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Provenance of metasedimentary rocks from the Ceará Central Domain of Borborema Province, NE Brazil: implications for the significance of associated retrograded eclogites

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ABSTRACT

In the Forquilha area (NE Brazil), in NW Borborema Province, high to ultra-high pressure rocks are an important geological key to understanding West Gondwana amalgamation. U–Pb geochronological data for a retrograded eclogite sample yielded an upper intercept age of ca. 1520 Ma and a lower intercept age of ca. 620 Ma. These ages most likely represent the crystallization age of the basaltic protolith and the regional metamorphism, respectively. The retrograded eclogites are enclosed in migmatized quartz-feldspathic gneiss and sillimanite (after kyanite)-garnet-biotite gneiss. Detrital U–Pb zircon data for these paragneisses show only Paleoproterozoic zircon grains with ages clustering from ca. 1800 Ma (the maximum depositional age) to ca. 2480 Ma, and frequency peaks at 2.2–2.0 Ga. Combined with Nd isotopic data from the Forquilha paragneisses, one can assume a single Paleoproterozoic source. Basement rocks of the Ceará Central and the Rio Grande do Norte domains are the most likely candidates. The absence of Meso- and Neoproterozoic zircon grains suggest that the retrograded eclogite bodies possibly do not represent slivers of oceanic rocks captured in active margin sequences during subduction. It was identified that the high-pressure rocks of the Forquilha area are in tectonic contact with high-pressure granulite facies rocks of the Ceará Complex (Independência unit) that present detrital zircon records of an active margin setting, with ages ranging from ca. 660 Ma to 2200 Ma. Metamorphism of this sequence occurred at ca. 650 Ma. Considering previous studies, field relationships, and metamorphic parageneses, a tectonic scenario is inferred, in which the Forquilha retrograded eclogites represent Mesoproterozoic basaltic rocks of an extensional event that were metamorphosed under eclogite facies conditions during Late Neoproterozoic continental subduction/collision, and juxtaposed to an active margin sequence during the exhumation process.

1. Introduction

Provenance studies based on detrital zircon U–Pb ages coupled with whole-rock Nd isotopic data are powerful tools for the reconstruction of tectonic and paleogeographic settings. Using this approach, it is possible to infer the depositional environment of (meta)sedimentary rocks (Arthaud et al., 2015; Lahtinen et al., 2002; Payne et al., 2006; Piuzana et al., 2003; Van Schmus et al., 2003), while avoiding any misinterpretation related to an exclusive detrital zircon provenance analysis (Howard et al., 2009; Moecher and Samson, 2006). Provenance studies have also been applied in high-pressure and ultra-high-pressure belts to help the understanding of tectonic evolution. Combining a provenance study of the country rocks and the eclogite geochemical-geochronological constraints, it is possible to infer whether the basaltic protolith was part of an oceanic crust that was tectonically juxtaposed in an active margin setting sequence or whether rocks

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of continental affinity that underwent eclogite facies conditions during continental subduction/collision processes (e.g. Chen et al., 2009; Fernández et al., 2010; Liu et al., 2007; Mattinson et al., 2009; Xu et al., 2010; Zhang et al., 2012).

In the northwestern part of the Borborema Province, NE Brazil, the presence of ultra-high to high pressure rocks in the Forquilha area represents an important feature for the reconstruction of West Gondwana amalgamation during the Brasiliano/Pan-African orogeny (ca. 600 Ma). This information adds evidence for the correlation between northeastern Brazil and western Africa during the assembly of West Gondwana, as previously indicated by geophysical (Lesquer et al., 1984) and geological data (Affaton et al., 1991; Araújo et al., 2014b; Santos et al., 2008b; Trompette, 1994; Van Schmus et al., 1995). The retrograded eclogites of the Forquilha area are located to the west of the Tamboril-Santa Quitéria batholith (Fetter et al., 2003) and are enclosed in migmatized quartz-feldspar gneiss and sillimanite(after kyanite)-garnet-biotite gneiss. The peak metamorphic conditions is defined by coesite inclusions and thermobarometric data describe retrograde conditions (Santos et al., in press, 2009b). Geochemistry analyses indicate that the basaltic protoliths combine island-arc tholeiite (IAT) and mid-ocean ridge basalt (MORB)-like signatures (Amaral et al., 2011). These previous data suggest a tectonic scenario in which the retrograded eclogites of the Forquilha area could represent remnants of Neoproterozoic ocean floor (Amaral et al., 2011; Santos et al., 2009b, 2008b) and thus correlate with the high-pressure granulites and eclogites of the African suture zone, which is located east of the West African Craton, in Hoggar and Dahomey (Agbossoumondé et al., 2001; Caby and Monié, 2003; Caby, 1994; Caby et al., 2008; Jahn et al., 2001). Moreover, the alignment and proximity of high-pressure and ultra-high-pressure rocks to the Transbrasiliano/Kandi/4°50′ lineaments support this interpretation.

Previous regional provenance study suggests that the metasedimentary rocks to the west of the Tamboril-Santa Quitéria batholith are part of a Neoproterozoic active margin sequence (Araújo et al., 2012). However, geochronological data of the retrograded eclogites of the Forquilha area and their metasedimentary host rocks are not yet available to test this hypothesis. These data are important to reveal if the retrograded eclogite are enclosed in active margin type rocks.

