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Antimony Isotope Fractionation in Hydrothermal Systems and its Potential Exploration Application

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To date, few studies report antimony (Sb) isotope compositions in natural systems and the dominant factors controlling Sb isotope fractionation are still unclear. The literature has focused on the environmental and geological applications in some detail, while no studies have focused on one location that possesses concentrated amounts of Sb. Antimony mainly occurs as stibnite (Sb_2S_3) in a variety of intermediate-low temperature hydrothermal ore deposits worldwide and has been the simplest matrix to analyze. Scant Sb isotope data from stibnite exists in the literature described above, yet the key controls of its isotope fractionation in these systems are still largely unknown

In order to characterize antimony (Sb) isotope fractionation in hydrothermal systems, we present Sb isotope compositions of primary stibnite ores from a large Sb deposit in south China. A total number of 39 analyses reveals a large δ^{123}Sb range of -0.27 to +0.86‰, representing an up to 1.13‰ variation in this hydrothermal system. A gradual increase of Sb isotope ratios from the proximal to the distal parts was observed in stibnite ores. Rayleigh distillation models the systematic variation trend of the Sb isotope values, demonstrating that ore fluids are preferentially enriched in heavier Sb isotopes during the precipitation of isotopically light stibnite. In this way, we consider separation of stibnite from an Sb-bearing fluid related to reaction kinetics as a cause for Sb isotope fractionation.

The modeled data constrain a Sb isotope fractionation factor ($\alpha_{fluid\text{-}stibnite}$) between hydrothermal fluid and stibnite at approximately 0.9994. The model also constrains an initial Sb isotope value of ~0.45‰, which indicates metal sources in the basement rocks of the study area. Stibnite ores precipitated further away from their fluid source will gradually have higher Sb isotope compositions, which indicates that Sb isotopes can be used to fingerprint hydrothermal fluid flow directionality and may provide a vector to mineral mineralization.