TUESDAY, AUGUST 23, 2005, A.M.

SESSION 13: INTERNATIONAL SYMPOSIUM ON THE TREATMENT OF GOLD ORES

ORE CHARACTERIZATION AND RECOVERY OF GOLD BY GRAVITY 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. ABOLS, Canadian Operations, Gekko Systems, Canada and
A.R. LAPLANTE, McGill University, Canada

PAPER 13.1—8:30
CHARACTERIZATION OF HIGH ARSENIC REFRACTORY GOLD ORES.
M. OLIAZADEH, S. MOHAMMADNEJAD, Tehran University, Iran and
B. MEHRABI, Tarbiat Moallem University, Iran
A new method using a combination of comprehensive mineralogical and analytical approach which includes optical and electrical microscopy and several analytical techniques with diagnostic leaching has been used to characterize the associations and distribution of gold in a variety of minerals from the Zarshuran refractory gold ore, NW Iran. Zarshuran ore with an average of 7.9 g/t Au-grade and about 8% arsenic with gold recovery less than 20% in direct cyanidation is considered as high arsenic, high au-grade refractory gold ore. In most of the refractory ores, gold is associated with arsenopyrite and co-para genetic ore minerals, while in Zarshuran ore; gold is associated with orpiment, realgar and arsenian-pyrite. Considering its mineralogy and As content, it can be considered as the most difficult refractory ore for characterization and processing. Results from the mineralogical examination and diagnostic leaches indicate that there is only a small amount of free gold (17-19%) that is present in cyanide-soluble sulfo-arsenides compounds, predominantly orpiment and realgar. Diagnostic leaches also indicate that little gold is occluded within the silicate structure (14%). Overall, the gold is mostly included in sulfides, arsenic sulfides and sulfo-arsenides (50%). The results also have shown how the technique can be used to gain a good initial understanding of potential metallurgical problems for a refractory gold ore.

PAPER 13.2—8:55
THE PROCESS MINERALOGY OF PRECIOUS METALS IN LARONDE FLOTATION PRODUCTS AND ITS EFFECT ON PROCESS OPTIMIZATION.
J. ZHOU, C. MARTIN, SGS Lakefield Research Limited, Canada
P. BLATTER, P.A. BOSSÉ and J. ROBITAILLE, Agnico-Eagle Mines, LaRonde Division, Canada
The LaRonde ore is a Cu-Zn-Pb ore with gold (3-4 g/t) and silver (60-100 g/t). The precious metals are recovered with copper concentrate, zinc concentrate and cyanidation of zinc tails via Merrill Crowe precipitation. Subsequent to a recent mill expansion, excessive gold was reporting to zinc concentrate with a concurrent decrease in gold to copper concentrate. Owing to the higher return obtained from the metal, the mill endeavors to recover additional gold and silver to the copper concentrate and minimize the placement of precious metals to the zinc concentrate. A gold deportment study showed that the gold occurs mainly as kustelite, with a moderate amount of electrum and a minor amount of native gold. It also showed that various sulfur-based Au- and/or Ag-bearing coatings on liberated kustelite and electrum were the major mineralogical factors that caused gold and silver to report to zinc concentrate. Such coatings were observed on 70-80% of the gold particles reporting to the zinc concentrate. Based on the gold deportment and the chemistry of the coatings, the collector chemistry was reviewed and a new collector was added into the circuit which resulted in a significant increase in gold and silver recovery to the copper concentrate. The information obtained from the mineralogy confirmed and guided other process optimization. In this paper, the authors will describe the process mineralogy of the LaRonde ores, and in particular to the mineralogical evidence diagnosing the problem. Reference will also be made to the rationale behind how the problem was solved, the results achieved, and future steps in optimization.

PAPER 13.3—9:20
THE BEHAVIOUR OF CARBONACEOUS MATTER IN GOLD EXTRACTION.
J.S.J. VAN DEVENTER, H. TAN, D. FENG and G.C. LUKEY, University of Melbourne, Australia
The effect of carbonaceous matter on gold extraction was investigated in cyanide systems with pure gold as well as pre-robbing sulfide gold ores. Auger studies demonstrated that the carbonaceous matter preferentially smeared on iron sulfide rather than aluminosilicate surfaces during wet or dry grinding. During mechanically mixed leaching, coating and stripping of carbonaceous matter occurred simultaneously. TEM and XPS studies indicated preferential

coating in the form of elemental (graphitic) carbon at the edges and the defect sites of particles. Interestingly, carbonaceous matter extracted from the gold ore was amorphous carbon and not preg-robbing itself. However, the carbonaceous coating had a significantly detrimental effect on gold dissolution when gold was pre-ground with the gold ore. Artificial coating on gold surfaces with the natural carbonaceous matter from the ore was also found to substantially retard gold dissolution. With the addition of the natural carbonaceous matter from the gold ore, gold extractions from two non preg-robbing sulfide gold ores were inhibited owing to carbonaceous coating. The presence of carbonaceous matter significantly reduced the current density for gold oxidation and increased the current density for pyrite oxidation. This could explain the fact that carbonaceous coating hindered gold dissolution while enhanced sulfide preg-robbing.

