

An Integrated Framework Investigation of the Sheep Creek REE-Nb-Cu System: Preliminary Constraints from Structural Mapping, Geochemical Assays, and Pending Geochronology

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The Sheep Creek REE-Nb-Cu deposit in Ravalli County, Montana, represents a complex zoned mineralized system within complex structural domains: NE-trending Paleoproterozoic Great Falls Shear Zone (GFSZ) and NW-trending Mesoproterozoic Clearwater Shear Zone (CSZ) intersection and later transposed Mesozoic Salmon River Suture Zone (SRSZ) and Western Idaho Shear Zone (WISZ). This study considers a syn-kinematic, Cretaceous carbothermalite model utilizing an integrated framework of field mapping with geochemical assay data, previous work, automated mineralogy (TIMA), and U-Pb and Re-Os LA-ICP-MS geochronology supported by cathodoluminescence (CL) imaging. No associated spatially and temporally calc-alkaline igneous body for Sheep Creek has been identified.

Structural mapping identifies several structural features parallel to the GFSZ and CSZ. Deformation associated with the SRSZ (c. ~144-105 Ma) and dextral transpressional N-trending WISZ (c. ~105-86 Ma) may have reactivated Proterozoic basement structures. The timing of mineralization correlates to the transient shift in tectonism (c. 105–100 Ma) from Early Cretaceous thin-skinned-style thrusting (SRSZ) to Mid-Cretaceous dextral transpression (WISZ). These basement structures may have served as pathways for the ascent of REE+Nb+Cu mantle-derived fluids, favoring NE tension gashes, thrusts, shear zones, and favorable host lithologies.

Mineralization is further partitioned by a large, E-W trending high-angle structure in the Beaver Creek area that separates a REE-Nb mineralized domain to the south from a distal copper-magnetite-skarn domain hosted in the Belt Supergroup to the north. REE+Nb enriched fluids infiltrated a contact between a Mesoproterozoic megacrystic granite and diabase-quartz diorite complex, concentrating REE-Nb mineralization within NE tension gashes and NW structures along the contact. In contrast, a broader hydrothermal halo is hosted within the calcareous sandstones of the Belt Supergroup, manifesting as widespread disseminated copper (chalcopyrite/malachite), mesothermal chalcopyrite veins, localized skarn occurrences, and shear-hosted massive magnetite.