SEG 2023 Conference: Resourcing the Green Transition

Characterization of Refractory Gold Behaviour in Witwatersrand Mine Tailings: Implications for Gold Recovery

Steve J. Chingwaru, Bjorn Von der Heyden, Margreth Tadie
Stellenbosch University, Stellenbosch, South Africa

The Witwatersrand Basin is the largest gold province in the world, having produced more than 6 billion tons of mine tailings over the past century of mining. As the basin has matured in terms of gold production, traditional cyanidation techniques are now used to extract gold from the tailings concurrently with primary gold ores. Despite these efforts, the tailings remain refractory, and an estimated 1,325-1,855 tons of gold are still present in tertiary tailings. The complete mineralogical composition of this remaining gold is not yet fully understood. This study uses separation, mineralogical, and chemical analyses to characterise the refractory behaviour of Witwatersrand tailings material gold obtained from spatially varying goldfields. Results indicate that the heavy mineral concentrate has a higher gold concentration of 0.71-10.12 ppm, while the light (<2.95 $g.cm^{-3}$) and slimes (<10 μm) fractions have 0.05-0.22 ppm and 0.17-0.76 ppm concentrations of gold, respectively. Detailed in situ analyses and leach tests of the different mineral fractions suggest that the gold is encapsulated by tailings mineralogy in the form of "invisible" or "solid-solution" gold, mainly in pyrite and arsenian pyrites. These minerals have gold concentrations ranging up to 2,730 ppm and, from mass balance, may account for up to 420 tons of gold locked as refractory gold in the existing surficial tailings heaps. Additionally, the tailings sulphides host a significant concentration of deleterious and critical heavy metals such as As, Ni, and Co. Identifying the invisible gold represents an under-utilized gold resource, as it accounts for up to 31% of the 50-70% of gold unrecovered during secondary processing. The primary Witwatersrand ores are known for their native liberated gold, which explains the refractory behaviour of remaining re-dump gold during traditional extraction. The study's results have implications for mining, economics, environment, optimization of flowsheets, and the origin of the Witwatersrand.