Sn-Isotopic Evidence of Vapor Transport of Tin in Shallow Mineralization Systems, Gejiu Polymetallic Ore Field, China

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The range of the Sn isotopic composition for tin ores and the geological mechanisms by which Sn fractionates during ore-forming processes remain unknown. Tin isotopic data have the potential to reveal the physiochemical reactions that occurred with metal transport and ore deposition. We compare cassiterite Sn isotope values from a deposit that spans formation depths of 1 to 6 km in which the nature of the transport phase varies from supercritical fluid to vapor.

Tin is known to partition into the vapor phase as chloride compounds at relatively low temperature (>130°C). Thus, it is possible that volatilization into vapor may be a mechanism by which shallow-level tin deposits could incorporate isotopically fractionated tin. Rhyolite-hosted cassiterite (wood tin) deposits are thought to have formed as a result of vapor-based transport and deposition of tin, and so provide a test for this hypothesis. Analysis of Sn isotopes in cassiterite from greisen-hosted (Saxony, Cornwall, Iberia) and pegmatite-hosted (Pakistan-Afghanistan, Zimbabwe, Serbia) tin deposits indicate that most tin deposits that form at moderate depths display a range of approximately 0.5‰ for $\delta^{120}Sn/^{116}Sn$ (Sn Standard: NIST 3161a, Lot number 07033). In contrast, rhyolite-hosted cassiterite from Mexico and New Mexico display a fractionation range of approximately 1‰ for $\delta^{120}Sn/^{116}Sn$, consistent with increased fractionation of Sn in vapor-associated systems.

The process can also be seen within the district scale of the polymetallic deposits of the Gejiu ore district, China. Cassiterite is accompanied by Cu-, Zn-, and Pb-sulfides in a variety of settings, including skarn, veins, and strataform bodies. Mineralization occurred over a range of depths (1–5 km), with supercritical fluids being associated with deep-seated mineralization, and immiscible vapor-fluid or boiling fluids associated with shallower levels of ore formation. Tin-isotopic analysis of cassiterites from the cassiterite-sulfide zones of three deposits in the Gejiu ore district yield contrasting fractionation patterns that may be correlated with variation between mineralization from supercritical and immiscible fluids. The granite-hosted cassiterite vein ores of Tangziao yield $\delta^{120}Sn/^{116}Sn$ values between –0.11 and –0.18‰, similar to skarn-related cassiterite from the Laochang deposit which cluster between –0.04 and –0.19‰. In contrast, the Gaosong ores are associated with two clusters of $\delta^{120}Sn/^{116}Sn$ values over a significantly larger range of –0.19 to 0.39‰. The variable nature and large range of $\delta^{120}Sn/^{116}Sn$ from Gaosong may be attributable to variation in the nature of the transport fluid, from supercritical to immiscible. The observation has value for understanding fluid characteristics in these systems and displays the potential for Sn isotopes to be used as vectors in exploration.