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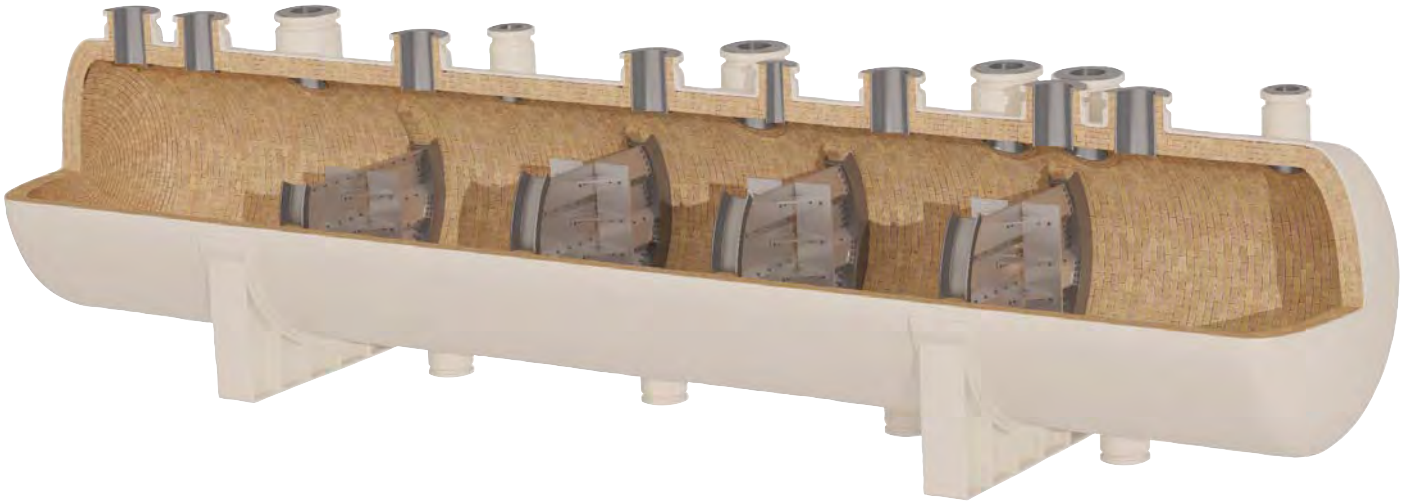

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Gold-Precious Metals Contents

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Gold-Precious Metals Contents

Gold-Precious Metals Proceedings

Conference Keynote Address

DEALING WITH COPPER IN GOLD ORES; IMPLEMENTED AND FUTURE APPROACHES

By

Dr Paul Breuer

Gold Processing Team Leader
CSIRO Mineral Resources Flagship, Australia

Presenter and Corresponding Author

Paul Breuer

ABSTRACT

Cyanidation via heap leach or carbon-in-leach (CIL) / carbon-in-pulp (CIP) has become the predominant gold processing and recovery technique adopted since the late 1970's. A major advantage of cyanidation compared to the chlorine/chloride method used prior to the advent of cyanidation (and many alternative lixiviants) is the selectivity for gold (and silver) over most other metals. However, the selectivity over copper is often poor as most of the copper minerals commonly associated with gold, including sulfides (chalcopyrite being an exception), oxides, carbonates and native copper, are readily dissolved in the cyanidation process. The dissolution of copper impacts the cyanidation process economics, at the very least as additional cyanide is required to complex the copper (in addition to the gold). In addition downstream issues may arise and there may be increased cyanide destruction costs.

Due to the dwindling resources of simple cyanide extractable gold deposits, a large proportion of the gold processed in the 21st century will be recovered from lower grade and more complex gold ores, many of which will contain cyanide soluble copper minerals. By way of example, the data for Australia (from 2012) indicates a significant opportunity for gold recovery from iron oxide copper-gold (IOCG) deposits, which contain 24.7% of the inferred gold resources but only contribute 3.9% of gold production in Australia. In comparison, other (non IOCG) copper-gold deposits in Australia containing 12.4% of the inferred gold resources and have contributed 25.2% of gold production from these deposits.

The main approaches considered to treat copper-gold ores or gold ores containing copper are:

1. Flotation to generate a copper concentrate containing gold as a co-product and cyanidation of the flotation tail and/or other concentrate streams to recover additional gold.
2. Cyanidation of selectively mined ore having low soluble copper.
3. Preleach of copper before cyanidation.
4. Minimising/reducing copper dissolution during cyanidation.
5. Cyanidation with cyanide (and copper) recovery.
6. Alternatives to cyanidation for gold recovery.

