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2016 SME KEYNOTE SESSION

Sponsored by Hecla Mining



Monday, February 22, 2016, 8:30 am
North Ballroom 120B-D

GUARDING AGAINST A “NORMALIZATION OF DEVIANCE”

Colonel Mike Mullane

Normalization of deviance is a long term phenomenon in which individuals or teams repeatedly accept a lower standard of performance until that lower standard becomes the “norm.” Usually, the acceptance of the lower standard occurs because the individual/team is under pressure (budget, schedule, etc.) and perceives it will be too difficult to adhere to the original higher standard. Their intention may be to revert back to the higher standard when this period of pressure passes. However, by getting away with the deviation from the higher standard, it is likely they will do the same thing when the same stressful circumstances arise again. Over time, the individual/team fails to see their actions as deviant.

Mullane uses the Challenger tragedy to make this point. Under tremendous schedule and budget pressures and over multiple launches, the NASA team accepted a lower standard of performance on the solid rocket booster O-rings until that lower standard became the “norm.” By the dawn of Challenger, the NASA team had become so comfortable with seeing occasional O-ring damage and getting away with it, the original standard, in which ANY O-ring damage was defined as intolerable deviance, was no longer considered. Disaster resulted.

Teams maintain their high standards of performance by “setting the highest standards;” “connecting the dots” (to insure multiple problems aren’t just symptoms of a single “normalization of deviance” problem); and by “considering the instincts of team members” in the decision making process (with Challenger, some engineers had a gut feeling there were serious O-ring design issues but management refused to react to “instincts”).

Biography

Colonel Mullane was born September 10, 1945 in Wichita Falls, Texas but spent much of his youth in Albuquerque, New Mexico, where he currently resides. Upon his graduation from West Point in 1967, he was commissioned in the United States Air Force. As a Weapons Systems Operator aboard RF-4C Phantom aircraft, he completed 150 combat missions in Vietnam. He holds a Master’s of Science Degree.

Mullane was selected as a Mission Specialist Astronaut in 1978 in the first group of Space Shuttle Astronauts. He completed three space missions and logged 356 hours in space aboard the shuttles Discovery (STS-41D) and Atlantis (STS-27 & STS-36) before retiring from NASA and the Air Force in 1990.

SESSIONS-AT-A-GLANCE

Sessions are arranged by day, chronologically, alphabetically

MONDAY AFTERNOON

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Environmental: Analytical Technologies for Metal Mining Influenced Water (ADTI-MMS)	21	225A
Environmental: Big Mining Data Intelligence – A Financial Game Changer	23	226A
Environmental: Models for Sustainable Development	24	226B
Environmental: Permitting and Compliance Strategies I - Air and Water	27	226C
Health & Safety: Matters of Safety Culture in Today's Mines	30	131B
Health & Safety: Research Efforts Informing Regulation and Compliance	31	131A
Industrial Minerals & Aggregates: Health and Safety	34	221A
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Mining & Exploration: Management: Managing Projects Internationally	43	127B
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Mining & Exploration: Operations: Innovative Information Mining & Equipment Reliability I	45	127C
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Mining & Exploration: Technology: Automation, Where is the Value?	48	125B
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SESSIONS-AT-A-GLANCE

Sessions are arranged by day, chronologically, alphabetically

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MPD: Comminution: Comminution I	104	228B
MPD: Plant Design I	107	232A
MPD: Reagents in Flotation: Flotation I	110	232B
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Part B - Drones, Stockpiles, and Emeralds	142	221C
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MPD: Flotation Equipment: Flotation III	219	232B
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SESSIONS-AT-A-GLANCE

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Wednesday Afternoon

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Research: Geostatistics for Risk Management in the Mining Value Chain: Reserve and Mine Planning	279	122A

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TECHNICAL PROGRAM

Monday, February 22 – Afternoon

ROOM: 221C

2:00 pm

Career Development Right from the Start – Defining Your Professional Path

M. Furniss; Corsa Coal Corp, Friedens, PA

This session will feature presentations from senior level mining industry professionals about their specific career paths. A career in the mining industry can take many different forms from Industry to Services to Government to Academia. Each of these areas include diverse professions. It can be hard to understand the implications of making (or not making) different moves as a professional early in one's career. One of the best ways to evaluate different paths and their potential fit is to understand the paths of senior professionals. This session is intended to answer the burning question of – “How did they get there?” Scott Lawson - Executive VP of Technical Services, Newmont Mining Corporation Mike Henderson – Mining Practice Leader, DOWL HKM Scott Britton – General Manager of Rabbit Lake Uranium Mine and Mill, Cameco Resources Jeff Parshley – Corporate Consultant, SRK Consulting Dr. Thom Seal – Barrick Gold Professor, University of Nevada, Reno.

ROOM: 224A

2:00 pm

Coal & Energy: Best of Ground Control

Chairs: M. Murphy, National Institute for Occupational
Safety and Health, Pittsburgh, PA
S. Tadolini, Orica, Lakewood, CO

2:00 pm

Introductions

2:05 pm

Void Fill Techniques for Stabilizing Roof Conditions During Longwall Recovery

R. Oldham; GMS Mine Repair, Mtn. Lake Park, MD

It has been proven that longwall faces can be moved safely and efficiently. However, abutment pressures and poor ground control conditions can halt operations and be hazardous to coal miners. Recently at a mine in Southwestern Pennsylvania, roof material collapsed above shields that created two large voids and caused major challenges for shield recovery. A unique, engineering solution was developed that utilized a modified concrete material to fill the voids, creating stability in the affected area. The many phases of this project included the construction phase, void pumping, cutting out, and bolting of the concrete material. This project eliminated the hazards associated with bolting the recovery face and removing shields in adverse conditions, making it possible for the mine operator to safely complete the longwall move.

2:25 pm

Evaluating the Risk of Coal Bursts in Underground Coal Mines

M. Gauna; MSHA, Department of Labor, Pittsburgh, PA

Coal bursts involve the sudden, violent ejection of coal or rock into the mine workings. They are almost always accompanied by a loud noise, like an explosion, and ground vibration. Bursts are a particular hazard for miners because they typically occur without warning. Despite decades of research, the sources and mechanics of these events are not well understood, and therefore they are difficult to predict and control. Experience has shown, however, that certain geologic and mining factors are associated with an increased likelihood of a coal burst. A coal burst risk assessment consists of evaluating the degree to which these risk factors are present, and then identifying appropriate control measures to mitigate the hazard. This paper summarizes the U.S. and international experience with coal bursts, and describes the known risk factors in detail. It includes a framework that can be used to guide the risk assessment process.

2:45 pm

16-022

Energy Concepts in the Analysis of Unstable Coal Pillar Failure

E. Poeck; Colorado School of Mines, Golden, CO

A coal bump is characterized by the sudden failure of one or more pillars and an associated release of kinetic energy. This paper presents the development of an approach to assess the potential for coal bumps in room and pillar mines through the use of energy concepts and special consideration of the interface properties between the coal and overlying rock. Back analyses were performed on the widespread collapse of a room and pillar mine with an associated 3.9 local magnitude seismic event. A variety of loading conditions, material properties, and interface properties were evaluated for their effect on unstable failure of single pillars, and the mine-scale model was used to study the evolution of failure during progressive mining. The extent of unstable failure was quantified in these models by calculating the total kinetic energy released during each mining stage. Through the parametric analysis of single pillar models, it was found that softening parameters in either the coal or the coal/rock interface can individually facilitate unstable failure of pillars, but the combination of the two in a single model produced a much higher release of energy during failure.

3:05 pm

Dynamic Failure in Coal Seams: Implications of Coal Composition for Bump Susceptibility

H. Lawson; OMSHR, NIOSH, Spokane, WA

As a contributing factor in the dynamic failure (bumping) of coal pillars, a bump-prone coal seam has been described as one that is "uncleated or poorly cleated, strong... that sustains high stresses." Despite extensive research regarding engineering controls to help reduce the risk for coal bumps, there is a paucity of research related to the properties of coal itself and how those properties might contribute to the mechanics of failures. To investigate a new approach for identifying coal characteristics that might lead to bumping, a principal component analysis (PCA) was performed on 306 coal records from the Pennsylvania State database to determine which characteristics were most closely linked with a positive history of reportable bumping. Results of the PCA suggest a clear correlation between low organic sulfur content and the occurrence of dynamic failure, and a secondary correlation between volatile matter and dynamic failure phenomena. These compositional controls are distinct from other previously established engineering and geologic criteria and represent a missing piece to the bump prediction puzzle.

3:25 pm

A Case Study of Multi-Seam Coal Mine Entry Stability Analysis using the Strength Reduction Method

I. Tulu; OMSHR, NIOSH, Pittsburgh, PA

In this paper, the advantage of using numerical models with the strength reduction method (SRM) to evaluate entry stability in complex multiple-seam conditions is demonstrated. A coal mine under variable topography from the central Appalachian region is used as a case study. At this mine, unexpected roof conditions were encountered during development below previously mined panels. Stress mapping and observation of ground conditions were used to quantify the success of entry support systems in three room-and-pillar panels. Numerical model analyses were initially conducted to estimate the stresses induced by the multiple-seam mining at the locations of the affected entries. The SRM was used to quantify the stability factor of the supported roof of the entries at selected locations. The SRM-calculated stability factors were compared with observations made during the site visits, and the results demonstrate that the SRM adequately identifies the unexpected roof conditions in this complex case. It is concluded that the SRM can be used to effectively evaluate the likely success of roof supports and the stability condition of entries in coal mines.

3:45 pm

Analysis of Roof and Pillar Failure Associated with Weak Floor at a Limestone Mine

M. Murphy; OMSHR, NIOSH, Pittsburgh, PA

A limestone mine in Ohio has had instability problems that have led to massive roof falls extending to the surface. This study focuses on the role that weak, moisture-sensitive floor has in the instability issues. Previous NIOSH research related to this subject did not include analysis for weak floor or weak bands and recommended that when such issues arise they should be investigated further using a more advanced analysis. Therefore, to further investigate the observed instability occurring on a large scale at the Ohio mine, FLAC3D numerical models were employed to demonstrate the effect that a weak floor has on roof and pillar stability. This case study will provide important information to limestone mine operators regarding the impact of weak floor causing the potential for roof collapse, pillar failure, and subsequent subsidence of the ground surface.

Monday, February 22 – Afternoon

ROOM: 224B

2:00 pm

Coal & Energy: Carbon Management

Chairs: M. Mohanty, Southern Illinois University Carbondale, Carbondale, IL
B. Zhang, Derrick Corporation, buffalo, NY

2:00 pm

Introductions

2:05 pm

Carbon Regulation and Application of the Social Cost of Carbon

A. Lundin; HDR, Denver, CO

Emerging greenhouse gas (GHG) emission regulations in the U.S., and varying federal agency approaches to addressing GHG and climate change, have led to an unprecedented increase in civil suits against mines. Focus will be on applying and

assessing a carbon value on U.S. coal mines in order to not only assist mining companies through the permitting and planning process, but to also enhance mine feasibility studies and operations planning.

2:25 pm

Managing Greenhouse Gas Emissions in the Mining Sector

M. Cote; Ruby Canyon Engineering, Grand Junction, CO

The effort to manage greenhouse gas emissions (GHG) in the mining sector can vary depending on the type of mining operations and emission sources. GHG emissions sources typically include electricity consumption, heating of buildings, and mobile equipment combustion, but certain underground operations can have significant fugitive and vented methane emissions as well. Mines that chose to monitor or reduce their carbon footprint need to conduct a comprehensive GHG emissions inventory as a first step using GHG accounting principles. This presentation will guide mine operators through the steps needed to develop a GHG inventory and inventory management plan.

2:45 pm

Pore Characterization and Sorption Property of Coal in the Central Appalachian Coalfields and its Implication for Carbon Dioxide Geological Storage

X. Tang and N. Ripepi; Department of Mining and Minerals Engineering, Virginia Polytechnic Institute & State University, Blacksburg, VA

Deep unminable coal seams are one of the promising sites for geological storage of carbon dioxide. Because of the stronger affinity of carbon dioxide to adsorb onto coal when compared with coalbed methane, injected carbon dioxide will not only displace the methane molecule adsorbed on the coal surface but will also fill the free pore space and stay sequestered. Since the pore space is the primary place for carbon dioxide to be stored, it is essential to characterize the pore feature and sorption property of coal. This paper characterizes coals from the Central Appalachian coalfields where Virginia Tech is currently injecting carbon dioxide into unminable coals as part of a US Department of Energy funded project. Carbon dioxide and nitrogen adsorption tests under sub-atmosphere are used to identify both the pore and surface area features of coal from this coalfield. The high pressure isothermal adsorption test of carbon dioxide on coal is also conducted to evaluate sorption capacity of carbon dioxide. Test results will be helpful for understanding the carbon dioxide storage status in coal seams and evaluating the carbon dioxide storage capacity in the Central Appalachian coalfields.

