

Potential Magmatic-hydrothermal Tracers in Zircon CL “Dark Zones” From the Ruby Star Granodiorite, Pima Mining District, Arizona

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Copper is critical to the global energy transition, and demand is rising rapidly. The main global sources of copper are Porphyry Copper Deposits (PCDs). New PCDs are becoming more challenging to find, and major discoveries from the past decade are being found deeper in the subsurface. To improve exploration strategies, a holistic understanding of the processes that drive PCD emplacement is required.

Recent work has focused on accessory igneous minerals (e.g. zircon, apatite) within intrusions associated with PCDs as recorders of magmatic and hydrothermal evolution. Zircon textural features revealed by Cathodoluminescence (CL) spectroscopy record variations in the chemical evolution through its characteristic oscillatory growth zoning. CL-dark growth zones enriched in U, Th, and rare earth elements (REE) are commonly observed in fertile systems, and may represent relics of magma recharge events, fO₂ variations in the magma, or variable degrees of magma mixing. Regardless of which scenario, these mechanisms may have the potential to record processes that underpin the ore-forming potential of magmas.

Analyzing zircon dark zones is analytically challenging and requires high spatial resolution. Here, we present results from an analytical Laser Ablation Split Stream Inductively Coupled Mass Spectrometer (LASS-ICP-MS) depth profiling campaign. In this work, we analyzed zircon grains from the Ruby Star Granodiorite associated with the Sierrita deposit by depth profiling. We followed these analyses by plucking individual grains, rotating them, remounting, and polishing to the midsection to expose the depth profile. This was then followed by Scanning Electron Microscope (SEM) imaging and Electron Probe Microanalyzer (EPMA) chemical mapping to evaluate zircon morphology and chemistry of zircon ‘dark zones’. Here, we present these findings, discuss their implications for the petrogenetic mechanisms responsible for dark zones in porphyry intrusions associated with PCDs, and evaluate their potential as indicators for identifying “fertile” intrusions.