

Applying Mappable Criteria to Prospectivity Analysis of Calc-alkaline Porphyry Epithermal Mineral Systems

Carl Beno¹, Jackson Borchardt², Sean Gaynor³, Peter Vikre⁴, Mitchell Bennett³, Eric Anderson³, Douglas Kreiner⁵

¹U.S. Geological Survey, Tucson, United States, ²U.S. Geological Survey, Moffett Field, United States, ³U.S. Geological Survey, Lakewood, United States, ⁴U.S. Geological Survey, Reno, United States, ⁵U.S. Geological Survey, Anchorage, United States

Mineral system components (e.g., trigger, driver, sources, transport, traps, preservation) associated with calc-alkaline porphyry epithermal mineral systems are required to form economic mineral deposits. Regional- to deposit-scale geologic, geochemical, geochronological and geophysical databases contain criteria for application to development of prospectivity maps. We identify relevant mappable criteria and provide descriptions of their qualitative and quantitative expression(s) in available datasets.

Calc-alkaline porphyry-epithermal systems are triggered by convergent tectonics and driven by intermediate-to-silicic magmas. Identification of these elements relies on paleogeographic reconstructions, framework geology models, geochronology, geophysics, and magma chemistry. Metals, ligands, and fluids are sourced during melt generation in the lower crust and concentrated during subsequent evolution. Magma compositions can be used to assess the first-order mineralization potential of igneous suites through whole-rock and mineral chemistry. Crustal architecture exerts a first-order control on melt transport and near-field stress regimes control melt conduits in the upper crust. Framework models, geologic mapping, and geophysics can delineate terrane boundaries. Detailed structural geology and geologic mapping at the deposit-scale can identify local transport mechanisms. Fluids exsolved from rising and/or crystallizing magmas concentrate metals and drive fragmentation and brecciation. Deposit-scale mapping can identify fragmentation/brecciation and epigenetic mineral zonation(s) can map the extent and evolution of fluid circulation. Fluid infiltration through focusing conduits facilitates local metal accumulations and epigenetic mineral distributions can be used to reconstruct fluid flow. Metals precipitate as hydrothermal brines cool and/or depressurize in structural traps and/or chemically reactive wall rocks. Mapping can identify structures and/or rock types receptive to fluid infiltration and mineralization. Post-mineralization processes (e.g., faulting, erosion, burial) can facilitate preservation and/or destruction of portions of the mineral system. These processes can be assessed using framework geology models, geologic mapping, geochronology, and paleoclimate reconstructions.