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Granulite accretion to Rio de la Plata Craton, based on zircon U-Pb-Hf isotopes: Tectonic implications for Columbia Supercontinent reconstruction

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ABSTRACT

The paleogeographic reconstruction of the Rio de la Plata involved either allocthonous or autochthonous process reflecting directly the Paleoproterozoic connection of the craton to Columbia Supercontinent. Santa Maria Chico Granulite Complex is a significant fragment of Rio de la Plata intensely affected by the Brasiliano Orogeny. Zircon U-Pb-Hf isotopes by LA-ICP-MS, mineral and whole-rock chemistry and a pseudo-section are presently interpreted. U-Pb-Hf isotopes characterize two main accretionary and metamorphic events: oceanic juvenile crustal accretion (i) 2430–2290 Ma ($\varepsilon Hf_{(t)} = -3.17$ to $+7.00$), with arc related metamorphism (830–870 °C, 6.7–7.2 kbar) at ~2.3 Ga; and continental arc accretion (ii) 2240–2120 Ma ($\varepsilon Hf_{(t)} = -4$ to $+2.4$), with continental collision metamorphism (770–790 °C, 8.7–9.1 kbar) at 2.1–2.0 Ga. Alkaline granitic dikes related to crustal extension at 1.8 Ga cut the granulitic rocks after the stabilization of this crustal segment. The present data point to formation of Paleoproterozoic granulitic rocks of the Santa Maria Chico Granulite Complex and adjacent Nico Pérez and Rivera terranes in multi-stage volcanic arcs to continental collision environment over 370 Ma (2430 to 2060 Ma). These terranes were amalgamated in the Paleoproterozoic to the core of the Rio de la Plata Craton as part of Columbia Supercontinent and intensely reworked during the amalgamation of Western Gondwana in the Neoproterozoic.

1. Introduction

Landmasses composing Mesoproterozoic Columbia Supercontinent are currently dispersed worldwide. These fragments include the nucleus of main cratons, e.g., Congo-São Francisco, North China, Rio de la Plata, Baltica (Meert and Santosh, 2017). The connection between Laurentia and eastern India rift systems was the first evidence of the existence of this Mesoproterozoic Columbia supercontinent (Rogers and Santosh, 2002). Presently, Columbia Supercontinent is defined by Paleoproterozoic 2.1–1.8 Ga orogens (Zhao et al., 2002), Paleoproterozoic to Mesoproterozoic sedimentary basins (e.g., Furlanetto et al., 2016), paleomagnetism (e.g., Evans and Mitchell, 2011; Meert and Santosh, 2017) and 1.8–1.7 Ga, 1.5 Ga and 1.1 Ga dyke swarms (e.g., Ernst et al., 2016, Teixeira et al., 2013; Peng, 2015). Rio de la Plata Craton (RLPC) remains little known within Columbia Supercontinent (e.g., Rapela et al., 2007) and requires additional investigations.

RLPC is one of the most extensive cratons in South America and registers a long magmatic-metamorphic history between Archean and Stenian (e.g., Hartmann et al., 2001; M.M. Santos et al., 2017). Two main domains compose the craton: (I) The Rhyacian juvenile Buenos Aires Piedra-Alta Province (BAPAP) (Hartmann et al., 2002; J.O.S. Santos et al., 2017a), and (II) Archean to Stenian terranes reworked during the Brasiliano tectonic cycle (Hartmann et al., 1999, 2008; Mallmann et al., 2007; Oyhantçabal et al., 2012; Oriolo et al., 2016a). In recent years, two geotectonic contexts for the craton were proposed: (I) RLPC composed by BAPAP and reworked margin (Hartmann et al., 2008; Mallmann et al., 2007; Bossi and Cingolani, 2009; Chemale et al., 2011; J.O.S. Santos et al., 2017b); (II) RLPC composed of BAPAP, repositioning the reworked margin as an allochthonous terrane accreted during the Neoproterozoic (Oyhantçabal et al., 2011; Rapela et al., 2011; Oriolo et al., 2016a).

