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Continental subduction recorded by Neoproterozoic eclogite and garnet amphibolites from Western Hoggar (Tassendjanet terrane, Tuareg Shield, Algeria)

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ABSTRACT

Neoproterozoic eclogite and garnet amphibolites, representing retrogressed eclogites, from the Tassendjanet-Tidéridjaouine terrane in the Pan-African Western Hoggar (Tuareg shield, Southern Algeria) form lenses enclosed in 1.8 Ga subalkaline Paleoproterozoic orthogneisses. They lie along a major sinistral shear zone marking the boundary with the Archean/Paleoproterozoic granulitic In Ouzzal terrane and are associated with high-pressure metasediments. According to thermodynamic calculations, peak condition of the eclogitic stage is 650 °C, 20–22 kbar followed by post-peak heating and exhumation at 730 °C, 10–14 kbar and cooling to 610 °C, 7–10 kbar. Their major, trace-element and isotopic compositions are consistent with emplacement of former basalts in the shoulder of a 700–800 Ma continental rift that evolved to an oceanic basin. The eclogite and garnet amphibolites were thus part of the continental portion of a subducting slab that was pulled down by a denser oceanic lithosphere. Sheath and recumbent folds associated with the exhumation of HP units are verging toward the west, meaning that the former slab was dipping to the east. U–Pb zircon dating on metamorphic zircons bordering ilmenite and rutile in the eclogite gave an age of 623 ± 2 Ma, interpreted as the syn-collisional exhumation stage of the high-pressure unit. This event was rapidly followed by transpressional tectonics and abundant magmatism linked to the northward motion of the adjacent In Ouzzal terrane.

1. Introduction

Eclogites, blueschists and high-pressure (HP) metasediments are a common feature of Phanerozoic and especially peri-Mediterranean alpine belts. They are formed in subducting slabs either of continental or oceanic affinity. Exhumation of the HP units is a tricky process, especially if the slab is oceanic with a crustal section dominated by dense basaltic rocks. The density of an eclogite is close or higher than surrounding mantle rocks at lithostatic pressures corresponding to HP metamorphism (>14 kbar); it usually precludes an exhumation controlled by buoyancy forces only. Subducted continental margins are dominated by felsic material whose density is always lower than mantle rocks at pressure at which HP rocks form. The exhumation of continental units is therefore at least partly driven by their positive buoyancy (Chemenda et al., 1996; Ernst et al., 1997). Exhumation of both continental and oceanic slabs is also controlled or facilitated by early-orogenic tectonics and erosion (see Guillot et al., 2009), slab eduction following detachment (Duretz et al., 2012), flow within a weak subduction channel above the plunging slab (Gerya et al., 2002; Guillot et al., 2009), or corner flow (Burov et al., 2001). Each process occurs at different depth (Burov et al., 2001). UHP units are thus mostly of continental origin because they have a positive buoyancy (Chopin, 2003) that lead to fast exhumation from great depths. In contrast, most oceanic eclogites did not record pressures higher than 20–23 kbar (Agard et al., 2009).

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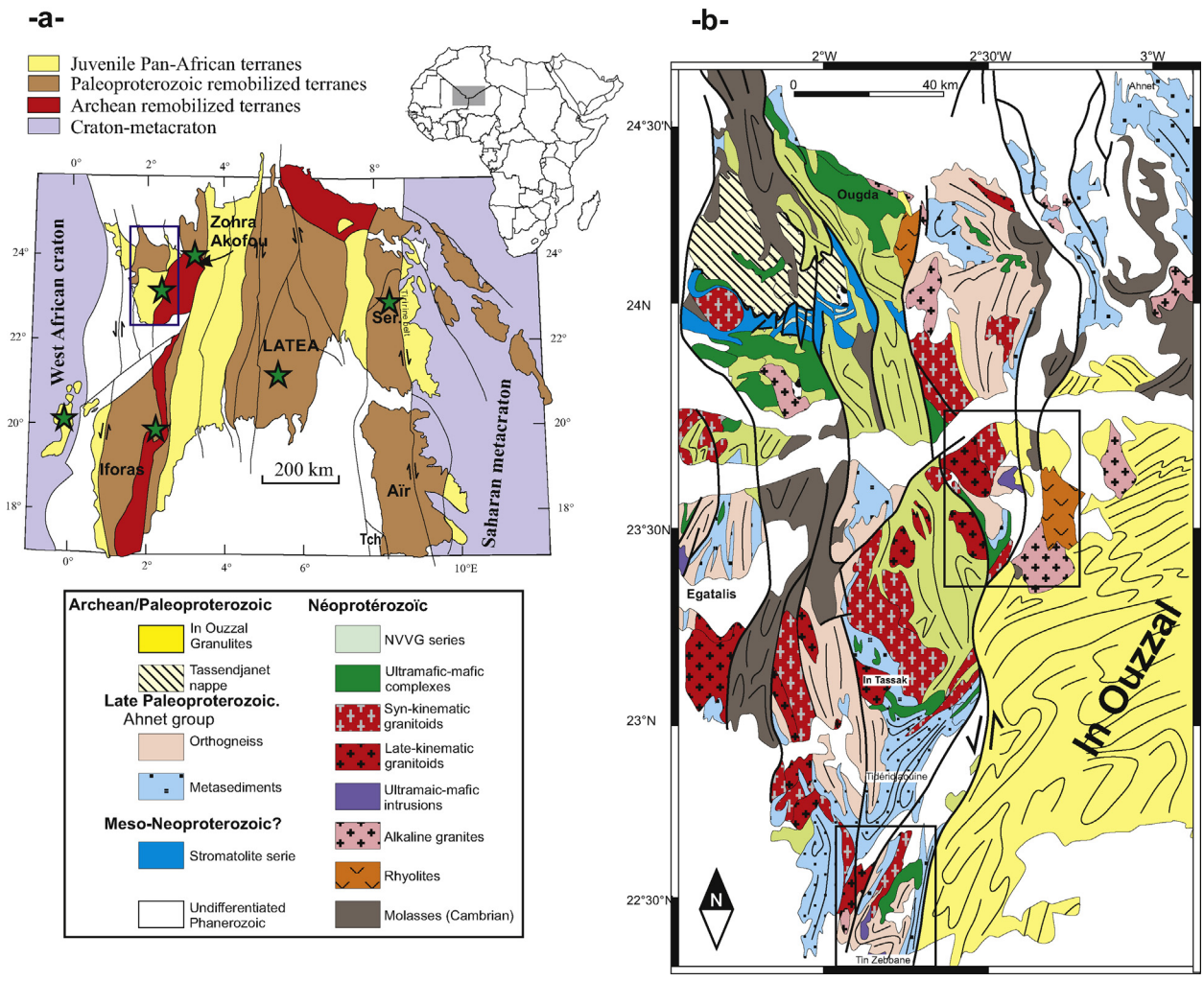