3:05 pm

16-087

Sensitivity Analysis for Optimizing Carbon Dioxide Injection to Improve Enhanced Coalbed Methane Recovery and Carbon Dioxide Storage Capacity

C. Keles, N. Ripepi, C. Schlosser, A. Louk, E. Gilliland, J. Amante and M. Karmis; VCCER, Virginia Tech, Blacksburg, VA

Carbon dioxide (CO₂) injection in deep unmineable coal seams can enhance coalbed methane recovery as well as effectively and permanently store the CO₂. Enhance coalbed methane recovery and capacity of the CO₂ storage can be improved by several injection parameters such as injection well locations, number of injection wells, time and rate of the injection. A sensitivity study was performed on a coalbed methane field in Buchanan County, Virginia to understand the influence of the injection parameters on methane production and CO₂ storage. The simulation results were compared to field results from an active US Department of Energy funded pilot project.

3:45 pm

Cementless “Green” Concrete with Reduced Carbon Footprint

*X. Yang*¹, *L. Ackah*¹, *A. Matenda*², *M. Peiravi*¹, *P. Kolay*³, *S. Kumar*⁴ and *M. Mohanty*⁵; ¹Graduate Student, Carbondale, IL; ²Engineer, Baton Rouge, LA; ³Civil and environmental engineering, Assistant Professor, Carbondale, IL; ⁴Civil and environmental engineering, Professor, Carbondale, IL and ⁵Mining and Mineral Resources Engineering, Professor, Carbondale, IL

The main objective of this study was to develop a geopolymer-based composite to be used as a substitute for Ordinary Portland Cement (OPC) in concrete application to significantly lower the carbon footprint of the construction industry. F-class coal fly ash collected from two different power generation plants in IL were used as the main precursor for the geopolymer-based composite. Parametric study on concrete mixture design and curing process were conducted using statistical response surface methodology to optimize the strength and mechanical properties of geopolymer concrete. Short-term and long-term compressive strength of the geopolymer concrete were monitored and compared with that of the conventional OPC concrete. Mechanical properties of the geopolymer concrete, such as stiffness and freeze-thaw resistance, were analyzed and a relationship between tensile strength and compressive strength of geopolymer concrete was developed. Our overall finding is that flyash based geopolymer composite is an extremely good alternative to OPC-based concrete both from technical and economic points of view.

Monday, February 22 – Afternoon

ROOM: 229A

2:00 pm

Coal & Energy: Special Topics in Coal Mine Ventilation

Chairs: J. Brune, Colorado School of Mines, Golden, CO
K. Luxbacher, Virginia Tech, Blacksburg, VA

2:00 pm

Introductions

2:05 pm

Pressure Balancing Methods Used to Reduce Spontaneous Combustion in Coal Mines

C. Bateman, *F. Calizaya* and *M. Nelson*; Mining Engineering, University of Utah, North Salt Lake, UT

The implementation of passive and dynamic pressure balancing methods can be used to reduce the risk of spontaneous combustions and accumulation of explosive gas mixtures in confined areas. These methods have been applied in mines outside of the United States, mostly practiced in Australia, India, and some European countries. Pressure balancing, when applied correctly, may reduce or eliminate the flow of air through caved areas, thus reducing the possibility of self-heating of coal. Dynamic and passive pressure balancing designs were engineered for two underground longwall mines, one ventilated by a bleeder system and the other by a bleederless system. The study includes pressure quantity surveys in these coal mines, computer simulation exercises, and laboratory tests performed at the University of Utah. The simulations of surveyed coal mine models are compared with field data and model data to produce results of potential pressure balancing implementations. The results are analyzed and compared to each other, and used to develop strategies to prevent spontaneous combustion, create safe working conditions, and minimize ventilation requirements for each mine.

2:25 pm

Prediction of Ventilation Air Quantity for Dispersing the Methane in Underground Coal Mining: A CFD Analysis

K. BHATIA; Mining Engineering, Indian School Of Mines, Dhanbad, Dhanbad, India

The layering of methane commonly takes place in poorly ventilated and highly gassy underground coal mines. In flammable concentration it leads to explosion hazards. Therefore, detection of methane at regular intervals of time in coal mines is an imperative aspect from safety point of view. In addition, it is important to understand the circumstances that lead to the formation of methane roof layers and the needed air quantity used to disperse them. The paper presents the application of ANSYS, CFD simulation as a tool to study the dispersion of methane in cul-de-sac gallery based on the methane emission rate from a real coal mine. The standard k-epsilon turbulence model is used. The distribution of methane-air mixture velocity and dispersion of methane in the cul-de-sac gallery at air velocity has been investigated. The study revealed that ventilation plays a significant role on methane dispersion in underground coal mines and minimum air velocity is required for lowering the average methane concentration in the blind-heading to a safer level. The simulation results were compared with the experimental results of earlier researchers and the results were found to be closely matching.

2:45 pm

16-050

Pressure Balancing Techniques to Control Spontaneous Combustion

F. Calizaya, M. Nelson, A. Jha and C. Bateman; Mining, University of Utah, Salt Lake City, UT

This study presents the results of three laboratory experiments on pressure balancing techniques carried out at the University of Utah's coal mine ventilation model. The model includes simulations of two working areas, one longwall mine gob, and a set of stoppings and seals. It also includes a pressure chamber between the longwall face and the gob. The model is ventilated by two fans, one main fan, and one bleeder fan. A carbon dioxide injection system, equipped with flow control valves operated by a microprocessor, is used to maintain the pressure difference between the chamber and the gob slightly higher than that of the workings. During each experiment, fan pressures and stopping resistances were changed, the carbon dioxide injection rate was regulated, and the differential pressures across the stoppings were monitored and controlled. The results of these experiments along with those collected from field surveys were used to develop guidelines for the utilization of these techniques to control spontaneous combustion in underground coal mines.

3:05 pm

Methane fire event at a coal mine working face with consideration of ventilation curtain damage

A. Haghighat¹, K. Luxbacher¹ and B. Lattimer²; ¹Mining & Minerals Engineering, Virginia Tech, Blacksburg, VA and ²Mechanical Engineering, Virginia Tech, Blacksburg, VA

Mine face ignition due to a methane explosion is one of the most common fire incidents in underground coal mines. Depending on the magnitude of explosion or fire, ventilation curtain in a continuous miner (CM) area may be damaged or dislodged, affecting the ventilation into the area. A computational study was conducted to investigate the effects of different levels of damage to the ventilation curtain on the ventilation flow into the CM area. The computational fluid dynamics software Fire Dynamics Simulator (FDS), Version 6.0 was used to predict the conditions that develop due to a 200 kW fire on the coal mine face following methane explosion with different levels of curtain damage. Smoke layer depth, tempera-

tures, and mass flow into the CM area were used to evaluate the impact of no damage to the curtain, partially dislodging the curtain, and full removal of the curtain. Partial removal of the curtain allowed more smoke to accumulate in CM area and a reduction in ventilation into the CM area. With full removal of the curtain, smoke accumulated through the entire depth of the CM area and flowed out the entrance to the CM area and the ventilation completely bypassed the region.

3:25 pm

Network Analysis Modelling of Mine Fires

F. Yang, K. Luxbacher, E. Jong, S. Schafrik and C. Brown; Mining and Mineral Engineering Department, Virginia Polytechnic Institute and State University, Blacksburg, VA

Mine fires pose big threats to miners, firefighters and properties. Mine fires along with explosions claimed massive losses of lives and were the most devastating events. Fire simulation is an integral part of mine fire study. Mine fire simulation programs can be classified into two categories. The Computational Fluid Dynamic (CFD) methods can simulate mine fire behaviors in multiple entries due to the limitations of computational capabilities. However, Mine engineers are mostly concerned about the mine-wide impacts, which are the merits of network analysis modelling. Comparisons of MFIRE, MineFIRE and VentFIRE, three mine ventilation and fire modeling programs were made and smoke rollback was discussed. MFIRE is a well acknowledged software from the NIOSH. The solver kernel of MineFIRE is exactly same as MFIRE, and only several modifications were made to run on the Vnet platform. VentFIRE is a fire simulation module from the Ventsim software package. Incorporating Ultrasonic technology of real time airflow monitoring into the network analysis programs was discussed. And the limitations and drawbacks of current network analysis simulation programs were also mentioned in this paper.

4:05 pm

Validating the Key Matrices When Choosing Ventilation Duct – A Case Study

A. Rai¹, C. Kocsis², J. Poor¹ and D. Powell¹; ¹Barrick Turquoise Ridge Inc, Winnemucca, NV and ²Mining, University of Nevada, Reno, Reno, NV

Ventilation duct maintenance and operation has always been a challenge with limited air quantity in dead-end entry or working face. The focus to choose low frictional factor, low physical constraint and minimum leakage ventilation duct has been a wishful thinking for every ventilation engineer. The duct development covering operational and total cost of ownership with on-going success will be presented with actual data and ventilation survey in underground condition. This paper will discuss different key matrices to measure against vent duct in underground making a difference.

Monday, February 22 Afternoon

ROOM: 229B

2:00 pm

Coal & Energy: Surface Processes and Practices

Chairs: M.Furniss, PBS Coals, Inc, Friedens, PA
J. Saloman

2:00 pm

Introductions

2:05 pm

Greater Digging Depth – Same Machine

J. Wientjes and J. Mills; Application Engineering, Komatsu America Corp., Peoria, IL

The Application Engineering department within Komatsu America Corp. was recently asked by a customer to conduct an evaluation of using bulldozer capacity to effectively increase the digging height and production volume of an existing hydraulic excavator operation. The mine site had little experience with a large-scale bulldozer application in a supplemental role. So, this study had to encompass the key variables that can affect not only bulldozer performance but the excavator fleet operation as well. Due to the complexity of synchronizing multiple mining applications and the uncertainty regarding a new mining technique, this study had to deviate from producing a typical finite result. Instead, our team created a series of tools that allow the consideration of numerous performance variables and production goals. This presentation will describe the processes used in this exercise and will illustrate the key design principles included when incorporating different mining applications into a single mining system. The distinctive evaluation tools will be reviewed in detail to convey how variables in certain application parameters can be represented in a simplified and understandable manner.

2:25 pm

Carryback Analysis on Conveyors at a PRB Coal Mine: The Lessons Learned

R. Shields² and A. Marti¹; 1Corporate Marketing, Martin Engineering, Neponset, IL and 2Martin Engineering, Neponset, IL

In early 2012, a large surface coal mine in the Powder River Basin expressed concern over the initial and ongoing costs of operating its conveyor belt cleaning systems. To evaluate the relative effectiveness of its belt cleaning systems, the company commissioned technicians to undertake a testing program including the capture of belt borne material and the analysis of collected material. A test regimen was designed to provide a quantitative means to measure carryback and track performance improvements from adjusting components, upgrading existing equipment, and/or implementing a routine maintenance program. A test rig was developed to collect samples of the material remaining on the belt, and protocols were intended to ensure consistent handling of the material. Analysis of the testing program demonstrated that the performance of the belt cleaning systems at this plant could be significantly improved, when cleaners were properly designed, installed, and maintained. This paper will look at the methodology and the results of this carryback testing program, and consider what it teaches coal-handling operations about belt cleaning and the benefits of scientific testing.

2:45 pm

Legal Drone Implementation – North American Coal Falkirk Mine

S. Burke and G. Obrigewitch; Engineering, North American Coal Corporation - Falkirk Mine, Underwood, ND

North American Coal Falkirk Mine will share details on how they became the first surface coal mine in the country to receive an exemption to operate a survey drone. They will also show how they are currently utilizing this fixed wing survey drone at the mine to save money, save time, and collect better information.

3:05 pm

Two Birds, One Stone: Fuel Supply Chain Cleanliness and Water Management using a Coalescing Filter

C. Bauer; SLS, Pall Corporation, Port Washington, NY

Modern mine sites are among the world's largest consumers of diesel fuel, with typical annual consumption per mine site of over 200 million liters of diesel fuel. Delivered diesel fuel can contain significant quantities of solid contaminants and

water, but vehicle on-board fuel filters are not designed to tolerate high contamination levels without significant impact on service life; most engine manufacturers have issued specific fuel cleanliness requirements, particularly for engines with common rail fuel injection systems. Therefore, contamination and water control throughout the entire fuel supply chain is critical. In this work, the author discusses case studies highlighting best practices in fuel supply chain cleanliness management.

3:25 pm

A Case History of Accelerated Geosynthetic Procurement, Design, Construction & Certification For Unique Closure Application

C. Eichelberger¹, R. Baker² and M. Furniss³; 1Agru America, Georgetown, SC; 2Tetra Tech, Pittsburgh, PA and 3Corsa Coal, Friedens, PA

Coal has been a major resource mined within Pennsylvania during the last 150 years. During the mining process, underground or surface, other unwanted soil and rock materials are mined along with the coal. After separation, various amounts of coal still exist in the refuse piles of material left behind, which are typically steep sloped and have a dark gray color. Some piles with high commercial value have been re-mined for their coal content, while the historic industry practice for reclamation or closure has been to minimally regrade the piles and cap with a soil layer that will minimize water intrusion and promote the growth of vegetation. In 2014, PBS Coals Inc. raised the bar on effective closure of a coal refuse pile. An initial attempt during 2011 to close the facility with a geosynthetic cap system was not successful. The cover soil and top layer of geotextile experienced shear failure and the project was put on hold. A revised, selected solution utilized a unique structured geomembrane product that excels in steep slope applications and provides an integrated drainage system to accommodate and remove the water that drains through the cover soil from the closure system.

