Lithos 151 (2012) 57–73

Contents lists available at SciVerse ScienceDirect

Lithos

journal homepage: www.elsevier.com/locate/lithos

Geochemistry, geochronology, and origin of the Neoarchean Planalto Granite suite, Carajás, Amazonian craton: A-type or hydrated charnockitic granites?

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ARTICLE INFO

Article history:
Received 21 February 2011
Accepted 28 February 2012
Available online 7 March 2012

Keywords:
A-type granite
Charnockitic rocks
Hydrated charnockite
Archean
Carajás
Amazonian craton

ABSTRACT

New whole-rock geochemistry and LA-MC-ICPMS and Pb-evaporation geochronological data were obtained on zircon from the Neoarchean Planalto suite granites and associated charnockitic rocks of the Canaã area of the Carajás province, eastern Amazonian craton, Brazil. The Pb-evaporation ages of three samples from the Planalto suite are around 2730 Ma (2733 ± 2 Ma, 2731 ± 1 Ma and 2736 ± 4 Ma), whereas U–Pb LA-MC-ICPMS concordia ages obtained for these samples are 2729 ± 17 Ma, 2710 ± 10 Ma, and 2706 ± 5 Ma, respectively. An orthopyroxene quartz gabbro associated with the Pium complex and Planalto suite yielded a U–Pb concordia age of 2735 ± 5 Ma, interpreted as its crystallization age. The Planalto suite granites and the charnockitic rocks associated with the Mesoarchean Pium complex were probably crystallized at 2730 ± 10 Ma. The Planalto granites have ferroan character and are similar geochemically to reduced A-type granites. In previous studies, they have been classified as such, despite the fact that they are syntectonic. The tectonic setting and the association between the Planalto suite and charnockitic series led us to classify these biotite–hornblende granites as hydrated granites of the charnockitic series. The Planalto suite and the Neoarchean charnockitic magmas were more probably derived by partial melting of mafic to intermediate tholeiitic orthopyroxene-bearing rocks similar to those of the Pium complex. At 2.76 Ga, upwelling of asthenospheric mantle in an extensional setting propitiated the formation of the Carajás basin. Later on, at ca. 2.73 Ga, heat input associated with underplate of mafic magma induced partial melting of mafic to intermediate lower crustal rocks, originating the Planalto and charnockitic magmas. The emplacement of these magmas occurred under active regional stress and resultant major shear zones found in the Canaã dos Carajás area. The close association between the Planalto suite and charnockitic rocks suggests that they are similar to the high temperature granite magmatism found near the borders of Precambrian domains with different ages and tectonic evolution or in their zone of interaction.

1. Introduction

A-type granites are a distinctive group of rocks of diversified magmatic origin (Anderson and Bender, 1989; Bonin, 2007; Collins et al., 1982; Dall'Agnol et al., 2005; Eby, 1992; Frost and Frost, 1997; Loiselle and Wones, 1979; Nardi and Bitencourt, 2009; Rämö and Haapala, 2005; Whalen et al., 1987). They are normally associated with anorogenic or post-collisional extensional tectonic settings (Sylvester, 1989; Whalen et al., 1987) and are generally undeformed. However, in southern Brazil, early post-collisional deformed granites interpreted as A-type granites derived of tholeiitic series have been described (Florisbal et al., 2009; Nardi and Bitencourt, 2009).

A-type granites are abundant in the late Paleoproterozoic and Mesoproterozoic, between 1900 and 1000 Ma, when most of the rapakivi granites and anorthosite–mangerite–charnockite–granite (AMCG) complexes were formed (Emslie, 1991; Rämö and Haapala, 1995). However, comparatively earlier Paleoproterozoic ~2.44 Ga A-type intrusions are found, e.g., in eastern Finland (Lauri et al., 2006); these are relatively enriched in the high-field-strength elements (HFSE) and show, in this respect, some affinity with A-type granites also described from Archean terranes (e.g., Yilgarn craton; Champion and Sheraton, 1997). Archean granites associated with rocks of the charnockitic series (nomenclature adopted in this paper for the hypersthene-bearing rocks of the charnockitic series follows that of Le Maitre et al., 2002, their Table 2.10) have also been

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doi:10.1016/j.lithos.2012.02.020

identified in the Kaapvaal, Siberian, and Singhbhum-Orissa cratons and the East Antarctic shield (Larin et al., 2006; Misra et al., 2002; Moore et al., 1993; Sheraton and Black, 1988). In the Archean, granites with A-type affinity are generally restricted to the Neoarchean.

