Metal mobility and sources during hydrothermal alteration of the oceanic crust: LA-ICP-MS study of sulfides from the Troodos ophiolite

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Constraining source-deposit relationships in VMS systems is crucial for understanding oceanic hydrothermal processes and the formation of sulfide ores. The mechanisms behind metal mobilisation during hydrothermal alteration of the lower oceanic crust by leaching of sulfide and silicate minerals within the sheeted dyke complex are not fully elucidated. The Troodos ophiolite in Cyprus, which hosts dozens of metal-rich VMS deposits and exposes a well-preserved, complete section of the Cretaceous oceanic crust, represents an ideal site to investigate these processes. Recent studies provide quantitative estimates of metal fluxes through the sheeted dyke complex from bulk measurements of metal budget in the ophiolite rocks. Here we present in-situ analyses of metal contents in sulfide minerals from a range of selected samples covering the most part of the ophiolite section, from the volcanic unit down to the plutonic complex. Textural observations allow us to distinguish several types of secondary sulfide minerals (high temperature hydrothermal, metasomatized/leached, low temperature, and patchy sulfides), and reconstruct hypothetical circulation paths of mineralizing fluids through the crust. Various metal concentrations between the different types of sulfides indicate selective metal mobilisation and trapping as a function of fluid temperature and type of alteration. For instance, low-temperature sulfides observed in altered basalts are relatively metal-poor except for Co and likely witness late, off-axis circulation of low temperature fluids within the volcanic section. In contrast, the occurrence of rather metal-rich, metasomatized and partially leached sulfides in the altered diabases and gabbronorites suggests processes of metal-enrichment during moderate temperature fluid recharge and high temperature fluid discharge in the lower oceanic crust. We suggest that not only the epidosite zone contributes as a source of metals, but most of the sheeted dyke complex (i.e. the altered diabase) and the plutonic complex as well. Metal mass-balance and sulfide/fluid partitioning calculations constraining the water/rock ratio at the peak of alteration at Troodos are presented, and the role of silicate minerals as significant source of metals, besides sulfides, is emphasized.