

Alteration, Mineralization, and Geochemical Footprint of the Polymetallic Au–Ag–Pb–Zn Peñasquito Deposit, Mexico

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Several styles and genetic origins of Au–Ag–Pb–Zn ($\pm$ Cu–Mo) mineralization characterize the Peñasquito deposit, which records a well-preserved vertical and lateral footprint that is spatially and temporally associated with both porphyry and epithermal mineralization. The well-developed and zoned magmatic-hydrothermal center at Peñasquito provides an excellent case study and offers exploration vectoring tools for similar systems hosted in the Mexican Fold and Thrust Belt and sedimentary basins elsewhere.

Peñasquito comprises a multi-phase cluster of finger-like porphyry intrusions emplaced at ~34 Ma into a carbonate-dominated sedimentary sequence. At shallow levels, this high-K calc-alkaline intrusive complex produced zones of polymetallic intermediate-sulfidation epithermal-style ('ISE') Ag–Au–Zn–Pb mineralization and associated alteration. At depth, it hosts sub-economic porphyry-style Cu–Mo mineralization and adjacent Cu–Zn $\pm$ Au–Ag skarn alteration. The bulk of the polymetallic mineralization is associated with the epithermal stage.

A ~3 km $\times$ 2 km hydrothermal cell defines the Peñasquito deposit. It extends well beyond the two main economic centers: Peñasco (diatreme breccia-hosted) and Chile Colorado (base metal sulfides vein-style stockwork). The Chile Colorado rich polymetallic mineralization, in particular, is characterized by an exceptionally tight footprint, making it a challenging deposit type for exploration, with a lateral extent of only ~850 $\times$ 600 m.

At the deposit scale, the hydrothermal cell is spatially associated with disseminated pyrite and pyrite–carbonate veinlets, coincident with a pronounced IP anomaly (+10mV/V). It is further characterized by pervasive K-feldspar-bearing phyllic alteration (pyrite–white mica $\pm$ quartz $\pm$ carbonate) and strong geochemical enrichment in Ag, As, Sb, Mn and S that follows the same spatial pattern. Potassium (+Ti) is strongly correlated with high-grade Ag–Au–Zn–Pb mineralization and represents the most effective vector toward mineralized domains. These enrichment zones are closely mimicked by systematic depletion in Sr and Ca. Collectively, this multi-parameter alteration and geochemical footprint provides a robust exploration vectoring tool for ISE-type systems hosted in carbonate rocks.