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Petrogenesis of the igneous Mucajaí AMG complex, northern Amazonian craton — Geochemical, U–Pb geochronological, and Nd–Hf–O isotopic constraints

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ABSTRACT

The ca. 1525 Ma igneous Mucajaí anorthosite–monzonite–granite (AMG) complex in northern Brazil is a rare manifestation of Mesoproterozoic intraplate magmatism in the northern Amazonian Craton. The complex comprises a two-phase rapakivi granite batholith with subordinate quartz–fayalite monzonites and syenites and the closely associated Repartimento anorthosite. Zircon U–Pb (ID–TIMS) geochronology reveals that the anorthosite (1526 ± 2 Ma), monzonite (1526 ± 2 Ma), and the main-phase biotite–hornblende granite (1527 ± 2 Ma) of the complex intruded the Paleoproterozoic (~1.94 Ga) country rocks simultaneously at ~1526 Ma and that the more evolved biotite granite is marginally younger at 1519 ± 2 Ma. Intraplate magmatism in the Mucajaí region was relatively short-lived and lasted 12 million years (1529–1517 Ma) at maximum. The Nd (whole-rock, ID–TIMS; ε_{Nd} from −1.9 to −2.8), Hf (zircon, LAM-ICP-MS; ε_{Hf} from −2.0 to −3.1), and O (zircon, SIMS; $\delta^{18}O$ from 6.1 to 7.0‰) isotopic compositions of the studied rocks are fairly uniform but still reveal a small degree of isotopic heterogeneity in the Paleoproterozoic crust enclosing the complex. The small isotopic differences observed in the two types of rapakivi granites (biotite–hornblende granite and biotite granite) may result either from an isotopically heterogeneous lower crustal source or, more likely, from contamination of the granitic magma derived from a lower crustal source during prolonged residence at upper crustal levels.

1. Introduction

Occurrences of Proterozoic intraplate magmatism characterized by the so-called anorthosite–mangerite–charnockite–granite (AMCG) suite are known from nearly all Proterozoic terranes on Earth (e.g., Ashwal, 1993). Typical localities include for example the Nain suite (in Labrador, eastern Canada; Emslie et al., 1994) and the *locus classicus* rapakivi granite association in southern Finland, Sweden, the Baltic countries, and far northwest Russia (Rämö and Haapala, 2005, and references therein). Massif-type anorthositic rocks (anorthosite ± olivine-bearing leucogabbroic rocks; Ashwal, 1993) represent the major basic magmatic member, whereas charnockitic rocks and ferroan (Frost and Frost, 2011) rapakivi granites typify the felsic phase of these suites (e.g., Bonin, 2007). Despite long-standing research efforts, the primary sources of the parental liquids for the rock groups are still not agreed upon (e.g., Bonin, 2007; Longhi, 2005; Morse, 2006). They have been suggested to be derived from the crust (e.g., Duchesne et al., 1999; Longhi, 2005), the mantle (e.g., Frost and Frost, 1997; Frost et al., 2002), or by different combinations of juvenile mantle and recycled crustal material (e.g., Emslie et al., 1994; Rämö and Haapala, 2005).

The ~4000 km^2 Mucajaí AMG complex (Fig. 1a; Fraga et al., 2009a) in Roraima (Brazil) is a part of a northwest trending ~900-km-long belt of rapakivi granite intrusions in the northern Amazonian Craton (Dall'Agnol et al., 1999). Besides Mucajaí, these rocks comprise the rapakivi granite of Parguaza (Fig. 1b; Gaudette et al., 1978; Mendoza, 1975) in Venezuela, and the Surucucus suite (Fig. 1b; Dall'Agnol et al., 1975; Pinheiro et al., 1981) on the border between Venezuela and Brazil. The igneous rocks in these suites are similar in age ranging from 1.55 to 1.53 Ga (Fraga et al., 2009a; Gaudette et al., 1978, 1996; Santos et al., 1999, 2003) and they have been interpreted to represent a single intraplate magmatic event (the Parguaza event, Gaudette et al., 1978) in the northern Amazonian craton (e.g., Dall'Agnol et al., 1999).

The amount of anorthositic rocks associated with the Mesoproterozoic north Brazilian rapakivi granites is notably smaller than in similar associations elsewhere (e.g., in Labrador; Ashwal, 1993). However, a prominent occurrence of massif-type anorthosite – the Repartimento anorthosite – is found associated with the rapakivi granites of the Mucajaí complex (Brandão and Freitas, 1994; Fraga et al., 2009a; Santos

