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Fe, Cu and Zn isotopes: proxies to constrain the magmato-hydrothermal history at oceanic core complexes (Mid-Atlantic Ridge Kane area, MARK, 23°N, ODP Leg 153)

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Mantle exhumation is a common tectonic feature of slow-spreading ridges (e.g., at oceanic core complexes) and is often accompanied with magmatic and hydrothermal processes. Magmatism-driven hydrothermal convection enhances seawater interaction with deep magmatic and mantle rocks, producing various metamorphic mineral assemblages. However, the spatio-temporal evolution of magmatic and hydrothermal processes is poorly understood. Additionally, because deep hydrothermal alterations are often overprinted by pervasive serpentinization and rarely preserve the forming fluid, the related physico-chemical conditions are complex to retrieve.

We carried out a Fe, Cu and Zn isotope tracing on drilled mantle rocks, that locally escaped extensive serpentinization, at MARK to constrain i) the impacts of magmatic and hydrothermal processes on metal mobilities and isotope fractionation ii) the physico-chemical conditions related to fluid circulation. Mantle rocks underwent complex melt-rock interactions during melt percolation overprinted by fluid-assisted metamorphism at variable temperatures (830 down to < 350°C) that led to the formation of secondary metamorphic mineral assemblages. Mantle rocks affected by melt percolation present either light or heavy δ^{56}Fe (-0.44 to 0.07 ± 0.03‰) and δ^{66}Zn (-0.24 to 0.32 ± 0.04‰) compared to the primitive mantle (δ^{56}Fe = 0.025 ± 0.025‰ and δ^{66}Zn = 0.16 ± 0.06‰), that are ascribed to diffusion-related kinetic isotope fractionation during the percolation of Fe- and Zn-rich melts in mantle rocks. The Cu contents (0.5 to 23.9 ppm) and δ^{65}Cu (-0.11 to 0.32 ± 0.04‰) of these rocks suggest Cu mobilization during high-temperature (~600°C) hydrothermal alteration. Late calcite-bearing hydrothermal veins present high metal contents (120 to 248 ppm Cu and 126 to 317 ppm Zn), low δ^{65}Cu (-0.19 to 0.02 ± 0.02‰) and high δ^{66}Zn (0.27 to 0.34 ± 0.05‰) compared to primitive mantle compositions, suggesting formation at decreasing temperature (~300°C) from a fluid interacting with serpentinized peridotites. Transition metal (Fe, Cu, Zn) isotopes thus record different events related to the life cycle of oceanic core complexes, from deep-seated high-temperature melt-rock interaction associated with important Fe and Zn isotope fractionation to fluid-rock interactions at decreasing temperatures (600 to 300°C) during progressive mantle unroofing at the seafloor and which are associated with Cu mobility and isotope fractionation.