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Leaching and electrochemical dissolution of gold in the presence of iron oxide minerals associated with roasted gold ore

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ABSTRACT

This study investigates the electrochemical interactions between gold and roasted gold ore (RGO), with its associated oxide minerals serving as slurry, in an electrolyte saturated with atmospheric oxygen. Conventional cyanidation yielded a decrease of ~40% in the gold leach rate with magnetite slurry, while increases of 25% and 10% were observed for hematite and maghemite, respectively. These gold leach rates were obtained by applying cathodic Tafel slopes only. SEM-EDS, in the case of maghemite slurry, exhibited a high accumulation of iron oxides on the gold surface, which is an indication of slowdown in the gold leach rate. In the case of roasted gold ore slurry, lower amounts of iron oxides were detected with the association of calcium-magnesium coating. XPS results also exhibited a small amount of gold in the slurry of maghemite particles after leaching, i.e., suggesting the adsorption of gold by maghemite, which also justifies the slowdown in the gold leach rate. Magnetic separation tests of cyanidation tailings containing 20% Au resulted in a 4% (mass-pull) magnetic concentrate sample with 72% non-leached Au. Roasted gold ore, magnetic tailings, and synthetic maghemite electrodes exhibited a cathodic peak, suggesting the reduction of ferric to ferrous ions, which could be responsible for the slowdown of leach kinetics, whereas magnetic concentrate did not. Furthermore, when oxygen was bubbled, this peak disappeared in the case of roasted gold ore and synthetic maghemite, though magnetic tailings still exhibited the peak.

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1. Introduction

Due to the rapid depletion of free-milling types of gold ores, it is accepted worldwide that there is an increasing trend in the treatment of refractory gold ores, which often requires oxidation, such as roasting, as a pre-treatment process prior to cyanidation (Adams, 2016; Zhou and Fleming, 2007). Via oxidizing/roasting, pyrite (the most common gold carrier sulphide phase) is made to consist of predominantly hematite, magnetite (Eqs. (1)–(3)) and maghemite (Stephens et al., 1990). Paktunc et al. (2006) reported that maghemite associated with gold is problematic for cyanidation as a result of its non-porosity. It has been reported that iron oxides, which are often found to be detrimental in cyanidation (Filmer, 1982; Lorenzen and van Deventer, 1992), can contain appreciable amounts of gold (30 ppb to 260 ppm) (Paktunc et al., 2006).

FeS₂ → FeS + S (1)

FeS + 5/3SO₂ → 1/3Fe₃O₄ + SO₂ (2)

1/3Fe₃O₄ + 1/12O₂ → 1/2Fe₂O₃ (3)

Dissolution of gold may be reduced/slowed down in some conditions, and if so, passivation and galvanic interaction phenomena are considered as potentially significant electrochemical factors (Lorenzen and van Deventer, 1992; Mrkusic and Paynter, 1970). The passivation phenomenon of gold has been known as the formation of a surface film on gold since 1907 (Cathro, 1961). Passivation is a commonly used term to explain a phenomenon in many fields, but its meaning could potentially create confusion according to the area of use. In general, two main approaches are considered for the passivation phenomenon: one is defined “as the formation of an adsorbed layer on the tested specimen, e.g. like in stainless steel,” and the second is defined as “a passive film as a diffusion layer of reaction products, e.g., oxides, therefore corrosion rate decreases” (Uhlig, 1963). In a similar manner, Crundwell (2015) identifies passivation, in terms of the corrosion of metals, as the formation of a passive layer composed of metal oxides that lower the rate of dissolution by several orders of magnitude. Hence, the passivation phenomenon should be carefully considered.

The presence of metals/minerals such as silver, iron, arsenic, calcium, and magnesium, which are associated with gold, are important phases that could influence the gold leach rate (Marsden and House, 2006).