3:45 pm

Before You Buy – Re-Evaluate the Operation

J. Wientjes, J. Mills and R. Kafka; Application Engineering, Komatsu America Corp., Peoria, IL

Typically, the initial response to greater productivity requirements is to acquire additional capacity. The Application Engineering department within Komatsu America Corp. recently experienced such an approach at a coal handling facility needing greater train unloading productivity. During a site visit, it was recognized that multiple variables are involved in defining bulldozer fleet capacity needs for varying facility throughput requirements. Variables such as stockpile locations, build/reclaim rates, and train unloading rates all affect bulldozer production requirements. To address the complexity of the coal-handling operation, KAC developed a multifaceted tool that integrates the application variables into the process of defining bulldozer fleet capacity needs for fluctuating production goals at the site. As opposed to adding equipment to the fleet, this tool established that production goals can be met by combining material handling abilities. This presentation will describe the key design principles incorporated into this dynamic tool. Also, examples of using this tool to aid in identifying bulldozer fleet needs for many coal handling applications will be reviewed.

4:05 pm

White Oak Resources Installs Dust Suppression Water Line 10 Times Faster with New HDPE Pipe-Joining Method

G. Trinker; Victaulic, Easton, PA

Data-driven mining operations such as White Oak Resources recognize the value of time. The faster a piping system is joined, the sooner it can be put into service. The easier a joining system makes maintenance, the less downtime. There's a

direct relationship between system uptime and the production of revenue-generating product. When it was given the opportunity to beta test a new joining system for HDPE pipe that enables installation of 10 joints in the time it takes to fuse 1, White Oak immediately saw the value. The mechanical pipe couplings were installed on several services, including the surface dust suppression water line at the company's McLeansboro, Illinois mine. Fusing the system in place would have been impossible given the location of the line along the elevated conveyor belt; it would have required fusing on the ground then dragging the pipe up a cat-walk-like space, lifting and fastening it into position. Mechanical couplings enabled installation of the line in situ without special equipment, contributing to completion 10 times faster. This case history will discuss the challenges of joining HDPE pipe and the solutions offered by mechanical joining systems.

ROOM: 231B

1:30 pm

DREYER LECTURE:

An Explorationist's Odyssey Following Trends – Culminating in Rare Earths

Don Ranta

Monday, February 22 – Afternoon

ROOM: 225A

2:00 pm

Environmental: Analytical Technologies for Metal Mining Influenced Water (ADTI-MMS)

Chairs: C. Bucknam, Au (Analytical Unlimited LLC), Parker, CO
W. Lipps, Shimadzu Scientific Instruments, Columbia, MD

2:00 pm

Introductions

2:05 pm

16-054

ASTM Standardization of Gold ICPMS Method for Mining Influenced Waters

J. Lorengo² and C. Bucknam¹; ¹Au (Analytical Unlimited LLC), Parker, CO and ²Metallurgical Services, Newmont, Englewood, CO

Standardization the Inductively Coupled Plasma Mass Spectrometry (ICPMS) method for gold in cyanide solutions was undertaken to provide a more sensitive method to quantify the gold content than the atomic absorption method standardized in 1994 (E1600). The gold concentration range covered is from 0.001 mg/L Au - 0.3 mg/L Au (0.00005 toz/t Au – 0.009 toz/t Au). Interlaboratory testing was carried out with the assistance of the American Society of Testing and Materials (ASTM) International on two committees to determine the within laboratory and between laboratory reproducibility. Three barren solutions from metallurgical operations were measured in triplicate to satisfy statistical requirements for Committee E01 on Analytical Chemistry of Metals, Ores and Related Materials. A synthetically prepared matrix representing the metallurgical processing solutions was used to prepare Youden pairs to satisfy the requirements of Committee D19 on Water. Results of the standardization program are presented.

2:25 pm

Factors Affecting Accurate Measurement of Sulfate in the Effluent of Anaerobic Bioreactor

L. Figueroa¹ and J. Gusek²; ¹Civil and Environmental Engineering, Colorado School of Mines, Golden, CO and ²Sovereign Consulting Inc., Lakewood, CO

Sulfate concentrations in mining influenced water can be accurately determined by ion chromatography (IC), inductively coupled plasma atomic emission spectrometry (ICP-AES) and turbidimetric methods (TM). The accurate measurement of sulfate in the effluent of anaerobic bioreactors is more difficult. Factors that affect the measurement accuracy in anaerobic effluents include both sample processing/ preservation and chemical interferences. The method of anaerobic sample filtration can result in the oxidation of reduced sulfur species to sulfate and thus bias the measured value high. Soluble organic material can produce interferences in all three typical methods for sulfate analysis. Pitfalls in the standard methods for sulfate sample processing/preservation and analysis IC, ICP-AES will be identified for anaerobic effluents. Recommendations for sample handling and analysis for sulfate in anaerobic bioreactor effluents are proposed.

2:45 pm

Analysis of Highly Mineralized Solutions by ICP-AES

W. Lipps; Shimadzu Scientific Instruments, Columbia, MD

Inductively Coupled Plasma - Atomic Emission Spectroscopy (ICP-AES) is widely used in environmental methods, such as EPA 200.7, to analyze major, minor, and trace elements. In relatively clean water, method 200.7 provides accurate trace metal data, however, samples that contain high concentrations of transition metals, such as iron, or high concentrations of dissolved salts can produce erroneous results. This presentation discusses how features in most modern ICP spectrometers can be used to overcome these spectral and physical interferences.

3:05 pm

Untapped Resources: A Geochemical Examination of Humidity Cell Tests

A. Maest; Buka Environmental, Boulder, CO

Humidity cell tests (HCTs) are longer-term leach tests that are considered by some to be the gold standard for predicting the environmental behavior of mined materials. A number of modifications have been added to the original ASTM method, but the interpretation of test results varies widely. The HCTs represent an untapped resource of geochemical data, with a year-long test generating ~2,500 individual chemical data points. Our detailed examination of HCTs from three projects with different geology and mineralization shows that sulfide oxidation dominates over a limited period of time that is rarely at the end of the test. No simple rules of thumb reliably link laboratory and field results, although the first flush concentrations, which are uniformly ignored in HCT interpretation, are often similar to those from scaled-up field tests. Factors that complicate the use of HCTs for predicting field behavior of mine wastes include: sample representation, time for microbial oxidizers to grow, sample storage before testing, geochemical reactions that add or remove constituents, and the HCT results chosen for modeling. Improved guidance is needed for interpretation of HCT results.

3:25 pm

Net Acid Generation Test pH, Alkalinity, and Sulfate, Experimental and Modeled Results in a Well Constrained System

B. Greer, B. Petri, A. Nicholson and S. Helgen; Integral Consulting Inc., Louisville, CO

Net acid generation tests were performed on mixtures of pyrite, calcite, and silica. The combined mineral samples, mixed with a consistent amount of silica (92%), ranged from neutralizing to acid generating. Agreement between experimental

data and thermodynamic modeling (PHREEQC) for pH, alkalinity, and sulfate in the acid-generating samples suggests that they have fully oxidized. However, modeled sulfate concentrations in the neutralizing samples deviate from the experimental data. Preliminary thermodynamic modeling indicates that most of the sulfate will remain in solution regardless of whether the sample is acid-generating or neutralizing. Experimental data indicate that more than 90% of the available sulfur is present in acid-generating sample leachate, while as little as 20% is present in neutralizing sample leachate. These results suggest that either the sulfate is precipitated or sorbed in the neutralizing samples, or oxidation of pyrite in the neutralizing samples was incomplete.

3:45 pm

Instrumentation for On-line Sulfate Analysis of Mine-Influenced Waters

N. Ergang and R. Davis; Nalco Company, Naperville, IL

Due to tightening sulfate discharge regulations for mine-influenced waters there is a need for automated measurement of sulfate in mine effluents and process waters. Traditional sulfate analysis methods typically require complex sample handling and preparation. These often include sample dilution and/or acid digestion. Such methods are not well suited for long-term automated operation in the field. This paper describes a new on-line, automated prototype sulfate monitor based on Nalco TRASAR technology. The method has a wide active sulfate concentration range and a resolution of about 10 mg/L. Species present in typical mine influenced water yield minimal method interference. The system can be wirelessly accessed remotely to troubleshoot alarms, determine instrument operating conditions, download data or modify instrument operational parameters.

Monday, February 22 – Afternoon

ROOM:

2:00 pm

Environmental: Big Mining Data Intelligence – A Financial Game Changer

Chairs: V. McLemore, NMBGMR/NM Tech, Socorro, NM
G. Robinson, R Squared Inc, Sedalia, CO

2:00 pm

Introductions

2:05 pm

Real Time Data Visualization Utilizing GIS

C. Franks and R. Billakanti; Land and Water, Freeport-McMoRan Inc., Phoenix, AZ

Freeport-McMoRan Inc. (FCX) has extensive property interests, both active and inactive on multiple continents across the globe. In 2014 and 2015, in response to growing demand from internal stake holders to integrate real time data into their daily workflows, the GIS team at FCX worked with the MIS big data group and the business stakeholders to create, test and deploy a working solution integrating PI System data residing in an electronic data warehouse into a mobile and dash-board application. As a result, the work groups within the business who had little experience with GIS data were able to visualize and assess existing conditions in nearly real time resulting in reduced time in the field and a solution supporting multiple individual and group needs.

2:25 pm

Benefits of 3D Visualization and Quantification using Large Environmental Datasets for Mining Applications

E. Rogoff; ARCADIS, Scottsdale, AZ

Advancements in high-resolution data acquisition from aerial surveys and subsurface characterization methods, coupled with large historical databases, provide today's mining restoration practitioners tremendous potential for remediation cost-savings - if they can effectively manage the challenges associated with large data sets rather than being overwhelmed. This presentation will demonstrate 3D visualizations of complex datasets and volumetric analyses performed using CTech's Mining Visualization System™ (MVS) software. Examples from mining project case studies will illustrate the integration of large datasets and information from a wide variety of sources (e.g. LIDAR topographic surveys, historical database queries, GIS information, geologic information, water levels, analytical data, AutoCAD drawings, aerial photographs, computer model output, subsurface tools, geophysical surveys). Resulting interactive 3D models may be zoomed, panned and rotated, allowing flexibility and control to view data or geologic features from any angle or magnification. Animations of temporal changes such as groundwater flow, or movement of plumes through time, will also be shown.

2:45 pm

Integrating Water Management and Operations Management Systems in Mining Supply Chains

F. Mielli and G. Johnson; Schneider Electric, Alpharetta, GA

Water is a key issue for most mining operations. The availability and use of water has a profound effect on the triple bottom line and yet the treatment of water management from a supporting systems perspective is lacking in many ways. Mining and processing produce and consume the majority of water; yet mining and processing systems often have little relationship to the systems used for water management. The consequences of this can be large, with several large mining operations known to have been forced into unplanned downtime because of poor information on water availability. This paper discusses the 2 worlds of water management and operations management and proposes some ways to bring the 2 worlds together for better results. Examples are shown from other industries and also from good practice within the mining industry.

3:05 pm

Big Data-Smart Systems DOING IT RIGHT

G. Robinson; Operations, Wildcat Mining Corporation, Sedalia, CO

The mining industry has been profoundly affected by the convergence of several significant trends, and as a result, the opportunity to deploy data intelligence technology is more compelling now than perhaps at any other time in the industry's history. After a prolonged boom cycle leading up to the 2008 financial crisis, dramatic changes in market forces wrought havoc on demand and commodity prices. The resulting demand for data analytic tools has now reached a critical state. However, the currently available data management systems are generic and not designed for the unique demands of the mining industry. The focus of the session is focused on introducing advanced data analytic solutions specific to the mining industry in order to optimize and generate ROI timelines in months or even weeks.

Monday, February 22 – Afternoon

ROOM: 226B

2:00 pm

Environmental: Models for Sustainable Development

Chairs: S. Fecht, Ramboll ENVIRON, Westford, MA

L. Wrong, Lundin Mining, Toronto, Ontario, Canada

2:00 pm

Introductions

2:05 pm

16-031

A Socio-Economic Model for the Convergence of Corporate Strategy and Sustainability

J. Botin and M. Murillo; Ingenieria de Mineria, Pontificia Universidad Catolica de Chile, Santiago, Chile

Mining has always played a key role in the in the improvement of the quality of life, but also, It has been a source of environmental and social conflict. Despite the great progress in social responsibility and sustainability experienced in recent decades, the public image of mining remains low and mining projects and operations must face growing difficulties and demands, which results in increasing capital and operating costs. In practice, the objective of a mining company is to create value for its shareholders and therefore, the best approach to Sustainability would be to foster those drivers aligning sustainability and shareholders value, this is, the "Business case for Sustainability (BCS). Only under this assumption, convergence of corporate strategy and sustainability may be assured. This paper discusses partial results of a Research Project being carried out at the Catholic University of Chile, aiming to develop a social and economic model for the effective integration of the values of sustainable development in the strategy of mining companies and their stakeholders.

