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U-Pb zircon age and regional setting of the Lapeyrère gabbronorite, Portneuf–Mauricie region, south-central Grenville Province, Quebec

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Abstract

High-grade tectonite bodies of the Portneuf–Mauricie region were intruded by a number of small and scattered, late Grenvillian, mid-crustal gabbroic intrusions. These consist chiefly of fresh and massive gabbro and gabbronorite with well preserved igneous mineral textures, to locally recrystallized and foliated gneissic equivalents. The Lapeyrère gabbronorite is the largest of these intrusions.

Uranium-lead dating of igneous zircon crystals gives a crystallization age at 1069 ± 2 Ma, close to ages previously reported for the Shawinigan gabbronorite, and two small gabbroic intrusions in Canton Taché, along the southern margin of the Lac-Saint-Jean anorthosite complex. Although modest in size, these distant intrusions signal a regionally extensive gabbroic intrusive event in the 1080–1067 Ma interval, at the onset of widespread granitoid plutonism in the south-central Grenville Province. The almost complete absence of anorthosite and the limited volume of gabbroic rocks, appear, however, to set apart this 1080–1067 Ma gabbroic pulse from those leading to classic anorthosite-mangerite-charnockite-granite (AMCG) association.

Résumé

Les tectonites de haut rang métamorphique de la région de Portneuf-Mauricie renferment un certain nombre de petites intrusions gabbroïques d`âge tardigrenvillien et d'origine médiocrustale. Ces corps intrusifs géographiquement dispersées sont constitués essentiellement de gabbro et de gabbronorite massif et frais, dont les textures et la minéralogie magmatiques ont été conservées. La formation d'une foliation tectonique et la recristallisation ont produit localement des équivalents métamorphiques. La gabbronorite de Lapeyrère est la plus volumineuse de ces intrusions.

La datation par la méthode U-Pb sur zircon a donné un âge de cristallisation magmatique de 1069 2 Ma. Cet âge s'approche de ceux obtenus antérieurement pour la gabbronorite de Shawinigan et deux petites intrusions gabbroïques situées dans le canton de Taché, qui ont été mises en place dans la bordure méridionale du complexe anorthositique du lac Saint-Jean. Quoique de petites dimensions, ces intrusions géographiquement éloignées les unes des autres signalent une poussée de magma gabbroïque régionalement importante dans l'intervalle 1080-1067 Ma. Cet événement serait précurseur du plutonisme granitoïde aux effets étendus qui s'est manifesté dans le centre sud de la Province de Grenville. L'absence presque complète d'anorthosite et le volume restreint des roches gabbroïques de l'épisode 1080-1067 Ma semblent distinguer cette poussée gabbroïque de celles qui ont conduit à l'association anorthosite-mangérite-charnockite-granite (AMCG) classique.

INTRODUCTION

The Portneuf–Mauricie region covers a large segment of the Grenville Orogen, between the Lac-Saint-Jean and the Morin anorthosite-mangerite-charnockite-granite (AMCG) complexes (**Fig. 1**). It includes a large number of small and scattered bodies of variably deformed and metamorphosed anorthositic, gabbroic, and ultramafic rocks (**Fig. 2**). These subkilometre- to kilometre-size bodies occur in a number of distinct field settings and associations, pointing to a polygenetic origin. Among them, the Lapeyrère and Shawinigan gabbronorite intrusions typify a group of late-tectonic intrusive bodies consisting chiefly of fresh and massive gabbronoritic rocks with well preserved igneous-mineral textures. Although petrologically important, anorthosite and diorite occur in subordinate amounts in these bodies.

The Lapeyrère gabbronorite is the largest of this group of intrusions, outcropping over roughly 160 km^2. It stands out as a strong bull's-eye on the regional Bouguer anomaly map; there are no other comparable gravity anomalies in the region. A tectonic fabric is present only locally, namely in narrow shear zones and along the margin of the body. The deformation has taken place under lower-amphibolite-facies conditions, as indicated by the assemblage plagioclase-quartz-hornblende-biotite±epidote, typical of the foliated rocks, and lack of chlorite. The field relationships, petrography, geochemistry, and petrogenesis of these rocks were described in details by Nadeau and Brouillette (1977) and Nadeau et al. (1998). The focus is placed here on establishing the age relationship of the intrusion.

