

Copper Isotope Systematics of the Lucky Strike, Rainbow, and Logatchev Sea-Floor Hydrothermal Fields on the Mid-Atlantic Ridge

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Abstract

In this paper, we present the copper isotope signatures of black smoker sulfides, massive sulfides, and their alteration products and provide new insights into mineralization processes and applications of copper isotope geochemistry to sea-floor hydrothermal systems on the Mid-Atlantic Ridge. The hydrothermal systems studied include the Lucky Strike field at 37°17'N on a basaltic substrate and the Rainbow and Logatchev fields, situated on ultramafic rock. Copper isotope variation in the hydrothermal precipitates was examined in conjunction with S isotopes and Se and Co concentrations. The comparison between $\delta^{65}\text{Cu}$ and Se contents shows that subsurface precipitation of Cu-rich sulfides does not control significantly the $\delta^{65}\text{Cu}$ values of the hydrothermal chimneys. It appears that the major cause of copper isotope fractionation in hydrothermal systems (up to 3‰) is the sea-floor oxidation of primary copper sulfides. Enrichment in the heavy copper isotope can be explained by processes occurring at the sea floor, such as hydrothermal reworking of previously altered sulfides by high-temperature fluid. Massive sulfides characterized by negative $\delta^{65}\text{Cu}$ values have undergone extensive recrystallization. In these mineralogical assemblages, isotopically heavy copper typical of altered sulfides has been leached and redeposited in the external zones or incorporated in hydrothermal fluids. Copper isotopes are therefore a promising tool for the study of supergene processes and the recycling of previously oxidized sulfides, as well as a means of characterizing the degree of hydrothermal reworking of large sulfide deposits. Further studies of copper isotope fractionation under controlled laboratory experimental conditions are required to identify copper isotope fractionation during sulfide alteration. In particular, the possible biological mediation of copper isotope fractionation during sulfide oxidation may be an important direction for further studies.

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