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Tightening-up NE Brazil and NW Africa connections: New U–Pb/Lu–Hf zircon data of a complete plate tectonic cycle in the Dahomey belt of the West Gondwana Orogen in Togo and Benin

Carlos E. Ganade[a,b,*], Umberto G. Cordani[b], Yao Agbossoumounde[c], Renaud Caby[d], Miguel A.S. Basei[b], Roberto F. Weinberg[e], Kei Sato[b]

[a] Geological Survey of Brazil (SGB/CPRM), Avenida Pasteur 404, CEP 22290-240 Rio de Janeiro, Brazil
[b] Instituto de Geociências, Universidade de São Paulo, Rua do Lago, 562, CEP 05508-080 São Paulo, Brazil
[c] Department of Earth Sciences, University of Lome, P.O. Box 1515, Lome, Togo
[d] Geosciences Montpellier, Université de Montpellier II, Place E. Bataillon 34095, Montpellier Cedex 5, France
[e] Monash University, School of Earth, Atmosphere and Environment, 28, Clayton, Melbourne, VIC, Australia

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ABSTRACT

The Dahomey belt in Togo and Benin is an important segment of the larger West Gondwana Orogen. Here, we review the geodynamic evolution of the Dahomey belt and discuss new U–Pb and Lu–Hf zircon data in light of similar data previously acquired on the geologically related Northern Borborema Province, in NE Brazil. Eighteen samples from different tectonic settings and regions within the belt were collected for zircon isotopic investigation. Passive margin deposits of the Atacora Structural Unit and lower units of the Volta Basin have detrital zircon signatures compatible with the flanking West Africa Craton. The arc-related magmatism resulted from the east-dipping subduction of the Goiás-Pharusian oceanic lithosphere and is represented by a variety of granitoids emplaced in the Benino-Nigerian Shield between 670 and 610 Ma. These granitoids were mainly sourced from crustal reservoirs with subordinate juvenile input. Detrital zircon ages from syn-orogenic deposits in Benino-Nigerian Shield suggest that arc development could have started as early as 780 Ma. The main period of melting in the internal part of the belt, the Benino-Nigerian Shield, is related to crustal thickening and occurs only ca. 30 m.y. after initiation of the continental collision, marked by the ca. 610 Ma ultra-high pressure (UHP) metamorphism recorded at Lato Hills. Foreland development represented by the upper units of the Volta basin developed soon after continental collision and persisted with the development of the west-verging thrust front synchronously with the main period of crustal melting due to collision at ca. 580 Ma. The subvertical Transbrasiliano Lineament in South America, that corresponds to the Kandi Lineament in Africa, provides a present-day fit between NW Africa and NE Brazil. Restoration of the movement of the Transbrasiliano-Kandi Lineament (strike-slip plate boundary) places the Dahomey belt and Borborema Province (NE Brazil) along the same section of the West Gondwana Orogen. This configuration would explain some of the misfits previously discussed in the literature and aligns the UHP eclogites in Togo and NE Brazil.

1. Introduction

Geological correlations between Brazil and Africa have been proposed since the advent of plate tectonics theory (Hurley et al., 1967; Almeida and Black, 1968) or even earlier (see De Wit et al., 2008a,b and references therein). The Neoproterozoic events in Africa (Kennedy, 1964), particularly those recorded along the eastern edge of the West African Craton (WAC) have been grouped in the well-defined Trans-Saharan orogeny (Caby, 1989) and its continuation into South America has been extensively debated (e.g. Caby, 1989; Santos et al., 2008; Arthaud et al., 2008; Cordani et al., 2013a,b; Kalsbeek et al., 2012). Based on the synchronous timing of the continental collision constrained in each sector, this extensive orogenic area was recently re-assembled into the major West Gondwana Orogen (WGO), which extends from present-day northeast Africa to central Brazil (Ganade de Araujo et al., 2014a) (Fig. 1).

