Sulfide mineralogy as a tracer for fluid-rock interaction in serpentinites

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Fluid-rock interaction in ultramafic rocks leads to considerable changes in the fluid redox conditions and the formation of highly reducing conditions. In this regard, serpentinization systems are some of the most reducing environments found on Earth allowing for the stabilization of native metals and metal alloys and thus affecting the petrophysical properties of the oceanic lithosphere. At the Chimaera hydrothermal field in Turkey highly methane-enriched fluids issue from an ultramafic basement that is undergoing continental serpentinization, though partial serpentinization already took place during mantle exposure along an oceanic spreading center. Here, we study the sulfur geochemistry and mineralogy of selected, highly serpentinized peridotites to track sulfur sources, mobilization mechanisms of sulfur and the evolution of the redox conditions during hydrothermal alteration of these rocks – from high-temperature oceanic to low temperature continental serpentinization.

Sulfur isotope compositions document seafloor alteration with introduction of Cretaceous seawater and a mostly magmatic origin of the sulfide that mainly includes pentlandite. However, sulfide and metal mineral assemblages also document fluid-rock interaction processes; awaruite and native Cu reflect highly reducing fluid conditions whereas hematite and magnetite reflect oxidizing conditions suggesting secondary formation or alteration of primary formed pentlandite during fluid-rock interaction. Sulfide minerals show distinct decomposition features with formation of native metals (mostly native Cu) providing evidence for disequilibrium conditions. Furthermore, we find strong redox gradients on the micrometer scale indicating that late stage fluid infiltration – most likely during continental serpentinization and associated with highly reducing fluids – overprinted earlier sulfide and metal mineral assemblages from oceanic serpentinization. These observations provide evidence that redox conditions strongly vary during the evolution of peridotite-hosted hydrothermal systems.