ASSESSING THE CHALLENGES IN THE EXTRACTION OF GOLD FROM BACTERIAL-TREATED DOUBLE-REFRACTORY CONCENTRATE

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ABSTRACT

In the application of the BIOX® technology, high tailings grade (2-16 g/t) may be generated with a decrease in overall gold recovery, which sometimes make it economically unattractive. This paper investigated the causes of the high tailings grade by using samples from the Bogoso BIOX plant. Partial chemical analysis, diagnostic tests and cyanidation optimisation studies were conducted to invoke understanding into the high tailings grades. Diagnostic study on the tailings showed 48.34% of gold in carbonaceous matter, 17.12% in quartz, 13.40% as liberated gold, 11.51% imbedded in sulphides and the remaining 9.65% in carbonates. Optimum cyanidation recovery of 90.4% was established for the BIOX concentrate at 7 kg/t NaCN, 40-50 g/L activated carbon and residence time of 40 hours. The recovery was sensitive to carbon and cyanide concentrations but additional cyanide was not economical. High preg-robbing indices of 72.7% and 64.4% were recorded for the BIOX product and the flotation concentrate respectively. This confirms the inability of the BIOX process to deactivate carbonaceous matter, which remains a serious precursor for low overall gold recoveries and high CIL tailings.

INTRODUCTION

Gold ores may be broadly classified as refractory and non-refractory. Non-refractory ores are easy to treat but refractory materials require complicated flowsheets for metal extraction (Hausen and Bucknam, 1985; Schmitz et al, 2001; Marsden and House, 2006). As near surface non-refractory gold deposits are getting depleted, the increasing price of gold and increasing demand for gold, have encouraged many gold producing companies to treat refractory ores for gold recovery. The refractory behaviour of these ores may be due to the presence of sulphides, tellurides, cyanicides and/or carbonaceous matter. Refractory ores do not respond well to conventional cyanidation as the gold is either occluded by or in solid solution in sulphides, or is in association with cyanicides (Marsden and House, 2006). Further, carbonaceous matter preg-robs gold during leaching (Osseo-Asare et al, 1984; Hausen and Bucknam, 1985; Schmitz et al, 2001). The two major causes of refractoriness are the presence of sulphides and carbonaceous matter, and these render the ore double refractory (Nyavor and Egiebor, 1992).

Oxidative pre-treatment processes such as high pressure leaching/oxidation; biological oxidation, ultra-fine grinding and roasting are required to render refractory ores amenable to conventional cyanidation (Marsden and House, 2006). Biological oxidation, however, has become the preferred pre-treatment route because it is more environmentally friendly and convenient even where only partial oxidation is required. Comparative tests have demonstrated that bioleaching can achieve the same or better results than roasting or pressure leaching in terms of gold recovery (Yannopoulos, 1991; Brierley, 1997). Further, biological treatment processes are more cost-effective, environmentally friendly and safer.

The BIOX® process has made the processing of refractory gold ores possible. It however continues to face recovery challenges where double refractory gold ores are encountered. This is because bioxidation utilises chemolithotrophic microbes that derive their energy from the oxidation of sulphur and iron, transforming the sulphide matrix into oxide matter and liberating gold particles for leaching (Marsden and House, 2006). Carbonaceous materials are, however, not oxidized or deactivated by this pre-treatment step and continue to serve as preg-robbers in the subsequent gold leaching process (Brierley and Kulpa, 1993; Amankwah et al, 2005; Ofori-Sarpong and Osseo-Asare, 2013).

Though commercial BIOX® plants around the world operate at above 90% leach recovery, unpublished survey results of six operating BIOX plants revealed leach tail grades in the range of 2.5-16 g/t after sulphide oxidation of greater than 90% This situation leads to overall recoveries in the range of 70-80% (Anon, 2013), which presents a great deal of challenge in running these plants. The low recoveries are commonly attributed to the inability of the BIOX® process to oxidize or deactivate carbonaceous matter which serves as preg-robbers in the subsequent gold leaching process (Brierley and Kulpa, 1993; Amankwah et al, 2005; Yen et al, 2008; Ofori-Sarpong et al, 2010; 2013b).

To improve upon this situation, recent research has therefore focused on processes that oxidize sulphides and deactivate or suppress the preg-robbing potential of the carbonaceous matter using two stage bacterial and/or fungal processes (Amankwah et al, 2005; Afidenyo, 2008; Yen et al, 2008). Ofori-Sarpong et al (2010, 2013a) demonstrated the ability of the fungus, Phanerochaete chrysosporium to reduce the preg-robbing properties of various ranks of coal (lignite, sub-bituminous, bituminous and anthracite-grade) which served as surrogates for carbonaceous matter and to oxidize sulphides. All these processes are however at the bench-scale level and require further research to bring it to commercial realisation.

Aside the preg-robbing challenge, ore variability, frothing, arsenic stabilisation and high cost of BIOX leach effluent are among the problems encountered by BIOX plants around the world. The Bogoso Sulphide Treatment plant of the Golden Star Resources is one of the largest of such operating plants in the world. The plant sometimes experiences challenges such as incomplete sulphide oxidation, excessive frothing, low cyanidation recovery and extensive preg-robbing. It is thus necessary to investigate the causes of these observations and also work to improve on gold extraction from the double refractory gold ores processed by the plant. The objective of this paper was thus to investigate the gold deportment of the flotation concentrate, BIOX® product, and post-BIOX® Carbon-in-Leach tailings (BIOX® CIL tails), the optimum cyanidation conditions for the BIOX® product, and the preg-robbing characteristics of the flotation concentrate and BIOX® product.

EXPERIMENTAL INVESTIGATIONS

MATERIALS AND EQUIPMENT

Reagent grade ammonium tartrate, sulphuric acid, sodium hydroxide, quicklime and sodium cyanide were obtained