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ALTA 2012 GOLD CONFERENCE

CHALLENGES AND OPPORTUNTIES IN THE TREATMENT OF REFRACTORY GOLD ORES

By

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ABSTRACT

The introduction of pressure and biological oxidation as well as some innovations to roasting starting in the mid 1980's has revolutionized the way that refractory gold ores are treated. These technologies allowed previously uneconomical gold deposits to be processed. This paper provides a high level overview of the flowsheets and chemistry used in each of the technologies. A breakdown of where and who are currently using the different technologies is also provided. Finally some discussion is presented on what the future may hold in respect of challenges and opportunities.

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PROCESS TECHNOLOGY

THE GOLD TECHNOLOGY GROUP AND THE AMIRA 420 PROJECT: 25 YEARS OF RESEARCH, DEVELOPMENT AND SERVICE TO INDUSTRY

By

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Curtin University, Australia

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Background – AMIRA and Collaborative Gold Research in Australia

- **AMIRA**
  - an independent association of minerals companies which develops, brokers and facilitates collaborative research projects
- **History of Aust Collaborative Gold Research**
  - P173 "Carbon in Pulp Gold Technology" 2yrs commenced Feb 1984
  - P173A "Carbon in Pulp Gold Technology" 2 yrs commenced April 1986
  - P314 "Gold Technology for Complex and Refractory Ores"
  - P277 "Fate of Cyanide in the Environment"

HYDROMETALLURGICAL PRODUCTION OF ANTIMONY

By

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Overview

- Antimony in General
- Antimony Hydrometallurgy
- Learnt by Experience
- Conclusion

CYANIDE DETOXIFICATION OF CYANIDATION TAILS AND PROCESS STREAMS

By

Danielle Hewitt, Paul Breuer & Coby Jeffery

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ABSTRACT

Cyanide detoxification by chemical means (sulfite, hydrogen peroxide or Caro's acid) has typically been adopted by the gold industry to meet the International Cyanide Management Institute (ICMI) code and/or regulatory compliance for discharge into tailings storage facilities (TSF) or the discharge of excess water from the mining operation. The treatment of process streams or TSF return water is also often required as residual cyanide in reclaimed/recycled water can impact on upstream processes. This paper presents and discusses results from a number of different evaluations that have been conducted to reduce the cyanide concentration in cyanidation tails and process streams by chemical means. Pre-oxidation before cyanidation and the ore mineralogy were both found to potentially have a significant impact on reagent requirements in the treatment of cyanidation tails. The solution speciation provided important insights into the reagent consumption, which becomes very high in targeting residual weak acid dissociable (WAD) cyanide concentrations below 1 mg L^{-1}. Preliminary evaluations of polishing and alternative processes for reducing the WAD cyanide showed potential to achieve these low concentrations and reduce the treatment costs.

PRACTICAL USE OF COMPUTATIONAL FLUID DYNAMICS (CFD) FOR MIXING APPLICATIONS

By

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ABSTRACT

Computational Fluid Dynamics (or CFD) is a branch of fluid mechanics where flow fields are modeled and numerically solved using computers. Prior to the advent of the computer, the study of fluid dynamics was limited to complex analytical solutions and experimental methods. CFD has been used to analyze the flow patterns and their effects on mixing applications for over 20 years. With the improvement in computer speed and solver efficiency, the use of CFD has grown considerably in the mixing industry over the past few years. The CFD engineer using these tools must have a firm understanding of the governing equations and boundary conditions surrounding the problem. In addition, experimental validation must be available to be able to rely on the output predicted by the CFD model. The first part of this paper will cover the basic theory behind CFD as it applies to mixing applications. With this theory outlined, three examples will be covered showing how CFD can be useful in evaluating mixing applications for a variety of situations in the mining industry.

PROCESS SIMULATION FOR IMPROVED PLANT DESIGN THROUGH P&ID VALIDATION

By

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ABSTRACT

Advanced dynamic process simulation can help mining companies and engineering contractors improve plant design through P&ID Validation. This paper will discuss the P&ID Validation performed by ANDRITZ AUTOMATION for Newmont Mining Corporation's Conga copper and gold project in Peru. ANDRITZ AUTOMATION built a dynamic process model, or Virtual Process Plant, in the IDEAS Simulation Software for Conga. Then in conjunction with Newmont and the engineering contractor, ANDRITZ AUTOMATION performed P&ID Validation to identify process design problems/concerns, and assist in determination of solutions and/or design improvements. Investigations into the planned process plant behavior included analysis over a range of ore characteristics, ore feed rates, and operational settings and limitations. Investigations helped align Newmont and the engineering contractor by illuminating key process design assumptions and decisions. Finally, the Virtual Process Plant helped discover dynamic system behavior problems, including process control issues. As with the Conga project, P&ID Validation with advanced dynamic process simulation improves the engineering design for mining projects.