Age problem

The Lapeyrère gabbronorite was previously considered as one of the main distinctive units in the making of the early Mesoproterozoic La Bostonnais Complex (Rondot, 1978). The field relationships do, however, suggest that this intrusion is late Grenvillian, and unlikely to be related to the La Bostonnais Complex (Nadeau and Brouillette, 1997). Collectively, gabbroic bodies sharing some petrological similarities with the Lapeyrère gabbronorite intrusion may signal a regionally extensive plutonic event that could be related either to i) the 1160–1130 Ma Lac-Saint-Jean and Morin AMCG suite, ii) the Shawinigan gabbronorite intrusion emplaced at 1076 +4/-3 Ma (Corrigan and van Breemen, 1997), or to iii) a distinct gabbroic intrusive event not recognized previously. Dating the igneous crystallization of the Lapeyrère gabbronorite intrusion is primarily aimed at distinguishing between these possibilities.

REGIONAL SETTING

The Portneuf–Mauricie region straddles four major Grenvillian lithotectonic domains (Nadeau and Brouillette, 1994, 1995; Fig. 2). On the west, the Mékinac–Taureau domain makes up a broad, crustal-scale dome composed mainly of intermediate and felsic granulite. This dome is structurally overlain on its south and west flanks by the allochthonous monocyclic Morin terrane and, on the east, by the allochthonous polycyclic Portneuf-Mauricie domain. While the Morin terrane stands out by its hosting of the Morin AMCG complex and its abundance of metasedimentary and metavolcanic rocks of the Grenville Supergroup, the volcanosedimentary rocks of the Montauban Group and the calc-alkaline metaplutonic rocks of La Bostonnais Complex constitute the distinctive lithological assemblages of the Portneuf–Mauricie domain. Farther east, the Parc des Laurentides domain is dominated by regionally extensive and variably deformed, commonly K-feldspar-porphyritic, quartz-monzonite and granite. This domain widens to the east and north, where it borders the Lac-Saint-Jean AMCG complex domain, and encompasses the Château-Richer and Saint-Urbain anorthosite complexes (Fig. 1).

Neodymium model ages in the 1.44–1.62 Ga range, and a U-Pb zircon igneous crystallization age ca. 1.37 Ga were obtained from orthogneiss of the eastern Mékinac–Taureau domain (van Breemen and Nadeau, unpub. data, 1992). Supracrustal rocks of the Morin terrane were formed and regionally metamorphosed ca. 1250 Ma and ca. 1180 Ma, respectively (Martignole and Friedman, 1998). They are cut by the Morin AMCG suite emplaced in the 1165–1135 Ma age range (Emslie and Hunt, 1990; Doig, 1991). In the Portneuf–Mauricie region, the northeast extension of the Morin terrane includes the Lejeune mangerite and the Lac Paul granite emplaced at 1059 $\pm$ 2 Ma and 1153 +2/-1 Ma, respectively (Corrigan and van Breemen, 1997). The juvenile arc-related rocks of the Montauban Group and La Bostonnais complex have yielded crystallization ages ca. 1450 Ma and ca. 1400 Ma, respectively (Nadeau et al., 1992). Farther east, granite and quartz-monzonite from far distant localities of the Parc des Laurentides domain include the 1058 ± 1 Ma Rivière-à-Pierre Granite (Nadeau et al., 1992), the 1067 ± 3 Ma La Baie Granite (Higgins and van Breemen, 1996), the 1068 ± 3 Ma Poulin-de-Courval Mangerite (Hébert et al., 1998), the 1082 ± 3 Ma Chicoutimi Mangerite (Hervet et al., 1994), and the coeval Chicoutimi Syenite (Higgins and van Breemen, 1996). On the northern side of these intrusions, the 1160–1140 Ma rocks of the Lac-Saint-Jean AMCG complex were intruded at 1076 ± 3 Ma by the two small Canton Taché leucogabbro intrusions (Higgins and van Breemen, 1992).

Occurrences of gabbroic rocks

In the Portneuf–Mauricie region more specifically, variably metamorphosed anorthositic, gabbroic, and ultramafic rocks occur in all four lithotectonic domains, and in at least three distinct field associations (**Fig. 2**). These rocks are likely to be polygenetic in origin, and to differ significantly in age.

Meta-anorthosite

Medium- to coarse-grained, granoblastic meta-anorthosite makes up the Langelier anorthosite (Baer, 1976), a circular body approximately 12 km in diameter outcropping in the northern Portneuf–Mauricie domain. This body consists of 95 per cent or more, recrystallized plagioclase crystals ($An_{45–60}$). Mesoscopically similar meta-anorthosite also occurs in eastern Mékinac–Taureau domain as tectonic slivers, and as a small ovoid body south of La Tuque (Fig. 2). These meta-anorthosite slivers are spatially associated with similarly occurring, extensively recrystallized metagabbro, hence suggesting that they represent parts of a dismembered initially much larger intrusive complex. In addition, a few outcrops of anorthositic rock are also found in the Shawinigan and Étoile gabbroic intrusions described below.

