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Isotope geochemistry of Paleoproterozoic metacarbonates from Itatuba, Borborema Province, Northeastern Brazil: Evidence of marble melting within a collisional suture

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ABSTRACT

Strongly-deformed marbles may be easily confused with linear and elongated carbonatite intrusions. Both rocks may present similar texture and foliation to the host rock, or even cross cutting field relationships, which could be interpreted either as igneous or high-grade metamorphosed marble. Diagnostic criteria are even more complex when there is evidence of melting of the metasedimentary carbonate rock, such as has been described in the Himalayas and in the Eastern Ghats, India.

In the Alto Moxotó Terrane, a high-grade gneissic domain of the Borborema Province, Northeastern Brazil, there are metacarbonates associated with banded gneisses and different metaplutonic rocks. Field evidence indicates the absence of other metasedimentary rocks associated with these marbles, thus suggesting that these carbonates were separated from other siliciclastic metasedimentary rocks. The presence of marble also suggests that it may represent the initial stage of a crustal carbon recycling into the mantle. These marbles present many field similarities to carbonatites (e.g., fluid-flow structure) and, together with metagranites and metamafic intrusions, may represent a major collisional tectonic suture.

A detailed study of the carbon, oxygen and strontium isotopic composition of these marbles is presented. This study aims to identify the origin of the different isotopic components. It is argued that these rocks were subjected to temperature and pressure conditions that were sufficiently high to have melted them. The isotopic data presented here support this interpretation and indicate the mixing of two components: (i) one characterized by radiogenic Sr isotopes and mantle-like carbon isotopes, which is associated with the gneissic and mafic rocks, and (ii) another characterized by low $^{87}Sr/^{86}Sr$ ratios and highly positive $\delta^{13}C$ values. Available geochemical data for the upper Paleoproterozoic indicate that the $^{87}Sr/^{86}Sr$ ratio of ocean water, varying between 0.7050 (2.25 ± 0.25 Ga) and 0.7047 (1.91 Ga), falls within the lower range of the samples from Itatuba and thus reinforces the interpretation that these marbles are sedimentary-derived and were partially contaminated by interaction with the host gneissic and mafic rocks.

1. Introduction

Deformed carbonatites are rarely described in the literature because such igneous rocks in general occur in stable tectonic environments such as in old cratonic areas. Examples of linear and deformed carbonate-bearing rocks showing petrographic and geochemical appearance similar to carbonatites have been described in the literature and have been interpreted either as chemically modified marbles or as deformed carbonatites emplaced in mobile belts (Fourcade et al., 1996; Lapin et al., 1999; Lentz, 1999; Burke et al., 2003; Attoh et al., 2007; Chakhmouradian et al., 2008).

The problem is even more complex, because both intrusive carbonate rocks formed by melting or by tectonic extrusion of ductile carbonates, and deformed carbonatites may present similar textural features such as foliation and crosscutting field relationships with the host rock. Diagnostic criteria fail when there is no evidence of melting of the metasedimentary carbonate rock, such as those described in the Eastern Ghats, India (Bhowmik et al., 1995; Le Bas et al., 2002) and the Himalayas (Liu et al., 2006).

There may be, however, an important link between carbonatites and marbles, because there is increasing evidence that carbon is recycled into the mantle by subduction. For instance, increase in

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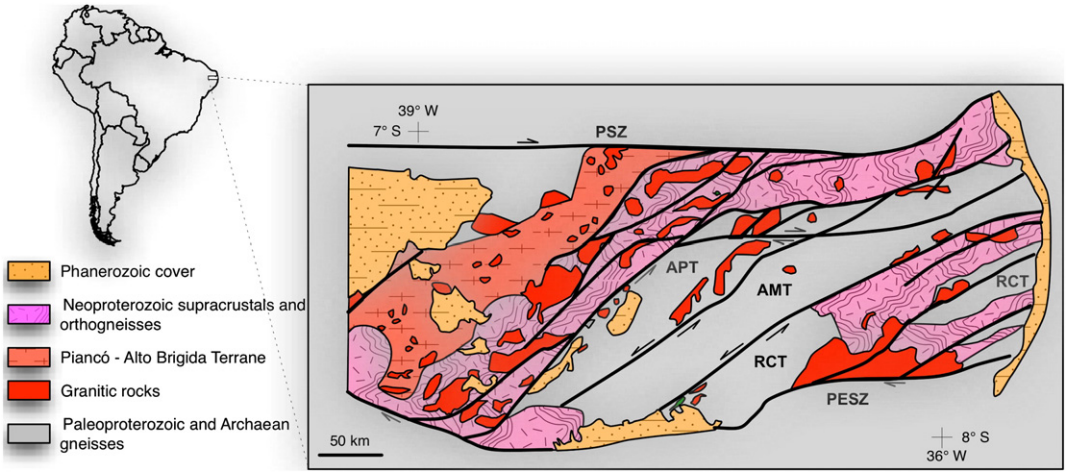

Fig. 1. Geologic scheme of the Borborema Province showing the main structures and trend of mafic rocks. PSZ = Patos Shear Zone; PESZ = Pernambuco Shear Zones; TAPT = Alto Pajeú Terrane; AMT = Alto Moxotó Terrane; RCT = Rio Capibaribe Terrane.
Modified from Santos and Medeiros (1999).

strontium and lead isotopic ratios of carbonatite over time has been related to an increase in the radiogenic character of the carbonatite mantle source due to crustal recycling (Baker, 1996). Evidence of crustal carbon recycling into the mantle is also recorded in diamonds, which, in contrast to carbonatites, can preserve the record of different mantle regions as they grow (Cartigny et al., 1998; Thomassot et al., 2009).