This paper describes the various approaches and the large number of processing options that have been considered to treat gold ores with cyanide soluble copper. Notably, flotation has been mostly adopted, particularly for ores containing copper sulfide, with cyanide recovery rarely implemented. A number of approaches and processing options, that are yet to be demonstrated on a commercial scale, have potential for adoption in the future as the industry strives to process more challenging copper-gold and copper containing gold ores.

Ultimately, there is no universal process solution for dealing with copper in gold ores and the most profitable processing approach is highly dependent on the mineralogy and metal grades of the ore.

Gold-Precious Metals Proceedings

Project Development

THE SANTA ROSA GOLD PROJECT: MOVING TOWARD PRODUCTION

By

[1]W. Joseph Schlitt, [2]R.W. (Bob) Bell and [3]Robert H. Cuttriss

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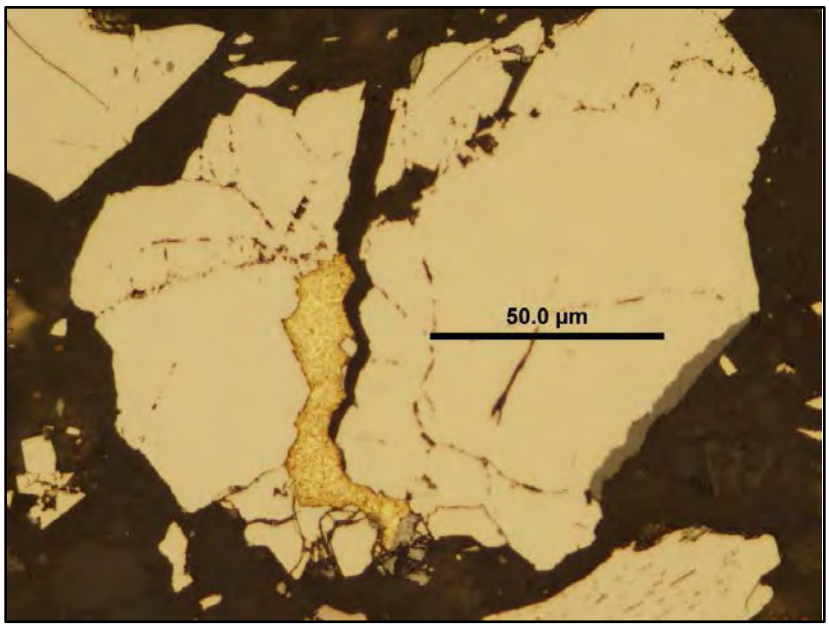
Presenter and Corresponding Author

W. Joseph Schlitt

ABSTRACT

The San Ramon Gold Project is being developed by Red Eagle Mining Corporation on their San Ramon concession approximately 70km north-east of Medellin, Colombia. A positive definitive feasibility study was released in October 2014 and the project has now moved into the engineering phase. Based on the initial exploration activity, the project first appeared to be amenable to development as an open pit mine with gold production achieved by conventional heap leaching. However, as the project advanced, it morphed into a combination open pit-underground operation mainly producing sulphidic ore with minor amounts of oxide and transition ores. Further development and metallurgical testing, coupled with the sensitivity of developing a new open pit mine in Colombia, shows that the best economics would be achieved with a high-grade underground operation. During development, various process routes have been tested including direct leaching of the ore and flotation with leaching of the rougher concentrate, with or without a gravity concentration step to recover the free gold. Further testing showed that the most attractive process option involves a coarse SAG mill primary grind, followed by flotation of the gold-bearing sulfides and ultra-fine grinding of the concentrate. The reground concentrate is then blended with the flotation tails and the combined product is leached in a CIP circuit. Using this hybrid approach, gold recovery is expected to average 96 percent, along with 69 percent silver recovery. This paper describes the project as it currently stands and focusses on the various metallurgical testwork programs that have been conducted to-date.