* Corresponding author at: Geological Survey of Brazil (SGB/CPRM), Avenida Pasteur 404, CEP 22290-240 Rio de Janeiro, Brazil.
E-mail addresses: caegeo@gmail.com, carlos.ganade@cprm.gov.br (C.E. Ganade).

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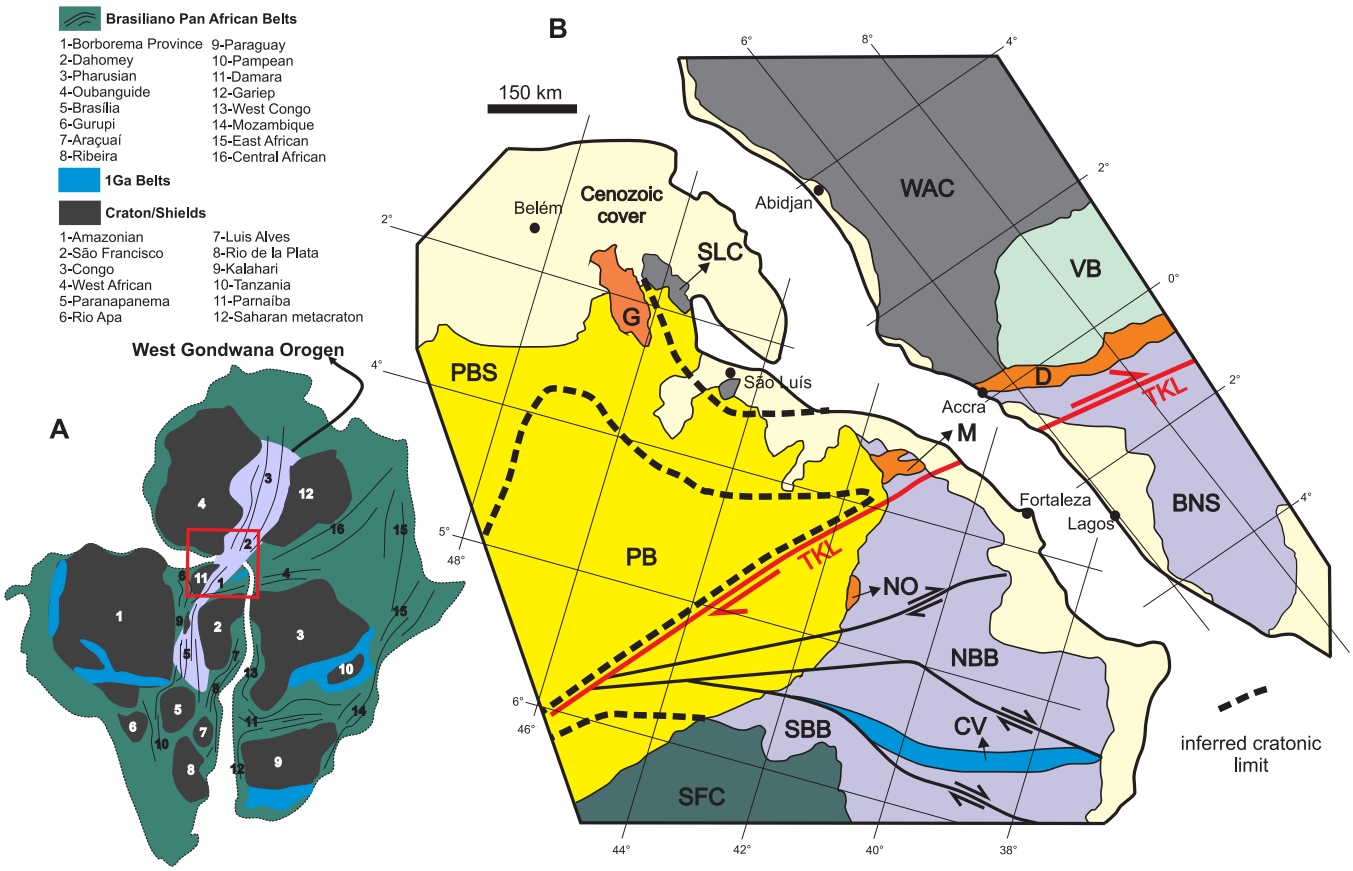

