Recovery of Critical Metals from Copper Mine Tailings Utilizing Microanalytical Characterisation for Improved Geometallurgical Outcomes

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Cobalt is a critical metal commonly hosted in cobalt-sulphides and pyrites associated with copper mineralisation. In Australia, cobaltiferous minerals are rarely recovered in copper concentrators, especially if hosted in pyrite, and are often rejected to waste streams. Integration of circular economy principles into mining has encouraged exploration of historic and current mine wastes as supplementary cobalt resources. Understanding cobalt tenor and deportment in mine tailings is essential to modelling these repositories and informing appropriate mineral reprocessing flowsheets.

A case study to determine cobalt endowment in pyrites was undertaken on sulphidic mine tailings from a sedimentary-hosted copper deposit in Queensland, Australia. Field sampling obtained 585 samples from 26 auger holes down to 10m depths. High variability was observed in the facies (16 subgroups), geochemistry and cobalt endowment across the dam. Mineral Liberation Analysis (MLA) and Laser Ablation Inductively-Coupled Plasma Mass Spectrometry (LA-ICP-MS) analyses (1197 spots) were collected from 10 representative samples. The average cobalt grade in pyrite was 485ppm, with individual grains ranging from 1.8ppm to 8% (w/w). Several different pyrite chemistries were identified; including varying combinations of end-member compositions of cobalt-rich, arsenic-rich, and copper-rich pyrite. These pyrites were distributed throughout the tailings profile, however were weakly zoned from arsenic-rich pyrite in upper oxidised tailings (0 to 2m), to cobalt-rich pyrites below the oxidation front (4 to 8m), to copper-rich pyrite at depth (8 to 10m). Cobalt occurred as refractory substitution in the pyrite matrix, zones of enrichment (averaging 791ppm) and micro-inclusions of cobaltite and carrollite (averaging 3,334ppm). Only 45% of pyrites were liberated, with the majority locked in binary associations with non-sulphide gangue. Pyrite p80 (average 46µm) was much finer than the tailings particle size p80 (average 97µm). These geometallurgical observations will help inform the selection of mineral processing technologies if tailings processing is considered a viable option..