

Critical Metal Incorporation and Distribution in the Tom Sediment-Hosted Zn-Pb Deposit, Macmillan Pass, Yukon

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Sediment-hosted Zn-Pb (SHMS) deposits are increasingly recognized as important secondary sources of energy-critical metals such as germanium (Ge), gallium (Ga), indium (In), tin (Sn), and cadmium (Cd). Despite their growing economic significance, the mechanisms by which trace metals are incorporated into the primary Zn-Pb sulphide mineral sphalerite, and subsequently redistributed during deformation, remain poorly understood. This study investigates the processes controlling critical metal enrichment in the Macmillan Pass 'Tom' SHMS deposit via a multi-scaled approach linking chemical zoning at the deposit scale with mineral-scale incorporation of critical metals.

Laser Ablation Inductively Coupled Plasma Mass Spectrometry (LA-ICP-MS) is used to quantify concentrations and characterize trace metal speciation in sphalerite, distinguishing lattice-bound from inclusion-hosted occurrences. This study examines variations in critical metal concentrations across mineralization textures, spatial gradients, and stratigraphic units, providing constraints on the physicochemical parameters governing metal sources, transport, and deposition. These relationships are used to assess whether critical metals were introduced synchronously with primary Zn-Pb mineralization or reflect evolving fluid sources and/or post-depositional remobilization.

At the mineral scale, trace metal concentrations are evaluated in relation to sphalerite colour, texture, deformation, and spatial position within the different domains of the deposit. This approach tests the hypothesis that deformation and recrystallization modify critical metal residence within sphalerite, with direct implications for metal deportment during comminution and leaching.

By linking mineral-scale trace metal speciation to deposit-scale architecture and subsequent processing, this study provides new insight into the temporal, spatial, and physicochemical evolution of critical metal enrichment in SHMS deposits. These findings will ultimately inform exploration strategies and metallurgical processing approaches aimed at improving critical metal recovery and supporting the sustainable development of these resources in Canada.