Front Piece - - Coarse Gold in Brecciated Pyrite in Shear Zone Ore

COMMISSIONING AND RAMP UP OF THE ALBION PROCESS AT THE GPM GOLD PROJECT

By

[1]Paul Voigt, [1]Mike Hourn, [1]Daniel Mallah and [2]Duncan W. Turner

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Presenter and Corresponding Author

Paul Voigt

ABSTRACT

The GPM Gold Project is located in Armenia, and consists of an open cut mine at Zod, near the Azerbaijan border, and a CIL processing plant at Ararat near the Turkish border. Mining at Zod commenced in 1976, and focused on near surface oxide ores, which overlay deeper refractory sulphides. Historical mining has now almost depleted the oxide ores, and the sulphide content of ore delivered to the processing plant at Ararat is increasing. Gold and silver recoveries through the Ararat plant were declining steadily.

GeoProMining, the owners of the project, have expanded the Ararat facility to deal with the increasing sulphide content in the ore. In 2014, GeoProMining refurbished an existing concentrator on site to recover a sulphide concentrate from the ore, and have constructed an Albion Process™ plant to oxidize the refractory concentrate. Glencore Technology (GT) provided the Albion Process™ plant as a technology package.

In July 2014, the progress of the GPM Gold Project Albion Process™ Plant was reported (Hourn, Voigt and Turner, 2014). At the time of writing, the construction of the plant was nearly complete. This paper presents an update of project progress, covering commissioning and ramp up of the GPM Gold Project.

The commissioning phase occurred over June to August 2014, which included an M3,000 IsaMill™ fine grinding plant, a 6 tph limestone milling plant, a 60 tpd vacuum pressure swing adsorption oxygen plant, a 10m residue thickener and a 12tph Albion Process™ oxidative leach plant. Since commissioning was completed, ramp up occurred over the following three months with downstream gold recoveries from cyanide leaching reaching over 98%.

Hourn, M., Voigt, P., & Turner, D., (2014) Development of the Albion Process plant to treat refractory concentrates from the GPM Gold Project, Proceedings – Hydroprocess Conference, 2014.

WHITE DAM GOLD PROJECT DUMP LEACH

By

Damian Connelly

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Presenter and Corresponding Author

Damian Connelly

ABSTRACT

The White Dam gold project is located in South Australia, approximately 95 kms west of Broken Hill, with a total resource of 10.12 Mt containing 338,000 ounces of gold. The project was operated by Polymetals and Exco Resources. The proposal was for a dump leach project, and based on the high risk and short life of the project, the bank sought external Due Diligence in order to arrive at a funding decision.

This was a complex Due Diligence exercise, particularly deciding what the likely overall gold recovery would be based on column tests. Furthermore, there was a potential process risk with cyanide soluble copper in addition to the normal dump leach issues. Dump leaching being a quantum leap carries a higher risk than heap leaching where the ore is crushed. In addition, there was little experience in Australia with dump leaches.

This paper describes the process that was undertaken so funding could be provided, and discusses the final project performance compared to what was predicted.

Gold-Precious Metals Proceedings

Refining

PHOSPHONICS – 5 TOP TIPS FOR MAKING MONEY FROM REFINING STREAMS

By

Grant Mascini

PhosphonicS Ltd, South Africa

Presenter and Corresponding Author

Grant Mascini

ABSTRACT

PhosphonicS works with leading PGM and Au refineries to help them make money from their refining streams using high performance functionalized silicas which scavenge platinum group metals and Au selectively from these streams. The scavengers are highly selective for PGMs + Au in high base metal concentration matrices, they are effective across a wide range of pH and can achieve 2-8% PGM loadings.

Following a standard screening and optimisation pathway, a robust scale-up model as well as custom engineering options allow for successful implementation and rapid economic benefit from the recovery of mg/L levels of PGM.

PhosphonicS here presents an update on its experience working with mining refineries including 5 top tips to help you get the most out of your refining streams, with live-project case studies.

OUTOTEC'S GOLD REFINING TECHNOLOGIES: PROCESS, EQUIPMENT AND DESIGN

By

Mikhail Maliarik and Bjorn M. Ludvigsson

Outotec, Precious Metals Technology, Sweden

Presenter and Corresponding Author

Mikhail Maliarik

ABSTRACT

This paper presents Outotec's technologies for gold refining. Particular attention is devoted to technologies for gold refining of Doré metal received from gold cyanidation plants. Outotec® Gold Refining Plant covers all process steps from atomization of gold bullion to casting of 99.99% gold bars. Incoming bullion ingots are melted and treated in atomizing unit to produce fine powder suitable for further hydrometallurgical processing. The refining process essentially consists of leaching of atomized gold bullion followed by precipitation of purified gold sand. Different oxidizing agents can be used for solubilizing gold as tetrachloroauric acid. >99.99% gold is recovered from the solution by selective reduction. Outotec's gold refining solutions have been successfully applied at many installations world-wide with plant capacities ranging from 3 to 36 tpa.

