Geophysical Research Abstracts
Vol. 20, EGU2018-13740, 2018
EGU General Assembly 2018

P–T–t–d evolution of Devonian eclogite from the Mariánské Lázně Complex (Bohemian Massif): Rapid transition from oceanic HP subduction to HT extensional exhumation

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Devonian HP sequences represent pivotal tectonometamorphic assemblages for understanding the early evolution of the Variscan orogenic system, particularly the transition from oceanic subduction to the onset of collisional dynamics. Through combined petrological, geochronological, and structural analysis, we can constrain Pressure-Temperature-time-deformation (P-T-t-d) paths to better understand these processes.

The Mariánské Lázně Complex (MLC) in the Bohemian massif represents an excellent example of a Devonian HP sequence. It occurs at the important triple juncture between the Saxothuringian (lower plate) domain and the Teplá-Barrandian and Moldanubian (upper plate) domains. The core of the complex is dominated by amphibolite and migmatite amphibolite; however, retrogressed eclogites with relict high-pressure (HP) assemblages (Grt + Omp + Rt + Qtz $\pm$ Ky $\pm$ Ph $\pm$ Zo) occur as lenses or boudins in the core of the complex.

Structural measurements taken from across the MLC and adjoining regions indicate the presence of relict eclogite-facies (S1) and later migmatite (S2) fabrics. Both S1 and S2 fabrics show moderate to steep eastwards dip and have been reworked through shearing and/or folding into a dominant, shallower, S3 fabric.

Two samples have undergone detailed petrological and geochronological study. A least retrogressed sample shows relict kyanite and omphacite (Jd33-36) porphyroblasts and clusters of fine grained, inclusion-poor, garnet (Alm33−41Prp38−42Grs18−25Sps1). The garnet cores show weak compositional zoning, with decrease of grossular and increase of almandine and pyrope toward the rim, followed by a sharp decrease in pyrope content at the very rim. Rare phengitic (up to 3.33 Si p.f.u.) white mica inclusions in omphacite enable constraint of peak eclogite-facies conditions at around ∼25 kbar and 650–750 °C. Kyanite (by plagioclase and spinel), omphacite (by amphibole, clinopyroxene, and plagioclase), and garnet (by amphibole and plagioclase) all show partial replacement by sympletite or coronitic intergrowths. P-T modelling of the replacement textures, combined with study of a more retrogressed sample — garnet-bearing, but without relict omphacite or kyanite — indicate a high-temperature (HT) overprint (> 800 °C) at the base of the lower crust followed by combined cooling and decompression.

Both samples underwent Lu-Hf and Sm-Nd garnet - whole rock geochronology. The Lu-Hf method yields older (∼390 Ma) ages than the Sm-Nd method (∼375 Ma). The ages reported by the Lu-Hf method are interpreted to record the HP event. As temperatures for the HT overprint exceed the empirically and experimentally determined closure temperature of the Sm-Nd system, the Sm-Nd ages are interpreted to date cooling following the HT overprint.

The combined structural, petrological, and geochronological data suggests a relatively rapid (c. 15 Ma) transition from oceanic HP subduction through HT Barrovian-thickening to extensional exhumation. This exhumation path does not fit the suggestion of monocyclic exhumation in a subduction channel proposed for the Münchberg and ZEV Devonian HP units to the west. But rather show important similarities — Early- to Mid-Devonian HP-HT metamorphism followed by initial contractional exhumation and subsequent extensional shearing — to other Devonian high-grade units in the European Variscides, notably the Allochtononous Complexes of NW Iberia.