The Application of Process Mineralogy to Improve Gold Extraction from Wits Tailings

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Abstract

The extraction of gold from secondary resources such as historical Witwatersrand (Wits) tailings has been vital in extending the life of the South African gold industry. For a long time, Wits gold tailings have been a liability to mining operations due to the cost of the management of tailings dams. If tailings are not adequately managed, they can have long-term negative effects on the environment and human health and safety, with pollutants from effluent and dust emissions possibly being hazardous to humans, animals, and plants. However, due to a decrease in ore grades, the growing drive for zero waste, and improvements in technology, tailings retreatment is now a sustainable form of revenue for gold operations in South Africa.

While the Wits gold tailings are characterised by low gold content, there is however, an expectation that this residual gold can be efficiently and economically extracted since gold extraction technologies have improved. However, low gold extraction efficiencies have typically been observed with typical plant operations operating at 40-50% recoveries. Poor liberation is a common postulation on the causes of low gold extraction and slow leaching kinetics. As a result local Wits tailings toll treatment plants apply ultra-fine grinding (P80 -20 µm) to partially liberate the gold and achieve economical gold extraction. However, an alternative hydrometallurgy approach that does not come with the capital and process implication of fine grinding can prove to be more economical. The study aimed to establish the cause of reduced gold extraction in a Wits tailings concentrate followed by the establishment of a hydrometallurgy process route that improves the gold extraction. The aim of the research was achieved through a process mineralogy study of a typical Wits pyrite concentrate sourced from the DRDGold's Ergo flotation plant. Data from the process mineralogy study was then interpreted to develop a test work program that aimed to improve the gold extraction from Wits pyrite concentrate.

The results from the study showed that gold in Wits tailings appears predominantly by way of native gold which can easily leach with cyanide, with a negligible amount of electrum. The locking and reactive gangue minerals in the form of iron sulphides pyrite and pyrrhotite were noted to restrict cyanide access to the gold particle. Furthermore these minerals tend to partially dissolve during cyanidation in an alkaline medium. Three options identified to improve gold extraction included the passivation of iron sulphide mineral facades using an arrangement of pre-oxidation, lead nitrate addition to improve leaching kinetics and reduce cyanide consumption, and leaching at elevated dissolved O_2 concentrations with excess cyanide addition. The application of pre-oxidation (lime + air) with increased dissolved oxygen (DO) and cyanide (CN^-), increased gold extraction to 77% at a decreased retention time of 18 hours, which is 17% higher than gold extraction achieved during cyanidation of the same resource at DRDGold ERGO plant. The addition of lead nitrate did not improve gold extraction but was beneficial in reducing cyanide consumption by 0.13 kg/t.