Partial melting and $P$-$T$ evolution of eclogite-facies metapelitic migmatites from the Egéré terrane (Central Hoggar, South Algeria)

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Abstract

The Egéré terrane (Central Hoggar, South Algeria) includes mafic eclogite lenses boudinaged in metapelitic rocks with high-pressure relics. These metapelites show textural records of partial melting, mainly primary melt inclusions enclosed in garnet crystals and later crystallized as “nanogranitoids.” Garnet porphyroblasts also contain inclusions of quartz, kyanite, phengite, biotite, staurolite, rutile, and melt and show a smoothed prograde zoning with a Mn bell-shaped profile. The peak high-pressure metamorphic assemblage consists of garnet, kyanite, phengite (Si up to 6.36), quartz, rutile, ilmenite, ±feldspars, and melt. Phengite has partially transformed into fine-grained aggregates of biotite, plagioclase, and K-feldspar, a microstructure interpreted as resulting from a dehydration melting during exhumation. Phengite breakdown, along with other retrograde reactions, produced a late paragenesis with biotite, plagioclase, K-feldspar, quartz, almandine-rich garnet, ±sillimanite, ±staurolite, ±muscovite, and ilmenite. The thermodynamic modeling of $P$-$T$ pseudosections allows us to constrain various steps of the metamorphic history: beginning of the garnet growth at 4.0 kbar and ~600 °C during prograde metamorphism; pressure peak at 14–20 kbar; temperature peak at 800–820 °C; formation of the last assemblage at 6.0–5.5 kbar and 725–685 °C. Partial melting likely started during the prograde path when crossing the H$_2$O-saturated solidus, at $T \geq 650–670$ °C and $P \geq 10$ kbar, continued upon heating, up to the peak conditions, as well as during decompression. This evolution is interpreted in terms of subduction of the continental crust to mantle depths, followed by an exhumation through a clockwise $P$-$T$ path during the Pan-African orogeny. The Egéré metapelites are relatively well-preserved eclogite-facies rocks, contain inclusions of “nanogranitoids” hitherto very little known in eclogite-facies metamorphic rocks, and represent an unusual trace of subduction within a Neoproterozoic orogen.

Keywords: Hoggar, Egéré, high-pressure metapelites, phengite, partial melting, nanogranitoids, pseudosections; High-Grade Metamorphism, Anatexis, and Granite Magmatism

Introduction

The study of anatexis and $P$-$T$ conditions of high-grade rocks is fundamental for understanding the geodynamic evolution and rheological behavior of the continental crust, particularly in convergent plate boundaries (e.g., Rosenberg and Handy 2005). Understanding the significance of anatexis requires the coupling of detailed petrological, (micro)structural, geochemical, and geochronological studies on migmatites.

This work combines two modern techniques to retrieve information on the petrogenesis of Neoproterozoic anatectic continental crust exposed in the Hoggar orogen, a Pan-African collisional belt extending from southern Algeria to northwestern Niger (Black et al. 1994; Caby 2003; Liégeois et al. 2003): (1) thermodynamic modeling of $P$-$T$ pseudosections, and (2) microstructural study of melt-bearing inclusions, including nanogranitoids (i.e., crystallized melt inclusions) and providing information on the relative timing and nature of anatexis.

While melt inclusions are well known to igneous petrologists and have been extensively studied in subvolcanic and extrusive rocks, their occurrence in high-grade metamorphic rocks of anatectic terranes is a novel and powerful research tool (Cesare et al. 2009, 2015). Melt inclusions in migmatites and granulites are generally trapped by peritectic minerals produced by incongruent melting reactions and, hence, represent snapshots of primary anatectic melts (Cesare et al. 2009, 2015; Ferrero et al. 2012, 2018; Bartoli et al. 2014, 2016). Although the study of melt inclusions in metamorphic rocks is still in its infancy, those investigated so far indicate that the retrieved melt compositions can be representative of the matrix melt present in the rock during entrainment (Acosta-Vigil et al. 2010, 2012; Cesare et al. 2015; Bartoli et al. 2016).

An increasing number of high-grade metamorphic rocks have been recently discovered and investigated from different localities in the Hoggar. Among them, rocks that reached eclogite-facies conditions and preserved high-pressure (HP) parageneses are particularly interesting because their study is essential to unravel the nature and evolution of orogenic processes (e.g.,