American Mineralogist, Volume 103, pages 1591–1598, 2018

Sn-isotope fractionation as a record of hydrothermal redox reactions

Junming Yao[1], Ryan Mathur[2,*], Wayne Powell[3], Bernd Lehmann[4], Fernando Tornos[5], Marc Wilson[6], and Joaquin Ruiz[7]

[1]Key Laboratory of Mineralogy and Metallogeny, Guangzhou Institute of Geochemistry, Chinese Academy of Sciences, Guangzhou, China
[2]Department of Geology, Juniata College, Huntingdon, Pennsylvania 16652, U.S.A.
[3]Department of Earth and Environmental Sciences, Brooklyn College, City University of New York, Brooklyn 11210, New York, U.S.A.
[4]Mineral Resources, Technical University of Clausthal, Clausthal-Zellerfeld, Germany
[5]Instituto de Geociencias (CSIC-UCM), Madrid, Spain
[6]Carnegie Museum of Natural History, Pittsburgh, Pennsylvania 15213, U.S.A.
[7]University of Arizona, Tucson, Arizona 85712, U.S.A.

Abstract

A redox reaction in which Sn^{2+} oxidizes to Sn^{4+} is thought to occur during the precipitation of cassiterite (SnO_2) and stannite (Cu_2FeSnS_4) from high-temperature hydrothermal solutions. In four stanniferous regions with differing mineralization environments (South Dakota, U.S.A.; Cornwall, England; Erzgebirge, Germany/Czech Republic; Andean tin belt, Bolivia), the tin isotope composition in stannite (mean value $\delta^{124}Sn = -1.47 \pm 0.54‰$, n = 21) is consistently more fractionated toward negative values than that of paragenetically earlier cassiterite (mean value $\delta^{124}Sn = 0.48 \pm 0.62‰$, 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 $\delta^{124}Sn$ 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. Therefore, the Sn isotopes may provide information on both redox reactions and petrologic sources and processes.

Keywords: Tin isotopes, cassiterite, stannite, metal isotope fractionation, redox