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Geochronology of granitoid and metasedimentary rocks from Togo and Benin, West Africa: Comparisons with NE Brazil

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ABSTRACT

The westernmost part of the Pan-African (c. 600 Ma) Dahomeyide orogen in Togo and Benin consists of a complex stack of thrust sheets, mainly composed of Palaeoproterozoic ('Eburnean', c. 2000 Ma) granitoid rocks and younger volcanic and metasedimentary successions. This thrust stack comprises the suture between the West-African craton and the Benino-Nigerian province to the east. This eastern province consists largely of migmatites, supracrustals and granitoid rocks. Rb–Sr and Sm–Nd isotope data for four granites from the western domain confirm the Palaeoproterozoic age of these rocks found by earlier studies. One of these granites yielded a zircon U–Pb age of c. 2060 Ma. Twenty samples from the eastern region yield Rb–Sr and Sm–Nd data indicating that both migmatites and granitoid rocks are of Neoproterozoic (Pan-African) age. Zircon U–Pb data on six of these samples yielded ages ranging from c. 650 to c. 550 Ma. Suggestions that parts of the migmatites might be of Eburnean age could not be confirmed. The Neoproterozoic granitoid rocks may represent a Pan-African arc overlying an eastward dipping subduction zone, and Sm–Nd data indicate that they contain significant proportions of older crustal material. Age probability diagrams for detrital zircons from three metasedimentary rocks (one from Nigeria) and one S-type quartz diorite from the eastern region show prominent peaks at c. 1900 Ma and 2400–2200 Ma. A provenance of the zircons from sources in the Borborema province in NE Brazil or lateral equivalents thereof is suggested. A few Neoproterozoic zircons are present in three of the samples. On the basis of Th/U ratios a distinction can be made between Neoproterozoic zircons of metamorphic and detrital origin. The zircon age probability diagram of a quartzite from northern Benin exhibits one peak, at c.1900 Ma, different from the other metasedimentary samples. This quartzite might be correlated with sedimentary strata of the Volta basin that overlie the Eburnean basement in Ghana, Togo and Burkina Faso. Correlation of the rocks in the study area with those in the Borborema province is discussed.

1. Introduction

Pre-Mesozoic correlation of geological units in Africa and South America, across the South Atlantic Ocean, has been generally accepted since the 1960s (De Wit et al., 2008a). Amongst the numerous links that have been proposed (Pankhurst et al., 2008), the Pan-African (c. 600 Ma) Benino-Nigerian province in West Africa is correlated with the Brasiliano (c. 600 Ma) Borborema province in NE Brazil, both of which are essentially Palaeoproterozoic terranes, strongly reworked by Neoproterozoic tectonometamorphic and magmatic activity (Fig. 1; Caby, 1989; Arthaud et al., 2008; Van Schmus et al., 2008; Dos Santos et al., 2008; Dada, 2008; De Wit et al., 2008b, and further references therein). In these reconstructions, major lineaments in Brazil and West Africa, which sometimes separate areas with different proportions of preserved Palaeoproterozoic rocks, have been used to refine the correlation (Fig. 1). Relevant for the present study, most of these correlations assume that the Trans-Brasiliano lineament in South America (Sobral fault, SF, in NE Brazil, Fig. 1) continues into the Trans-Saharan lineament in West Africa (Kandi Fault, KF, in Benin, Fig. 1; see e.g., Caby, 1989; Attoh and Brown, 2008). However, as pointed out by Brito Neves et al. (2002), this precise correlation is not without problems. For example, the complex thrust stack and suture, that represent the collision between the Benino-Nigerian province and the West-African craton (below), is recognised by geophysical features in the basement beneath the Parnaiba basin of the Borborema province, but the latter are not in line with the structures on the African side. In the present paper, zircon U–Pb

