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SPECIAL COLLECTION: WATER IN NOMINALLY HYDROUS AND ANHYDROUS MINERALS

Water transport by subduction: Clues from garnet of Erzgebirge UHP eclogite

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ABSTRACT

A key question concerning the water budget of Earth's mantle is how much water is actually recycled into the mantle by the subduction of eclogitized oceanic crust. Hydrous phases are stable only in quartz eclogite not coesite eclogite so that water transport to greater depths is mainly governed by structural water in omphacite and garnet. Here we explore if garnet can be used as a proxy to assess the amount of this water. Available data on the water contents of garnet in coesite eclogite vary over orders of magnitude, from a few up to ca. 2000 ppm. By implication, the maximum bulk-rock water contents are unrealistically high (wt% level). New data from the Erzgebirge indicate moderate amounts of structural H_2O stored in garnet (43–84 ppm), omphacite (400–820 ppm), and in the bulk coesite eclogite (ca. 280–460 ppm). Higher garnet water contents occur, but these are not primary features. They are related to molecular water in fluid inclusions that can be attributed to eclogite-facies fluid influx postdating the metamorphic peak. Fluid influx also caused the uptake of additional structural water in garnet domains close to fluid inclusions. Such secondary H_2O incorporation is only possible in the case of primary water-deficiency indicating that garnet hosted less water than it was able to store. This is insofar astonishing as comparably high H_2O amounts are liberated by the breakdown of prograde eclogite-facies hydrous minerals as a result of ultrahigh-pressure (UHP) metamorphism. Judging from Erzgebirge quartz eclogite, dehydration of 5–10% hydrous minerals (±equal portions of zoisite+calcic amphibole) produces 1500–3000 ppm water. We infer that the largest part of the liberated water escaped, probably due to kinetic reasons, and hydrated exhuming UHP slices in the hanging-wall. Depending on the physical conditions, water influx in eclogite during exhumation (1) produces fluid inclusions and simultaneously enhances the structural water content of nominally anhydrous minerals—as in the Erzgebirge—and/or (2) it may give rise to retrograde hydrous minerals. We conclude that eclogite transports moderate quantities of water (several hundred parts per million) to mantle depths beyond 100 km, an amount equivalent to that in ca. 1% calcic amphibole.

Keywords: Eclogite, garnet, infrared spectroscopy, nominally anhydrous minerals, omphacite, subduction, water