There are no absolute age constraints for the meta-anorthositic rocks of the Portneuf–Mauricie region. The field relationships, the deformation fabric, and the metamorphic mineralogy, however, are consistent with a pre-Grenvillian or early Grenvillian emplacement. These meta-anorthosite bodies are geographically distributed between the 1160–1135 Ma Lac-Saint-Jean and Morin AMCG complexes. They also share some mesoscopic similarities with the Château-Richer meta-anorthosite body (Feininger, 1993), and the presumably significantly younger Saint-Urbain anorthosite, for which a Sm-Nd isochron age ca. 1079 ± 22 Ma has been proposed by Ashwal and Wooden (1983a).

Gabbro–gabbronorite

In contrast to the meta-anorthosite, the Shawinigan and Lejeune intrusions of Morin terrane, and the Lapeyrère, Lac Édouard, and Étoile intrusions of Portneuf–Mauricie domain (Fig. 2) consist largely of fresh and massive gabbro and gabbronorite with well preserved igneous mineral textures. The much smaller Wessonneau and Sandford intrusions, respectively outcropping in the Mékinac–Taureau and Parc des Laurentides domains, also comprise mesoscopically similar gabbronoritic rocks. Several of these bodies include a significant amount of pyroxene diorite, but only a few exposures of anorthosite and ultramafic rocks; i.e. anorthositic gabbro, is a minor phase in the Shawinigan body (Béland, 1961), and a single outcrop of ultramafic rock has been reported in the Lapeyrère gabbronorite intrusion (Nadeau and Brouillette, 1997).

Among these bodies, the Shawinigan norite has yielded a U-Pb zircon crystallization age at 1076 +4/-3 Ma (Corrigan and van Breemen, 1997). This is coeval with the emplacement of the two small Canton Taché leucogabbro intrusions at 1076 ± 3 Ma in the southern margin of the Lac-Saint-Jean complex (Higgins and van Breemen, 1992).

Meta-ultramafic rocks

A few subkilometric bodies of ultramafic rocks are also scattered throughout the Portneuf–Mauricie region (Fig. 2). These are of special interest because they host a number of Ni-Cu-PGE-sulphide-enriched mineralized zones (Clark, 1998). The most comprehensive descriptive account of these occurrences is given in Poirier (1988). Most appear to be associated with the early Mesoproterozoic metagabbroic to dioritic rocks of La Bostonnais Complex. Field constraints, however, are very limited. In addition, the occurrence of Ni-Cu-sulphide mineralizations in the Shawinigan intrusion suggests that there could be more than one setting and age for these mineralizations and their parent bodies. There are no absolute age constraints on these intrusions.

U-Pb ZIRCON GEOCHRONOLOGY

Sample description

The sampling site is one of the type localities for the Lapeyrère gabbronorite (Hébert and Nadeau, 1995); over 2000 m^2 of cleaned rock surface have been exposed as a test site for dimension-stone quarrying. The sample consisted of approximately 40 kg of fresh homogeneous gabbronorite. The rock is medium-grained, equigranular, with a steeply dipping, pervasive, mineral foliation that is conformable with locally developed, decimetre-thick, and laterally discontinous compositional layering. There are no deformation or metamorphic effects; plagioclase is unrecrystallized, and there is no coronitic overgrowth on pyroxenes (**Fig. 3**). The latter are clearly in textural equilibrium with plagioclase and intergranular hornblende. The gabbronorite sampled is very homogeneous in modal composition. It consists chiefly of cumulus plagioclase (~67%), augite (~15%), and hypersthene (~11%), with accessory intercumulus Fe-Ti oxides (~5%), hornblende (~1%), and trace amounts biotite, quartz, apatite, and zircon (Fig. 3).

Plagioclase is dusted with minute opaque oxide inclusions, giving the rock a dark brown colour on fresh and weathered surfaces. The cumulate texture and the nature of intercumulus phases is consistent with plagioclase and pyroxene fractionation, and concurrent enrichment in incompatible elements of the residual liquid. Indeed, the abundance of zircon increases in the more differentiated dioritic facies together with intergranular biotite and apatite (**Fig. 4**; Nadeau and Brouillette, 1997).