The reworked margin is a key area to understand RLPC limits and tectonic evolution. This margin is made up of Nico Perez, Rivera and Taquarembó terranes. These terranes are continuous in subsurface and separated by Phanerozoic sedimentary cover (Oyhantçabal et al., 2011). They comprise the Valentines – Rivera (VRGC) and Santa Maria

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Chico Granulitic Complexes (SMCGC) (Hartmann et al., 1999, 2008; Santos et al., 2003; Oyhantçabal et al., 2011, 2012; Oriolo et al., 2016a, 2016b). These Paleoproterozoic high-grade rocks were extensively intruded and reworked during the Brasiliano Orogeny, forming a metacraton (J.O.S. Santos et al., 2017b). The SMCGC corresponds to the northern fragment of the reworked margin and was the first arc-related environment identified in the RLPC (Hartmann, 1998; Hartmann et al., 1999).

The understanding of RLPC tectonic evolution and Columbia Supercontinent correlation requires detailed studies of the reworked margin. We studied the SMCGC by integrating petrography, mineral chemistry, lithogeochemistry, geothermobarometry and zircon U-Pb-Hf isotopes. We suggest that the granulitic terranes from the reworked margin constituted a multi-stage volcanic arc to continental collisional environment, amalgamated during the Paleoproterozoic to the core of the RLPC to become part of Columbia Supercontinent.

2. Geological setting

The Precambrian of southern Brazil and Uruguay (Fig. 1) is composed of Archaean to Neoproterozoic units contained in the Uruguayan–Sulriograndense Shield. Crustal growth occurred in the Transamazonian and Brasiliano orogenic cycles (Hartmann et al., 2000). Mesoproterozoic crustal fragments crop out in small portions in the Rocha Group (Basei et al., 2000), Capivarita Anorthosite (Chemale et al., 2011) and Parque UTE Group (Gaucher et al., 2011). The shield is compartmented geotectonically into the RLPC and Dom Feliciano Belt.

RLPC (Ramos, 1988), contains two terranes, separated by the Sarandí del Yí Shear Zone (Rapela et al., 2007). The BAPAP to the west was little affected by the Brasiliano Orogeny (Chernicoff et al., 2014, 2015; J.O.S. Santos et al., 2017b), and comprises the Piedra Alta, 2.2–2.0 Ga (Bossi et al., 1993; Hartmann et al., 2000; Santos et al., 2003), and Tandilia Terranes, 2.26–2.07 Ga (Hartmann et al., 2002; Cingolani, 2011; Chernicoff et al., 2015; Oriolo et al., 2016a). The BAPAP was stabilized at 1.8 Ga (Teixeira et al., 2013). Statherian, Ectasian, and Stenian magmatic rocks are also present in the province (M.M. Santos et al., 2017).

The eastern portion of RLPC is a reworked margin, compatible with a metacraton (J.O.S. Santos et al., 2017b). The margin is made up of three terranes accreted between the Archean and Statherian, Nico Perez, Rivera and Taquarembó. All three were reworked and intruded by several granitic bodies during the Brasiliano orogeny (e.g., Mallmann et al., 2007; Hartmann et al., 2008; Oyhantçabal et al., 2012). The Nico Perez Terrane has the oldest basement inliers in the craton, the La China, and Las Tetas greenstone complex (Hartmann et al., 2001). Granulitic complex VRGC occurs both in Nico Perez and Rivera Terranes; added to the SMCGC in the Taquarembó Terrane, they constitute the largest granulitic areas in the craton. They are mainly orthoderived mafic and felsic gneisses and paraderived successions (Hartmann et al., 1999, 2008; Mallmann et al., 2007; Oyhantçabal et al., 2011, 2012; Oriolo et al., 2016a, 2016b). Statherian anorthosite-mangerite-charnockite-granite (AMCG-type) granites (Campal and Schipilov, 1995) are the younger units in the reworked margin.