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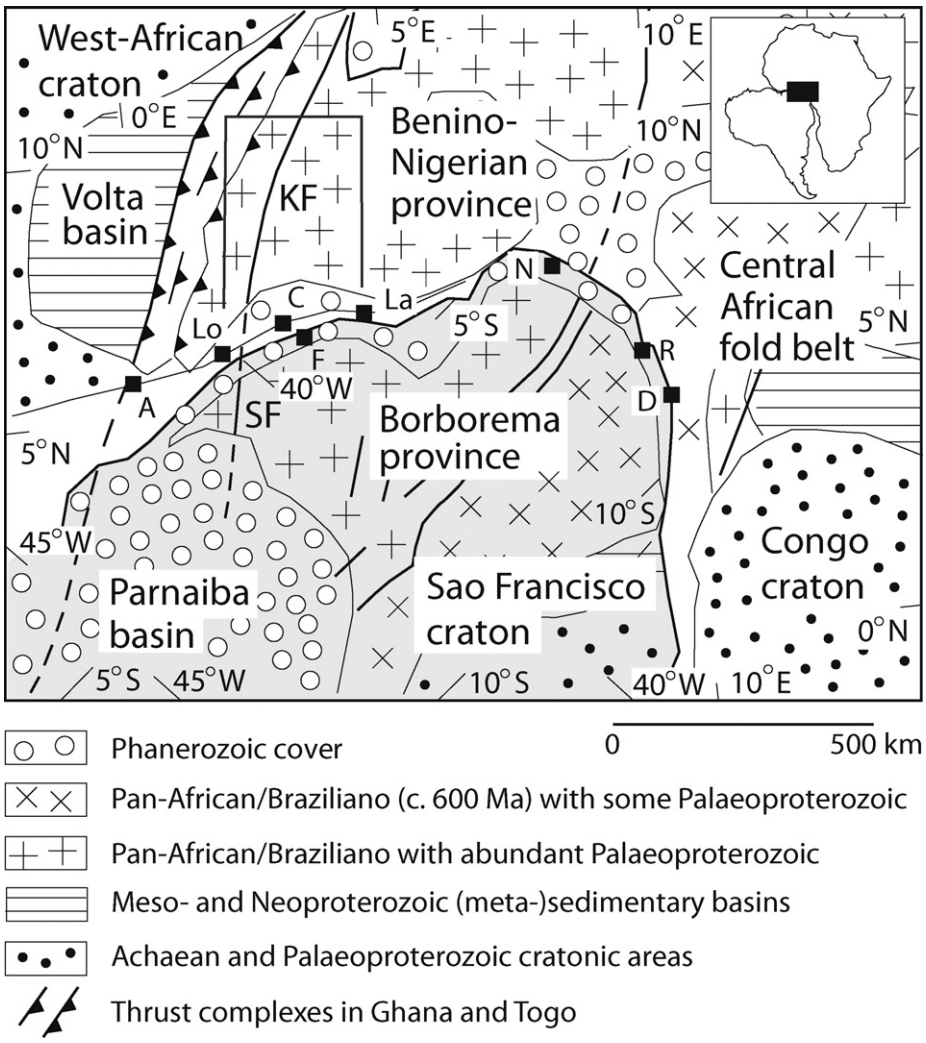

Fig. 1. Sketch of a Pre-Mesozoic correlation of geological units of Western and Central Africa with similar units in the North-Eastern parts of South America (shaded), based on Fig. 1 in Van Schmus et al. (2008), which covers a much larger area. SF: Sobral fault (part of the Trans-Brasiliano lineament). KF: Kandi Fault (Part of the Trans-Saharan lineament). A: Accra; Lo: Lomé;. C: Cotonou; F: Fortalesa; La: Lagos; N: Natal; R: Recife; D: Doualé. The area in West Africa treated in this paper is outlined.

geochronological and Rb–Sr and Sm–Nd isotope data are presented for granitoid and metasedimentary rocks from Togo and Benin with two aims: (1) to contribute to the geochronological data base of the Pan-African basement of Benin and Togo, where such information has been scarce and (2) to test the presently favoured correlations with the Borborema province in NE Brazil. The latter aim is facilitated by the fact that the data presented in this paper are from samples located on both sides of the Kandi fault, the Benin section of the Trans-Saharan lineament.

2. Outline of the geology of Togo and Benin

The western part of the study area (Fig. 2) consists of a complex, up to c. 100 km wide stack of thrust sheets, that comprise the suture between the West-African craton to the west and the Benino-Nigerian (Pan-African) province to the east (Affaton et al., 1980, 1991; Sylvain et al., 1986; Deynoux et al., 2006). To the west, in Ghana, outside the area covered in Fig. 2, the craton is dominated by 2200–2000 Ma ('Eburnean') granitoid, metabasaltic and metasedimentary rocks (Geological Survey Department, Ghana, 2009; for details see Abouchami et al., 1990; Boher et al., 1992). In the east, these are unconformably overlain by a succession of undeformed sedimentary strata, the 1000–450(?) Ma Volta basin (Affaton, 1990; Carney et al., 2010, and references therein). The thrust sheets, in turn, overlie the sediments of the Volta basin. They consist mainly of reworked lithologies of the craton and the Volta basin, but also contain high-grade (up to eclogite facies) mafic and ultramafic rocks (Attoh, 1990, 1998; Affaton et al., 1991, 2000; Castaign et al., 1993, 1994; Agbossoumondé et al., 2001, 2004; Tairou, 2006). These rocks are regarded to mark the suture between the West-African craton and the Benino-Nigerian province, and are associated with positive gravimetric anomalies (Bayer and Lesquer, 1978; El-Hadj Tidjani et al., 1994). Granulite facies metamorphism within the suture zone has been dated by zircon Pb–Pb analysis at 612 ± 1 Ma (Affaton et al., 2000), and exhumation of the thrust sheets by $^{40}Ar/^{39}Ar$ mineral ages at c. 580 Ma (Attoh et al., 1997).

The terrain east of the thrust complex mainly consists of migmatites and granitoid rocks (Fig. 3) that dominate parts of Togo, Benin and Nigeria, whilst supracrustal rocks ('Schist belts') are widespread in Nigeria (Fig. 2). On the basis of their calc-alkaline to subalcaline chemistry Affaton et al. (1987, 1991) suggest that the granitoid rocks may represent a magmatic arc overlying an eastward dipping subduction zone. In northern Benin, quartzites occur locally that have been correlated with quartzitic sandstones of the lower sequence of the Volta basin (Carney et al., 2010). It has been suggested that lateral equivalents of these quartzitic