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Technical Program @ a Glance .......... Back Cover
A few studies have indicated that the absorption of hydrogen fluoride (HF) from the atmosphere by the dry scrubber is governed by diffusion or film diffusion and the absorption of fluoride in the alumina is determined by kinetics. However, no comprehensive performance equation for dry scrubbers has been published in the literature. Experimental data from a pilot dry scrubber were compared with results from three kinetic models, which were based either on the mechanism of absorption or film diffusion or pore diffusion. Both the HF concentration profile along the dry scrubber and the fluoride content of the alumina were predicted. All kinetic models were successfully fitted within the accuracy of the data. One kinetic model was considered suitable as a performance equation and was extended to include the recycle operation. Operating results of a few dry scrubbers with co-current flow were evaluated by means of the performance equation, which includes the effect of gas flows, fresh alumina feeds, HF inlet concentrations and the recycle ratio.

Towards Industrial Aluminum Spent Pot Lining Treatment with Complete End-Product Valorisation: Ghislain Hamel1; Nicolas-Alexandre Bouchard1; Raymond Breault1; Simon Leclerc1; Stéphane Poirier1; Rio Tinto Alcan

The LCL&L process (Low Caustic Leaching & Liming) is a patented hydrometallurgical route developed by Rio Tinto Alcan (RTA) to economically process spent pot lining (SPL) generated by aluminum cells. The three resulting end-products (carbonaceous, fluorinated and caustic liquor) are inert and have valorization possibilities. An industrial size pilot plant located in Saguenay (Quebec) was inaugurated in mid-2008 to demonstrate and optimize the technology. This paper describes characteristics of the LCL&L process and the experience acquired by RTA since the plant’s start-up, including ramp-up capacity and technology challenges that were overcome. Possible end-products valorization methods are also presented. The carbonaceous end-product can be separated into carbon and brick rich fractions and used as either alternative fuel, reducing agents, or as raw material for third party processes. The development of a conversion process for the fluorinated end-product would allow its reuse as a substitute to fluor spar mineral for aluminum fluoride production. Finally concentrated caustic liquor is already valorized at the nearby RTA Vaudreuil alumina refinery.

Physiochemical Properties of Cryolite-Silica Melts: Samira Sokhvanar1; Mansoor Barati1; Sridevi Thomas1; University of Toronto

High price of solar grade silicon caused by limited supply has become a major challenge that has necessitated the development of new production processes. In this research, data on dependence of electrical conductivity and density for cryolite–SiO2 melts will be presented. It is thus essential to develop a method for analysis of solar silicon which is energy efficient and will deliver inexpensive feedstock material.

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Potential of Laser Welding and Friction Stir Welding for Joining AA1100-16Vol.% B4C Metal Matrix Composite: Junfeng Gao; Patrick Gougeon; François Nadeau; X. Grant Chen; University of Quebec at Chicoutimi; National Research Council Canada

This work illustrates the potential of two welding processes for joining AA1100-16vol.% B4C metal matrix composite: laser welding process using a 4 kW Nd: YAG laser and Friction Stir Welding. A comparison is made between these two welding techniques in terms of microstructure and mechanical properties of welded joints. A large amount of brittle needle-like phases, together with some residues of B4C particles were observed in the fusion zone of laser joints. The use of Ti filler can improve the microstructure and increase the joint efficiency from 63% to 75%. On the other hand, the friction stir welding process being a solid state welding technique does not lead to the formation of brittle intermetallic phases. In addition, the breakage of B4C particles and the grain refinement of the matrix were observed in the weld zone. Consequently, the FSW joints show much better mechanical properties than laser joints. Up to 100% joint efficiency can be achieved by FSW for annealed AA1100-16vol.% B4C materials.
When we superimpose on the chemistry of the project severe predictions of product imposes greater demands on the process to produce benign wastes. From waste inherently becomes riskier as the purification of the desired value and technology as reaction rates are increased and the capture and disposal of unwanted products are subjected to greater restrictions. Separating value from waste inherently becomes riskier as the purification of the desired product imposes greater demands on the process to produce benign wastes. When we superimpose on the chemistry of the project severe predictions of throughput rates, that bring in facets of manufacturing, we are introducing complexities that the records show are not handled well. This paper discusses some of the more common challenges that operators face and what methods are available and are likely to be successful in preventing the loss of value as projects are brought on-stream. This thinking needs to start much earlier and at greater intensity than our industry has normally chosen to employ.

11:15 AM
Keynote: Implementing New Technology in Metallurgical Processes: Building Plants that Work: Bert Wasmund; Nils Voermann; Brady Haneman; Jim Sarvinis; Greg Sheehan; 'HATCH

Success in implementing new technology for metallurgical processes is not a foregone conclusion: This paper includes a survey of 25 new-technology based metallurgical plant start-ups, in which the authors have identified 7 successes, 9 difficult start-ups, and 7 failures. Success is defined not only as achieving the schedule and budget to mechanical completion; the key goal is a fast ramp up to the full design production level, with minimum plant and equipment modifications required after start-up. This paper sets out the key factors that underlie achievement of a quick production ramp up curve, as determined from the authors’ project experiences and a quantitative analysis of over twenty metallurgical plant start-ups, both pyro and hydro. Thorough test-work and pilot plants, plus appropriate scale-up to the full commercial plant, are key determinants of success in implementing new technology in metallurgical processes. Another critical factor is the number of new elements and their interactions. Project phasing was also particularly important for new technology projects, with appropriate review after each phase to develop a risk mitigation plan for the subsequent phase. New technology projects need committed champions to advance the project in the face of skeptics, but also require dispassionate and unbiased experts to ask the hard questions. As a project evolves, it is important to periodically question the appropriateness of assumptions, as well as reassess the relevance and completeness of data from test-work/pilot plants/industrial analogues. Sufficient human and financial resources are required to complete the often arduous implementation phase. During the ramp-up period, the operation generates little positive cash flow; however, significant expertise and capital are required for the de-bottlenecking projects that are typically necessary to reach the plant’s design output level.

10:25 AM  Keynote
Overview of Waste Processing & Recycling of Nonferrous Metals in Metallurgical Industries in China: Xueyi Guo; ‘Central South University
The total production of nonferrous metals in China is 31.35 million tons in 2010 including aluminum 16.2 million tons, copper 4.57 million tons, lead 4.2 million tons, zinc 5.16 million tons. It ranks first in the world for the past nine years and is expected to reach 42 million tons in 2015. Large quantities of waste residues, waste water and dust are produced every year in the production of nonferrous metals. These secondary resources are renewable, not only contain abundant valuable metals which can be recycled by metallurgical processing, but also could eliminate the pollution to the environment. In this paper, the status quo of the nonferrous metals recycling in metallurgical industries in China was summarized and the future development of waste processing and resource recycling was also prospected.

10:50 AM  Keynote
Physical Separation Process for Recovering Tantalum Capacitors from Electronic Devices Mounted on Printed Circuit Boards: Tatuya Oki; ‘National Institute of Advanced Industrial Science and Technology
Several tantalum capacitors can be seen on printed circuit boards of electronic devices such as personal computers, servers, communication instruments, and other commercial calculators. These capacitors contain a considerable quantity of expensive metal tantalum. Some impact breakers can detach and liberate a large number of various types of electron devices from printed circuit boards. However, there are few reports on the recovery of specific devices from these electron devices mixtures. First in this study, size and density distribution of the liberated electron devices were investigated. Then, tantalum capacitors were recovered from the other electron devices using size separation and pneumatic gravity concentration methods. More than 70 per cent of Newton’s separation efficiency can be obtained for electron devices liberated from several types of printed circuit boards used in this study. And, the results of separation examinations suggested a possibility to separate other types of electron devices such as chip resistors and other kinds of capacitors by this simple physical separation process.

10:00 AM  Review of Lead Recycling Technology: R. Prenganam; Abbas Mirza; Timothy Ellis; ‘RSR Technologies, Inc.
Recycled lead, i.e. material produced by the recycling of lead-acid batteries, has become the primary source of lead in much of the world. This has been important to the recycled lead industry as other uses have dwindled, e.g. lead based pigments, chemicals, fuel additives, solders and CRT glasses. Presently, battery manufacturing accounts for greater than 85% of lead consumption worldwide while recycled lead accounts for approximately the same market share of lead supply. Battery manufacturing and production of recycled lead are intimately coupled. In 2007, of all the industrial base metals, lead from lead-acid batteries had the highest recycling rate in North America at greater than 95%. In this paper we will review some of the processes and technologies used in a modern lead acid battery recycling facility, and how recycled lead has become the material of choice for battery construction through the development of a recovery and refining process that exceeds the industry requirements. We will also briefly review an advanced air emissions treatment system in a modern lead recycling plant that demonstrates the feasibility of a new maximum available control technology (MACT) for secondary lead smelters.

10:05 AM  Morning Session Chair: Michael Sudbury, Consultant
10:00 AM  Session Chair: Michael Sudbury, Consultant
METALLURGICAL INDUSTRIES: Metal Recycling I
Monday AM  October 3, 2011  Room: Verdun  Location: Hilton Bonaventure Hotel
10:00 AM  Session Chair: Michael Sudbury, Consultant
10:00 AM  Keynote

Gold Space from a Producer’s Prospective: Peter Kinver1; 1Barrick Gold

Abstract currently not available.
11:40 AM

An Alternative Automated Electron Beam Technology for Gold Characterization: Denise Doer;1 Daniel Lopez;2 Ronel Kappes;1 Timothy Drake;1 Newmont Mining Corporation;2 ASPEX Corporation

Automated scanning electron microscopy has been widely used in recent years for gold and other precious metals characterization. However, application of this technology is resource intensive and in most instances needs specialized technical personnel to process the samples and information. Newmont Metallurgical Services (NMS) has recently acquired a personal SEM (PSEMTM) from ASPEX. The PSEMTM offers some significant benefits/improvements in sample preparation and sample processing time. NMS and ASPEX have been working together to develop an approach utilizing this technology for the minerals processing industry and specifically for gold characterization.

WORLD GOLD: Plant Practice and Projects I

Monday AM  Room: Mont Royal
October 3, 2011  Location: Hilton Bonaventure Hotel

Session Chair: Bryn Harris, McGill University

10:50 AM

Plant Expansions and Leach/CIL Optimization at IAMGOLD’S Rosebel Operation in Suriname: Chris Fleming;1 Mohammed Ouirribah;1 Pierre Pelletier;2 SGS;1 IAMGOLD

The IAMGOLD Rosebel operation in Suriname is a large tonnage, low grade operation comprising an open pit mine, crushing, SAG/ball mill grinding, gravity separation, cyanidation and CIL. Production at the Rosebel plant commenced in February 2004 at a design treatment rate of 4.8 Mtpd, and by January 2009 throughput had been increased by 150% to 12 Mtpd, through a series of mill expansions in 2005, 2007 and 2008. Moreover, mill feed was changed from predominantly soft saprolite ore (BWI = 2.6 kWh/t) to predominantly transition and hard rock ore during this time (BWI = 4.7 and 13.1 kWh/t, respectively). The expansion was achieved through the addition of a primary crusher to handle the hard rock, pebble crushing capabilities in the SAG circuit, an additional ball mill and more leach/CIL tanks. The amount of gold recovered per annum has more than doubled in six years as a result of the expansions, and plant operating conditions in the leach/CIL circuit were adjusted to accommodate the higher throughput. The carbon advance rate was increased, but this resulted in shorter residence times in acid washing, elution and regeneration, and the recycling of poorly regenerated carbon meant gold losses to the CIL tails were unacceptable high at times. A survey of the CIL plant was therefore undertaken in early 2010 to determine whether the plant performance could be improved by changing the operating conditions in the existing plant, or whether new equipment would have to be bought and installed. A simple approach was adopted by IAMGOLD, which involved the development of a mathematical model of the Rosebel CIL plant that simulated and accurately predicted the plant performance.

11:15 AM

Agnico-Eagle Laronde Plant: Metallurgical Challenges Present and Future: Jean Couto;1 Paul Blatter;1 Agnico-Eagle Mine - Laronde Division

The Laronde mill was commissioned in 1988 and has been treating the Laronde Pena ore since 2000. The Laronde plant, situated in the Abitibi region of Quebec, has experienced mill expansions to accommodate 7500 tpd and to recover gold and silver as well as important amounts of base metals (Cu, Zn, Pb). Ten sequential metallurgical and environmental processes are responsible for metals recovery and process viability. Over 200,000 ounces of gold, 4.5 million ounces of silver, 7000 tonnes of copper, and 78,000 tonnes of zinc are produced annually. In 2008, the Goldex plant in Val-d’Or began trucking high grade (35-45 g/t Au) sulphide concentrate for gold extraction at a newly constructed treatment plant, increasing gold output at Laronde site by 40,000 ounces. In 2009, the high gold grade Lapa ore processing facilities were annexed to the Laronde plant increasing output by 120,000 ounces of gold. Laronde, Goldex and Lapa productions are forecasted until 2023, 2018 and 2015 respectively, with known reserves of each mine. Today, up to 140 permanent employees run and optimise ore processing facilities at the Laronde mine. This new Laronde operation plant has intrinsic intricacies inherent in a large and varied operation. The paper will outline the metallurgical challenges, highlights, and future outlook related to the treatment of each ore type (Laronde, Goldex & sulphide concentrate; and Lapa).

11:40 AM

Continuous Improvement Initiatives at the Newmont Ghana Gold Limited Ahafo Operations: Johan van Huyssen;1 Newmont Ghana Gold Limited

Newmont Ghana Gold Limited’s Ahafo Operation has matured from its project ramp up stage into steady state operations after three years of continuous operation. Management focus has shifted from addressing construction and commissioning problems to optimization and improvement. This focus change has coincided with the introduction by Newmont of a continuous improvement (CI) program across the company. This paper will focus on the application of CI principles at the Ahafo Gold Processing Facility with particular reference to the following case studies: As an example of a black belt project, the mine to mill initiative, including optimization of blasting patterns in the pit, improvement of blending on the ROM pad and implementation of an expert system and particle size analyser. As examples of green belt projects: optimization of the elution circuit, reduction in plant down time through the improvement of maintenance planning and reduction of re-work, As examples of lean belt projects: optimization of the primary crusher gap setting, developing of a management operating system to manage process plant contractors. Each of the above projects could be presented as a technical report in itself. However, the paper will focus on the before and after situation for each project and the financial benefits that were realised for the company through the application of CI principles. Reference will also be made to the CI projects planned for the immediate future, including: reduction of gold in solution inventory in the milling circuit (black belt), implementation of oxygen addition into the leaching circuit to enhance leaching rate and reduce cyanide consumption (green belt), improving tool room management (lean belt)

WORLD GOLD: Strategic Mine Planning I

Monday AM  Room: Fontaine D
October 3, 2011  Location: Hilton Bonaventure Hotel

Session Chair: Roussos Dimitriakopoulos, McGill University

10:50 AM

Kinross Mine Planning Best Practice: Rob Henderson;1 Chris Turek;1 Kinross Gold Corporation

Mine planning is the foundation of value for a mining company. Good mine planning requires solid understanding of the ore body, rigorous standards and processes, robust and useful information technology and skilled people. Life of mine planning is key to identifying strategic direction for any mine and short range mine planning is key to delivering forecast and budget expectations. Mine planning at Kinross has been identified as a critical success factor and initiatives are being prepared to improve the quality of our plans and to build bench strength in our teams. The Kinross Way for Mine Planning (KWMP) has been developed and implemented to establish the standards to ensure a strong business foundation. This paper briefly describes the process used to develop the KWMP and presents a selection of mine planning best practice initiatives at Kinross mines.
temperatures and are presented in this paper.

and Young's modulus of laboratory samples were obtained at various compaction. Finally, preliminary results related to the compressive strength adequately duplicates paste density from the cell for both one and two layer representative sample was measured ranging from 1.51-1.76 g/cm³. The results demonstrate that the proposed fabrication method of peripheral seams in Alcoa’s smelters. The density distribution in the was compacted in multilayers in a mould designed to be representative fabricate ramming paste samples in the laboratory. To this end, paste material density range obtained by the proposed methodology in laboratory is 1.47-1.77 g/cm³. The was compacted in multilayers in a mould designed to be representative

2:25 PM

Delay of the Temperature Measurements in High Temperature Furnace: Marc-André Marois¹; Martin Désilets¹; Marcel Lacrosse¹; Université de Sherbrooke

This paper proposes an improved temporal stability condition for the implementation of an inverse heat transfer method for predicting the time-varying bank thickness of the phase change protective bank inside a high temperature furnace. The direct problem is handled with the enthalpy method. The inverse method rests on the Adjoint Problem and the Conjugate Gradient Method. It is shown that the temporal stability condition for the inverse phase change problem relies on the time delay of the temperature measurements. Results indicate that this time delay is proportional to the heat diffusion time including heat diffusion through the mushy zone.

2:50 PM

Modeling and Simulation of Green Anode Forming Process: Hicham Chaouki¹; Stéphane Thibodeau¹; Houshang Alamdari¹; Donald Ziegler¹; Kamran Azari¹; Mario Fafard¹; Laval university

The aim of this work is to simulate the forming process of a green anode. For this purpose, a nonlinear compressible viscoelastic constitutive law is presented. The concept of natural reference configuration is considered [1]. Within an isothermal thermodynamic framework, a Helmholtz free energy is proposed to take into account the nonlinear compressible deformation process occurring between natural reference configuration and actual configuration. A dissipative potential is introduced in order to characterize the irreversible aspects of compaction process. Thus, the behavior law is formulated through two equations: 1) an expression of Cauchy stress tensor and 2) a differential equation characterizing the natural reference configuration evolution. Material parameters are assumed to be functions of bulk density. This allows capturing the micro-mechanical phenomena within the chosen macroscopic approach. An experimental study based on uniaxial simple and cyclic compression tests is carried out in order to characterize mechanical behavior of the anode paste. A user’s material VUMAT subroutine for finite elements dynamic explicit analysis has been developed and implemented in ABAQUS software. To evaluate the model predictive capability, the following numerical simulations were performed: 1) uniaxial simple and cyclic compression tests and 2) compaction forming process of anode paste. Simulation results show that the behavior law reproduces the experimental trends for compression tests and gives interesting physical responses for the compaction formations. This constitutes a first step toward making a benchmark with experimental results on forming process of anode paste. References [1] Konener et al, 2008. A thermo mechanical framework for modeling the compaction of asphalt mixes, Mechanics of Materials, 40, 846-864.

3:15 PM

Testing the In Situ Aluminium Cell Control with the Dyna/Marc Cell Simulator: Marc Dupuis²; Michael Schneller²; GeniSim Inc.; Stéphane Thibodeau²; Université de Sherbrooke; Marc-André Marois¹; Donald Ziegler¹; Houshang Alamdari¹; Kamran Azari¹; Mario Fafard¹; Laval university

Recently, a new approach to controlling alumina feeding in a H.H. cell has been proposed [1,2,3]. This new approach, called In Situ aluminium cell control, is based on a correlation between the slope of the cell voltage during a no feed observation period and the dissolved alumina concentration in the bath. Once the dissolved alumina concentration has been estimated, a primary calibration surface uniquely relating the dissolved alumina concentration and the anode-cathode-distance (ACD) to the cell voltage is used to estimate the cell ACD. Once both the alumina concentration and the ACD have been estimated at the end of the observation period, a PID controller can be used to regulate the rate of alumina feeding using only the cell voltage to estimate the error between the estimated dissolved alumina concentration and a target value. The In Situ aluminium cell control algorithm has now been tested with the Dyna/Marc [4,5,6] cell simulator demonstrating that it should be possible to control a H.H. cell in this manner with less variation in the dissolved alumina concentration and other process variables producing a prediction of improved cell current efficiency.

LIGHT METALS: Aluminium Production II

Monday PM Room: Lachine Location: Hilton Bonaventure Hotel

Session Chairs: Martin Désilets, Aluminium Research Centre - REGAL, Université Sherbrooke; Lyes Hacini, Rion Tinto Alcan, ARDC

2:00 PM

Development of Representative Assembly for the Fabrication of Cold Ramming Paste Samples at Laboratory: Sakineh Orangi¹; Donald Picard³; Houshang Alamdari¹; Donald Ziegler²; Mario Fafard¹; NSERC/Alcoa Industrial Research Chair MACE3 and Aluminium Research Centre-REGAL, Laval University; ²Alcoa, Primary Metals

A representative sample of ramming paste from a peripheral seam in an aluminium electrolysis cell was taken in order to develop a process to fabricate ramming paste samples in the laboratory. To this end, paste material was compacted in multilayers in a mould designed to be representative of peripheral seams in Alcoa’s smelters. The density distribution in the representative sample was measured ranging from 1.51-1.76 g/cm³. The density range obtained by the proposed methodology in laboratory is 1.47 - 1.77 g/cm³. The results demonstrate that the proposed fabrication method adequately duplicates paste density from the cell for both one and two layer compaction. Finally, preliminary results related to the compressive strength and Young’s modulus of laboratory samples were obtained at various temperatures and are presented in this paper.

www.metsoc.org
The reaction of O2 with the carbon anode is considered as the main parasitic chemical reaction affecting Hall-Heroult process anodes. The current study aims at investigating the influence of the microstructure of baked anode on its overconsumption. Samples were removed from different positions of an industrial anode. Density, porosity, LC and BET specific surface area were measured. The anode reactivity was evaluated based on the weight losses for the samples resulting from the reaction of anode with air at 550°C after 7h. The essential parameters determined to control the air reactivity are closed porosity, LC and pores with a pore entrance radius of 1.5, 8.5 and 12 µm. The knowledge of effects of these parameters allows better understanding of the reactivity of anodes and consequently reduction of their overconsumption in electrolysis bath.

4:20 PM

X-Ray Microtomography Analysis of Aluminium Electrolysis Cathodes: Martin Lebeuf; Marc-André Coulombe; Gervais Soucy; Bénédicte Allard; Université de Sherbrooke; Carbone Savoie

The phenomena occurring in the cathode and at the cathode surface of aluminum electrolysis cells are very important in regards to cathode voltage drop and cathode wear. In the current study, laboratory-scale aluminum electrolysis cell cathodes were analyzed by X-ray microtomography. This technique allows an excellent visualization of the distribution of different substances, if their respective x-ray attenuation coefficients are different enough. In the current case, the important difference in the mean atomic number between cryolitic bath and graphitic carbon results in good contrasts. The volumetric bath penetration profile, porosity and additives distribution in the cathode were thus obtained. Furthermore, metallic impurities and bath heterogeneities were observed at the cathode surface. Observations were also made with Scanning Electron Microscopy - Energy Dispersive Spectroscopy (SEM-EDS).

4:45 PM

Some Hypotheses Concerning Cathode Wear in Aluminium Reduction Cells: Ashorn Solheim; SINTEF

The service life for aluminium reduction cells is often limited by the cathode carbon, due to preferential wear along the periphery of the cell leading to the so-called “W” wear pattern. The reason for this preferential wear is not well understood. Carbon may dissolve into the aluminium pool and disappear by ordinary mass transfer across boundary layers at the cathode, at the metal-bath interface, and at the anode or gas bubbles. This can explain the average wear rate, but not the characteristic wear pattern. Two additional mechanisms for cathode wear are suggested in the present paper; 1) non-stationary dissolution of aluminium carbide into a layer of sludge that periodically forms and disappears, and 2) electrochemical formation and dissolution of aluminium carbide within an aluminium carbide layer containing bath-filled pores. The latter mechanism may be related to the high local current density at the periphery of the cathode.

5:10 PM

Cathode Wear Investigations in a Laboratory Test Cell: Kati Tschoppe; Anne Store; Stein Rorvik; Egil Skybakmoen; Arne Ratvik; Tor Grande; NTNU; SINTEF

Cathode wear has become an increasing challenge in the aluminum industry due to the use of more graphitized materials. Today, there exist no standard laboratory methods for measuring cathode wear where different commercial materials can be ranked. The typical average wear rate in an electrolysis cell is quite small (approx. 2 cm/year) but it is considerably higher in parts of the cell. The aim of this work was to design a test method where the wear could be accelerated compared to commercial electrolysis cells. It was focused on polarized tests where the cathode is exposed to electrolyte, which gives higher aluminium carbide solubility. Different set-ups were tested, and the most promising design was investigated intensively. The cathode materials were thoroughly charaterized by optical and electron microscopy and by image analysis, in order to measure the surface topography before and after the wear test.
rates, to minimize the number of weld passes while still achieving good penetration depth. This provides an opportunity to optimize welding waveforms, alternating currents, which provide maximum duration at peak current and flux combinations, and it results in reduced bead penetration. Traditional sinusoidal alternating current (which cycles polarity rapidly between positive and negative values) results in reduced bead penetration. These two issues strongly with the heavy upsetting in friction welding, or complex alloy mingling and substructure variations in friction stir joints.

3:55 PM
The Effects of Submerged Arc Welding (SAW) Waveform Variables on Productivity and HAZ Characteristics, for Single and Tandem Electrode Welds: Joel Pepin1; Hani Henein1; Douglas Ivey; Chris Penniston; Laurie Collins; Douglas Boyd; 1AITF; 2Dept. of Chemical & Materials Engineering, University of Alberta; 3Transcanada Pipeline Ltd.; 4Evraz Inc. NA; 5Dept. of Mechanical & Materials Engineering, Queens University;

High deposition, quality, and repeatability are just three of the characteristics of submerged arc welding (SAW) that make it an attractive welding process for producing pipes from microalloyed linepipe steels. Direct current electrode positive (DCEP) is the most common SAW polarity, due to good arc stability, adequate bead penetration, and availability of welding equipment. For higher deposition rates, one can use direct current electrode negative (DCEN) polarity, though this requires specialized wire/flux combinations, and it results in reduced bead penetration. Traditional sinusoidal alternating current (which cycles polarity rapidly between DCEP and DCEN) has reduced duration at peak current at either polarity, and significant periods of time at low voltage values. These two issues respectively result in reduced productivity and arc stability.

New inverter power sources address both issues through the use of square-wave alternating currents, which provide maximum duration at peak current and minimal time durations at low voltage. Such power sources also allow the welding operator to manipulate waveform variables (such as balance, offset, and frequency), providing greater control of deposition rates and penetration depth. This provides an opportunity to optimize welding waveforms for specific applications. When welding microalloyed steels, it is critical to optimize the balance of penetration and high deposition rates, to minimize the number of weld passes while still achieving good heat affected zone microstructures. A series of bead-on-plate welds were performed on microalloyed steel, to provide a greater understanding of the effects (and extent of the effects) that waveform manipulation has on welding deposition rates, penetration profiles, and heat affected zone properties. Both the effects of single electrode and tandem electrode welds will be presented. The mechanical properties, hardness, and toughness, of the heat affected zones were measured for different welding variables and will be presented.

4:20 PM
Process Engineering for the Freeforming of Al-based Components Using CSC-MIG Welding: Sean Brophy1; David Heard2; Mathieu Brochu3; 1McGill University

Controlled Short Circuit – Metal Inert Gas (CSC-MIG) welding is a process that can be referred as a “Cold Welding” technology. The CSC process is based on accurate control of the welding wire position, thus the mandatory requirement for the automation of the process. One of the main advantages of the CSC-MIG process is the rapid solidification of the deposited material, resulting in weldments displaying low porosity contents, and enabling the joining of thin sheet materials. These characteristics render this process an ideal one for freeforming of components, where rapid solidification would be efficacious. This presentation will focus on the progress made towards the freeforming of Al-based components in the NAIN laboratory at McGill University. The relationship between the filler metal used, freeforming (deposition) parameters, resulting microstructure and mechanical properties will be presented.