2:25 pm

A Conceptual Model of Sustainable Mine Financing and Development: A Simple Plan

E. Munroe; AngloGold Ashanti, Victor, CO

This presentation attempts to illustrate the interdependence of mine stakeholders including financiers, engineers, scientists, brokers, regulators and the community through a simple conceptual model. The model involves at least four strata that includes: the investor, those engaged in project development and permitting, the product in the form of salable raw materials, and the beneficiaries of the project. The project success is dependent on each parties understanding of the others expectations and their abilities to recognize opportunities to rectify perceived disparate expectations and interests. The investor is interested in minimizing risk to the investment and historic trends indicate the investor prefers large scale mining operations. The large operations in turn drive the permitting effort level and the benefits to the local community. This results in a one size fit all set of expectations. Defining the expectations includes the sustainable community benefit and the investor's profit. The conceptual model considers the possibilities if the project proponents and stakeholders can mutually define the sustainability expectations and take responsibility for doing so.

2:45 pm

The Outcomes of Inadequate Stakeholder Engagement With Outraged Communities

J. Anderson; Yirri Global LLC, Denver, CO

Too often extractive companies create their own problems with respect to their social context. They overly rely on official permits. They either assume the community understands their business and operations and values it or that it does not matter if they do not. Companies end up creating a vacuum: of trust, of knowledge, of relationships. People and organizations then rush in with goals that are, at best, to criticize the company, or at worst, threaten the very existence of the business. This situation points to inadequate stakeholder identification and engagement. This paper will describe three case studies of mines (from Turkey, Indonesia and the United States) where this occurred. These cases also provide another aspect of common practice in the extractives: using only science to argue against

what is seen as a mistaken community concern. We will thus look at the cases from an 'Outrage Management' perspective to analyze why stakeholders reacted the way they did. This is a common aspect of stakeholder engagement that is missing. Finally, we will look at some successful stakeholder engagement capacity building examples and contrast the mining and oil&gas sectors in this regard.

3:05 pm

16-064

Mining Stakeholder Analysis Using Discrete Choice

Theory: A Case Study in Salt Lake City S. Que2, K. Awuah-Offei1, N. Weidner1 and V. Samaranayake1; 1Missouri

University of Science & Technology, Rolla, MO and 2Resource and Environmental Science Department, Chongqing University, Chongqing, Chongqing, China This research sought to facilitate improved stakeholder (community) analysis using discrete choice theory (DCT). The work considered 16 project attributes and four demographic factors. The discrete choice experiment was conducted in Salt Lake City, Utah to illustrate the usefulness of DCT in mining stakeholder analysis. The data was used in discrete choice modeling of individual preferences. The approach answers three important questions for enhanced stakeholder analysis: (1) What are the factors that affect individual preferences? (2) What is the effect of demographics on individual preferences? (3) What is the value of environmental and social impacts to individuals in the community?

3:25 pm

Yukon College's Centre for Northern Innovation in Mining (CNIM): How Communities, Government, and Industry Cooperation is Solving the Skilled Mining Workers Shortage in the Canadian North

S. Rowles; Centre for Northern Innovation in Mining (CNIM), Whitehorse, YT, Canada

Employment in the mining sector may fluctuate seasonally, & through boom and bust cycles, but the need for skilled labour never changes. As baby boomers enter their retirement years, the need for skilled labour is only growing. Studies show thousands of positions go wanting in Canada for lack of trained workers. The problem is particularly acute in the north of Canada. That's why the Centre for Innovation in Mining was created in the Yukon: to provide the best training to maximize opportunities for northerners in the region's labour market. The CNIM is a one-stop, state-of-the-art training facility, founded in close co-operation with the territory's government, communities, and business leaders. CNIM's goal is to help build a highly skilled northern workforce, a stronger economy through greater opportunity, & a more efficient, sustainable mineral industry, as well as to produce entry-level miners who can come into an operation, work safely, be productive immediately, & understand the mining process and their role in it. CNIM, through the Yukon Research Centre, conducts applied research to grow & improve the Yukon's mining sector competitiveness & its environmental sustainability.

3:45 pm

What to Say to Make Friends and Overcome Opponents

J. Davies; Davies Public Affairs, Santa Barbara, CA

Getting a mine permitted no longer happens in a bubble simply decided on fact and science alone. That's why for mines going through the permitting process developing an effective public engagement strategy has become a critical component. Well-funded environmental groups team-up with local opponents and inundate regulators and officials with negative comments pressuring them to delay or kill mining projects. They try to create the impression that opposition is authentic, spontaneous, and overwhelming. In order to counter opponents'

efforts and build a substantial base of public support requires creating persuasive messages. Often, mines attempting to win public support rely too heavily on the jobs, money, and tax revenue arguments. But the public is no longer willing to “sell out” the environment. This session examines what to say to make friends and overcome opposition, and how to build authentic and active public support that can influence public perception and key officials. Also how to use modern psychology, social media, and proven grassroots tactics to get the public to take an active role in support of mining projects and counter opponents’ efforts to derail them.

Monday, February 22 – Afternoon

ROOM: 226C

2:00 pm

Environmental: Permitting and Compliance Strategies I – Air and Water

Chairs: D.Anderson, Haley and Aldrich Inc, Boise, ID
A.Williamson, Twin Metals Minnesota LLC, St Paul, MN

2:00 pm

Introductions

2:05 pm

The Value of a Carefully Prepared Project Description in the Permitting Process

T. Burke² and C. MacDougall¹; ¹Golder Associates, Lakewood, CO and ²California Operations, Rio Tinto Minerals, Boron, CA

Rio Tinto Minerals, US Borax needed Prevention of Significant Deterioration (PSD) and New Source Review (NSR) air quality permits in addition to completing an environmental review for a project at their Boron, California mine and mineral processing facility. US Borax incorporated many elements into the project description to streamline the permitting process. US Borax incorporated voluntary measures in the project description to avoid findings of potential significant impacts for concerns other than air quality, allowing the local air district to be the lead agency for the environmental process and concurrent public processes for the environmental review and the air permit. The project need based on the shut-down of an offsite facility was included in the project description. An emissions summary of both operations to demonstrate the overall emissions reduction was presented. Also included in the project description were detailed descriptions of operations of equipment to meet facility needs that explained why equipment could not always be operated in the manner that resulted in the lowest GHG emissions avoiding further analysis of energy efficiencies in the GHG BACT analysis.

2:25 pm

Permitting for Potential Impacts to the Rarest and Most Protected Wetland Type in Minnesota: the Backstory, Description of the Complex and Inventive Mitigation, and Contentious Agency Interactions

J. Swenson¹, D. Losee¹ and A. Weegar²; ¹Environmental Affairs, UNIMIN Corporation, Mankato, MN and ²Weegar-Eide & Associates, LLC, Austin, TX
Unimin Corporation has an operation in MN along the MN River bluff that dry mines the Jordan Sandstone for silica sand. This mine is advancing adjacent to a calcareous fen wetland (Kasota 7) which is a wetland that receives calcium-en-

riched groundwater & meets specific hydrology, chemistry, soil, & vegetation characteristics. As one of the rarest wetland types in the US & the most protected wetland type in MN, Kasota 7 was designated by the EPA as an Aquatic Resource of National Importance. To amend an existing dewatering permit for mine advancement by dewatering to temporarily lower the static water elevation of the aquifer at the mine face, a MN DNR approved Calcareous Fen Management Plan (CFMP) was required. This is only the fourth CFMP approved in MN & the first for mining. The CFMP includes a hydrology management system designed to minimize indirect impacts. As an additional CFMP component, a \$3.9 million Fen Conservation Fund was also established. The work leading up to approval included a four-year EIS, a first-of-its-kind Pilot Project which tested & validated multiple hydrology systems, & multiple regulatory agency interactions on the local, state, and federal level.

2:45 pm

Ozone National Ambient Air Quality Standard: An Emerging Issue for the Mining Industry

C. Kaiser; GP Environment and Health, Ramboll Environ, Salt Lake City, UT

In 2014 USEPA proposed to lower the ozone NAAQS from 75 ppb to a range of 65 to 70 ppb. The new standard will be set close to background concentrations, particularly in the Intermountain West. No longer will miners be able to dismiss ozone as an issue that does not impact them. There is a growing body of science indicating that background concentrations in rural areas nationwide are much higher than previously understood, particularly in high altitude areas. These elevated background concentrations are strongly influenced by mechanisms such as stratospheric intrusions, frontal passages, wildfires, and international transport, rather than anthropogenic emissions. For mining operations in this region, managing this nonattainment situation will pose new and unique challenges. This new standard will also pose significant challenges for our markets. During this session environmental managers will be provided a practical roadmap of what to expect during the attainment determination process and nonattainment planning process. Additionally, companies will be presented strategies to participate in industry advocacy activities to minimize the burden of this new standard.

3:05 pm

How Do I Meet That Limit When I Can't Even See It?

G. Bodnar and S. Anderson; Environmental, The Doe Run Company, Boss, MO

Permitted effluent limits under NPDES within the mining industry are continually becoming more stringent, leaving mining operations with the challenge of developing effective and economic water treatment strategies in a continually changing permitting environment. Many of these limits were not even within the detection limit of analytical equipment only a decade ago. This paper outlines some of the strategies examined at the Doe Run Brushy Creek Mine and Mill facility to address their water treatment needs within this complex environment.

3:25 pm

Managing Wetlands/Aquatic Resources Permits – What to Do With Long-Term, Legacy Mining Projects as Regulations and Personnel Change, but Permit Conditions Do Not

A. Kramer; Natural Resources, Short Elliott Hedrickson Inc., Duluth, MN

U.S. mining projects undergo comprehensive environmental review and mitigation planning for wetlands/aquatic resources permits to be authorized. Complex mine plans of operation often dictate when, where, and how wetlands/aquatic resources will be impacted, typically leading to required mitigation. Such permits may be authorized for different timeframes depending on the agency or the mine plan. With mining operations driven by current and projected economic conditions,

which can alter, temporarily idle, or even close a mine indefinitely, how are existing permits affected when operations change? Can permit conditions and expirations dates be amended? Who's responsible for maintaining valid permits? When regulations change, what happens to older, legacy permits still having valid, enforceable conditions? What steps should mine managers and personnel take to ensure that permits do not expire, that conditions are adhered to, and that legacy decision-making is accurately documented. This presentation will provide recommendations for maintaining permits, understanding the legalities of permit decisions and enforceable conditions, and the importance of accurate record-keeping.

3:45 pm

Minimizing Wetland Permitting Uncertainties in the Land of 10,000 Lakes

J. Lucas; Cliffs Natural Resources, Hibbing, MN

Hibbing Taconite Company (HTC) operates an 8-mile long open pit iron ore mine in NE MN that has required over 300 acres of wetland permitting by Federal and State Agencies for overburden removal and stockpiling. The State of MN has the Wetland Conservation Act (WCA), overseen by the MN Dept of Natural Resources (DNR) on mining projects, with an aim for no-net-loss of wetlands, including isolated wetlands that may not be regulated under the Clean Water Act's (CWA) Section 404, administered by the Army Corps of Engineers (ACOE). The CWA Section 401 requirements are managed separately by the MN Pollution Control Agency (MPCA) in alignment with the ACOE 404 process. Obtaining necessary regulatory approvals from these varied agencies requires extensive preparation prior to application submittal and continued shepherding throughout permitting. HTC has developed a data-driven approach focused on improving upon past permitting practices to minimize overall ecological impacts, shorten the "application to shovel-in-the-ground" timeframe and improve stakeholder relationships. These changes have resulted in greater timing predictability and management of the process.

4:05 pm

Mine Site Wastewater and Stormwater Discharges An insight on how water quality modeling can be used to determine both current and future water quality conditions and best management practices (BMPs)

L. Lehigh; Engineering, TREC / Woodard & Curran, Bozeman, MT

Mine site wastewater and stormwater have the potential to affect the quality of surrounding surface water and groundwater. In response to environmental concerns and ever increasing governmental regulations, the global mining industry increasingly monitors water discharged from mine sites, and implement a number of management strategies to prevent water pollution. The development and implementation of these management strategies can be costly and quickly obsolete if not properly planned. Integrating a water quality model into the planning process can be a critical tool in developing risk analyses, evaluating site-specific potential environmental impacts, facilitating BMP selection and design, and optimizing operations. As a result, a multitude of scenarios can be modeled, allowing for a data driven decision before a shovel is ever put into the ground. A legacy mining site will be presented that involves the use of a water quality model that was used to help facilitate BMP selection and management. Discussion includes an overview of model selection, calibration, and BMP evaluation.