Neoarchean granite bodies with A-type affinity have also been described in the Carajás Province, Amazonian craton, Pará state, northern Brazil. They include the Estrela Complex and the Serra do Rabo and Igarapé Gelado plutons (Barros et al., 2009; Sardinha et al., 2006) within or northwest of the Carajás basin (Fig. 1). Moreover, immediately to the south of the Carajás basin, several elongated plutons with A-type characteristics have been reported and are grouped in the present paper in the Planalto Suite. This suite is spatially associated with charnockite rocks and peculiar sodic granitoids and is found only in the Carajás basin. 1.88–1.87 Ga post-kinematic (yet synorogenic) granitoids with A-type and C-type granite characteristics related to a bimodal (mafic–felsic) magmatic association were also identified in the Central Finland Granitoid Complex (Elliott, 2003; Rämö et al., 2001).

In this paper, we present geological, geochemical, geochronological, and Nd isotope data for the Archean granites of the Planalto suite of the Carajás Province. The new data are employed to discuss the petrogenesis of this Neoarchean granitoid magmatism, the complex relationships between A-type granites and charnockitic series, and implications for crustal evolution of the northern Carajás Province.

2. Tectonical setting and regional geology

The Archean Carajás Province of the Amazonian craton comprises two distinct tectonic domains (Fig. 1a, b; Santos et al., 2000; Tassinari and Macambira, 2004; Vasquez et al., 2008): The Mesoarchean Rio Maria domain (RMD) in the south (3.0 to 2.86 Ga; Almeida et al., 2011; Leite et al., 2004; Macambira and Lancelot, 1996; Souza et al., 2001) and the Carajás domain in the north (3.0 to 2.55 Ga; Dall'Agnol et al., 2006; Gibbs et al., 1986; Machado et al., 1991). The border zone between the RMD and the Carajás domain is located north of the Sapucaia belt (Fig. 1b).

The Mesoarchean Rio Maria domain (Fig. 2) is composed of greenstone belts (3.00–2.90 Ga; Macambira, 1992; Souza et al., 2001) and several granitoid series: (1) Older tonalite–trondhjemite–granodiorite (TTG) series with four distinct units (2.98–2.93 Ga; Almeida et al., 2011; Althoff et al., 2000; Leite et al., 2004; Macambira and Lancelot, 1996); (2) Rio Maria sanukitoid suite (~2.87 Ga; Macambira and Lancelot, 1996; Oliveira et al., 2009); (3) Younger TTG series (~2.87–2.86 Ga; Almeida et al., 2011; Leite et al., 2004); (4) High Ba–Sr leucogranodiorite–granite suite (~2.87 Ga; Almeida et al., 2010); and (5) Potassic leucogranites of calc-alkaline affinity (~2.87–2.86 Ga; Leite et al., 2004).

The northern part of the Carajás domain (Fig. 2) corresponds to the Neoarchean Carajás basin (CB). Its southern part was denominated informally as 'Transition subdomain', a terrane originally similar to the RMD but intensely affected by the magmatic and tectonic Neoarchean events recorded in the CB (Dall'Agnol et al., 2006 and references therein; Domingos, 2009). However, Feio (2011) argued that the crustal evolution of the Canaã area and possibly also that of the Transition subdomain is distinct from the evolution of the RMD, and suggested that the Canaã area could belong to another tectonic terrane.

