

Mineral Mapping and Zonation of the Butte Porphyry Copper and Main Stage Vein System in the Boulder Batholith, Southwest Montana

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Mineral mapping using multielement geochemical analysis and short-wave infrared spectra of surface and drill core samples in a porphyry system is compared here with Earth Mapping Resources Initiative airborne magnetic and radiometric surveys at Butte. Integration of geological and geophysical data documents district-scale zoning critical to understanding and exploration of mineral systems.

Major and trace element geochemistry (Sc, Th, Ti, K) distinguish Butte Granite from granoaplite sills, the two host lithologies, and post-ore K-rich volcanics. Similarly, gamma-ray spectra partially distinguish these units.

Potassic hydrothermal alteration (biotite-muscovite-K-feldspar±magnetite-chalcopyrite-pyrite) dominates porphyry Cu-Mo ores that are largely deep, poorly exposed, and affected by late argillic alteration. These zones occur beneath the Butte townsite and mines, so are difficult to map with airborne geophysics.

Deep pyrite-rich and copper-poor sericitic alteration in drill core samples cuts the potassic alteration, and younger Main Stage polymetallic veins extend west and north of Butte. Deep pervasive sericitic alteration is characterized by short wavelength muscovite (~2200-2204 nm) that locally replaces pyrophyllite, whereas surface samples near Main Stage veins north and west of Butte have feldspar-stable alteration with long wavelength white mica (2207-2014)±chlorite±pyrite that replaces hornblende and biotite. Both zones destroy magnetite and have low magnetic susceptibility. Pervasive sericitic alteration exhibits loss of Na + Ca and gain of K (3-4 wt%) to yield muscovite (≈400°C) with rock K/Al molar ratios of 0.3-0.4. In contrast, in feldspar-bearing weak sericitic alteration has loss of Na + Ca and gain of K (4-8 wt.%) to produce K/Al molar ratios of 0.4-0.7, indicative of K-feldspar-sericite formation. The K-feldspar addition is cryptic, and not previously documented, but is also imaged in gamma-ray spectra. Fluid inclusion temperatures, muscovite-illite compositions, and metal zonation are consistent with outward fluid flow and cooling at ≈300°C in the Main Stage from a central source in the deep sericitic zone.