

Anatomical Difference Between Spatially and Temporally Associated Porphyry Copper Deposits at Reko Diq H14-H15 Complex, Balochistan-Pakistan

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Reko Diq porphyry clusters in the western Chagai belt, Pakistan, contain an enormous geological resource of 5.9 Gt at 0.41% Cu and 0.22 g/t Au, largely in the H14 and H15 porphyry deposits. The H14 and H15 deposits, located approximately 1 km apart, are spatially and temporally associated with a series of petrologically similar, late Miocene (12.5–12.0 Ma) calc-alkaline porphyry intrusions hosted by Oligocene andesitic volcanic and clastic sedimentary rocks. The porphyry intrusions are characterized by phenocrysts of plagioclase, biotite, quartz, and minor amphiboles embedded in a microcrystalline mafic silicate-bearing quartzofeldspathic groundmass. Sodic-calcic, potassic, transitional sericite-chlorite, sericitic, and propylitic alteration assemblages are zoned about the porphyry intrusions. The early and intramineral porphyry intrusions are overprinted by pervasive potassic alteration of hydrothermal biotite-K-feldspar-magnetite assemblage with associated chalcopyrite and bornite. Secondary biotite replaces amphibole and, locally, biotite phenocrysts, whereas K-feldspar replaces plagioclase and forms vein selvages or suture zones in quartz A- and B-type veins. Magnetite is mainly disseminated but also forms hairline microveinlets. A network of quartz ± magnetite ± K-feldspar A veins and disseminated and vein-hosted chalcopyrite-bornite ± pyrite containing up to ~1.5% Cu and 1.0 g/t Au accompanies the potassic assemblage. Pale purple anhydrite veins are locally present in the potassic-altered zone. Bornite forms a distinct high-grade core to the H14 deposit, but bornite, although present, is less common and always subsidiary in volume to chalcopyrite in the slightly older H15 deposit. Locally, high sulfidation-type mineral assemblages of sericite-pyrite-covellite-bornite-chalcopyrite are present in stratabound horizons in H15; this atypical assemblage appears to reflect protolith compositions.

Potassic alteration at depths >1,000 m below surface is overprinted by a sodic-calcic alteration assemblage of albite-epidote ± actinolite ± chlorite, where cream-white albite replaced K-feldspars. Total sulfide drops to less than 1% at these depths. At shallow depths in the upper parts of the present levels of erosion, potassic alteration assemblages are overprinted by sericite-chlorite assemblages, mainly along late-stage, cm-scale chalcopyrite-pyrite D veins carrying ~0.40% Cu and 0.20 g/t Au. Outside the Cu-Au mineralized core, an outer sericitic (phyllic) alteration assemblage is characterized by pale white aggregates of quartz, fine-grained sericite (muscovite), abundant pyrite, and traces of chalcopyrite with a late overprint by kaolinite and montmorillonite. A propylitic alteration assemblage of chlorite-epidote ± pyrite-carbonate assemblage is extensively developed in the peripheral volcanic and sedimentary host rocks surrounding H14-H15 porphyry complexes.

The multiple and overlapping magmatic-hydrothermal events with high-temperature and saline fluids that formed the H14 and H15 deposits are typical for most porphyry Cu deposits with intensity of potassic alteration, veins, and total sulfide content decreasing with time. The youngest and late mineral intrusions in each complex form a narrow, low-grade core in the H15 and H14

deposits. Overall, a short time duration characterizes the formation of each of the porphyry centers, which, together, are responsible for Reko Diq being one of the world's largest porphyry Cu-Au resources.