Monday, February 22 Afternoon

ROOM: 131B

2:00 pm

Health & Safety: Matters of Safety Culture in Today's Mines

Chair: E. Cullen, University of Utah, Chattaroy, WA

2:00 pm

Introductions

2:05 pm

16-108

Mine Disasters and Their Correlation to Mine Safety Legislations in the U.S

M. Cleason and Z. Hyder; Mining Engineering, Missouri University of Science & Technology, Rolla, MO

Mining historically has been one of the dangerous occupations. As the mining progressed from late 17th century to the modern days, it saw a series of devastating disasters that took thousands of lives and affected thousands of families. Despite better understanding of mining procedures and advancements in technology, mining disasters are still a part of modern day mining. However, the frequency and severity of these disasters have significantly decreased with the adaptation of mine safety legislations. These mine safety legislations that led to current safe mining practices, have been enacted because of several mine disasters and loss of thousands of precious lives of miners. This paper looks at the correlation between historic safety legislations and mine disasters that influenced those legislations. This helps us appreciate the background of mine safety legislations and their importance in the development of safer and more sustainable mining industry.

2:25 pm

16-096

The Great Swindles, Scams and Myths in Safety

C. Pitzer; ASSE, Vancouver, BC, Canada

Safety is fraught with myths and falsehoods - preventing real and sustainable breakthroughs in safety performance. For example, it is a myth that complacency is a human failure; that accidents are preventable; that zero targets are 'aspirational' and that risk-taking behavior causes accidents. These paradigms see humans as 'flawed' and let us manage them as if they have to be protected against themselves. But the human being has amazing capabilities, if unleashed. We can learn remarkable techniques and systems from the world of risk-takers: soldiers, fire fighters, solo mountaineers, explorers...and learn that humans have capacities that will drive your safety to the next level.

2:45 pm

Who Are We, Where Are We Going and Will We Get There Safely?

L. Evans and R. Jameson; Central Mine Services, Inc., Danville, KY

Many industries such as mining, are at an important juncture when it comes to managing risk and employee safety with the expanding use of technology and a rapidly changing workforce. Bringing new technology into the workplace can have an immediate, positive impact on employee safety, and at the same time, bring in new, more subtle safety concerns. For example, when companies hire less experienced staff (typically Millennials) to operate new equipment and maintain

information systems, their lack of safety awareness and higher risk tolerance, can have a negative impact on safety performance. At the same time, experienced, older workers (Baby Boomers), who are needed to manage the changes this technology brings to operations, are working past traditional retirement ages and are having their own negative impact on overall safety due to their often declining health and “de-conditioning”. To be successful in managing risk, companies must understand and manage the expectations Millennials and Baby Boomers bring to the work area. Each group can have a significant impact on a company’s overall safety performance.

3:05 pm

16-097

Breaking Language Barrier: A review of the costs and benefits of current approaches

M. Boateng; Mining Engineering, Missouri University Of Science And Technology, Rolla, Mo

Language barrier in a workplace affects workers’ productivity and safety. The objectives of this paper are: (1) to review the various approaches for breaking language barriers among miners; and (2) to analyze the costs and benefits of these approaches, and make recommendations on the way forward. The authors achieve these objectives by reviewing the current approaches in breaking language barriers among miners. The review reveals that some of these approaches can be expensive with less benefits. Thus, it is concluded that mining companies should carefully select the optimal approach to break language barrier.

3:25 pm

The Power of Stories to Train Miners: Learn to Listen... Listen to Learn

E. Cullen; Enterprise Development, University of Texas, Arlington, TX

Based on Bureau of Labor Statistics, the mining industry is expected to grow and diversify its workforce over the next 10 years due to the retirement of veteran miners and incoming generation of new workers. Significant and immediate labor needs will attract younger, inexperienced employees who represent a change in culture and increased risk in the safety and health environment. With fatality and injury rates declining in the past due to strengthened regulation, enforcement and training, employers are encouraged to continue seeking ways to reach a “zero” culture in order to sustain these improvements. These challenges present the need for refined training approaches. Funded by a NIOSH grant, The University of Texas at Arlington (UTA) and Safety Solutions International, Inc. is currently working to produce and distribute a new documentary featuring the Fire in the Wilberg Mine which occurred in 1984 with the loss of 27 Utah miners. By sharing the stories of workers who directly experienced and investigated the disaster, this documentary will facilitate the transfer of knowledge, and demonstrate just how powerful stories are in training the next generation of miners in our country.

Monday, February 22 – Afternoon

ROOM: 131A

2:00 pm

Health & Safety: Research Efforts Informing Regulation and Compliance

Chairs: J. Brune, Colorado School of Mines, Golden, CO
S. Moore, NIOSH, Pittsburgh, PA

2:00 pm

Introductions

2:05 pm

16-153

Advanced Life Support in the Mining Environment

C. Enright, C. Harman and J. Brune; Mining Engineering, Colorado School of Mines, Golden, CO

The mining environment presents one of the most challenging and complex situations where medical care may be required. The combination of remote locations, dangerous work, difficult access and long response times create a perfect storm that we believe creates an increase in morbidity and mortality in the event of serious accidents. Initial responders at mine sites generally are trained no better than the Emergency Medical Technician Level (EMT), with MSHA only requiring that mine rescue teams are trained at the Emergency Medical Responder (EMR) level, and the training and scope of practice for these providers is not sufficient for response to a complex or critically injured patient. It is believed that the introduction of advanced life support (ALS) capable providers and equipment, (paramedic-level) can reduce morbidity and mortality from serious accidents and critical medical emergencies dramatically. The shortening of the response time for advanced critical care can help bridge the gap between the accident and definitive care; ALS-level care provides lifesaving interventions that can make a considerable difference in the outcomes of critical patients.

2:25 pm

16-011

Analysis, Conversion, and Visualization of Survey Position and Magnetic Field Strength Data for a Proximity Detection System

C. Jobes, J. Carr, H. Gerald and A. Smith; OMSHR/EMSSB, NIOSH, Pittsburgh, PA

Underground mobile mining machines pose a difficult safety challenge since their operators generally work in close proximity to these machines in very restricted spaces. Intelligent software for use with electromagnetic proximity detection systems have been shown to accurately locate workers around mining machinery in real time. Calibrating these systems require the manipulation of a lot of data to determine the system calibration constants. Researchers have developed software to analyze, convert, and visualize data acquired during this calibration process to more accurately model electromagnetic fields and their interaction with the environment. This paper details the background, development, and operation of the resulting application software focusing on the utility of the graphical user interface to visualize the electromagnetic field calibration data. The refined data developed by this process can then be utilized by the proximity detection system to more accurately identify the location of miners working in an underground mining environment.

2:45 pm

An Analysis of the Effectiveness and Utility of the MSHA Respirable Dust Sampling Program

A. Lashgari and J. Kohler; Energy and Mineral Engineering, Pennsylvania State University, University Park, PA

The MSHA database of respirable dust exposure for metal/non-metal surface mine workers has the potential to provide meaningful insights into compliance, deterrence, intervention effectiveness, and even the efficacy of the sampling program itself. These insights speak to the effective allocation of resources by both the government and the industry. The database for the period of 1997 to 2014 was analyzed to assess the efficacy of the sampling program to reduce overexposures and to identify further use of the data to improve the respiratory health of miners.

3:05 pm

16-146

DPM Surveying in an Underground Mine

E. McCullough, S. Gaillard and E. Sarver; Mining & Minerals Engineering, Virginia Tech, Blacksburg, VA

In spite of recent technological improvements for detection and monitoring, diesel particulate matter (DPM) remains a prominent health hazard in many underground mines. DPM has been regulated by the Mine Safety and Health Administration (MSHA) in metal/nonmetal operations since 2002. The Final Rule requires that the NIOSH 5040 standard method be followed in order to demonstrate regulatory compliance. The FLIR Airtec DPM monitor provides another means of measuring DPM. It offers near real-time results and has proven to be a very useful engineering tool. As part of a current field study, the instrument will be used to survey DPM concentrations in an underground stone mine. Via "spot-checking" and shift monitoring over multiple days, the surveying effort is aimed at determining spatial (with the cross section) and temporal (throughout the week) DPM variation in several key locations. This study will also compare the utility of "sensitive" filter cassettes versus those conventionally used for 8-hour personal monitoring.

3:25 pm

Important Thresholds in Anticipating Safety Incidents: A Machine Learning Analysis of MSHA Data to Evaluate Current Policy

J. Gernand; Energy and Mineral Engineering, Penn State University, University Park, PA

Regulators and mining companies have an interest in understanding what kinds of factors influence worker injuries or fatalities and make them more or less likely to occur. While previous studies have examined this question, most have relied on linear regression-type models to identify important factors influencing mine safety. Linear methods assume that each new unit of equipment, worker training, or job experience will influence safety by the same amount. These methods downplay situations where thresholds may exist, such as when a certain amount of monitoring equipment may improve safety up to a point, but beyond that point additional equipment has no effect. This study relied on Random Forest models, a machine learning algorithm that is especially sensitive to thresholds, to identify some of the important thresholds in mine safety, such as how much job experience is needed to reach the minimum risk, through analysis of the MSHA reported data. This paper discusses the implications of these thresholds on current rules and policy.

3:45 pm

16-013

Proximity Detection Zones Design to Prevent Striking and Pinning Fatalities around Continuous Mining Machines

P. Bissert, J. Carr, J. Ducarme and A. Smith; NIOSH, Pittsburgh, PA

Underground coal miners are exposed to many hazards. Miners working with a continuous mining machine (CMM) are at risk of being fatally struck or pinned by the machine. This has resulted in 39 fatalities since 1984. Researchers at the National Institute for Occupational Safety and Health (NIOSH) developed the Intelligent Proximity Detection (iPD) system that utilizes multiple zones to disable potentially dangerous actions while allowing safe motions to continue uninterrupted. This paper provides an analysis of the fatalities that have occurred since 1984 and compares the anticipated effectiveness of conventional and iPD systems. Multiple iPD zone configurations were studied to determine its effect on performance. Researchers found that 82% of fatalities may have been prevented by both conventional and intelligent proximity systems. The results indicate that a properly configured iPD system can provide equivalent protection to conventional proximity while allowing operators greater freedom to position themselves and avoid hazards.

Monday, February 22 – Afternoon

ROOM: 221A

2:00 pm

Industrial Minerals & Aggregates: Health and Safety

Chairs: E. Tarshizi, Michigan Technological University, Houghton, MI
J. Zdunczyk, Pike Industries, Inc., Westbrook, ME

2:00 pm

Introductions

2:05 pm

16-009

Instituting a Filtration/Pressurization System to Reduce Dust Concentrations in a Control Room at a Mineral Processing Plant

J. Noll, A. Cecala and J. Hummer; NIOSH, Pittsburgh, Pa, United States Minor Outlying Islands

NIOSH has observed that many control rooms and operator compartments in the US mining industry do not have filtration systems capable of maintaining low dust concentrations in these areas. In this study at a mineral processing plant, to reduce respirable dust concentrations in a control room which had no cleaning system for intake air, a filtration/pressurization system originally designed for enclosed cabs was modified and installed. Eighty-seven percent of submicron particles were reduced by the system at static conditions, meaning that greater than eighty-seven percent of respirable dust particles should be reduced. The particle size distribution for respirable dust particles are greater than for submicron particles, and filtration systems usually are more efficient in capturing the larger particles. A positive pressure near 0.02 inches of water gauge was produced which is an important component for an effective system and minimizes particles (e.g. dust) from entering into the room. The intake airflow was around 118 cfm, which is greater than the airflow suggested by ASHRAE for acceptable indoor air quality.

2:25 pm

Using Tablets, Internet of Thing Beacons, and Big Data Analytics for Safety and Productivity in Small mines and Quarries

S. Dessureault; MISOM Technologies Inc. / University of Arizona, Tucson, AZ

Mobile devices have transformed our personal lives making tracking and information collection and consumption intuitive and often automatic. The Internet of Things is empowered through tablets where small low-cost sensors, often connected to the web through mobile devices, can provide tracking capabilities that were previously cost prohibitive for all except for the very largest metal mines. Collecting safety and location data also unlocks the information contained in safety forms and audits that were previously collected on paper and partially recorded into spreadsheets. Managing then gaining value from this new, greatly expanded mountain of data of largely unstructured data, would also require the use of modern tools and approaches, such as gamification. Case studies of the application of these technologies will show the challenges and opportunities in introducing these new technologies at small mines and quarries.

2:45 pm

Creating a Leadership Vision for EHS – The foundation for the path to world class EHS performance

D. McClain; EHS&S, Agrium US, Inc., Denver, CO

“Where there is no vision the people perish.” Proverbs 29:18 This paper will discuss the power of creating a senior leadership vision for EHS. The strategies, methods and tools to use that get senior leadership to see their influence on EHS performance and how that influence provides value to the business. The main components will be described are: Developing the senior leadership “Want” for an ESH vision Industry Benchmarking Showing business value for EHS Using the “small end of the wedge” to allow leaders to discover the power in EHS leadership and it’s referred effects Crafting the vision Using operational and functional leaders in a collaborative approach Must be simple, powerful, memorable and inspiring. Instilling the vision Face to Face—not via e-mail or posters Consistency in Message Cascaded message and accountability Teeing up senior leaders for high influence opportunities Roadmap for achieving the vision Narrow focus Designed for leaders to lead with EHS Integrated into Business model Examples of this process successfully used in Mining companies will be discussed. “Vision without action is a daydream. Action with without vision is a nightmare.” Japanese Proverb.