The Borborema Province, NE Brazil, is part of the West Gondwana Margin and is characterized by complex geological/geotectonic domains that evolved from the Archaean to the Neoproterozoic (Brito-Neves et al., 2000a,b; Van Schmus et al., 2011; Amaral et al., 2012). These subdomains are made of Paleoproterozoic basement and Neoproterozoic supracrustal rocks bounded by continental-scale shear zones (Vauchez et al., 1995; Brito-Neves et al., 2000a,b; Santos et al., 2002; Van Schmus et al., 2011). These terrains were welded together during the Neoproterozoic (Vauchez et al., 1995; Brito-Neves et al., 2000a,b; Sá et al., 2002), during which most of the Paleoproterozoic tectonic and deformational histories were obliterated. In the Itatuba area, located in the Domínio da Zona Transversal of the Borborema Province, occur Paleoproterozoic metacarbonate rocks associated with retroeclogitized metamafic–ultramafic rocks and plagioclase-bearing orthogneisses (Bimodal Suite) hosted by a gneissic complex (Fig. 1) (Almeida et al., 1997; Carmona, 2006). These rocks are located within the Alto Moxotó Terrane, which has been interpreted as a major collisional Paleoproterozoic tectonic suture by Santos et al. (2010).

In this paper, a detailed study of the carbon, oxygen, strontium and neodymium isotopic composition of these metacarbonates is presented. Previous investigation of C and O isotopes conducted by Carmona (2006) in various carbonate rocks of this area was inconclusive because the isotopic C and O data fall in a field between sedimentary carbonates and carbonatites. The new isotopic data indicate that these carbonates have been separated from the associated siliciclastic metasedimentary rocks, thus suggesting that it may represent the initial stage of a crustal carbon recycling into the mantle.

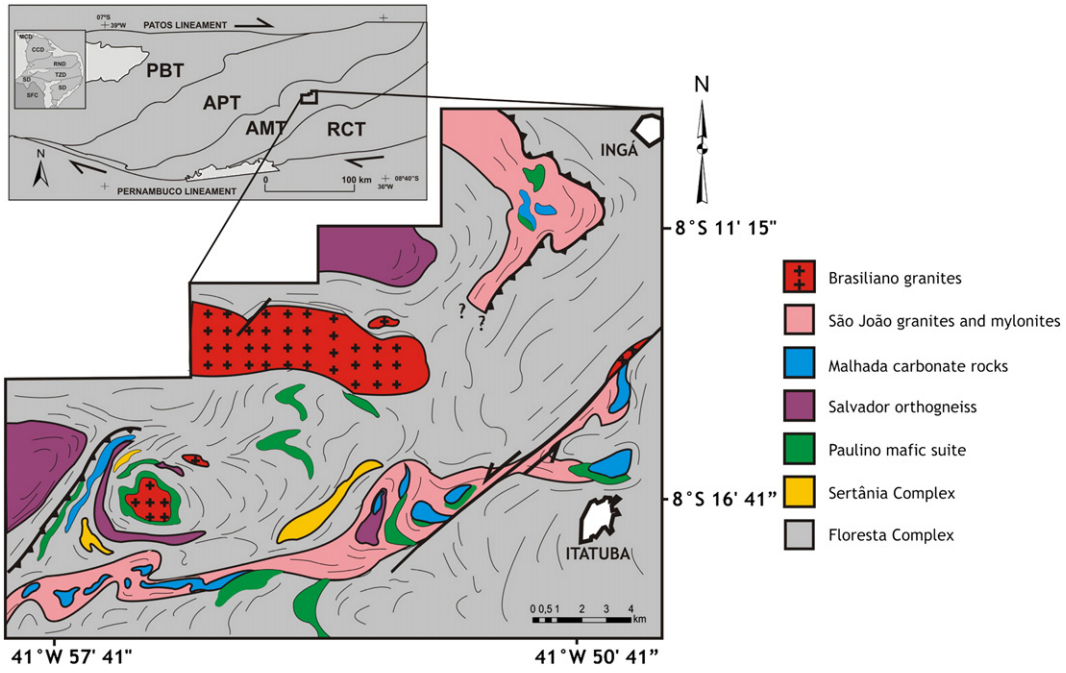

Fig. 2. Geological map of the Itatuba area, NE Brazil.