

**TUESDAY, AUGUST 23, 2005, P.M.**

**SESSION 24: INTERNATIONAL SYMPOSIUM ON THE TREATMENT OF GOLD ORES**

**NEW LEACHING TECHNOLOGIES II**

Sponsor(s): Hydrometallurgy Section, The Metallurgical Society of CIM, Canadian Mineral Processors Division of CIM, CANMET-MMSL

Room: Imperial Ballroom 3

Chair(s): J. MCMULLEN, Barrick Gold Corporation, and W. STAUNTON, Murdoch University

**PAPER 24.1—14:00**

**THE KINETICS OF THE COPPER-CATALYSED OXIDATION OF THIOSULFATE IN AMMONIACAL SOLUTIONS.**

**C. VAN WENSVEEN and M.J. NICOL, Murdoch University, Australia**

The kinetics of the oxidation of thiosulfate by copper(II) in ammoniacal solutions have been studied in the presence and absence of dissolved oxygen. The formation of an intermediate mixed ammine/thiosulfate copper(II) complex ion has been confirmed and the rate of the reaction monitored by simultaneous on-line spectrophotometric, dissolved oxygen and potentiometric measurements. The rate of the anaerobic oxidation of thiosulfate by copper(II) was found to be orders of magnitude slower than that in the presence of dissolved oxygen and is inhibited in the presence of ammonia and anions such as sulfate and chloride as a result of competition with thiosulfate for the axial coordination sites on the copper(II) tetrammine complex. In the presence of dissolved oxygen, it was found that the copper(I) thiosulfate complexes are only very slowly oxidized while the copper(I) diammine complex is rapidly reoxidised to the copper(II) state. Thus, the initial rapid reaction with copper(II) leads to a pseudo steady-state condition in which the concentration of copper(I) is relatively constant and the rate of oxidation of thiosulfate can be predicted from the measured rate of oxidation of copper(I) by oxygen in ammoniacal solutions. The effects of the concentrations of ammonia and thiosulfate on the oxidation rate can be rationalized on the basis of the above coupled to the species distribution of copper(I) in the ammonia/thiosulfate system. It is shown that, with relatively simple measurements of dissolved oxygen and copper concentrations, the rate of oxidation of thiosulfate can be predicted under typical leaching conditions.

**PAPER 24.2—14:25**

**A NOVEL THIOSULFATE LEACH PROCESS FOR THE TREATMENT OF CARBONACEOUS GOLD ORES.**

**P.G. WEST-SELLS, Placer Dome Research Centre, Canada and**

**R.P. HACKL, Placer Dome Technical Services Limited, Canada**

Carbonaceous gold ores are particularly attractive for leaching by ammonium thiosulfate as the gold thiosulfate complex is not significantly adsorbed by the organic carbon present in the ore. A technically and economically feasible process for treating these ores with ammonium thiosulfate has been developed. In this process, gold is extracted by leaching the ore with ammonium thiosulfate, the solution is separated from the ore by counter-current decantation, and the gold is recovered by precipitation with ammonium sulfide. The precipitation filtrate is recycled back to the grinding step to close the solution balance. Reagent consumption is not excessive. Besides precipitating gold, the precipitation step removes most deleterious solution impurities and converts a portion of the polythionates back to thiosulfate. This paper discusses the optimization of the leaching and precipitation steps, and the influence of grinding and solution recycle on leaching. The results of a 10 kg/h pilot plant campaign are also discussed.

**PAPER 24.3—14:50**

**LEACHING OF A GOLD ORE USING THE HYDROGEN SULFIDE-BISULFIDE-SULFUR SYSTEM.**

**B. WASSINK, D. DREISINGER, University of British Columbia, Canada,**

**P. WEST-SELLS, Placer Dome Research Centre, Canada and**

**N. FISHER, Independent Metallurgical Laboratories Pty Ltd., Australia**

Gold leaching from a commercial cyanide-amenable gold ore was studied at 25°C using sodium bisulfide-hydrogen sulfide solutions containing elemental sulfur. Gold extraction from the ore using 0.55 M NaSH, 4.1 atm (60 PSI) H<sub>2</sub>S, 1 g/L S<sub>8</sub> and 26% solids by weight was about as good as the best extraction obtained by cyanidation. Maximum extraction was achieved in roughly 48 hours. Sulfur dissolves in the bisulfide solutions to form a mixture of polysulfides. Simple speciation calculations indicate that gold solubility as bisulfide complexes should be roughly ten times higher than in the absence of added zerovalent sulfur. The principal bisulfide complex is believed to be [Au(HS)<sub>2</sub>]. Gold dissolution is favoured by increasing HS<sup>-</sup> concentration and by increasing H<sub>2</sub>S pressure. Polysulfide complexes of gold are also likely to be formed, and may contribute substantially to gold leaching. Two experiments using pure gold were also performed. Up to 100 mg/L gold was dissolved in 140 hours using 0.55 M NaSH, 1 g/L added elemental sulfur and 6.2 atm H<sub>2</sub>S.

