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Controls on cassiterite (SnO_2) crystallization: Evidence from cathodoluminescence, trace-element chemistry, and geochronology at the Gejiu Tin District

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Abstract

This paper evaluates controls on cassiterite crystallization under hydrothermal conditions based on the textural setting and geochemistry of cassiterite from six different mineralization environments from the world-class Gejiu tin district, southwest China. The cassiterite samples feature diverse internal textures, as revealed by cathodoluminescence (CL) imaging, and contain a range of trivalent (Ga, Sc, Fe, Sb), quadrivalent (W, U, Ti, Zr, Hf), and pentavalent (Nb, Ta, V) trace elements, with Fe, Ti, and W being the most abundant trace elements. Cassiterite Ti/Zr ratios tend to decrease with distance away from the causative granite intrusion, and so has potential to be used as a broad tool for vectoring toward a mineralized intrusive system.

Elemental mapping of cassiterite grains reveals that trace-element concentration variations correspond closely to CL zoning patterns. The exceptions are distinct irregular domains that sharply cut across the primary oscillatory zoning, as defined by the concentrations of W, U, Sb, and Fe. These zones are interpreted to have formed after primary cassiterite growth via fluid-driven dissolution-reprecipitation processes. Zones with low W and U (and Sb) and high Fe are interpreted to have formed during interaction with relatively oxidized fluids in which W and U are stripped from cassiterite due to cation exchange with Fe^{3+}. Systematics of W, U, Sb, and Fe partitioning into cassiterite can, therefore, be used as a monitor of the relative oxidation state of the hydrothermal fluid from which cassiterite precipitates.

Cassiterite U-Pb geochronology results obtained by LA-ICP-MS return ages between 77 and 83 Ma, which is consistent with previous geochronology from the region. Ages determined on zones of dissolution-reprecipitation are similar to ages for primary cassiterite growth, indicating a short (<3 m.y.) timespan of hydrothermal activity. These results confirm the potential of U-Pb dating of cassiterite for directly constraining the timing of Sn deposition.

Keywords: Cassiterite, cathodoluminescence (CL) imaging, trace element, fluid redox, geochronology