

Geology, Geochronology, and USGS Earth MRI Geophysics Reveal Stress Control of Polymetallic Vein Swarms in the Northeastern Colorado Mineral Belt

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The Colorado Mineral Belt (CMB) hosts upper crustal mineral deposits hypothesized to have been localized by reactivation of transcrustal structural weaknesses. Recent high resolution aeroradiometric and aeromagnetic data combined with mapping, stress-strain inversions, and $^{40}\text{Ar}/^{39}\text{Ar}$ illite alteration dating along polymetallic quartz vein swarms (PMVS) and contractional, brittle fault zones (BFZ) permit hypothesis refinement.

The Idaho Springs and Boulder-Tungsten districts in the NE CMB hosted polymetallic mineralization and mining. The NE striking, Proterozoic Idaho-Ralston plastic shear zone (IRSZ), partially within Idaho Springs, deforms Proterozoic basement but lacks illite alteration and evidence of brittle reactivation at intensities different than in the surrounding host rocks. BFZ strike NW, are illite altered, and cut IRSZ. Steeply dipping, WSW-ENE striking PMVS are not co-located with Late Cretaceous-early Tertiary stocks and lack systematic orientations near them. Slip along BFZ and PMVS are consistent with subhorizontal, WSW-ENE shortening, whereas IRSZ shows NW and SE, Proterozoic dip slip. BFZ (n=19) and PMVS (n=7) illite dates, excluding outliers, overlap and range from ca. 126 to 49 Ma and ca. 75 to 45 Ma, respectively.

PMVS domains exhibit distinctive radiometric and magnetic co-located and co-oriented anomalies. Low radiometric thorium domains within a single Proterozoic granitoid suggest thorium depletion in the Boulder-Tungsten PMVS. Low thorium correlates with complex, multi-lithology patterns in Idaho Springs PMVS. A low magnetic anomaly mirrors the extent of the Idaho Springs PMVS and crosscuts lithologic units. The IRSZ lacks distinct geophysical expression, but anomalies track folding in adjacent lithologies.

BFZs and PMVSs show kinematic compatibility and overlap temporally, consistent with Laramide contraction while showing minimal correlation with IRSZ. Geophysical data independently indicate shallow hydrothermal alteration consistent with illite dates in PMVS domains. These relations suggest that NE CMB mineralization reflects thermally activated hydraulic fracturing sensitive to the Laramide stress field, rather than simple reactivation of Proterozoic structures.