Lithos 282–283 (2017) 339–357

Contents lists available at ScienceDirect

Lithos

journal homepage: www.elsevier.com/locate/lithos

New U-Pb SHRIMP-II zircon intrusion ages of the Cana Brava and Barro Alto layered complexes, central Brazil: constraints on the genesis and evolution of the Tonian Goias Stratiform Complex

Tommaso Giovanardi [a,*], Vicente A.V. Girardi [a], Ciro T. Correia [a], Colombo C.G. Tassinari [a], Kei Sato [a], Anna Cipriani [b,c], Maurizio Mazzucchelli [b]

[a] Instituto de Geociências, Universidade de São Paulo, Rua do Lago 562, Cidade Universitária B-05508-900, São Paulo, Brazil
[b] Dipartimento di Scienze Chimiche e Geologiche, Università di Modena e Reggio Emilia, Via Campi 103, I-41125 Modena, Italy
[c] Lamont Doherty Earth Observatory of Columbia University, Palisades, New York, 10964, USA

ARTICLE INFO

Article history:
Received 6 October 2016
Accepted 26 March 2017
Available online 31 March 2017

Keywords:
Layered complex
U-Pb
Zircon
Tonian age
Goias
Brasil

ABSTRACT

The Cana Brava, Niquelândia and Barro Alto complexes (Goiás, central Brazil) are three of the largest mafic-ultramafic layered complexes in the world and their origin has been a matter of debate for several decades. One hypothesis suggests that Niquelândia and Barro Alto were both formed by two distinct igneous events at 1.3 Ga and at 790 Ma and were later overlapped during tectonic exhumation at 650 Ma; according to this reconstruction Cana Brava belongs to the youngest intrusion at 790 Ma. A second hypothesis suggests that the three complexes formed during the same event. Here we provide new U-Pb SHRIMP-II zircon ages for the Cana Brava and Barro Alto complexes, constraining their intrusion age to the Neoproterozoic (between 770 and 800 Ma), coeval with Niquelândia. A review of new and literature ages indicate that these complexes formed during a single igneous event and were not modified by regional metamorphism. We propose that the complexes represent fragments of the larger Tonian Goiás Stratiform Complex, which was likely part of a back-arc environment connected to the formation of the Goiás Magmatic Arc at about 790 Ma, later disrupted and accreted to the São Francisco craton.

1. Introduction

Barro Alto, Niquelândia and Cana Brava are three mafic-ultramafic layered complexes, which outcrop in a 350 km NNE trend alignment within the Brasilia Belt in the northern Goiás (central Brazil). They share several field, stratigraphic, geochemical and geochronological features that led to their interpretation as a cogenetic and coeval large intrusion (Carminatti, 2006; Ferreira Filho et al., 1998; Giovanardi et al., 2016). In contrast, several authors claim that Barro Alto and Niquelândia were both formed by two different intrusive events (a Meso- and a Neo-Proterozoic intrusion, with Cana Brava belonging to the Neoproterozoic event; Pimentel et al., 2004, 2006; Ferreira Filho et al., 2010; Della Giustina et al., 2011). According to this two-intrusion model, the Mesoproterozoic (~1.3 Ga) anorthositic upper units of Niquelândia and Barro Alto (formerly called, by these authors, the Serra das Borges and Serra da Malacacheta complexes) were emplaced in a continental rift setting during the formation of the upper metavolcanic-metasedimentary sequences of Indaianopólis and Juscelândia. The ultramafic and gabbroic lower units of Niquelândia and Barro Alto, along with Cana Brava, were instead emplaced during a later Neoproterozoic (~800 Ma) intrusion stage. The complexes were later metamorphosed during their accretion to the São Francisco craton (Della Giustina et al., 2011; Ferreira Filho et al., 2010; Moraes et al., 2006; Pimentel et al., 2004, 2006).