Fig. 1. Simplified geological maps of the Tuareg Shield (a) and the Tassenjanet-Tideridjaouine-Ahnet-In Ouzzal area. Modified after Black et al. (1994) (a) and Caby (1969)(b). The stars in map (a) show the location of high-pressure units. Ser.: Serouenout oceanic terrane, Zorha and Akofou: camp Zohra complex and Akofou andesites.

The existence of subduction in the Early Earth is much more controversial. Preserved HP-LT rocks before the Neoproterozoic are scarce (Cawood et al., 2006; Mints et al., 2010; Ganne et al., 2012) meaning that subduction probably existed but also that subducted units were more difficult to exhume or to preserve in hot and light Early Earth mantle. There is now a consensus on the idea that modern style plate tectonics exist at least since the Neoproterozoic as evidenced by the occurrences of ophiolites, eclogites and other HP metamorphic rocks (Stern, 2005). Neoproterozoic HP units are however rare, except in Pan-African belts (Agbossoumondé et al., 2001; Jahn et al., 2001; John et al., 2003; Boniface and Schenk, 2012) but growing evidences suggest that processes forming HP-LT units were the same that in modern Earth. Neoproterozoic eclogites are abundant in the Tuareg Shield (Algeria, Mali and Niger, see Fig. 1a), an area mainly structured during the Pan-African orogenic event (Black et al., 1994). They occur along former major thrusts in the Central Hoggar (LATEA, Sautter, 1985; Bernard-Griffiths et al., 1991; Liégeois et al., 2003; Zetoutou et al., 2004), in the Serouenout oceanic terrane (Bittam-Derridj et al., 2010), along the West Ouzzalian Shear Zone in the Western Hoggar (Caby and Monié, 2003) and in the Adrar des Iforas some garnet amphibolites may represent retrogressed eclogites along the same shear zone (Champenois et al., 1987).

The age of high-pressure metamorphism in Hoggar is not well established. ^{39}Ar–^{40}Ar laser dating on phengites from the Tidéridjaouine garnet-kyanite-phengite metasediments yielded ages down to 620 Ma (Caby and Monié, 2003). Garnet amphibolites from the central Hoggar were dated by Sm–Nd mineral isochrons (Liégeois et al., 2003), the oldest age obtained is 680 Ma but these samples show many evidences for isotopic and metamorphic re-equilibration after HP crystallization. This means that the process of accretion of the western Tuareg terranes during the Pan-African orogeny is still poorly constrained.

This paper presents petrological, geochemical and geochronological investigations on the eclogite and garnet amphibolites reported by Caby and Monié (2003) to better define: (i) the *P*–*T* conditions and the dynamics of the fossil subduction zone; (ii) the composition and tectonic setting of their magmatic precursor as well as (iii) the age of HP event and the geodynamic evolution of Western Hoggar.

2. Geological setting

The Tuareg shield, in which is included Hoggar (southern Algeria), is composed of both juvenile Neoproterozoic terranes and Archean/Paleoproterozoic blocks (Fig. 1) variably remobilized during the Pan-African orogeny (Black et al., 1994; Caby, 2003; Liégeois et al., 2003). The later Variscan and Alpine orogeny had no major imprint on the structure of the area, they were limited to open folding in the Early Permian (Haddoum et al., 2001) and uplift in