



Recognition of Early and Late Neoproterozoic supracrustal units in West Africa and North-East Brazil from detrital zircon geochronology

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ABSTRACT

The ²⁰⁷Pb/²⁰⁶Pb age distributions of detrital zircons from eight samples of high-grade Neoproterozoic metasedimentary rocks from Nigeria, Cameroon, and NE Brazil have been studied by LA-ICP-MS, and the results have been compared with published data for non-metamorphic sediments from the Volta basin, Ghana, and associated rocks. Apart from detrital zircons, several samples from Nigeria, Cameroon and NE Brazil contain 630–640 Ma metamorphic zircon, formed during an event of high-grade Neoproterozoic (Pan-African – Brasiliano) metamorphism. This young zircon occurs mainly as rims around older zircon, and can often be recognized by its low Th/U ratios. The detrital zircons vary widely in age: Palaeoproterozoic zircons are present in all samples; Archaean, Mesoproterozoic and Neoproterozoic are present in some. Five samples (one from Nigeria, two from Cameroon and two from NE Brazil) lack detrital zircons younger than ca. 950 Ma, and are argued to represent units of early Neoproterozoic sedimentary rocks. Three samples (one from Nigeria, Cameroon and NE Brazil each) contain numerous zircons with ages of 650–950 Ma, and have been deposited during the late Neoproterozoic. An age difference of several hundred millions of years between the two groups is implied. These results are similar to those earlier obtained for the lower and upper parts, respectively, of the Volta basin in Ghana.

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1. Introduction

Eastern West Africa and North-East Brazil which, before the opening of the Atlantic Ocean, formed a contiguous land mass, consist of rock units that have been strongly reworked during ‘Pan-African’ – ‘Brasiliano’ orogenic events, in connection with the Neoproterozoic (ca. 600 Ma) assembly of West Gondwana (Trompette, 1994). Among the older rocks Palaeoproterozoic orthogneisses predominate, e.g., the ‘Eburnean’ of West Africa and ‘Transamazonian’ of Brazil, but occurrences of Archaean rocks have also been documented (Bruguier et al., 1994; Dantas et al., 2004; Poulet et al., 2007). This Archaean to Palaeoproterozoic basement complex is overlain by, or tectonically interleaved with, metamorphic Neoproterozoic supracrustal formations, and cut by numerous Neoproterozoic granites (Affaton et al., 1991; Van Schmus et al., 2008; Fig. 1). In this paper we present new chronological data on detrital zircons of metasedimentary samples from Nigeria, Cameroon and NE Brazil, acquired by LA-ICP-MS (see below). This method permits the analysis of large numbers of zircons in a short

period of time, giving a solid basis for statistical considerations. As a basis for comparison we use similar data from the Volta basin in Ghana, the largest occurrence in our study area of Neoproterozoic sedimentary rocks that have not been affected by Pan-African deformation and metamorphism.

2. Sampling and analytical procedures

Samples from Cameroon and NE Brazil were collected during field trips in 2011 under the guidance of Joseph Penaye and Zorano S. de Souza, respectively. Samples from Nigeria were provided by Barth N. Ekwueme (Fig. 1).

Zircons for U–Pb geochronology were separated using standard techniques: crushing and sieving to <300 μm, washing on a Holman-Wilfley shaking table, followed by hand picking. Hand-picked zircon grains were set in 1-inch epoxy mounts, sectioned and polished to approximately half their thickness. Back-scatter images of the zircons were obtained by Scanning Electron Microscopy (SEM) at the Geological Survey of Denmark and Greenland (GEUS), and analytical spots (diameter 25 μm) were selected with the help of the SEM images. Isotopic analysis was performed by laser ablation–single collector magnetic sector field–inductively coupled plasma–mass spectrometry (LA-ICP-MS)

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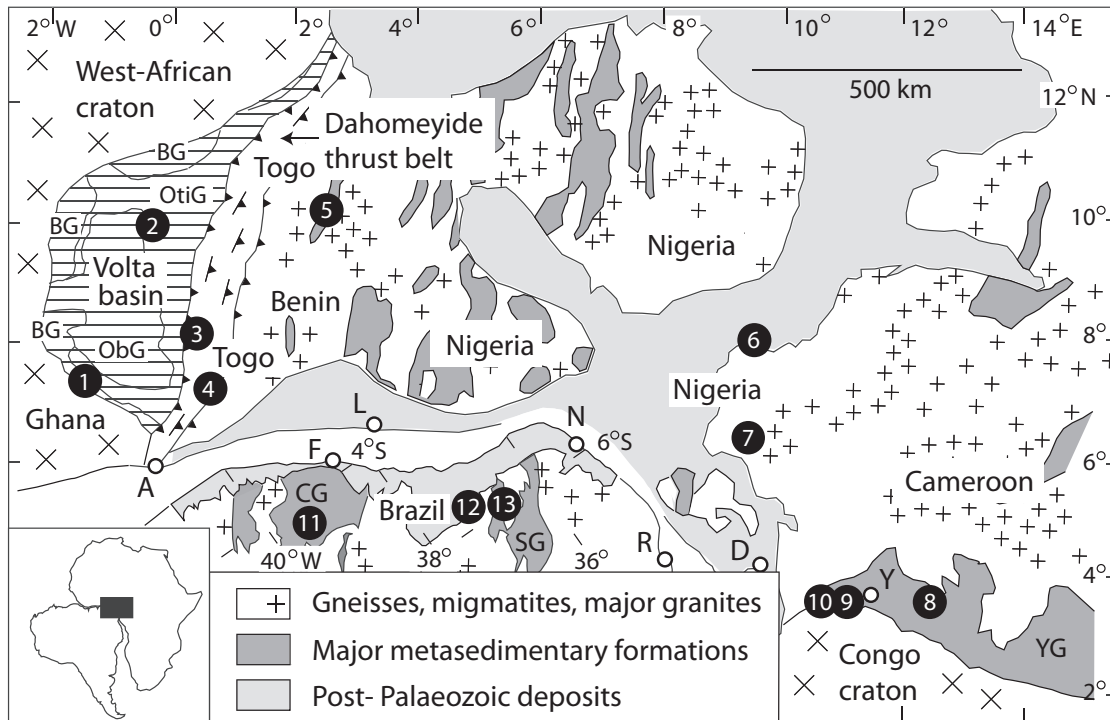