4:45 PM
Study On the Quality of Friction Stir Welds Made by a Robot: Michel Guillot1; Yousef Imani2; 1Laval University

Friction stir welding is a solid state joining process that is often used for joining aluminum alloys. Robotic implementation of FSW especially using existing heavy duty robots presents a strong potential for complex 3D assemblies in many industries. Although high capacity robots have been used for years, the implementation of FSW on these robots is relatively recent. Despite the fact that robots involve lack of stiffness, positioning inaccuracies and require more adapted control algorithms especially for 3D joints, their application still requires proper setting of many process parameters like the speed and feed of the tool, the plunging depth and setting forces, the tool geometry and attack angle. Accordingly, this paper proposes first a brief overview of the robot, a Fanuc M900 of 700kg of payload, and FSW head. The complete experimental set-up is introduced as well as acceptable robot settings and force control algorithms for the FSW needs. Secondly, sets of experiments made on 1.52 and 2.54 mm thick AA 6061-T6 plates are carried out with linear and circular joints using several parameters to optimize the weld strength. These include the rotational speed in the range of 700-1800 rpm, the welding speed in the range of 0.3-1.5 m/min and the attack angle between 1 and 4 degrees. The weld quality is checked with surface appearance and the microstructure of the cross section of the joints and by use of mechanical tests such as bending, tensile and hardness measurements. Linear joints obtained from robotic FSW have been compared to similar joints produced by a CNC machine. Overall, the results have shown that it is possible to make linear and circular defect free FSW joints with good mechanical and microstructural quality using an industrial robot.
NEW TECHNOLOGY IMPLEMENTATION IN METALLURGICAL PROCESSES: New Technology Implementation

Monday PM  Room: Fontaine H  October 3, 2011  Location: Hilton Bonaventure Hotel

Session Chair: Pascal Cousoul, Alouette

2:00 PM  An Advance in Nickel Laterite Dust Processing at PT Inco: Anchal Santhani; Angaa Luckita; Richard Jones; Jafri Syarifuddin; Roimon Barus; Jeffrey Donald; Vale Base Metals Technology Development Ltd.; 3PT International Nickel Indonesia Tbk.

In conventional RK-EF laterite nickel processing, management of dust continues to be problematic. A large proportion of the material flowing through the kilns represents recycled dust, typically around 15%. More efficient processing of dust represents an opportunity for energy efficiency, increased production and productivity. PT Inco, in partnership with Vale Base Metals Technology Development (VBMTD), has successfully developed and implemented a novel flow sheet enhancement that capitalizes on these opportunities. Dust released by the kiln off gas is captured and recycled by injecting it into the main burner of the kiln at the calcine discharge point. The dust then joins the calcine, while the dusting rate of the kiln is unchanged. The present work describes the technology, the process through which it was developed and summarizes the lessons learned. A key conclusion is that successful new technology development requires a multi-disciplinary team involving R&D, study management, engineering consultants, project implementation management, process technology and operations.

2:25 PM  Empowering Operations and Maintenance through Wireless: Neil Freeman; Sorosh Amidi; David Fisk; 1Honeywell; 2Matrikon

Wireless technologies are permeating the mining and metals industry and enabling a myriad of benefits. With standards such as IEEE 802.11 for wireless devices and ISA100.11a for wireless field instruments protecting their investments, customers look to benefit from the cost and flexibility offered by wireless devices. Using wireless field instruments, plants are eliminating the costs associated with wired system by 50-70 percent and using these savings to install more field instruments which used smartly enables them to optimize their processes efficiency and equipment reliability. Wireless also empowers a mobile workforce by allowing them to have access to key process and maintenance data directly from the field. This paper describes how wireless can help operations and maintenance personnel to be more effective. Three case studies, illustrating how the mining and metal industry are taking advantage of the technology today, are presented: - Optimisation of the water recovery process using wireless - Field operations improvement with wireless handhelds - Improving fleet maintenance through wireless mobile equipment management Finally the paper will conclude with an examination of some of the future technologies that will be enabled through wireless.

2:50 PM  Monitoring Refractory Linings in Operating Furnaces by Acousto Ultrasonic-Echo Technique: Afshin Sadrí; Pawel Gębski; Koorosh Mirkhani; Wai-lai Ying; 1HATCH

The campaign life of an industrial metallurgical vessels strongly relies on the quality and quantity of the refractory lining. An operating furnace or converter refractory lining can be assessed either by thermal modeling or by acousto ultrasonic-echo (AU-E) technique or a combination. AU-E is a Non-Destructive Testing (NDT) stress wave propagation technique that has been utilized on a wide variety of smelting vessels for over 12 years with good success. AU-E can determine the thickness of remaining refractory lining, estimate the thickness of build-up or accretion, detect and locate metal penetration and impregnation into the lining, and identify hydrated or cracked areas of refractory. This paper details the AU-E principles, equipment and recent improvements to the data analysis to further improve speed and accuracy. In addition, the paper discusses the AU-E accuracy and limitations through a diverse and vast array of practical examples including a comparison with thermal modeling and physical measurements.

3:15 PM  Optibar Technology Successfully Implemented in Copper Electrowinning: The Myth is Fading: Eduardo Wiechmann; Guillermo Vidal; Dolfrentino Muñoz; Cristian Castro; 2Optibar Ltd.; 3Barrick Gold Corporation Zaldívar Mining Company

Different authors and publications indicate that Optibar Segmented Interell Barcause a remarkable distortion in the distribution of the current in a cell group. However, these results were based in inaccurate computer based models and do not represent the technology. During the last trimester of 2010, a 92 cells circuit from Barrick Zaldívar EW plant was implemented with Optibar Segmented Interell Bars. The technology was incorporated progressively without disrupting the plant production. Depending on operational conditions, this led to a 2 to 4% current efficiency increase and 3 to 5% specific energy consumption reduction. By October 2011, 40,000 tons of copper will be produced with the technology.

3:55 PM  Design of the New Lihir Gold Pressure Oxidation Autoclave: Michael Collins; A. Hasenbanl; B. Hewitt; 2Serritt Technologies; 3Newcrest Mining Limited

Newcrest Mining Limited, originally as Lihir Gold, has operated a pressure oxidation plant for the recovery of gold from refractory ore since 1997. The mine and gold plant are located on Lihir Island in Papua New Guinea. Design of the original pressure oxidation circuit was based on the results of pilot plant tests conducted by Serritt Technologies in Fort Saskatchewan. Following a decision to expand the plant in 2008, Lihir Gold contracted Serritt to design a new autoclave. The design exercise utilized the original pilot plant test results, commercial process results at Lihir, and an understanding of advances in autoclave technology since the original plant was built. The new Lihir autoclave will be the largest pressure oxidation autoclave in the world. Mechanical challenges encountered in the design of this new vessel are described in this paper.

4:20 PM  Cobalt from Slag- Lessons in Transition from Laboratory to Industry: Arthur Barnes; Rodney Jones; 2Xstrata Process Support; 3Mintek

Anglovaal Minerals acquired the Nkana dump from ZCCM in 1998 and embarked on an ambitious project to pioneer the recovery of cobalt from slag using DC smelting technology. Anglovaal Research Laboratories performed initial pioneering smelting tests in a 250 kW DC furnace over a 3-year period before engaging Mintek for three piloting campaigns at the 1.5 MW level. Mintek had previously developed a reductive smelting process, patented in 1995, using a DC arc furnace for the recovery of cobalt from slags. The results of the pilot-plant test campaigns were used as the basis for engineering the commercial 40 MW operation installed at Chambishi Metals plc in Zambia in 2001. This paper traces the development of understanding of the metallurgical fundamentals ultimately used to predict furnace performance, reviews some of the extreme technical challenges faced, how solutions were identified and highlights some of the critical issues identified during piloting and how these impacted both positively and negatively on the final commercial operation.

4:45 PM  Copper EW Processes: State of the Art in Optimizing Current Density Distribution: Guillermo Vidal; Eduardo Wiechmann; Cristian Castro; 2Optibar Ltd.; 3Barrick Gold Corporation Zaldívar Mining Company

In copper EW plants the optimal current density setpoint depends on the electrolyte composition and temperature. However, conventional plants operate with large standard deviations. A value of 14% with current densities offsets up to ±50% is typical. For worst, during opencircuit or
shortcircuit events this variation can be from -100% to +200%. Naturally, energy consumption and copper quality are compromised. Several devices have been successfully employed to reduce set point deviations. Last developments include: Optipar Segmented Intercell Bars, Outotec Electrodes Arranging Method and NTC Selective Electrodeposition Enhancers. This paper researches and compares these technologies. It is shown that short circuits can be effectively reduced in occurrence and magnitude. Moreover, 80% of the electrodes can be forced to operate within ±10% of the set point. The specific energy consumption is reduced from 2,000 kW per Ton to values close to 1,900 kW per Ton.

5:10 PM
Implementation of Magnetic Conditioning in Two Stages of a Sequential Cu-Zn Flotation Separation: Barry Lumsden1; Jodi Wilding2; 1Ausmec Pty Ltd; 2Jaguar Metals

The implementation of new technology to mineral separation operations requires rigorous testing to confirm the technology’s technical and economic benefit. The Jaguar Mine owned by Jabilcu Metals is located in Western Australia and sequentially separates a copper concentrate and then a zinc concentrate. Fine grinding (80% of zinc in tail is

WASTE RECYCLING IN MINERAL AND METALLURGICAL INDUSTRIES: Metal Recycling II

Monday PM  Room: La Salle
October 3, 2011  Location: Hilton Bonaventure Hotel

Session Chair: Michael Sudbury, Consultant

2:00 PM
The Characteristics of Electrolytic Refining of Tin Soldering Scrap Material in Hydrochloric Acid Solutions: Gergo Rimaszéki1; Tibor Kulcsár1; Tamas Kekesi2; 1University of Miskolc

The efficient purification of soldering waste material can be achieved in a single operational step by the electrolytic refining in pure hydrochloric acid – tin-chloride media. The complex formation of the ionic species may offer a beneficial level of natural inhibition. Using the PCR (periodic current reversal) technology, is efficient in affecting the morphology of the cathodic deposit. In order to optimize the process, the investigation of the solution stability and the electrode reactions is essential. The natural tendency of the Sn(II) oxidation and precipitation can be overcome by properly controlling the concentration of the main components and the ratio of Sn(VI)/Sn(II) in the electrolyte solution. Polarization curves were obtained for different concentrations Sn and hydrochloric acid. Conclusions referring to the electrode reaction were derived from the overvoltage - current plots. The morphology of the deposit can be correlated with the exchange current density, also determined from the polarization curves. The cathodic current efficiency and the morphology of deposited metal are effected by the distribution of tin species and the principal electrolysis parameters.

2:25 PM
Vanadium and Molybdenum Recovery from Industrial Wastes Using Cybber Ion Exchange Resins: Dmitry Kipper1; Vadim Korovin2; Yury Shestak3; Alexey Tikhonov1; Alexey Olifirenko1; 1NVK“Syntez”; 3N. Polyakov Institute for Geotechnical Mechanics at National Academy of Sciences of Ukraine

The present paper deals with vanadium and molybdenum sorption from industrial wastes and intermediate processing products using Cybber macro porous strong- and weak-base anionites. Regularities of vanadium and molybdenum recovery by Cybber anion-exchange resins as well as desorption processes were studied in static and dynamic modes; their efficiency was demonstrated for that purposes. The results of the work may be used while designing technologies for complex processing of both ores and industrial wastes containing vanadium and molybdenum.
comes from their sorption properties, i.e. affinity for contaminant solutes, and/or ion exchange capacity. Once adsorbed, contaminants can become permanently stabilized within an operating window (pH, temperature, dilution extent). The aim of this study is to immobilize heavy metal pollution in north Belgium region due to historical metallurgical activities, in particular, As, Cd, Pb and Zn with both commercially available (Iron (hydro)oxides, Hydroxypatite and natural Zeolites) and in-house made synthetic absorbents (synthetic Zeolite and WTRs).

2:25 PM The Effects of Thiocyanate Loading and Incubation Temperature on the Thiocyanate Degradation Ability of a Mixed Microbial Population: Andries van Zy1; Sue Harrison1; Rob van Hille1; ‘University of Cape Town

The BIOX® process uses a combination of iron and sulphur oxidising microorganisms to liberate pyrite/arsenopyrite occluded gold prior to recovery by cyanidation and CIP. The reaction between cyanide and residual sulphur species results in the formation of a complex matrix containing thiocyanate (SCN < 1500mg/L) and residual cyanide (CN < 70mg/L). The BIOX® culture is inhibited by thiocyanate (> 1mg/L), precluding the recycling of tailings water up-stream of the bioleaching circuit. The drive toward water recycling and the desire to be zero-discharge has necessitated on-site treatment. The activated sludge tailings effluent remediation (ASTER) process was developed to facilitate water recovery and treat waste water (to SCN < 1mg/L) for disposal. Driven by the desire to commercialise and export the ASTER technology, research has been conducted to characterise operating window, composition and tolerance of the microbial consortium and thiocyanate degradation kinetics. The investigated temperature- and thiocyanate concentration ranges were 15-40°C and 60-1500mg/L respectively. Batch data showed SCN degradation rates to range between 12-60mg/L/h at initial SCN concentrations of 60-1500mg/L at 27°C. Linear SCN degradation rates were observed, following an initial adaptation period of approximately 10h. SCN degradation rates were reduced at 15°C and 40°C. Individual species were isolated using classical microbiological techniques. Pure culture kinetic data is being obtained as a function of substrate loading, dilution rate and temperature. Integration of these data, coupled with microbial ecology investigations will provide the necessary information to develop a predictive performance model.

2:50 PM Factors Affecting the Start-up, Operation and Decline of a Laboratory-Based Passive Treatment System for Selenium and Sulfate Removal: Parissa Mirjafar1; Luke Moger2; Ron Martel1; Susan A. Baldwin1; ‘University of British Columbia; 2Mount Polley Mining Corporation

Mine drainage contains metals and sulfate, which may be toxic to aquatic life at certain concentrations and should be removed to acceptable levels before release of any drainage to the environment. One method for treating mine drainage is passive treatment systems, which is increasing in popularity due to lower construction and operating costs. This method is based on the activity of sulfate reducing bacteria (SRB) respiring on sulfate while using fermentation products from decomposing complex organic materials. The product of this biological process is hydrogen sulfide, which reacts with metals in mine drainage and precipitates them as metal sulfides. However, in practice passive treatment systems are not always effective, reducing the reliability of this approach. In this study, a mixture of hay, cow manure and wood chips was tested in continuous flow experiments for efficacy at sustainable treatment of sulfate and selenium containing water from a mine tailings pond. Factors that contributed to a decline in performance included lowering of the pH due to acids leaching out of the organics, re-oxidation of sulfide back to sulfate and a reduction in dissolved organic compounds over time. In this paper we describe methods to overcome these problems so that treatment is more reliable.

3:15 PM The Behaviour of As(III) and As(V) during the Precipitation of Alunite at 98°C: Alba Sanyaer1; John Dutrizac2; ‘University of Barcelona; ‘CANMET

The factors affecting the precipitation of arsenic-free alunite (KAl(SO4)2(OH)4) were investigated in a series of laboratory experiments. Although the amount of alunite precipitated increased with increasing retention time, temperature, solution pH and the concentrations of Al(SO4)2 or K2SO4, the composition of the products remained nearly constant. The preferred conditions identified for the precipitation of arsenic-free alunite were then used to assess the behaviour As(III) and As(V) during alunite precipitation at 98°C. Increasing additions of As(III), as NaAsO2 or As2O3, resulted in a slight increase in the amount of precipitate formed at pH 2.80. However, X-ray diffraction analysis showed all the precipitates to be alunite, and <0.2% As(III) was detected in the products. In contrast, increasing additions of As(V), as KH2AsO4 or As2O5, resulted in significant increases in the amount of precipitate formed at pH 2.80 or 3.00. Furthermore, the arsenate (AsO4 3-) contents of the precipitates increased up to 15%, and the sulphate content decreased, as the As(V) concentration of the synthesis solution increased from 0 to 9 g/L. X-ray diffraction analysis of the products detected only alunite, but there was a progressive expansion of the alunite cell with increasing arsene content. The implication is that arsenic substitutes for sulphate in the alunite structure. Preliminary observations on the environmental stability of the arsenate-bearing alunite using the TCLP protocol gave solubilities <0.4 mg/L from a precipitate containing 8.5% As2O3 and 7.8 mg/L from a product containing 19.5% As2O5. Thus, it appears that alunites containing less than ~10% As2O3 would be an acceptable vehicle for the disposal of arsenic from hydrometallurgical processing solutions.

3:55 PM The Application of Advanced Characterization Techniques to Industrial Waste Removal Procedure: Nicolas Geoffroy1; Suzie Poulin1; George Demopoulos2; ‘Ecole Polytechnique; 2McGill University

Most metallurgical industries generate toxic waste that must be treated prior to being released to the environment. However, in a lot of cases, the waste materials are poorly characterized or the analytical results are not well interpreted. These shortcomings often result in the development of inefficient industrial procedures, thus causing economic waste and difficulty meeting environmental regulations. Fortunately, a wide range of analytical techniques are available to guide researchers and engineers into making sound process development decisions. In this work, an industrial selenium and mercury removal process is used as an example to illustrate the application of X-ray photoelectron spectroscopy (XPS), scanning electron microscopy (SEM) coupled with Energy-dispersive X-ray spectroscopy (EDX) and powder X-ray diffraction (PXRD) on solid waste. Furthermore, samples of analytical results are presented and interpreted and the modifications to the industrial process that resulted are explained. Finally, a brief description of the advantages and limitations of the aforementioned analytical techniques is given with an emphasis on industrial solid waste material.

4:20 PM Characterization and Reduction of Filter Dusts in the Liquid Phase: Gerald Schneeberger1; Stefan Steinlechner1; Jürgen Antrekowitsch1; ‘University of Leoben

The recycling of steel mill dusts is getting more and more important in future. The costs and requirements of land filling are rising and companies are interested in new recycling strategies. The rising of sustainability hand in hand with the high rate of valuable metals in these residues supports new research activities on the recycling sector. Especially zinc but also iron and lead are economical factors due to the treatment of steel mill dusts. This paper gives a small overview of fundamental studies concerning the chemical and physical composition of these dusts. Furthermore, aggregates for the reduction of these dusts in the liquid phase are introduced and compared. The Flash-Reactor, the TBR-Technology (Top Blown Rotary
Converger and submerged arc furnaces and there use for melting and treatment of these dusts are in the center of interest of this paper. The final conclusion gives an overview of possibilities for reduction of filter dusts in the liquid phase.

4:45 PM

Characterisation of Sulphide Oxidation in a Passive Acid Rock Drainage (ARD) Treatment System: Neelam Mooruth1; Robert van Hille2;
1University of Cape Town
2Cabri Consulting Inc.

Acid rock drainage (ARD) is a significant problem associated with the commercial exploitation of sulphide minerals. Remediation is typically through active chemical treatment (lime dosing), although active and passive biological systems are receiving increasing attention. In water scarce regions, such as South Africa, the sulphate salinity in addition to acidity and heavy metal load is a concern. A demonstration scale plant based on the IMPI (Integrated Managed Passive treatment) process has been constructed at a coal mine in South Africa. The sulphate reduction components have operated successfully, but the sulphide oxidation reactor, which relies on the formation of a floating sulphur biofilm, has not. The research involved a robust characterisation of the system using purpose-built laboratory scale (2.5m x 0.1m x 0.15m, 25L liquid volume) linear flow channel reactors (LFCRs). The work focussed on the hydrodynamics, sulphide oxidation kinetics and the microbial community structure. An oxygen requirement model, based on reaction stoichiometry and mass transfer kinetics, was developed to determine the required interface area for different volumetric loading rates. A comprehensive hydrodynamic tracer study was conducted to accurately describe the flow patterns within the reactor. The laminar flow and significant vertical stratification has important implications for reactor operation. The LFCRs were fed continuously with the effluent from two sulphate reducing degrading packed bed reactors (DPBRS), with a sulphide concentration ranging from 100-220mg/L. A 90% reduction and > 75% conversion to elemental sulphur was achieved at a hydraulic residence time of 5 days.

WORLD GOLD: Geology I

Monday PM  Room: Fontaine E  Location: Hilton Bonaventure Hotel
Session Chair: G. Kirkham, Consultant

3:15 PM

Status of “Invisible” Gold: History and Analytical Methodology: Louis Cabri1; Gabriel Voicu2;
1Cabri Consulting Inc.
2Iamgold

The earliest account of gold occurring “invisibly” in sulphides was by Bürg (1930, 1935) and its significance in mineral processing was discussed by Haycock (1937); both long before routine use of SEM, EPMA, and application of more specialized characterization methodology such as micro-PIXE, SIMS, LA-ICPMS, XANES, 197Au Mössbauer spectroscopy, and TEM. Boyle (1979) concluded that it is more probable that gold is present in a finely divided (colloidal?), often submicroscopic state (<0.1 µm). Interestingly, this size limit was also similar to that suggested by Haycock (1937) based on optical microscopy. Prior to 1986 there was no proof of chemically-bound gold until appearance of reports by Marion et al. and Wagner et al. (1986). Today, we have abundant proof of the occurrence of gold in sulphides in concentrations not readily visible optically or by SEM, which can occur either at the atomic level (chemically-bound) or down to nm-size particles of native gold. We may refer to both types of occurrence as “invisible” or “sub-microscopic” gold. Determination between chemically-bound and fine particulate gold requires detailed characterization using techniques such as XANES, 197Au Mössbauer spectroscopy, XPS, and TEM, which is complicated for many reasons. Factors making characterization challenging include (a) common heterogeneity of gold distribution, (b) extrapolation from very high magnifications up to grain- and sample-size, (c) quantification of measurements/images, and (d) common presence of both types of gold in a single grain. Present-day methodologies for characterizing invisible gold will be reviewed, together with a personal view of best practices and pitfalls to avoid.
4:45 PM
Orogenic-Type Gold Mineralization at Klipwal Gold Mine, Southeastern Kaapvaal Craton, South Africa: Sakshi Chinnasamy; Ron Uken; Jürgen Reinhardt; 1University of KwaZulu-Natal

The Kilpwal Gold Mine is located on the Klipwal Shear Zone, in the southeastern part of the Kaapvaal Craton, South Africa. Gold mineralization is confined to laminated quartz-carbonate lodes and associated alteration along the shear zone in sandstone and silstone of the Delfkom Formation and associated intrusive diabase in the upper Mozaan Group of the Mesoprochacne Pongola Supergroup. The moderately dipping brittle-ductile shear plane strikes N-S and displays an oblique-reverse sinistral sense of shear. Intense anastomosing shears define a sheaf fabric in the host rocks with numerous shear-parallel laminated quartz-carbonate veins and in places, a quartz vein stockwork. There is evidence of subsequent brittle faulting that reactivated the shear plane. Three closely spaced economic reefs (lodes) are developed: the main R-reef constitutes the shear zone while the J- and H- reefs are footwall splays of varying dip. Alteration comprises chlorite, epidote, sericite and feldspar along with pyrite, arsenopyrite and pyrrhotite ± chalcopyrite. At least two distinct hydrothermal alteration zones are observed. An inner zone, dominated by laminated quartz-carbonate veins and a proximal zone characterized by alteration halos and associated quartz veins. Gold mineralization is confined to flexures in the Klipwal Shear Zone with possible sources of gold derived from: (i) palaeo-placer U-Au rich conglomerates in the underlying Singeni Formation of the Mozaan Group (ii) the underlying ~4.6 km thick mafic volcanics of the Nsuze Group; (iii) greenstones belts in the basement to the Pongola basin. Post-Pongola Supergroup granites are considered to have provided the heat to mobilize auriferous fluids into the Klipwal Shear where gold and sulfides were precipitated under suitable physicochemical condition.

WORLD GOLD: Plenary

Monday PM  Room: Hampstead / Cote St. Luc
October 3, 2011  Location: Hilton Bonaventure Hotel

Session Chair: Peter Kondos, Barrick Gold

2:00 PM Panel Discussion Gold Company COO’s and CEO’s Panel discussion of top leaders in the Gold industry. Guest moderator Amanda Lang, Senior Business Correspondent, CNBC News

Panelists include:
- Peter Kunver, EVP and COO, Barrick Gold Corporation
- David Harquail, President and CEO of Franco-Nevada
- Gordon Stothart, EVP and COO, IamGold Corporation
- Sean Roosen, President and CEO, Osisko Mining Corporation

WORLD GOLD: Mineralogy of Precious Metals II

Monday PM  Room: Hampstead / Cote St. Luc
October 3, 2011  Location: Hilton Bonaventure Hotel

Session Chair: J. Zhou, Consultant

3:45 PM
The Novel Use of XRF Spectrometry in the Refining of Gold: Michael Hinds; 1Royal Canadian Mint

X-ray Fluorescence Spectrometry is used at various stages of gold refining. Initially, incoming impure gold is analysed for content and deleterious elements such as As, Cd, Hg, Se, and Te using a portable XRF spectrometer for a screening assessment. Based on the levels of these impurities the material can be returned to the client or accepted for refining. The gold is then melted and the purity assessed by wavelength dispersive XRF to determine Au, Ag, Cu, and other elements to assist the Fire Assay of gold and silver. Other elements such as Cu, Fe, Ni, and Zn are also determined and the refinery alerted if any of these elements are abnormally high. A simple energy dispersive XRF is used to determine the end point of chlorination refining step (max 0.5% sum of Ag and Cu) before the gold goes on to the final electrolysis refining. This paper will highlight the utility of XRF to determine impurity concentrations at critical steps in the refining process.

3:55 PM
Mineralogical Investigation of Carbon Leader Reef samples from TauTona Mine, South Africa: Katarien Deyse1; 1AngloGold Ashanti

Gold has been mined from a variety of deposit types that range in age from Archaean to Recent. The large variability in the geological settings of the gold deposits implies transport and concentration of gold by magnetic, hydrothermal and sedimentary processes. The factors that control the concentration of gold at certain sites and the grade estimation thereof remain major topics of debate. Due to the complex nature of the Witwatersrand Basin a mineralogical study, including mineralogical, petrographic and geochemical investigation was launched on TauTona Mine in order to characterize the various reef facies. The aim of the investigation was to determine if a correlation could be found between macroscopic characteristics of the reef, hanging wall and footwall, and the microscopic nature of the ore (especially gold grade).

4:20 PM
Process Mineralogy of the Refractory Gold Part of the Lapa Deposit: Raphael Mermillod-Blondin1; Hassan Bouzahzah2; Mustafa3; Philippe Marion; Nathalie Vallée4; Paul Cousin5; 1Agnico-Eagle Mines; 2University of Quebec in Abitibi-Temiscamingue ; 3INSA Lyon LGCIE; 4Philippe Marion, Laboratory for Environment and Mineral Processing; 5CRP-Gabriel Lippmann

The gold deposit of Lapa mine shows a contrasted gold mineralogical state with coarse and fine native gold, aurostibite and submicroscopic gold within arsenopyrite. Pyrrhotite and pyrite are the other main sulphides in the ore. The Lapa mill plant is designed to recover essentially the native gold proportion accounting for 80 to 85 % of the total gold content. A specific mineralogical characterization of the refractory fraction was conducted combining various techniques. The optical microscopy and the electron microscopy have characterized the arsenopyrite grains. The electron microprobe and the secondary ion mass spectrometry have characterized the gold content as well as the gold distribution within the arsenopyrite grains. In parallel, the mineral processing behaviour and the recovery of the refractory gold were studied combining sulphide flotation and pressure oxidation / cyanide leaching of the sulphide concentrate. This paper presents the mineralogical method developed to characterize the gold distribution within arsenopyrite. These results are presented and interpreted in order to plot gold recovery versus sulphide oxidation. The comparison of the metallurgical behaviour yields predicted from mineralogical data and the one calculated from leaching tests shows a good agreement and allows mineralogical explanations of the metallurgical behaviour.

4:45 PM
New Developments in Characterization of Sulphide Refractory Au Ores: Louis Cabri1; Simon Jackson2; 1Cabri Consulting Inc.; 2Geological Survey of Canada

Quantitative determination of sub-microscopic gold at sub-ppm concentrations in sulphide minerals can be an important component of department studies for sulphide-gold deposits. Modern in situ analytical techniques, which are now capable of low to sub ppb detection limits, are preferred for this application because they are cost-effective and provide not only concentration data but also precise information on the spatial variation of gold and other elements both within and between grains. From 1989, Secondary Ion Mass Spectrometry (SIMS) was the analytical method of choice until about 2003-2005 when Laser Ablation Inductively Coupled
**Pilot Plant Pressure Oxidation of Refractory Gold-Silver Concentrate**

3:15 PM  
Session Chair: Chris Fleming, SGS

Pilot Plant Pressure Oxidation of Refractory Gold-Silver Concentrate  

1. Its greater speed to measure a greater number of elements (typical analysis ~2 minutes for ~20 or more elements) – more analyses per day provides more robust statistics and lower costs; (2) much reduced matrix dependence – all sulphide mineral analyses can be accurately calibrated using synthetic pyrrhotite standards; (3) readily variable spot or raster diameter and depth (from ~20 to >100 μm) – provides the ability to sample a larger mass for more elements. Recent advances in LA-ICP-MS analysis include the development and application of elemental mapping. This employs multiple line ablations across petrographic sections, allowing sampling of the (polished) surface of entire grains. The data can then be deconvoluted to generate elemental maps which provide detailed information on spatial variations of gold and other elements within grains. This will be demonstrated with specific examples.

