustal unit is dominated by mafic volcanic and pelitic rocks with subordinate psammite, felsic volcanic rocks, quartzite and conglomerate. The orthogneiss unit consists of foliated to gneissic tonalite and granodiorite. Both units are intruded by a plutonic suite of granite, diorite and gabbro. U-Pb zircon geochronology of four tonalite samples indicates that the majority of orthogneiss in the Orma domain was emplaced in the Late Archean (2682–2675 Ma). These data confirm earlier ideas that parts of the Rae Province consist of reworked Archean crust. U-Pb results of both zircon and titanite analyses from the same samples indicate a

Labradorian Pb-loss, but show no influence by either the Hudsonian or Grenvillian orogenies on the U-Pb isotopic systematics.

Introduction

Central Labrador lies near the convergence of the Nain, Makkovik, Churchill and Grenville Provinces. The Superior Province is only 200 km to the west, and, in addition, the Grenville Province incorporates the older Labrador Orogen near its northern margin (Figure 1). Consequently, the rocks in the region might record the effects of Archean (2500 Ma or older), Hudsonian (*ca.* 1950– 1750 Ma), Labradorian (*ca.* 1700–1600 Ma), or Grenvillian (*ca.* 1150–950 Ma) orogenesis. The study area was thought to contain Hudsonian, "Paleohelikian" (Labradorian) and Grenvillian structures (Nunn and Noel, 1982), but only the latter were known with any degree of confidence. The dating program was aimed at the pre-Labradorian history and in particular at the timing of emplacement and amphibolite-facies metamorphism of a regional orthogneiss unit.

The map area spans the boundary of the Rae Province with the Grenville Province (Figure 1). The "Grenville Front" (Figure 2) is defined within the map area as the approximate northern limit of Grenvillian (*ca.* 1.0 Ga) deformation. Immediately south of the front is an area of non-penetrative Grenvillian deformation, commonly referred to as the Grenville Front Tectonic Zone (GFTZ; Wynne-Edwards, 1972), in which the effects of Grenvillian tectonism and metamorphism increase southward. The tectonic features consist of folds and cleavage in cover rocks, and faults and anastomosing shear zones in plutonic and basement rocks; these structures occur in the greenschist facies in southern parts of the map area.

Labradorian structure consists of a non-penetrative protoclastic to low-grade foliation that is only recognized in the Trans-Labrador Batholith (TLB) and its coeval cover rocks. No equivalents of the high-grade Labradorian fabrics that predate the TLB and characterize the rocks south of the batholith (Thomas *et al.*, 1985, 1986) have been found to the north of the TLB.

The eastern Churchill Province (Figure 1) of Labrador and Québec exhibits a three-fold division (Wardle *et al.*, 1990). The central division, or Rae Province, forms the hinterland to the New Québec and Torngat Orogens (Hoffman, 1989) and is composed of orthogneiss of largely unknown age in association with lower Proterozoic supracrustal rocks and minor lower Proterozoic plutonic rocks. The eastern Churchill Province underwent its last major deformation during the Hudsonian Orogeny (*ca.* 1.8 Ga) at the time of aggregation of Archean cratonic nuclei and lower Proterozoic mobile belts to form the proto-Laurentian Shield. Although previous isotopic work (*e.g.*, Ashwal *et al.*, 1986) has suggested the presence of reworked Archean crust in the Rae Province, it is only recently that U-Pb dating (*e.g.*, this paper; Machado *et al.*, 1989; Ryan, 1990) has begun to confirm this suspicion.

Orthogneiss and supracrustal rocks of the Rae Province extend across the front into the GFTZ where they are both intruded by granite belonging to a gabbro, diorite and granite plutonic suite of unknown age. In the east of the map area, where intrusive relationships between the supracrustal rocks and tonalite precursors of the orthogneiss are present, this association comprises the Orma domain (Wardle *et al.*, 1990) and provides the first record (this paper) of Archean supracrustal rocks amongst Rae Province gneisses in this area. The westerly extent of the Orma domain is not yet known as relationships between the orthogneiss and a supracrustal unit, the Petscapiskau Group (Emslie, 1970; Figure 2), farther west are contradictory and the ages of that association remain uncertain.

The Orma domain

The Orma domain (Figure 2) is underlain by supracrustal rocks (eastern supracrustal unit, Figure 2), a granitoid orthogneiss unit and a younger plutonic suite of granite, gabbro and diorite.

The Orma domain supracrustal rocks consist of paragneiss, metasediment, and metavolcanic and related hypabyssal rocks. They are dominated by massive amphibolite, flattened pillow lavas and their amphibolite equivalents, and metagabbro (probably sills and small intrusions). Layered gabbro, metagabbronorite and amphibolitized, layered ultramafic rocks also occur with the mafic volcanic rocks and may be relicts of larger and/or deeper-level intrusions. The volcanic rocks are locally interlayered with hornblende (after pyroxene?) and/or plagioclase-porphyritic felsic tuffs, coarse plagioclase-porphyritic metagabbro (probably cumulate sills), sillimanite paragneiss, semipelitic to