RADIOACTIVITY IN COPPER ANODE SLIMES

By

Karin H. Soldenhoff and Marina Fainerman-Melnikova

Australian Nuclear Science & Technology Organisation (ANSTO), Australia

Presenter and Corresponding Author

Karin Soldenhoff

ABSTRACT

Anode slimes derived from copper electrowinning contains significant amounts of gold and silver. The processing of the slimes is complicated by the presence of impurities such as Te, Se, Pb, As and Bi. The processes adopted by commercial operations vary widely and are dependent on the initial copper anode slimes composition. Conventional technology usually incorporates the following unit processes:

i. Sulfuric acid leaching to remove copper;
ii. Roasting and/or smelting to control lead and selenium;
iii. Silver recovered by electrolysis; and
iv. Gold recovered by electrorefining.

Oxidative chlorination of decopperised anode slimes is an attractive hydrometallurgical processing alternative which has been adopted by a number of refineries. The gold is recovered by solvent extraction and there are various processing alternatives for recovering silver from the silver chloride leach residue. Advantages reported for refineries that have adopted the oxidative chlorination processing route include reduced process inventory and processing time and improved first pass metal recoveries.

ANSTO Minerals carries out routine radioactivity deportment studies in copper smelters and has had a long standing interest in anode slimes copper processing.

In this paper we broadly discuss radioactivity deportment in copper anode slimes processing. In particular we present results from ANSTO patented technology for separating gold from Po-210 applicable to the oxidative chlorination processing route.

Gold-Precious Metals Proceedings

Process Improvement

GRAVITY RECLAIM STOCKPILES, AND OPTIMISING LIVE CAPACITY AND FEED TO GOLD PROCESSING PLANTS

By

Chris Muller

Jenike & Johanson, Australia

Presenter and Corresponding Author

Chris Muller

ABSTRACT

Gravity reclaim stockpiles are often used following a gold mining crushing operation to store material prior to being fed to a processing plant. Often the feed rate and the properties of the feed itself can affect the processing plant's performance, and in many cases this is influenced by the live capacity of the stockpile and segregation effects within the stockpile. This can apply to both hard rock and soft rock gold mining operations.

A gravity reclaim stockpile is essentially the same as an expanded flow hopper design, whereby the flow channel establishes above the base of the pile in a funnel flow pattern, and below the base of the pile (upon entry to the reclaim draw point), in a mass flow pattern. This flow channel combination performs best if the formation of a stable rathole can be minimised or eliminated to minimise stagnant material. However, due to variations in material properties, such as moisture content, particle size and bulk density, the formation of a stable rathole can occur, and in some cases extend considerably upwards into the pile resulting in increased stagnant material. This results in the live capacity of the pile being reduced and consequently the feed being rate limited or varying to the plant.

Segregation effects by particle size or chemical composition within a gravity reclaim stockpile can also affect the feed to a plant. For example, if the fine to coarse particle size ratio is outside the allowable range for the plant, then the higher particle size proportion will often dictate and limit the overall feed rate that can be achieved. Similarly, if the chemical composition of the feed material is outside the quality range required for the plant, then the product output per unit time or feed rate can be compromised. These segregation effects within a gravity reclaim stockpile are often associated with the way the pile is originally formed (stacked) and refilled (restacked), but only realised when reclaimed through the draw point, and therefore need to be considered to ensure the performance of the plant is not negatively impacted in terms of rate or quality.

SUCCESSFULLY SUPPLYING NF AND RO MEMBRANES TO BASE METAL CYANIDE LEACH TO SEPARATE THEM FROM PRECIOUS METALS AND RECOVER THE CYANIDE

By

Johannes Herrmann

AMS Technologies, Israel

Presenter and Corresponding Author

Johannes Herrmann

“WALKING THE GOLD PATH” – CONTINUOUS IMPROVEMENT OF AGITATION SYSTEMS FOR GOLD PROCESSING

By

Franck Bénéfice, Ralph-Oliver Schmidt, Wolfgang Keller and Jochen Jung

EKATO RMT, Germany

Presenter and Corresponding Author

Franck Bénéfice

ABSTRACT

As mineralogy has become more complex in the long history of gold processing, the process routes and equipment used had to adapt to the changing conditions. Starting with atmospheric leaching, complex sulphide mineralogy has led to the development of pressure oxidation autoclaves (POX) as well as bioleaching process routes.

