Journal of African Earth Sciences 129 (2017) 1–16

Contents lists available at ScienceDirect

Journal of African Earth Sciences

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

# Metamorphic *P–T* evolution of garnet-staurolite-biotite pelitic schist and amphibolite from Keffi, north-central Nigeria: Geothermobarometry, mineral equilibrium modeling and *P-T* path

Emmanuel Nwachukwu Ugwuonah [a, b, *], Toshiaki Tsunogae [b, c], Smart Chika Obiora [d]

[a] Department of Geology, Anambra State University, Uli, Nigeria
[b] Graduate School of Life and Environmental Sciences, University of Tsukuba, Ibaraki 305-8572, Japan
[c] Department of Geology, University of Johannesburg, Auckland Park, 2006, South Africa
[d] Department of Geology, University of Nigeria Nsukka, Nigeria

ARTICLE INFO

*Article history:*
Received 23 April 2016
Received in revised form
10 December 2016
Accepted 12 December 2016
Available online 18 December 2016

*Keywords:*
Nassarawa
Pan African
Geothermometry
Geobarometry
Magmatic arc
Tectonic setting

ABSTRACT

We report the first detailed petrological and pressure-temperature data from the pelitic schists and amphibolites of the Keffi area, north-central Nigeria, which is located on the eastern flank of the western Nigerian based, Great Nigerian Schist Belt. In one fresh exposure of the schist, staurolite-bearing and staurolite-absent, garnet-rich assemblages occur. All pelitic samples contain garnet, quartz, biotite, plagioclase, chlorite and ilmenite, but the staurolite-bearing assemblage contains euhedral to subhedral staurolites and very subordinate retrograde chlorites in addition. Mineral compositions applied to calculate metamorphic *P–T* conditions using different approaches reveal a temperature range of 570–630 °C for the garnet-biotite geothermometry. *P–T* pseudosection analyses calculated using THERMOCALC software for the suitable rock types, constrain garnet/staurolite equilibration within the range of 6.4–7.7 kbar and 610–630 °C. Empirical calculations and pseudo-section approaches indicate a clockwise *P-T* path for the rocks of the study area. The result of geothermobarometry (peak conditions) from this study is consistent with previous *P–T* estimations for the Pan-African episode on several areas within the Trans-Saharan Belt. All evidences point towards a magmatic arc tectonic setting for this area of study.



## 1. Introduction

The Pan-African Trans-Saharan Belt is an orogenic belt that is more than 3000 km long and occurs to the north and east of the >2 Ga West-African craton within the Anti-Atlas and covering the Tuareg and Nigerian Shields (Kröner and Stern, 2004). Even the Pan-African belt of central northwest Africa is part of the Trans-Saharan Belt (Cahen et al., 1984) (see Fig. 1) and it stretches also into Brazil (Ferré et al., 1996). It consists of Pre-Neoproterozoic basement strongly reworked during the Pan-African event and of Neoproterozoic intra-oceanic magmatic rocks (Umberto et al., 2013). Black et al. (1994) and Liégeois et al. (1994) showed that this belt consists of continental terranes amalgamated during oblique collision between the West African Craton and the Tuareg Shield (Caby, 1989; Affaton et al., 1991; Castaing et al., 1993). The Precambrian Basement Complex of Nigeria lies within the internal region of the reactivated part of the Trans-Saharan Belt, east of the West African craton and northwest of the Congo craton. Reactivation at this plate margin is believed to be due to the collision of these two cratons. Lithologically, the Precambrian basement rocks of Nigeria have been subdivided into; Gneiss-migmatite complex (including the Older Metasediments), the Younger Metasediments (the schist belt) and the Older Granite suit (see Fig. 2a). They were later intruded by the Younger Granites in the Jurassic times (Obiora, 2005; Dada, 2006).

McCurry (1976) used the term "Older Metasediments" to refer to the metasedimentary remnants within the gneisses and migmatites, which was deposited perhaps 2500 m.y. ago, and the term "Younger Metasediments" for all low to medium-grade metasedimentary belts which she considered to have been deposited 1000–800 m.y. ago. Using structural distinctions, Grant (1978) distinguished two units of the Nigerian Schist Belt (Younger Metasediments) as; one, a simple and monocyclic type and the other a

* Corresponding author. Graduate School of Life and Environmental Sciences, University of Tsukuba, Ibaraki 305-8572, Japan.
*E-mail address:* emma.ugwuonah@unn.edu.ng (E.N. Ugwuonah).

