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Evolution of the Breccia-Hosted Porphyry Cu-Mo-Au Deposit at Agua Rica, Argentina: Progressive Unroofing of a Magmatic Hydrothermal System

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Abstract

Detailed geologic mapping has been used to show that Agua Rica is a porphyry-style Cu-Mo-Au deposit that was first overprinted by polystage brecciation associated with a high sulfidation epithermal event and then by a barren surface-venting phreatomagmatic diatreme, prior to a final stage of supergene enrichment. It was emplaced in the Miocene (~8–5 Ma) as an outlier of the Farallón Negro Volcanic Complex in northwestern Argentina.

The Agua Rica deposit lies next to the contact between Precambrian or lower Paleozoic metasedimentary rocks and coarse-grained Ordovician granites. In a first pulse of Miocene magmatism, equigranular to porphyritic intrusions were emplaced, with minor potassic alteration and weak Cu-Mo mineralization. Subsequent intrusion of feldspar porphyries was associated with intense porphyry-style stockwork veining, potassic and propylitic alteration, and disseminated Cu-Mo-Au mineralization (molybdenite, chalcopyrite ± bornite ± pyrite). The present alteration and mineralization pattern is dominated by an almost pervasive overprint of high sulfidation epithermal assemblages (phyllic and advanced argillic alteration and Cu-Au-Ag-As-Pb-Zn mineralization) in breccia cements and as void fillings. Covellite is the dominant copper mineral in the ore and seems to have partly or completely replaced chalcopyrite and bornite of the earlier porphyry events. The high sulfidation epithermal assemblages are closely related to the emplacement of a largely clast-supported hydrothermal breccia. Three major bodies of this breccia have been mapped on the basis of clast lithology, clast shape and size, degree of alteration, and composition of breccia matrix. Igneous breccia with a fine-grained porphyritic matrix is intimately associated and interfingers with the base of the hydrothermal breccia columns. A final phase of magmatic hydrothermal activity formed a matrix-supported and commonly bedded crater infill breccia. It formed by a surface-venting phreatomagmatic eruption, as shown by a continuous downward transition from bedded breccias to clast-supported breccias with sandy or pumiceous matrix to a solid igneous breccia with a fine-grained porphyritic matrix in the lower core of the conical crater infill breccia body. Graded, matrix-rich epiclastic sediments subsequently filled the crater. Magmatic activity was terminated by a dike of unmineralized biotite porphyry, which intruded the crater infill breccia. Talus breccia was shed into the crater from the rim. Supergene leaching and enrichment, which replaced covellite, pyrite, chalcopyrite, and bornite by chalcocite and secondary covellite, formed an enrichment blanket that was dissected by the present-day, steeply incised topography.

The distinctive feature of the Agua Rica hydrothermal system is the occurrence of early, weakly mineralized intrusions, later feldspar porphyries with stockwork-hosted chalcopyrite-bornite-molybdenite mineralization, hydrothermal breccias with an epithermal pyrite-covellite overprint, and barren surface-venting breccias—all exposed at one location within 1,000 m of vertical exposure. Reconstruction of the time sequence of these geologic elements indicates that Agua Rica is the result of a protracted history of magmatic hydrothermal activity with superposition of several intrusion events that probably extended over several million years during progressive regional uplift, erosion, and explosive unroofing.