Economic Geology, v. 103, pp. 939–956

Root Zones of Porphyry Systems: Extending the Porphyry Model to Depth

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Abstract

The root zone of a porphyry system is a specific region beneath a porphyry orebody that was a site of focused fluid flow, as evidenced by abundant quartz veins, widespread wall-rock alteration, or porphyry dikes merging downward into a porphyritic granite cupola. These zones constitute an important source region of ore fluids and other components, and in certain geologic terrains the characteristics of root zones may point to previously undiscovered deposits.

The root zones of four Laramide porphyry copper systems in Arizona recently have been characterized at a reconnaissance level: the Miami Inspiration system associated with the Schultze Granite, the Sierrita-Esperanza system associated with the Ruby Star Granodiorite, the Ray system associated with the Granite Mountain pluton, and the Kelvin-Riverside system associated with the Tea Cup pluton. The two well-studied root zones related to the Jurassic Yerington batholith in Nevada, and associated with the Yerington mine and the Ann-Mason deposit, provide a basis of comparison. All six systems occur in areas with unusually large exposures in both lateral and vertical paleodirections, locally to paleodepths of >10 km, because of postore extensional faulting and associated tilting. No two systems are alike, but many share the presence of the following hydrothermal characteristics: quartz veins and potassic alteration, sodic-calcic and sodic alteration, calcic alteration, and relatively coarse grained muscovite-quartz (greisen). Quartz veins and potassic alteration are focused centrally, directly above related cupolas; sodic-calcic and sodic alteration, calcic alteration, and evidence for leaching of silica are observed on the deep flanks of certain systems; and greisen occurs directly beneath ore within and beneath coeval cupolas in many systems. Certain systems exhibit evidence of multiple cycles of release of magmatic fluid followed by incursion of saline ground waters, which are analogous to the biological cycle of exhale-inhale, respectively.

The characteristics of the root zones provide important constraints on the exsolution and transport of the magmatic aqueous phase that leads to ore formation, the variable incursion of external fluids into the hydrothermal system, and the degassing of magmatic volatiles that may not be related directly to porphyry ore formation. The most robust conclusions are drawn from the localities that offer the greatest quality of exposure and degree of continuity (including compelling structural reconstructions) between the roots and the ore deposit, from the studies that identify timelines linking processes in the roots with those in the mineral deposit, and from systems in which the deposit itself is well characterized.

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