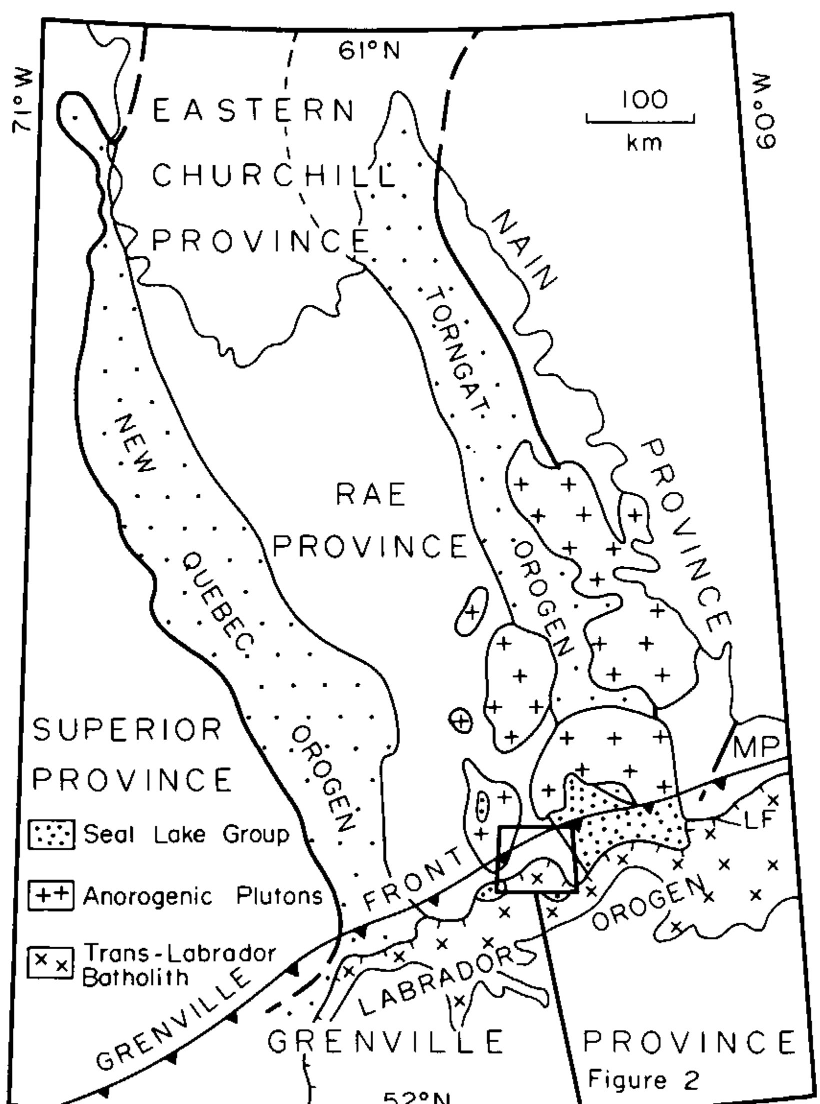

Figure 1 *Regional geology and location of the map area in Rae Province rocks spanning the Grenville Front. MP, Makkovik Province; LF, northern edge of Labrador Orogen.*