5:10 PM  
Procedure for Characterization of Carbonaceous Matter in an Ore Sample with Estimation Towards its Preg-Robbing Capacity: Brian Hart; Stamen Dimov; Raphael Mermillod-Blondin; University of Western Ontario; Agnico-Eagle Mines

Active carbonaceous matter (c-matter) in sulphide ores can adversely affect the process of gold recovery during cyanidation due to its ability to adsorb, or preg-robb, gold from a cyanide leach solution. This paper describes a standardized procedure for the full characterization of carbonaceous matter in an ore sample. The data will provide an estimate on the impact the c-matter will have on the gold recovery process. The procedure utilizes the following complementary analytical techniques in conjunction to several chemical tests and assays: scanning electron microscopy coupled with energy dispersive x-ray analysis (SEM/EDX), laser Raman spectroscopy (Raman) and Time-of-Flight Secondary Ions Mass Spectrometry (TOF-SIMS). The application of the various techniques and the information they provide are outlined below. SEM/EDX provides compositional analysis of various types of carbonaceous particles in the sample. It identifies the disseminated component within gangue particles and provides information on the distribution of the c-matter within the various grains. The organization of the carbon (maturity), in the carbonaceous matter is determined by laser Raman spectroscopy. The technique uses the shape and width of characteristic Raman peaks for C to provide information on the nature of the carbon bonds. The degree of their symmetry (or asymmetry) combined with their shift in wavelength provides information on the nature of the carbon bonds. The technique can differentiate a wide range of carbonaceous materials: from pure graphitic carbon to combined with their shift in wavelength provides information on the nature of the carbon bonds. The degree of their symmetry (or asymmetry)

**WORLD GOLD: Refractory Ores**

Monday PM  
October 3, 2011  
Room: Mont Royal  
Location: Hilton Bonaventure Hotel  
Session Chair: Chris Fleming, SGS

3:15 PM  
Pilot Plant Pressure Oxidation of Refractory Gold-Silver Concentrate: Michael Collins; Ding Yuan; Ian Masters; Robin Kalanchey; Lin Yan; Sherritt Technologies

Sherritt Technologies recently completed a program of batch and pilot plant pressure oxidation test work for a refractory gold-silver project located in China. The feed concentrate composition was 39 g/t Au, 970 g/t Ag, 3.3% As, 20% Fe and 22% S; the major sulphide minerals were pyrite and arsenopyrite. Since the feed material contained a significant amount of silver, which is known to be refractory to cyanide leaching after pressure oxidation due to the formation of argentojarosites, the process development work included investigation of methods to enhance silver recovery. The “lime boil” process proved successful and was incorporated into the flowsheet. The pilot plant results confirmed the viability of the pressure oxidation process. Gold extraction from the lime boil residues was 95 to 98%; silver extraction was up to 94%.

3:55 PM  
Roasting Renaissance- Fluid Bed Roasting for Enhanced Gold Recovery from Double Refractory Ores: Arthur Barnes; Nathan Stubina; Xstrata Process Support; Barrick Gold Corporation

Increasingly, gold producers are forced to treat ever more refractory ores. While ores containing pyrite, arsenopyrite and carbonaceous material have been subjected to complete pressure oxidation (POX) as the standard process for such ores, recent improvements in fluid bed roasting technologies have led to a resurgence of interest in roasting as a viable alternative. The lower capital and operating costs of roaster installations add further impetus to this trend. The Extractive Metallurgy Group at Xstrata Process Support operates 3 fluid bed reactors of various sizes which have been utilised on a large number of projects to treat highly refractory ores. Preliminary mineralogical modelling of both the physical and chemical aspects of the roasting process and subsequent testing under carefully controlled conditions has allowed clients to obtain gold recoveries approaching or matching those achievable by POX. The flexibility of the units to operate in various modes- bubbling bed, circulating bed, two stage, sub-stoichiometric and combinations of these, and the range of sample sizes accommodated, from a few kilograms to a few tons, has enabled XPS to accommodate clients with a wide variety of gold bearing refractory ores from all over the world. This paper outlines the key challenges of fluid bed roasting of refractory gold ores, describes the methodology used to design the testwork program and provides some results from select test campaigns.

4:20 PM  
Fluidised Bed Technology for Gold Ore and Gold Concentrate: Marcus Punktel, Jörg Hammerschmidt; Jochen Güntner; Ake Holmström; Outotec GmbH; Outotec AB

A significant portion of Outotec’s business relates to the application of fluidised bed for processing a wide range of industrial materials, including gold ore and gold concentrate. As part of the former Lurgi and Boliden organization, our division constructed the first industrial reactor for roasting sulphur-bearing materials in 1950, based on the principles of fluidised bed technology. This process, when combined with efficient heat recovery and off-gas treatment and its conversion to sulphuric acid, eventually became the standard for processing sulphur-bearing ores. In the last 60 years we have delivered more than 265 plants and developed (in addition to the standard fluid bed solution) variants of the sulphurisation technology, such as the circulating fluidised bed and the bubbling fluidised bed. This paper describes the different options of the fluid bed technology for gold roasting under reflecting main process design criteria.

4:55 PM  
The CESL Gold Process: Tom Robinson; Keith Mayhew; David Jones; Kevin Murray; TECK

The CESL Copper Process was developed as a hydrometallurgical alternative to smelting and refining for copper sulphide concentrates. As the majority of such concentrates contain appreciable gold and silver values, effective recovery of these metals is an intrinsic part of any hydrometallurgical processing technology. Unfortunately, conventional cyanide processing cannot be used due to the unusual characteristics of most hydrometallurgical copper residues when compared with naturally occurring gold and silver ores. An abundance of elemental sulphur, as well as the presence of cyanide leachable copper, leads to the formation of both thiocyanate and copper cyanide which is detrimental to process economics due to excessive cyanide consumption. This, however, can be reduced to
acceptable levels by process innovations such as pressure cyanidation and cyanide recovery. This paper outlines the successful application of the CESL Gold Process to various gold-bearing copper concentrators.

5:10 PM
Development (Optimization) of the Detour Lake Concentrator: Integration of the Results of Communion and the Metallurgical Test Work Program: Jorge Torrealba1; André Allaire1; Rickardo Welyhorsky2; Jean François Dupont1; IBMA; Detour Gold Corporation
The Detour Lake property is located in Northeast Ontario, approximately 185 km northeast of Cochrane Ontario. The production of the mineral process plant envisioned will be 55 000 tpd during the first three years of operation and an expansion to 61 200 tpd is planned from the fourth year and beyond. The mill will process a free milling gold ore utilizing both a gravity circuit and leaching with a state-of-the art carbon-in-pulp circuit. The results of the analysis of the pre-feasibility study indicated that further optimization of the circuit configuration was possible. Additional testwork required to support optimization of the plant design criteria for the feasibility study was conducted in a second phase of metallurgical testing and analysis. The test results showed that the recovery of gold was not sensitive to grind size in the range of 75 to 105 microns. An additional result was that the presence of lead nitrate did not improve the kinetics of gold leaching. This conclusion was supported by the low content of sulphides in the ore. It was also found that the presence of lead nitrate increased copper dissolution, producing the potential for an increase of copper reporting to electrowinning, which is detrimental to the overall gold recovery process. The use of oxygen in leaching was investigated as a clean alternative to the use of lead nitrate for an increase to the leaching kinetics. The results of leaching tests to compare using oxygen instead of air indicated that, due to the improved leach time, it was possible to reduce the number of leaching tanks from twenty-four (24) to twenty (20).

WORLD GOLD: Strategic Mine Planning II

Monday PM
Room: Fontaine D
October 3, 2011
Location: Hilton Bonaventure Hotel
Session Chair: R. Henderson, Kinross Gold

3:15 PM
The Resource Valuation and Optimisation Model: Real Options Impact Applied to Mining: G Evatt1; P Johnson2; P Duck3; S Howel4; J Moriarty5; 'School of Mathematics, University of Manchester, U.K.; 'Gemcom Software; 'Manchester Business School, University of Manchester
This paper presents the scientific framework underpinning the Resource Valuation and Optimisation Model (RVOM). The RVOM is a Real Options software package, which helps mine owners optimally plan their operations, understand their project risks, and make defensible valuations. This is achieved in the presence of both financial and physical uncertainty. The three key outputs from the RVOM are: Valuation, Optimal Decision and Probability of Decision, where a decision can include normal operation, expanded operation, care and maintenance, and abandonment (and variants thereof). This paper presents a clear example of the RVOMs usage to a case-study gold mine.

3:55 PM
Use of Conditional Simulation to Assess Misclassification of Ore and Waste in a High Nugget, Low Continuity Gold/Copper Deposit: Lawrence Allen1; William Hardièke1; Bruce Perry1; Ian Douglas1; 'Newmont Mining Corporation
Model reconciliation problems at the low-grade, high-nugget Phoenix gold-copper deposit led to an examination of the influence of production decisions on ore-waste classification. A conditional simulation study of the deposit was used as the basis for: 1) quantification of dilution at different bench heights, 2) quantification of ore-waste misclassification relative to bench heights and cut-off grades, and 3) determination of an appropriate number of samples to optimize ore-control polygon definition. Actual reconciliation data were empirically used to support conclusions. Simulations of both gold and copper were combined through net revenue modelling. These simulations increased the understanding of the nature of the deposit and provided insight for resource modelling and mine planning.

4:20 PM
Goldex Mine – Overview: Jean-François Laguenue1; 1Agnico-Eagle Division Goldex
The Goldex Mine is an underground gold mine located in the prolific Val-d’Or mining district of northwestern Québec, Canada. Because of its shape and low grade, the Goldex deposit is mined using a hybrid mining method midway between block caving, longhole stoping and shrinkage. Since most of the ore is stored inside one big stope and only one extraction level is available, sequencing of the extraction is crucial to both minimize dilution and ensure stability of the stope walls. After less than 3 years of production and 25% of the material extracted from the mine, Goldex remains a continual challenge for the team in place. After the development and construction phases, production requires adaptation and innovation from the staff, contractors, consultants and suppliers to always keep in focus the cost reduction and safety at the mine complex. Goldex is, at this time, one of the lowest UG gold producers with an average cost below 223 CDN$/t and remains in good position to increase mine life by addition of satellite zones and good exploration targets below the GEZ zone. Goldex has managed to maintain very good relationships with neighbours and community although the operation is very close to city limits. Decisions on operations and management of mining site were always based on welfare of the population and represented a team effort of all concerned. The Goldex goal remains to be an example by increasing industry standards.

4:45 PM
A Segmented Reconciliation Matrix Approach to Monitor Gold Operations and Reserve Estimation: Ana Chieregatia1; Luiz Pignatari2; Kim Esbensen3; Francis Pitard4; 1University of Sao Paolo; 2YamanaGOLD; 3GEUS; 4FPSC
Mine reconciliation is seen, for many, as a test of the quality of model estimates, while in fact it should be seen as a powerful tool for detecting and correcting problems in each step of mining operations, from resource estimation to metal production. Adequate reconciliation practices allow a more efficient control of the mining processes; however, its results can be illusory unless all parties involved have been in compliance with the principles of sampling correctness. This paper presents a new, segmented reconciliation matrix, which is based on the Theory of Sampling (TOS), developed to monitor gold operations and reserve estimation.

5:10 PM
High-Order Spatial Simulation of the Structurally Controlled Apensu Gold Deposit, Ghana: David Machuca Mory1; 1Roussos Dimitrakopoulos; 'Stochastic Mine Planning Laboratory, McGill University
Stochastic simulation techniques are used for assessing the uncertainty in the spatial distribution of grades in a deposit. Among them, Gaussian based simulation algorithms are popular. These rely on the assumption that the spatial relationship between different locations can be described by a standard multivariate Gaussian model and the covariances between them. This hinders the modelling of non-linear and non-Gaussian mineralization patterns. Several new simulation techniques are based on training images. A representative training image is assumed to contain the patterns of the spatial distribution of grades in a deposit. These new algorithms do not require of the Gaussian assumption and are able to reproduce complex mineralization patterns. However, the effort of building a representative training image of grades may amount as the effort of building the final model. Moreover, if the training image is not representative, the simulated model will be erroneous. The proposed algorithm is based on the use of cumulants and do not require the assumption of a probabilistic distribution (cont’d on page 17)
model. Cumulants are statistics that characterize the spatial relation between three or more points. They are obtained directly from data and backed by a training image when data is very sparse. The resulting realizations honour the probabilistic distribution of data as well as their complex spatial structure. In this paper, the proposed multiple-point simulation algorithm is applied to a structurally-controlled gold deposit to produce multiple realisations of grades. The data used comes from a drill-hole exploration campaign. The resulting realizations are compared with those produced by Gaussian simulation. The realizations obtained using multiple-point simulation reproduce better the complex spatial features of gold mineralization. Stochastic ore resource models that are geologically more realistic are potentially a better basis for mine planning and design.
The tensile test results of the A356 alloy castings in the as-cast condition show that the tensile strength can be improved by strontium modification (SrM), superheating at 900°C (SH), and strontium modified melt thermally treated (SrM) process. Both SrM and SrM/TT processes can greatly improve the percentage elongation of the as-cast A356 alloy castings. During solution heat treatment at 540°C, eutectic Si particles undergo fragmentation, spheroidization, and coarsening, thereby affecting the relevant particle morphology. The effects of solution heat treatment on the tensile properties of the various A356.2 alloy castings can be summed up as follows. The yield strength of the various A356.2 alloy castings is significantly improved after 8 h solution heat treatment due to the precipitation of Mg2Si. The yield strength remains more or less the same with the further increase in solution treatment time to 80 h. The ultimate tensile strength is also greatly improved within the first 8 h of solution heat treatment and remains at the same level as solution time increases up to 80 h. The improvement is attributed to Mg2Si precipitation, dissolution of Si within the aluminum matrix, and changes in the Si particle morphology (spheroidization). The ductility of the as-received grain refined non-modified (NM), grain refined and superheated at 900°C (SH), and melt thermal treated grain refined (non-modified) processed (MTT) A356.2 alloy castings can be improved considerably with solution heat treatment e.g. from ~6% in the non-modified casting in the as-cast condition to ~10% after 80 h solution treatment.

10:35 AM
Effects of the Melt Thermal Treatment Process on the Tensile Properties of 356 Type-Alloys: Hu Chen1; Agnes-Marie Samin1; Harry Ammar2; Fawzy Samy1; Abdulrahman Al-Abdari3; 1Université de Québec à Chicoutimi; 2Center of Excellence for Research in Engineering Materials, College of Engineering, King Saud University, P.O. Box 800, Riyadh 11421, Saudi Arabia; 3Center of Excellence for Research in Engineering Materials, College of Engineering, King Saud University, P.O. Box 800, Riyadh 11421, Saudi Arabia

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11:00 AM
Virtual Modeling in Tube Hydroforming Process of Complex Aluminum Parts: Mihaita Matei1; Augustin Gakwaya2; Julie Lévesque1; Michel Guillot1; 1Laval University

An adaptive approach to control the deformation in tube hydroforming process is presented. This requires: the use of an existing non-linear FE software (ABAQUUS) that incorporates a user material model (VUMAT); the development and implementation of an adaptive control strategy to coordinate the internal pressure and the axial load so as to prevent fracture and wrinkling failures (knowledge-base controller) and the application of the developed adaptive simulation approach for finding the optimal loading path required to hydroform a defect-free part with as uniform thickness distribution as possible (user’s load subroutine (VDLOAD)). In order to validate the approach, the case of conical hydroforming and the case of bending followed by hydroforming component is discussed.

11:25 AM
Effect of Lubrication and Application Modes on Drilled Aluminum Part Quality: Yasser Zedan1; Riad Khettabi2; Victor Songmene1; Jacques Masounave1; 1ETS

Cutting fluids play important roles during machining including reduction of friction and temperature. The use of the cutting fluid, however, degrades the quality of the environment and increases the machining cost. The aim of the present research work is to study the effect of cutting fluids and their interactions with cutting parameters and workpiece heat treatment on surface finish and burr formation during drilling of 7075, 6061, and A356 aluminum alloys. Multi-factorial experimental design (DOE) and analysis are used. A procedure has been developed to assess and optimize the chosen factors to minimize burr formation and surface roughness. It has been found that the dry machining can be competitive compared to wet machining in term of part quality when using the optimal cutting conditions.
11:50 AM
Residual Stress Mapping in the Intervertebral Region of a Heat Treated Aluminum Engine Block: Dimitry Sedliakov\textsuperscript{1}; Anthony Lombardi\textsuperscript{1}; Francesco D’Elia\textsuperscript{2}; Comondore Ravindran\textsuperscript{3}; Alan Machin\textsuperscript{2}; Ronald Roggie\textsuperscript{1}; Robert MacKay\textsuperscript{1}; National Research Council of Canada; Ryerson University; Nemak Canada Corporation

Excessive residual stress in Al engine blocks may result in cylinder distortion which reduces engine operating efficiency. As such, neutron diffraction was used to measure residual strain along the Fe liners and Al, in the hoop, radial and axial orientations with respect to the cylinder axis, at the cylinder interbore region. Residual stresses were subsequently calculated using generalized Hooke’s law and related to the microstructure along the cylinder bridge. The results suggest that the residual stresses in the Al interbore region are tensile and increase with depth within the cylinder. The increase in residual stress at the bottom coincides with a finer and more uniform microstructure in this region of the cylinder. The refinement in microstructure at the bottom of the cylinder likely increased alloy strength, thereby decreasing this section’s susceptibility to distortion.

LIGHT METALS: Light Metals Ti and Mg

Tuesday AM Room: Lachine Location: Hilton Bonaventure Hotel

Session Chairs: Franco Chiesa, Aluminium Research Centre - REGAL, Centre de métallurgie du Québec; Mihaela Isac, McGill Metals Processing Centre

9:30 AM
Influence of Mold Coating on the Metallurgical Quality of Titanium Cast into Graphite Ingot Molds: Bernard Tougas\textsuperscript{1}; Franco Chiesa\textsuperscript{1}; Martine Combos-Par\textsuperscript{1}; Lucie Forget\textsuperscript{1}; Gheorghe Marin\textsuperscript{1}; Centre de Métallurgie du Québec

Recycling of titanium represents an important economic activity due to high cost of the material and the amount of returns of machined parts which represent the bulk of finished titanium products (typical “buy to fly” of 10 in the aeronautical industry). In the present work, the metallurgical quality of 76 mm in diameter and 20 cm ingots poured in coated graphite mold will be assessed against the nature and condition of application of 4 coatings namely aluminum oxide, yttrium oxide, zirconium oxide and zirconium oxide with 4% aluminum oxide. The metallurgical quality has been evaluated in terms of alpha case thickness, microstructure and composition. Microhardness from surface will be assessed against casting conditions. Least square regression analysis have been use to optimize casting conditions.

9:55 AM
Characterization of AZ91 Type Alloy with Silicon Addition: Sophie Lam Sin\textsuperscript{1}; Comondore Ravindran\textsuperscript{3}; Ryerson University

This research focused on the effect of silicon on the hot tearing susceptibility of permanent mould cast AZ91E magnesium alloy. Varying amounts of silicon (0.5, 1.34 and 1.5 wt\%) were added to AZ91E in the form of an Al-53 wt\% Si master alloy. The microstructure, grain size and solidification behavior of each alloy were characterized and related to their hot tearing susceptibility. The results showed that silicon significantly reduced the hot tearing susceptibility of AZ91E. This was attributed to a reduction in grain size and decrease of the freezing range of AZ91E, which thereby improved interdendritic feeding during the last stage of solidification. This research demonstrates the effectiveness of silicon in improving the castability of AZ91E alloy by alleviating hot tearing.

10:35 AM
Evaluation of Hot Cracking in AZ91E and AE42 Mg Alloys: Francesco D’Elia\textsuperscript{1}; Comondore Ravindran\textsuperscript{3}; K. Prasad Rao\textsuperscript{2}; Ryerson University; Indian Institute of Technology - Madras

Hot cracking of magnesium (Mg) alloys during welding creates a barrier to enhancing the use of these alloys in automotive applications. As a result, it is imperative to understand the mechanisms responsible for hot cracking of Mg alloy welds in order to develop means of eliminating this problem. In this study, the hot cracking susceptibility of AZ91E and AE42 magnesium alloys were assessed using the moving torch Varestraint test method. Plates of 3 mm thickness were extracted from AZ91E and AE42 ingots and subsequently tested. Quantitative cracking data in terms of maximum crack length (MCL) was used for evaluating the cracking susceptibility. Optical and scanning electron microscopy was carried out. The results suggest that AE42 showed a higher resistance to hot cracking in comparison to the AZ91E alloy. This was attributed to the difference in freezing ranges between the two alloys. The relatively long freezing range of AZ91E enabled segregation of Mg17Al12 into grain boundary regions, which weakened these regions and led to hot cracking. In contrast, significantly less segregation of secondary phases in AE42 occurred, thereby resulting in no hot cracks.

11:00 AM
Improving Melt Cleanliness and Mechanical Properties of AZ91E Permanent Mould Castings with Melt Filtration: Abdallah Elsayed\textsuperscript{1}; Mobaraz Khokhar\textsuperscript{1}; Comondore Ravindran\textsuperscript{3}; Ryerson University

Increased dependence on fossil fuels has promoted a higher concentration of carbon dioxide within the atmosphere that has been linked to changing weather patterns and other extreme weather phenomena. An increase in fuel economies of transportation vehicles by reducing component weight could help counteract carbon emissions. Lightweight metals such as magnesium show potential in replacing aluminum alloy castings for engine cradles, cylinder heads and transmission cases. Unfortunately, magnesium alloys are susceptible to entrapping oxides and other impurities during casting pouring and solidification. The presence of these unwanted particles seriously hinders the strength and ductility of magnesium permanent mould castings. The current study examined various filter sizes and configurations in hopes of improving the mechanical properties of permanent mould cast AZ91E by reducing the presence of oxides and inclusions.Specimens for tensile testing were prepared using a H13 permanent tensile mould in accordance with ASTM standard B108-06. The castings were produced with pouring and mould temperatures of 720 °C and 400 °C. The castings were produced in four different configurations: no filter, coarse filter on top of sprue, coarse filter within sprue, coarse filter within well and a fine filter within well. The use of filters during castings was an easy and effective method to produce consistently sound castings with improved mechanical properties for commercial use. Further research aims to optimize material properties and dimensions of the filters and utilize casting simulation software to model mould filling with and without filters.

11:25 AM
Thermodynamic Modeling of the Mg-Cu-Ni Ternary System using the Modified Quasichemical Model: Mohammad Mezbahul-Islam\textsuperscript{1}; Mamoun Medraj\textsuperscript{1}; Concordia University

Thermodynamic modeling of the Mg-Cu-Ni system has been carried out as a part of multi component thermodynamic database for Mg alloys. This system has been modeled for the first time using the modified quasichemical model which considers the presence of short range ordering in the liquid. The Cu-Ni binary system has been re-optimized based on the experimental phase equilibrium and thermodynamic data available in the literature. The optimized thermodynamic parameters for the Mg-Cu and Mg-Ni systems have been taken from the previous thermodynamic assessment of the Mg-Cu-Y and Mg-Ni-Y systems by the same authors. The thermodynamic descriptions of the binaries Mg-Cu, Cu-Ni and Mg-Ni have been extrapolated to the ternary Mg-Cu-Ni system using Toop geometric model which is an asymmetric model. Mg has been singled
out as the asymmetric component since Cu-Ni system showed completely different thermodynamic characteristics than Mg-Cu and Mg-Ni binary systems. The sublattice model has been employed to describe the CuMg2, Cu2Mg, NiMg2 and Ni2Mg compounds. The ternary solubility of these compounds has been modeled properly by involving temperature dependent parameters. The constructed database has been used to calculate and predict thermodynamic properties, isothermal sections and liquidus projections of the Mg-Cu-Ni system which showed very good consistency with the experimental data.

11:50 AM
A Study on the Deformation Behavior of Mg and Mg Alloys Using 4D Processing Maps: Shashi Prakash Narayan; Sasi Bhushan Bhimavarapu; Deepti Bhargava; Amit Kumar Maheshwari; Advanced Materials & Processes Research Institute (CSIR)

The hot deformation behavior of Pure Mg and Mg-0.29Ce alloy were studied by isothermal hot compression tests in the temperature range of 250 - 5000C and strain rate range of 10-3 - 102 s-1 in a computer-controlled 50kN servo hydraulic universal testing machine (UTM). The results show that the flow stress of Mg pure and Mg-0.29Ce alloy increases with strain rate and decreases after a peak value, indicating dynamic recovery and recrystallization. Process efficiency was increased by nearly 10 to 12% by addition of Ce in Mg. Mg pure exhibits instability zones between 250-2750C at 101 – 102 s-1 and 400-5000C at 101 – 102 s-1 temperatures and strain rates respectively, rest is the safe deformation zone. Wherein, Mg-0.29 Ce exhibits two low efficiency zones at 250 – 3000C at 10-2 – 100 s-1, 400 – 5000C at 101 – 102s-1 and high efficiency zone at 450 – 5000C at 10-3 – 10-1s-1. 4D process maps were generated for the above said alloys which illustrate contours of power dissipation and instability in the 3D space of strain rate, temperature and strain.
### MANAGING THROUGH RECESSION: Managing Through Recession I

**Tuesday AM**

October 4, 2011

**Room:** Fontaine G  
**Location:** Hilton Bonaventure Hotel

**Session Chair:** Daniel Brosig, Hatch

**9:30 AM Keynote**

**Next 50 years - Mining and Metallurgy in Canada at a Crossroads: New Golden Cycle or Bust?: Nathan Stubber; Mackey Philip; Joël Kapusta**

A special commemorative book is being published as part of this year’s quinquenary. The book documents how the “metallurgical landscape” in Canada has evolved over the past 50 years. This retrospective also provided us with an opportunity to look forward and try to predict the forces that will shape our metallurgical and material industries 50 years into the future. This paper explores some of the key issues that the industry will likely face in the future. A brief survey was sent out to a select group of MetSoc members during the summer of 2011. This presentation will also summarize their views.

**10:35 AM**

**Tracking the Trends 2011 - The Top 10 Issues Mining Companies Will Face in the Coming Year: Jurgen Beier; Deloitte & Touche**

This presentation is based on global research undertaken by Deloitte which identifies the top 10 issues mining companies will be required to deal with in 2011. The ten issues which will be discussed in the presentation are:
1. The nickel face of financing
2. When supply can’t match demand
3. Securing a social license to operate
4. New taxes, new regulations and new governments
5. How to invest more strategically
6. The war for talent
7. At the end of the rainbow - maintaining the search for new deposits
8. Climate change disclosure
9. Inadequate infrastructure in developing jurisdictions
10. New revenue opportunities

**11:00 AM**

**Can the Implementation of Innovative HR Practices Reduce the Effects of the Cycle?: Barbara Kirby; Mining Industry Human Resources Council**

During the recent downturn, several mining employers shifted their focus from long term HR planning and aggressive recruitment to implementing cost saving measures through hiring freezes, temporary shutdowns, reducing their support for students and even layoffs. As short lived as the recession was, mining companies are now faced with renewed challenges around attraction, recruitment and retention in the face of significant labour shortages. In fact, the latest research from the Mining Industry Human Resources Council (MiHR) indicates a need to hire over 100,000 people by 2020 to meet the needs of the sector. To address the skills shortage and reduce the effects of the cycle, the mining industry has recognised that it needs to collaborate. Collectively, we can implement the strategies needed to ensure an appropriately skilled workforce is in place and maintained through the volatility of commodity cycles. Mining Industry Human Resources Innovate (www.mihrinnovate.ca) is a collaborative platform for sharing knowledge and effective HR practices and initiatives, in the interest of working towards addressing the HR challenges specific to the mining industry. This session will focus on the HR challenges in mining and highlight examples of innovative HR practices from Vale, DeBeers, Cameco, Noront and Goldcorp submitted to MiHR innovate.

**11:25 AM Invited**

**Restructuring during the Credit Crunch: Teck’s Experience: Ron Millors; Teck Resources Ltd.**

By taking positive steps, Teck was able to withstand the credit crunch. In this session learn how management developed and stayed focused on a strategy for reducing the firm’s debt and refinancing the corporation to take advantage of opportunities in a recovering economy.