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REFRACTORY GOLD ORES SYMPOSIUM

MAXIMISING THE VALUE OF GOLD DIAGNOSTIC LEACHING

By

Rebecca Meakin, Nicole Chapman, Zoe Frangeskides & Laura Kuhar

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ABSTRACT

A detailed understanding of ore mineralogy and elemental deportment is required to select the optimal processing route for the extraction of valuable metals from ore, such as copper and gold. However, common ore characterization techniques, such as Mineral Liberation Analyser (MLA), are costly and time-consuming. Diagnostic leaching is potentially a cheaper and simpler alternative for the determination of the mineralogy and deportment of valuable minerals within an ore, involving the use of selected reagents and conditions to dissolve targeted minerals. Traditional diagnostic leaches currently used in processing plants worldwide, use sodium cyanide and sulfuric acid as reagents to provide details on copper and gold recoveries. This paper shows that these leaches can provide information on not only gold and nuisance copper recoveries for gold ores but also information on trace element recovery, mineralogical associations, reagent consumption and speciation. Leaches conducted on a gold ore sample set indicated variances in gold and copper recoveries, owing to the differing mineral concentrations and types. Low gold recoveries were attributed to the ore being refractory in nature. Chalcopyrite and pyrrhotite were found to contribute directly to the formation of thiocyanate. The importance of monitoring impurity element concentrations was demonstrated, since some sample leach liquors contained high toxic trace element concentrations. The use of additional information (reagent consumption, trace element recovery etc.) from diagnostic leach data may prove to be of great advantage in process design or optimisation.

THE PROCESSING OF GOLD COPPER AND COPPER GOLD ORES WITH FLOWSHEET DEVELOPMENT AND STRATEGIES

By

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Presented by

Denis Yan

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ABSTRACT

The processing of gold copper and copper gold ores can be highly problematic, site specific and the process selection is dependent on ore grade, mineralogy, acid leach behaviour, cyanide chemistry, product saleability and environmental considerations. The production of a copper gold concentrate is also an option where the copper is of a marketable grade. In some situations the flotation tailings may be subject to cyanide leaching. The general effects of copper on cyanide leaching chemistry are increased cyanide and lime consumption and decreased dissolution rates for gold and silver. The severe fouling of carbon, high solution losses and even re-precipitation of gold can occur.

IMPREGNATED ACTIVATED CARBON FOR GOLD EXTRACTION FROM THIOSULFATE SOLUTIONS

By

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ABSTRACT

Hydrometallurgical processing of gold is almost exclusively accomplished with cyanidation. However, the technology has been attacked due to cyanide toxicity leading to an increase in studies about cyanide alternatives, particularly thiosulfate. Unfortunately, gold recovery from thiosulfate solutions is not possible with conventional carbon adsorption necessitating the use of more expensive resin adsorption processes. In this regard, a novel gold thiosulfate solution recovery process is described and characterized in which activated carbon is impregnated with cyano-cuprous species allowing for high gold extraction followed by traditional elution. Results indicate that, at low cyano-cuprous adsorption densities, gold extraction occurs via an ion-exchange reaction yielding adsorbed cyano-aurous species; however, at high adsorption densities, gold extraction occurs via a polymerization reaction yielding adsorbed cyano-cuprous/aurous complexes. Elution efficiency depends on the resulting gold state. Optimal conditions were identified from models developed from statistically designed experiments. This paper has been slightly modified from its original version and is republished with permission(1).

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GEOMETALLURGICAL MAPPING OF A COMPLEX GOLD ORE BODY TO MANAGE PROCESS RISK AND VALIDATE THE PROPOSED PROCESS FLOWSHEET

By

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Presented By

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ABSTRACT

The Paulsens gold deposit in the Pilbara region of Western Australia was discovered by CRA in 1998. In 2001, St Barbara Mines Limited (St Barbara) made a successful takeover offer for Taipan Resources NL and then began an update of the previous Bankable Feasibility Study (BFS) undertaken by Minproc Limited.

This paper describes the history of the metallurgical testwork, plant design and initial development to optimise a project with complex metallurgical process characteristics and manage the risks.