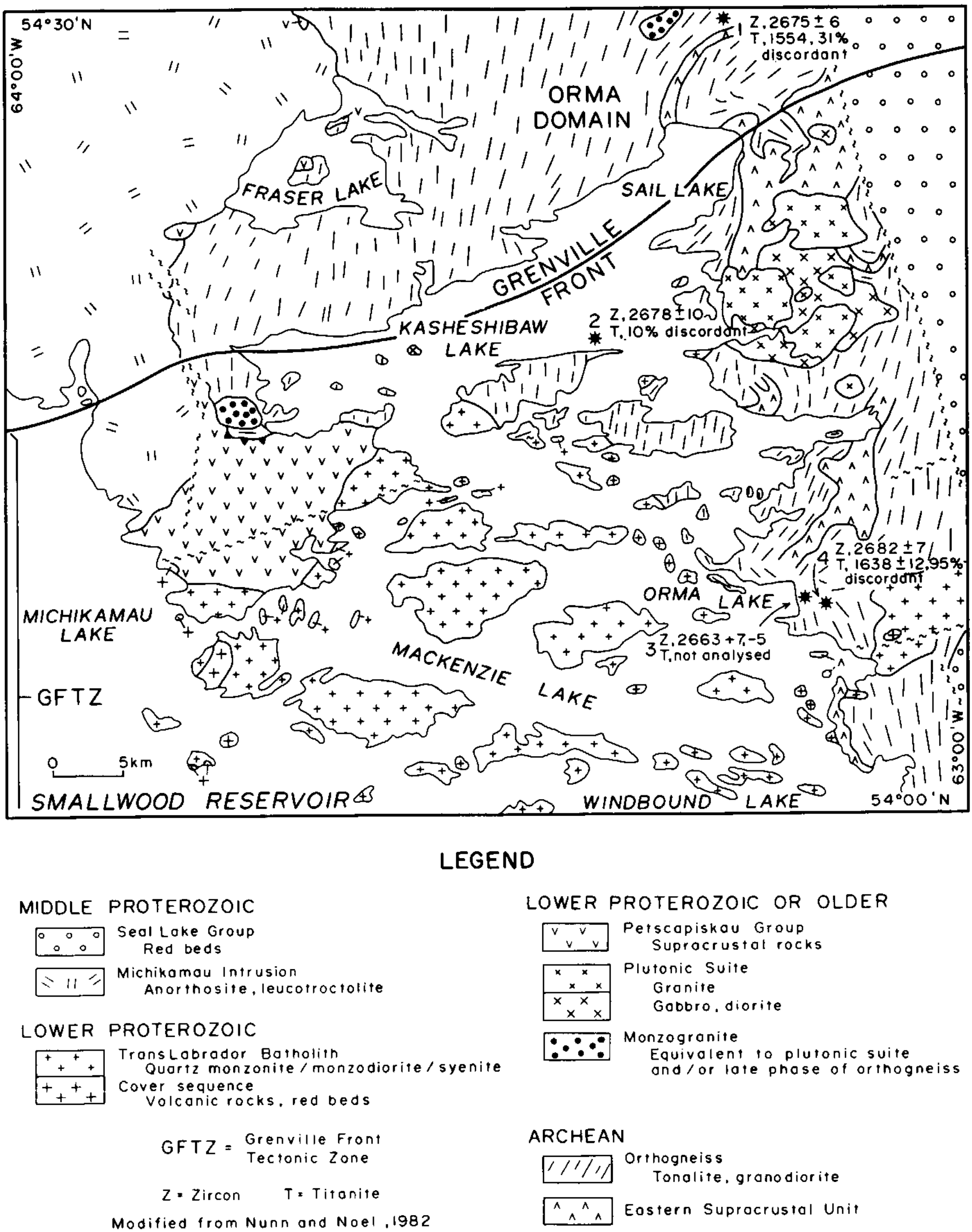

Figure 2 *General geology and location of dated samples. (Modified from Nunn and Noel, 1982).*

psammitic metasediment and white quartzite. Minor felsic pillow lava, finely bedded siliceous or volcaniclastic metasediment, polymict conglomerate and dominantly arkosic metasediments (of uncertain age) are also present. Metamorphosed felsic and mafic dykes intrude the supracrustal sequence, and all rocks contain variable amounts of pink granitic, or grey felsic, dykes and veins related to later migmatization. Strain states are very variable: lineations are typically well developed, but relict igneous textures are commonly visible normal to the stretching direction.

Tonalitic rocks of the orthogneiss unit intrude the metasedimentary rocks and the mafic volcanic and gabbroic rocks as dykes, and locally form agmatites. The bulk of the orthogneiss unit varies from foliated tonalite or granodiorite to stromatic gneiss. The main tonalite phase, the Orma Dyke tonalite (ODT), was coarse grained, but is now predominantly a strongly foliated and lineated, weakly gneissic, biotite±hornblende-bearing rock. Localized areas of polyphase intrusion with a range of coarse- to fine-grain sizes and quartz diorite through tonalite to granodiorite compositions are found in some areas. Foliation development is less intense in the post-ODT phases; however, similar grain size, texture and linear fabric orientations as those in the ODT suggest a syntectonic relationship for these phases. The granodiorite rocks appear to lack the outcrop-scale heterogeneity of the ODT, though this may be a function of the poor exposure. Earlier amphibolite, diorite and tonalite patches and inclusions, pre-tectonic diabase dykes and a host of later granitic and other felsic sheets and veins (as in some of the supracrustal rocks) complete the orthogneiss assemblage. Deformation-related changes in grain size and increases in the amounts of concordant or cross-cutting migmatization are the main structural variations within the orthogneiss unit. Scattered, strongly foliated, K-feldspar-porphyritic bodies of granodiorite to monzogranite composition may be a variant of the orthogneiss unit or may be related to the younger plutonic suite (see below).

Early deformation produced a migmatitic banding and folding in the early tonalite patches and in the paragneiss. These structures are cut by the main intrusive phases of the orthogneiss. The rocks then underwent major deformation, which resulted firstly in an incipient to well-developed migmatitic layering, and secondly in the production of penetrative LS-tectonites accompanied by lesser migmatization. The L-S fabrics, the result of a strong constrictional deformation, transposed any previous structures and produced isoclinal folds of layering. The foliation is defined by the stable ferromagnesian mineral assemblage of biotite+opaque+titanite±hornblende±garnet and the quartzofeldspathic components are also thoroughly recrystallized. Cores of large plagioclase and/or K-feldspar, and presumably zircon (see below), are the only relicts of the igneous mineralogy. Post-tectonic garnet and polygonal replacement of quartzofeldspathic aggregates indicate that recrystallization outlasted deformation in places. Later folds are not associated with fabric development.

The younger plutonic rocks form a spatially associated suite of gabbro, diorite and granite. Wherever contact relationships are seen, granite intrudes gabbro and diorite as well as the supracrustal and orthogneiss units. The gabbro is homogeneous or layered; some is recrystallized and grades into pyroxene, hornblende or biotite diorite. The gabbro and dioritic rocks contain patches of incipient migmatization, but fabrics are weak or absent except for rare shear zones. The granitic rocks are red, coarse-grained, non-megacrystic, undeformed to strongly lineated and/or foliated, biotite

Table 1 U-Pb zircon/titanite results for Archean tonalite samples, central Labrador.

