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Tonian granitic magmatism of the Borborema Province, NE Brazil: A review

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ABSTRACT

Tonian granitoids, today augen-gneisses and migmatites, showing crystallization ages ranging from 870 Ma to 1000 Ma occur in the Borborema Province, NE Brazil. The majority of them have ages within the 925–970 Ma interval. Few intrusions with ages of ~1.0 Ga and <900 Ma occur in the Transversal and South subprovinces. The Tonian granitoids constitute the most expressive magmatic rocks of the Cariris Velhos event. The studied granitoids (herein CVG -Cariris Velhos granitoids) intrude slightly older bimodal (but mostly felsic) volcanic successions and metasedimentary sequences in the Transversal and South subprovinces. Tonian granitoids are unknown in the North subprovince. The CVG comprise mainly coarse-grained augen-gneisses of granite to granodiorite composition. Fe-rich biotite (annite) is the main mafic mineral phase, constituting up to 15% of the modal composition. Garnet, muscovite and tourmaline occur as accessory phases in many plutons.

The CVG augen–gneisses have high SiO_2 (>71%) and alkali contents, they vary from slightly peraluminous to slightly metaluminous, and from slightly magnesian to typical ferrroan rocks. In the migmatized orthogneisses the SiO_2 contents are usually <70%. Trace element variations in the CVG are extensive, reflecting the migmatization recorded in some plutons and/or distinct sources. They are Ca-, Sr- and Nb-poor, showing variable Ba (100–1260 ppm), Rb (164–400 ppm) and Zr (144–408 ppm) contents, and high abundances of Y (>40 ppm). The chondrite normalized REE patterns are characterized by strong to moderate negative Eu anomalies ($Eu/Eu^* = 0.23–0.70$). In general, the spidergram patterns show deep troughs at Ti, P, Ba and Sr and less pronounced Nb–Ta troughs. These patterns are similar to those reported for anorogenic granites evolved from mixtures of magmas from both crustal and mantle sources. The CVG exhibit T_{DM} model ages ranging from 1.9 to 1.1Ga, with slightly negative to slightly positive εNd(t) values, suggesting the involvement of distinct proportions of mantle and crustal components in the source of their protoliths.

There is no consensus in the literature about the tectonic setting of the CVG ie they have been related to either continental margin magmatic arc, with possible back–arc association, or extention-related setting, with generation of A-type granites. However, all the available geochemical data suggest that the CVG represent extension related magmatism. The geochemical signature associated to bimodal volcanism, including pyroclastic rocks, with similar ages, and absence, up to now, of evidence for metamorphism of Tonian age, support the hypothesis of extension - related magmatism.

1. Introduction

The Borborema Province (Almeida et al., 1981) constitutes a region located in the northeast part of the South American continent, between the West Africa-São Luis craton to the north, and to the west by late Neoproterozoic (Brasiliano/Pan African) terranes that extend northward from central Brazil (Pimentel and Fuck, 1992; Pimentel et al., 1997, 2000) mostly covered by Phanerozoic sediments. According to Van Schmus et al. (2008), the Borborema Province resulted from the breakup of a Palaeoproterozoic

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supercontinent (Columbia: Rogers and Santosh, 2002, 2003; 2004) during the late Mesoproterozoic to early Neoproterozoic.

Van Schmus et al. (1995) proposed that the E–W trending Patos and Pernambuco shear zones divided the Borborema Province into three tectonic domains, later denominated subprovinces (Van Schmus et al., 2011): North, Transversal and South.

The North subprovince, located north of the Patos shear zone, comprises Paleoproterozoic basement, including some Archean nuclei, overlapped by Neoproterozoic metasedimentary sequences, and Ediacaran plutonic rocks. The South subprovince comprehends the region between the Pernambuco shear zone and the São Francisco craton, resulted from a tectonic collage of various blocks, terranes or domains with ages ranging from Archean to Neoproterozoic (Van Schmus et al., 2008).

The South subprovince comprises three domains (Fig. 1): (a) Sergipano, north of the São Francisco Craton; (b) Pernambuco–Alagoas (PEAL), north of the Sergipano domain, and (d) Riacho do Pontal. The Rio Preto belt is considered part of the South subprovince, but is not referred to as a domain by Van Schmus et al. (2011). The Sergipano domain or belt (Oliveira et al., 2010) is subdivided into five lithotectonic domains: Canindé, Poço Redondo-Marancó, Macururé, Vaza Barris, and Estância. The PEAL domain constitutes a region of high-grade gneisses, migmatites, and the largest Brasiliano granitic intrusions in the Borborema Province, which lies to the north of the Sergipano domain. The Riacho do Pontal domain consists of metasedimentary and metavolcanic supracrustal sequences with late Neoproterozoic (Brasiliano) granites and some older gneisses.

The Transversal subprovince lies between the Patos and Pernambuco shear zones, within a major shear couple formed by dextral displacement of these two shear zones. This shear couple formed many faults, that caused fragmentation and clockwise block rotation, during the Pan African/Brasiliano Orogeny, which makes complex the reconstruction of the pre-Brasiliano geotectonic history of this domain. The Transversal subprovince was subdivided into two belts by Brito Neves (1983) and in four terranes by Santos (1995) and Santos et al. (1999). The terranes model has been contested by several works, and the Van Schmus et al. (2011) designation, will be used in this work.