The Transition subdomain comprises poorly known, strongly deformed Mesoarchean to Neoarchean granitoid and gneissic rocks generally grouped in the Xingu Complex (Fig. 1b). In the Canaã area (Figs. 1c, 2), studied in more detail, four major magmatic events, three Mesoarchean and one Neoarchean, were distinguished (Feio,

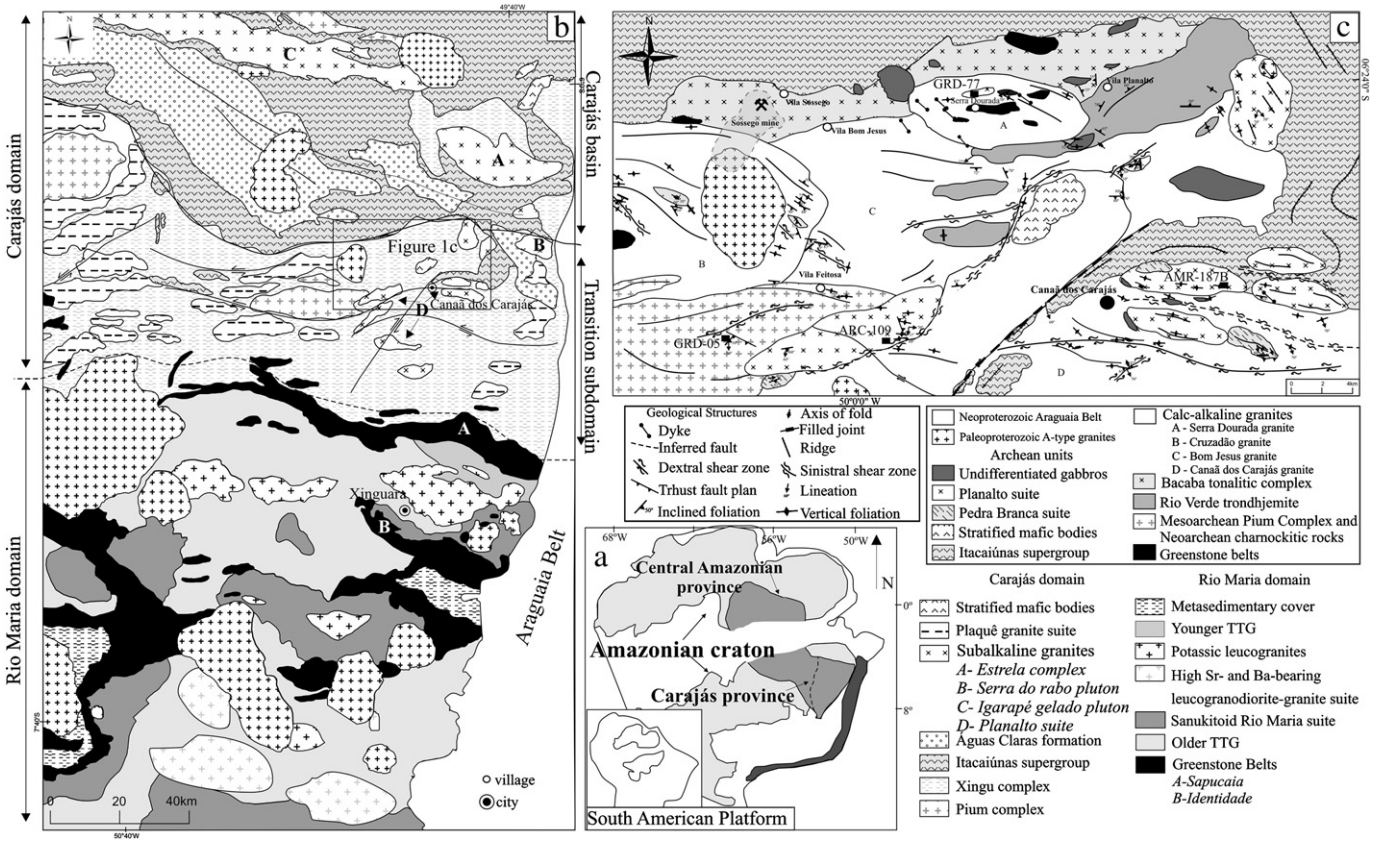

Fig. 1. (a) Location of the Carajás Province in the Amazonian craton. (b) Geological map of the Carajás Province, showing the location of the Canaã dos Carajás area and the approximate limits between the Rio Maria and Carajás domains (dashed line), and the Carajás basin and transitional subdomain (continuous lines). (c) Geological map of the Canaã dos Carajás area, showing the location of the dated samples.