Description	Weight	Concentration			Atomic Ratios **					Apparent Age (Ma)		
Sample Number / Fraction *	Sample (μg)	U (ppm)	Pb (ppm)	Common Pb (pg)	$^{206}Pb/^{204}Pb$	$^{208}Pb/^{206}Pb$	$^{206}Pb/^{238}U$	$^{207}Pb/^{235}U$	$^{207}Pb/^{206}Pb$	$^{206}Pb/^{238}U$	$^{207}Pb/^{235}U$	$^{207}Pb/^{206}Pb$
1, TONALITE (GN81-994)												
1 Z,ONM,a,cl,abr,(21)	112	89	54	9	34,052	0.2008	0.5087	12.7160	0.18131	2651	2659	2665
2 Z,ONM,a,cl,abr,(24)	130	95	56	9	44,193	0.1765	0.5078	12.6830	0.18116	2647	2656	2664
3 T,5M,a,o,abr	213	203	106	170	6,722	0.2094	0.4392	10.0197	0.16548	2347	2437	2512
4 T,5M,a,o,(29)	120	227	120	229	3,145	0.2192	0.4367	9.9611	0.16545	2336	2431	2512
2, TONALITE (GN81-1148)												
5 Z,ONM,b,cl,abr,(22)	25	242	132	10	18,559	0.1287	0.4847	11.7144	0.17527	2548	2582	2609
6 Z,ONM,b,cl,abr,(14)	12	228	128	8	9,613	0.1451	0.4921	11.9203	0.17569	2580	2598	2613
7 T,IF1.7A,a,o,abr,(52)	140	55	43	117	1,928	0.6804	0.4798	11.3388	0.17141	2526	2551	2572
3, TONALITE (GN84-021)												
8 Z,OM,a,cl	183	156	83	20	40,433	0.1438	0.4683	11.1685	0.17298	2476	2537	2587
9 Z,OM,a,cl,abr	153	120	71	172	3,561	0.1834	0.5020	12.4074	0.17924	2623	2636	2646
10 T,OM,a,cl,abr	19	76	45	84	5,233	0.1871	0.5053	12.5514	0.18017	2636	2646	2654
4, TONALITE (GN81-1196)												
11 Z,ONM,b,cl,abr,(27)	30	111	63	10	10,300	0.1723	0.4873	11.9277	0.17751	2559	2599	2630
12 Z,ONM,b,cl,abr,(13)	21	121	69	11	7,265	0.1679	0.4907	11.9971	0.17731	2573	2604	2628
13 T,5M,a,o,abr	103	337	122	126	4,995	0.2713	0.3012	4.4943	0.10821	1697	1730	1770

NOTES

* Mineral analyzed: ***Z*** = zircon; ***T*** = titanite. Magnetic susceptibility: ***NM,M*** = non-magnetic and magnetic at the indicated angle of side tilt on a Frantz Isodynamic Separator. ***IF1.7A*** refers to a magnetic split at a 10 degree side tilt at a current of 1.7 amps. Grain size (mesh): ***a*** = +100; ***b*** = -100+200. Colour: ***cl*** = colourless; ***o*** = orange. ***Abr*** = abraded (Krogh, 1982). The numbers in parentheses correspond to the total number of grains analyzed.

** Atomic ratios corrected for blank (zircon: Pb=10pg, U=5pg; titanite: Pb=15pg, U=5pg) and initial common Pb (Stacey and Kramers, 1975). Analytical procedures are outlined in Krogh (1973) and Heaman and Machado (in press). Error estimates (2 sigma) for intercept ages were calculated with the program of Davis (1982) using blanket errors of 0.25% and 0.05% (zircon) and 0.50% and 0.10% (titanite) for the uncertainty in the U/Pb and $^{207}Pb/^{206}Pb$ ratios, respectively. Decay constants for ^{238}U (1.55125×10^{-10} yr^{-1}) and ^{235}U (9.8485×10^{-10} yr^{-1}) are those recommended by Jaffey *et al.* (1971).

alkali-feldspar granite. They appear to have undergone a similar, but far less pervasive, constriction-type deformation to that in the orthogneiss unit, but lack evidence of earlier deformations.

The Orma domain rocks are in intrusive or tectonic contact with the Trans-Labrador Batholith (TLB) to the southwest, and fault contact with cover rocks of the Seal Lake Group to the east. Several satellite plutons of the TLB and arkosic metasedimentary pendants are present within the domain.

Post-Hudsonian rocks

These include the TLB, the Michikamau Intrusion and the Seal Lake Group (Figure 2). The granitoid TLB (Thomas *et al.*, 1986), which has an intrusive or structural contact with older rocks, is the major unit of the northern margin of the Labrador Orogen (Figure 1; Thomas *et al.*, 1985). The batholith was emplaced across the boundary between earlier rocks of the Labrador Orogen and the pre-assembled craton to the north, mostly at around 1650 Ma although some phases in the study area may be as young as 1570 Ma (see compilation of age data in Nunn *et al.*, 1985).