3:05 pm

Safety & Health Management Systems: Design & Implementation at Mining Operations

A. Abrams; Law Office of Adele L. Abrams PC, Beltsville, MD

Safety and health management systems have been demonstrated to be effective ways to reduce injuries/illnesses and to implement robust risk assessment and hazard mitigation programs. While they are most commonly used in non-mining work environments, the basic principles codified in consensus standards such as ANSI Z10 and A10.33 can have utility within the mining industry to help break through the injury rate plateau. Key principles include: –Management leadership and employee participation; - Planning; –Implementation and operation; –Evaluation and corrective action; and –Management review It is critical to understand the legal exposures that are created within the MSHA enforcement context arising from the creation and implementation of SHMS, such as MSHA’s use of audit documents, the role of safety and health committees and more. Some mines are already subject to mandatory utilization of these programs (e.g., Cal-OSHA, which has dual jurisdiction with MSHA over mines, has an “I2P2” program requirement). MSHA has also had a SHMS standard on its long-term regulatory agenda.

Monday, February 22 – Afternoon

ROOM: 221B

2:00 pm

Industrial Minerals & Aggregates: Underground Mining in Stone

Chair: H. Head, Behre Dolbear and Co Inc, Warrenville, IL

2:00 pm

Introductions

2:05 pm

The Design of Multi-Level Underground Stone Mines

D. Hambley; Agapito Associates, Inc., Lakewood, CO

The first consideration is the thickness of the resource horizon. In stone mines cost is a critical variable so it is customary to use relatively large equipment for excavation — breast headings are typically 22- to 28-ft high. However, it is significantly cheaper to bench from such a level than it is to drive a second level using horizontal drilling. For safety reasons, the total height of a level should not exceed the reach of scaling and bolting equipment. The sizing of rooms and pillars on a single level must consider the width-to-height (W/H) ratio of the pillar. Where the height of the resource zone is insufficient to allow another level, a second bench can be considered provided adequate roof and pillar support has already been provided. Otherwise, the next consideration is the required thickness of the sill pillars left between levels. Once chosen, this plus the room height will determine the number of possible levels. This paper will address room and pillar design for single and multiple levels and sizing of the sill pillars.

2:25 pm

Multi-Level Stone Mine Design and Considerations

M. Dunn; Retired, Columbus, OH

Starting a second level of a mine needn't be considered a quantum leap if properly planned. Elements of planning a multi-level operation will be discussed to include design considerations and necessary data, structural parameters, ramps, shafts; and integrating these with current operations. Case history examples will be referenced. Specific mining techniques such as surveying and blasting control, and how they can add to successful mine levels will be included.

2:45 pm

Using 3-D Laser Scanning Technology to safely map underground mines

M. Haddock; Golder Associates Inc., St. Charles, MO

The development of underground mines has led to an increased need for accurate mapping of old mines and the need to plan for multi-level development. 3D laser scanning survey technology using modern instruments and software can provide safe survey of difficult access areas and has become cost competitive with traditional mine survey methods. Recent technology development has led to mobile 3D laser scanning systems that can quickly collect survey data in underground mines and produce accurate results. This has proven useful for underground stone mines planning expansion where little if any detailed mapping exists and accurate maps are needed for multi-level mine planning. 3D laser scanning systems can now be mounted on a vehicle for mobile operation, producing fast survey with accuracy of 1cm or less. 3D data can be imported into existing mine planning and survey software packages that can be used for creating maps, models, and volume calculations. Some software can perform geotechnical mapping and characterization of joint/plane features. Innovation in 3D laser scanning technology provides mine owners with cost effective and powerful new ways to safely conduct underground survey.

3:05 pm

Chicago – A Major Mining Center

B. Archibald; Archibald Consulting Group, LLC, Carrollton, OH

Currently seven large underground stone mines are producing aggregates within 50 miles of downtown Chicago. The reasons for this are both practical and geological. The most practical of reasons is that the Chicago area is a huge consumer of aggregates for infrastructure and construction. This stone needs to come from nearby producers, since long transport distances become cost prohibitive. The

geological reason for underground mining is because, as the upper limestones are mined out in Chicago's quarries, producers are developing the deeper and higher quality limestone beneath a prominent shale seam. The higher quality of this dolomitic limestone, relative to most near surface limestone, helps to make the higher cost underground reserves price competitive. Interestingly, several of these underground mines have been developed via access ramps mined with roadheaders. This paper will set the stage for the later papers in this session, by describing the conceptual and logistical issues facing quarries preparing to go underground.

3:25 pm

16-078

Roof Control, Pillar Stability, and Ground Control Issues in Underground Stone Mines

D. Newman; Appalachian Mining & Engineering, Lexington, KY

The U.S. stone industry is in a transition from surface quarries to single level and multiple level underground stone mines. The factors driving this transition include surface quarries; 1. reaching their economic stripping ratio, 2. encroaching on the mineral reserve boundary where the remaining reserves are below the active pit, and 3. dust, noise, and blast vibration concerns as suburban neighborhoods and development move into formerly rural areas. Ground control is critical to a safe, productive, and successful mining operation. The primary focus of the ground control engineer in an underground stone mine is the stability of the roof or back, development and benched pillar stability, stability of the sill pillar between the mining levels, and floor stability. The ground control issues for underground stone mines are most clearly presented through a series of case histories. The case histories presented in this paper are a mix of ground failures and of successful mines. The focus is on the geotechnical data required for underground stone mine ground control for roof, pillar, and floor design and stability analysis.

3:45 pm

The changes of fragmentation and energy absorption of Red, Berea and Buff sandstones along loading rates and water content

E. Kim² and A. Garcia¹; ¹Mining Engineering, University of Utah, Salt Lake City, UT and ²Mining Engineering, Colorado School of Mines, Golden, CO

Annually, the global production of construction aggregates reaches over 40 billion tons; making aggregates the largest mining sector by volume and value. Currently, the aggregate industry is making a major move from sand to hard rock as a result of legislative limiting the extraction of natural sands and gravel. A major implication of this change in the aggregate industry is the need for understanding rock fragmentation and energy absorption to produce more cost-effective aggregates. We focused on incorporating dynamic rock and soil mechanics to understand the effects of loading rate and water saturation on the rock fragmentation and energy absorption of three different sandstones (Red, Berea and Buff) having different pore size. The particle size distribution and fineness modulus of the fragments generated by the destructive testing were analyzed using mechanical gradation tests. Our results support the conclusion that rock fragment size is correlated with the energy absorption amount of fractured rocks. Thus, our data can provide insightful information for advancing cost-effective aggregate production.

Monday, February 22 – Afternoon

ROOM: 128B

2:00 PM

Mining & Exploration: Geology: Best Practices for Mineral Resource and Mineral Reserves Estimation and Reporting

Chairs: D. Doe, Newmont, Greenwood Village, CO
H. Parker, amEC, Vancouver, BC, Canada

2:00 pm

Introduction

2:05 pm

The Role of the Competent Person

D. Armstrong; Butte, MT

SEC Guide 7 requires the reporting entity to include the name of the author on material reports. The concept of the Competent Person originated with the JORC Code and took that role much further. With the release of Canadian NI 43-101, the SME Guide and further updates to the JORC Code, the role of the Competent Person/ Qualified Person has been further delineated. As other countries have adopted the CRIRSCO Template, they have also added their interpretations to the role of the CP/QP. Any person signing as a CP/QP needs to understand fully the now expansive role he has taken on when he prepares and signs a report.

2:25 pm

Competent Persons Reports

H. Parker; amEC, Vancouver, BC, Canada

Competent Persons Reports are supposed to convey material issues to the investor or his advisers in a transparent manner so that he/they can make an informed decision as to the mineral property that is the subject of the report. The Competent Person must keep this in mind as he prepares each section of the report. Are material issues being covered to a sufficient level of detail in writing, tables and figures? Which means: writing, a table or a figure conveys the message most efficiently. And importantly, does the report demonstrate the competence of the SMENET 2016 Annual Meeting 13 author(s). Often the time available to prepare the report is limited. This means that materials (graphics, spreadsheets etc.) required to prepare the report must be accumulated in real time as the work is done.

2:45 pm

Exploration Target Definition

D. Birak¹ and D. Earnest²; ¹Consulting Geologist, Coeur D'Alene, ID and ²Resource Eval Inc, Tucson, AZ

Exploration targets are geographic areas of the earth with potential for occurrence of a valuable mineral deposit and justification for investment in evaluation of that potential. The evaluation involves the use of regional- to outcrop-scale geologic and geographic data, remote sensing imagery, geophysical and geochemical surveys, surface and subsurface sampling by prospecting, trenching or drilling, sample preparation and analysis and corresponding quality assurance/quality control (QA/QC) procedures, and bulk sampling for metallurgical testing. These activities must incorporate industry-accepted best practices for the collection of all of the various types of data required, as well as conform to the legal requirements related to the right to explore given targets

3:05 pm

Economic Questions to be Addressed in Competent Persons Reports

E. Bohnet; Parker, CO

In order to report Resources or Reserves, economic questions must be addressed. "A Mineral Resource is a concentration or occurrence of solid material of economic interest in or on the Earth's crust in such form, grade or quality and quantity that there are reasonable prospects for eventual economic extraction." And, "A Mineral Reserve is the economically mineable part of a Measured and/or Indicated Mineral Resource." This paper/presentation discusses the economic nuances utilized by mining industry professionals to create the modifying factors (economic parameters) that are used to estimate Mineral Resources and Mineral Reserves.

3:25 pm

16-152

Health and Safety

F. Heivillin; HGPS LLC, Thomasville, GA

Health and Safety problems can make a mineral deposit, operating plant, or finished product unprofitable or worthless. They are quality of life issues which are at or near the top of priorities for communities, employees, and government bodies. Past, present, and future health issues or perceived issues in the district, the deposit, the ore, the overburden, the water supply, the mineral deposit, and the tailings must be dealt with clearly and openly with enough facts in hand so that there are no problems with employees, neighbors, the communities or other interested parties. Best practices for dealing with these issues are described.

3:45 pm

16-092

International Social License in Mining Projects

D. Hulse; Gustavson Associates LLC, Aurora, CO

Social License, the consent of the neighbors and community to develop and operate a mine, has received little attention until recently. Though social license is intangible, not having this relationship with the community carries operational and economic risk to a project, potentially including future impairment of the asset. Acquiring and maintaining social license is like a long-term personal relationship. It requires communication, commitment, consistency and transparency. This presentation will review the building blocks to acquire and maintain a social license based on experiences with mining projects in Mexico.

4:05 pm

16-091

Mineral Resource and Mineral Reserve Classification

N. Prenn; Mine Developments Associates Inc, Reno, NV

The basic considerations for classification include sample integrity, sample QAQC, database integrity and completeness, geological understanding, and geological and grade or quality continuity. Mineral Resources are divided into three classifications of Inferred, Indicated, or Measured. Mineral reserves include Probable and Proven classifications. These classifications imply improved knowledge of the deposit from inferred to indicated to measured. Mineral Reserves, which are a modified sub-set of the Indicated and Measured Mineral Resources, require consideration of those factors affecting extraction, including mining, metallurgical, economic, marketing, legal, environmental, infrastructure, social and governmental factors, and should in most cases be estimated with input from a range of disciplines.

Monday, February 22 – Afternoon

ROOM: 128A

2:00 pm

Mining & Exploration: Geology: Hydro Geology

Chair: P. Kowalewski, Tierra Group International Ltd, Salt Lake City, UT

2:00 pm

Introductions

2:05 pm

Using Geologic Models for Groundwater Management in Mining

S. Schorr; Montgomery & Associates, Tucson, AZ

Managing groundwater is a common issue at mine sites. A numerical groundwater model, such as MODFLOW, is used for simulating and predicting various hydrologic conditions and groundwater management scenarios related to mining activities. Leapfrog® geologic modeling software is used to construct three-dimensional geologic models, and also has tools to create and parameterize MODFLOW model grids and view model results. A case study will be presented to describe a workflow that 1) improves efficiency of developing a groundwater model that better represents the hydrogeology of a project area, and 2) facilitates the sharing and communication of model results with stakeholders.

2:25 pm

The Nuts and Bolts of Completing Underground Dewatering Wells at Barrick Cortez Hills Underground Mine, Lander County, Nevada

S. Conley; Barrick Cortez, Elko, NV

Mining priorities at Barrick Gold's Cortez Hills Underground Middle Zone ore body required rapid dewatering in a zone with limited hydrologic information of a fracture controlled aquifer. This required the installation of a robust piezometer network, hydrologic modelling, and field testing of the models assumptions. This information provided conclusive evidence that the aquifer was confined geologically from the surrounding ore bodies and lithological units. This also confirmed initial assumptions that underground dewatering wells were economical when compared to a surface wells. Hydro-physical downhole surveys in test holes were used for determining the ideal well locations. A modified Cubex was used to drill the wells and specialized equipment was built to complete them which allowed for the Middle Zone to be dewatered on schedule and eliminate mining delays due to dewatering.