NEW LEACHING TECHNOLOGIES

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

PAPER 13.4—9:45

THIOSULPHATE DECOMPOSITION IN THE PRESENCE OF SULPHIDES.

D. FENG and S.J. VAN DEVENTER, University of Melbourne, Australia

The mechanism of thiosulfate decomposition and the products formed were investigated in the presence of pyrite or pyrrhotite in copper-ammonia solutions used for leaching gold. The presence of the sulfides significantly increased the decomposition of thiosulfate. The sulfide-surface-catalyzed oxidation of thiosulfate to tetrathionate by dissolved oxygen or the cupric tetra-ammine complex was proposed to be the dominant thiosulfate decomposition mechanism. The catalysis of the sulfides in this reaction could originate from their strong affinity for aqueous sulfur species and their semiconducting properties. Oxygen was found to be the initial driving force for thiosulfate decomposition in the absence of cupric ions and the driving force for the continuous decomposition of thiosulfate in the presence of cupric ions. Under an oxygen free atmosphere, the decomposition of thiosulfate was limited to reduce the cupric ions and the catalytic effect of the sulfides was also marginal. The dominant oxidative product of thiosulfate was trithionate in alkaline solutions especially in an oxygen rich or cupric ion rich environment. Tetrathionate was found in relatively smaller amounts in an oxygen and cupric ion deficient environment. Tetrathionate was not stable and would further decompose after extended periods. Trithionate concentrations increased almost linearly with time.

COFFEE BREAK—10:10-10:40

PAPER 13.5—10:40

FUNDAMENTALS AND APPLICATIONS OF ALKALINE SULFIDE LEACHING AND RECOVERY OF GOLD.

C.G. ANDERSON. D.L. STACEY, E. DAHLGREEN, H. HUANG, P. MIRANDA The Center for Advanced Mineral and Metallurgical Processing, U.S.A. and
I. CHANDRA and M.I. JEFFREY, Monash University, Australia

The latter part of the 20th century saw great advances in the treatment of refractory gold ores coupled with increased reliance on the use of cyanide for gold processing. Now, in many parts of the world, there is social pressure to limit or eliminate the use of cyanide. As well, treatment of some refractory ores or concentrates which have excessive cyanide consumption, gold cyanide pregrobbing or significant sulfide content remain difficult. This paper will outline the history of the development of alkaline sulfide leaching as an ancillary process to nitrogen species catalyzed (NSC) pressure leaching. Electrochemical fundamentals and the applicable thermodynamics of the alkaline sulfide hydrometallurgical system will be outlined. As well, examples of refractory gold recovery with alkaline sulfide hydrometallurgy such as an arsenopyrite gold concentrate application, a chalcopyrite gold concentrate application, a pregrobbing gold ore application, and a cyanide consuming gold ore application will be delineated in this paper.

PAPER 13.6—11:05

THE RECOVERY OF GOLD FROM LOW GRADE AND REFRACTORY ORES.

J. MCMULLEN, P.D. KONDOS, BARRICK Gold Corporation, Canada and
J.R. GOODE, J.R. Goode and Associates, Canada

Given the global inventory of low grade and refractory gold deposits, processes that could turn these challenged deposits into mines are of considerable interest. Such gold deposits have low value and potentially high operating costs and so they pose special challenges for the mining engineer and metallurgist. Conventionally, refractory gold ores have been processed by whole ore pressure oxidation and roasting, or flotation followed by roasting, pressure oxidation or bio-oxidation of the concentrate. Halide-based processes have recently been developed that might be applied to concentrates. Low grade refractory gold ores have been processed using heap bio-oxidation followed by cyanide heap leaching or milling. Other processes are emerging. Barrick has completed an inventory of emerging technologies (1). A summary of the current status of these developments will be presented with the view that, with additional development, some of these technologies or a combination thereof may unlock the value of these deposits.

PAPER 13.7—11:30

THE INTEC GOLD PROCESS - A HALIDE-BASED ALTERNATIVE FOR THE RECOVERY OF GOLD FROM REFRACTORY SULPHIDE DEPOSITS.

J. MOYES, F. HOULLIS, J-L. HUENS, University of Sydney, Australia and
D. SAMMUT, Consultant, Canada

The Intec Gold Process has been developed as a halide-based alternative for the recovery of gold from refractory sulphide deposits. The halide medium allows sulphide oxidation and gold extraction to be performed concurrently at moderate temperature and atmospheric pressure sourcing oxygen from direct air injection. The dissolved gold is loaded onto activated carbon and stripped in a conventional Zadra circuit. High gold extractions have been achieved from a range of refractory gold concentrates at laboratory scale, which has led to a continuous locked-cycle pilot plant program. The pilot plant operated at >99% availability, with a maximum of 96.5% gold extraction from a concentrate containing 58.6 g/t gold. >99% of the dissolved gold was loaded onto carbon at up to 1% w/w, with no loss of carbon activity detected over five loading/washing/elution cycles. This paper describes the process and presents both laboratory and pilot plant results as well as economic data from two costing studies.