Analytical methods and results

Zircons are not abundant in the gabbronoritic rocks. They range from anhedral to subhedral prismatic crystals with simple facets. They are colourless and contain inclusions, some of which are negative crystals. All zircon fractions were strongly abraded until the crystals assumed a well rounded shape (Krogh, 1982) to minimize the effects of peripheral lead loss and/or to remove metamorphic rims. Analytical techniques for measuring U-Pb isotopes in zircon at the GSC are summarized by Parrish et al. (1987), and are based on Krogh (1973). Mass spectrometry, data reduction, and method of propagation of analytical uncertainties of the relevant components in the calculation of isotopic ratios and ages followed the numerical procedure of Roddick (1987). A modified form of York's (1969) method for linear regression analysis was used (*see* Parrish et al., 1987). The isotopic data are presented in **Table 1**. All age uncertainties are given at the 95% confidence level.

Three zircon data points are aligned, and range from concordant to 2.1 per cent discordant (fractions A, D, and C). The reverse discordance of data point B is interpreted in terms of an inherited component. Because the zircon crystals grew in an igneous mode in a late-tectonic environment, it is considered unlikely that they were affected by subsequent Grenvillian recrystallization. Also, as the zircons are low in uranium, it is considered unlikely that they accumulated lattice damage significantly before the present.

The age of crystallization of the zircon is therefore calculated using a regression analysis through points A, C, D, and the origin, corresponding to a mean square of weighted deviates of 1.3. The igneous age is 1069 ± 2 Ma (Fig. 5).

GEOLOGICAL IMPLICATION

The 1069 ± 2 Ma U-Pb zircon igneous crystallization age obtained for the Lapeyrère gabbronorite is very close to the 1076 +4/-3 Ma age of the Shawinigan gabbronorite intrusion (Corrigan and van Breemen, 1997) of the Morin terrane, and of the emplacement age at 1076 ± 3 Ma of the two small Canton Taché leucogabbro intrusions in the southern margin of the Lac-Saint-Jean complex (Higgins and van Breemen, 1992). These nearly coeval and distant intrusions signal a significant and regionally extensive gabbroic intrusive event between 1080 and 1067 Ma. The Lapeyrère gabbronorite is by far the largest intrusive body associated with this gabbroic pulse in the south-central Grenville Province.

The 1080–1067 Ma gabbroic plutonism discussed here may appear, at first, to be coeval with the emplacement of the Saint-Urbain anorthosite complex, as suggested by the Sm-Nd age of ca. 1079 ± 22 Ma reported by Ashwal and Wooden (1983a). The significance of this age, however, is very difficult to assess; to our knowledge the analytical data, assumptions, and the reasoning behind the age have remained unpublished. Directly interpreting this whole-rock and mineral isochron age as that of igneous crystallization could be misleading. Indeed, a number of Sm-Nd isochron ages reported by Ashwal and Wooden (op. cit.) have been shown to be much older than the igneous crystallization interval subsequently constrained by zircon and baddeleyite U-Pb method; for example, compare Ashwal and Wooden (1983a, b) with McLelland and Chiaranzelli (1990). Therefore, we consider the ca. 1079 ± 22 Ma Sm-Nd isochron age as a maximum for emplacement of the Saint-Urbain complex. Direct affiliation of the 1080–1067 Ma gabbroic plutonism, discussed here, with the emplacement of the Saint-Urbain AMCG complex requires confirmation by U-Pb techniques.

It is emphasized that the Lapeyrère, Shawinigan, and Canton Taché gabbroic intrusions contain very little anorthositic rock, and are modest in size compared to the gabbroic rocks of the Lac-Saint-Jean, Morin, and Saint-Urbain complexes. If significant, these differences set the 1080–1067 Ma gabbroic plutonism apart from that leading to the classic AMCG association (e.g. Higgins and van Breemen, 1996; Corrigan and Hanmer, 1997). The space and time association of the 1080–1067 Ma gabbroic plutonism with the onset of regionally voluminous granitoid emplacement, however, is firmly established both from field relationships and geochronology. As noted by others, the 1080–1067 Ma gabbroic and granitoid plutonism reported here for the south-central Grenville Province is also coeval with the 1089–1076 Ma potassium-rich plutonism in the Central Metasedimentary Belt (Corriveau et al., 1990).

