

Tin isotopes via fs-LA-MC-ICP-MS analysis record complex fluid evolution in single cassiterite crystals

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ABSTRACT

Tin isotope geochemistry of cassiterite may allow for reconstructing the fluid evolution of tin ore deposits. Here, we present cathodoluminescence (CL) imaging, trace element, and in situ Sn isotope compositions of two cassiterite crystals from an early and a relatively late stage of ore formation of the Xiling vein-style Sn deposit, southeastern China, by femtosecond laser ablation multi-collector inductively coupled plasma mass spectrometry (fs-LA-MC-ICP-MS). Our results show that the early-stage cassiterite from a high-temperature feldspar-stable hydrothermal environment has core, mantle, and rim zones with a systematic decrease in $\delta^{124/117}\text{Sn}_{3161\text{A}}$ (relative to the Sn standard NIST 3161 A) from $+0.38 \pm 0.06\text{‰}$ in the crystal core to $-0.12 \pm 0.06\text{‰}$ (2 SE) in the mantle zone. This isotopic evolution, also paralleled by a decrease in Ta content by two orders of magnitude, suggests a fluid batch evolving toward isotopically lighter Sn. The very rim zone of this crystal has an intermediate tin isotope composition at about $+0.05\text{‰}$ $\delta^{124/117}\text{Sn}_{3161\text{A}}$, combined with elevated Ta, suggestive of a second fluid batch. The late-stage cassiterite crystal from a muscovite-stable hydrothermal environment has a core with an evolved Sn isotope composition at about -0.15‰ $\delta^{124/117}\text{Sn}_{3161\text{A}}$ combined with low Ta, and a rim with heavier Sn isotope compositions up to $+0.30 \pm 0.08\text{‰}$ $\delta^{124/117}\text{Sn}_{3161\text{A}}$ and higher Ta contents. As for the early-stage crystal, two different fluid batches must be involved in the formation of this crystal. Our pilot study highlights the advantage of spatially resolved analysis compared to conventional, solution Sn-isotope analysis of bulk cassiterite crystals. The Sn isotope variations at the microscale reveal the complexity of cassiterite crystal growth by a combination of closed- and open-system fluid evolution and isotope fractionation.

Keywords: Xiling, tin ore deposit, cassiterite, trace-element mapping, in-situ Sn isotope