Geophysical Research Abstracts
Vol. 16, EGU2014-14398, 2014
EGU General Assembly 2014

Metamorphism at ultrahigh-temperature and ultrahigh-pressure conditions: what comes first?

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Recent discoveries of diamond, and coesite, in several metamorphic terranes show that ultrahigh-pressure metamorphism is a rather common phenomenon in orogenic belts of various ages worldwide. Whereas models applicable for UHP belts with low-temperature imprint exist, the genesis of ultrahigh-pressure and ultrahigh-temperature rocks is still not well understood. Our study of ultrahigh-pressure units of the Bohemian Massif, where diamonds have been found in various rocks including high-pressure granulites characteristic of the internal zone of the European Variscan Belt, helps to shed some light on these processes.

Diamond and coesite occur in the northern part of the Bohemian Massif as an inclusion in garnet, kyanite and zircon in the rocks classically described as HP granulites. And indeed, composition of the major phases corresponds to equilibration under conditions of high-pressure granulite metamorphism. However, presence of UHP index phases, omphacite relics enclosed in garnet in intermediate lithologies, and associated mafic UHP eclogites suggest that these rocks are ultrahigh-pressure rocks, or UHP eclogites.

Garnet lherzolites associated with the North Bohemian UHP rocks do not contain spinel-bearing coronas around garnets; these are rimmed by hornblende instead. Garnets are largely homogeneous, with only a slight MgO decrease in a narrow rim. An inclusion of spinel has been found in garnet. Mafic eclogite is devoid of diopside and plagioclase symplectites after omphacite due to low silica content, but contains characteristic symplectites of pargasite and quartz indicative of the decompression. In summary, both mantle and crustal rocks record prograde evolution with P-T increase, UHP-HT-UHT peak conditions, and rapid cooling during their exhumation. It is obvious that our petrological, P-T and geochronological data show striking similarity with the UHP unit in the Erzgebirge, to the N from our area.

Although the north Bohemian crystalline basement is poorly exposed, an E-W trend of the lithological boundaries that is consistent with the structures in the Erzgebirge is documented by numerous boreholes. Steep E-W- trending foliations in northern Bohemian UHP area are overprinted by a flat-lying ones in the Erzgebirge, whereas E-W strike of the lineations is characteristic of both areas. The fabric can be interpreted in terms of an initial vertical extrusion of the UHP rocks from mantle depths followed by W-directed (for the Erzgebirge) flow and emplacement in mid crustal levels, related to the late Variscan N-S compression.

Association of the mantle and both mafic and intermediate-felsic UHP-UHT crustal rocks with similar peak P-T conditions relates to a deep subduction of predominantly felsic continental crust. Present setup of the units is consistent with the early extrusion of the deepest subducted crustal material in an exhumation channel without temperature increase, allowing preservation of their UHP assemblages. Only then the units showing high-temperature overprint due to the interaction with the hot asthenosphere, without UHP indicators preserved, are exhumed. Thus the UHT comes after UHP.