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### MATERIALS - INNOVATIONS IN JOINING OF ADVANCED MATERIALS: Understanding Innovations

**Tuesday AM**

October 4, 2011

**Room:** Longueuil  
**Location:** Hilton Bonaventure Hotel

**Session Chairs:** Mathieu Brochu, McGill University; Joel Pepin, AITF

**9:30 AM Keynote**

**Successfully Patenting New Materials and Processes: Evangelos Vekris; Sim & McBurney**

Materials research efforts often give rise to materials and processes that are eligible to be protected by a patent. In today’s business environment, patents are playing an increasingly valuable role in a company’s intangible assets. A diverse patent portfolio that contains an array of different patents can enable a company to corner the market and to thereby obtain a monopoly. In the academic world, one or more patents can provide a foundation for growing a start-up company, and can enable investment funds to be secured. The inherent value of patents was recently demonstrated by the U.S. Courts in i4i Ltd. v. Microsoft Corp., which resulted in a payout of $290 million USD by Microsoft to the Canadian owners of the U.S. patent at issue. However, though patents are inherently valuable, there are steps that must be properly followed in order to successfully obtain a patent. Failure to follow these steps, such as by prematurely disclosing an invention to the public, can be detrimental or even fatal to obtaining a patent, and can result in inadvertent loss of all rights to that invention. The steps for successful patenting, and the pitfalls to be avoided, will be reviewed.

**10:35 AM**

**Failure Mechanisms in Thermo-Mechanical Fatigue of DS Superalloy Rene 80: E. Abrokwa; N. Richards; O. Ojo; The University of Manitoba**

Directionally solidified (DS) Rene 80 Superalloy was tested in thermo-mechanical fatigue (TMF) over the temperature range 500-900°C and plastic strain levels from 0.2 to 0.8% using a DSI Gleeble thermal simulator. Thermo-mechanical testing was carried out on the parent material in the conventional solution treated and aged condition (STA), as well as gas tungsten arc welded with an IN-738 filler, followed by solution treatment and ageing. Comparison of the base TMF unwelded alloy with that of the welded and heat treated alloy showed that varying crack initiation mechanisms, notably oxidation either by stress assisted grain boundary oxidation, or associated with grain boundary MC carbides fatigue crack propagation along grain boundaries and creep deformation were operating, leading to different “weakest link” failure initiation points.

**11:00 AM**

**Determination of the Constitutive Behaviour of AA6022-T4 Aluminium Alloy Spot Welds at Large Strains: Jingdong Kang; Joseph McDermaid; David Sigler; Durren Edmison; McMaster University; GM Global R&D**

There is increasing demand to utilize aluminium alloy sheets and their spot welds by the automotive industry. While traditional uniaxial tensile tests only determine mechanical properties to small strain, direct measurement of the constitutive behaviour of aluminium alloy spot welds at large strain remains a challenge. A technique was successfully developed using digital image correlation coupled with shear tests to directly measure the constitutive behaviour of an AA6022-T4 spot weld to large strains. The results show that the spot welding process not only decreases the yield strength but also lowers the work hardening rate of the nugget versus the base material. Details of sample preparation, experimental approach and results will be discussed.
9:55 AM

McGill Contribution to Vale’s Ultramafic Project: James Finch1; Mitra Mirnezami1; McGill University.

The McGill component of the consortium took on detailed examination of the electrokinetic properties of the constituent minerals, primarily pentlandite and serpentine. Mineral specimens were derived from an ore sample; mineralogical examination showed the serpentinite was predominantly clinochrysotile. The study included design of a novel sedimentation potential measuring device to classify the surface charge of the ore and electrophoresis measurements on single and mixed minerals which progressively approached flotation conditions. The sedimentation potential measurements provided a general association surface charge and the visual state of aggregation as a function of pH. The device was subsequently modified to measure bubble swarm potential to test the hypothesis that serpentine is floated by hetero-coagulation with bubbles, work still in progress. The electrophoresis experiments started with single minerals in a background of indifferent electrolyte and progressed to mixed minerals in a background of supernatant derived from an ore sample. The single mineral tests supported the suspected electrostatic interaction at flotation pH, the pentlandite being negatively charged the serpentine positively charged. The mixed mineral tests upheld this interaction but also revealed hetero-coagulation with Mg(OH)2 precipitates, derived from the supernatant, at flotation pH. This interpretation was confirmed by optical and electron beam imaging. A series of agents, CMC, polyphosphate, soda ash, EDTA, were examined to disperse the system. To accommodate the small mass of mineral a novel turbidity measurement using a UV/Vis spectrophotometer was used to estimate degree of dispersion. Selected conditions were used in contact angle and small scale flotation tests. The series of meetings provided a forum for interchange of ideas and results which were used to guide batch and mini-plant flotation tests at Vale. The outcomes for McGill include training of 2 PhDs and 3 co-op students and publication of 4 conference papers and 3 journal articles with 4 more to be submitted.

1. McGill, P. Somasundaran of Columbia and R. Pelton of McMaster have been attempted. In the 2000’s as other resources became scarcer, recovery of nickel from these ultramafic deposits has been an elusive goal. As high grade nickel sulphide ores are being depleted and the continuing drive for competitiveness in economically processing nickel laterite ores, it is important to develop technologies to extract nickel from low grade ultramafic ores present in large quantities worldwide. In the Thompson Nickel Belt there are some 300 millions tonnes of mineralization that are potentially amenable to surface mining. Since discovery of the Thompson orebody, recovery of nickel from these ultramafic deposits has been an elusive goal.

Research and development projects as well as commercial processing have been attempted. In the 2000’s as other resources became scarcer, major drilling, mine evaluation and research project was initiated. In 2007, Vale Base Metals Technology Development invited Cytec and potential academic partners to participate in an industry-university research consortium with the goal of developing new technologies and methods of processing the ultramafic deposits. Three university professors, J. Finch of McGill, P. Somasundaran of Columbia and R. Pelton of McMaster accepted, each group attacking the problem with a different approach. This paper describes the management of the research consortium and the significance of the results from Vale’s perspective. The next four papers in this session will summarize the project and results from the partners’ point of view. Vale is pleased to share the experience of the collaborative research and development with the mining industry.

TUESDAY AM

NEW TECHNOLOGY IMPLEMENTATION IN METALLURGICAL PROCESSES: Industry-University Interaction

Tuesday AM

Room: Fontaine H
Location: Hilton Bonaventure Hotel

Session Chair: Ken Coley, McMaster University

9:30 AM

Vale-Cytec-University Research Consortium on Processing Low Grade Ultramafic Nickel Ore: Manqiu Xu1; Ken Scholey2; Sam Marcuson2; 1Vale Base Metals Technology Development

As high grade nickel sulphide ores are being depleted and the continuing challenges in economically processing nickel laterite ores, it is important to develop technologies to extract nickel from low grade ultramafic ores present in large quantities worldwide. In the Thompson Nickel Belt there are some 300 millions tonnes of mineralization that are potentially amenable to surface mining. Since discovery of the Thompson orebody, recovery of nickel from these ultramafic deposits has been an elusive goal.

Research and development projects as well as commercial processing have been attempted. In the 2000’s as other resources became scarcer, major drilling, mine evaluation and research project was initiated. In 2007, Vale Base Metals Technology Development invited Cytec and potential academic partners to participate in an industry-university research consortium with the goal of developing new technologies and methods of processing the ultramafic deposits. Three university professors, J. Finch of McGill, P. Somasundaran of Columbia and R. Pelton of McMaster accepted, each group attacking the problem with a different approach. This paper describes the management of the research consortium and the significance of the results from Vale’s perspective. The next four papers in this session will summarize the project and results from the partners’ point of view. Vale is pleased to share the experience of the collaborative research and development with the mining industry.

9:55 AM

Impact of Aspect Ratios of Serpentines in Beneficiation of Ultramafic Ni Ores: PARTHA PATRA4; Mukund Vasudevan2; Tarun Bambhani2; D. R. Nagaraj2; P. Somasundaran1; 1Columbia University; 2Cytec Industries Inc.

Historically, efficient beneficiation of ultramafic Ni ores has been difficult to achieve. This is due to the lack of clear-cut scientific understanding of the effects of serpentine in processing. Recent research efforts at Columbia-Cytec as a part of the Vale JDP have led to new insights into these problems. Factors other than slime coating were found to be more important - namely (a) pulp rheology, and (b) Mg silicate transport to froth phase. The severity of these effects of the fibers leading to poor Ni separation. Effects of various reagents and schemes on pulp viscosity will be explored in this talk.

11:00 AM

Efficient Processing of Ultramafic Ni Ores: Challenges and Solutions: Mukund Vasudevan1; D.R. Nagaraj1; Partha Patra1; Tarun Bambhani2; P. Somasundaran2; 1Cytec Industries, Inc.; Columbia University

Selective Ni separation from ultramafic ores rich in serpentines has been a huge challenge in the mineral processing industry, and therefore highly inefficient. Analysis of the root causes of the challenges and consequent development of robust processing solutions were the main goals of the Cytec-Columbia University-Vale Joint Development Program, and also forms the subject matter of this paper. The main finding of this research program was that the metallurgical problems were driven through two main pathways - namely pulp rheology and Mg silicate transport to froth phase – that were dictated by a central factor, i.e. the morphology of the serpentine minerals. In light of these challenges, the application of proprietary Cytec modifiers led to substantial improvements in metallurgical performance, and significantly improved processing efficiency.
Changes in volume of the slag droplet, while in contact with the solid coke/observed through the optical microscopic images of slag droplets. Dynamic chromatographic (GC) analyser. The entrapped gas and the reduced iron are introduced into the slag phase. The generation of gas at high temperatures provided during steelmaking will break down the polymeric chains and extracted from the videos and volume changes were analysed. The system inert atmosphere (1l/min Ar). In-situ dynamic changes occurring during sessile drop approach, interfacial reactions taking place in the slag/carbon foaming is important because it enhances furnace efficiency. Using the materials as carbon sources for slag foaming in EAF steelmaking. Slag EAF steelmaking. Investigations were conducted in both laboratory and composition, were considered in the present study as carbon resources in recycling processes. Different polymeric materials (i.e. rubber, high wastes derived from polymeric materials, avenues are researched. Due to the inherent limitations of current methods of disposal of polymeric material substrate is measured and a comparison shows that chemical property of the polymeric materials plays an important role in the gasification of the blends which influences slag foaming.

WASTE RECYCLING IN MINERAL AND METALLURGICAL INDUSTRIES: Metallurgical Slag, Dust

Tuesday AM Room: Verdur
October 4, 2011 Location: Hilton Bonaventure Hotel

Session Chairs: Charles Jia, University of Toronto; Chris Pickles, Queen’s University

9:30 AM Recycling Waste Polymeric Materials for Slag /Carbon Interactions in EAF Steelmaking: Veena Sahajwalla1; Magdalena zaharia1; Somyote Kongkarat1; James Dankwah1; Rita Khanna1; Narendra Saha-Chaudhury1; Paul O’Kane1; Catherine Skidmore2; Jonathan Dicker2; David Knights2; 1University of New South Wales; 2OneSteel

Due to the inherent limitations of current methods of disposal of wastes derived from polymeric materials, avenues are researched towards developing alternative, environmentally friendly and economic recycling processes. Different polymeric materials (i.e. rubber, high density polyethylene (HDPE), polyurethane (PU) and polyethylene terephthalate (PET)) quite distinct in terms of chemical structure and composition, were considered in the present study as carbon resources in EAF steelmaking. Investigations were conducted in both laboratory and industrial scale steelmaking to assess the effectiveness of using these materials as carbon sources for slag foaming in EAF steelmaking. Slag foaming is important because it enhances furnace efficiency. Using the sessile drop approach, interfacial reactions taking place in the slag/carbon region were investigated at 1550°C in a horizontal tube furnace under inert atmosphere (11/min Ar). In-situ dynamic changes occurring during slag/carbon interactions were captured at high temperatures, images were extracted from the videos and volume changes were analysed. The system was quenched at high temperatures to study gas entrapment that occurred while using different materials. The rapid heating to high temperatures provided during steelmaking will break down the polymeric chains and the direct physical contact with liquid slag will enable gas formation when introduced into the slag phase. The generation of gas at high temperatures from the carbonaceous samples is investigated using a Infrared (IR)/gas chromatographic (GC) analyser. The entrapped gas and the reduced iron are observed through the optical microscopic images of slag droplets. Dynamic changes in volume of the slag droplet, while in contact with the solid coke/
process is chosen for investigation of carbonation of AOD, CC and BOF slags. Two experimental approaches are tested: carbonation in slurry phase (gas-solid-liquid) and carbonation of at high temperature (gas-solid).

The main goals were to (i) sequester the maximal amount of CO2 under optimal conditions, (ii) stabilize free lime and leaching properties of the waste material, and (iii) find the most appropriate carbonation method for industrial implementation and to produce a valorized product. Several process parameters that influence carbonation were studied, such as temperature, pressure, particle size and mineralogy.

11:25 AM
Pyrometallurgical Treatment of Flue Dust from Copper Smelters for Stabilization of Va Elements and Cu Recovery: Roberto Parra1; Eduardo Balladare1; Igor Wilkomirsky1; Fernando Parađa1; Ignacio Saavedra1; Juan Alex Carrasco1; Roberto Parađa1; 1Universidad de Concepción; New Tech Agro1; Xstrata Copper1; Anglo American PLC

In most of the smelters, the management of flue dust has a double objective: the control of minor elements in the anodes and the management of volatiles compounds that can cause contamination due to fugitive gas emissions. This is a special concern when high content of Va elements (As, Sb & Bi) are present in concentrates. We present the results of the experimental study to prove the principle of a novel process that recovers, via volatilization, the As, Sb and Bi in the flue dust as sulfides gaseous compounds, due to a previous sulfidization. In the case of As control, the gas collect it, and any further classical treatment for its stabilization is possible. The clean calcine can be returned to the smelter avoiding any concentration of these minor elements in the circuit. This process is now tested at pilot scale and shows better indices on carbon footprint than the classical hydrometallurgical process for flue dust.

11:50 AM
A Mathematical Model for Carbothermic Reduction of Dust-carbon Composite Agglomerates: Yuki Kuwauchi1; Mansoor Barati1; 1University of Toronto

Recycling of iron-bearing wastes from steel mills has gained a considerable attention in the past two decades to recover the secondary iron values while reducing environmental impact of steelmaking. Reduction of the dust in the form of dust-carbon pellet or briquette using a rotary hearth furnace (RHF) has been successfully practiced. However, its process and product control have proved to be demanding tasks due to the unpredictability of the reaction behaviour of the dust-carbon composite, which is attributed to the following two reasons. First, within the composite pellet, iron oxide reduction and carbon gasification reactions take place simultaneously, while their extent and rate are greatly affected by other variable components of dust. Secondly, unlike iron ore, the composite contains considerable amount of zinc, carbon and other gangue materials; thus, the reactions are reciprocally affected and all three phases and their interactions should be considered within the composite. In other words, each pellet acts as a micro reactor. In order to predict the reaction behaviour of the dust-carbon composites, a mathematical model was developed. The model takes into consideration the rates of reduction for iron and zinc oxides and carbon gasification as well as the influence of the slag components and phase change on the reactions. The model was validated with experimental results and it can be utilized as a process designing tool for the dust recycling using RHFs. Some calculation outputs and findings specific to the dust-related reactions will be presented.

WORLD GOLD: Environment

Tuesday AM
9:30 AM
Assessment of Acid Rock Drainage and Metal Leaching Risks at Barrick Gold Corporation:
1Bill Williams; 2Bill Upton; 3Barrick Gold Corporation

Barrick Gold Corporation is the gold industry leader, with 25 operating mines and a pipeline of large, long-life projects located across five continents, in addition to large land positions on some of the most prolific mineral districts. Barrick’s high level of commitment to sustainable economic development, environmental stewardship was recognized by Dow Jones Sustainability Index (DJSI) World, for the third consecutive year in 2010. The potential for adverse environmental effects from acid rock drainage (ARD) and metals leaching (ML) and their financial implications for Barrick are key considerations in our environmental assessment and business development processes. Barrick's membership in the International Network for Acid Prevention (INAP) reflects the importance of these issues to our business. INAP's development of the GARDGuide (best practices guide for acid rock drainage prevention) provides Barrick with an important tool to assist in the assessment of environmental and financial risks from ARD and ML associated with our planned and ongoing mining operations.

In this paper we will discuss how Barrick incorporates the GARDGuide and its principles for ARD and ML prediction and prevention in our business development processes and the management of our operations. The GARDGuide serves as a key reference for our project environmental assessments and as common link between our projects and operations management, consulting specialists, permitting and regulatory authorities and the public. We will discuss how the GARDGuide is being ?syndicated? throughout Barrick as a standard of practice and present a case study of how it was used in recent Barrick Business Development Project.

9:55 AM
Proactive Mineral Waste and Acid Rock Drainage Management at Rio Tinto: Rich Borden1; 1Rio Tinto

Rio Tinto is a diversified mining company that manages copper, iron, nickel, diamond, coal, gold and industrial minerals operations across the world. Many of these ore bodies pose acid rock drainage (ARD) risks and Rio Tinto is committed to proactive mineral waste and ARD management. Corporate requirements are closely aligned with the GARDGuide principles of early geochemical characterization and prediction followed by selection and implementation of management strategies to prevent or minimize ARD. Rio Tinto has had mandatory internal standards and guidance notes addressing ARD and mineral waste management since 2003. An ARD risk review program which brings internal and external technical expertise to higher risk operations has been running since 2004. In 2009 a formal mineral waste strategy for the company was developed which is focused on chemically reactive wastes and which includes a corporate statement of principles on mineral waste management. Each operation is required to design and implement an ARD and Mineral Waste Management Plan. These plans must include background on the geochemical behavior of the mineral waste, management strategies to prevent or control the geochemical risks, accountabilities for implementation of the plan and monitoring programs needed to ensure the strategies are working as designed. Successful implementation of the plan requires commitment and cooperation at all levels of the company, from senior management, to geologists, mine planners, environmental staff and equipment operators. Examples of the successful integration of ARD management strategies into mine operations and closure plans are cited from several projects and mines.
1:10 PM Achieving Stakeholder Support for New Gold Developments that Contain Sulphide Minerals: John Robertson; Terrence Chatwin; Rens Verburg; Detour Gold; INAP; Golder Associates Inc.

While jobs and economics are one of the major incentives for a community to support a mine in their vicinity, local stakeholders must also be assured that the environment will be protected. Mining companies can help achieve stakeholder support for a new mine containing potentially leachable materials by presenting and addressing Acid Rock Drainage (ARD) issues from a sustainable development perspective. Decades of research and experience in mining sulphide ore bodies have resulted in the development of reliable methods for predicting and preventing ARD. To prevent ARD, miners must begin early in the mine life-cycle to develop an ARD management plan and integrate it into the mining operations. As this proactive preventative program is initiated, mining companies also need to engage, inform and collaborate with stakeholders to ensure that the plan meets the expectations and objectives of all. Stakeholders’ engagement is enhanced and credibility gained as mining companies develop an integrated and responsible approach that accounts for short- and long-term environmental, social and economic issues, and emphasizes the importance of clean and available water for current and future generations. In this paper, examples of effective ARD prevention will be presented within a sustainable development context.

WORLD GOLD: Gravity Recovery

Tuesday AM
Room: Hampstead / Cote St. Luc
Location: Hilton Bonaventure Hotel

Session Chair: Y. Choi, Barrick Gold

9:30 AM
Gravity Gold Concentration at Newmont Mining: Aidan Giblett; Newmont Mining Corporation

The process of gold recovery by gravity concentration is incorporated in the metal recovery flowsheet at seven Newmont Mining Corporation owned mining operations in Australia, North America and Africa. In 2009 gold recovered by gravity processing was equivalent to nine percent of Newmont’s total gold sales of 5.3 million ounces. This paper will discuss these applications in detail including a review of plant flowsheets and presentation of recent operating results. Operating performance will be discussed with reference to ore characterisation procedures, interpretation of results, design considerations and optimisation practices as they relate to the recovery of gold by gravity concentration.

9:55 AM
Optimising Circuit Design for Gravity Gold Recovery: William Staunton; Alan Bax; Curtin University of Technology

To determine the optimal circuit configuration for gravity gold recovery consideration should be given to a range of factors in addition to the efficiency of the gravity circuit, including capital costs, ease of operation and impact on comminution. The most common gravity gold circuits utilise a centrifugal concentrator treating a portion of the cyclone underflow. This paper will examine this option and alternative circuit configurations to illustrate the effect of various gravity circuit feed and tailings configurations on the equipment sizing, capital costs, operating costs, water balance, comminution efficiency and gravity gold recovery. The optimum circuit configuration can provide reduced capital and operating costs, maximise gravity gold recovery and improve comminution efficiency.

10:35 AM
Evolution of Gold Gravity Recovery in Grinding Circuits - A Critical Review: Sunil Koppalkar; Ahmed Bouajila; Claude Gagnon; Sami Makni; COREM

Gold recovery within grinding circuits has evolved tremendously with the development of enhanced gravity separation technology. This paper reviews briefly the gravity recovery practices involving conventional gravity separators, operated at natural gravitational force, and semi-continuous centrifugal gravity separators that operate at 60 times the gravitational force or more. The evolution and advantages of semi-continuous gravity separators will be discussed. Techniques for further upgrading the gravity concentrates obtained will be dealt with briefly, as for example the “reinvention” of the intensive cyanidation technique as a supplement or as an alternative to the “not-so-efficient” tabling operations. The research efforts that were deployed in optimizing semi-continuous gold gravity separation will be recalled. The use of continuous centrifugal gravity separators, primarily aimed at recovering gold carriers, in combination with semi-continuous machines will also be addressed. Finally, innovative gravity circuit configurations for eliminating or minimizing the use of complex processing schemes involving costly reagents will be reviewed. On-going research at COREM to understand the discrepancies between predicted and actual plant GRG recoveries has revealed that gold particle shape transformation is the main factor explaining the lower gravity recoveries of the plant units. Efforts to devise possible remedies for improving gravity recovery at plant scale will be presented.
and arable land has refocused attention on water and tailings management with respect to quantity and quality. As it makes more sense to tackle problems at source, there exists a strong need for additional level process information to be generated that enable proactive decision making. Instead of focussing only on gold and gold recovery, the impacts of different pre-oxidation methodologies were evaluated also taking into consideration the sustainability parameters, (cyanide speciation and consumption, thiocyanate formation, arsenic liberation from arsenopyrite, heavy metals dissolution, high salt loads, overall process water quality, resulting residue stability), ensuring a holistic process view. Results of duplicate refractory gold leaches comparing bio-oxidation, oxygen pre-oxidation, ozone pre-oxidation, ultra fine grinding, high pressure grind rolls, high shear and pressure oxidation are presented in conjunction with a relative capital and operating cost comparison. The environmental and sustainability effects associated with each of these technologies are outlined. Keywords: Arsenic, cyanidation, oxidation, sulphide ores, environmental

10:35 AM
Improvements in Leaching of Gold and Silver from Sulphide Ore from Mexico with the Celp: Guy Deschênes; Mike Fulton; 'Natural Resources Canada

An open-pit mine, located in Mexico, processes an ore averaging 0.35 g/t Au and 80 g/t Ag at a rate of 4000 tpd. Conventional cyanidation is used (2400 ppm NaCN) to extract gold and silver. Cyanide is recycled using AVR (Aridification-Volatilization-Recycling) to reduce the environmental impact, cyanide consumption and reclamation costs and copper is recovered from the cyanide solution by electrowinning. A laboratory study was conducted to increase silver extraction and to reduce the concentration of cyanide in leaching. The sample contained 0.41 g/t Au, 125 g/t Ag, 0.73% S, 1.64% Fe, 0.52% Zn, 0.03% Cu and traces of Sb and As. The mineralogical analysis showed the presence of 99% gangue minerals, pyrite at 0.7%, 0.07% sphalerite, chalcocite at 0.03% and 0.01% galena. The plant conditions (2400 ppm NaCN, pH 11.3, 96 hours leaching) produced 90.2% gold extraction (leach residue at 0.04 g/t Au) and 92.7% silver extraction (leach residue at 9.1 g/t Ag) on a sample with a P80 of 86 microns. The Celp (CANMET Enhanced Leaching Process), using the same test time that the plant and 500 ppm NaCN produced 97.0% silver extraction (leach residue at 3.8 g/t) and 90.2% gold extraction. The incremental gross revenue was estimated at $US7.6 million and the reduction of cyanide costs was $2.9 million per year (79%). Silver leaching kinetics with the Celp were faster than the plant leaching conditions.

11:00 AM
Cyanide Leaching of Gold-Copper Porphyries: Chemistry and Challenges: Chris Fleming; Michael Botz; Kinross Gold; 'Elbow Creek Engineering

In recent years, there has been an increase in the number of projects where processing of metallurgically complex, low-grade gold ores is conducted. This results from a decline in the availability of large free-milling oxide ore bodies where high gold extractions can be accomplished with relative ease. Porphyry ores are frequently a source of low-grade gold ore, but gold in these ores is often associated with significant levels of cyanide-soluble base metals, especially copper. Cyanide leaching of such ores increases flowsheet complexity, operating costs and requires planning to satisfy environmental requirements for tailings disposal and mine closure. Cyanide leaching of gold-copper porphyry ores typically results in leach solutions with elevated levels of copper, and possibly other metals such as cadmium, mercury, nickel and zinc. Dealing with these ores under heap or agitated tank leach conditions requires a thorough understanding of ore mineralogy and process chemistry in order to maximize efficiency of gold extraction and recovery. In many cases, the continuous removal of cyanide-soluble copper and other metals from leach solution is necessary to limit their build-up with time. Build-up of these metals can significantly affect gold recovery onto activated carbon and prohibitively increase the consumption of cyanide. Removal of cyanide-soluble metals from leach solution will result in the regeneration of free-cyanide, and yield by-product metals with potential sales value. This paper reviews the chemistry of cyanide leaching of gold-copper porphyry ores, with focus on the cyanide leach process, carbon adsorption phenomena and means of removing base metals from leach solutions. Primary economic drivers behind the processing of such complex ores are also analyzed. Data from mine operations and development testwork conducted on gold-copper porphyry ores in Chile are presented to support discussion on the chemistry and challenges facing the gold sector in cyanide processing of complex ores.

LIGHT METALS: Aluminium Production III

Tuesday PM  October 4, 2011  Location: Hilton Bonaventure Hotel

Session Chairs: Marc Dupuis, GeniSim; Abdelkader Bagagag, Aluminium Research Centre - REGAL, University Laval

2:00 PM
P155 Cell Start-Up Thermal Electrical Mechanical Slice Model Including Sodium Expansion Effect: Lyès Hascini; Jean-François Bildeau; Yves Caratini; 'Rio Tinto Alcan

Independently of the technology, the start-up is the most critical phase of the cell life, as an uncontrolled start-up could lead to early infiltrations, instabilities, and in some cases to the cell death. Lots of efforts are put to increase the lifespan of cells, as it has a major impact on both the operating costs and the environmental footprint of the aluminium industry. Obviously, true size test on a cell is resources and time consuming approach that could be used only to validate mature concepts. Moreover, numerical modeling is a low cost and versatile tool capable to test a wide range of potential ideas and concepts. In the present article a thermal electrical mechanical slice model is presented. This model describes the preheating period of a P155 aluminum cell start-up, as used at the Grande Baie smelter. This model will be useful to study different problematical issues such as the global behaviour of lining materials, shell and cradle degradations during start-up and several start-up scenarios. Such model will also be able to answer some interrogations regarding early infiltrations and their impact on the lifespan of the electrolysis cell.

2:25 PM Invited
Rio Tinto Alcan – Recent Developments from AP60 Jonquiere Plant, Quebec: Francois Charmier; 'Rio Tinto Alcan

The paper provides the most recent information on the construction of the AP60 Phase 1 Plant of Jonquiere which is due to be commissioned and started up in the first Quarter of 2013. HSE management on site by RTA, and cooperation with local equipment manufacturers and contractors of the Saguenay-Lac Saint Jean region are highlighted in this section. The AP60 Phase 1 Jonquiere Plant aims at the demonstration of the AP60 Technology at the industrial scale and allows the further developments of the AP60 cell. The advantages of the AP60 cell technology in terms of productivity, power consumption and environmental footprint are also briefly presented in the paper.

