Chlorine-bearing aqueous fluid at crust/mantle boundary in mid-ocean ridge hydrothermal system: a case study of crustal diopsidite from Oman ophiolite

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Hydrothermal circulation in the mid-ocean ridge system is responsible for elemental enrichment, and modification of original chemical composition of the oceanic crust. In recent times, deep-rooted hydrothermal circulation down to crust/mantle boundary has been introduced regarding geological investigations and numerical models. The deep-rooted hydrothermal circulation in the mid-ocean ridge system can be one of the necessary mechanisms generating plate tectonics due to mantle hydration lowering mantle viscosity. In order to assess the mechanism of the mantle hydration in the mid-ocean ridge system, chemical composition of mantle-buffered hydrothermal fluids must be characterized. Here, we present a series of intense investigations for aqueous fluid inclusions in crustal diopsidites from Oman ophiolite. The crustal diopsidite is considered as a reaction product between gabbro (lowermost crustal material) and seawater-derived hydrothermal fluids en route from the mantle to the crust. Considering that Cr-rich minerals such as chromian spinel (Cr-spinel) and chromian garnet (uvarovites) are contained in the crustal diopsidites, the hydrothermal fluids involved were enriched in Cr. A few micrometer-sized inclusion of aqueous fluid with chromian spinel grains was frozen with a nitrogen gas-cooled cold stage, and investigated with a focused ion beam equipped with a scanning electron microscope and an energy dispersive X-ray spectrometer (cryo-FIB-SEM-EDS system). The results showed that the Cr-spinel-bearing aqueous fluid inclusion contains Cl. Regarding the mass and chemical composition of the Cr-spinels in the aqueous fluid inclusion, Cr content in the aqueous fluid was estimated at ~71400 ppm. Although Cr is considered relatively insoluble in aqueous fluids, solubility of Cr depends strongly on the activity of Cl due to complexation reactions with Cl. We propose a possibility that seawater-derived hydrothermal fluids penetrated throughout the crustal section reacted with Cl-bearing magma portion. Flow direction of the hydrothermal fluids probably changed from downward to upward in response to the heat release of the magma to the hydrothermal fluid.

Keywords: cryo-FIB-SEM-EDS, fluid inclusion, hydrothermal circulation, Cr-spinel, Chromium, microthermometry

