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Provenance of the Novo Oriente Group, southwestern Ceará Central Domain, Borborema Province (NE-Brazil): A dismembered segment of a magma-poor passive margin or a restricted rift-related basin?

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ABSTRACT

Integrated field, LA-MC-ICP-MS geochronology and geochemical data from the Novo Oriente Group have been investigated in order to determine their provenance and possible tectonic setting. This group in the southwestern portion of the Ceará Central Domain, is a well-preserved metavolcanosedimentary sequence, in part exhalative, composed of two distinct formations. The proximal coastal Bonsucesso Formation comprises mainly quartzite and minor basic metavolcanic rocks and is in gradational contact with the distal Caraúbas Formation which constitutes a metapelitic–volcanic-carbonate sequence, including metabasic rocks with pillow structure and sheared serpentinized ultrabasic rocks. The youngest detrital zircon found in the quartzite of the Bonsucesso Formation yielded an age of ca. 2.1 Ga and well-defined peaks around 2.2, 2.3–2.4 and 2.5 Ga. In addition, zircons from a related metabasalt yielded an upper intercept age of 2083 ±28 Ma. We interpret the zircons found in this metabasalt as inherited from the host quartzite. This fact is supported by depleted-mantle Nd model ages (T_{DM} age) from correlated metabasic and metaultrabasic rocks from other places in the Novo Oriente sequence, which have yielded ages between 1.36 and 1.69 Ga, that is younger than the zircon age obtained in the metabasalt extruded over the Bonsucesso quartzite. Geochemical data of the metasedimentary rocks from the Caraúbas Formation indicates a provenance composed of a mixture of felsic and intermediate sources typical of old stable cratons and older continental roots of active tectonic settings. The rocks of the Granja (Médio Coreaú Domain) and Bacajá Complexes (southeastern Amazonian Craton) exposed to the west of the Novo Oriente Group, and largely covered by the Phanerozoic Parnaíba intracratonic basin, are the most likely source rocks. Since the precise age of the Novo Oriente Group is not yet well constrained, two distinct settings may be proposed: (1) it may represent a more evolved basin developed from extensional processes during the Mesoproterozoic (ca. 1.5–1.3 Ga); and (2) it could constitute part of the passive margin systems developed during the break-up of the Rodinia crown copyright supercontinent (ca. 0.95–0.8 Ga), associated with a pre-Brasiliano/Pan-African ocean (e.g. Pharusian Ocean).

1. Introduction

Different techniques and studies have been used to determine the source of detritus in clastic material from basins that are found within orogenic systems. It has long been recognized that chemical composition of sedimentary rocks reflects the nature of the source region; and therefore the tectonic setting of the sedimentary basins should be considered as the overall primary control on the composition of sedimentary rocks (Bathia, 1983; Dickinson, 1985; McLennan et al., 1990). The use of geochemical data coupled with detrital zircon U–Pb geochronology has greatly contributed to the understanding of provenance and tectonic setting related to the evolution of sedimentary basins (e.g. Nelson, 2001; Eriksson et al., 2001; Goodge et al., 2002; McLennan et al., 2003; Najman, 2006; Sun et al., 2008; Fergusson et al., 2009; Veevers and Saeed, 2009; Bahlburg et al., 2010).

Recent improvements of the geological knowledge of the Ceará Central Domain (CCD) in the Borborema Province has led to a better understanding of the tectonic architecture of this crustal segment and its role in West Gondwana assembly during the late Neoproterozoic (Caby and Arthaud, 1986; Fetter et al., 2003; Castro, 2004; Arthaud et al., 2008; Santos et al., 2008, 2009).

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The questionable timing of continental break-up and seafloor spreading prior to the installation of the Neoproterozoic subduction system proposed by Fetter et al. (2003) in the CCD remains unclear. Some authors favour time of break-up at around 770 Ma (Fetter et al., 2003; Castro, 2004) on the basis of conventional TIMS U–Pb geochronological data on granitic gneisses that have been interpreted as syn-sedimentary rhyolite flow and/or sills of alkaline character. Based on SHRIMP U–Pb detrital zircon studies, Arthaud (2007) argued that continental fragmentation and passive margin development was around 800 Ma; however the lack of Early Paleoproterozoic and Archean detrital zircons in his study is anomalous for an intracontinental rift developed over an Early Paleoproterozoic–Archean crust, which is ubiquitously found as the basement of younger supracrustal rocks in CCD. The age of the continental break-up (Rodinia break-up) prior to the formation of the subsequent subduction and collisional-related settings in other Brasiliano–Pan-African belts, and in its equivalents worldwide, is currently constrained between 1.0 and 0.85 Ga (e.g. Tack et al., 2001; Cordani et al., 2003; Silva et al., 2008; Stern, 2008 and references therein). Nonetheless, examples of older extensional rift-related basins that were inverted only during the Neoproterozoic orogenesis are also found in the geological record (Brito Neves, 2002; Danderfer et al., 2009).

The available geochronological data of the supracrustal rocks from the CCD are not enough to allow a solid tectonic reconstruction of the geodynamic evolution of this domain. In this context, the Novo Oriente Group in the southwestern portion of the CCD was the target of regional reconnaissance scale works in an attempt to contribute to the tectonic evolution of this complex domain.

In this paper we present field, U–Pb detrital zircon geochronological and geochemical data for the metasedimentary rocks from the Novo Oriente Group, in order to constrain their provenance and tectonic setting. Even though the age is relatively poorly constrained, we favour a magma-poor rifted passive margin setting for these rocks. We also provide insights into the tectonic evolution of the CCD during the development of West Gondwana.