2:50 PM
Investigation of the Increase in Resistivity in the Steel Collector Bar Used in Aluminium Electrolysis Cells: Guillaume Gauvin; Daniel Larouche; Denis Larouche; Mario Fafard; 'Laval University; 'Rio Tinto Alcan

Life span of aluminium smelting electrolysis cells can reach up to 3000 days. During this period, cathode blocks go under various physical and chemical changes that could result in an increase of electrical resistivity. The increase may be due to carbon migration from the cast iron to the steel bars, gap evolution between the cathode block and the cast iron, cathode cracking, etc. This paper focuses however only on the collector steel bar electrical resistivity evolution. To reveal the main phenomena responsible for the electrical resistivity increase, chemical analysis, metallographic
and electrical resistivity tests were conducted on two steels bars picked from two Hall-Héroult cells after autopsies. Cathode voltage drop and temperature were measured using electrically insulated internal probes and thermocouples on 16 samples from each steel bar. Electrical resistivity can reach up to 1.21µΩ-m for a steel bar aged 2505 days compared to 0.142µΩ-m for steel AISI 1008 at room temperature.

3:15 PM
Towards a Probe to Determine the Direction of Velocity in Liquid Aluminum: Mitren Sukhram1; Stavros Argyropoulos2; 1University of Toronto

This paper presents a technique to determine the direction of velocity in liquid aluminum (Al) by measuring the temperature distribution within a cylindrical rod while it is inserted into the flow. The heating pattern of the rod is a result of the interaction of the thermal fields of the rod with the liquid Al. This interaction freezes aluminum onto the cylinder in a characteristic pattern and as a result the temperature response within the rod also follows a distinctive heating pattern. Monitoring the temperature within the cylindrical rod as a function of spatial and temporal coordinates, the direction of velocity can be inferred. Experimental research work involving liquid Al was conducted at the University of Toronto using the Revolving Liquid Metal Tank (RLMT). The RLMT is a resistance furnace which can hold up to 50kg of liquid Al. In this RLMT tangential velocities up to 0.35m/s can be generated. Experimental data for different superheat and magnitude of velocity demonstrate that the sensor records different heating patterns under different fluid flow conditions. Using the transient temperature information, the direction of velocity of the molten Al flow field can be detected.

3:55 PM
The Riotinto’s P155 Smelters Now Operating at 210 KA: V. Gaudreault1; H. Vermette2; Valérie Langlois3; Louis Lefrançois4; 1Rio Tinto Alcan - CRDA; 2Rio Tinto Alcan - UGB

Rio Tinto Alcan (RTA) has three smelters that use the Alcan P155 technology: two in Canada (Grande-Baie and Laterrière, Saguenay, QC) and one in the United States (Sebree, Kentucky). The oldest RTA P155 smelter was built in the 1970s (Sebree) and had an initial current intensity of 155 kA. In the 1990s, RTA installed an amperage booster in Grande-Baie smelter to increase cell productivity. Since then, RTA has continuously pushed the limit of this technology and the target amperage that was 195 kA in 2005 has been increased to 210 kA in 2010. This article describes the successful plant-scale trials to increase current intensity from 195 kA to 210 kA, and the key performance indicator results. It demonstrates RTA’s technology leadership to undertake such a development with its Brownfield smelters.

4:20 PM
Thermal Conductivity of Anode Cover Materials in Hall Héroult Cells: Hasini Wijayarathne1; Margaret Hyland2; Mark Taylor3; Andreaa Gra man3; Tina Su4; 1University of Auckland

Anode cover material, a mixture of crushed electrolyte and alumina, is a crucial part of an aluminium reduction cell because of its important role in maintaining overall heat balance. However, until recently little attention has been given to understanding or controlling its composition and quality. The thermal conductivity of anode cover material determines the extent of the heat loss from the top of the cell. This will change as a function of the granulometry and composition of the applied cover as well as over time as the cover material consolidates on top of the cell. The ability to measure or predict the thermal conductivity of fresh and ageing cover is an important tool for managing cell heat balance. Recent studies have shown that granulometry or more correctly, voidage is likely to be the predominant determinant of thermal conductivity of anode cover materials. We have developed equipment to measure the thermal conductivity of granular cover material and tested the relative importance of composition (ratio of alumina to crushed electrolyte) and granulometry/voidage on cover thermal conductivity. In general, our results confirm that granulometry is the dominating factor. Generally, high voidages contribute to lowering the thermal conductivity especially when particles are mostly fine. However the relationships between granulometry, voidage and thermal conductivity are complex due to the varying nature of heat transfer between particles. Aging of granular cover material occur during cell operation forming a consolidated crust due to exposure to heat and fumes over time. Structure and thermal behaviour of this consolidated crust is also important in understanding the overall properties of cover. This paper presents the outcomes of laboratory studies conducted in order to understand the thermochemical behaviour of anode cover material and in particular, the role of fines in anode covers mixtures.
Development of Hypereutectic Al-Si Casting Alloys with Variable Mg Content: Alireza Hekmat-Arakakan1; Frank Ajerchi2; X.G. Chen3; M. Tebib2; 1Université de Sherbrooke; 2École Polytechnique; 3Université du Québec a Chicoutimi

Conventional hypereutectic Al-Si alloys such as A390 are used principally for the casting of components used in wear applications requiring abrasive resistance such as in engine or compressor blocks. A comprehensive study was undertaken to investigate the potential of improving the mechanical properties of these alloys by the addition of magnesium. A thorough thermodynamic study of the effect of the addition of Mg to the conventional A390 alloy showed that Mg2Si starts to form as a primary phase at 4.2% Mg as well as in the products of the binary and ternary eutectic reactions forming the matrix. Experiments were carried out in producing castings with different cooling and solidification rates of alloys with up to 10% Mg. Mg additions were found to increase the hardness over the as cast alloy due to solid solution strengthening. Also, T6 heat treatment greatly improved the tensile properties of these alloy compositions due to the strengthening effect of the theta-Al2Cu phase. The elongation of these alloys generally decreases marginally with Mg content. The most significant property improvement of the alloys with higher Mg content is the substantial increase in wear resistance. This is attributed to the dispersion of smaller particles of Mg2Si and their coherence with the matrix as compared to the large Si particles in the conventional alloy. A new rheoforming process for A390 is presented that improves the processing of the semi-solid slurry. Structure modification elements were also added to refine the primary and eutectic silicon greatly improving the processing of the semi-solid slurry.

Dissolution Studies of Si Metal in Liquid Al with Gas Injection: Mehran Seyed Ahmadi1; Stavros Argyropoulos1; Markus Bussmann1; Don Doucet2; 1University of Toronto; 2Novelis Global Technology Center

This study investigates the role of nitrogen gas injection in the dissolution rate of Si into liquid Al. A unique revolving liquid metal tank was used, with a capacity of 50 kg of liquid Al. Experiments without gas injection have shown that the dissolution of Si increases as the bath superheat and the tangential velocity of the liquid Al increase. When injecting nitrogen gas at flow rates between 0-5 l/min in the vicinity of the solid Si, results so far clearly show greater dissolution. In addition, results on the role of the gas flow rate relative to the position of the nozzle are presented and analyzed.

Experimental Design Approach to the Effects of Chemical Composition on the Mechanical Properties and Machinability of Near-Eutectic AL-11%Si Casting Alloys: Yasser Zedan1; A.M. Samue2; F.H. Samuel2; A.M.A. Al Ahmari3; 1ETS; 2UQAC; 3King Saud University

In the present study, statistical design of experimental (DOE) has been applied to study and control the properties of near-eutectic Al-11%Si alloys and develop regression equations between response variable including hardness, yield stress, ultimate tensile stress, elongation, total cutting force, cutting power, and tool life and the factors varied which include percentage composition of the alloying element and modification level. These equations may be analyzed quantitatively to acquire an understating of the effects the main variable and their interactions on the mechanical behaviour and the machinability of the alloy under investigation. Analysis of variance (ANOVA) has been performed to verify the fit and adequacy of the developed mathematical models. The results show that increasing level of Cu and Fe contents results in an increase in hardness, yielding stress and ultimate tensile strength in both modified and non-modified alloys. On the other hand, both Cu and Fe appear to affect the elongation adversely while the Sr-level shows a positive effect on the percentage elongation. It was found that the Sr-level has the most significant effect on the cutting forces and cutting power followed by Fe and Cu-contents. The results also show that the interaction coefficients of these variables have the significant effect on the tool life in comparison to main independent variables. This fact may be attributed to the formation of complex insoluble phases between Cu, Fe, Si, and Al as investigated using Scanning Electron Microscopy (SEM) attached to an EDX analysis. The accuracy of the regression equations in predicting the properties has been verified by carrying out random experiments in the range of variation of these variables.

On Particle Emission during Machining of Titanium and Aluminum Alloys: Riad Khettab1; Yasser Zedan1; Jacques Masounave1; Victor Songmene1; 1École de technologie supérieure, ÉTS

The mechanical, thermal and bioproperties of titanium alloys allow their wide use in different industries. Compared to aluminum alloys, titanium alloys are very tough, making them that much more difficult to machine than aluminum alloys. Most studies conducted on these types of materials have mainly covered and made comparisons in terms of cutting speed, cutting force and mechanical properties. Recently however, their sustainability and environment parameters have begun to attract significant interest, and it has been found that machining processes generate particles that can be harmful for health and the environment. In this paper, particle emission is investigated during the turning of the titanium Ti6Al4V and 6061-T6 aluminum alloys.

Recycling of Aluminum Alloy by Direct Conversion Method of Cutting Chips and Its Mechanical Properties: Harun Mindivan1; Recep Yatansever2; Eyyup Kayali1; 1Ataturk University; 2Istanbul Technical University; 3Istanbul Technical University

In the present study, the feasibility of recycling AA6061 Al alloy chips by a combination of cryomilling, cold compaction and hot extrusion processes was investigated. Furthermore, the effect of Al powder addition to the recycled Al alloys chips on the mechanical properties was investigated. The characterization of recycled Al alloys was made by structural examination and mechanical tests (hardness, compression and dry slidding wear tests). The results indicated that by increasing wt. % of Al powder added to the recycled Al alloy chips the studied properties (the density, hardness, compressive strength and wear resistance) increased due to reduction of porosity in the recycled Al alloys.

Surface Quality of 7075-T6 Aluminum Alloy Machined Using High-Speed Milling Process: Rene Kamgouem1; V. Songmene1; J. P Kenne1; A. Tahan1; 1Université du Québec

The surface of a mechanical part plays an important role in determining performance in service. The presence of scratches left by the cutting or tearing of the material on the surface of the workpiece supports the concentration of stress and strain. This article presents the experimental study for high speed milling of the aluminum alloy 7075-T6, using cutting tools different by the nose radius and coatings (TiCN, TiAlN, TiCN + Al2O3 + TiN). A multi levels factorial design of experiment (DOE) and statistical analysis was used. The roughness parameters investigated were Ra, Rq, Rv, Rz, Rsm and Rk. The results show that the feed rate, the types of coatings and geometry of cutting tools have the major impact on the surface quality. Surface finish charts according to feeds and cutting speeds were established for each tool tested.
MANAGING THROUGH RECESSION: Managing Through Recessions II

Tuesday PM  Room: Fontaine G  Location: Hilton Bonaventure Hotel

Session Chair: Daniel Brosig, Hatch

2:00 PM  Keeping Pace with the Times – WorleyParsons Innovations for Lower Capital Mining and Projects: Tony Warner; Philip Mackey; Niraj Dave; Lou Bruno; WorleyParsons Canada

The metal and minerals industry has emerged from the recent recession with good prospects for the near and longer term future. Thus the World Economic Forum in Davos this year considered that the world may be entering a new long term growth cycle with some short term disruptions. Current developments in China, India, Brazil and elsewhere appear to support this situation. Amid this situation, unchecked, plant construction costs in future are likely to escalate. By introducing innovations to the engineering and plant design aspects of new mines and metallurgical plants, WorleyParsons, in part learning from the economical downturn, is looking at approaches towards higher quality capital projects with lower capital cost and will review some of these approaches. There are many issues involved in Capital Mining and Metallurgical Projects that might impact CAPEX, OPEX and schedule and become risks to the overall project at the construction or operational stage. WorleyParsons provides services that incorporate consideration of these risks. It is very important to include sustainability assessment at early stage of project development. Some sustainability aspects have a direct impact on project cost as well as other indirect results and will be reviewed. Sustainability and Risk analysis delivery minimises these business and project risks to deliver an optimised outcome. Our company is also looking at new ways to help operating plants contend with higher operating cost, such as keeping higher energy costs in rein. This presentation will explore these topics including a review of modular plant design, construction concepts and the effective use of energy surveys as a step towards lowering unit energy consumption and hence achieving lower costs.

2:25 PM  Managing through Economic Cycles – An Engineering and Technology Perspective: Nils Voermann; HATCH

Periodic recession, the nadir of the economic cycle, continues to be a fact of business life: Economic down-turns tend to recur rather regularly once a decade or so (2009, 2000, 1991, 1982...`). Recessions are painful, but like winter they are also a useful opportunity to prepare for the inevitable following spring and summer. Mining & metals engineering and operating companies aside can use the time of slackened demand to efficiently build their capacity to take advantage of the inevitably following boom times. During recessions, engineering firms can re-assign key staff from implementation projects to research and development of new technologies, writing technical papers, and enhancing their own internal work methods and systems - important activities that tend to have lower priority in boom times. Companies with a sufficiently long-term view also use the opportunity to strengthen the expertise of their organizations, attracting people that may become available from competitors who feel the urgent need to reduce staff costs. Especially given the long time frames for project implementation, operating companies can use the opportunity of lower project costs prevalent in recessions to economically augment their production capacity; the increased capacity is then ready in time for the predictable rebound in metals demand at the recession’s end. Recessions are also an ideal time for maintenance shut-downs or plant rebuilds and upgrades, since the opportunity cost of temporarily lost production is of course much reduced with the low metals prices typically prevalent in recessions. An illustrative example is BHPB’s doubling the capacity of their Cerro Matoso ferro-nickel plant in the 1998–2000 recession. This expansion was completed just in time to take advantage of the subsequent decade long boom in metals demand and prices.

2:50 PM  Mining and the Future Industrial Development of the Canadian Shield: Michael Sutherland; TSX Venture Exchange

The expanding global population and improved standards of living arising out of industrialization of the developing world economies are expected to substantially increase the demand for mining industry, agricultural and forestry products. This increase in demand is expected to benefit Canada as a supplier of metals, minerals, food and wood products. The Canadian Shield may be expected to benefit from the increase in mining activity to supply the expanded demand for metals. Much of the mining activity in the past has been concentrated around the main transportation corridors (roads and railways) where people and power are also available and coincide with favorable mineral potential. Economic expansion on a broader basis will require an improved transportation network and the development of population nodes (communities with good education and health facilities) to attract the people for the efficient operation of high technology mining and mineral processing operations. The development of such “nodes” would be favored if industrial activity through the Shield could be expanded and diversified. The pressure of increasing global population on the biosphere and particularly the need to increase the productivity of the finite area of prime agricultural land in the world is expected to provide new opportunities for the Canadian Shield. This paper examines in a decadal time frame some of the changes expected to mining practice, what other industrial opportunities may open for the Shield and the potential significance of such development for the mining industry.


The global downturn in 2008 driven by the collapse of the sub-prime market and subsequent tightening of credit markets caused nickel prices to drop precipitously to less than 20% of the highs of 2007. Prices deteriorated even further in 2009, reaching levels close to $4.00/lb. Faced with a generational-defining event of the magnitude of the Global Financial Crisis, Xstrata Nickel was confronted with an opportunity to embrace the uncertainty as a galvanizing moment for the business to make decisions that would be impossible to execute in more buoyant times, and that would position the business in the short and longer term in a fundamentally stronger competitive position. With the benefit of hindsight, the timely decisions and courageous delivery of the teams across the nickel business delivered just that – a business transformed from the upper third quartile on the cost curve to the lower second quartile, and a near-term growth pipeline that will more than double production by 2014 while maintaining the competitive cost position. The result has delivered clearer accountability, higher employee engagement and commitment, significant increased shareholder value, and a quiet sense of self-belief and accomplishment in the team.

3:55 PM  Title Not Available: Louis Doyle; TSX Venture Exchange

Canada is undeniably a world leader in natural resources - particularly in the mining sector. On Toronto Stock Exchange (TSX) and TSX Venture Exchange (TSXV), mining finance is incredibly strong – and growing stronger every day. Our two exchanges combined are home to over 58% of the world’s public mining companies and we’re the global leader in equity mining finance. Here are some of the many reasons why: Our deep, liquid markets are a key element of one of the world’s most sound economic environments; Our unique two-tier market structure accommodates earlier stage exploration companies right through to the most mature producers; Our mining issuers benefit from a flexible system for going public with listing requirements tailored to a company’s stage of development, financial performance and operational resources; We provide our mining issuers with unprecedented support to help inform decisions, navigate the listing process and more.
Rapid Solidification of Al-Ni Alloys by Electrospark Deposition: Gilberto Portillo\textsuperscript{1}; Mathieu Brochu\textsuperscript{1}; \textcopyright McGill University

Electrospark Deposition (ESD) is a pulsed-arc micro-welding process characterized by using high current electrical pulses, of a short duration, to deposit an electrode material on a metallic substrate. The short duration of the electrical pulse allows for a low heat input over the substrate and an extremely rapid solidification of the deposited material. As a result, the ESD is capable of a wide variety of microstructures like micro-segregation-free solid solutions, nanostructured grains, metastable structures, and amorphous phases. The present work shows a microstructural analysis of rapidly solidified Al-Ni alloys coatings by the ESD process. Field Emission Scanning Electron Microscopy (FE-SEM) and X-Ray Diffraction (XRD) were performed to present the microstructural evolution as a function of the welding parameters. The phases and non-equilibrium metastable structures present in the alloys, and their distribution, were found to be a sensitive function of the alloy composition; hence its formation is governed primarily by thermodynamic considerations.

Electrospark Deposition as a Technique to Repair Damaged MCrAlY Coatings: Rabab Farhat\textsuperscript{1}; Mathieu Brochu\textsuperscript{1}; \textcopyright McGill University

Coatings that yield a thermally grown oxide (TGO) protective layer have been proposed as a potential method for extending the lifecycle of components exposed to high temperature corrosion. This is particularly relevant to the petrochemical industry, where any reduction in corrosion rates can yield substantial cost reductions. The primary goal of this project is to develop a coating repair procedure and to investigate the oxidation performance of the repaired location. Electrospark deposition (ESD) was used to repair spalled segments of TGO grown on MCrAlY substrates using various electrodes possessing mixed crystal structures. Specifically, electrodes of NiCoCrAlY (BCC-FCC mixtures) and CoNiCrAlY (FCC-BCC mixtures), were deposited and oxidized to develop the TGO using a heat treatment of 24 hours at 1000°C in air. This presentation will focus on the microstructural evolution of the base metal and ESD repair on damaged area, in both as-deposited and oxidized forms. Results of SEM and XRD analysis will be presented.
Development of New Technology at Barrick Gold: Peter Kondos; Peter Lind; Nathan Stubina; Barrick Gold Corporation

Barrick Gold is in the process of building several new mines and implementing new processes at existing mines for which metallurgical technology is of key importance. The roles of the company’s Strategic Technology Solutions team and the Barrick Technology Centre are discussed within the context of their responsibilities within Barrick’s Operations Support group. The paper will present an overview of the development of the technology centre from the former Placer Dome Research Centre to its current form supporting strategic technology, capital projects, and operating sites. Novel approaches to research and development will be presented as well as an overview of some of the technologies developed from bench-scale to pilot-scale, and beyond.

Development of Low Technical Risk Commercial Designs Using Fluidized Bed Pilot and Demonstration Plants: Stanley Dunk; Eric Eccleston; Jennifer Amsden; Technip

Fluidized bed technology has been widely applied to mineral and metallurgical processes. Over the years, modeling of fluidization technology has progressed to a level at which basic design parameters can usually be defined based on empirical correlations. In addition, scale-up considerations have become better understood, and significant advances have been made in the area of computer simulation. Despite these advances, fluidization is a complex phenomenon, and modeling tools remain limited in their ability to simultaneously model both fluidization and chemical process parameters. As a result, almost all mineral and metallurgical applications of fluidized bed technology require pilot testing prior to commercial scale design. This paper outlines pilot plant testing requirements and process development considerations for development of low technical risk commercial designs.

Successful Project Implementation: Kenneth Thomas; Kinross Gold Corporation

Since approximately 2003 we have witnessed the unprecedented escalation in commodity prices. Couple with economic chaos following the 2008 downturn this has caused difficulties in controlling schedule, capital costs and operating costs for mining projects. Once again escalation has returned to commodity prices fueled by growth in the BRIC countries especially China and Brazil. This is further exacerbated by the missing generation of skilled technical personnel not graduating from universities in the 1980’s and 1990’s owing to depressed commodity prices. This paper examines the six tenets for successful project implementation.

Developing Vale’s Nickel Hydroxide Processing Technology: Gregg Gavin; Ahmed Vahed; Vale Base Metals Technology Development

The Vale pilot plants in Port Colborne were constructed by Inco in the 1960s and used extensively to test major process changes in existing operations as well as developing new technologies. The Copper Cliff Nickel Refinery using the pressure carbonyl process was one of the outcomes. Developing new technologies for the lateritic nickel deposits Inco owned in various countries was a multi-year program of research in the 1970’s. This was also major role of the Port Colborne pilot plants. Initial technical feasibility and miniplant test programs for these projects were generally performed at one of Inco’s R&D centers in Copper Cliff or later in Mississauga and, if warranted, followed with pilot scale studies at the Port Colborne pilot plant. These studies were essential to provide the company with robust designs for its commercial plants worldwide, as well as redesigning or modernizing its operating plants. During the 1980’s, the major development efforts were to refine the processes to be adopted during the billion dollar refit of the Copper Cliff Smelter in the early 1990’s. After this success, and amid the industry’s recession of the 1990’s, the 3 pilot plants (called Research Stations) were mothballed. In 1998, as Vale (Vale Inco at the time) was developing the flowsheets for a new generation of laterite processing plants, it was decided to restart the Pyrometallurgical Research Station. This paper describes the role of the newly refurbished pilot plant in the successful piloting of a process to turn nickel hydroxide precipitate into a marketable nickel product. The value of pilot scale processing was once again clearly demonstrated.

Design and Implementation of Modified Mo Addition to EAF at Uddeholm AB, Sweden: Seshadri Sentharaman; Andrei Chychko; Royal Institute of Technology; Era Steel Kloster; Uddeholms AB

During Mo additions, there were significant losses to the dust (ca 7 %) and to the slag phase (ca 2 %), which had serious economic and environmental impacts. The present work was aimed at designing a suitable Mo precursor, as the Mo source and a process sequence. The criteria were a) low cost of raw materials, b) minimize vapour losses and c) easy dissolution of the precursor in molten steel. After thermodynamic considerations, three precursor materials were chosen, viz. CaMoO4, MgMoO4 and Fe2MoO4. Synthetic mixtures of the component oxides in each case as well as pure MoO3 were investigated by TGA and high temperature XRD in order to find out the temperature range in which the compounds were formed. Experiments were also conducted separately where the evolved gases were analyzed. All the three precursors were formed easily and the loss of MoO3 to the vapour phase was found to be extremely low. Addition of the oxide mixtures to steel melts were conducted in three different scales, viz. 16 g, 500 g and 3 tons (induction furnace). Initial experiments showed that MgMoO4 was not suitable since the Mo yield in the steel melt was not very high. Fe2MoO4 was found to perform best, the Mo yield reaching 98 %. Further trials were conducted in the 100 ton Electric Arc Furnace at Uddeholm AB in Hagfors. Mixtures of mill scale, MoO3 and carbon in suitable proportions were added in a pre-determined addition sequence. It was found that, in the actual practice, the Mo yield reached 99 %, equaling in performance the addition of ferromolybdenum. The process has been patented and is being currently implemented at Uddeholm AB, Hagfors, Sweden.

DRI-based Continuous Steelmaking: From Theory to Practice: Mansoor Barati; University of Toronto

A collaborative research between University of Toronto and Hatch was conducted to understand and optimize the process conditions pertaining to a novel steelmaking technology. In this technology, known as CRISP, direct reduced iron is continuously melted and refined in a stationary electric arc furnace. The major challenge against continuous operation of the electric furnace was identified to be minimizing the corrosion of the refractory in order to achieve uninterrupted operation for a minimum of one year. Theoretical analysis and bench scale experiments together with two pilot runs resulted in defining an operating window for slag chemistry that would minimize chemical attack to the refractory while satisfying the oxidizing conditions required for sufficient decarburization. An analysis of the process in terms of energy consumption and emission of greenhouse gases revealed that it is superior to the current batch DRI-based steelmaking technologies.
Several pulverization methods were tried and compared to separate installed metals that can be extracted and/or stocked for future treatment. In the research, metals were pulverized and concentrated to produce the concentrates from which rare kinds of rare metals are distributed in the "E-waste" and how they should be recovered from the treatment of waste. The paper also describes detailed research work to clarify how various procedures and technologies for pretreatment, concentration, and extraction were achieved by optimizing the experimental conditions.

The two samples were heated at predefined temperatures (ranging from 300 °C to 900 °C) in a chlorine gas flow. The chlorine gas flow into the furnace was set at a rate of 100 mL/min. As a result, copper in Sample 1 began to volatilize at 600 °C and completely vaporized at 700 °C. In Sample 2, copper started to volatilize at 600 °C and reached 100% vaporization at 800 °C. For Sample 1, zinc finished volatilizing at 500 °C, while for Sample 2, zinc volatilization reached only about 80% (maximum).

Also, lead, nickel, and tin showed similar results. Consequently, the volatilization rate of Sample 1 is higher than Sample 2 and the temperature dependency was verified for copper, lead, zinc, nickel, antimony, titanium, and chromium. In fact, the volatilization rate of these metals increased with the temperature. This result reflects the difference between pure metal and metal oxide, as Sample 2 was combusted before chlorination–volatilization test. Moreover, the chlorination reaction may be accelerated by a reductive atmosphere because Sample 1 contains carbon. In this study, the volatilization behavior of some valuable metals in PCBW by chlorine gas was observed. Further improvement in the rate of volatilization can be achieved by optimizing the experimental conditions.

Recent Trend of Rare Metals Recycling in Japan: Shuji Owada; Waseda University

Scrap electric and electronic appliances, so-called "E-waste", is not a present target to be collected and recycled in Japanese regulation. The materials, however, contain considerable amount of base, precious metals, and in especial rare metals which facilitate multifunction and downsizing of the appliances, then, such kinds of metals should be recovered from the "E-wastes", i.e., keeping stable supply and establishing "sound material-cycle society". Ministry of Economy, Trade and Industry (METI), and Ministry of the Environment (MTE) have recently started a national project for creating collection systems in several areas and for developing technologies to recover them. The paper describes the present situation of Japan's rare metals recycling system, involving various collection procedure and technologies for pretreatment, concentration, and extraction. The paper also describes detailed research work to clarify how various kinds of rare metals are distributed in the "E-waste" and how they should be pulverized and concentrated to produce the concentrates from which rare metals can be extracted and/or stocked for future treatment. In the research, several pulverization methods were tried and compared to separate installed electronic parts from the printed wiring board and the combination of several physical concentration methods was applied to achieve "parts separation" and "powder separation" for the concentration of rare metals. Pulverization and concentration mechanism were also clarified for each rare and other metal element.

Lead Recovery from Waste CRT Glass by Hydrofluoric Acid and Electrochemical Treatments: Etsuro Shibata; Mio Itoh; Takashi Nakamura; IMRAM, Tohoku University

Both landfill and recycling of used cathode ray tubes (CRT) have been done in the world and which way was selected in each country depends on environmental policy of each country. Almost 100% of material recycling was achieved in Japan past decade. However, recycling of waste CRT glass has recently faced a strong difficulty to continue because a demand of CRT TV has drastically decreased due to wide spreading liquid crystal display (LCD) TV in the world. It becomes necessary to treat and recycle the waste CRT glass domestically due to the shutdown of the foreign CRT manufacturers. A part of CRT glass is recycled as a raw material in the lead blast furnace. However, it is difficult to treat all of the waste CRT glass in the lead blast furnace because the CRT glass contains a high content of silica. We need some additional treatments of waste CRT glass for lead smelting materials. In this study, we treated the waste CRT glass using hydrofluoric acid to dissolve the contained silica, and then the dissolved lead was recovered by precipitation methods. Besides, the lead metal was recovered by electrodeposition from the prepared hydrofluorosilicic acid solution.

