

Paragenesis and Hydrothermal Alteration Characterization Using Short-Wave Infrared (SWIR) in the Intermediate Sulfidation Epithermal Deposit of Ajaruni, Huacullani, Puno, Peru

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The Ajaruni deposit is an intermediate sulfidation epithermal Ag-Pb-Zn deposit located in southern Peru, with estimated reserves of approximately 60 Moz of Ag. The main mineralization is hosted within Miocene andesitic volcanic rocks and primarily occurs along veins and hydrothermal breccias. This study integrates geological mapping, petro-mineralogical analysis, geochemistry, and short-wave infrared (SWIR) spectroscopy to characterize lithological units, mineral paragenesis, and hydrothermal alteration patterns. The mineral paragenesis is divided into five stages: (I) an early low-temperature assemblage dominated by chlorite, carbonates, and quartz; (II) barite and hematite deposition; (III) the main sulfide stage with pyrite, chalcopyrite, sphalerite, galena, argentite, and Ag sulfosalts, accompanied by white micas; (IV) late-stage amethyst quartz and carbonates; and (V) a supergene alteration stage marked by manganese oxides and jarosite, reflecting surface oxidation and weathering processes. SWIR analysis of white micas in the mineralized zones reveals Al-OH absorption features between 2200 and 2220 nm, indicating a composition ranging from muscovite to phengite, with a crystallinity index (CI) between 0.28 and 4.7, higher near veins and breccia zones, reflecting intense high-temperature hydrothermal fluid activity. Multi-element geochemical analysis shows elevated silver concentrations (>100 ppm), Pb and Zn contents >1%, and anomalous Cu values averaging 1000 ppm, confirming a well-developed polymetallic mineralization system. Additionally, the presence of a phreatomagmatic breccia with clasts containing truncated quartz veinlets and pyrite sutures suggests a potential connection to deeper porphyry-style mineralization. This multidisciplinary approach enhances the understanding of the Ajaruni deposit and provides valuable insights for the exploration of similar epithermal systems in southern Peru.