Another model, based on zircon geochronology and petrological modelling of Niquelândia, suggests that the anorthosites were formed by fractionation of a plagioclase-rich crystal mush during the formation of the ultramafic units (Correia et al., 2007, 2012; Rivalenti et al., 2008). This is the so-called one-intrusion model. Moreover, a careful inspection of Niquelândia and Cana Brava suggest that no high-grade metamorphism occurred and the superimposed foliation was due to hyper-to-sub-solidus deformation during the intrusive accretion of the complexes (Correia et al., 2012; Giovanardi et al., 2016).

Here, we present new U-Pb SHRIMP-II data on zircons from the Barro Alto and Cana Brava complexes to finally constrain their age and model of formation (one- versus two-intrusions). We studied four samples (three gabbros and one diorite) from Cana Brava, being the least studied among the three complexes and with poor intrusion ages, and two samples (one gabbro from the lower units and one anorthosite from the upper units) from Barro Alto. We carefully reviewed the

* Corresponding author.
E-mail address: tommaso.giovanardi@gmail.com (T. Giovanardi).

http://dx.doi.org/10.1016/j.lithos.2017.03.026
0024-4937/

geochronology and stratigraphy of both complexes and compared them with those of Niquelândia. We comprehensively discuss the one-intrusion model that best fits our data and the possible former existence of the Tonian Goiás Stratiform Complex (according to the new International Chronostratigraphic Chart, v2016/04; Cohen et al., 2013; Shields-Zhou et al., 2016), whose disruption might have originated the three mafic-ultramafic complexes.

2. Geological setting

The Barro Alto, Niquelândia and Cana Brava layered mafic-ultramafic intrusive complexes outcrop in the Goiás state (central Brazil). They form a c.a. 350 km belt with NNE direction within the Brasilia Belt (Fig. 1) and are considered part of the Goiás Massif. This is an exotic terrane, or microcontinent, disrupted and accreted to the São Francisco craton during the Neoproterozoic Brasiliano/Panafrican event that led to the formation of the Gondwana supercontinent (Brito Neves and Cordani, 1991; Fuck et al., 1994; Pimentel and Fuck, 1992; Pimentel et al., 2000).

The three complexes overthrust to the E the rocks of the Rio Maranhão Thrust Zone, whereas to the W they exhibit intrusive contacts with the metamorphic volcano-sedimentary sequences of Palmeirópolis, Indaianópolis and Juscelândia, respectively (Figs. 2, 3 and 4).

Over the years, several names and stratigraphic subdivisions have been attributed to the three Goiás complexes (Correia and Girardi, 1998; Ferreira Filho et al., 1994, 2010; Giovanardi et al., 2015; Girardi and Kurat, 1982; Girardi et al., 1986). A review of their literature names and subdivisions is reported in Table 1. Each stratigraphy begins with a basal gabbroic unit followed by one (or more) ultramafic unit and one (or more) mafic gabbroic unit. Above the latter, in Niquelândia and Barro Alto a gabbroic-anorthositic unit and a roof unit outcrop, which are alternatively considered as part of the complexes (one-intrusion model) or different intrusives (two-intrusion model).

A first attempt to simplify the stratigraphy of the three complexes was recently made based on the two-intrusion model (Ferreira Filho et al., 2010), which suggests that the complexes are formed by Meso- and Neoproterozoic intrusive events which have crystallized the upper and the lower parts of the complexes. This attempt has unified the names of the lower units of the complexes and differentiated the upper units as different intrusive. Conversely, according to the one-intrusion model (which suggests that complexes were formed during a single Neoproterozoic event), the Niquelândia complex is divided in a Lower Sequence (LS hereafter) and an Upper Sequence (US hereafter) with several sub units (Correia et al., 2007, 2012; Rivalenti et al., 2008). In this work, we revisit the classification of Ferreira Filho et al. (2010) for the lower units and the model of Correia et al. (2007, 2012) and Rivalenti et al. (2008) for the upper units and propose a new unified terminology as discussed throughout the paper.

