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Pan-African metamorphic evolution in the southern Yaounde Group (Oubanguide Complex, Cameroon) as revealed by EMP-monazite dating and thermobarometry of garnet metapelites

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ABSTRACT

Garnet-bearing micaschists and paragneisses of the Yaounde Group in the Pan-African Central African Orogenic Belt in Cameroon underwent a polyphase structural evolution with the deformation stages D_1–D_2, D_3 and D_4. The garnet-bearing assemblages crystallized in course of the deformation stage D_1–D_2 which led to the formation of the regional main foliation S_2. In X_{Ca}–X_{Mg} coordinates one can distinguish several zonation trends in the garnet porphyroblasts. Zonation trends with increasing X_{Mg} and variably decreasing X_{Ca} signalize a garnet growth during prograde metamorphism. Intermineral microstructures provided criteria for local equilibria and a structurally controlled application of geothermobarometers based on cation exchange and net transfer reactions. The syndeformational *P–T* path sections calculated from cores and rims of garnets in individual samples partly overlap and align along clockwise *P–T* trends. The *P–T* evolution started at ~450 °C/7 kbar, passed high-pressure conditions at 11–12 kbar at variable temperatures (600–700 °C) and involved a marked decompression toward 6–7 kbar at high temperatures (700–750 °C). Th–U–Pb dating of metamorphic monazite by electron microprobe (EMP-CHIME method) in eight samples revealed a single period of crystallization between 613 ± 33 Ma and 586 ± 15 Ma. The EMP-monazite age populations between 613 ± 33 Ma enclosed in garnet and 605 ± 12 Ma in the matrix apparently bracket the high temperature–intermediate pressure stage at the end of the prograde *P–T* path. The younger monazites crystallized still at amphibolite-facies conditions during subsequent retrogression. The Pan-African overall clockwise *P–T* evolution in the Yaounde Group with its syndeformational high pressure stages and marked pressure variations is typical of the parts of orogens which underwent contractional crustal thickening by stacking of nappe units during continental collision and/or during subduction-related accretionary processes.

1. Introduction

Although geothermobarometric and geochronological studies exist, many details of the Pan-African thermochronological history in the Central African Orogenic Belt (CAOB) or Oubanguide Complex are still discussed. This Neoproterozoic orogen is linked to the Trans-Saharan belt of western Africa and to the Braziliano Orogen of northeastern Brazil (Fig. 1a). In Cameroon, the Neoproterozoic realm (Nzenti et al., 1994, 1998, 2006, 2007; Ngnotué et al., 2000; Ngako et al., 2003, 2008; Mvondo et al., 2003, 2007) is subdivided into northern and southern Supergroups by the Central Cameroon Shear Zone (CCSZ) (Fig. 1b):

1. The Northern Cameroon Supergroup (NCSG) consists of metasedimentary rocks known as the Poli Group which is associated with subordinate 830 Ma-old volcanics of tholeiitic and alkaline affinities (Fig. 1b). Widespread 630–660 Ma-old calc-alkaline granitoids from Adamawa and West Cameroon Groups were transformed to gneisses. The inherited zircons in the granitoids provide ages up to 2 Ga and may attest a Palaeoproterozoic crustal source in this region (Toteu et al., 1987);
2. The Southern Cameroon Supergroup (SCSG) is subdivided in two domains by the Sanaga Fault (Fig. 1b). These large NE-striking transcurrent faults are regarded as possible prolongations of

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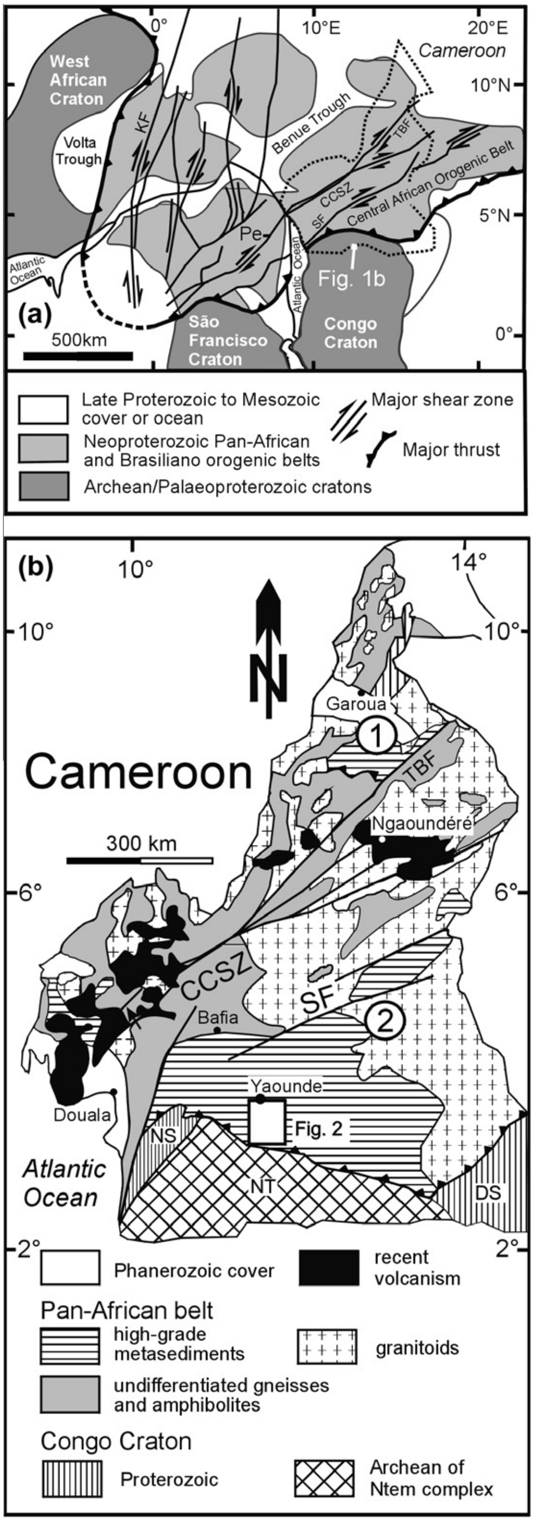