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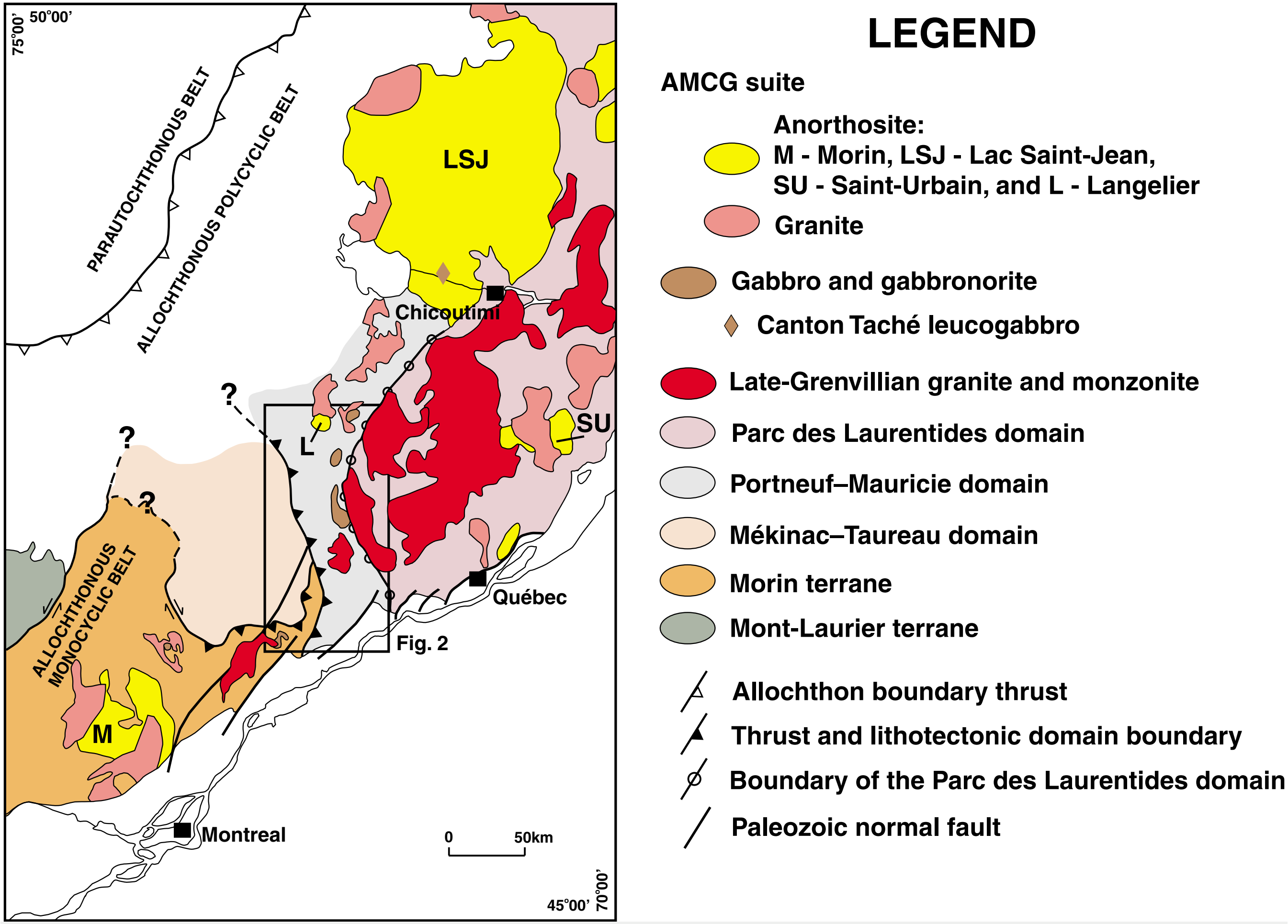

Figure 1. Location sketch map and tectonic subdivisions of the south-central Grenville Province.