A Computer Simulation of an Agitation Mill Abrasion Process for Waste Printed Circuit Boards: Chiharu Tokoro; Yuki Tsuranawa; Kenichiro Torigoe; Shuji Owada; Waseda university

Recycling of printed circuit boards (PCBs) is an important subject not only from the treatment of waste but also from the recovery of valuable materials including rare metals. However, effective physical separation process including comminution has remained to be established. We already confirmed that a special and selective grinding such as parts abrasion from the board using agitation mill was effective for the recycling of a part of rare metals. It is important to investigate the brief mechanism of parts abrasion process from PCBs in agitation mill. The objective of this study is revealing the mechanism of parts abrasion process from PCBs using discrete element method (DEM) simulation. In order to calculate parts abrasion process directly in DEM, a PCB was constructed by many fine particles bonded each other. This connection between them was broken if the bonding force calculated from DEM became over a threshold level. An anchoring model was developed as a new bonding model to avoid the displacement of bonding point between particles. Simulation results were compared with experimental comminution data using agitation mill with similar PCBs on which nine capacitors were solder-mounted. In experimental comminution test, both of parts abrasion rate and boards breakage rate were increased as rotation speed increased. On the other hand, as the amount of input increased, parts abrasion rate was increased while boards breakage rate was slightly decreased. Simulation results obtained from DEM with the anchoring model corresponded to these experimental trends successfully.

Distributions of Minor Metals in E-Waste: Tetsuya Yamoto; Toshikazu Shiratori; Tohoku University (Present at Dowa Eco-System Co.,Ltd.); Tohoku University

E-Waste that originates in EOL (End of Life) is abandoned after a certain period of use. It is important that we obtain information on the elements used for these E-Waste from the viewpoint of recycling. Especially, the usage conditions of various minor metals (rare earth etc.) that have been used for the recent equipments and some elements that have been limited to use due to harmfulness are constantly changing. However, these information are not sufficient. Therefore, we analyzed several parts in WEEE (Waste Electrical and Electronic Equipment) of EOL collected directly from the citizens. The
Selective Recovery of Gold from E-wastes by Using Cellulosic Wastes: Katsutoshi Inoue1; Bimala Pangeni1; Minoru Abe1; Hidetaka Kawakita1; Keisuke Ohto1; Shafig Alam2; 1Saga University; 2Memorial University
Selective and effective recovery of gold was investigated by using adsorption gel prepared from pure cellulose by crosslinking with concentrated sulfuric acid. It was found that only gold was quantitatively adsorbed with extraordinary high loading capacity from varying concentration of hydrochloric acid separated from other metals including other precious metals and base metals. The formation of fine powders of metallic gold was visually observed, which is attributable to the selective reduction of gold(III) ion to metallic gold due to its high oxidation-reduction potential. This technology was extended to prepare similar adsorption gels from cellulosic wastes like spent paper and spent cotton. These adsorption gels were tested for the effective recovery of gold from leach liquor of hydrochloric acid of various e-wastes like circuit board of spent mobile phones.

Recovery of Precious Metals by Means of Adsorption Using Persimmon Tannin Gels: Manju Gurung1; Katsutoshi Inoue1; Keisuke Ohto1; Hidetaka Kawakita1; 1Saga University; 1Memorial University
Two kinds of adsorbents were prepared from persimmon tannin extract; one was prepared by treating with concentrated sulfuric acid for crosslinking between polymer matrices of tannin and/or polysaccharides existing in the extract together with tannin while another was prepared by immobilizing functional groups of quaternary amine. These are termed as CPT and QAPT, respectively, while the original persimmon tannin extract as PT powder. The adsorption tests were carried out from varying concentration of hydrochloric acid, from which it was found that only gold(III) was selectively adsorbed on PT powder and CPE gel while not only gold(III) but also palladium(II) and platinum(IV) were selectively adsorbed on QAPT gel. In these cases, base metals such as copper(I) and iron(II) were not practically adsorbed. Adsorption isotherm tests suggested that maximum adsorption capacities of CPT, CPT and PT powder were 4.16, 7.7 and 5.8 mol/kg, respectively, for gold(III) while those of QAPT for palladium(II) and platinum(IV) were 0.84 and 0.52 mol/kg, respectively. The formation metallic gold by the reduction of gold(III) ion by polyphenols was considered to be responsible for the high selectivity and adsorption capacity for gold(III).

Precious Metals Leaching from Electronic Wastes: Fereshteh Rashchi1; Nasrollah Naseri Joda1; 1University of Tehran
Recycling of electronic wastes is an important subject not only from environmental treatment point of view but also from the recovery of valuable materials. In this research, PCB board scraps were used for leaching of Cu, Ag, Au and Pd. Due to the high cost of crushing and grinding processes and to avoid secondary pollution from odors and dusts created during the comminution process, board scraps were cut in pieces of 5±5 cm². To determine the most effective leachant, aqua regia, nitric acid, hydrochloric acid, ammonium persulfate and potassium persulfate were tested. The operating variables, the leachant concentration (1-5 M), temperature (30-70 °C), leaching time (0.5-2.5 hr) and liquid to solid ratio (5-25) were studied and optimized using Response Surface Method.

The Current Status of the Chemistry of Gold Flotation in Industry: Ronel Kappes1; Robert Dunne1; Carole Fortin1; 1Newmont Mining Corporation
The subject of gold flotation has been reviewed extensively in a number of publications. The focus in most of these reviews has been on the theories of gold flotation as well as the physical and chemical effects that may impact the efficacy of the gold flotation process. It is evident that the current status of gold flotation chemistry as it is being applied in industry would like to apply the information to the separation techniques that the advanced recycling will be requested in the future.
has not been addressed widely. It is the intent of this paper to review current gold flotation practice and how these applications tie in with the current understanding of the chemistry of gold flotation.

2:50 PM
Hydrocyclone Classification Modeling for Gold Ore Grinding Circuit Simulation: Steve Bellec; 1 Universite Laval

Industrially, cyanidation is widely used to extract gold from raw ores. To enhance the kinetics of the dissolution reaction that occurs at gold grain surface, gold accessibility is facilitated by ore crushing and grinding under a critical particle size. Grinding is achieved in closed circuits where hydrocyclones are used to recycle coarse particles back to the mills. The separation performed by hydrocyclones is influenced by particle density and size. As gold density is larger than that of the accompanying gangue, the gravimetric effect in hydrocyclone classification is important and for a given size, free gold particles have larger probability to be recovered at the hydrocyclone underflow than mixed or gangue particles. This paper proposes a classification model to predict the split coefficient as a function of the particle size and gold content. The model is calibrated and validated using data obtained from the sampling of an industrial grinding circuit equipped with two parallel grinding mills. Model calibration requires a complete simulation of the circuit and involves parameters related to the gold grain distribution in the raw ore as well as a liberation model. Since cyanide is added into the studied grinding circuit, it is necessary to make assumptions about gold dissolution in the mills. The simulation results confirm the preferential recirculation of free gold. The model is used to propose a hydrocyclone tuning that reduces gold recirculation in the grinding circuit with minimal impact on gold surface accessibility to the cyanidation reaction.

3:15 PM
Mineral Separation Techniques in Gold Recovery from Refractory Ores: Qi Liu; 1 University of Alberta

Gold recovery from refractory ores can be very complicated depending on the causes of the refractoriness. Typically, a fine grind and/or the oxidation of the gold-bearing sulfide minerals are required to liberate gold from the host rock matrix. Mineral separation techniques, particularly surface-wettability based (flootation) separation and magnetic separation, can be used to pre-concentrate the gold and sulfide minerals, or to remove mineral species that are harmful either to the oxidation of the gold-bearing sulfides or to the cyanidation following the oxidation. In this paper, several possible processes are described, including oil-agglomeration-flootation recovery of fine gold, reverse flotation of carbonate minerals prior to pressure or bio oxidation, reverse flotation of elemental sulfur after pressure or bio oxidation but prior to cyanide leaching, and flotation recovery of fine gold-bearing activated carbon, as well as magnetic concentration of gold. The simulation results propose a hydrocyclone tuning that reduces gold recirculation in the grinding circuit with minimal impact on gold surface accessibility to the cyanidation reaction.

3:55 PM
Selective Separations of Gold and Contaminants from Various Gold and Silver Process Streams: Neil Izatt; 1 Steven Izatt; Ronald Bruening; 1 IBC Advanced Technologies, Inc.

IBC Advanced Technologies- Molecular Recognition Technology (MRT) SuperLig® products selectively and rapidly bind with target metal ions to remove them from solution. The MRT process can produce a high purity separation product of maximum added value at low cost. This paper discusses applications for MRT in the gold industry, including recovery of gold and silver as well as contaminants from various process and recycle streams.
Syngenetic Gold: Lode Vein Geology and Exploration Implications: Ulrich Kretschmar1; Golden Scarab Corporation

Mapping, core logging, WR analyses and re-interpretation of textures shows lode veins (LVs) occur in a “gold cycle”. In turbidite terminology, LVs occur in “E” (pelagic-pelitico) rocks or at contacts. E lithologies are “shear zone”, lamprophyre, mafic dike, flow or “enclave”. They are small scale correlative conformities described by Thurston et al. 2008 (Ec Geol 103 p.1097). Basal or “A” division volcanics annulled by metamorphism resemble igneous texture. “Intrusion” gold is hosted by gabbro, diorite, granite, syenite and TTG. “Gold-cycles” in these rocks indicate extensive early Archean pyroclastic volcanism. The 2.830 my Maskwa, MN “batholith”, a quartz (Q)-feldspar (F)-hornblende (H) crystal tuff (CT) hosts high grade LVs over 8,000 m by 500 m. The 2.730 my Chester Twp, ON “trondhjemite-diorite”, is a heterolitic volcanic breccia and felsic CT host to the 4M oz Cote Lake deposit of Trelemawen Mining. The Baxter shaft is on the S limb of an overturned syncline. In Beardsmore ON, Hercules veins (Prodigy Gold, >130,000 oz) are hosted by >10 km long SW facing Elmhirst mafic CT and volcanic breccia. Eight mines in the 2.700 my PQ Bourlamaque batholith, a metamorphosed QFH CT, correlate across a syncline with an overturned S limb. The geopetal nature and asymmetric alteration of LVs indicates sea-floor genesis. Bedding parallel LVs differ from fragmentation-breccia (feeder) veins. Often Q was deposited as a gel. Grade-thickness plots reflect vent geometry (fracture, point source or diffuse seep) and bottom topography. LVs are commonly 500-2,000 m long and disc-shaped or lobate. Average 2-450 m ore “shoot” spacing represents sea-floor fractures. LV grades reflect geothermal fluid composition, P-T and sedimentation rates. Structural upgrading is not required. Syngeneis clarifies and simplifies genetic models. Exploration becomes more cost-effective. Basin analysis, WR geochemistry, ore lens geometry and vent spacing can be used. Gold cycle facing survives metamorphism.

3:15 PM
Meeting the Challenges of Gold Exploration through Earth Probe High Resolution Borehole and Surface IP: Bob Gordon1; Caracle Creek Geophysical exploration for gold is known to be challenging. Recently, some of the limitations of traditional IP have been addressed by drawing upon smaller-scale technologies developed for engineering geotechnical and hydrogeologic applications. The University of Toronto, through CAMIRO funding, progressed initial studies to adapt a geotechnical resistivity system developed by Geoseve in Germany for mining applications (Qian et al, 2007). Caracle Creek has further developed Geoseve’s resistivity system, with the assistance of IRAP funding, to incorporate induced polarization measurements for mining applications. The resultant EarthProbe DCIP system is successfully enabling geophysicists to adjust their scale of surveying to the scale of geologic features applicable to gold exploration. EarthProbe’s narrow electrode spacing and ability to operate in multiple surface and borehole configurations facilitates both improved target delineation and characterization of host rock and mineralization signatures. Integration of high-resolution surface and borehole IP survey techniques is helping to address many of the challenges faced by geologists when exploring gold environments. This is attributed to the system’s ability to: rapidly collect integrated surface, borehole, borehole-to-borehole and surface-to-borehole data; image smaller features and disturbances often related to narrow vein type systems of disparate mineralization due to the use of tight electrode spacings; provide a range of information to the geologist regarding near surface and mid-depth features; identify in-hole and off-hole features and between hole connectivity of electrical/chargeable features; and characterize bulk resistivity/chargeability of key lithologies and alteration/mineralized zones. Three recent case studies will be showcased.

3:55 PM
Use of Multivariate Geochemical Domains as a Validation Tool in the Classification of Predicted Resource Metal Extraction Recoveries: Cristian Dragusana1; John Sims2; James Connolly3; SGS Minerals Services; Kinross Gold Corporation

Geometallurgical methods of ore classification are more and more part of the current practice believed to enhance the economic predictability of a deposit. In this sense, the basic geological observation of drill cores can benefit from a combined approach where quantitative measurements from densely probed core can validate relationships between metal recovery and metallogenetic assumptions. Such complementary techniques can solve cases of apparent decoupling between host rock genetic controls and mineral processing which may be seen in complex environments. Based on a statistical analysis of the categorical and numerical data from the established geological model, a geochemical classification of mineralization has been shown to be objective in nature and correlated to the envisioned metal extraction process. On the assumption that the major chemical variation is controlled by the different mineral assemblages, a relationship can be found and turned into a model of mineralogical variation as a function of major chemistry. This work shows the potential of multivariate classifications based on the chemistry of the sampled core intervals to discriminate within a combined response from different types of alteration and metal abundances. Distinct domains of chemical response determined by clustering analysis were used to validate a geologically driven analysis of the gold occurrence. The groups established are spatially distinct, suggesting their intimate link to the geological process responsible for their genesis. The probabilistic occurrence of each group in the deposit was analyzed through sequential indicator simulation. Furthermore, a general spatial model was generated by grouping the nodes of the present block model using the same clustering technique on the linear estimates of the chemical elements that were used for the classification of the core intervals. This model proved robust in its interpretation of the geological observation and provided clarity in geologic modeling both from a validation and quantification viewpoint.

4:20 PM
Gold Exploration in Metamorphic Terrains Using Fluid Inclusion Compositions in Quartz: Signification of Their Volatile Content: Damien Gaboury1; Université du Québec à Chicoutimi

Most hydrothermal gold deposits contain quartz with fluid inclusions that recorded composition and temperature. Quartz has strong chemical and mechanical resistances to weathering and mechanical abrasion. Hence, quartz fragments occurring at weathered surface or in till cover have the potential to be used for gold exploration; as far as we know what is the volatile content signifies for gold mineralization. In this perspective, fluid inclusions were analyzed in pure quartz by mass spectrometry following the method of Gaboury et al. 2008 (Econ Geol) from gold deposits hosted in the Archean Abitibi and Paleoproterozoic Birimian belts. This approach provides the relative abundance of volatiles from families of fluid inclusions deceptivating at specific temperatures (Td). Fluids in gold deposits are aqueous-dominated with CO2 and H2S in accordance with their fundamental role as gold-ligands (H2S) and for pH-buffering (CO2) of the gold-bisulfide solubility. However, there is no correlation between CO2 and H2S contents of fluid inclusions and gold content of the samples. This implies that trapped fluids represent a marginal portion of the fluid history recorded by the veins. However, in barren quartz veins away from known mineralization CO2 or H2S are absent. Wide H2O Td spectrum from 200-450°C and CO2-H2O Td offset are common, indicating phase separation. The content of other volatiles seems to be more dependent of the geological setting. Helium content may suggest proximity of a crustal-rooted fault, a critical parameter for gold mineralization. Methane and especially C2H6 appear to be indicative of fluid buffering with organic-rich material such as graphic-shale. These rocks may provide an important primary gold reservoir from sedimentary metal-rich pyrite. Nitrogen-
TUESDAY PM

3:15 PM Opportunities for Managing Community Relations through the Supply Chain: Monica Ospina; ’0 trade and market access

Trade across the supply chain can boost demand for products, services and labour, not only in international markets but also at the local level, where mining companies have a direct input in local economies. Apart from good governance and socially and environmentally responsible practices, local supply and employability are recognized by the International Financial Corporation, Export Development Canada and financial institutions when evaluating companies applying for financing. In this session, participants will learn how to analyze trade within the supply chain and harness its potential for building local economies and managing community relations. Emphasis will be given to the role of capacity building in presenting a long-term solution to reducing poverty, and building self-sustaining and sustainable economies at the local level, thus making of the mining industry an agent for sustainable development.

3:55 PM Banro Corporation: Investing in Long-Term Community Development: Martin Jones; ’Banro Foundation
Banro is a Canadian-based gold exploration and development company with projects in the DR Congo. The Company is constructing its first mine at its Twangiza project, which is scheduled to begin production in late 2011. Banro has made a commitment to the people of its region to work with them to lift the quality of life in the years ahead. This commitment is expressed through the Banro Foundation, a registered charity which makes strategic investments in education, health and infrastructure development. Among the principles guiding the Banro Foundation is a focus on needs identified by local community leaders, with priority given to projects that benefit communities as a whole. Since 2008, the Foundation has, among other projects, completed the construction of four new schools, a women’s resource centre, a potable water delivery system serving 18,000 people, a new health care centre, the development of over 100 kilometres of roads and bridges and two shipments of medical equipment from Canada to several regional hospitals in the eastern DR Congo. 2011 is planned as the most active year ever for the Foundation, with four new schools, a regional marketplace, a health care centre and a major bridge under construction.

4:05 PM WORLD GOLD: None Cyanide Lixivants

Tuesday PM
Room: Hampstead / Cote St. Luc
Location: Hilton Bonaventure Hotel
Session Chair: P. Breuer, CSIRO

2:00 PM Recovery of Gold and Associated Metals from Refractory Ores and Concentrates via a Chloride-Based Processing Route: Bryn Harris; ’Neomet Technologies Inc
Cyanide has been used for the recovery of gold since the mid 1800s. However, a number of jurisdictions have already banned its use, and recent spils, such as that into the Danube, are increasing environmental pressures to finding an alternative for cyanide. It has long been known that gold also forms chloride complexes similar to those of cyanide, but its use has never achieved widespread acceptance. This paper describes a chloride-based flowsheet, wherein the key unit process is the recovery and recycle of chloride ion. Results of continuous miniprint runs on a low-grade refractory gold ore are presented, together with preliminary operating and capital costs. It is shown that the chloride-based flowsheet is competitively economically with the conventional cyanide-based flowsheets, and that it has a number of other advantages, particularly environmentally.

2:25 PM The Nichromet Technology for Precious Metal Recovery: Jean-Marc Lalancette; David Lemieux; Bertrand Dubreuil; Caroline Chouinard; ’Nichromet Extraction Inc.
Nichromet Extraction Inc. has developed a new technology for the extraction and recovery of base and precious metals calling upon the use of halogens. This approach has been evaluated on a great variety of polymetallic ores, concentrates or tailings with recoveries at 95-98 % for gold, at 90-95 % for silver and at 95-99 % for base metals (Cu, Zn). The approach calls for the use of elemental chlorine in the presence of a small amount of bromide as the active agents for precious metals collection. Prior to chloridation, the ores concentrate or tailings are freed of sulfur by controlled oxidation. This operation brings the sulfur content down to 0.2-1.5 % from values as high as 40 %. This operation generates sulfur dioxide that can be transformed into sulfuric acid needed further down in the process. Arsenic, if present, is partly volatilized as arsenic oxide, which is stripped from the gas stream and stabilized as scorodite. After the sulfur removal, the residual solid is presented as (con’t page 37)
The beautiful city of Niagara will host the 51st Annual Conference of Metallurgists (COM2012), held with Pressure Hydrometallurgy 2012 (42nd Annual Hydrometallurgy Meeting).

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washed with water to remove sulfated base metals produced during the controlled oxidation; then, with hydrochloric acid to complete the leaching of base metals. The removal of sulfur and base metals prior to chloridation reduces very substantially the halogen consumption during the precious metals extraction, allows the collection of said base metals and leaves a barren solid with no capacity for lixiviate generation after precious metals recovery. 2 The chloridation is performed in a brine slurry in a vat reactor, at low temperature and at near atmospheric pressure, said brine containing low concentration of sodium chloride and small amount of sodium bromide. Chlorine is injected in the stirred slurry and the duration of the reaction is adjusted to achieve near complete extraction of precious metals, generally after one hour to three hours.

2:50 PM
An Electrochemical Investigation into the Effect of Lead on the Dissolution of Gold in Ammonium Thiosulfate-Copper Media: Gabor Csicsokovszki1; John G. Peacey1; Queen’s University It is well known that lead ion is an effective accelerator of gold lixiviation in cyanide solutions. However, the effect of lead on the dissolution of gold in conventional ammonium thiosulfate-copper solutions is not as well-defined, based on the limited literature on this topic. Therefore, the main target of this study was to clarify the role of lead on the dissolution of gold in the (NH₄)₂S₂O₃–Cu leaching system. For this purpose, chronopotentiometry, linear sweep voltammetry and chronoamperometry were utilized to study the dissolution of a rotating gold disk electrode under various conditions. Chronopotentiometry with flame atomic absorption (FAA) analysis was first applied to monitor the mixed potential of the leaching system with different concentrations of lead under open circuit potential conditions. It was found that the dissolution of gold was significantly increased with lead concentration up to 10 mg/l Pb in the system of 0.1 M (NH₄)₂S₂O₃ and 50 mg/l Cu. To further investigate the effect of lead, linear sweep voltammetry was used on solutions containing only 0.1 M (NH₄)₂S₂O₃ and lead in different concentrations. The voltammograms suggested that the anodic dissolution of gold was virtually independent of lead concentration in the range of 1-10 mg/l while at a higher level of 20 mg/l Pb gold oxidation was improved. Chronoamperometry coupled with FAA assay was utilized to investigate the effect of lead on the anodic lixiviation of gold at constant potentials in solutions containing copper as well. In solutions containing copper, additions of lead were found to significantly increase the anodic dissolution of gold, even at concentrations as low as 1 mg/l Pb. As a practical benefit of the effect of lead observed on gold dissolution, high consumption of thiosulfate caused by high copper.

3:15 PM
Kinetics of Gold in Leaching Alkaline Sulphide Solutions: Simon Joshi1; Edouard Asselin; University of British Columbia Electrochemical testing was used to study the leaching of pure gold (99.99%) in 1 M Na₂S solution. Potentiodynamic testing showed the corrosion current density and corrosion potential were about 0.6 uA/cm² and -788 mV vs. SCE, respectively. During potentiostatic testing at -0.487 mV vs. SCE, relatively high current densities (3 to 7 uA/cm²) were observed. After potentiostatic testing the gold content of the test solution was measured and found to be on the order of 0.02 ppm. The current efficiency for gold dissolution was low indicating that sulphide oxidation was the dominant reaction occurring on the gold electrode with very little leaching of gold occurring concurrently.

3:55 PM
Electrochemical Studies of the Gold-Electrolyte Interface under Thiosulfate Based Leaching Conditions: Janet Baror1; Jeffrey Mirza1; Anna Frydrychewicz1; Jacek Lipkowski1; Younuk Choi2; University of Guelph; 3Barrick Gold Corporation Leaching of gold using thiosulfate as a lixiviant has been considered as an alternative to the current industrial process that involves the use of cyanide. Research has shown that the reaction rate of the gold leaching process in thiosulfate solution can be improved by addition of thiourea [1]. However, the mechanism by which thiourea improves the gold leaching reaction is still unknown. The main objective of this work was to understand the mechanisms of action of different additives, such as thiourea, that enhance the leaching of gold in thiosulfate solution. The gold leaching reaction in alkaline thiosulfate solution, and the surface passivation seen in this lixiviant, were investigated using sweep voltammetry. The leaching currents in different electrolytes were determined using Tafel plot analysis based on the mixed potential theory. The electrochemical studies were complemented with a characterization of the gold-electrolyte interface using surface enhanced Raman spectroscopy. The obtained results show how thiourea changes the mixed potential of the leaching reaction by preventing formation of oxysulfur compounds, which passivate the gold surface and decrease the rate of leaching. Other molecules such as 3-mercaptopropionic acid and Leysteine were also studied as possible additives to prevent formation of this passive layer in the thiosulfate leaching system.

4:20 PM
Oxidative Leaching of Pyrargyrite by Ozone: F Nava-Alonso1; Carolina Rodriguez-Rodriguez1; Alejandro Uribe-Salas1; CINVESTAV Salthillo Pyrargyrite (Ag₃SbS₃) is a silver species that is not soluble in cyanide solutions. It is very abundant in some Mexican deposits causing low silver recovery when using the cyanidation process. This work proposes the use of ozone as oxidizing agent to dissolve the silver contained in pyrargyrite. Natural pyrargyrite from Zacatecas, Mexico, was used to evaluate, by means of a factorial experimental design, the effect of acid and ozone concentration on the silver leaching. The tests were performed with 1 g pyrargyrite (-25 µm) in 800 ml water at 25°C, 800 rpm mechanical stirring and 1.2 L/min addition. Two levels of sulfuric acid concentration and ozone in gas concentration were evaluated: 0.18 y 0.72 mol/L and 0.054 y 0.077 gO₃/L. The highest silver dissolution (50 %) was obtained when using the higher acid and ozone concentrations, suggesting that further increases in the ozone concentration could increase the silver recovery.

LIGHT METALS: Aluminium Transformation III
Wednesday AM
Room: Lachine
Location: Hilton Bonaventure Hotel
Session Chairs: Gilles Dufour, Alcoa; Donald Gallienne, Aluminerie Alouette

8:30 AM
Promoting Aluminium Development in Canada: Vision of AAC. Jean Simard1; Association de l’aluminium du Canada We are in an era of optimal choices within societies that are under mounting pressure by consumers who are better educated, better informed, more demanding and who are mobilized around unprecedented issues. By using aluminum in areas that contribute to reducing greenhouse gases – in materials used for mass transit, institutional architecture and certain civil engineering projects – we provide our engineers, designers and architects with the opportunity of creating sustainable work defined only by their imagination and talent.

8:55 AM
Aluminum Ships: Myths and Facts: Thomas Lamb1; University of Michigan There are many horror stories about aluminum in the marine environment and many are not based on facts, so they are myths. Myths must be addressed before progress can be made. This paper attempts to dispel the myths and state the facts. A common perception is that aluminum ships cost significantly more than steel ships. This paper illustrates that even though the cost of the aluminum structure is over 50% more than the steel structure, an “equivalent” aluminum naval ship can be built within 7% of the acquisition price of a steel ship. This is possible because of the cascading benefits of the aluminum ship’s significantly lighter weight. Aluminum ships also have a life-cycle cost advantage over steel ships because of reduced maintenance and fuel cost savings.

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Aluminum in Public Transportation: Russell Long; 1 Alcoa
Globally, society is striving for transportation that is comfortable, clean and fuel efficient. Governments are requiring improved fuel economy, reduced emissions and in many cases encouraging the use of hybrid or electric powertrains to meet this desire. City buses with their urban usage cycle, many hours of daily use and their high loaded weight are logical vehicles for emissions reduction efforts. Aluminum has been used extensively to reduce the weight of two different types of buses, a conventional diesel powered bus and an electric bus. The curb weight of the diesel bus was reduced by 11.8% resulting in a 6% fuel economy improvement. The use of aluminum in an electric bus reduced the curb weight by 7% resulting in a longer range. The electric bus prototypes have been completed and are being tested in normal usage conditions.

Aluminum in Transportation: Case Study of the Development of a Light Weighted Refuse Collection Unit: Yves Archambault; 2 Gilles Dufour; 2 Petrinio Buzatu; 1 Louis Lefebvre; 1 Jean Fortin; 1 Clermont Fortin; 1 Alcoa Innovation; 2 Véhicules Inpak Inc. / Inpak Vehicles Inc.
In the domain of transportation, aluminum has proven its contribution to increase fuel efficiency by light weighting automobiles and many types of trucks. Still, some sectors are reluctant to the arrival of a material replacing steel, used for decades; the sector of refuse collection is among those. An ambitious project has been set forth to develop the next generation of a light weight side-loading refuse collection unit. The unit was entirely redesigned using aluminum and based on the future requirements of municipalities regarding residential refuse collection. The new compacting systems were designed for low friction and allowed for smaller size hydraulics. The aluminum alloys were selected for their performance in other comparable and well known applications in heavy transportation vehicles. The final outcome of this project is a refuse collection unit showing a weight reduction of almost 30% compared to the actual steel design. This gain translates into an increased load capacity, thus reducing the number of trips to the dump site. Two prototypes were built and are presently being tested in real conditions.