Fig. 1. (a) Geological sketch map of west-central Africa and northern Brazil with cratonic masses and the Pan-African and Brasiliano provinces of the Pan-Gondwana belt in a Pangea reconstruction; modified from Castaing et al. (1994). CCSZ: Central Cameroon Shear Zone; KF: Kandi Fault; Pe: Pernambuco Fault; SF: Sanaga Fault; TBF: Tibati-Banyo Fault. Dashed outline roughly marks the political boundary of Cameroon. (b) Geological map of Cameroon with the two main domains of the Pan-African orogenic belt, modified from Nzenti et al. (2006, 2007): (1) northern domain; granitoid suites are not further distinguished. (2) Southern domain corresponding to the Yaounde series thrusted onto the Congo Craton. CCSZ Central Cameroon Shear Zone; DS Dja series; NS Nyong series; NT Ntem complex; SF Sanaga Fault; TBF Tibati-Banyo Fault. Location of study is marked by a square.

the major shear zones of NE Brazil in a pre-drift Gondwana reconstruction (Castaing et al., 1994; Njonfang et al., 2008). The northern domain consists of high-grade gneisses (Tchato et al., 2009), intruded by widespread Neoproterozoic syntectonic plutonic rocks of high-K calc-alkaline affinities (Nguiessi et al., 1997; Nzenti et al., 1994, 2006; Tagne Kamga et al., 1999; Nzolang et al., 2003; Djouka-Fonkwe et al., 2008;Kwékam et al., 2010; Njanko et al., 2010). The southern domain comprises Neoproterozoic lithostructural units of metasedimentary rocks, such as the Yaounde, Lom, Dja and Yokadouma Groups (Owona et al., 2003; Owona, 2008). Protoliths of these units were deposited in a passive margin environment at the northern edge of the Congo craton. An alkaline magmatism (Nzenti et al., 1998; Mvondo, 2003; Mvondo et al., 2003; Toteu et al., 2006) was also recognized in association with these Neoproterozoic units. The rocks of this southern domain were transported top-to-the SSW onto the Archean Congo craton (Nzenti et al., 1988; Mvondo et al., 2003, 2007; Owona, 2008). The thrust zone continues towards the east, forming the Oubanguides Complex in the Republic of Central Africa (Rolin, 1982; Abdelsalam et al., 2002).

The study area to the southeast of Yaounde (Figs. 1 and 2) belongs to the Southern Cameroon Supergroup (SCSG) and the Oubanguide Complex (Abdelsalam et al., 2002; Bessoles and Trompette, 1980; Toteu et al., 2004; Owona, 2008). According to previous studies, the Yaounde Group underwent amphibolite- to granulite-facies medium- to high-*P*–*T* metamorphism (800–575 °C, 12–9 kbar in metapelites) with subsequent retrogression during the Pan-African (∼616 Ma) orogeny (Ball et al., 1984; Ngnotué et al., 2000; Nzenti et al., 1988; Penaye et al., 1993; Mvondo et al., 2003; Nkoumbou et al., 2006; Yonta-Ngoune et al., 2010). A major part of the Yaounde Group is composed of metasedimentary rocks with predominant micaschists and paragneisses (Fig. 2a and b). When chemically zoned garnet occurs with adequate low-variance mineral assemblages, this allows to reconstruct the pressure–temperature-(*P*–*T*)-evolution in such lithologies in some detail. The dating of the tectonometamorphic evolution is also fundamental to understand the processes involved in the evolution of orogenic belts. The occurrence of monazite as an abundant accessory mineral in micaschists and paragneisses provides an interesting opportunity for the dating of multiple thermal events (Finger et al., 2002; Bell and Welch, 2002; Fitzsimons et al., 2005; Pyle et al., 2005; McFarlane et al., 2006; Finger and Krenn, 2007; Krenn and Finger, 2007). In the present study, the geothermobarometric calculations on garnet-bearing assemblages in numerous samples indicate that garnet crystallised in single prograde segments of an overall clockwise *P*–*T*-evolution. Electron-microprobe dating revealed a single crystallization event of metamorphic monazite. A combination of both methods allows a detailed insight to the geodynamics of the Pan-African orogeny.

2. Geological and structural setting

The Yaounde Group (Fig. 1b) is the most southern part of the Southern Cameroon Supergroup (SCSG) that belongs to the Oubanguide Complex. Its evolution started with the opening of the Neoproterozoic Yaounde, Lom, Bafia and Poli basins between 850 and 700 Ma. The Yaounde micaschists and paragneisses have the average sandy-clay composition of post-Archean shales (Nzenti et al., 1988). They occur with some intrusive rocks, now meta-diorites and -tonalites (dated at 620 ± 10 Ma, Pb–Pb–zircon, Penaye et al., 1993), and meta-gabbro and amphibolites of yet unknown protolith ages (Lasserre and Soba, 1979; Ball et al., 1984; Nzenti et al., 1988; Seme Mouangue, 1998, Ngnotué et al., 2000; Mvondo,