Agitation systems have picked up the challenge of serving all of the existing process requirements for CIL, CIP, POX and bioleaching applications. Be it high temperatures or high pressures and demanding chemical-physical requirements to the material of construction, agitation systems always have to cope with the same challenges: achieving the required mass transfer, providing proper gas dispersion, blending the diverse feed stream and of course achieving highest availability and reliability.

This presentation and technical paper will provide the latest state-of-the-art technologies and improvements of agitation systems that render possible the next step towards a new generation of gold processing plants.

OPTIMISING CARBON MANAGEMENT IN A CIP/CIL CIRCUIT – A NEW CARBON METER

By

W. P. Staunton, T. D. H. McGrath and J. J. Eksteen

Gold Technology Group, W.A. School of Mines, Curtin University (Australia)

Presenter and Corresponding Author

William Staunton

ABSTRACT

In a CIP/CIL circuit the key performance indicator of good performance is a low soluble gold solution loss. The usual target for solution loss is 0.01 mg/l, although the industry average is more typically 0.02-0.3 mg/l. As gold ore grades being treated continue to drop, soluble gold loss represents an increasing loss in percentage recovery.

Minimising gold solution loss requires that carbon management is optimised. Carbon management comprises two key components; the quality of the activated carbon (in particular its kinetic activity following regeneration) and the carbon inventory (quantity of carbon, carbon movement, and carbon distribution in the circuit). Carbon management in the circuit is often less than ideal due to infrequent measurement of carbon concentration in the tanks, and manual control of carbon movement between tanks.

The Gold Technology Group at Curtin University and its collaborative partners has designed and constructed an automated carbon meter, which regularly and automatically measures the carbon concentration in each tank. The meter can be used to automate carbon movement through the circuit.

A prototype unit has recently undergone final development testing at Sunrise Dam Gold Mine. The test demonstrated the mechanical reliability of the unit and improved measurement frequency and accuracy. The meter can provide improved carbon management in the circuit, thus reducing gold solution loss, and optimising carbon inventory, particularly when coupled with Curtin University's proprietary SIMCIL process software.

OPTIMIZING AGITATION FOR GOLD PLANTS USING EXPERIMENTAL AND COMPUTATIONAL TECHNIQUES

By

[1] Antonio Iniguez, [2]Graham Seal, [1]Richard Kehn and [2]Joe Kontur

[1]SPX Corporation, USA
[2]SPX Flow Technology, Australia

Presenter and Corresponding Author

Graham Seal

ABSTRACT

With global demands for gold reaching a steady state over the past couple of years, processing plants are seeking out new ways to optimize their existing resources while minimizing new capital equipment investment. Slurry agitation exists in all gold process plants and in many cases represents a significant portion of the processing plant's operating costs.

Optimization an existing plant doesn't always require brand new equipment. Considering new impeller designs that require less power and torque to achieve a given process results can lead to operating cost savings while possibly reusing the geardrive. In addition to optimizing the mixer, the tank internals (baffles, upcomer design, separation walls in autoclaves) can have a large impact on the process result as much as just the agitator design. Thus it is important to treat the problem as an agitator system problem and not just an equipment problem.

Both computational methods and experimental methods can be used to justify proposed changes in the agitator system design. Computational fluid dynamics (CFD) is a great way to visualize flow fields and investigate how tank internals affect this. It also can be used to predict whether an inlet/outlet flow will mix properly with minimized short circuiting and be used to assist with determining tank internal design loads such as baffle forces. It is important however to perform experimental hydrodynamic studies as well in order to validate the computational methods, especially when considering agitation of slurries.

Three case studies will be discussed. In each case, both CFD and experimental methods were used to optimize existing mining installations leading to improved performance while minimizing capital cost investment.

Gold-Precious Metals Proceedings

Pressure Oxidation

LOW GRADE REFRACTORY GOLD ORE – IS POX THE SOLUTION?