2:45 pm

Best Practice Methods For Implementation of a Mega Dewatering Program at Bingham Canyon Mine, Utah USA

G. Ghidotti¹, R. Peavler² and H. Olsen²; ¹Rio Tinto Kennecott Copper, Salt Lake City, UT and ²MWH, Salt Lake City, UT

Rio Tinto Kennecott Copper is implementing a multifaceted dewatering and depressurization program to meet pit wall pore-pressure and water management requirements at the Bingham Canyon Mine. The program is being executed over a 5-year period, and recently completed its first full year. Best practice methods are the foundation for each element of the program, from conceptual development to schedule and cost management. The dewatering infrastructure associated with the

5-year dewatering program includes underground drainage galleries, in-pit pumping wells, pumping wells targeting flooded historic workings, horizontal drains, and interception of meteoric water. The ability to track real-time depressurization trends through a network of high density vibrating wire piezometers (VWP) is critical to the program. VWP data are tied to an integrated database so that depressurization trends can be assessed alongside other hydrogeologic data such as lithology, pumping rates, and precipitation. Modeled targeted pore pressures at VWP locations are used to evaluate depressurization progress, and results are used to inform decision making for the subsequent phases of the program.

3:05 pm

Designing open pit dewatering with exploration and geotechnical data

G. O'Brien; NEIRBO Hydrogeology, Fort Collins, CO

Final open-pit designs depend on effective dewatering to reduce high pore pressures in low strength geologic units. Effective pit slope depressurization depends on identifying areas with increased permeability that will drain large rock volumes. Hydrogeologic data are often insufficient or lack the detail necessary to design pit-scale dewatering systems. Groundwater flow models developed to predict environmental impacts hundreds of years into the future at distant locations are based on properties representative of large rock volumes. This model scale may indicate that dewatering will require an excessive number of wells and may be incompatible for developing detailed pit dewatering systems. Increased permeability zones created by faulting and fracturing can be cost effectively identified and simulated by analyzing exploration and geotechnical data. Detailed exploration and geotechnical data may have clues about the areas that have higher permeability. Regional-scale hydrogeologic models can be refined by integrating these pit-scale data and simulating fault and fracture zones that will control depressurization and guide dewatering strategies.

3:25 pm

A Novel Time Series Prediction Model of Groundwater Inflow in Underground Mining

H. Pu and X. Miao; China University of Mining & Technology, Xuzhou, China

The prediction of groundwater inflow has an important impact on safety underground mining, the occurrence of these groundwater disasters is likely to be controlled and decreased via establishing an accurate groundwater inflow prediction system. However, the relationship between groundwater inflow and the factors such as geological structure, hydrogeology, aquifer, groundwater pressure, groundwater resisting layer, mining damage, fault throw and so on can be highly nonlinear, so it is difficult to establish a suitable model using traditional mechanics methods to predict the groundwater inflow using time series data. It is appropriate to consider modeling methods developed in other fields in order to provide adequate models for rock behavior on groundwater inflow, nonlinear grey Bernoulli model (NGBM) is a new grey prediction model which is a simple improvement of GM(1,1) together with Bernoulli differential equation. This paper presents a new parameter optimization scheme of NGBM using the genetic algorithm (GA).

Monday, February 22 – Afternoon

ROOM: 125A

2:00 pm

Mining & Exploration: Operations: Continuous Improvement in Surface Operations I

Chair: A. Harmon, Freeport-McMoRan. Phoenix, AZ

2:00 pm

Introductions

2:05 pm

Air Decks in Production Blasting

M. Hayat¹, M. Khan¹, S. Saqib² and M. Waqas¹; ¹Mining & Nuclear Engineering, Missouri University of Science & Technology, Rolla, MO and ²Mining Engineering, University of Engineering & Technology Lahore, Lahore, Punjab, Pakistan

In order to increase the profits from mining operations it is always desired to reduce the mining cost. Cost of explosives is one of the major parts of the overall mining cost; it is therefore always desired to reduce the explosive consumption without compromising the production rate and blast performance. Introducing air decks in the explosive column during production blasting is thought to be a solution to reduce explosive consumption without compromising the fragmentation results of the shot. In this study best possible settings for air deck in the explosive column during production blasting are reviewed and optimum settings for air deck are suggested based on economy and performance keeping in view the geology of the blasting site.

2:45 pm

Increased Truck Uptime Through Automated Fuel Dispatching in the Alberta Oil Sands

A. Blazenko, D. Wells and B. Stilley; North America, Wenco International Mining Systems Ltd., Tucson, AZ

Fuel presents one of the biggest costs in mining, running millions of dollars each month. In addition to the cost of fuel, slower production due to fueling procedures contributes to millions more dollars in lost revenue each year. Since January 2015, a key operator in the oil sands region of Alberta, Canada, has experimented with an automated fuel dispatching service that has extended the time between fueling sessions over 30% on average. At the same time, the mine has experienced improved production numbers by reducing the attention to fueling required by dispatchers and operators. This paper discusses how implementation of the Wenco Fuel Dispatch service has increased production time and contributed to optimized operator performance at this operation in the Canadian oil sands.

3:05 pm

New Thinking to Improve Conveyor Loading Zones

A. Marti¹ and G. Bieri²; ¹Corporate Marketing, Martin Engineering, Neponset, IL and ²Corporate Accounts, Martin Engineering, Neponset, IL

Belt conveyors see a number of problems, like off-center loading, belt wander, and the release of fugitive materials as dust and spillage. These problems are magnified by the maintenance, safety, and housekeeping issues they create and compound. Perhaps ninety percent of these problems arise in a conveyor's loading zone. But new modular concepts offer ways to upgrade loading zones, to control fugitive material and belt tracking, reducing housekeeping while improving safety and maintenance. This presentation will examine several new or improved concepts that address the common issues in conveyor loading zones. It will discuss fixtures that improve load placement, providing centralized loading and improved belt tracking. It will look at improved transfer point enclosures that slow air movement and so reduce the entrainment of particles into the air to prevent the escape of dust. It will review dust management systems, including suppression systems and insertable air cleaners that control dust at the source. The presentation will feature results from recent trials and installations of these technologies, in operating mines and mills.

3:25 pm

16-126

The Big Picture Approach to Surface Mining

R. Riggle and L. Widdifield; Cat Global Mining, Menomonee Falls, WI

In today's challenging mining environment the big picture approach to mining is often neglected. This paper will discuss the aspects of taking the time to observe an operation from the big picture approach. In today's mining business, miners, engineers, trainers, supervisors, and managers have ever increasing roles and responsibilities as never seen before in the past decade; often at the expense of precious time that may have been dedicated to examining the day to day operation. Having examined numerous mining operations over the past several years, one common denominator is lack of time to properly examine operating practices in the field and recognize both positive and negative observations. The old fashioned vocation of observing the operation to assess the haulage, loading and maintenance processes to adjust, maximize or enhance operations have sometimes vanished. Four areas to be discussed in this paper: (1) Look at the big picture (2) Use common sense (3) Areas identified for biggest improvements in the operations (4) Observation of small details for big impacts to lower cost per ton and increased production.

3:45 pm

Improved Large Diameter Sealing Systems for Mining Equipment

K. Bommer and J. Cleason; Applicaitons Engineer, SKF, Elgin, IL

Bearing replacement in stationary mining equipment is largely due to one major factor – solid particle contamination creating wear and surface fatigue. All mines are at risk to this mode of bearing damage whether on ball mill pinion drives, crushers, shaker screens, conveyors, etc. Due to the nature of the environment, the bearing housings are often completely covered in debris increasing the risk of contamination ingress. Bearing replacement becomes costly not only in components and labor, but also in lost production time. The correct sealing system on the equipment is key to mitigating bearing damage. This paper will explore various sealing options from traditional to improved new designs with their benefits identified. Furthermore, case studies illustrating improved sealing methods will be discussed.

Monday, February 22 – Afternoon

ROOM: 127B

2:00 pm

Mining & Exploration: Management: Managing Projects Internationally

Chair: C. Cossio, Stantec, Tempe, AZ

2:00 pm

Introductions

2:05 pm

16-086

Business Management: Lead the People and Manage the Work

M. Bunch; Summit Mining International, Denver, CO

Successful operating managers require two different skill sets of Leadership and Management; knowing how to lead people in their organization and manage the work they do. This paper outlines means by which managers can take control of their operation through the implementation of an integrated Business Model of

Value Based Leadership, Organizational Development, and Systems and Structure. This is a proven model with significant results that uses a “top down” and “bottom up” structured approach to business management focusing on strategic development to tactical implementation of day-to-day activities. Using these key business concepts, the secrets of true employee empowerment can be unlocked and lay the foundation of a continuous improvement culture in any organization in any country of operation.

2:25 pm

Remote System Performance Monitoring with Cloud Application

E. Chow, N. Himmelman, D. Chan, W. Liu and S. Tafazoli; Motion Metrics, Vancouver, BC, Canada

Motion Metrics International provides monitoring solutions such as ShovelMetrics™ and LoaderMetrics™ for shovels and loaders. These systems feature sensors and cables that are exposed to the harsh mining environment, and require regular maintenance to ensure optimal performance. A Cloud Application is developed to establish an efficient process for monitoring the health and performance of these systems. This paper describes the design and implementation of the Cloud Application and ways in which the Support Engineers use the web interface to monitor the globally installed systems and provide periodic reports on how to plan system maintenance and optimize system performance.

2:45 pm

Effective Design Collaboration on Grasberg's Rail Haulage Chute Galleries

S. Goosney and B. Stronach; Mining, Stantec, Tempe, AZ

At an elevation of almost 3,000 meters above sea level on the west side of the island of Papua, PT Freeport Indonesia's Grasberg Block Cave (GBC) is being developed beneath the existing Grasberg Open Pit. The underground train haulage system being designed within GBC will transport 160,000 tonnes of ore per day from multiple chute galleries to the underground crushing plants. The design entails 28 km of rail and 119 ore chutes which will be brought online over the course of ten years. The system is advanced—it will be driverless and fully automated, complete with remote controlled loading chutes, autonomous train haulage, and autonomous unloading. This presentation will illustrate the use of modeling software in the GBC Chute Galleries project as a communication tool to review design concepts and resolve design issues across multiple disciplines, multiple engineering companies, and three continents. Also included in the presentation is an introduction to use of BIM (building information modeling), which enables objects in the model to contain all relevant information (technical, purchasing, scheduling, etc.) related to the individual objects.

3:05 pm

SME 2016 Copper Creek Project, AZ Summary

R. Sandberg; Redhawk Resources, Spring Creek, NV

The Copper Creek property is located in the Bunker Hill Mining District on the western flank of the Galiuro Mtns. It is located in the Laramide SW porphyry copper province. Modern era exploration beginning in the early 1960's and continuing to the present have discovered NI 43-101 resources including both near surface, high-grade, breccia style deposits and underlying deeper “early halo” style porphyry deposit. Multiple Laramide porphyries provided numerous copper/molybdenum hydrothermal events that mineralized any earlier porphyries and primarily the pre-mineral Laramide granodiorites and Cretaceous andesitic volcanics.

3:25 pm

Utilizing an Operator Training Simulation on a New Copper Concentrator in Peru

M. McGarry; Andritz Automation, Bellingham, WA

The Operator Training Simulator (OTS) is a training system that utilizes a real-time dynamic simulator integrated with a Distributed Control System (DCS) emulator. It is widely used in industries such as Mining, Oil & Gas, Power, and Pulp & Paper to train operators and to optimize plant performance. A high-fidelity dynamic OTS was used to train operators at a new Copper Concentrator in Peru. The OTS provided an effective platform to train operators on control system skills, and on process conditions such as cold start, abnormal operations, and shut down sequences. Well trained operators are essential in production, reducing potential upsets, and to standardize on best operational practices. Operators who have access to a high-fidelity OTS gain confidence before plant start-up and have a tool for continuous re-training. Using an OTS to train operators accelerates the learning curve, allowing training to be conducted without negatively affecting production, equipment, people, or the environment. In addition to the direct training benefit, regulatory and advanced control strategies can be tested in order to optimize the performance of the plant.

3:45 pm

15-13

Evaluation of Operational Strategies for Heap Leaching of Gold Ores under Sub-Zero Temperatures, Coffee Project, Kaminak Gold

T. Schrauf; Hydrogeology, Geo-Logic Associates, Tucson, AZ

Cyanide heap leaching of gold ores in areas with extremely low winter temperatures requires special considerations to prevent freezing of the leach solution. Factors that impact the solution temperature include ore temperature at the time of stacking and during operation, burial of drip irrigation lines, use of geomembrane covers, and heating of the leach solution. Thermodynamic modeling was performed to simulate expected ore and solution temperatures under different operating strategies for Kaminak Gold's Coffee Project mining operation in the Yukon Territory. Mean monthly temperatures at the site ranged from a low of -22.5 oC to a high of 13.6oC, while in-situ ore temperatures ranged from -0.5 to -1.0oC. The modeling results were used to optimize the operational parameters and indicated that a combination of drip line burial and heating of the leach solution during the winter months was required to maintain solution temperatures above freezing during the initial years of stacking, although as the size of the heap increased heating was no longer necessary.