Fig. 1. Geological sketch map of West Africa and NE Brazil in a Pre-Mesozoic setting, based on maps of Affaton et al. (1991) for West Africa and Arthaud et al. (2008) for NE Brazil. Major towns: A: Accra, L: Lagos, D: Duala, and Y: Youandé in West Africa; F: Fortalesa, N: Natal, and R: Recife in NE Brazil. The Volta basin in Ghana (ruled) consists of undeformed Neoproterozoic strata; the three major stratigraphical units: Bombouaka Group (BG), Oti Group (OtiG) and Obosum Group (ObG) are shown after Carney et al. (2010). YG in Cameroon represents the Yaoundé Group; CG and SG in Brazil are the Ceará and Seridó Groups, respectively. The numbered circles show the locations of the investigated samples; see the text.

at GEUS, using a Thermo-Fischer Element II sector field ICP-MS coupled to a NewWave UP 213 nm Nd-YAG laser ablation unit. The methods applied essentially follow those of Gerdes and Zeh (2006), Frei et al. (2006) and Frei and Gerdes (2009).

The GJ-1 zircon (609 Ma; Jackson et al., 2004) was used as primary standard. Samples were analysed in sequences with six standards analysed initially, followed by ten unknowns, again three standards, followed by ten unknowns, etc. Raw data were processed off-line using in-house developed Excel® spreadsheets. During this process analyses that did not provide an age were rejected. No ages were rejected because of large errors or high degrees of discordance.

The chronological data are presented as $^{207}\text{Pb}/^{206}\text{Pb}$ age probability diagrams, prepared with the help of the AgeDisplay program of Sircombe (2004). In these diagrams analyses that are 90–110% concordant are shown with a dark grey colour, while the light grey areas (in part hidden behind the field of concordant zircons) show all analyses, including the discordant ones. In most cases there is a good agreement between concordant and discordant $^{207}\text{Pb}/^{206}\text{Pb}$

ages, which indicates that the latter also provide useful information. Histograms illustrating the ages of concordant zircons are also shown. The Isoplot program of Ludwig (2003) was used for further data presentation and calculation of ages. Since many of our analyses yield discordant data, $^{207}\text{Pb}/^{206}\text{Pb}$ ages are used instead of $^{206}\text{Pb}/^{238}\text{U}$ ages throughout this paper, also for younger zircons. Unless otherwise stated, the term ‘age’ in this paper therefore refers to the $^{207}\text{Pb}/^{206}\text{Pb}$ age of the zircons. Errors are quoted at the 2 sigma level of confidence. All analytical data are shown in Appendix A as supplementary data. A disk with images of all zircons with analysed spots is available on request from the senior author.

3. The Volta basin

The Volta basin (Figs. 1 and 2; Junner and Hurst, 1946; Affaton, 1990; Carney et al., 2010 and references therein) consists of a succession of well preserved Neoproterozoic sedimentary rocks, up to 5–6 km in thickness. The strata dip shallowly ($1\text{--}2^\circ$) to the East and South-East and are virtually undeformed and unmetamorphosed over most of the basin. Near the eastern edge of the basin the rocks have been deformed during Pan-African orogenic events, and overridden by major thrust sheets belonging to the Pan-African Dahomeyide orogen (see below).

In Ghana, the strata of the Volta basin have been divided into three Groups, separated by major unconformities: in upward succession the Bombouaka Group, Oti Group, and Obosum Group (Fig. 2; note that other terminologies have also been used – see Carney et al., 2010). The Bombouaka Group unconformably overlies the Eburnean basement; it is up to 1 km thick and consists mainly of medium-grained sandstones, commonly with well preserved sedimentary structures. It is envisaged to have been deposited along the margins of an epicontinental sea. The Oti Group, up to 4–5 km thick, consists of shales and immature sandstones. It overlies the

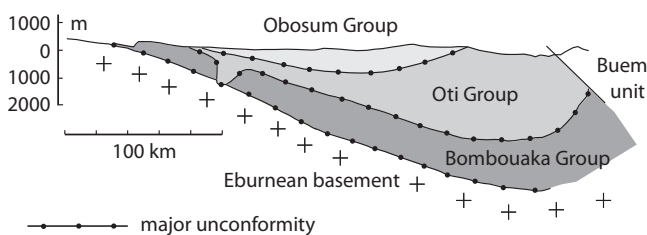


Fig. 2. Schematic W–E section of the Volta basin, Ghana, after Affaton (1990); note large difference in horizontal and vertical scales. To the East the sediments of the Volta basin are deformed and structurally overlain by the Buem structural unit, the lowermost of a succession of Dahomeyide (Pan-African) nappes.

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