

Sulfide Mineral - Fluid Isotope Exchange Systematics in Hydrothermal Systems

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Mid-ocean ridge (MOR) hydrothermal systems play an important role in the mass transfer of elements between seawater and the oceanic crust during water-rock interaction in the subseafloor. However, mechanistic effects such as (in)congruent exchange between minerals and solution species, mineral transformation, and/or differences in solution chemistry may impart significant variations in elemental and isotopic specific reactivity and mobility. At the moment, however, there is a lack of these specific data at experimental conditions relevant for high temperature MOR hydrothermal systems.

This study examines recent experimental multiple S isotope exchange rate data derived from the chalcopyrite-fluid system at 350°C and 500 bars coupled with complementary studies, which have examined Fe and S exchange systematics with pyrite and chalcopyrite¹⁻³. The inferences gained from the experimental results are compared to natural data derived from active MOR hydrothermal systems and expanded to examine how changes, such as temperature and seawater solution chemistry, may have an effect on the chemical and isotopic composition of hydrothermal fluids and minerals in the subseafloor.

Briefly, comparison of experimental mineral-fluid data indicates isotopic exchange is a strong function of solution chemistry (i.e. pH, ΣFe , ΣS) and that chalcopyrite exchanges more effectively than pyrite with constituent dissolved Fe and S species. Interestingly, incongruent exchange is apparent for both chalcopyrite and pyrite, where the S-component of either phase exchanges more readily than the Fe-component with dissolved constituent species. These experimental data indicate that the relative reactivities between minerals and fluid and the extensive chemical controls therein allow for isotopic disequilibrium to persist between sulfide minerals and hydrothermal fluid in the subseafloor of MOR systems.

¹ Syverson et al., 2013, *GCA*, **122**, pg. 170-183

² Syverson et al., 2015, *GCA*, **165**, pg. 418-434

³ Syverson et al., 2017, *GCA*, **200**, pg. 87-109