Process Mineralogical Constraints on the Recovery of Platinum Group Metals via Direct Leaching of UG2 Ore in the Bushveld Complex

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As global efforts to reduce carbon emissions intensify, the demand for platinum group metals (PGMs) continues to rise. This is driven by their unique physicochemical properties such as good corrosion and oxidation resistance, high melting temperatures, electronic and catalytic properties, and their important role in platinum-catalysed hydrogen-powered fuel cells for electric vehicles. Traditionally, PGMs have been recovered via a crush–mill–float–smelt process followed by multi-stage leaching process to recover base metals and PGMs. However, the complex mineralogy and texture coupled with declining ore grades, often result in suboptimal metal recoveries during flotation and create mounting uncertainties in long-term PGM supply. Direct leaching has attracted significant attention as a potentially cost-effective and environmentally benign alternative to the conventional processing route, particularly for low-grade, mineralogically complex ores. The crux of successful direct leaching hinges on a rigorous mineralogical investigation that explain the distribution, association, and textural attributes of PGM-bearing minerals. In this study, we employed a process mineralogy framework to evaluate the feasibility of direct leaching over froth flotation. Representative samples from the UG2 Reef were characterised using the TESCAN Integrated Mineral Analyser (TIMA) for mineralogical properties and inductively coupled plasma mass spectrometry (ICP-MS) for chemical composition. TIMA analysis revealed that PGM minerals are mostly fine-grained and occur within chromite and base-metal sulphides, resulting in poor liberation and limited lixiviant access. ICP-MS confirmed high concentrations of Ni, Cu, and Co, which may compete with PGMs during leaching, increasing reagent consumption and lowering overall recovery. Understanding these textural complexities and PGM associations is important for modulating key parameters such as particle size distribution, leaching reagent type(s), conducive solution pH and temperature and overall leach kinetics in order to improve recovery of PGMs. Insights gained from this mineralogical investigation offer guidance for developing more efficient direct leaching process route of complex and low-grade PGM ores.