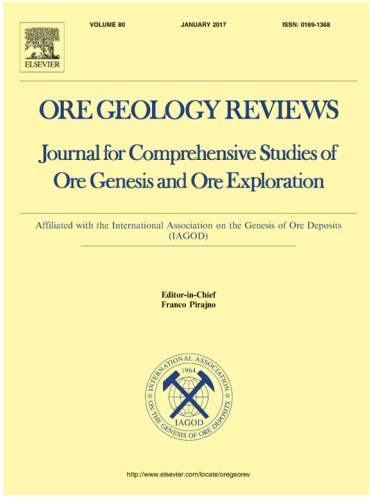

Two-event lode-ore deposition at Butte, USA: $^{40}Ar/^{39}Ar$ and U-Pb documentation of Ag-Au-polymetallic lodes overprinted by younger stockwork Cu-Mo ores and penecontemporaneous Cu lodes

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Two-event lode-ore deposition at Butte, USA: $^{40}Ar/^{39}Ar$ and U-Pb documentation of Ag-Au-polymetallic lodes overprinted by younger stockwork Cu-Mo ores and penecontemporaneous Cu lodes

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Abstract

The ore-genesis model for world-class deposits of the Butte mining district, Montana, USA, is deep pre-Main Stage porphyry Cu-Mo and overlying Main Stage Ag-Zn-Cu zoned-lode deposits, both of which formed from hydrothermal fluids driven by minor volumes of rhyolitic magma. The lode-specific model is that hydrothermal processes diminished in intensity outward from district center along lode veins, synchronously forming metal zones. The accepted models are controverted by new geologic and multi-method geochronologic studies.

The new data reveals the following sequence of events: (1) Thermal study of country rock indicates that the 76.9-Ma Butte Granite cooled to 350-400°C by 4 m.y. after emplacement. (2) Five quartz porphyry rhyolite dikes were emplaced at 67-65 Ma and another at 60 Ma (SHRIMP U-Pb) into the cooled Butte Granite without resetting $^{40}Ar/^{39}Ar$ ages in country rock. (3) Fifty-eight white mica and K-feldspar samples from alteration envelopes adjacent to Ag-Au-polymetallic lodes in outer parts of the district, Zn-rich lodes in intermediate parts, and Cu-rich lodes in the district center yield $^{40}Ar/^{39}Ar$ ages of 73-70 Ma for Ag-rich lodes, 65-64 Ma for Cu-rich lodes, and complex age spectra of 69-65 Ma for Zn-rich lodes.

The data show that Ag-Au-polymetallic lodes occupied cross-district fractures by about 73 Ma, forming the greater Butte mining district. At 67-65 Ma, minor quartz porphyry dikes were emplaced into central and eastern parts of the rejuvenated fracture system but without evidence of related cupola or volcanic rocks or of thermal disturbance in the country rock. At 64.5 Ma, overlapping hydrothermal cells formed two stockwork Cu-Mo domes in deep parts of the fracture system. At 65-64 Ma and closely related to late-stage stockwork Cu-Mo activity, a penecontemporaneous hydrothermal pulse formed a high-sulfidation hydrothermal plume that (1) utilized the large re-opened fractures to cannibalize and remobilize Cu from autologous, stockwork, and older Ag-Au-polymetallic lodes and (2) ultimately formed the rich, high-sulfidation Cu lodes.

Metals zones in lodes of the Butte district are the result of an intensely focused, Cu-rich hydrothermal plume that variably reworked the center of significantly larger, 10 m.y. older, Ag-Au-polymetallic lodes.