Step-by-step exhumation of a high-pressure granulite revealed by sequential replacement of Ti-bearing mineral (Variscan French Massif Central)

Luc De Hoÿm De Marien*[1], Pavla Štípská[1], Pavel Pitra[2], Andrew Kylander-Clark[3], Vít Peřestý[1], Martin Racek[4], and Jonas Vanardois[5]

[1]Czech Geological Survey – République tchèque
[2]Observatoire des sciences de l'environnement de Rennes – Université de Rennes, Institut National des Sciences de l'Univers, Université de Rennes 2, Centre National de la Recherche Scientifique, Institut National de Recherche pour l'Agriculture, l'Alimentation et l'Environnement – France
[3]Department of Earth Science [Santa Barbara) – États-Unis
[4]Insitute of petrology and strcutral geology, Charles University, Prague – République tchèque
[5]Institut des sciences de la terre [Lausanne] – Suisse

Résumé

Post-peak-pressure P–T paths of high-pressure units provide important constraints about the processes of exhumation and orogenic building. The P–T path of a high-pressure unit of the Variscan French Massif Central is poorly constrained from symplectites in former eclogites. While the peak eclogite facies conditions (20–25 kbar, 850–900 ◦C) were previously determined, the present study of a mafic granulite from the same unit provides further details about the subsequent P–T evolution.
The studied sample consists of pristine high-pressure granulite facies domains of garnet–diopside–plagioclase grading to domains where amphibole is common in replacement textures. Ti-bearing accessory minerals are rutile, titanite or ilmenite. Rutile is included in garnet, plagioclase and titanite, whereas titanite and ilmenite occur in the matrix. Titanite is commonly texturally related to amphibole, suggesting the introduction of a fluid. Titanite is partially or totally replaced by vermicular ilmenite. The observations constrain the sequential replacement of rutile by titanite, followed by the replacement of titanite by ilmenite.

Phase equilibrium modelling indicates the conditions 10–15 kbar and 800–1000 ◦C for the peak high-pressure granulite facies event. Amphibole and titanite were associated with incomplete hydration during the introduction of a fluid. Titanite stability is modelled at T < 800 ◦C in a range of pressure of 10–15 kbar, suggesting the replacement of rutile by titanite during cooling and limited decompression. On the other hand, ilmenite is modelled at lower pressure, below 7–8 kbar, suggesting a subsequent decompression along a steeper P–T path.
Petrological data and P–T modelling suggest three metamorphic stages during the exhumation: 1) decompression from the eclogite (20–25 kbar, 850–900 ◦C) to the granulite facies (10–15 kbar, 800–1000 ◦C); 2) cooling under 800 ◦C with limited decompression; and 3)

*Intervenant

steeper decompression below 8 kbar. This sequence points to at least two main decompression stages separated by cooling. This sequence is compatible with exhumation from mantle to crustal depth, followed by partial cooling in the lower orogenic crust and subsequent crustal thinning or redistribution within the crust.