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Enhancing Platinum Group Mineral Recovery from Flotation Tailings: A Process Mineralogy Approach for Alternative Pretreatment

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The shift toward a circular economy and green energy is driving increased interest in sustainable supplies of critical metals (CMs). In this geometallurgical study, platinum group mineral (PGM) flotation tailings from the highly weathered silicate reef in the Bushveld Complex were pretreated using acidic chemical media to optimise a unit process stage. This stage aimed to expose locked PGMs and base metals (BMs) not recovered in a prior flotation campaign for extraction in a downstream selective dissolution stage. We investigated the effects of sulphuric acid, nitric acid, and ammonium hydrogen sulphate as reagents, leaching times of 3, 24, and 96hrs, temperatures of 25°, 50°, and 70°C, and pulp densities of 20, 30, and 40w/v%.

Process mineralogy evaluation was conducted using a scanning electron microscopy (SEM)-based Tescan integrated mineral analyser (TIMA). The automated mineralogy (AM) investigation demonstrated significant alterations in the bulk mineralogy and surface morphology of the starting material. Acidic media, particularly sulphuric acid> nitric acid> ammonium hydrogen sulphate, effectively disintegrated the gangue minerals' crystal structure, exposing locked-in PGMs and BMs.

Postleaching TIMA analysis revealed that amorphous silica was the predominant product of the pretreatment, constituting ~30 to ~50wt%. While amphiboles and pyroxenes remained largely unaffected, serpentine, talc, chlorite, and other primary silicates, including feldspars and micas, were notably affected by the pretreatment, resulting in the formation of these postleached silica phases.

Optimised process conditions were identified as 3hrs leaching time, 20w/v% pulp density, 2M sulphuric acid, at 70°C in a two-stage process. However, AM results indicated that energy and economic efficiencies could be further optimised with 3hrs leaching time, 40w/v% pulp density, 4M sulphuric acid, at 50°C in a two-stage process. The chemical pretreatment was successfully validated on weathered flotation tailings, with future studies anticipated to extend the approach to low-grade run-of-mine stockpiles and other Bushveld orebody tailings.