Previous work (Brito Neves, 1983) did not consider the east branch of the Pernambuco shear zone as the limit of distinct domains, ie, the north part of the Pernambuco Alagoas domain continues in the Transversal subprovince of Van Schmus et al. (1995, 2008, 2011). Some recent works, carried out in the north part of the Pernambuco Alagoas domain and in the southeast part of the Transversal subprovince, have shown that the east branch of the Pernambuco shear zone is not a limit of distinct domains (Neves et al., 2012; Silva Filho et al., 2014a, b).

The Tonian (Cariris Velhos) suite comprises bimodal metavolcanic (mostly felsic) with small occurrence of pyroclastic, metasedimentary and metaplutonic rocks, yielding U–Pb zircon ages ranging from 870 Ma to 1000 Ma. This suite, mostly identified in the Transversal subprovince, is coeval with rocks from other parts of the South subprovince, notably in the Poço Redondo-Marancó subdomain of the Sergipano domain, in the Pernambuco Alagoas, Riacho do Pontal and Rio Preto domains.

At present, there is no integration for the Tonian orthogneisses dataset from distinct domains of the Borborema Province. The aim of this paper is to present a review of the Tonian orthogneisses from the Borborema Province, including geochronological, geochemical and Sm–Nd isotopic data from the literature and new geochemical and geochronological data. It is an attempt to constrain the Tonian orthogneisses geotectonic meaning in an integrated way, and doing so, to contribute to the understanding of the Cariris Velhos event in the Borborema Province.

2. Geological aspects of the Borborema Province

The Borborema Province consists of gneissic and migmatitic basement complexes, mostly formed during the Paleoproterozoic (1.98 Ga to 2.2 Ga), including minor Archean blocks, partially covered by Neoproterozoic metasedimentary and metavolcanic rocks (Van Schmus et al., 1995, 2008; Dantas et al., 1998; Fetter, 1999; Brito Neves et al., 2001; Kozuch, 2003; Guimarães et al., 2012).

Two contrasting tectonic models have been proposed to the late Neoproterozoic evolution of the Borborema Province: The accretionary model (Brito Neves and Cordani, 1991; Santos, 1995; Jardim de Sá, 1994 among others) in which the main shear zones represent boundaries of continental fragments or terranes amalgamated during the Pan-African – Brasiliano Orogeny. In opposition to the accretionary model, Neves (2003) and Neves et al. (2006) argued that the Borborema Province constitutes a consolidated block since 2.0 Ga ago (the single-block model).

Trompette (1997) suggested the continuation of the Transversal subprovince to the African side of West Gondwana, between the Adamaoua and Garoua shear zones in Cameroon (Median Shear Corridor). Some recent works (Silva Filho et al., 2014a; Neves et al., 2015) showed the at least in the east side of the Borborema Province, the Pernambuco lineament does not separate distinct blocks. However, there is a major contrast in Sm–Nd T_{DM} ages on either sides of the Patos shear zone: Archean model ages to the north and Mesoproterozoic model ages to the south. The distribution of the Sm–Nd T_{DM} model ages favors the hypothesis that the Patos shear zone represents a major terrane boundary (Brito Neves et al., 2001; Kozuch, 2003; Van Schmus et al., 2008). Geochemical and geochronological similarities between the Paleoproterozoic orthogneisses from the north and south of the Patos shear zone (Souza et al., 2007; Neves et al., 2006) suggest that they represent the basement of the supracrustal rocks with Mesoproterozoic T_{DM} model ages, recorded in the south of the Patos shear zone. They are now in the same level due to later vertical movement of the Patos shear zone. Dias et al. (2015), using seismic data, concluded that the Patos shear zone is likely to be a supracrustal structure, rather than a limit of lithospheric terranes, as suggested in the single-block model discussed above.

The Paleoproterozoic basement of the Borborema Province was affected by three major events, which took place at 2.35 Ga; 2.15 Ga and 2.0 Ga (Dantas, 1997; Neves et al., 2006, 2015; Souza et al., 2007). These events are interpreted as part of a Paleoproterozoic collage which led to the assembly of the Columbia Supercontinent of Rogers and Santosh (2002).

Sá et al. (2002); Accioly (2003) reported A-type metagranitoids and meta-anorthosites emplaced at 1.6 Ga and 1.77 Ga respectively, within the Transversal subprovince of the Borborema Province. In addition to the Paleoproterozoic orogenic cycle, the Borborema Province was affected by a Tonian event, the so-called Cariris Velhos event with magmatic ages within 870 Ma – 1000 Ma interval, and the Brasiliano (650–580 Ma) event.

The Cariris Velhos event in the Transversal subprovince is represented mainly by bimodal metavolcanic rocks, including pyroclastic varieties and granitic plutons, now orthogneisses (Santos, 1995; Brito Neves et al., 2001; Kozuch, 2003; Guimarães et al., 2012) and, restricted occurrence of metasediments (muscovite-biotite gneisses, garnet-biotite schists, marbles and BIF) intercalated with metavolcanic rocks. Jardim de Sá et al. (1988), reported the first Tonian age in the Borborema Province. Using Rb–Sr whole rock, they defined an isochronic age of 968 ± 35 Ma, for the orthogneisses of the Afeição suite in the South subprovince (Riacho do Pontal domain) of the Borborema Province, which has been interpreted as representing mixed ages. Later, Van Schmus et al.