2.1. Field observations from Barro Alto

In contrast to Niquelândia and Cana Brava and according to Ferreira Filho et al. (2010 and references therein) the stratigraphy of Barro Alto does not comprise ultramafic rocks between the lower and upper gabbroic units. Therefore, the gabbroic rocks outcropping in the Barro Alto complex have been always ascribed to the basal gabbroic unit (Della Giustina et al., 2011; Ferreira Filho et al., 2010). However, during our recent fieldwork, excavation for the enlargement of highway GO338 near the city of Goianesia, has exposed levels of ultramafic rocks in the lower gabbroic sequence of Barro Alto (Fig. 5). Some small outcrops of ultramafic rocks have also been recognized in the lower part of the

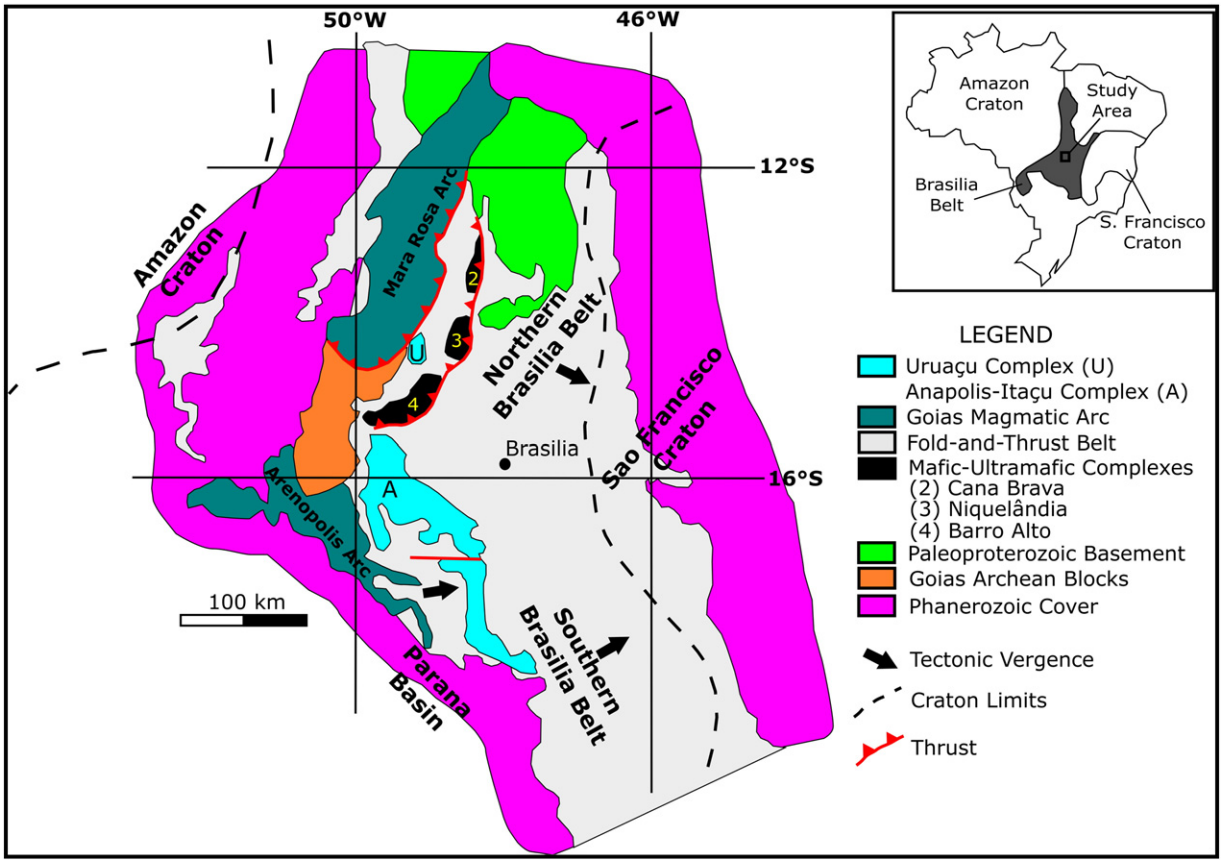

Fig. 1. Regional geotectonic setting of the Brasilia Belt. Each complex is identified with the number of the figure of the detailed geological map reported in this article. Modified after Pimentel et al. (2006).