

Decoding Hydrothermal Histories: Cassiterite Signatures From the “Tin Corridor” at Neves Corvo Cu-Zn-Pb-Ag($\pm$ Sn) Deposit (Portugal)

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Cassiterite from the Neves Corvo Cu-Zn-Pb-Ag($\pm$ Sn) deposit (Portugal) preserves a remarkably complex record of hydrothermal evolution within a volcanic-hosted massive sulfide (VHMS) environment. Through an integrated petrographic, SEM-BSE, cathodoluminescence (CL), electron probe microanalysis (EPMA), and Laser Ablation Inductively Coupled Plasma Mass Spectrometry (LA-ICP-MS) dataset, we show that cassiterite in both stockwork and massive tin ores exhibits intricate oscillatory, sector, and irregular zoning, locally overprinted by dissolution-reprecipitation and reaction-induced microporosity. These textures document multiple stages of cassiterite growth and later fluid–mineral interaction.

Major and trace element compositions reveal systematic differences between stockwork/stringer and massive cassiterite. Stringer cassiterite incorporates higher Ti, Zr, Nb, and Sc–V, whereas cassiterite from massive ores is characterized by extremely low Ti and higher Fe, In, and Sn. Element correlations reveal multiple substitution vectors, primarily involving Fe–W–Sn, with Fe³⁺ and H⁺/OH[−] incorporated into the cassiterite structure via coupled substitution mechanisms. Cathodoluminescence zoning strongly reflects redox-sensitive substitutions: dark zones are enriched in W–U–Sb and represent precipitation under reduced conditions, whereas brighter Fe-rich overgrowths correspond to later, more oxidizing fluids. Reaction-induced porosity enabled fluid incursion and selective element mobilization, particularly the depletion of W and U and the simultaneous enrichment of Fe³⁺ in altered zones.

These findings suggest that early cassiterite precipitated rapidly from reduced Sn-bearing fluids with minimal water–rock interaction, likely during focused, near-seafloor venting. Subsequent oxidizing fluid pulses, likely linked to Na-metasomatism associated with the massive sulfide system, overprinted primary textures through dissolution–reprecipitation and redistribution of redox-sensitive elements. Elevated Ti, Zr, Nb, and Sc–V in stringer cassiterite is consistent with a magmatic Sn source from reduced, fractionated peraluminous granites. Cassiterite at Neves Corvo thus records a dynamic sequence of hydrothermal events and serves as a sensitive tracer of redox evolution, metasomatism, and fluid pathways in magmatic-hydrothermal and hydrothermal systems.