http://dx.doi.org/10.1016/j.jafrearsci.2016.12.005
1464-343X/

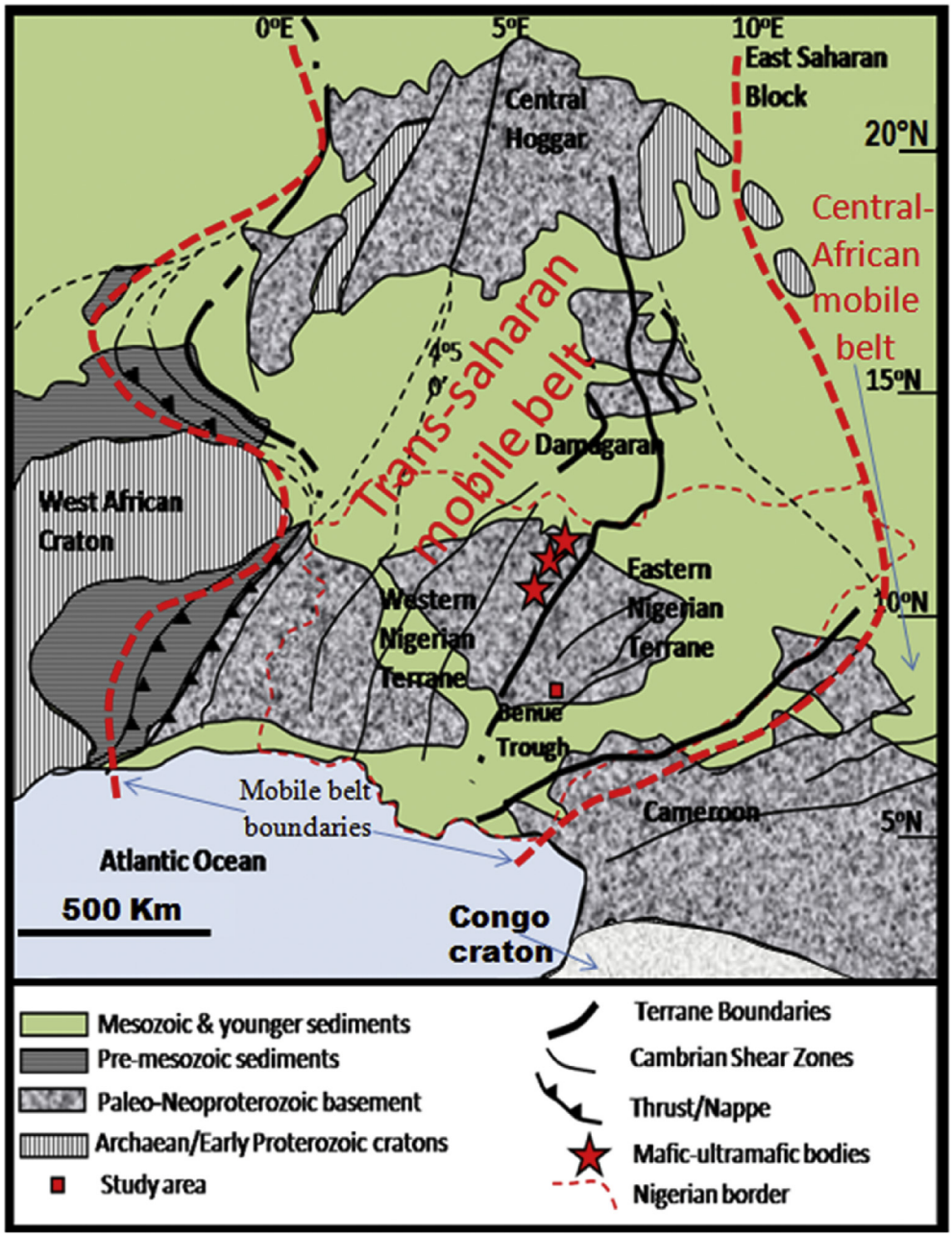


**Fig. 1.** Regional geologic map of the area under study. Showing geological sketch map of the Hoggar–Aïr–Nigeria province showing the Neoproterozoic Trans-Saharan Belt resulting from terrane amalgamation between the cratons of West Africa and Congo and the East Saharan block. Redrawn from Ferré and Caby (2006). Mobile belt boundaries as adapted from Cordani et al. (2013).

complex and polycyclic type. Grant (1978) identified these two structurally diverse signatures imprinted on two schist belts side by side within the northwest Nigerian basement. He described the first type at Birnin Gwari area as having the simple linear style with uniform north-south structural trends. This belt was called the Birnin Gwari Schist formation. The second – the Kushaka Schist formation, is the complex type with great variability in structural trends. The complex style appears in the mixture of north-south and east-west structural trends and also in the presence of refolded major folds. But all other occurrences of the Younger Metasediments preserve only the NNE-SSW Pan-African imprints of foliation (McCurry, 1976; Grant, 1978; Rahaman, 1988; Bruguier et al., 1994). We can therefore assume for now, with a high degree of accuracy, without further chronological analysis that all such rock units (schist) with the simple linear structural styles, within the Nigerian Schist Belt belong to the Younger Metasediments group. Though geographically, they are restricted to the western half of Nigeria from north to south, some units of schistose rocks, contemporaneous with the Younger Metasediments have been mapped in the far eastern Nigerian basement by Ekwueme (1991, 2003), Ephraim (2005), Ephraim et al. (2008) and some parts of Cameroun by Mvondo et al. (2003). However, according to these researchers, the schist belts in Eastern Nigeria (Eastern Nigerian Schist Belt; ENSB) are more closely related to the Central African Fold Belt group than with the schist belts in western Nigerian province (Western Nigerian Schist Belt; WNSB).