The pre-1460 Ma (Krogh and Davis, 1973) Michikamau Intrusion (Emslie, 1970) is one of a suite of anorogenic, anorthositic and granitoid complexes that intrude the Rae and Nain provinces and the Torngat Orogen (Figure 1; Emslie, 1978). Anorthosite and leucotroctolite are the main rock types. The Seal Lake Group is predominantly a continental red bed succession of Middle Proterozoic age (Wanless and Loveridge, 1978).

Geochronological results

The U-Pb results for zircon and titanite separated from four tonalite samples, collected from a 30 km transect across the Grenville Front region in central Labrador (Figure 2), are presented in Table 1 and on concordia diagrams (Figures 3a-d). Single populations of colourless, euhedral, prismatic zircons were recovered from all four samples, and are interpreted to represent igneous crystals with no visible evidence of core-overgrowth relationships. In addition, three samples contained abundant, orange titanite crystals of metamorphic origin. The range in uranium content for zircon (76–242 ppm) and titanite (55–337 ppm) is similar (Table 1).

From north to south (samples 1, 2, 3 and 4), the best estimates for the U-Pb upper intercept ages are 2675±6 Ma, 2678±10 Ma, 2663+7/-5 Ma and 2682±7 Ma. Sample 1 (Figure 3a), with a well-defined upper intercept of 2675±6 Ma, and sample 4 (Figure 3d), with a good mixing line between 2682±7 Ma and 1638±12 Ma, best constrain the upper intercept age. Sample 3 (Figure 3c) gives a

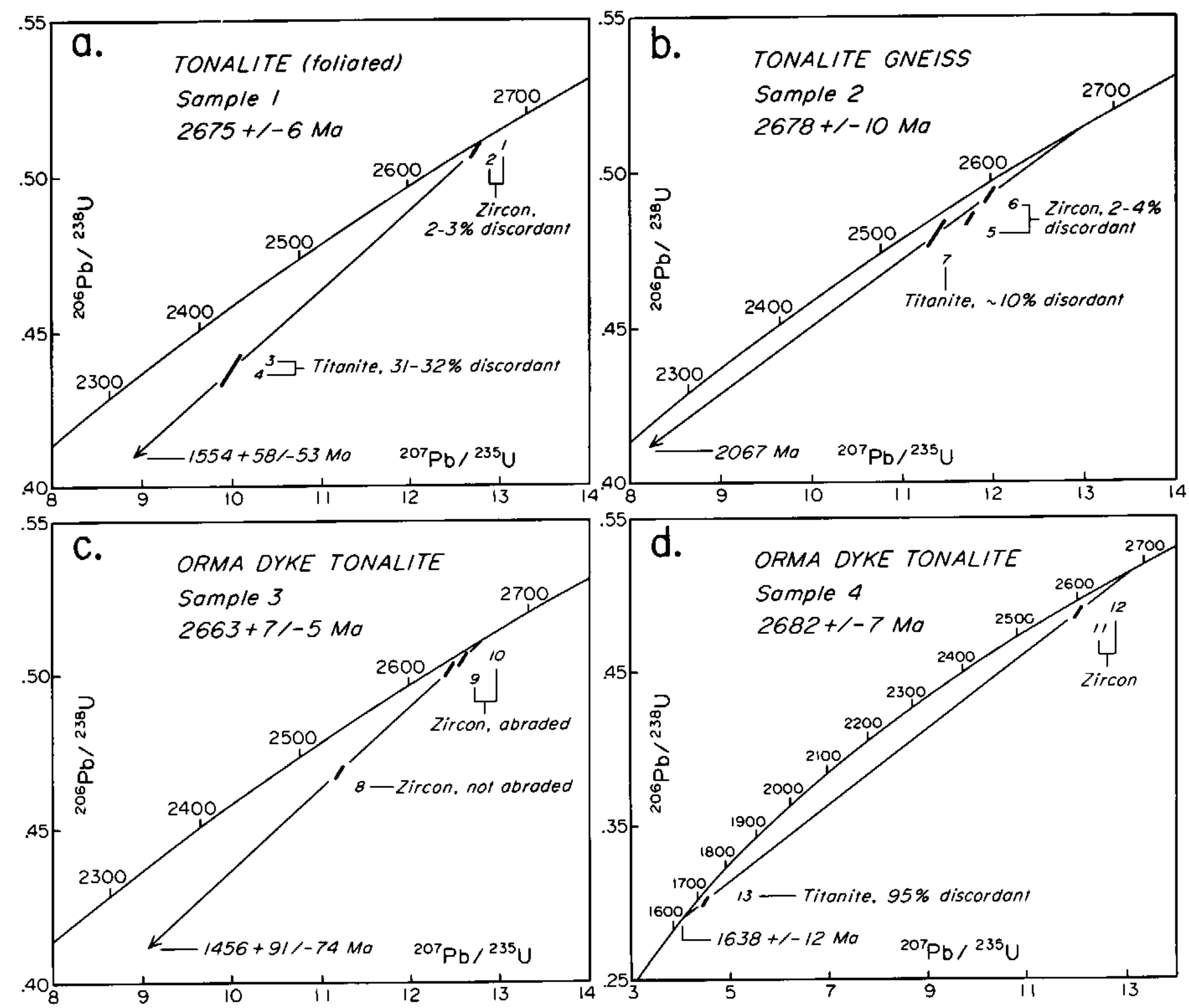

Figure 3 *U-Pb zircon and titanite discordia for the Orma domain.* **(a)** *Sample 1: foliated tonalite.* **(b)** *Sample 2: foliated tonalite paleosome in granitoid-sheeted orthogneiss.* **(c)** *Sample 3: foliated tonalite.* **(d)** *Sample 4: foliated tonalite paleosome in stromatic orthogneiss.*