The Paulsens ore is preg robbing, has cyanide soluble copper and nickel and is highly sulphidic. The ore is relatively hard and requires a very fine grind size of P80 53 microns. The metallurgical challenges have been met for this complex ore and the process flowsheet included aspects not commonly associated with a typical gold plant.

Geometallurgical mapping of the global ore body to understand the variability of cyanide soluble copper and nickel as well as potential problems from preg robbing waste was undertaken to assess the risks and suitability of the proposed flowsheet. Concurrently, the mine schedule could be optimised to manage the levels of copper and nickel in the feed by understanding the copper behaviour with respect to block modeling.

Problems encountered, which will be discussed and project examples noted, with cyanide soluble gold in Carbon in Pulp (CIP) plants include:

- High cyanide consumption;
- High WAD (weak acid dissociable) stabilised in tailings dams and high tailings return water levels;
- Determining the free cyanide level in the leach solution;
- Preg robbing of gold onto copper minerals;
- Very high copper loadings on the carbon resulting in high gold solution losses to tails, poor carbon activity, Dore gold bars with low fineness and increased refining charges;
- Very high oxygen demand limiting gold leaching kinetics; and
- Increased ferrocyanide and ferricyanide levels in solution impacting on the leach and adsorption.

THE INCREASED ACTIVITY IN THE DEVELOPMENT OF THIOSULFATE BASED PROCESSES FOR GOLD RECOVERY

By

Paul Breuer, Xianwen Dai, Hongguang Zhang & Danielle Hewitt

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ABSTRACT

Thiosulfate has been researched as an alternative lixiviant to cyanide for several decades now. CSIRO's patented breakthrough in the elution of gold thiosulfate from strong base ion exchange resins has seen activity in the development of thiosulfate based processes increase recently. Particularly, the research and development has become focused on the whole process with some of these process developments at the stage of being piloted or trialled. As evident from the thiosulfate process developments presented in this paper, the oxidant system employed depends on the ore to be treated and thus each process requires customising. The process developments discussed in this paper include 1) copper-ammonia-thiosulfate process for gravity concentrates; 2) oxygen-thiosulfate process for pyritic ores and concentrates; and 3) iron-EDTA-thiosulfate process for in-situ leaching of oxidised gold ores.

GOLD RECOVERY FROM COPPER-RICH ORES EMPLOYING THE PUROLITE S992 GOLD-SELECTIVE ION EXCHANGE RESIN

By

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Presented by

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ABSTRACT

There has been renewed global interest in the exploitation of historically marginal gold ore bodies, as a result of the recent steep rise in the gold price. The majority of these ores are complex and many of them contain significant amounts of copper minerals. The presence of copper causes a number of problems, including lower gold recoveries, increased cyanide consumption and increased toxicity of the effluent.

A variety of processes have been proposed to recover the copper and/or cyanide, amongst others the SART (Sulphidisation, Acidification, Recycling and Thickening) process. Any process that is performed on the pregnant leach liquor prior to gold recovery could cause gold loss, especially if a high removal efficiency of copper cyanide is required prior to gold recovery.

This paper discusses the use of a commercially available ion exchange resin with an exceptionally high selectivity for gold over copper. This would allow the effective recovery of gold from cyanide leach liquors that contain a relatively high copper concentration, thereby decreasing the risk of gold loss and potentially minimise the adsorbent inventory and flowrate.

LEACHOX™ REFRACTORY & SULPHIDE GOLD PROCESS

By

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Maelgwyn Mineral Services

- Develop & supply innovative & cost-effective mineral processing technologies
- Formed 1997
- Global operations

ROASTING OF REFRACTORY GOLD CONCENTRATES AND HANDLING OF MINOR ELEMENTS

By

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ABSTRACT

High gold recovery can generally be achieved by the roasting process where sulphur and carbon removal are essential to obtain acceptable gold recoveries in the subsequent calcine leaching steps.

The roasting process combines the formation of a porous calcine structure with the removal of elements that could hinder the gold recovery if present during the leaching process. This presentation describes how certain critical elements are eliminated from the calcine. Elements that negatively affect gold recovery are organic carbon, mercury, chlorides and tellurides. In addition, arsenic and sulphur are removed.

A complete removal of hindering elements can only be made in a roaster in a controlled atmosphere. Most hindering elements are either oxidized, including, carbon, sulphur, arsenic and antimony, or volatized as in the case with mercury, chlorides and telluride (arsenic and antimony). This results in a complex process gas that often needs special auxiliary processes for removal and stabilization of impurities. As a result, the roaster operation can collect hazardous elements such as mercury and arsenic in concentrated products with high stability and avoids generation of large quantities of contaminated leach residues.