Fig. 1. Continental context of the investigated area. (A) Extent of the West Gondwana Orogen and position of the main cratonic blocks. (B) Equatorial Brazil–Africa correlation modified from Klein and Moura (2008). WAC: West African craton; VB: Volta basin; D: Dahomey belt; BNS: Benino-Nigerian Shield; SLC: São Luiz craton; G: Gurupi belt; M: Martinópole Group; NO: Novo Oriente basin; NBB: Northern Borborema block; SBB: Southern Borborema block; SFC: São Francisco craton; CV: Cariris Velhos belt; PB: Parnaíba block; PBS: Parnaíba basin, TKL: Transbrasiliano-Kandi Lineament.

Modern and traditional views suggest that the WGO resulted from the consumption and closure of the Goiás-Pharusian Ocean that culminated in a continent–continent collision involving mainly the conjoined Amazonian and West African cratons plus the concealed Parnaíba Block colliding against the São Francisco and Saharan cratons (e.g. Trompette, 1994; Cordani et al., 2003; Ganade de Araujo et al., 2014a,b).

With a protracted tectonic history of over 400 m.y. the WGO records accretionary convergent tectonics since the Early Neoproterozoic with development of several intra-oceanic and continental arcs that are now preserved within a deeply eroded, paleo-collisional zone (e.g. Caby, 1989; Berger et al., 2011; Ganade de Araujo et al., 2014a,c). The dominant rock types caught up between the cratonic blocks are interpreted as passive margin deposits, early juvenile and late evolved continental-arc rock assemblages and syn-orogenic supracrustal sequences. Moreover, the orogen has all key features that are observed in modern collision zones with continental subduction occurring nearly simultaneously over at least a 2500-km-long section of the orogen during the Ediacaran period (610–620 Ma) (Ganade de Araujo et al., 2014a).

Here we review the tectonic evolution of the Dahomey belt of the WGO and discuss new geochronological and isotopic zircon data in light of similar data previously acquired for the geologically related Northern Borborema Province, in NE Brazil. This area records a complete cycle of plate tectonics and is not only important because of its crucial position for Gondwana paleogeographic recontructions, but also because it is an open laboratory exposing the deep roots of Himalayan-like mountains.

2. Geological outline of the Dahomey belt and Volta basin

The Dahomey belt resulted from collision between the passive continental margin of the West Africa Craton (WAC) and the eastern continental block known as the Benino-Nigerian Shield (Caby, 1987; Castaing et al., 1994; Attoh et al., 1997; Bessoles and Trompette, 1980; Affaton et al., 1991) (Figs. 1 and 2). The connection of this shield to the proposed larger Saharan metacraton (Abdelsalam et al., 2002) further east is tantalizing, but is yet to be demonstrated. The belt corresponds to the southern segment of the Pan-African Trans-Saharan orogeny that extends for >2500 km from the Sahara desert to the Gulf of Guinea (Caby, 1987). Prior to the opening of the Atlantic Ocean this large belt was connected to the orogenic areas of northeast and central Brazil running for more than 4000 km in the Neoproterozoic West Gondwana Orogen (Caby, 1989; Trompette, 1994; Cordani et al., 2013a,b; Ganade de Araujo et al., 2014a).

In Ghana and adjoining parts of Togo and Benin, the Dahomey belt has a well-organized orogenic architecture with passive margin-related rocks, belonging to the WAC dominating in the external (westerly) portion of the orogen and active margin-related rocks dominating its internal (easterly) portion, marking the western active margin of the Benino-Nigerian shield (Affaton et al., 1991; Agbossoumondé et al., 2004; Attoh and Nude, 2008).

The classical subdivision of the Dahomey belt (Affaton, 1990) includes three main structural units: (i) the western external structural units corresponding to the Buem and Atacora groups; (ii) the eastern internal structural units (Benino-Nigerian shield basement) and, (iii) in between the two, the so-called Dahomey