COFFEE BREAK—15:20-15:30

PAPER 24.4—15:30

AN ELECTROCHEMICAL STUDY OF AN ALTERNATIVE PROCESS FOR THE LEACHING OF GOLD IN THIOSULFATE SOLUTIONS.

H. ZHANG, M.J. NICOL and W.P. STAUNTON, Murdoch University, Australia

The leaching of gold with thiosulfate solutions in the absence of ammonia and copper ions was investigated using electrochemical and kinetic methods. In sodium thiosulfate solutions, the electrochemical oxidation of gold was hindered and the leaching rate using pure oxygen as the oxidant was very slow. It was found that the addition of a small amount of thiourea or formamidine disulfide to the thiosulfate solution greatly enhanced the oxidation of gold. However, the enhancement to the overall dissolution of gold using dissolved oxygen as the oxidant was limited. This was attributed to the fact that the oxygen reduction process was unaffected by the additives and remained slow, which limited further improvement to the overall kinetics. An alternative oxidant, the ferric EDTA complex having a reduction potential of approximately 0.12 V, was found to be promising. The cathodic reduction of ferric EDTA was fast and reversible at neutral pH. While the ferric EDTA complex was effective in oxidizing gold, it did not appear to significantly oxidize thiosulfate. A thiosulfate solution containing thiourea and ferric EDTA has been shown to quickly dissolve gold in the form of a powder as well as from gold ores. In the leaching with the ores high gold recoveries of above 90% was achieved with the best performance obtained in neutral solutions (pH 6-7).

PAPER 24.5—15:55

IRON SULFIDE MINERALS IN THIOSULFATE-GOLD LEACHING: PROBLEMS AND SOLUTIONS.

C. XIA and W.T. YEN, Queen's University, Canada

The negative effects of pyrite and pyrrhotite on thiosulfate gold leaching have been investigated. Possible remedies to reduce some problems are discussed. In a gold bearing pure silicate ore, 92% of gold could be extracted within 3 hours using a solution containing 0.2 mol/L ammonium thiosulfate, 0.9 mol/L ammonia, 30 ~ 300 ppm copper sulfate and 8.6 ppm dissolved oxygen at pH 10.26. The thiosulfate consumption was 7.1 kg/t under these conditions and could be further reduced to 3.5 kg/t by decreasing the dissolved oxygen to 0.3 ppm. Addition of 16% pyrrhotite or pyrite into the silicate slurry led to a decrease in gold extraction by 2% or 9% respectively and an increase of thiosulfate consumption by 11 kg/t or 12.8 kg/t respectively in three hours. Several adjustments, such as increasing copper ion and ammonia concentration and reducing the dissolved oxygen level to 0.3 ppm resulted in increased gold extraction and lower thiosulfate consumption despite the presence of these sulfides.

PAPER 24.6—16:20

LEACHING AND RECOVERY OF COPPER DURING THE CYANIDATION OF COPPER CONTAINING GOLD ORES.

P.L. BREUER, CSIRO Minerals, Australia

M.I. JEFFREY and X. DAI, Monash University, Australia

In the leaching and recovery of gold from copper containing gold ores using cyanidation, some copper minerals also dissolve which can have a detrimental effect on the process efficiency and economics. There are also environmental concerns with current operations discharging cyanide and copper cyanide species into tailings dams, and strict regulations prohibit this for greenfield plants. Cyanide destruction however is not an economic option for new plants treating copper-gold ores. This paper evaluates a potential recovery process to overcome the copper cyanide problem. Despite gold dissolution occurring in copper cyanide solutions having no free cyanide, gold recovery from ores is lower compared to free cyanide. Thus, cyanide addition has to be optimized to maximise the gold recovery whilst endeavouring to eliminate free cyanide at the completion of leaching (CN:-Cu less than 3:1). Subsequently, copper cyanide can be recovered using activated carbon. The loaded copper cyanide is easily recovered from the carbon with a cyanide soak and distilled water wash such that the eluted CN:-Cu ratio is less than 4:1. By decreasing the pH of the eluant to 5 the copper could be recovered efficiently by electrowinning. The remaining cyanide solution, after electrowinning, is then neutralisation to form NaCN and recycled.

PAPER 24.7—16:45

SOLUTION CHEMISTRY OF TRITHIONATE WITH RELEVANCE TO GOLD LEACHING BY THIOSULFATE: A REVIEW.

N. AHERN, D. DREISINGER, University of British Columbia, Canada and

G. VAN WEERT, Oretome, Canada

In the thiosulfate leaching of gold, degradation of the thiosulfate reagent is a major cost for the process. One of the major intermediary degradation products is trithionate, which also inhibits gold recovery from solution by ion exchange. Little attention has been given to this species in the context of gold leaching - the limited information on trithionate and its solution chemistry available in the literature is seldom directly related to gold leaching conditions. This review is a compilation of the published knowledge on trithionate, with a specific focus on identifying the relevance of this information to gold leaching and the shortcomings in this knowledge base.