Outotec (previously Lurgi and Boliden Contech) constructed the first reactor for the roasting of sulfur bearing materials in 1950, based on the principles of fluidized bed technology. Since then, with over 50 years' experience in commercialised fluidized bed technology, Outotec has delivered more than 270 fluidized bed plants. Outotec's gold roasting reference list includes a variety of processes and concepts, from high throughput circulating fluidized bed (CFB) for ore, to small two-stage stationary bed roasters for concentrate. Outotec can deliver the complete process chain including roasting, dedusting, calcine cooling, gas cleaning, water treatment and sulphuric acid.

RECENT ADVANCES IN THE BIOX TECHNOLOGY

By

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Contents

DEVELOPING THE NEXT GENERATION OF BIOX® DESIGN

By

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ABSTRACT

The BIOX® technology has been in commercial operation for over 25 years with twelve BIOX® plants successfully designed and implemented in that time. The BIOX® design has evolved over the years with the incorporating of the knowledge and experience from every project into the next BIOX® plant.

A structured process was followed to collate all the information from the recent BIOX® commissioning programs, BIOX® audit reports and operating experience from the BIOX® users. It was realised that there was a need to not only address the technical and process related issues but also to implement a more comprehensive service offering to the BIOX® clients including closer and more structured cooperation during the different phases of project implementation and a dedicated program to ensure effective knowledge transfer to all stakeholders during the execution of the project.

Although the BIOX® Generation III design is ready for implementation, the continued focus on improvement of the product offered to our customers will continue. The incorporation of the Generation III design principles in the execution of the new BIOX® projects has already resulted in an improved BIOX® design.

COMMERCIALISATION OF THE ALBION PROCESS

By

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ABSTRACT

The Albion Process™ is a combination of ultrafine grinding using Xstrata Technology's IsaMill™, followed by oxidative leaching at atmospheric pressure in a series of reactors designed to achieve high oxygen mass transfer efficiency. The feed to the Albion Process™ is a sulphide concentrate containing base or precious metals, and the Albion Process™ is used to oxidise the sulphide minerals in the concentrate and liberate these metals for recovery by conventional means. The oxidative leach circuit is operated at near neutral pH for treatment of refractory gold and silver concentrates, simplifying plant layout and reducing capital costs. For base metal concentrates, the oxidative leach is operated under acidic conditions.

The Albion Process™ has had a long and varied road from concept to commercialisation. The Albion Process™ technology was originally developed in 1994 by MIM Holdings/Xstrata and is patented worldwide. The idea for the Albion Process™ followed the successful commissioning of the first M3000 IsaMill™ at Mt Isa in 1994. The technology had been seen as strategic by MIM Holdings for the first 12 years of its development and was not offered to clients outside the MIM Holdings group. In 2005, after the Xstrata takeover of MIM Holdings, there was a change in strategic direction, and the technology was offered to external clients, through Xstrata Technology.

Interest in the technology has been very strong, with early licences signed in 2005 for the Las Lagunas Project, and 2006 for the Certej Project. The technology moved into commercial production in 2010 with the commissioning of Xstrata's Albion Process™ plant in Spain (4,000 tpa zinc metal), followed in 2011 by the commissioning by Xstrata of a second Albion Process™ plant in Germany (16,000 tpa zinc metal). The Las Lagunas refractory gold project will be commissioned in 2012, and the GPM Gold refractory gold project will be commissioned in 2013. A fifth Albion Process™ plant for the Certej refractory gold project in Romania is in final Permitting stages.

EVALUATING PROCESS OPTIONS FOR TREATING SOME REFRACTORY ORES

By

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ABSTRACT

A significant contemporary challenge for gold mining companies is to define economic process options for treating more complex ore bodies as the less refractory ores become depleted. Demonstration of economic treatment options allows gold companies to maintain and increase their ore reserves.

The selection of options to treat a specific ore is significantly impacted by factors such as mineralogy, precious metal grades and deportment, gold to sulphur ratios and hazardous impurities. Bateman Engineering has carried out a number studies to help mining companies evaluate further the potential for developing ore bodies.

This paper provides two examples of work to evaluate the potential for treating a low grade ore with high carbonate and arsenic content and an ore with high silver grade. Capital and operating cost estimates for different methods of pretreatment were prepared and these estimated costs and ore sulfide grades then used to compare the process economics.