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Mineral precipitation sequence from multi-stage fluids released by eclogite during high-pressure metamorphism

Ting-Nan Gong[1,2,3], Jin-Xue Du[1,*], Li-Fei Zhang[2], Zhen-Yu Chen[4], Ze-Ming Zhang[1,5], Wei-(RZ) Wang[3], and Yuan-Ru Qu[6]

[1]School of Earth Sciences and Resources, China University of Geosciences, Beijing 100083, China
[2]MOE Key Laboratory of Orogenic Belts and Crustal Evolution, School of Earth and Space Sciences, Peking University, Beijing 100871, China
[3]Key Laboratory of Paleomagnetism and Tectonic Reconstruction of Ministry of Natural Resources, Institute of Geomechanics, Chinese Academy of Geological Sciences, Beijing 100081, China
[4]MNR Key Laboratory of Metallogeny and Mineral Assessment, Institute of Mineral Resources, Chinese Academy of Geological Sciences, Beijing 100037, China
[5]Institute of Geology, Chinese Academy of Geological Sciences, Beijing 100037, China
[6]State Key Laboratory of Geological Processes and Mineral Resources, China University of Geosciences, Beijing 100083, China

Abstract

Arc magmas above subduction zones hold abundant fluid-mobile elements attributed to fluids released from the dehydrating subducted oceanic crust. However, the quantity of trace elements in the fluids and their evolution with the metamorphic processes during subduction and exhumation are still unclear. The precipitation sequence of vein minerals preserves the nature of multi-stage high-pressure (HP) metamorphic fluids and the fingerprint of mass exchange in deep subduction zones. In this contribution, we conducted detailed petrological studies and phase equilibria modeling on a unique HP omphacite-rich vein and its host eclogite from the Chinese southwestern Tianshan. The host eclogite consists mainly of garnet, omphacite, epidote, glaucophane, phengite, quartz, and rutile. Garnet in the eclogite records prograde subduction and early exhumation characterized by decompression heating at *P-T* conditions of ~2.4–2.6 GPa and 460–540 °C. The embedded omphacite-rich vein has similar mineral assemblage to the host eclogite. Garnet grains in this vein are predominantly distributed along or intersect the vein wall, which records similar eclogite-facies metamorphic conditions to the host eclogite. Omphacite is dominant in the vein, while epidote and glaucophane occur interstitially. Phase equilibria modeling reveals sequential growth of garnet-dominated, omphacite-dominated, and epidote-dominated assemblages from fluids originating from the breakdown of different hydrous minerals. These lines of evidence suggest that the formation of multi-stage HP fluids are a continuous long-term process with spontaneous short-distance transport and sequential mineral precipitation. Calculated fluid compositions demonstrate that the fluids released by lawsonite breakdown during exhumation have great potential to modify the trace element systematics of arc magmas. Our findings reveal the nature and evolution of multi-stage HP metamorphic fluids from internal sources during subduction and exhumation of oceanic crust, providing valuable insights into the chemical compositions of arc magmas.

Keywords: Metabasite, subduction zone, high-pressure fluid, arc magma, material cycle