slightly younger age of 2663+7/–5 Ma, but it is likely that zircon fraction #8 (Table 1; Figure 3c), the only fraction not given an abrasion treatment, plots slightly below the correct mixing line as a consequence of a second stage, more recent Pb-loss effect causing a rotation of the discordia and a slight lowering of the upper intercept age. Sample 2 (Figure 3b) is more difficult to interpret because the three fractions analyzed are not collinear and a multi-stage Pb-loss history is probable. A compatible upper intercept of 2678±10 Ma is obtained from sample 2 if zircon fraction #6 and titanite fraction #7 are regressed together as shown in Figure 3b; however, the significance of the resultant lower intercept is unknown. All four dates indicate a Late Archean age for orthogneiss in this region and, except for sample 3, the emplacement age is constrained between 2675 Ma and 2682 Ma.

Since titanite is much more susceptible to recrystallization during metamorphism than zircon, the U-Pb systematics in titanite are more easily reset and may provide information relating to the metamorphic history and, in particular, to the timing of the last major metamorphic event to affect the area. Titanite might be expected to be more discordant than zircon from the same sample and, in simple models, to indicate a time of lead loss.

Sample 2 (Figure 3b) and, to a lesser extent, sample 1 (Figure 3a) show that initial titanite crystallization was also Late Archean. The most significant and reliable lower intercept comes from the discordia line for sample 4 (Figure 3d) on which titanite fraction #13 (Table 1; Figure 3d) plots 95% down a mixing line from 2682 Ma to 1638 Ma. This intersection gives a good estimate of a time of metamorphism, indicating either new titanite crystallization or severe lead loss in the original titanite at around 1638±12 Ma. In sample 1 (Figure 3a), titanite is only about 30% discordant, resulting in a much less well-defined lower intercept of 1554+58/–53 Ma: however, within the errors, this date is close to that for sample 4. The 1456+91/–74 Ma lower intercept determined from the three zircon fractions in sample 3 (Table 1; Figure 3c) is, within the error limits, also not much younger than the other two and, if the suspected rotation due to multi-stage Pb-loss in fraction #8 has occurred, the correlation would be even stronger. As noted above, the lower intercept of *ca.* 2067 Ma in sample 2 (Figure 3b) is of unknown significance.

Discussion

The U-Pb titanite results presented here can be interpreted in a number of ways. It is clear from the U-Pb zircon results that the preponderance of tonalite in the study area crystallized in the Late Archean, between 2682 Ma and 2675 Ma, and the morphology of the zircons indicates that this is an emplacement age. The timing of the pervasive amphibolite-facies metamorphic overprint in this region is less certain. The simplest explanation for the titanite data is best illustrated in Figure 3d with nearly complete resetting, or new titanite growth, during the Labradorian Orogeny at *ca.* 1640 Ma. However, one might expect the zircon fractions to have experienced more Pb-loss than appears to be the case in sample 4, and not expect titanite, such as that in sample 2, to have survived such an event, although local conditions such as U content, fluid presence and recrystallization reactions might be critical in determining which minerals or areas are reset. Since thin section analysis shows that the titanite is a stable part of the upper-amphibolite-facies foliation-forming assemblage, and that some of this titanite must be old (samples 1 and 2), an alternative explanation, and the one preferred here, is that the Archean tonalites experienced a Late Archean amphibolite-facies metamorphic event (*i.e.*, soon after emplacement) which formed new titanite at that time. The syntectonic interpretation of part of the orthogneiss unit supports this explanation. As there would be negligible accumulated radiation damage in the zircon grains at that time, there would be negligible Pb-loss effects during such an Archean metamorphic event. Superimposed on this Late Archean metamorphic event were, probably localized, late Early Proterozoic events that caused variable resetting or new growth of titanite. The U-Pb results indicate a late Labradorian or early Middle Proterozoic lead loss that might have occurred as a result of reheating, fluid flushing or strain in the gneiss country rocks during emplacement of the TLB, although these features are not apparent from the fieldwork.

Evidence for the Hudsonian or Grenvillian orogenies is conspicuous by its absence in the zircon and titanite determinations reported here. Whereas the lack of Grenvillian effects might be expected, given the widespread occurrence of undeformed (Grenvillian) augen of basement rocks in the GFTZ, the apparent absence of Hudsonian effects, at least on the U-Pb isotopes, is more of a surprise since the Rae Province is flanked to the east and west by the Hudsonian Torngat and New Québec orogens, both of which locally attain intense deformation states and high-grade conditions.

These results demonstrate the potential utility of U-Pb titanite determinations in deciphering the timing of major metamorphic episodes in complex gneissic terranes.

