Sulfur as a tracer for peridotite-fluid-microbe interaction in the oceanic lithosphere

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The oceanic lithosphere is exposed to extensive water-rock interaction during and after its formation along mid-ocean ridge spreading centers. In particular at slow-spreading ridges, exhumation and alteration of mantle rock is associated with considerable chemical, physical and mineralogical transformations, and H_2, CH_4, and formate formed during serpentinization reactions lead to abundant microbial communities in peridotite-hosted hydrothermal systems. Here, we examined ultramafic rocks from the Atlantis Massif recovered during IODP Expedition 357. We combine sulfur geochemistry (including multiple sulfur isotope compositions) with mineralogy and petrology and compare the results with similar peridotite-hosted systems to constrain the hydrothermal evolution of these rocks.

The studied samples are variably talc-chlorite-amphibole-rich to highly oxidized, carbonate-veined serpentinites. Sulfur contents vary strongly and reach 0.8 wt.% S, with the sulfur being dominated by sulfate that has an isotopic composition similar to modern seawater sulfate. The sulfur isotopic compositions and the sulfide mineralogy documents that overall the different drill cores recovered during IODP Exp. 357 are dominated either by a low temperature regime (<120-150°C) controlled by extensive seawater interaction and microbial sulfate reduction, or by a high temperature regime (~300-350°C). High temperature fluid input was associated with the introduction of Si-Al-Ca-rich and S-enriched fluids that originated from leaching of mafic intrusions. Petrological examinations show that these high-T fluids mostly post-dated the main stage of serpentinization and that these fluid pulses were relatively localized resulting in a highly heterogeneous mineralogy. Locally, high-T fluid influx took place subsequent to microbial sulfate reduction and oxidation as indicated by geochemical modeling. Overall, this study documents the complex interplay of magmatic processes, fluid-rock interaction and microbial activity that take place during the formation of oceanic core complexes and where mantle rocks are exposed to seawater.