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# Evidence for Archean inheritance in the pre-Panafrican crust of Central Cameroon: Insight from zircon internal structure and LA-MC-ICP-MS U–Pb ages

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A B S T R A C T

The main geological feature of Central Cameroon is the wide spread occurrence of granitoids emplaced in close association with transcurrent regional shear zones. The basement of this vast domain is a Paleoproterozoic ortho-and para-derivative formation, which has been intensely reworked, together with subsequent intrusions and sediments, during the Panafrican orogenesis in the Neoproterozoic. As consequence, the area underwent pervasive metamorphism and intense deformation. This makes it difficult to distinguish between Panafrican metasediments or syntectonic plutonites and their respective basement. Our study presents zircon features (CL-BSE-SE) and in-situ U–Th–Pb LA-MC-ICP-MS geochronology of a meta-sedimentary pyroxene-amphibole-bearing gneiss of the Méiganga area in Central Cameroon. Based on the Internal structures of the zircon four characteristic zonation patterns can be deciphered: 1) cores with magmatic oscillatory zonation 2) zircons with oscillatory or sector zonation, 3) zircons with sector zoning or blurred zoning, and 4) narrow bright un-zoned rims. These groups suggest that the rock experienced a number of geological events. Considering this zircon characteristic, the U–Th–Pb data allow to distinguish four ages: 2116 ± 57 Ma, consistent with ages from the Paleoproterozoic West Central African Belt; 2551 ± 33 Ma which marks a late Neoarchean magmatic event; 2721 ± 27 Ma related to a Neoarchean magmatic even in Central Cameroon, similar to one found in the Congo Craton. A zircon core gives ages around 2925 Ma which provides some evidence of the presence of the Mesoarchean basement prior to the Neoarchean magmatism. A weighted average of lower intercepts ages gives a value of 821 ± 50 Ma, representing the age of later metamorphism event. The various characteristic group and related ages reflect not only the complexity of the history of the pyroxene amphibole gneiss, but also show that the meta-sediment has at least three zircon contributing sources. It is likely that erosion, transport and deposition took place between 2116 and 821 Ma. Geochemical data show that the REE, Y, Yb, Sr/Y of some samples are similar to the known Archean craton formations (depletion in REE, $Y \leq 10$ ppm, $Yb \leq 1$ ppm, $Sr/Y \geq 30$). These characteristics are known as specific for the Archean TTG (Tonalite—Trondhjemite—Granodiorite). It means that: i) Archean TTG contribute significantly to the detritus of the sedimentary basin, ii) The depositional basin and the source rock were close and the detritus was immature.

Our results show that the Pre-Panafrican history of central Cameroon includes Meso- to Neo-Archean crustal accretion and associated magmatism prior to the Paleoproterozoic event of the West Central African Belt. In respect to this new insight, any evolutionary reconstruction of the area should integrate the presence of Archean crust.



## 1. Introduction

The pre-Panafrican basement of the Cameroon is considered as comprising the northern part of the Archean Congo Craton known

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as Ntem complexe and towards its NW border the Paleoproterozoic Nyong Serie (Bessoles and Trompette, 1980; Maurizot et al., 1986).

The Ntem complex is well circonscript to South Cameroon and well documented. It is made up of metasediments and a TTG suite dated at ca. 2.8–2.9 Ga (Nedelec et al., 1990; Tchameni, 1997; Shang et al., 2004), which was later intruded by granite and syenite around 2721 ± 4 Ma (Nedelec et al., 1990; Tchameni et al., 2000; Shang et al., 2001, 2007).

The NNE-SSW stretching Nyong series is petrographically similar to the Congo Craton formation (Maurizot et al., 1987; Nedelec et al., 1993), and thus has been considered as its remobilized border. U–Pb and Sm–Nd isotopic data suggest an Archean origin (ca. 3.0 Ga) for its protoliths and late Eburnean (ca. 2.5 Ga) for tectonic and metamorphic overprinting events (Lasserre and Soba, 1976; Toteu et al., 1994; Tchameni et al., 2001). The West Central African Fold Belt (WCAF), as defined by Feybesse et al. (1998) resulted from polyphase continental crustal accretion during the Eburnean orogeny. Penaye et al. (2004) defined the extension of the WCAF in Cameroon which include the Nyong Series and the Paleoproterozoic occurrences in the Neoproterozoic Central African Fold Belt (CAFB). This concept was strengthened by similarities between the Nyong Series and the Paleoproterozoic occurrences in the CAFB; with respect to this, these authors consider the Nyong Series as the proximal domain of the WCAF and the Paleoproterozoic occurrences farther North as a more distal domain characterized by newly formed Paleoproterozoic crust. The extension and geometry of the WCAF in Central Africa are problems to be solved as far as a unanimous geodynamic model for the CAFB. Our study presents zircon zonation patterns (CL-BSE-SE) and in-situ U–Th–Pb LAM-ICPMS geochronology of a pyroxene-amphibole-bearing meta-sedimentary gneiss of the Méiganga area in Central Cameroon. Our results show that the pre-Panafrican history of Central Cameroon includes Meso- to Neo-Archean crustal accretion and associated magmatism prior to the Paleoproterozoic event of the West Central African Belt.