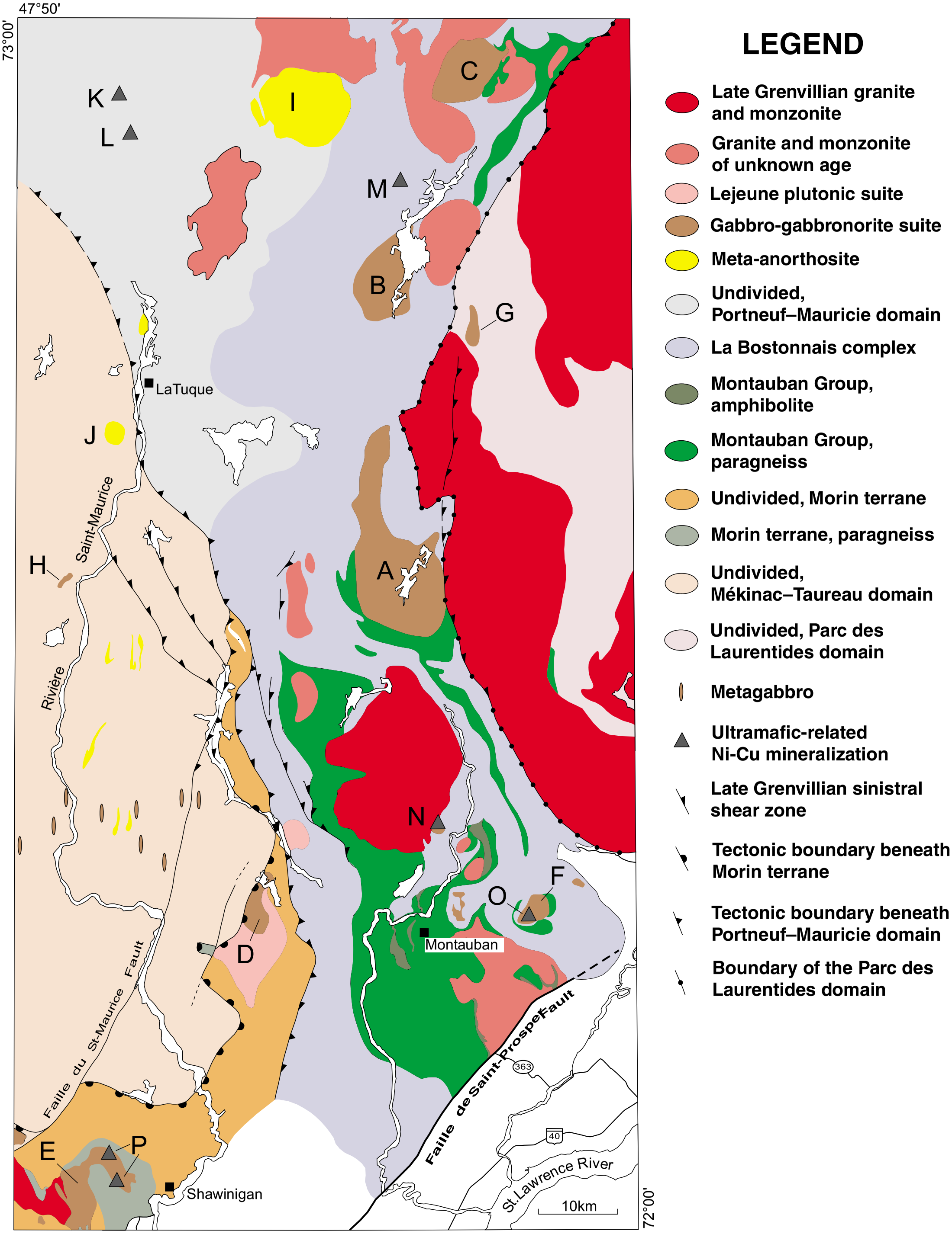

Figure 2. Geological sketch map of the Grenville Orogen in the Portneuf–Mauricie region (*after* Nadeau and Brouillette, 1994, 1995). Gabbro-gabbronorite and meta-anorthosite intrusions: A - Lapeyrère; B - Édouard; C - Étoile; D - Lejeune; E - Shawinigan; F - Montauban; G - Sandford; H - Wessonneau; I - Langelier; J - La Tuque. Meta-ultramafic intrusions and related Ni-Cu mineralization: K - Lac Matte; L - Lac Kennedy; M - Lac Édouard; N - Lac-à-la-Vase; O - Lac Nadeau; P - Shawinigan.