Conclusions

These geochronological results support ideas (*e.g.*, Hoffman, 1989; Wardle *et al.*, 1990) that some areas of the Rae Province are Archean. They are also the first indication of the presence of Labradorian Pb-loss, and possibly structural events, to the north of the Trans-Labrador Batholith. In contrast, there is no evidence that Hudsonian events have had any effect on the isotopes in the rocks studied, implying that the Hudsonian overprint in the southern Rae Province must have been, at least locally, relatively minor. The Grenville Front Tectonic Zone is shown to be a tectonic feature only (and not an isotopic one) in this area.

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References

Ashwal, L.D., Wooden, J.L. and Emslie, R.F., 1986, Sr, Nd, and Pb isotopes in Proterozoic intrusives astride the Grenville Front in Labrador: Implications for crustal contamination and basement mapping: Geochimica et Cosmochimica Acta, v. 50, p. 2571-2585.

Davis, D.W., 1982, Optimum linear regression and error estimation applied to U-Pb data: Canadian Journal of Earth Sciences, v. 19, p. 2141-2149.

Emslie, R.F., 1970, The geology of the Michikamau Intrusion, Labrador (13L, 23I): Geological Survey of Canada, Paper 68-57, 85 p.

Emslie, R.F., 1978, Elsonian magmatism in Labrador: age, characteristics and tectonic setting: Canadian Journal of Earth Sciences, v. 15, p. 438-453.

Heaman, L.M. and Machado, N., in press, The Coldwell Complex, North America: Isotopic constraints for the timing and origin of Midcontinent Rift alkaline magmatism: Earth and Planetary Science Letters, in press.

Hoffman, P.F., 1989, Precambrian geology and tectonic history of North America, *in* Bally, A.W. and Palmer, A.R., eds., The Geology of North America — An overview: Geological Society of America, The Geology of North America, v. A, p. 447-512.

Jaffey, A.H., Flynn, K.F., Glendenin, L.E., Bentley, W.C. and Essling, A.M., 1971, Precision measurements of half-lives and specific activities of ^{235}U and ^{238}U: Physics Reviews C, v. 4, p. 1889-1906.

Krogh, T.E., 1973, A low-contamination method for hydrothermal decomposition of zircon and extraction of U and Pb for isotopic age determination: Geochimica et Cosmochimica Acta, v. 37, p. 485-494.

Krogh, T.E., 1982, Improved accuracy of U-Pb zircon ages by the creation of more concordant systems using an air abrasion technique: Geochimica et Cosmochimica Acta, v. 46, p. 637-649.

Krogh, T.E. and Davis, G.L., 1973, The significance of inherited zircons on the age and origin of igneous rocks — an investigation of the ages of the Labrador adamellites: Carnegie Institute of Washington Yearbook, v. 72, No. 1630, p. 610-613.

Machado, N., Goulet, N. and Gariepy, C., 1989, U-Pb geochronology of reactivated Archean basement and of Hudsonian metamorphism in the northern Labrador Trough: Canadian Journal of Earth Sciences, v. 26, p.1-15.

Nunn, G.A.G. and Noel, N., 1982, Regional geology east of Michikamau Lake, central Labrador, *in* Current Research: Newfoundland Department of Mines and Energy, Mineral Development Division, Report 82-1, p. 149-167.

Nunn, G.A.G., Thomas, A. and Krogh, T.E., 1985, The Labradorian Orogeny: geochronological database, *in* Current Research: Newfoundland Department of Mines and Energy, Mineral Development Division, Report 85-1, p. 43-54.

Ryan, B. 1990, Does the Labrador–Québec border area of the Churchill (Rae) Province preserve vestiges of an Archean history?: Geoscience Canada, v. 17, p. 255-259.

Stacey, J.S. and Kramers, J.D., 1975, Approximation of terrestrial lead isotope evolution by a two-stage model: Earth and Planetary Science Letters, v. 26, p. 207-221.

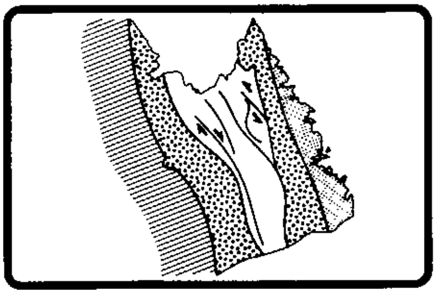
Thomas, A., Nunn, G.A.G. and Krogh, T.E., 1986, The Labradorian Orogeny: evidence for a newly identified 1600 to 1700 Ma orogenic event in Grenville Province crystalline rocks from central Labrador, *in* Moore, J.M., Davidson, A. and Baer, A.J., eds., The Grenville Province: Geological Association of Canada, Special Paper 31, p. 175-189.

Thomas, A., Nunn, G.A.G. and Wardle, R.J., 1985, A 1650 Ma orogenic belt within the Grenville Province of northeastern Canada, *in* Tobi, A.C. and Touret, J.L.R., eds., The Deep Proterozoic Crust in the North Atlantic Provinces: NATO Advanced Study Institute, Series C, v. 158, p. 151-161.

Wanless, R.K. and Loveridge, W.D., 1978, Rubidium-strontium isotopic age studies, report 2 (Canadian Shield): Geological Survey of Canada, Paper 77-14, p. 47-49.

