

Sn-Isotope Fractionation as a Record of Hydrothermal Redox Reactions

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A redox reaction in which reduced Sn²⁺ oxidizes to Sn⁴⁺ is thought to occur during the precipitation of cassiterite (SnO₂) and stannite (Cu₂FeSnS₄) from high temperature hydrothermal solutions. In four stanniferous regions with differing mineralization environments (South Dakota, USA; Cornwall, England; Erzgebirge, Germany/Czech Republic; Andean tin belt, Bolivia), the tin isotope composition in stannite (mean value $\delta^{124}\text{Sn} = -1.47 \pm 0.54\%$, n=21) is consistently more fractionated toward negative values than that of paragenetically-earlier cassiterite (mean value $\delta^{124}\text{Sn} = 0.48 \pm 0.62\%$, n=50). Given the oxidation-dependent mechanism for cassiterite precipitation, this isotopic shift is most likely attributable to the oxidation of Sn in solution; precipitation of heavy-Sn-enriched cassiterite results in residual dissolved Sn with lighter isotopic composition, which is expressed in the negative $\delta^{124}\text{Sn}$ values of later-formed stannite. Equally important is that the mean values for the cassiterite from the various deposits are slightly different and may indicate that the initial Sn isotope composition in early formed cassiterite relates to variations in the source or magmatic processes.