Frame Optimization of a Hybrid Spyder Roadster: Maxime Tacher; 1 Alain Desrochers; 1 Ahmed Maslouhi; 1 Université de Sherbrooke
BRP (Bombardier Recreational Products) designs and commercializes recreational vehicles such as watercrafts, sport boats, snowmobiles, ATVs... The Spyder roadster is the last product in the Can-Am product family lineup. To remain at the forefront of innovation, a hybrid motorization version of the Spyder is being developed in order to reduce fuel consumption and emission of greenhouse gases. But, the addition of electric components (e-motor, lithium-ion battery...) raises the issue of added weight and emission of greenhouse gases. This design has been optimized to comply or surpass the performances of existing-aluminum trailers.

Metallothermic Smelter Slags
Energy Recovery from High Temperature Steel, Copper and Nickel Smelter Slags: Utigard Torstein; 1 T. Marin; 2; A. Warczok; 1; R. Bergman; 4, 5; Mansoor Barati; 3; C. Diaz; 3; University of Toronto; 2 Vale
The world wide consumption of energy is steadily increasing and by 2030 it is forecasted to grow by another 50%, leading to mounting political and economic pressures. For any pyrometallurgical operation it is therefore paramount to investigate and implement methods to decrease the use of energy. In the pyrometallurgical processing of steel, copper, nickel and other high temperature metals, a large amount of energy is lost in the hot off-gases, molten slags, mattes and molten metals. Most of this energy is generally lost during the cooling and solidification steps with very little focus on energy recovery or reuse.
In this paper we will quantify how much energy is contained in the various slag streams, then review previous attempts and methods employed to recover some of this energy, and finally evaluate some novel technologies that could potentially be employed.
Heat Exchangers for Bulk Solids
Opportunities for Energy Savings and Energy Recovery using Indirect Heat Exchange

9:20 AM
New Technology of Oxygen Evolution Anodes for Electrowinning: Masatoshi Morimitsu; 1Doshisha University

This paper introduces new technology of oxygen evolution anodes which can be applied to produce copper, zinc, cobalt, and other metals by electrowinning. The anode consists of nano iridium oxide particles dispersed in amorphous tantalum oxide matrix as a catalytic layer formed on a titanium substrate. The anode can reduce oxygen evolution potential by 0.25 to 0.35 V compared to commercially available lead alloy anodes and can suppress unwanted side reactions such as manganese oxyhydroxide, lead oxide, cobalt oxyhydroxide which occur during oxygen evolution. This smart anode can work for environmentally friendly electrowinning processes with low energy consumption and less anodic deposition.

9:45 AM

Unconventional fuels can provide attractive alternatives to oil and gas in metallurgical processes to augment or provide the heat energy needed. Applications could be for ore dryers, rotosters and rotary kilns. Unconventional fuels have been used to reduce or eliminate coal, natural gas and fuel oil usage in rotary and vertical kilns in the cement, lime, lightweight aggregate, refractory clay, and other industries for many years. Unconventional fuels include petroleum coke, shredded tires (TDF), waste liquids, and wood based solid fuels, such as saw dust, lignin and torrefied wood. Issues related to preparation and application of various alternative unconventional fuels are discussed. If pulverized fuel grinding is needed the system must be properly engineered to comply with applicable codes and to ensure safe and efficient operation.

10:25 AM
Noranda/Teniente Copper Bath Smelting Process Variations - Impact on Energy Requirements: Pascal Coursol; 1Carlos Dias; 2Phillip Mackey; 1Aluminerie Alouette; 2Mackey Technology

In a recent paper, the present authors discussed calculated energy consumption numbers in copper sulphide concentrate smelting for four different smelting technologies. For the present study, from among these technologies, they selected the Noranda/Teniente continuous bath smelting followed by Peirce Smith (PS) converting route to investigate the impact on total energy requirement of some key process variations, such as tuyere injection of dry concentrate vs. slingering of wet concentrate over the molten bath, continuous converting vs. conventional batch PS converting and commercially proven slag cleaning alternatives. In their calculations, the authors used the same thermochemical model and methodology used in their earlier paper. The results of these calculations provide a basis for evaluating flowsheet modifications that could lead to significant copper smelting energy savings.

10:50 AM
Opportunities for Energy Savings and Energy Recovery using Indirect Heat Exchangers for Bulk Solids: Claudio Fornicov; 1Neville Jordison; 1Phoenix Process Engineering; 1Central South University

Indirect, gravity flow, heat exchangers have become a well established technology in mineral and metallurgical process plants. The technology is a conventional heat exchanger using high efficiency plates, with a free flowing bulk solid on one side of the exchanger and a fluid on the other side. This simple concept leads to many opportunities for achieving greater energy efficiencies in process plants. Indirect heat exchange is much more efficient than direct heat exchange using air such as in a fluid bed or rotary device. When air is used directly, large fans are required, it may also be necessary to chill the air, both high consumers of energy. By contrast, using water as the cooling medium requires only low horsepower pumps, typically only 10% of fan HP. Furthermore there are no stack emissions with the requirement for removal of dust or emissions. Indirect heat exchange also creates the opportunity to recover energy. This can work in two ways: energy can be recovered from a hot bulk solid, to heat pressurized hot water for steam generation or preheat air. Alternatively recovered energy from elsewhere in the plant in the form of hot water, steam, air or thermal oil can be used to preheat a bulk solid.
This paper will profile these technologies, and provide best practice case studies as is the potential commercial application.

Removal of Elemental Sulfur from Hydrometallurgical Waste Derived from Massive Sulfide Concentrates: John Halfyard;1 Kelly Hawboldt;1 Christina Bottaro;1 Memorial University of Newfoundland

The removal of sulfur from leach residues has been practised in the zinc industry using a combination of flotation and hot melt filtration. The process is highly dependent on the nature of the concentrate and the subsequent residue. When the mineral constituency of the concentrate alters, the process can encounter significant operational challenges. An alternate method of converting elemental sulfur to water-soluble polysulfides was applied to leach residue from Vale’s nickel demonstration plant in Argentia, Newfoundland. Reaction parameters, sulfur purity and other key indicators are discussed as is the potential commercial application.

Waste Processing and Recycling: Some Case Studies

Waste Processing and Recycling creates economic benefits and frees up space at the landfill sites. Process Research Ortech Inc. (PRO) has conducted extensive testwork in the area of waste processing and recycling. A process was developed for the recovery of Zinc from galvanized steel by alkaline leaching followed by solvent extraction and electrowinning. Extensive testwork has been conducted at PRO to obtain useful by-product from zinc scrap. Recycling helps to save energy and it’s better for the environment. It is also important for preserving the limited natural resources. In addition, recycling creates economic benefits and frees up space at the landfill sites. Recycling creates economic benefits and frees up space at the landfill sites. Recycling creates economic benefits and frees up space at the landfill sites.

Effective Removal of Selected Metals in Wastewater: Alain Consigny;1 BioteQ Environmental Technologies

 Sulphide precipitation technologies use biological or chemical sources of sulphide to selectively precipitate dissolved metals, producing saleable metal by-products and clean water that can be safely re-used or discharged. This technology can remove up to 99% of dissolved metals from mining effluents, reducing metal concentrations to trace levels. Sale of the recovered metal products can offset the cost to produce clean water significantly, and in the case where high concentrations are disposed of result in a profitable operation. As an add-on to an existing the plant the recovered metal is upgraded and recycled to the plant, but the production of a saleable metal can also be considered. Technology selection for metal recovery depends on the composition and flowrate of the effluent, but could incorporate resin-in-pulp or other ion-exchange technology; precipitation as sulphides, hydroxides or carbonates; or solvent extraction. This paper describes the technology selection process and uses data from Zincor, a subsidiary of Exxaro Base Metals (PTY) LTD, as a case study.

10:25 AM

Removal of Elemental Sulfur from Hydrometallurgical Waste Derived from Massive Sulfide Concentrates: John Halfyard;1 Kelly Hawboldt;1 Christina Bottaro;1 Memorial University of Newfoundland

The removal of sulfur from leach residues has been practised in the zinc industry using a combination of flotation and hot melt filtration. The process is highly dependent on the nature of the concentrate and the subsequent residue. When the mineral constituency of the concentrate alters, the process can encounter significant operational challenges. An alternate method of converting elemental sulfur to water-soluble polysulfides was applied to leach residue from Vale’s nickel demonstration plant in Argentia, Newfoundland. Reaction parameters, sulfur purity and other key indicators are discussed as is the potential commercial application.

10:50 AM

Sulphide Precipitation and Ion Exchange Technologies for Cost Effective Removal of Selected Metals in Wastewater: Alain Consigny;1 BioteQ Environmental Technologies

Alain Consigny BioteQ Environmental Technologies Canada New clean technologies? to treat mining and metallurgical effluents containing dissolved metals and sulphate have been successfully applied at mine sites in North America and Asia, treating water flows of up to 24,000 m3/day. These clean technologies offer significant benefits compared to conventional alternatives and provide a sustainable solution that eliminates residual waste sludge, improves water conservation, generates revenues from wastewater, and delivers overall improvements to the environment. Sulphide precipitation technologies use biological or chemical sources of sulphide to selectively precipitate dissolved metals, producing saleable metal by-products and clean water that can be safely re-used or discharged. This technology can remove up to 99% of dissolved metals from mining effluents, reducing metal concentrations to trace levels. Sale of the recovered metal products can offset treatments cost and deliver lower life cycle costs for water treatment. Ion-exchange processes use cationic and anionic resins to remove metals even where low levels of these metals (less than 15 mg/L) are present in a high flow of wastewater. The processes reduce TDS, achieve lower sulphate concentration levels than lime treatment, and produce a clean useful by-product that can be recycled. Ion-exchange processes consume less energy than membrane-based systems and deliver water recovery rates of up to 95%. This paper will profile these technologies, and provide best practice case study examples of their application at mining operations, including data for water chemistry, water flows, water quality, capital and operating costs, and life cycle costs of treatment compared to conventional treatment.
8:55 AM  Keynote  
**Global Gold Resources – Past, Present and Future**: Bruce Wilkinson; Stephen Kesler; Pat Dubreuil; Sarah Kesler; Sarah Lentz

Mining provides ~2,500 tonnes (0.025 Mt) of new gold per year and has yielded ~0.17 Mt of gold since the early 1800s (www.gold.org). Reserves and resources of gold in known deposits (~0.13 Mt, Frimmel, 2008) will support current mining for several more decades, but significant new discoveries will be needed to sustain the present business model after that. Although the Witwatersrand gold deposits account for almost half of cumulative world gold production plus resources, their contribution to global gold production has diminished steadily over the last 50 years. Hydrothermal deposits, which have made up the shortfall, provide ~85% of newly mined gold today and will likely provide even more in the future. Our estimates indicate that hydrothermal deposits (with >1 t Au) throughout Earth’s entire crust contain as much as 6.8 Mt of gold. Only deposits in the upper 1 to 3 km will be accessible to discovery and mining, however. Of these, epithermal deposits contain ~0.39 Mt above 1 km and ~1.2 Mt above 3 km. Estimated gold contents to these depths are 0.52 and 2.7 Mt for porphyry copper deposits, 0.03 and 0.17 Mt for Carlin-type, 0.10 and 0.13 Mt for volcaniclastic massive sulfide deposits, and 0.07 and 0.11 Mt for orogenic gold deposits. Other hydrothermal deposit types as well as magmatic deposits are unlikely to add much to this global total. Half or more of the gold in deposits to depths of 1 and 3 km will probably be impossible to discover or mine for reasons ranging from geologic to economic and environmental. If we can find 50% of the deposits above a depth of 1 km, gold mining might continue at present rates for ~200 years, a surprisingly short period compared to the 6000 years of historical gold mining.

**WORLD GOLD: Mining-Maintenance and Engineering**

Wednesday AM  Room: Fontaine D  Location: Hilton Bonaventure Hotel  
October 5, 2011  Session Chair: M. Harju

9:45 AM  Keynote  
**NRG1-ECO™ – Impact on Energy Savings and Air Quality**: Sarah Paajanen; Pat Dubreuil; Amy Fortier; BESTECH

Increasing energy costs associated with mining have become an issue that must be addressed by industry to ensure sustainable production. As energy costs increase, initiatives to maximize the efficiency of all mining processes must be addressed by industry to ensure sustainable production. As energy costs increase, initiatives to maximize the efficiency of all mining processes...
**WORLD GOLD: Mining III**

**Wednesday AM**

**October 5, 2011**

**Location:** Hilton Bonaventure Hotel

**Session Chair:** Carol Plummer, Agnico Eagle

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**9:45 AM**

**Some Observations on Corrosion of Support Systems in Selected Gold Mines:** John Hadjigeorgiou; Jean Dorion; Edward Ghali; Lassonde Institute, University of Toronto; Université Laval

The objective of support systems is to keep an excavation open and safe throughout its useful life. Support should guarantee the security of personnel and equipment but also allow the operation to extract the ore as economically as possible. Corrosion of support systems can be a major safety and economic concern in underground gold mines. An improved insight on the factors that contribute to the corrosion of support systems in gold mines can aid in the selection of appropriate support strategies and a reliable assessment of the predicted useful life of a support system. This paper presents the results of on-going investigations on the influence of corrosion on the performance of support systems in selected underground gold mines. In underground mines, rock support is exposed to various conditions that can be aggressive like high relative humidity, dust and various particles, splashing of water and gases from the blasting and diesel equipment. Support components such as bolts, lattice, plate, retaining nut, cable ties can deteriorate due to atmospheric or aqueous corrosion. Conditions vary from one gold mine to another and also within a mine. This study focused on massive sulphite associated gold, and quartz veins bearing gold mines. This investigation addresses the influence of atmospheric corrosion, as well as the presence of bacteria on aqueous corrosion and the impact of microbiological corrosion on support systems. Samples of corroded support were analysed using SEM and photomicrography to determine the main corrosion forms. Tests are on-going in controlled corrosion chambers to qualify and quantify the impact of rock particles on steel corrosion. Eleven different kinds of minerals and rocks were tested in 100% humidity chambers at 24°C. Preliminary results suggest that it is possible to quantify the performance of support systems under corrosion.

**10:25 AM**

**Keynote**

**Integrating Long- and Short-term Mine Planning through Stochastic Optimization and “Future Data” - Application and Comparisons:** Arja Jewbali; Newmont Mining

Mine design and production scheduling based on stochastic optimization is a relatively recent development aimed at addressing uncertainty in ore supply from an orebody and metal demand. A new multistage stochastic mine production scheduling approach is presented and tested in an operating gold mine. In Stage 1, high density future grade control data is simulated and stochastically generated pre-existing orebody models are updated. Stage 2 is based on a stochastic integer programming mine scheduling formulation that handles multiple simulated orebody models from Stage 1, and accommodates both maximizing net present value and minimizing deviations from production targets. Stage 3 includes quantification of risk in the produced schedules generated, comparison of schedules, and reporting. The application at an operating gold mine demonstrates that the approach is shown to deliver additional ore (3.6 Mt more) and metal (2.6 Mt more) which matches the mined reconciliations and results in a NPV which is on average 7.7 million dollars higher than that of a stochastic schedule without the simulated future drilling, and substantially higher (about 30%) compared to the NPV from the actual schedule of the mine.

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**WORLD GOLD: New Concepts I**

**Wednesday AM**

**October 5, 2011**

**Location:** Hilton Bonaventure Hotel

**Session Chair:** L. Lorenzen, Snowden

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**9:45 AM**

**Modelling of the Gold Content within the Size Intervals of a Grinding Mill Product:** Joel Bazit; Mohammad Khalesi; Laval University; RWTH Aachen University; Lütke Ketelhodt; Matthew Kowalczyk; Mathilde Robben; Lütke Ketelhodt; Matthew Kowalczyk; Mathilde Robben; RWTH Aachen University; CommodasUltrasort (Pty) Ltd; CommodasUltrasort

Batch grinding tests conducted on a gold ore indicated that gold is not randomly distributed within the size fractions of the ground ore. Since gold leaching performances were found to be dependent of the size of the gold carrying particles the development of integrated gold ore grinding-leaching model should incorporate a method to predict the gold size distribution in a ground ore. The paper describes the results obtained from batch grinding tests showing the distribution of gold within the size interval of a ground ore and the initial development of a grinding simulator to predict the gold size distribution in a batch grinding product.

**10:25 AM**

**Potential of Sensor-Based Sorting for the Gold Mining Industry:** Christopher Kleine; Hermann Wotruba; Mathilde Robben; Lütke Ketelhodt; Matthew Kowalczyk; Mathilde Robben; RWTH Aachen University; CommodasUltrasort

Decreasing reserves, water shortages, increasing energy costs, environmental and social constraints are challenges that have to be answered with innovative machines and methods. Sensor-based sorting is a practically and technically viable technique that is operating with little or no water and relatively little power consumption. Sensor-based sorting has already proven its operational stability at two Gold applications in South Africa. An optical sorter has been applied to upgrade waste dumps of Witwatersrand conglomerate Gold Ore in 2003 and 2004, turning those already mined resources into reserves. Same happened in 2009 where an X-Ray-Transmission sorter was applied to upgrade the dense media separation tailings of massive sulfide type Gold ore at Pilgrim’s Rest. Currently a “clean and green” processing plant is erected at Kloof mine including three optical sorters and a Gekko Python density separation plant. Sensor-based sorting cannot only turn waste dumps and diluted...
mining blocks into reserves. The implementation can also cause a decrease in specific operating costs of mill and mine when for example replacing selective mining by bulk mining methods with subsequent sorting. Results of test work done on a Witwatersrand run-of-mine gold ore underline this potential of mine-to-mill integration applying sensor-based sorting. Current research is conducted on the potential of near-infrared-spectroscopy sorting at Gold applications. Correlations between the occurrence of near-infrared active alteration minerals and ore related phases in Iron Oxide Copper Gold systems are present. Those correlations, which are nowadays used for exploration, can be transferred to sorting algorithms. Successful installations, operational experience, test work data and flow sheet integration from mine-to-mill underline the impact and potential that sensor-based sorting can have on the Gold mining and processing industry. The potential is far from being exploited.

10:50 AM
Recent Process Additions at the Royal Canadian Mint 2005-2011: Vicken Aprahamian; Rod Beauvre; Terry Cheng; Michael Tangen; Royal Canadian Mint

The Royal Canadian Mint has undergone significant changes in the form of new process additions since 2005. Implementation of a whole new highly automated silver refining circuit has allowed recovery of physical silver from gold and silver dorés. To complement this change, a small Top Blown Rotary Converter has been in operation. On the gold refining side, a new hydrometallurgical Miller Chlorination slag treatment circuit has been developed. In addition to a waste water treatment system, wet and dry fame and dust collection systems have been installed.

11:15 AM
Gold Powder Technology: A Review: Hossein Aminian; FiMatCon

Gold powders have many important industrial applications. In this paper the available processes for the preparation of gold nano and micron sized powders are described. The attention has been given to hydrometallurgy route and the recent works and achievements in controlling the powder morphology are highlighted.

WORLD GOLD: New Concepts II

Wednesday AM
Location: Hilton Bonaventure Hotel

Session Chair: M. Jefferey, not available

9:45 AM
Kinetics of Cyanide Oxidation under CIP or CIL Conditions: Xiawen Dai; Paul Breuer; Matthew Jeffrey; CSIRO

Within the CIP or CIL cyanidation processes, a decrease in cyanide concentration occurs as a result of several possible mechanisms: oxidation, volatilization, and formation of metal cyanide complexes followed by adsorption onto activated carbon. Commonly the cyanide loss is measured during leach testwork, with a number of studies having attempted to correlate the cyanide loss with ore characteristics and/or operating parameters. However, none have attempted to differentiate the loss of cyanide via oxidation from the other mechanisms. Of particular concern is the potential increase in cyanide oxidation in the presence of both carbon and copper. This paper presents results from a study in which the oxidation of cyanide was determined from the change in solution cyanate, the oxidation product, which is stable in alkaline solutions and does not adsorb onto activated carbon to any appreciable extent. Investigated is the effect of carbon, oxygen and copper concentrations and cyanide to copper molar ratios from 2:1 to 15:1. Results show that the oxidation of free cyanide and copper cyanide complexes follow a first order reaction. In the absence of carbon the oxidation of cyanide proceeds very slowly, whilst in the presence of carbon the oxidation of cyanide is substantially enhanced and increases with increasing carbon concentration. For the carbon catalysed oxidation, it has been found that the oxidation of the CuCN2- complex is the most difficult, followed by the oxidation of free cyanide and then Cu(CN)32-. When there is co-existence of both free cyanide and copper (i.e. CN-Cu3-), the oxidation proceeds most readily and increases with both copper and free cyanide concentrations.

10:25 AM
Significant Innovations in the Australian Gold Industry: Damian Connelly; Mineral Engineering Technical Services Pty Ltd

Significant Innovations In The Australian Gold Industry By Damian Connelly Director/Principal Consulting Engineer Mineral Engineering Technical Services Pty Ltd (METS) www.mets.net.au damian.connelly@ mets.net.au ABSTRACT This paper details a brief history of the Australian gold industry from the 1980s gold boom to the present day, highlighting an industry characterised by innovation in plant design and junior companies prepared to ‘have a go’ contrast to the conservatism of many larger mining companies. Design flexibility, the innovation of new processes, the preparedness to exchange ‘process know how’ and technology singularly differentiated the gold industry from other sectors over during the 1980s. The introduction of tight footprints, large plants and equipment, two stage crushing, SAG milling and pebble crushing, mill innovations, carbon in pulp (CIP) and carbon in leach (CIL), stepped tanks to flat tanks, the scale up challenges of large tanks and mixers, the North Kalgoorlie screen, carbon management systems, the development of a number of stripping systems, various electrowinning regimes and modularisation were all exciting changes in the industry. Australia can compete globally in the resource sector despite its high wage structure. This is the result successful implementation of process innovation and design changes. Research and development plus innovation by companies themselves and assistance from consultants has resulted in Australia becoming a leading supplier of commodities and an exporter of resource sector technology. Institutions such as Queensland University’s Julius Kruttscnnitt Mineral Research Centre, Perth based Parker Centre, the University of South Australia’s Ian War Institute, and CSIRO, AMIRA and the Cooperative Research Centres (CRCs) have fostered these innovations. Over the last thirty years there have been widespread innovations and process design changes.

10:50 AM
Pilot-Scale and Continuous Bench Testing of the MMS CN-D Cyanide Destruction Process on an Australian Gold Plant Tailings Effluent: Scotch Adams; Stuart Glen; Maelgwyn Australia Pty Ltd

Cyanide management practices on modern gold plants are becoming more onerous, due to environmental pressures, particularly for signatories to the International Cyanide Management Code. Operations are therefore seeking to reduce levels of weak-acid dissociable (WAD) cyanide reporting to spigot discharge as well as to any eventual discharges from the tailings storage facility (TSF). Current gold industry standard processes primarily include the oxidation of cyanide by means of sodium meta-bisulfitite (SMBS, or SO2) with air, Caro’s acid (H2SO5) or hydrogen peroxide (H2O2). These processes require the transport and usage of expensive oxidizing reagents, along with the safety and environmental issues associated with these corrosive and toxic chemicals. Maelgwyn Mineral Services (MMS) has developed the MMS CN-DTN process, which utilizes the Aachen ReactorTM, a high-energy mass-transfer superoxxygenation system, in conjunction with an activated carbon-based catalyst and no additional reagents, to increase the rate of cyanide oxidation to cyanate, the thermodynamically more stable form. Testwork conducted at the Maelgwyn Australia testwork facility in Perth Australia is described, at both pilot scale and continuous bench-scale, on a sample of tailings effluent obtained from an Australian gold plant. WAD cyanide is demonstrated to be lowered using the MMS CN-DTN process from an influent of 130 mg/L to the required levels for discharge to TSF (<50 mg/L). The continuous test results showed stable operation over three residence time turnovers. The pilot-scale results demonstrated the efficiency of the process at the reasonably large scales required for engineering cost estimation.
with constitutive contrasts. The ductility of the alloys with Cu is much described in terms of flow stresses and ductility over 300-500°C, along and are difficult in rolling as well. The behaviors of the two classes are good extrudability whereas the Cu-bearing alloys have low extrudability hot work processing also has marked differences; the Cu-free alloys have sized and distributed precipitation but causes high quench sensitivity. Their 7050) provide the high strength aircraft alloys. The Cu gives rise to suitably and architectural applications whereas the Al-Zn-Mg-Cu alloys (e.g. 7075, The Al-Zn-Mg alloys (e.g. 7004, 7020) are employed for land transport castings of widely different geometries: a thin 2mm wall cover and a 6mm in the model cavity is extremely turbulent. Due to the steady improvement porosity associated with the die casting process where the inflow of metal until recently, the heat treatment of pressure die cast parts has always been compared to the result of filling simulations. If the results of modeling have been validated, unless prohibitively long computing times are used. In order to overcome these practical difficulties, a simple method is proposed which consists in tracking the temperature of the advancing liquid metal front so as to make sure it will always remain above the so-called 'Misrun Critical Temperature' (MCT) determined experimentally for thin and thick aluminum A356 and magnesium AZ91E castings. If the predicted liquid metal front temperature falls below MCT, a cold-shut or misrun is likely to occur at this location. The values of MCT for thin and in aluminum A356 and magnesium AZ91E were determined experimentally on misrun castings of widely different geometries: a thin 2mm wall cover and a 6mm to 25mm thick bell housing. MCT was found to be lower for magnesium AZ91E and for the thicker casting (bell housing).

2:55 PM
Hot Workability Differences of 7000 Aluminum Alloys with and without Copper Additions: Hugh McQueen; Paola Leo; Concordia University; University of Salento
The Al-Zn-Mg alloys (e.g. 7004, 7020) are employed for land transport and architectural applications whereas the Al-Zn-Mg-Cu alloys (e.g. 7075, 7050) provide the high strength aircraft alloys. The Cu gives rise to suitably sized and distributed precipitation but causes high quench sensitivity. Their hot working process also has marked differences; the Cu-free alloys have good extrudability whereas the Cu-bearing alloys have low extrudability and are difficult in rolling as well. The behaviors of the two classes are described in terms of flow stresses and ductility over 300-500°C, along with constitutive contrasts. The ductility of the alloys with Cu is much reduced above 400°C by precipitation of a phase at the grain boundaries that can be avoided by suitable heating schedules. The high strength alloys are subject to delamination corrosion of sheared edges due to severely pancaked grains; this can be alleviated by holding between passes in mid-rolling schedule. In torsion tests at 10-1 to 10 s-1/250-500°C, the stresses (ductilities) at 300°C/ 1s-1 and activation energy Q for 7004 were 118 MPa (2) and 262 kJ/mol. The 7075 was tested after several pretreatments: completely overaged (softened): 107 MPa (5), Q=150 kJ/mol; whereas, solution and quick cooling to testing caused extraordinarily high peaks related to dynamic precipitation resulting in 160 MPa (1,2), Q=300 kJ/mol. 2:50 PM
Canadian Hot Workability Research on Al Alloys 1960 - 2010: Hugh McQueen; Gordana Avramovic-Cingara; Concordia University; McMaster University
Before 1950, hot working was simply deforming above the recrystallization point and gave a soft product compared to cold working. From 1960 onwards, improved testing in compression and torsion (stress, strain rate, temperature, quenching) provided valid specimens for microstructural analysis by polarized optical and transmission electron microscopy (TEM). Indeed, TEM was essential to uncovering the hot working mechanisms because it could distinguish between cold and hot substructures (dynamic recovery) in either initial or new grains (dynamic recrystallization). Over the years, teams at Concordia, McGill and UBC obtained NSERC support for students and equipment. CANNET built up a hot forming group having capabilities from high-rate cam-plastometer compression to rolling of experimental alloy billets; this was combined with latest metallurgical instruments for fundamental research. Al alloys of every class (2000, 3000, 5000, 7000, 8000) were studied to understand the effects of solutes, precipitates, dispersoids and composites. The complex flow patterns in extrusion were clarified and modeled by finite element methods. Physical simulations of rolling schedules (up to 20 passes and reductions of 98%) by torsion provided evidence of microstructure development during both the passes and the softening intervals, thus clarifying development of texture in different alloys. The results frequently appeared in proceedings of Light Metals symposia and Canadian Metallurgical Quarterly 3:15 PM
Microstructure and Hot Workability of Al-Mg-Si Alloy in the As-Cast and Homogenized State: Paola Leo; Hugh McQueen; Emanuela Cerri; Università del Salento; Concordia University
Al-Mg-Si alloys are widely used as medium-strength structural materials; extrusion is the most common processing route. In the present hot deformation investigation of a 6060 alloy, the microstructure of the alloy has been analyzed in the as-cast state, after homogenization heat treatment and after hot deformation by tensile tests in the range 400-490°C and 10-4 to 10-2s-1 on both as cast and homogenized alloys. After deformation the microstructure of the as-cast alloy exhibited cavitation. The flow curves at the lowest test temperature T show a gradual softening after a stress peak, being more evident for the alloy deformed in the homogenized state in association with a high yield stress; at higher T a plateau is attained which is lower as T rises and strain rates decrease. For each fixed T, the ductility decreases as strain rate increases for the homogenized alloy whereas, for the as cast alloy, it rises with strain rate. Constitutive analysis gives Q = 240kJ/mol for the homogenized alloy in agreement with published values; this indicates a more rapid strength decline with rising T than Al, suitable for good hot workability along with the lack of cavitation. 3:55 PM
Experience in the Heat Treatment of Pressure Die Cast Brackets: Nicolas Giguère; Franco Chiesa; Jean-Francois Blackburn; Centre de métallurgie du Québec (CMQ); Cégep de Trois-Rivières
The complex flow patterns in extrusion were clarified and modeled by finite element methods. Physical simulations of rolling schedules (up to 20 passes and reductions of 98%) by torsion provided evidence of microstructural development during both the passes and the softening intervals, thus clarifying development of texture in different alloys. The results frequently appeared in proceedings of Light Metals symposia and Canadian Metallurgical Quarterly
treatment can be applied without any damage to the casting. However the solutionizing temperature must be lower than that applied to macroporosity free castings and for mulch shorter time. The object of the present study is to determine the highest solutionizing temperature that can be applied to aluminum 383 die cast brackets along with the optimal temperature and time of aging resulting in the highest improvement in mechanical properties. (both strength and ductility). This will be done by testing strength and deformation on the casting itself using a specially designed jig; the crushing force to deformation curve will be analyzed so as to quantify the improvement in both strength and ductility brought about by the partial precipitation hardening heat treatment.