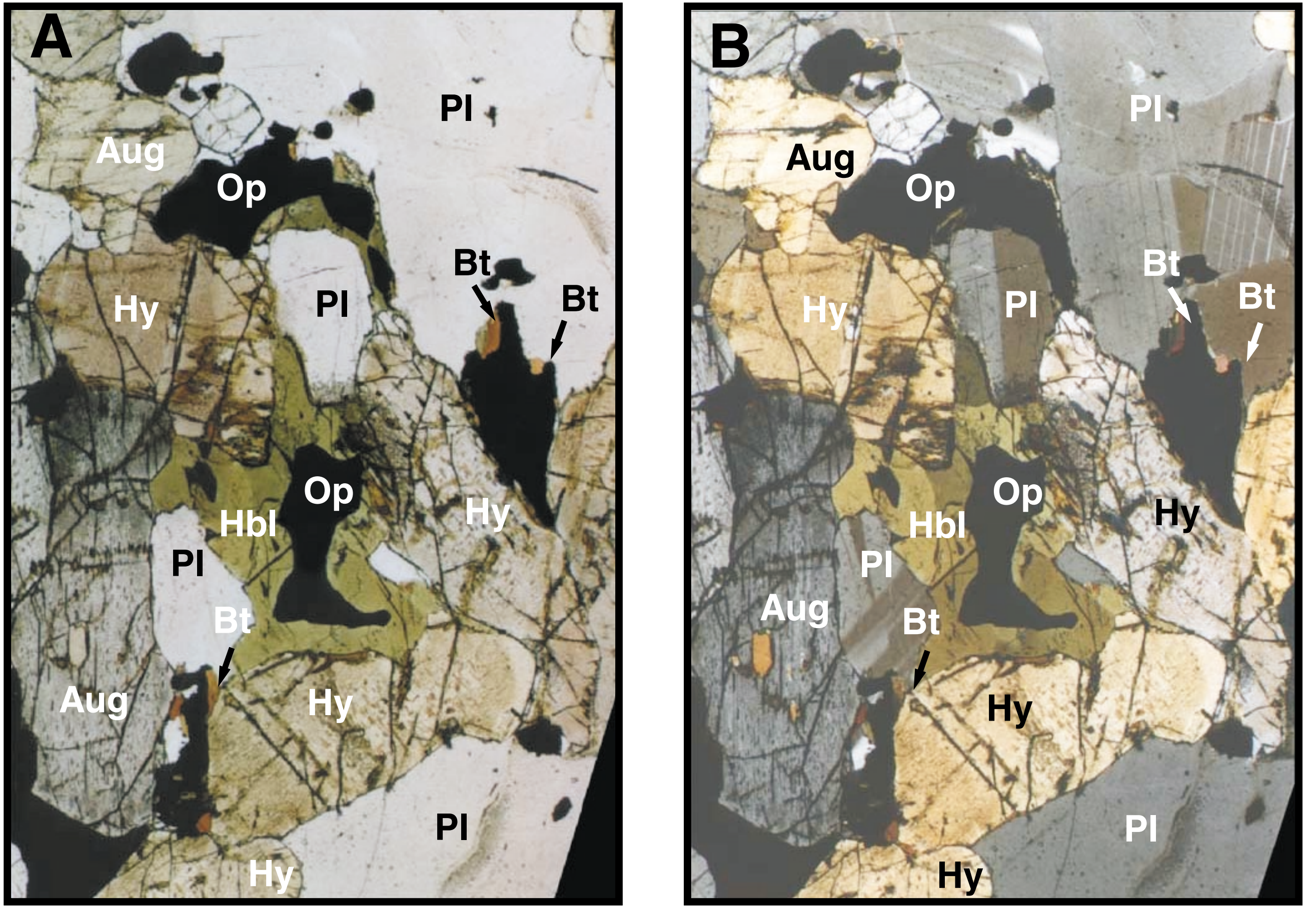

Figure 3. Textural relationships of the dated gabbronorite sample (field width = 1.7 mm); **A**) plane-polarized light, **B**) cross-polarized light. Hornblende (Hbl), Fe-Ti oxides (Op), and biotite (Bt) occur as intercumulus phase between cumulus plagioclase (Pl), hypersthene (Hy), and augite (Aug). Plagioclase is unrecrystallized, and pyroxenes show no metamorphic coronitic overgrowth. Apatite and zircon (not shown) typically occur with the intercumulus phases.