By

Jakolien Strauss

Mintek, South Africa

Presenter and Corresponding Author

Jakolien Strauss

ABSTRACT

Pressure oxidation (POX) has become an established pre-treatment technology for the recovery of gold from refractory ores due to high associated gold recoveries and for its environmental benefits. Modeling and simulation of pressure leach circuits is a valuable tool in the identification of optimal operating conditions and evaluation of plant performance.

Plants are often designed to treat the higher grade ores during the initial period of a project, whilst the lower grade gold portions or more refractory ore is stockpiled. The economic processing of lower grade ores as a concentrate thus becomes motivated by the depletion of higher grade ores.

A pressure oxidation model was developed based on the kinetic data from batch tests conducted on a flotation concentrate. The simulation was subsequently used to evaluate the effect of different process variables on the extent of sulphide conversion and to identify improved conditions. From the predicted outcomes, a high-level economic study of the reagent costs was performed.

Significant information regarding a suitable operating window for treatment of the material was obtained from the model. During the economic study it was found that the reagent costs seem reasonable and the gold to sulphide ratio in the concentrate was still high enough to justify pressure oxidation as economic pre-treatment method.

CONTROLLED RAPID AUTOCLAVE BLOWDOWN

By

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[1]Hatch, Canada
[2]MOGAS Industries, USA

Presenter and Corresponding Author

Kevin Jackson

ABSTRACT

In 2009, MOGAS presented a paper on “Controlled Rapid Blowdown”, a new approach to depressurizing autoclaves when coming off-line. Since then, the FlexStream control valve has been installed at the autoclave and due to the valve’s performance during start-up, commissioning and operational use, it was given the nickname “The Million Dollar Valve”.

MOGAS will present the impactful savings to the operator regarding reduction in downtime, increased product output as well as the environmental benefits.

First Presented 2009

Updated Operational Conclusion April 2015

Gold-Precious Metals Proceedings

Process Development

EVALUATION OF STABILIZED BROMINE TECHNOLOGY FOR GOLD LEACHING

By

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[2]Albemarle Corporation, USA
[3]SGS, Canada

Presenter and Corresponding Author

Mike Dry

ABSTRACT

This paper examines a novel technology using stabilised bromine for processing gold bearing ores, and compares it to cyanidation technology. The gold ore chosen for this work is not well suited to cyanidation due a high level of copper.

Process modelling was used to generate numerically rigorous mass-energy balances for the novel and the conventional technology, for the chosen feed. Preliminary experimental results were used to set up the mass-energy balances.

The mass-energy balances were used to generate preliminary estimates of the capital and operating costs associated with the two technologies. The results were evaluated using simple financial models showing the relative process economics of the stabilized bromine and cyanidation technologies.

The bromine technology has higher a capital cost than cyanidation, but lower operating costs for the ore used in the evaluation. For the ore used, the results of the exercise indicate that the bromine technology is competitive with cyanidation and does merit further development.

GOLD AND SILVER LEACHING IN ALKALINE AMINO ACIDS SOLUTIONS

By

Jacques Eksteen and Elsayed Oraby

Western Australian School of Mines, Curtin University, Australia

Presenter and Corresponding Author

Jacques Eksteen

ABSTRACT

As precious metals grades trends lower, the continued use of cyanide for low grade complex gold ores becomes more questionable, particularly as cyanide consumption scales with ore tonnage milled rather than gold content and gold production. In addition, as the precious metals grade in gold ores decreases, particularly below 1 ppm, conventional fine grinding for tank leaching is becoming harder to economically justify. Ore pre-concentration (where the ore is amenable to it) or heap (HL), vat (VL) or in-situ leaching (ISL) are becoming serious contenders to the conventional mill and leach approach, particularly in the current capital-constrained environment. However, for environmentally open systems, such as VL, HL and ISL, there is a need for the leaching reagent mixture to be environmentally benign, whilst still being economical.

This paper will discusses developments at Curtin University in the development of environmentally benign reagent mixtures for potential application in ISL, HL and VL modes, and the factors that influence the kinetics and extent of leaching and adsorption onto activated carbon.