2. Geological background: The Ceará Central Domain (CCD)

The Ceará Central Domain is a component of the Borborema Province (Almeida et al., 1981) which lies in the northeastern portion of the South America Platform (Fig. 1). This province is characterized by magmatic, tectonic, and thermal phenomena spanning the Archean to the Cambrian–Ordovician. Final arrangement was accomplished mainly through the Neoproterozoic Brasiliano–Pan-African orogenesis caused by convergence of major "cratonic" blocks such as the Amazonian–São Luiz–West Africa and the São Francisco–Congo and including the participation of minor blocks, during the assembly of West Gondwana (Brito Neves and Cordani, 1991, Brito Neves et al., 2000; Arthaud et al., 2008).

The CCD is composed of (1) Archean (3.2–2.7 Ga) remnants of tonalite–trondhjemite–granodiorite (TTG) units of the Cruzeta Complex; (2) vast tracts of juvenile Paleoproterozoic (2.1–2.2 Ga) high-grade felsic to intermediate orthogneisses and migmatites, including their related supracrustal rocks (Fetter et al., 2000; Martins et al., 2009); (3) high-grade Early Proterozoic to Neoproterozoic supracrustal rocks represented in part by the units from the Ceará Complex (e.g. Arthaud, 2007; Arthaud et al., 2008); (4) the lower crustal segment of a Neoproterozoic continental arc represented by the Tamboril–Santa Quitéria Complex (Fetter et al., 2003; Arthaud et al., 2008); and by (5) widespread Neoproterozoic to Ordovician post-collisional to anorogenic granitoids (Fetter, 1999; Castro et al., 2008). The first two associations acted as the basement for the so-called Brasiliano–Pan-African Neoproterozoic orogenesis (Fig. 1).

The Neoproterozoic Tamboril–Santa Quitéria Complex is a composite magmatic arc association, characterized by a number of magmatic pulses where large volumes of magma intruded in the form of veins, layers, sheets and plutons (Fetter et al., 2003; Arthaud et al., 2008). The plutonic rocks display a ubiquitous syn- to late-magmatic deformation that was in part coeval with the injection newer and less deformed magma (Arthaud et al., 2008). The emplacement age of magmas related to the development of this arc ranges from 660 to 611 Ma [εNd (600 Ma) −20 to +4] (Fetter et al., 2003; Brito Neves et al., 2003; Castro, 2004). Provenance studies on supracrustal rocks (Arthaud, 2007), coupled with a Pb–Pb evaporation zircon age of 795 Ma [εNd (800 Ma) = +4,4] obtained from granodioritic gneisses locally found in the eastern border of the Santa Quitéria arc (Torres et al., in press) suggest that the development of this arc terrane could have started as early as 800 Ma. A debate with two distinctive perspectives on the nature of this arc assemblage has emerged: (1) some argue that this unit is a giant allocthon (Caby and Arthaud, 1986); while (2) others favour an in situ development of this continental magmatic arc (Fetter et al., 2003). Seismic investigation under development on the highlighted area will be critical to answer some questions related with this issue.

High-grade supracrustal sequences from the Ceará Complex are represented by terrigenous metasedimentary rocks (metapelite, metasemipelite, and metagreywacke), which are commonly migmatized and occur on both flanks of the Santa Quitéria Complex. Associated rocks include thin quartzite beds, lens shaped marble and calc-silicate rocks, and are frequently associated with amphibolite that may represent basaltic flows or mafic tuffs (Arthaud et al., 2008). Relics of early eclogitic mineral assemblages are preserved in garnet-bearing amphibolites within these metasedimentary rocks, which are located on both sides of the Neoproterozoic arc assemblage and were described in detail by Castro (2004), Garcia et al. (2006) and Santos et al. (2009).

Conventional TIMS U–Pb ages around 770 Ma obtained on felsic orthogneisses interpreted as alkaline rhyolitic flows and/or sills emplaced on the metasedimentary rocks from the Ceará Complex are interpreted as the depositional age of part of the Ceará Complex (Fetter et al., 2003; Castro, 2004). U–Pb SHRIMP detrital zircon provenance studies carried out by Arthaud (2007) on metasedimentary rocks near the Itatira region contain three distinct zircon populations with age clusters around 800 Ma (four zircons); 1.0 and 1.2 Ga, and several zircons around 1.85 Ga. This author pointed out that the deposition of the Ceará Complex near the Itatira region occurred at around 800 Ma.

The Novo Oriente Group is inserted on the Acaraú Sub-Domain in the western portion of the CCD. The main distinguishing characteristics of this tectono-stratigraphic unit that separate it from the rest of the supracrustal rocks of the CCD are its low to intermediate metamorphic grade, the lack of any crustal anatexis, and the presence of well-preserved primary structures.

3. The Novo Oriente Group

Cropping out over an area of approximately 500 km^2 in the southwestern portion of the Ceará Central Domain, the Novo Oriente Group comprises a coarsening upward and deepening eastward metavolcanosedimentary sequence. It is in part exhalative and composed of two principal units: 1) a distal metapelitic–volcanic-carbonate sequence known as the Caraúbas Formation, which includes metabasic rocks and sheared serpentinized ultrabasic rocks interpreted as mantle slices or even as part of an oceanic crust; and 2) a proximal coastal metapsamitic sequence, comprising the quartzite of the Bonsucesso Formation associated with minor metabasalts (Fig. 2). The contact between these two formations is transitional and the bulk volume of the volcanic counterpart encompasses less than 15% of the whole package, the more primitive examples of which are hosted by the distal Caraúbas Formation. Structural data point to a local duplication of the stratigraphy by folding and thrusting in a SE directed transpressive regime related to the final collisional