## 2. Geological setting

In the Panafrican context of Central Africa, Central Cameroon is part of the Adamawa-Yadé domain (AYD) which extends over Southern Chad and the Northern Central Africa republic. It is found in an area between the Congo Craton to the South and the Saharan Metacraton (Kurst and Liegeois, 2001; Abdelsalam et al., 2002) to the North (Fig. 1). In Central Cameroon numerous occurrences of Paleoproterozoic rocks are encountered (Penaye et al., 1989; Toteu et al., 2001) and considered as part of the West Central African Belt (Penaye et al., 2004) which was intensively overprint by the Panafrican event during the Neoproterozoic. Archean ages (ca. 2600 Ma) have been obtained by zircon Pb evaporation dating in a Paleoproterozoic septa in the Méiganga area (Ganwa et al., 2008). An important feature of Central Cameroon is the wide spread occurrence of granitoids (Fig. 1). These granitoids are part of the Adamawa-Yadé batholith which shows ages in the interval of 500–600 Ma (Rb-Sr whole rock and mineral ages, Bessoles and Trompette, 1980); they include diorites, tonalities, granodiorites and granites of various compositions (pyroxene-amphibole-biotite granitoids, amphibole-biotite granitoids, biotite-muscovite granites; Ganwa, 2005; Tchameni et al., 2006) hosted in a meta-igneous and meta-sedimentary basement made up of gneisses (pyroxene-amphibole gneiss, amphibole-biotite gneiss, biotite gneiss) and amphibolite (Penaye et al., 1989; Ganwa, 2005). Granitoids and host basement have undergone multiphase deformation. Granitoids of the Adamawa-Yadé batholith are classified as syn-, late-, and post-tectonic (Lasserre, 1961; Toteu et al., 2001; Ganwa, 2005; Tchameni et al., 2006). In essence the basement of Central Cameroon has experienced four phases of deformation named D1, D2, D3, and D4, each of them being characterized by planar, linear and plano-linear structures (Ganwa, 2005; Njonfang, 1998; Njonfang et al., 2006). In the Méiganga area Ganwa (2005), Using zircon Pb evaporation age dating, proposed the intervals of 619–614 Ma for the D2 deformational phase, 601–558 Ma for D3 and that the D4 deformational phase was younger than 558 Ma. Granitoids in Central Cameroon have been associated to the regional transcurrent shear zones, especially the Central Cameroonian Shear Zone (Dumont, 1986; Ngako et al., 2003; Njanko et al., 2006; Ganwa et al., 2011a) which, in a pre-Atlantic opening reconstitution, continues into NE Brazil (Neves et al., 1996, 2000; Guimarães and da Silva Filho, 2000; Guimarães et al., 2004).

## 3. Petrography of the pyroxene-amphibole-bearing gneiss

The investigated pyroxene-amphibole gneiss is located to the SW of the Meiganga area (Fig. 2) where it forms topographic highs. Outcrops are present on top of the hills (Fig. 3a), in rivers bed or in a quarry in Kalaldi (Fig. 3b). At some localities as in Boutou (Fig. 3c) blocks of mafic rocks are found as enclaves in the **pyroxene-amphibole-bearing gneiss**. The mafic enclaves are massive, made up of amphibole essentially, intensively fractured and weathered.

The pyroxene-amphibole gneiss shows a banded structure with alternance of ferromagnesian minerals rich layers and quartzofeldspatic layers. This structure is faint when the rock is poor in ferromagnesian and sometimes reinforced by migmatisation which produced relatively thick quartzofeldspatic layers as result of partial melt accumulation. Main constituents are pyroxene, amphibole, biotite, feldspar, quartz, accessory minerals (zircon, sphene, opaque minerals, apatite) and secondary minerals (chlorite, epidote) (Fig. 4). Pyroxene forms relict crystals often as inclusion in amphibole. Amphibole is sometime transformed into epidote at its rim and along its cleavage. Biotite is arcuate. Feldspar is orthoclase and plagioclase with ondulatory zonation.

## 4. Analytical techniques

### 4.1. Mineral separation

Zircons were extracted by conventional mineral separation (crushing, sieving, shaking table, heavy liquid and hand separation). Highest quality zircons were mounted in 1-inch epoxy resin discs, grinded and polished to median sections and investigated by SEM-CL imaging to reveal internal chemical zonation features.

### 4.2. Laser-ablation MC-ICP-MS

The LA-MC-ICP-MS (laser-ablation multi collector - inductively coupled plasma - mass spectrometry) analytical work was performed at the joint ICP-MS laboratory of the Institut für Erdwissenschaften (Karl-Franzens Universität Graz, Austria) and the Institut für Angewandte Geowissenschaften (Technische Universität Graz, Austria). Analytical procedures were identical to the methodology outlined in Klötzli et al., 2009: Zircon $^{206}Pb/^{238}U$ and $^{207}Pb/^{206}Pb$ ages were determined using a 193 nm solid state Nd-YAG laser (NewWave UP193 Excimer) coupled to a multi-collector ICP-MS (Nu Instruments Nu Plasma II). Ablation using He as carrier gas was raster-wise according to the CL zonation pattern of the zircons. Line widths for rastering were 15 μm with a rastering speed of 5 μm/s. Energy densities were 5–8 J/cm$^2$ with a repetition rate of 10 Hz. The He carrier gas was mixed with the Ar carrier gas flow prior to the ICP plasma torch. Ablation duration was 60–120 s with a 30 s gas and Hg blank count rate measurement preceding ablation. Ablation count rates were corrected accordingly offline.