DEVELOPMENTS TOWARD A TRUE RESIN-IN-PULP GRADE ION EXCHANGE RESIN FOR GOLD

By

Jaco Bester

DOW Water and Process Solutions, The Netherlands

Presenter and Corresponding Author

Jaco Bester

ABSTRACT

The proven rapid kinetic response of commercial grade gold selective strong base anion exchange resin, Ambersep™ XZ-91419 has made it an ideal absorbent for gold from carbonaceous cyanidation processes employed in several commercial gold mining operations. Now this top performer is taken to the next level by DOW Water and Process Solutions' innovative development of a large uniform particle size resin whilst maintaining highest gold to copper selectivity in challenging Pregnant Leach Solutions.

CYANIDE TOLERANCE OF BIOHEAP® MICROBIAL CULTURES

By

Jason Fewings, Shawn Seet, Tim McCredden and Craig Fitzmaurice

BioHeap Ltd, Australia

Presenter and Corresponding Author

Jason Fewings

ABSTRACT

During 2014 and 2015 Western Areas Ltd engaged Tetratech Proteus to conduct a feasibility study on a bioleach facility at the Cosmic Boy concentrator to process a high arsenic waste stream. Part of the process is a cyanide detox circuit to treat cyanide species added during arsenic depression in the flotation circuit. To assess the risk to the bacterial leach process in the event of failure of the cyanide detox facility small scale tests were undertaken and showed that the BioHeap® microbial culture being used only suffered minor hindrance to leaching. Further work examining the performance of this culture in gold settings

POSSIBILITIES AND CHALLENGES IN GOLD CHLORIDE PROCESSING

By

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[2]Outotec (Finland) Oy

Presenter and Corresponding Author

Mari Lundström

ABSTRACT

This article discusses issues related to the possibilities and challenges of gold chloride leaching. Construction materials, gold leaching and recovery, silver leaching and recovery, impure raw materials and impurities in the process, chemicals used, water balance, environmental aspects and reliability of new technology are considered.

Gold chloride and bromide complexes are known to be less stable than corresponding cyanide complexes. This enhances preg-robbing and the tendency of gold to precipitate on organic materials, clays and other surfaces. Experiments were conducted in order to study the tendency of gold to precipitate on different materials. It was observed that super-duplex SAF 2507 stainless steel did precipitate some gold whereas Ti and FRP (fibre-reinforced plastic) did not precipitate any gold from a gold solvent extraction stripping solution.

Currently, development-stage gold chloride processes operate at high chloride and also optionally at high bromide concentrations and at temperatures close to boiling point. This may increase concerns related to corrosion. In order to study the effect of high bromide concentration on titanium, immersion tests with creviced samples were conducted for four weeks at 90 °C. It was shown that high bromide concentrations did not cause material damage and the titanium grade 2 samples tested were shown to be resistant against both uniform and crevice corrosion.

There are a lot of opportunities related to gold chloride technologies. Chloride is a safe low-cost chemical and available worldwide. It leaches not only gold but also silver, having fast dissolution kinetics. It is an environmentally sound chemical with good social acceptance. It is possible that gold chloride technology will become a transformational, market-shaping gold technology.

Gold-Precious Metals Proceedings

Gold/Copper Forum

GOLD EXTRACTION FROM GOLD-COPPER CONCENTRATE IN SOLUTIONS CONTAINING CAUSTIC SODA AND LOW FREE CYANIDE

By

[1,2]E.A. Oraby and [1]J.J. Eksteen

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[2]Faculty of Engineering, Assiut University, Egypt