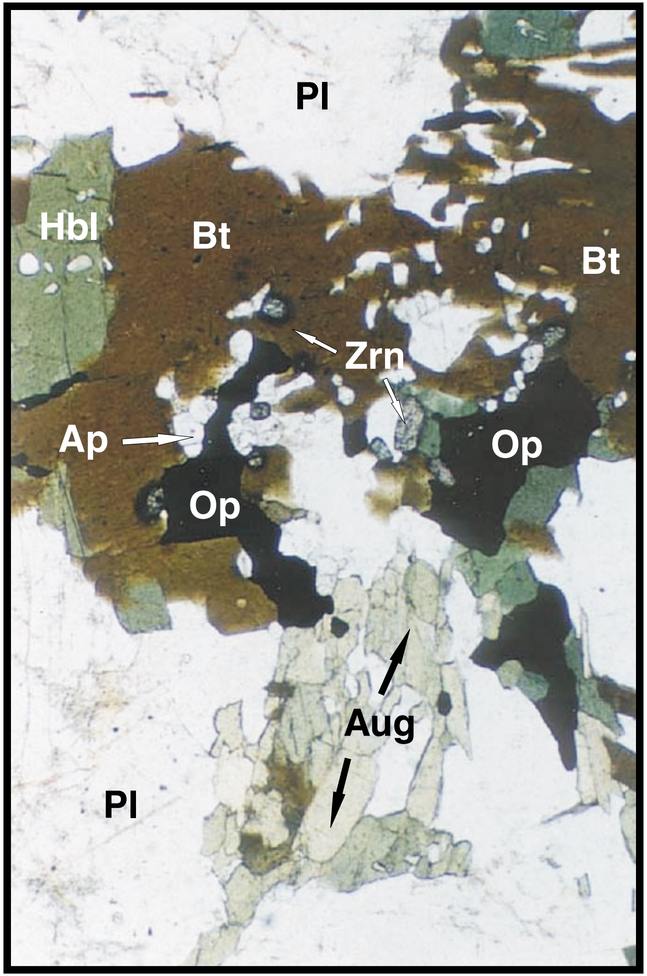

Figure 4. Typical example of zircon (Zrn), apatite (Ap), biotite (Bt), and hornblende(Hbl) -rich intercumulus phases in more-differentiated dioritic rock of the Lapeyrère gabbronorite (field width = 1.7 mm). Plagioclase (Pl) and augite (Aug). Plane-polarized light.

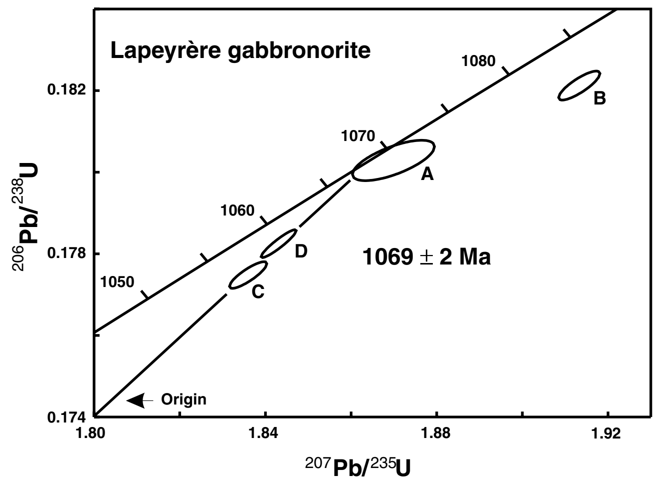

Figure 5. Concordia diagram of igneous zircon of the Lapeyrère gabbronorite. Error ellipses reflect the 2σ uncertainty.

Table 1. U-Pb isotopic data.

Fraction[1]	Weight[2] mg	U ppm	Pb[3] ppm	^{206}Pb[4] / ^{204}Pb	Pb[5] pg	^{208}Pb[6] / ^{206}Pb	^{207}Pb±1SEM[6] / ^{235}U	^{206}Pb±1SEM[6] / ^{238}U	^{207}Pb±1SEM[6] / ^{206}Pb	^{207}Pb±1SEM[7] / ^{206}Pb	Disc[8]
Lapeyrère gabbronorite (VK90-STMR4; #2334; 90NKL-10027a) Zone 18 Easting 700150 Northing 5227700											
A, +90-140	0.04	102	20	667	61	0.161	0.18029 ±.14	1.8699 ±.26	0.07522 ±.19	1074.5 ± 7.7	0.6
B, ca. 80	0.061	93	17	2,351	27	0.122	0.18212 ±.10	1.9133 ±.13	0.07619 ±.07	1100.1 ± 2.8	2.1
C, ca. 70	0.07	122	22	2,206	41	0.135	0.17748 ±.09	1.8360 ±.12	0.07503 ±.06	1069.2 ± 2.5	1.6
D, ca. 140	70	96	18	5555	13	0.12	0.1782 ±.10	1.843 ±.11	0.07499 ±.04	1068.3 ± 1.7	1.1

[1]Sizes in microns before abrasion; All fractions are non-magnetic on a Frantz isodynamic magnetic separator at 1.8 amps with a side slope of 10°;
[2]Error on weight = ± 1 µg;
[3]Radiogenic Pb;
[4]Measured ratio corrected for spike and Pb fractionation of 0.09 ± 0.03 percent per AMU;
[5]Total common Pb on analysis corrected for fractionation and spike;
[6]Corrected for blank Pb and U, common Pb, error quoted are 1 σ in per cent;
[7]Age error quoted is 2σ in Ma;
[8]Discordance in per cent along a discordia to origin.