The complementary Dom Feliciano Belt records the collage between RLPC and Congo-Kalahari cratons during the Neoproterozoic Brasiliano cycle (Philipp et al., 2016). The belt is formed by São Gabriel Terrane – a juvenile island-arc related terrane (Hartmann et al., 2011), Tijucas Terrane – the Encantadas Complex (Paleoproterozoic basement) and Neoproterozoic metavolcanosedimentary Porongos Complex (Saalmann et al., 2006), Neoproterozoic (650–550 Ma) Pelotas, Florianópolis, and Cuchilla Dionisio granitic batholiths (Philipp et al., 2016).

2.1. Taquarembó terrane

The Taquarembó Terrane (Fig. 2) is limited to the north with São Gabriel Terrane in Dom Feliciano Belt, through the NW-SE trending Ibaré Shear Zone, the remaining portions covered by the Phanerozoic sediments of the Paraná Basin. The terrane is mainly constituted by Paleoproterozoic SMCGC, Neoproterozoic Taquarembó Plateau in the west, and Ediacaran Dom Feliciano Belt related granites, e.g., Vauthier, Saibro, Santo Afonso in the east (Chemale, 2000).

The SMCGC (Nardi and Hartmann, 1979) has large rigid blocks up to 10 km in length, composed of quartzofeldspathic, mafic and ultramafic gneisses, anorthosite and pelitic rocks. Recent geological mapping at

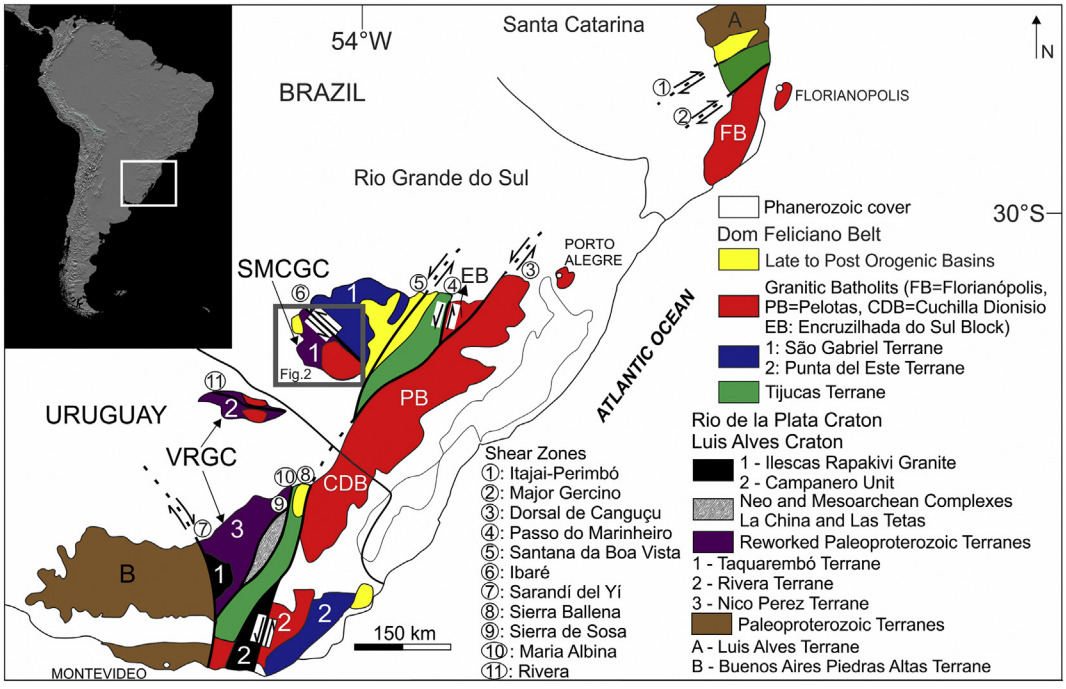

Fig. 1. Main geotectonic units of the Uruguayan-Sul Riograndense Shield with major shear zones (modified from Chemale, 2000; Mallmann et al., 2007; Oriolo et al., 2016a). SMCGC: Santa Maria Chico Granulitic Complex; VRGC: Valentines–Rivera Granulitic Complex.