NEW TECHNOLOGY IMPLEMENTATION IN METALLURGICAL PROCESSES: Modelling

Wednesday PM Room: Fontaine H
October 5, 2011 Location: Hilton Bonaventure Hotel

Session Chair: Boyd Davis, Kingston Process Metallurgy Inc.

1:35 PM
Role of Process and Logistics Simulation Modeling in Delivering Capital Effective and Operationally Efficient Solutions for RTFT: Cassandra Lee1; Jeff McGinley1; Yves Pepin2; Gabriel Issid2; 1Hatch, Rio Tinto Fer et Titane

Over the past decade, Hatch has used process and logistics models to assist Rio-Tinto Fer et Titane (RTFT) with capacity planning, debottlenecking, and optimization to help ensure design capability, capital effectiveness, and operational efficiency of the integrated production chain. Process models are used to optimize the physics-based aspects of the system, such as mass and energy balances, flow rates, yields, and equipment specifications. Dynamic logistics models are used to optimize how the various plant areas work together to achieve the desired ends and deal with such things as plant scheduling and synchronization strategies, sizing of buffers between processes, defining the required number of process and material handling units, and designing a layout that minimizes plant interferences and inefficiencies. The combined use of process models and logistics models enables the overall plant to be optimized from both a productivity and quality point of view, with each plant area working in harmony with one another to achieve targeted capacities and efficiencies. This paper describes the many benefits derived from such modeling efforts over the past decade for each of the major plant areas at RTFT: QIT’s Steel Plant, Slag Plant, and Smelter Plant, and QMP’s Powder Plant.

2:00 PM
Thermodynamic Modelling of Peirce-Smith Converter Slag at the Chagres Smelter, Chile: Nubia Canclona Valencia1; Roberto Parra F.1; Luis Bahamondes1; P.J. Mackey1; Philip J. Mackey1; 1University of Concepcion; 1Chagres Smelter, Anglo American PLC; 1P.J. Mackey Technology Inc.

The Chagres smelter in Chile, a unit of Anglo American, utilizes an Outokumpu flash furnace and Peirce-Smith converters to produce 92,000 tpy of anode copper. Two, fuel oil-injected rotary slag cleaning vessels are used to clean converter slag before the slag is discarded. Typically, Peirce-Smith converter slag from the matte blows (matte grade is 62% Cu) is transferred to the slag cleaners (along with flash furnace slag), while the high copper slag from the copper blow is normally cooled and recycled to the flash furnace as cold dope. The performance of the slag cleaning furnaces is dependent in part on the quality of the converter slag. In order to understand the impact of converter slag quality on slag cleaning and to help optimise the slag cleaning operation, thermodynamic modelling of the converter slag, supported by microscopic examination and electron probe microanalysis (EPMA) of industrial slag samples, was carried out to characterize the Peirce-Smith converter slag. The results of this investigation are described in this paper.

2:25 PM
Advanced Integrated Process Modelling of Ni-Cu Sulphide Treatment at Xstrata Nickel's Sudbury Smelter: Nagendra Tripathi1; Rajan Panderher1; Arthur Barnes1; Ron Schonewille1; Xstrata Process Support; Xstrata Nickel

Advanced process modelling tools were developed for the Xstrata Nickel Sudbury Smelter flow sheet using a combination of FACTSAGE®, METSIM® and ARENA® software. These tools were employed to assist with plant optimisation, emission control, process design and case studies as applied to a smelter. The development of process modelling tools in pyro-metallurgy commonly involves an in-depth study of the thermo-chemical properties (heat capacity, liquidus temperature, etc) of all high temperature phases, usually matte and slag. The preferred tool for this purpose is FACTSAGE®, a well-known thermo-chemical modelling software package. In this work, the results from the thermo-chemical model have been subsequently incorporated into the development of a process model for the entire smelting facility using the METSIM® platform. Such a process model also includes a number of special features adopted to effectively simulate matte and slag systems. To ensure the robustness and reliability of the process model, several process parameters and assumptions were verified with laboratory and plant data. Consequently, the model includes the ability to examine the impact of a number of plant parameters on potential plant performance. Potential variables are the percent sulphur elimination during concentrate roasting, furnace matte grade and degree of matte metallization. Key output parameters include operating temperature, furnace coke requirement, sulphuric acid production, CO2 emissions and overall energy requirements. Selected outputs from the process model (for example blowing time, slag production rate and matte converting rate) can then be utilised in the development of a discrete event model (DEM) for the smelter using ARENA® software. Incorporation of reliable and validated mass balance parameters enhances the robustness and reliability of the DEM model. The integration of thermo-chemical, process and DEM modeling tools has a distinct advantage in planning plant trials and examining process design initiatives at the Xstrata Nickel Sudbury smelter.

2:50 PM
Development of the System for Furnace Integrity Monitoring Based on Real-Time Continuous Acoustic Emission Data Acquisition and Analysis: Pawel Gebski1; Afshin Sadri1; Winnie Yong1; 1Hatch

Industrial smelting furnaces are subjected to significant structural changes and deterioration caused by the conditions under which they operate. The current methods for the structural assessment of furnaces are mainly focused on visual inspections, thermal data analysis, acoustic ultrasound-echo (AU-E) of the refractory lining and surveying of the key structural elements. Acoustic Emission (AE) non-destructive testing (NDT) technique has proven its capabilities for continuous monitoring of industrial installations and structures. Recently, Hatch Ltd. has been successful in applying AE for monitoring furnace tapblocks, and expanding the scope of the AE monitoring to the structural integrity of the entire furnace. The capability of detecting emissions related to the fracture development in the furnace shell, movement of the refractory, electrode arcing, combined with efficient source location algorithms is an AE system tool for the real-time furnace integrity monitoring. In this paper the concept of such state of the art structural integrity assessment system is presented. The initial results of the AE monitoring together with data analysis techniques are also discussed.

3:15 PM
Electric Furnace Freeboard Combustion CFD Modeling: Amir Golparvar2; 2Hatch

Poor combustion efficiency, roof and/or side wall overheating, carry over to off-gas system and non-ideal radiative heat transfer to processes or cooling systems have been common limiting factors causing inadequate process performance of the furnace, operational problems, and safety hazards. Application of Computational Fluid Dynamics (CFD) modeling for simulating fluid flow and combustion in industrial scale electric furnace will be presented. This paper will describe how CFD simulations can be

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used to address commonly observed problems associated with freeboard combustion. Examples will be presented to explain how combustion CFD modeling has been used as a tool to diagnose a problem with furnace (roof overheating), optimize existing design (air infiltration distribution) or develop a new design (freeboard furnace scale-up).

3:55 PM
Improving Energy/Water Specific Consumption Strategies in Industrial Complexes: Integration and Collaboration: Osvaldo Bascuñán; Curt Hertler; OSISoft, LLC

The lack of integrated information including the Energy/Utility Suppliers with sufficient detail for analysis causes inefficient operation in metallurgical complexes including the Energy/Utility Suppliers. Defining the right context for information use is essential for sustainable operations. This being said, what are we doing to enable people to act upon information and to be aligned to optimize the use of resources like raw materials, energy, water and carbon for an entire metallurgical complex? Collaboration between all company entities is a key component of improving efficiency. Evolution of web technology and object modeling of enterprise assets enables collaboration across the whole business. Operational troubleshooting occurs more quickly as the organization acts on issues to reduce wasteful operation. This paper presents a real time software infrastructure with tools that give users the ability to sift through available data, transform data into information for business continuous improvement and optimization. We will introduce a new technology for analyzing real time data, information and events using multidimensional analysis of information to detect anomalies based on the statistics of the data classified by time events to reduce the information into action. A new paradigm for collaboration at a local and strategic level is proposed to enable the enterprise to become proactive in dealing with wasted time and products. Three examples from the industry will presented and their benefits highlighted.

4:20 PM
Modeling & Software for Control Purposes of a Direct Blister Smelter: Mikko Korpimäki; Jouni Pihlasalo; Peter Björklund; Lauri Piesonen; Tuula Mäkinen; Outotec (Finland) Oy

Outotec Direct Blister Flash Smelting technology has proved to be an efficient and environmentally friendly way to treat the copper concentrates from the Zambian Copper belt at Konkola Copper Mines (KCM) Nchanga smelter in Zambia. The earlier applications of this technology are Olympic Dam smelter (Australia) and KGHM smelter (Poland) with quite different raw material base and customized process concepts. The process chain comprises of a direct blister furnace combined with two-stage electric furnace slag cleaning to recover blister copper and Cu-Fe-Co alloy. Lime and limestone are used as the fluxing agent producing an iron-calcium-silicate slag. The modeling of slag chemistry and thermodynamics with MTDATA software played a central role in deciding the operation parameters as well as in quickly overcoming metallurgical challenges in slag chemistry during the commissioning of the Nchanga smelter. The high oxide slag in the blister furnace as well as the low oxide slag in the electric furnaces is required to achieve a sufficiently low viscosity at acceptable temperatures. Outotec FSF Online Process Advisor, a process control model and a monitoring tool for a Flash Smelting Furnace, is used to calculate the process parameters and to give valuable information of the process state for operation personnel. Online Process Advisor automatically transfers information between the process control model, the process control system and the laboratory. The control model enables correct process parameters to stabilize the process operation. After the implementation of the online version of Process Advisor the process control improved significantly. Steadier process conditions also helped decrease Cu content in the slag, minimizing Cu carryover to the electric furnaces. The model also predicts the melt level, which helps to optimize the tapping schedule and the feed rate. It also seeks a ternary CaO-FeOx-SiO2 diagram of liquidus temperature that corresponds with the latest operation point.

4:45 PM
Risk Weighted Cash Flow, a Communication Tool for Engineers and Financial Professionals on New Technology Projects: Mark Kennedy; Cameron Harris; Allan MacRae; Norwegian University of Science and Technology; SNC Lavalin Inc.; MacRae Technology Inc.

New technology projects, particularly those involving first-of-a-kind metallurgical facilities, have a poor track record of achieving their overall financial targets, as they incorporate technological risks in addition to normal project risks. Traditional project management tools focus on risk from concept development through implementation, but typically fail to address the additional risks associated with a new technology project including slow start-up, slow ramp-up, and failure to achieve design performance (quality or throughput). These additional risks affect future cash flows produced by the project and hence its value, typically measured as net present value (NPV) or internal rate of return (IRR). Common accounting practice is to reduce the present value of future cash flows by applying a chosen discount rate, often reflecting the corporation’s cost of capital. This discount rate does not contain an allowance for technological risk, which is often underestimated or misunderstood by both the financial and engineering project managers. This paper will focus on the topic of project risk and new technology, and how these play a role in the probability of achieving the predicted future cash flows. By properly addressing technological risk in the form of risk-weighted returns, marginal projects can be prevented from proceeding, while sound projects can be given the additional time and resources required to achieve the optimal level of front-end-loading (the level which returns the maximum risk-weighted net present value). A simple set of mathematical tools should enable engineers and financial professionals to establish a common level of understanding, thereby leading to a more accurate assessment whether a new technology project is ready to pass through its next level of approvals.

5:10 PM
The Importance of Process Control to New Technology Implementation: Terry Gerritsen; Sylvain Picard; Bruce MacKay; Hatch

Virtually all new technologies require a control system. Any intense process has many process variables that react quickly making manual control difficult. Control system design has a significant impact on the success of a plant especially during ramp-up. New technology projects are particularly sensitive to control system design as the process response is unknown. This paper discusses the important factors encountered in the design of a control system for a new technology. Examples are given of successful new technology plant start-ups where tight coordination of the process control system implementation, process design and selection major equipment led to rapid ramp-ups.

WORLD GOLD: Fundamentals

Wednesday PM Room: Hampstead / Cote St. Luc
October 5, 2011 Location: Hilton Bonaventure Hotel

Session Chairs: Nathan Subina, Barrick Gold; M. Adams

2:00 PM
Fundamental Investigations of SART for Cyanide and Copper Recovery: Andrew Simons; Paul Breuer; Parker Centre/CSIRO/Curtin University; CSIRO

The presence of soluble copper in the ore can be a problem for many gold operations. This is due to copper consuming at least three moles of cyanide per mole of copper to form toxic copper cyanide species, which are discharged into the tailings storage facility unless treated. The SART (Sulfdisation, Acidification, Recycle, and Thickening) process can overcome this problem as it can separate copper and cyanide from each other in clarified tailings solutions. Cyanide can then be recycled while copper is recovered as a high grade copper sulfide precipitate. This paper
will discuss the results of factorial experimentation conducted on the SART process, the focus being the influence of process variables on SART performance and control. A key finding of this work is that cyanide and copper recovery decrease over time due to loss of sulfide from the system as hydrogen sulfide gas. An economic analysis of these results is also presented showing optimal operating conditions and profit sensitivity based on reagent costs. Finally, this paper will show how a variety of common species found in gold tailings respond to SART and the implications of their response. This includes the possibility of selectively recovering other metals from gold tailings including residual gold and silver as well as toxic elements such as arsenic, antimony, and mercury.

2:25 PM
The Dissolution of Chalcocite and Covellite in Cyanide Solutions: James Kyle; Paul Breuer; Khin Aye; Rebecca Meakin; Murdoch University (Parker Centre); CSIRO

Gold is often associated with copper ores, and during copper sulphide flotation, the gold only partially reports to the flotation concentrate with the remainder in the flotation tailings. In such cases, the flotation tailings are often treated with cyanide to recover the accessible gold. During this process the copper minerals in the flotation tailings, generally in concentrations in excess of the remnant gold, will also dissolve competing with the gold for cyanide and adsorption space on activated carbon. In addition, the solubile copper must be removed from the tailings water prior to recycle. As well as consuming large amounts of cyanide by the formation of complexes containing up to four moles of cyanide per mole of copper, the dissolution of copper minerals in cyanide solutions also results in cyanide losses by oxidation to thiocyanate and dissolved oxygen reduction in the solution by the oxidation of the sulfide ions. In this paper, the dissolution of chalcocite and covellite in cyanide solutions is examined under both anoxic andoxic conditions, and the concentration of copper, cyanide and sulfur species have been determined during the course of the reactions. This has lead to a new interpretation of the dissolution mechanisms for both copper sulfides in cyanide solutions.

2:50 PM
An Electrochemical and SERS Study of the Gold-thiosulfate Interface in the Presence of Copper: Eric Nicol; Janet Baron; Jeff Mirza; Jacek Lipkowski; Yeonuk Choe; University of Guelph; Barrick Gold Corporation

Due to recent concerns over the environmental impact, and toxicity of cyanide, much research has gone into the use of thiosulfate as an alternative lixiviant for gold leaching [1,2]. The addition of Cu (II) into the leaching solution has been shown to aid in gold dissolution and is believed to aid in partial removal of the passive layer forming on the gold surface [3]. Although it is known that addition of Cu (II) is beneficial, the exact mechanism by which it aids in the oxidation and dissolution of gold, and its role in determining the composition of the passive layer formed, remain unknown. The main goal of this project is to understand the role Cu (II) plays in the promotion of leaching over passivation. Results presented will stem from work accomplished using Surface Enhanced Raman Spectroscopy (SERS) in tandem with electrochemical techniques such as linear and cyclic sweep voltammetry. Electrochemical measurements show how the mixed potential shifts as Cu (II) aids in the oxidation of gold and partially removes oxysulfur species or sulfur from the gold surface. SERS spectra collected were used for fingerprint identification of sulfur species on the surface of the gold in an attempt to pinpoint which species promoted leaching over passivation. Due to the destructive nature of the leaching reaction, the SERS spectra were acquired using gold nanorod electrodes that showed increased stability compared to other SERS active surfaces.

3:15 PM
Pyrite Encapsulation in the Neutral/Alkaline Pressure Oxidation of Refractory Gold: Samuel Peters; Vladimirios Papangelakis; University of Toronto

Pressure oxidation of refractory gold ores can be conducted on ores with high carbonate content using just water or water with alkaline reagents to promote fast kinetics, and suppress the formation of elemental sulphur and CO2. In this work, a fundamental study was conducted to explore the silica-pyrite interaction in the presence of calcium and sodium carbonate. It was found that an alkaline environment increases the pyrite decomposition kinetics on one hand, but on the other dissolves silica, which encapsulates the dissolving pyrite thus hindering ultimately complete decomposition.

3:55 PM
The Deporment of Trace Toxic Elements in Cyanide Solutions: James Kyle; Vera Gella; Peter May; Murdoch University (Parker Centre)

The deporment and speciation of trace elements during mining and minerals processing is becoming an area of increasing concern with regards to potential health and environment risks within the immediate vicinity and surrounding area of mining and minerals processing operations. In Australia, the National Pollutant Inventory (NPI) lists antimony, arsenic, beryllium, cadmium, chromium (III&VI), cobalt, copper, cyanide, lead, manganese, mercury, nickel, selenium and zinc as monitoring targets. The use of chemical modelling can enhance our basic understanding of the deporment and speciation of trace metals under conditions present in gold processing solutions, and assist in laboratory and field investigations. In this paper, we report the results of chemical speciation modelling using the JESS software package for the trace toxic elements Pb, Cd, Hg, As, Sb, Bi, Se and Te in cyanidation solutions of varying salinity and relate the models to experimental data. The speciation of mercury cyanide species is examined in detail to assist in determining its behaviour throughout the gold cyanidation process. While the use of chemical speciation software can assist in understanding the deporment of these trace toxic elements in cyanide solutions, caution must be used in interpreting the models produced which must be related to the information in the software database.

4:20 PM
Cyanide Analysis for Complex Cyanide Solutions: Wendy van der Merwe; Paul Breuer; Mintek; ‘Australian Minerals Research Centre

With the gold industry looking to process more complex ores, the control of cyanide addition to the gold leaching circuit has become more crucial. On-line “free” cyanide measurement provides a rapid response to changes in ore mineralogy, however poor understanding of the various cyanide analysis methods has impaired their acceptance and uptake within the gold industry. This paper compares the two commonly employed “free” cyanide online analysis methods (amperometric and potentiometric end-point silver nitrate titration) with the common site laboratory rhodanine endpoint silver nitrate titration method and those obtained using an ion selective electrode. Some interferences, method considerations and measurement differences between these methods will be presented and discussed. Particular focus will be on cyanide solution containing copper and zinc with varying cyanide to metal ion ratios and the resulting cyanide available to leach gold.

WORLD GOLD: Geology III

Wednesday PM
Room: Fontaine D
Location: Hilton Bonaventure Hotel

Session Chair: David Lentz, University of New Brunswick

2:00 PM
The Gold Content of Volcanogenic Massive Sulphide Deposits: Patrick Mercier-Langevin; Mark Hannington; Benoît Dubé; Valérie Bécu; Geological Survey of Canada; University of Ottawa

VMS deposits worldwide revealed that a large proportion of deposits are characterized by a relatively low gold grade (<2 g/t), with a gradual decrease in frequency towards maximum grades. The geometric mean and geometric standard deviation appear to be the simplest metric for identifying subclasses of VMS deposits based on gold grade.

2:15 PM
The Geological Setting of VMS Deposits in the Lehigh District: Jeff Mirza; Paul Breuer; Mintek; ‘Australian Minerals Research Centre

VMS deposits contain variable amounts of gold, both in terms of average grade and total contents. The analysis of gold grades and tonnages of 513 VMS deposits worldwide revealed that a large proportion of deposits are characterized by a relatively low gold grade (<2 g/t), with a gradual decrease in frequency towards maximum grades. The geometric mean and geometric standard deviation appear to be the simplest metric for identifying subclasses of VMS deposits based on gold grade. The geometric mean gold...
WEDNESDAY PM

2:25 PM

Au-Rich Volcanogenic Massive Sulphide Deposits of the Flin Flon Belt, Manitoba and Saskatchewan: Alan Galley1; Patrick Mercier-Langevin1; Stephen Piercey2; Rambler Metals & Mining Canada Ltd.

In the present economic climate where bulk tonnage, low grade gold-rich deposits are a principal target for global exploration, volcanogenic massive sulphide deposits remain a viable exploration target where they contain abundant gold. There continued viability is due to both their polymetallic nature and high precious metal grades (Au and Ag) which allow companies to be buffered against swings in single commodity prices. Several Paleoproterozoic greenstone belts are host to Au-rich VMS systems, including the Flin Flon Belt accreted arc terranes in north-central Manitoba and Saskatchewan. These Au-rich VMS deposits are located within more evolved, rift-related volcanic arc assemblages in which abundant felsic magmatism is represented by both rhyolite flow complexes and more extensive volcaniclastic units. These are terranes are usually more calc-alkaline in nature, within a differentiated volcanic sequence that includes andesite and rhodacite. They are characterized by an aluminosilicate-rich alteration assemblage and zones of pervasive silicification not dissimilar to epithermal gold deposits. Within the metamorphosed and strongly deformed arc terranes of the Flin Flon Belt the gold is commonly redistributed along syn-kinematic structures, thereby complicating reconstruction of their original morphology and metal zoning. They are found spatially related to “normal” bimodal mafic and bimodal felsic VMS deposits within the same camp.

2:50 PM

Stratigraphy, Mineralogy, Geochemistry, and Genesis of the Au-Rich Volcanogenic Massive Sulphide (VMS) System from the Baie Verte Peninsula, NW Newfoundland, Canada: The 1806 Zone as an Example from the Ming Mine, Rambler Camp: Sean McClenaghan1; David Lentz2; ‘New Brunswick Department of Natural Resources; 1University of New Brunswick

Gold is an important commodity in Zn-Pb-Cu-Ag-type volcanogenic massive sulphide deposits of the Bathurst Mining Camp. The average Au content of massive sulphides is 0.8 ppm, but can reach up to 6.9 ppm in the Caribou deposit. The 329 Mt Brunswick No.12 deposit represents the largest concentration of sulphides, with historical resources of 124 Mt grading 8.8% Zn, 3.5% Pb, 0.4% Cu, and 103 g/t Ag. Mill feed for the Brunswick No.12 deposit typically ranges from 0.5 to 0.7 g/t Au, although Au contents of up to 8.2 ppm Au have been identified in hanging wall sulphide lenses. Several deposits in the BMC also exhibit higher average Au contents, notably the Caribou (Avg., 1.7 ppm), Restigouche (1.6 ppm), and Louvicourt (2.4 ppm) deposits. Gold correlates positively with Ag, As, Sb, and Sn, which tend to be concentrated in the exhalative Zn-Pb-rich bedded sulphide facies. Footwall stockwork and Cu-rich replacement (zone refining) zones are enriched in Cu, Bi, Co, and Se, and contain less Au, on average. Secondary-ion Mass Spectrometry and Laser-ablation ICP-MS analyses of sulphides confirms the refractory nature of Au, with elevated Au contents in pyrite (up to 42.9 ppm) and arsenopyrite (up to 10.9 ppm), whereas sphalerite, galena, and chalcopyrite have Au contents that are below detection. Concentration of Au likely occurred through exhalative processes in response to mixing of high-temperature hydrothermal fluids with seawater. Zone-refining processes were also responsible for some remobilization of Au, resulting in the sharp enrichment of Au with Sh, Sn, and Ag towards the stratigraphic hanging wall of many massive sulphide deposits. The strong enrichment of Au in primary pyrite (colloform) masses supports a syngenetic paragenesis of Au, whereas lower concentrations in pyrophyllys and late idiomorphic rims, indicate limited release of refractory gold during greenschist facies metamorphism.
In the spring of 2010 double refractory ores from historical stockpiles were processed through Barrick’s Goldstrike pressure oxidation facility, thereby providing preg robbing tests for a variety of metallurgical process. This paper describes the effects of amount, type, place and time of addition of activated carbons on CIL gold recovery and shows that native carbon in plant POX’ed discharge solids can still preg rob gold loaded activated carbon.

3:15 PM
Gold Preg-Robbing by Silicates in Chloride Media: Sima Mohammadnejad;1 John Provis;1 Jannie van Deventer;1 The University of Melbourne
The preg-robbing potential of framework and layer silicates in a chloride medium and in the absence of activated carbon is examined. Experiments are conducted on quartz, feldspar, kaolinite and pyrophyllite powders (0.1-2.5 µm) under acidic and alkaline conditions (pH 2-5.8). The adsorption of gold in acidic media is strong for all silicates evaluated. The overall uptake of gold per unit mineral surface area decreases in the following order: pyrophyllite, quartz, kaolinite, feldspar. The amount of sorbed gold is much more closely related to the specific surface area rather than the type of silicate at acidic pH (pH 2.5 to 3). In weakly alkaline conditions (pH 8), the adsorption is weak for all silicates except pyrophyllite. Reversibility analysis at pH values of 0-1 does not show any gold trapped or physisorbed on silicate surfaces, indicating that chemisorption is the primary mechanism of gold loss from solution. The mechanism of adsorption can be proposed to involve an attraction between the positively charged surfaces of silicates and anionic gold chloride species, which means that the degree of adsorption is greatly reduced in an alkaline environment where the silicates carry a net negative charge and thus do not attract the anionic gold complexes. The correlation between the dissolution of silica from the minerals and the loss of gold from solution may also be an indication that gelation of dissolved silica is causing entrainment and/or adsorption of gold from the solution. The chemisorption mechanism is also evaluated by XPS analysis of the loaded silicate surfaces.

3:55 PM
Functionalized Mesoporous Silica: An Effective Adsorbent for the Uptake of Gold Thiosulfate: Louis Mercier;1 Adil Aledresse;2 François Deroua;1 Rashmi Narendrula;1 Laxman Amarantung;1 Laurentian University;1 GoldCorp
Thiosulfate is recognized as a promising alternative lixiviant to cyanide for the extraction of gold from ore bodies. Gold thiosulfate, however, is not well-adsorbed by activated charcoal, making industrial scale use of thiosulfate for gold leaching impractical at present. Because of their high specific surface areas and uniform open-framework nanoporosity (pore channel diameters in the range 3-10 nm), functionalized mesoporous silicas are widely recognized as highly effective materials for the selective, rapid and high capacity uptake of mercury, gold and platinum group ions.

In the present work, the efficient adsorption of gold thiosulfate by thiol-functionalized mesoporous silica (hereafter designated MP-HMS) is demonstrated, whereby the thiol groups in the materials bind with the gold complexes by ligand displacement. Under slurry conditions in the range 0.25-1.00 g MP-HMS per L of gold thiosulfate solution (10 ppm at pH 7-10), 53-95% of the gold was adsorbed within 30 minutes of exposure. The adsorbed gold could be leached out using cyanide, regenerating the adsorbent for further uptake cycles. Functionalized mesoporous silica is thus a promising candidate for the preconcentration of gold from thiosulfate leachate solutions.
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