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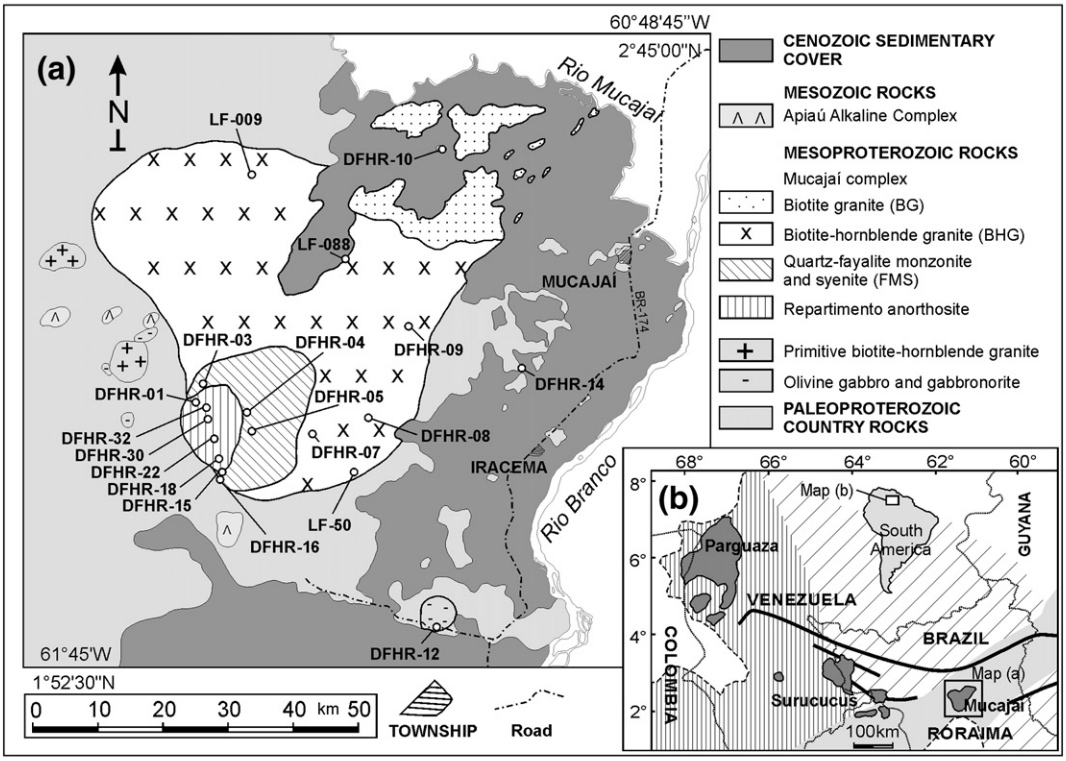

Fig. 1. (a) Geological map of the study area with sampling localities. (b) Regional map showing the location of the study area and the extent of the northern Amazonian rapakivi magmatism spanning from Roraima, Brazil (Mucajaí) through the border of Venezuela and Brazil (Surucucus) to the Colombian border in the west (Parguaza). Proterozoic geochronological provinces according to Santos et al. (2000, 2006) mentioned in the text are also shown: inclined hatching = Tapajós-Parima, vertical hatching = Rio Negro, gray fill = K'Mudku. Thick black lines trace the Cauarane–Coeroene belt of Fraga et al. (2009b). For further details and discussion on the geochronological provinces of the Guyana shield, see Fraga et al. (2009b). Inset shows a map of South America with the location of enlarged area in (b). Maps are adapted from Fraga et al. (2009a,b).

et al., 1999). The apparent intraplate features and the presence of massif-type anorthosite make the Mucajaí AMG complex a prime target for petrogenetic and comparative studies of Mesoproterozoic within-plate magmatism in northern Amazonia. Regardless of these apparent similarities with the classical AMCG suites (e.g., Fraga et al., 2009a) in this study we have adopted the descriptive AMG (Anorthosite–Monzonite–Granite) term for the Mucajaí complex.

We present whole-rock major, trace element, and Sm–Nd isotopic analyses, U–Pb ID–TIMS zircon geochronology, and O and Lu–Hf isotope compositions of zircons for the main rock types of the Mucajaí complex. These data constrain the petrogenetic and temporal relations of the different rock-types in the Mucajaí AMG complex and are used to characterize the intraplate rapakivi magmatism of the northern Amazonian craton and compare it to other similar localities around the world.

Table 1
Sampling and methods.

Sample	Rock type	Locality	Coordinates[a]		Geochemistry	U–Pb	Sm–Nd	Oxygen	Lu–Hf
			N	W	WR	Zircon	WR	Zircon	Zircon
					ICP-AES/MS	TIMS	TIMS	SIMS	LAM-ICP-MS
DFHR-01[b]	Anorthosite	Repartimento	2° 14.516	61° 31.564		x	x	x	x
DFHR-03	Monzonite	Mucajaí	2° 14.875	61° 31.423	x				
DFHR-04[b]	Monzonite	Mucajaí	2° 12.808	61° 25.654		x	x	x	x
DFHR-07	Biotite–hornblende granite	Mucajaí	2° 12.372	61° 20.886	x				
DFHR-08[b]	Biotite–hornblende granite	Mucajaí	2° 12.372	61° 20.886	x	x	x	x	x
DFHR-09	Biotite–hornblende granite	Mucajaí	2° 19.371	61° 13.633	x				
DFHR-10[b]	Biotite granite	Mucajaí	2° 35.382	61° 10.554		x	x	x	x
DFHR-12[b]	Gabbronorite	Caracaraí	1° 55.745	61° 10.882	x		x		
DFHR-14[b]	Gabbronorite	Country rock	2° 16.955	61° 02.903			x		
DFHR-15	Monzodiorite	Repartimento	2° 08.143	61° 28.947	x				
DFHR-16	Monzodiorite	Repartimento	2° 07.360	61° 29.415	x				
DFHR-18	Syenogranite	Repartimento	2° 08.718	61° 28.586	x				
DFHR-22	Anorthosite, coarse	Repartimento	2° 09.802	61° 29.046	x				
DFHR-30A	Anorthosite	Repartimento	2° 12.635	61° 30.725	x				
DFHR-30B	Anorthosite	Repartimento	2° 12.635	61° 30.725	x				
DFHR-32	Leuconorite, coarse	Repartimento	2° 13.670	61° 30.590	x				
LF-09A	Biotite–hornblende granite	Mucajaí	2° 33.526	61° 25.450	x				
LF-50	Monzonite	Mucajaí	2° 08.584	61° 19.297	x				
LF-88	Biotite-hornblende granite	Mucajaí	2° 26.813	61° 18.772	x				

[a] Coordinates are given in the WGS-84 reference system.
[b] Denotes that isotope analysis have been performed on the sample.