In this study, we present geochronological data for a retrograded eclogite sample and the results of a provenance study of the metasedimentary host and country rocks. We also include a discussion on the potential areas that could be sources of these sediments, their possible depositional tectonic settings and the relationship of these metasedimentary rocks with retrograded eclogites. In addition, comparisons with possible equivalents in the Pan-African belts were made to better understand West Gondwana geodynamic evolution.

2. Regional geological setting

In a pre-drift reconstruction of West Gondwana, the Borborema Province (Almeida et al., 1981) represents the central site of the amalgamation of the West African-São Luís Craton, the Amazonian Craton, and the São Francisco-Congo Craton (Fig. 1A). In general, the basement of the province is composed of small Archean blocks surrounded by large volumes of Paleoproterozoic rocks, which were reworked during the Late Paleoproterozoic (Sá et al., 1995), Early Neoproterozoic (Cariris Velhos event; Santos et al., 2010), and more intensively during the Late Neoproterozoic Brasiliano/Pan-African orogeny (Brito Neves et al., 2000). Large-scale lineaments due mainly to strike-slip faults and characterize a regional shear zone system (Vauchez et al., 1995), some of which define the limits of different geochronological blocks, domains, and geological units (Brito Neves et al., 2000). In this study, we focused on the geological setting of the northwestern portion of the Borborema Province (Fig. 1B and C), where the Transbrasiliano lineament is the feature that separates the Médio Coreaú Domain from the Ceará Central Domain.

The Médio Coreaú Domain is situated to the west of the Transbrasiliano lineament (Fig. 1B) and is characterized by 2.36 to 2.29 Ga juvenile basement (Fetter et al., 2000; Santos et al., 2009b) represented by high-grade metamorphic rocks and TTG orthogneisses generated in an arc-type geological setting (Santos et al., 2001). Minor amphibolite gneiss, mafic granulite, enderbite, kinzigite and leucogranite complement the suite of rocks known as the Granja Massif. This domain was affected by two extensional tectonic phases during Late Paleoproterozic (Santos et al., 2002) and Late Neoproterozic (Fetter et al., 2003) that promoted the deposition of the volcano-sedimentary sequences known as Saquinho unit and Martinópole/Ubajara groups, respectively. The domain was deformed and metamorphosed at ca. 620 Ma (Santos et al., 2004) and successively intruded by syn-to post-collisional granitoids from 600 to 520 Ma (Santos et al., 2008a).

The Ceará Central Domain is limited to the west by the Transbrasiliano lineament, to the east by the Senador Pompeu lineament, and to the south by the Phanerozoic sedimentary rocks of the Parnaíba basin (Fig. 1C). The basement comprises 2.85 to 2.67 Ga orthogneisses of the Tróia-Pedra Branca Massif (Fetter, 1999) surrounded by 2.14 to 2.10 Ga TTG orthogneiss and migmatite with slightly negative to positive $\varepsilon_{Nd\ (t\ =\ 2100\ Ma)}$, which suggests a predominantly depleted mantle contribution with incipient crustal contamination (Fetter et al., 2000; Martins et al., 2009).

Meso-to Neoproterozoic supracrustal units of the Ceará Central Domain are represented by the Novo Oriente Group and the Ceará Complex. The Novo Oriente Group is a low-grade metavolcano-sedimentary sequence thrusted over the southern portion of the Tamboril-Santa Quitéria Batholith. The youngest detrital zircon U–Pb age of a quartzite yielded ca. 2050 Ma, however the maximum depositional age of this sequence is considered to be at ca. 1.5 Ga, constrained by Nd isotopic data (T_{DM} ages) of a syn-sedimentary mafic rock of the sequence (Araújo et al., 2010). The Ceará Complex is divided into Indepedência and Canindé units. Both are predominantly composed of metapelite, thick bands of quartzite, and lenses of metacarbonate and metamafic rocks metamorphosed at amphibolite to eclogite facies conditions (Arthaud et al., 2008). According to Arthaud (2007) and Arthaud et al. (2008), the Ceará Complex represents a passive margin sequence deposited after 770 Ma. In contrast, Araújo et al. (2012), based on the detrital zircon U–Pb geochronology, interpreted the sequence as part of a long-lived active margin, from 850 to 650 Ma.

The Late Neoproterozoic Tamboril-Santa Quitéria batholith is mainly composed of high-K monzogranite with minor amounts of granodiorite, tonalite, and gabbro. The geological meaning of this unit remains controversial. Fetter et al. (2003) presented U–Pb crystallization ages ranging from 665 to 600 Ma and $\varepsilon_{Nd\ (t\ =\ 600\ Ma)}$ values between −13 and +4, which suggest that this continental arc is a mixture of juvenile Neoproterozoic magmas and older crustal rocks. In contrast, Araújo et al. (2012) presented geochemical data that show similarity of Tamboril-Santa Quitéria batholith rocks with the post-tectonic plutons of the region, and argued favor to a development of a collisional tectonic system contemporaneous with metamorphic ages obtained in the Forquilha area at 650–630 Ma and 620–600 Ma (Amaral et al., 2010; Santos et al., in press). Considering both points of view, the lack of detrital zircon of the main magmatic stage (640–610 Ma) in the metasedimentary sequences of the Ceará Complex strengthens the second interpretation (Araújo et al., 2012).