Wardle, R.J., Ryan, B., Nunn, G.A.G. and Mengel, F.C., 1990, Labrador segment of the Trans-Hudson Orogen: crustal development through oblique convergence and collision, *in* Lewry, J.F. and Stauffer, M.R., eds., The Early Proterozoic Trans-Hudson Orogen of North America: Geological Association of Canada, Special Paper 37, p. 353-370.

Wynne-Edwards, H.R., 1972, The Grenville Province, *in* Price, R.A. and Douglas, R.J.W., eds., Variations in Tectonic Styles in Canada: Geological Association of Canada, Special Paper 11, p. 264-334.



Evidence d'un magmatisme d'arc protérozoïque inférieur (2.3 Ga) sur le plateau de la rivière George

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Résumé

La suite intrusive de Pallatin, sise près du cisaillement de la rivière George, dans l'arrière-pays de la Fosse du Labrador, se compose d'un ensemble magmatique bimodal granodioritique et gabbroïque. Les filons-couches et massifs tabulaires de cette suite sont en continuïté avec les basaltes, dacites, rhyolites et volcanoclastites du complexe de Ntshuku. La séquence s'est mise en place dans un environnement bathyal sur un socle gneissique archéen en subsidence rapide. Le complexe et la suite, métamorphisés au faciès des amphibolites inférieures, sont recouverts de sédiments épicratoniques protérozoiques inférieurs affectés d'un métamorphisme au faciès des schistes verts.

Les roches magmatiques montrent une signature géochimique typique d'un environnement supra-subductif ensialique. La proximité du batholithe de De Pas (type andin) et du bassin intra-arc du complexe d'Atshakatsh supporte cette assertion. Toutefois, l'âge U/Pb sur zircon de 2.3 Ga obtenu sur la granodiorite de Pallatin rend ambiguë son affiliation à un événement précoce-hudsonien ou tardi-kénoranien.

Summary

The Pallatin intrusive suite, located near the George River Shear Zone, is a granodioritic-gabbroic hypabyssal sill complex. It is continuous, through a dyke swarm, with basaltic and dacitic lava flows, rhyolite domes, and turbiditic volcaniclastic sediments belonging to the Ntshuku complex. The sequence was developed in a bathyal environment and was juxtaposed upon a gneissic Archean basement. Affected by a lower amphibolite-facies metamorphism, the Ntshuku complex is unconformably covered by greenschist-facies lower Proterozoic epicratonic sediments.

The magmatic rocks show an ensialic arc geochemical signature. This is supported by their close association with the Andean-type Hudsonian De Pas batholith and the intra-arc Atshakatsh complex. However, the granodiorite yielded an enigmatic 2.3 Ga U/Pb zircon age, which could be assigned to either an early-Hudsonian or a late-Kenoran event.

Introduction

Le complexe volcanosédimentaire de Ntshuku et son équivalent intrusif, la suite intrusive de Pallatin, forment une séquence magmatique sise au coeur du domaine de la rivière George (figure 1), dans l'arrière-pays des orogènes du Nouveau-Québec et de Torngat (Hoffman, 1988).

Le domaine de la rivière George est formé d'une ceinture polycyclique, dans laquelle un socle archéen, apparenté au domaine de Mistinibi (Wardle *et al.*, 1990), et plusieurs cycles de roches supracrustales protérozoïques inférieures le surmontant se sont déformés et métamorphisés lors de l'orogène hudsonienne. Il n'inclut toutefois pas de séquence de plateforme typique des autres bassins du Protérozoïque inférieur des orogènes adjacentes. Le complexe de Ntshuku (Girard, 1990) demeure le seul ensemble supracrustal reconnu dans les orogènes de Nouveau-Québec et de Torngat qui soit explicitement rattaché à un arc magmatique. Son âge, intermédiaire entre celui du socle et de la déformation hudsonienne, rend ambiguë son insertion dans un schéma géodynamique.

Stratigraphie

Trois cycles de déposition-déformation sont rapportés dans la région de la rivière George.

1 : Des gneiss tonalitiques anciens, d'âge probable Archéen (2.7 Ga), fortement migmatitisés et intercalés aux paragneiss du complexe de Mistinibi (van der Leeden *et al.*, 1990) forment le socle.

2 : Chevauché sur le complexe de Mistinibi, le complexe volcanosédimentaire de Ntshuku (Girard, 1990), occupe une quille synclinale nord-sud de 8 kilomètres de large par 20 kilomètres de long. La suite intrusive de Pallatin s'injecte à sa base.

3 : L'extrémité nord du complexe de Ntshuku et les gneiss adjacents sont recouverts par le Groupe de la Hutte Sauvage (van der Leeden *et al.*, 1990). Ce groupe correspond à un bassin sédimentaire épicratonique, affecté d'une déformation et d'un métamorphisme aux schistes verts à l'Hudsonnien. Des galets provenant du batholite de De Pas lui confèrent un âge maximal de 1.84 Ga.

Le complexe volcanosédimentaire de Ntshuku

Le complexe de Ntshuku se compose d'une séquence basale de coulées basaltiques et dacitiques, de dômes de rhyolites et de quelques niveaux métriques de métapélites, le