Presenter and Corresponding Author

Jacques Eksteen

ABSTRACT

Copper-gold deposits contain significant amounts of cyanide soluble copper which can lead to high cyanide consumption with low gold extraction in the cyanidation process. Cyanide should be destroyed before the discharge of tailings containing metal-cyanide complexes. This increases the cost to the gold mining companies to cover both the extra cyanide consumption in the leaching stage and the additional cost for cyanide recovery/destruction. Therefore, in this study, a selective cyanide leaching process of gold over copper from copper-gold concentrate containing 490 g/t Au and 0.97% Cu present as metallic copper, oxides and sulphides has been studied. To decrease the cyanide consumption, cyanide is added into the leach solutions to achieve a ratio of cyanide to total reactive copper (CN/Cu) below 2. At low CN/Cu ratio, increasing the solution pH can lead to the precipitation of copper as $CuO/Cu(OH)_2$ and release cyanide ions for further both gold and copper dissolution. A comparison of leaching gold in cyanide-caustic; cyanide-ammonia and conventional cyanidation processes has been made. Higher gold extraction and lower copper concentration in the final leach was achieved in the cyanide-caustic system than in cyanide-ammonia and conventional cyanidation processes. The effects of the caustic soda (pH) concentration and cyanide concentration on gold extraction and copper precipitation have also been studied. The results show that at high pH (pH >12), the gold dissolution rate increases significantly in solutions containing cyanide and caustic soda at a very low, or zero, free cyanide concentration. Leaching of gold-copper concentrate was carried out in solutions containing 1.6 g/L NaCN in the presence of 4 g/L NaOH (pH 12.90). This extracted 97.9% Au with less than 180 ppm copper in the final leach solution after 48 hours leaching time. The gold extraction was only 13.75% using same cyanide concentration in the absence of NaOH (pH 10.95). In solutions containing 0.8 g/L NaCN at pH 12.7 (3 g/L NaOH), the gold extraction after 73 hours was 93.6% with only 13.5 mg/L Cu in the final leach solution. The total cyanide consumption was only 1.98 kg/tonne of the concentrate.

Keywords: Copper-Cyanide Complexes; Copper; Gold; Caustic

A SIMPLIFIED KINETIC MODEL OF COPPER CYANIDE ADSORPTION ONTO ACTIVATED CARBON AND ITS INCOPORATION INTO THE MODELLING OF A PROPOSED COPPER AND CYANIDE RECOVERY PROCESS

By

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ABSTRACT

There are two issues commonly involved in the cyanidation of copper containing gold ores: 1) high cyanide consumption due to the co-dissolution of copper and; 2) environmental concerns over the discharge of copper and cyanide to the tailings dams. Compared to cyanide destruction in meeting the environmental requirements, copper and/or cyanide recovery processes can offer an economic benefit. AVR (acidification-volatilisation-reneutralisation) and SART (sulfidisation-acidification-recycle-thickening) are the most popular commercial copper cyanide recovery processes. In these processes, however, copper is either not recovered or recovered as a low value product (e.g. Cu_2S in SART); SART also requires clarification of the entire cyanidation tails stream.

CSIRO has been developing a proposed copper and cyanide recovery process in which copper is recovered as copper metal with no requirement for clarification of the cyanidation tails. This process is based on the concept of recovering copper cyanide by activated carbon following the dissolution of recycled CuCl to complex the free cyanide and concurrently convert copper cyanide species with high coordination numbers ($Cu(CN)_4^{3-}$ and $Cu(CN)_3^{2-}$) to the readily absorbed $Cu(CN)_2^-$. The copper cyanide can then be recovered by a carbon elution process, followed by copper recovery and cyanide recycling. Unit operations of this process have individually been investigated and based on the results a process model has been developed. This process model includes a recently established copper cyanide carbon adsorption kinetic model, to better predict the carbon adsorption behaviour of copper cyanides, which is a key component of the overall process. The developed process model has been used for sensitivity testing of various design and operation parameters. An economic evaluation has also been conducted and the results indicate a CAPEX payback time of approximately two years which is comparable to a SART process.

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BIOLOGICAL TREATMENT OF REFRACTORY ORE ISSUES IN THE GUILDFORD MINE DISTRICT, VICTORIA, AUSTRALIA

By

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ABSTRACT

"Refractory" ores are defined as any mineral or mineral assemblage with a valuable resource (gold, silver, copper, etc) that is prevented from economic recovery by mineralogical or metallurgical encapsulation, complexation or occlusion. A typical example of an ore that is refractory to gold recovery is where a sulfide mineral encapsulates the gold resource making conventional cyanide dissolution of the gold impossible. In addition to sulfide refractory ores, other issues include metal resource encapsulation or coating by silicate minerals, iron oxide minerals, etc. These issues for metal resource recovery are equal to, if not larger than the effect of sulfide refractory ores on gold, silver and copper production. Biological processes present an alternative for the "other" refractory ores that lack an economic solution for metal resource recovery. The biological processes discussed in this paper include:

1. Silicate mineral bio-alteration or accelerated "weathering;"
2. Iron oxide mineral dissolution;
3. Coarse gold particle dissolution;
4. Production of biologically-produced surfactants for improved solution/ore contact and ore microfracture penetration leading to resource recovery;
5. Generation of alternative bio-lixivients, and chelating agents for enhanced metallic resource recovery.