Monday, February 22 – Afternoon

ROOM: 127C

2:00 pm

Mining & Exploration: Operations: Innovative Information Mining & Equipment Reliability I

Chair: L. Walker, Freeport-McMoRan Inc, Morenci, AZ

2:00 pm

Introductions

2:05 pm

Building from a Stable Foundation to Improve Equipment Health

B. Vaughn; World Wide Technology, Inc., St. Louis, MO

Modern mining generates huge amounts of data on mobile equipment but stores it in different places. By merging data and organizing it around equipment rather than systems we can achieve unprecedented visibility into operations. In this presentation we discuss the concept of predictive modeling and share examples of how merged data can be used to reduce failure, better handle alarms and increase equipment life.

2:25 pm

Building a Stable Foundation for Innovative Information Mining

R. Catron; Freeport McMoRan Inc., Phoenix, AZ

Technology is changing at an ever increasing pace and cutting edge capabilities now enable us to collect, store, and analyze massive amounts of data in a cost effective way. With these new capabilities come solutions from several 3rd party vendors and OEM's, each with distinct benefits and pitfalls. Concepts for a solid foundation that enables Innovative Information Mining will be presented from a Freeport McMoRan Inc., lessons learned perspective.

2:45 pm

Leveraging Operational Data for Competitive Advantage: How a Data Infrastructure Strategy Enables Results

L. Fountaine; OSIsoft, Knoxville, TN

As advances in instrumentation, mobile equipment, production processes, and networks make data more prevalent within a mining site, the integration and modeling of information from across these varied sources is becoming a critical differentiator for improving process productivity, asset reliability and EHS performance. Although many technology providers have their own applications to access and store the related data, it is often only available to meet very specific and limited functional needs. When data is recognized as a critical asset and managed as part of an infrastructure, however, it can become a key enabler to help transform the entire operations. By making all process and production data available, and providing information in a context model based on functional needs, mine operators can drive improved results against their critical business impacts. This presentation will introduce the concept of a data infrastructure and show how a related strategy can help deliver operational intelligence to enable real-time action and decisions, provide a common platform for analysis, and establish standardized KPIs to measure and evaluate ongoing performance.

3:05 pm

Condition Monitoring and Equipment Management Fundamentals

L. Etchevers; Hauling & Extraction Division, Caterpillar Inc, Peoria, IL

Equipment Management fundamentals are very important to achieving expected mobile mining fleet performance objectives. Condition Monitoring is one of those fundamentals. There many ways to do this, and many approaches have been created. We believe performing predictive analytics against the five types of condition monitoring data (electronic machine data, fluids analysis data, inspection history data, work order history data, and site conditions data) yields the best opportunity to identify and resolve emerging equipment issues prior to unplanned downtime. This presentation will review the best practices for condition monitoring and demonstrate actual examples of preventative intervention from using tools and applications built for these purposes.

3:25 pm

Safer, More Productive, Less Cost Per Ton: How the combination of smart connected products, advanced analytics and service is improving mining.

M. Rikkola; Joy Global, Milwaukee, WI

There are now several systems worldwide pulling near-real-time data off connected surface and underground mining equipment, but are they delivering value? The complexity of mining environments and equipment presents problems conventional systems and techniques cannot easily address. This paper will discuss some examples of a solutions-based approach being applied to real-world mining problems that delivers value to the bottom line.

3:45 pm

Remote Asset Monitoring Process™

L. Walker; Freeport McMoRan Inc, Morenci, AZ

RamP® (Remote Asset Monitoring Process)™ technology for heavy mining equipment is implemented at the Freeport-McMoRan Inc. America's mining locations. RamP allows centrally located reliability professionals to collect performance data in real time, analyze and diagnose potential problems, and take proactive action. The central idea of RamP is to increase reliability, prevent catastrophic and premature equipment failures and help operators safely and efficiently improve fleet performance. As part of a comprehensive maintenance philosophy of equipment reliability, RamP has supported a steady increase in equipment availability, a decrease in maintenance and operator induced alarms or events, and contributed to global equipment life cycle management.

Monday, February 22 – Afternoon

ROOM: 127A

2:00 pm

Mining & Exploration: Operations: New and Expansion Underground Operations Overview

Sponsored by: ThyssenKrupp Industrial Solutions (USA), Inc.

Chair: D. McDoniel, Nevada Copper, Yerington, NV

2:00 pm

Introductions

2:05 pm

Designing an Underground Fixed Facilities Complex for a “Supercave” Mining Operation

J. Harrower and N. Woodroffe; Mining, Stantec, Tempe, AZ

PT Freeport Indonesia's proposed Grasberg Block Cave (GBC) mine is located at an elevation of 3,000 meters in Papua, Indonesia. GBC is planned to sustain production of 160,000 tonnes per day and is scheduled to begin operation in 2018. The operation will require many underground facilities to service the mining equipment and provide office spaces. The terrain surrounding the site is densely vegetated and extremely rugged, leaving little room for expanding above ground infrastructure. Constructing the required fixed facilities underground is the most practical option for these conditions. The GBC mine will be Indonesia's largest underground block cave mine and one of the largest in the world. Over 1,200 workers will be transported 6 km into the mine on a daily basis and shuttled to their work spaces via buses and light vehicles. The underground facilities consists of underground maintenance and

repair shops, ten service bays, warehouses, offices, three fuel bays, bus terminals, light vehicle parking, three lunchrooms, three mosques, three chapels, and one wastewater treatment facility. This presentation discusses the unique challenges of designing this expansive underground community.

2:25 pm

Northwest Exodus: Adding Life to an Existing Mine

J. Rahn; Newmont, Elko, NV

Northwest Exodus is a new ore body that was found near and will be mined from Newmont's Exodus mine. The deposit adds eight years to the current mine life. Development of the deposit is currently underway and full production is scheduled to start up in 2017. This paper will discuss the mine design and the additional infrastructure needed to access a new deposit from an existing mine.

2:45 pm

Eagle Mine: America's Newest Underground Mine Comes Online

C. Connors; Lundin Mining - Eagle Mine, Champion, MI

After more than a decade of exploration, permitting and construction, the Eagle Mine began commercial production in the fall of 2014. Originally discovered in 2002 by Rio Tinto, the project endured a lengthy process of permitting and community engagement to reach the production phase. Purchased by Lundin Mining in the summer of 2013, the efforts of a great many individuals and organizations has culminated in Eagle becoming the only primary Nickel producer in the United States. This presentation will discuss some of the challenges of the permitting process, the development of the mine and some of the unique challenges of bringing the operation into production.

Monday, February 22 – Afternoon

ROOM: 125B

2:00 pm

Mining & Exploration: Technology: Automation, Where is the Value?

Chair: T. Berens, Atlas Copco, Garland, TX

2:00 pm

Introductions

2:05 pm

Comparison of the performance and effectiveness of semi-automatic and conventional load-haul dump (LHD) machines in underground metal mines

J. Paraszczak¹, J. Tuleau¹, A. Gustafson² and H. Schunnesson²; ¹Mining, Metall., Mat. Engrg, Université Laval, Quebec City, QC, Canada and ²Luleå University of Technology, Luleå, Sweden

Application of semi-automatic load-haul-dump (LHD) machines in underground metal mines is a promising avenue to overcome some challenges facing mine operators, as they offer significant advantages over conventional man-operated units. Among their potential benefits are: no risk of injuries and much better working conditions for operators, higher equipment availability, increased productivity, and reduced mining cost. However, using autonomous loading and haulage systems at their full capacity is a challenging and complex task. In harsh and demanding conditions, there exist several factors that affect equipment productivity and effective-

ness, and semi-automatic machines do not always outperform their conventional counterparts. The paper presents the results of comparative studies done for these two LHD types. Different factors affecting availability, utilization, productivity are analyzed and discussed. Technical and operational aspects are also addressed. Based on that, means and measures to maximize effectiveness of autonomous systems are proposed. The paper concludes with recommendations concerning the most promising applications of such systems and future research work proposed.

2:25 pm

Automation on a Grand Scale

J. Wientjes; Application Engineering, Komatsu America Corp., Peoria, IL

More than 25 years ago, Komatsu Ltd. recognized key challenges and future needs of the mining industry as it expanded its presence globally. Given its commitment and passion towards construction and mining equipment, Komatsu began its pioneering efforts in autonomous technology, and as such, its accomplishments within the mining industry have been noteworthy and precedent setting. This presentation will describe the key design principles of Komatsu autonomous applications and equipment. Inherent and realized operating benefits will also be discussed along with tangible performance accomplishments to date. Future development ideas will also be touched upon in this address.

2:45 pm

A World of Opportunity: High Precision Truck Applications

D. Goddard; Hexagon Mining, Englewood, CO

Modern fleet management systems rely on low-cost GPS systems to provide rudimentary positioning for use with assignment optimization and material tracking. Development of applications that require higher precision positioning have been hindered by the material cost of RTK capable GNSS receivers and industry accepted per-truck system costs. However, more precise positioning will become inexpensive and ubiquitous, as the automotive industry requires (and develops) decimeter accuracy to support autonomous automotive applications, even in GNSS challenged environments. The introduction of these high-precision positioning systems on mining haulage equipment will disrupt the FMS market and will introduce significant opportunities for applications that require this positioning accuracy. This presentation will introduce the first high-precision haulage applications from Hexagon Mining. The operational benefits and the associated ROI of these applications will be presented.

3:05 pm

Autonomous and Semi-Autonomous Systems: Lessons from the Front Line

M. Mundim and D. Goddard; Hexagon Mining, Englewood, CO

The application of autonomous and semi-autonomous systems to the mining environment demands highly disciplined operational and management processes to achieve full benefit. While counter-intuitive, the best run human operated mines make the best candidates for automation systems. This presentation discusses the results and lessons learned from the development and deployment of several of Hexagon Mining's autonomous and semi-autonomous systems, including an OEM-independent autonomous haulage system deployed in a large phosphate mine in Brazil. Technical and procedural challenges faced over a two-year development are presented, as are resulting guidelines to intelligent machine system adoption.

3:25 pm

Practical Autonomous Haulage Operations

C. Smith; Global Mining, Caterpillar, Perth, WA, Australia

The author discusses a "People, Process, Technology" strategy for implementation of advanced technologies drawing from experience gained through late

stage product development, early stage implementation and front line operations experience with autonomous haulage. Topics cover application development, change management, scalability, and planning. The author further discusses the importance of the people involved with both the introduction of the technology and its continued operation in order to overcome the challenges encountered.

3:45 pm

Wireless Directions

D. Fisk; 3D-P Inc., Calgary, AB, Canada

Mines present a very challenging environment for wireless networks. Technologies continue to advance providing additional capabilities, however not all wireless technologies are ideal for use in mines. This paper looks at the available options and technologies on the horizon and some of the advantage and disadvantages of each. This includes meshing and non-meshing WiFi options and LTE.

Monday, February 22 – Afternoon

ROOM: 130

2:00 pm

Mining & Exploration: Technology: Innovation in Mine Production Systems

Chair: L. Clark, Independent Consultant, Golden, CO

2:00 PM

Introductions

2:05 pm

Connected Mine – A New Data-driven Approach for Enterprise Decision Support

G. Kerkhoff; Trimble Mining, Denver, CO

Mines invest significantly in information systems that produce data used in planning, productivity, processing, and safety applications. However, these data assets remain locked in discrete systems resulting in suboptimization of data that could benefit other operational areas and the enterprise. This presentation will discuss the new, integrated Connected Mine approach to extract full value from every layer of technology from remote sensing systems to productivity applications to ERPs. Attendees will also learn about implementing a single information system to empower all professionals in the mining environment to make the best possible decisions for the business.

2:25 pm

Haul Truck Speed Analysis and Effect on Fleet Optimization

M. Yildirim; Global Mining, Caterpillar Inc, Chandler, AZ

Over the years, truck-shovel operation is established as the primary hauling method used in open pit mines. Since the haulage cost can be as high as 50 percent of the total operating cost, numerous studies addressed optimization of truck-shovel operations. Fleet management systems have also been used at open pit mines to increase the productivity and reduce overall cost. Although these systems help optimizing the truck assignments, the impact of the truck speed on the overall machine availability has always been difficult to quantify. With the introduction of autonomous trucks in last decade, the effect of truck speed on machine availability has been a very critical information to compare manned vs autonomous trucks. The misuse of brakes during hauling will cause time loss and fuel loss. Using brakes unnecessarily will also cause more maintenance time and this will reduce availability. This paper presents a data mining methodology to

model the cost of truck speed, deliberate gradual slow-downs, and truck bunches among other variables such as operator, time of day, location, maintenance down type. An open pit copper mine data is used for the research.

2:45 pm

Automatic Detection of Sensor Calibration Errors in Mine Systems

R. Pothina and R. Ganguli; Mining Engineering, University of Alaska Fairbanks, Fairbanks, AZ

Sensors play a vital role in the monitoring and control of various complex operations in the mining industry. Accurate measurement of various process parameters is essential at each stage to achieve overall optimization. Errors resulting in sensor biases and failures can produce 'gross measurement errors,' costing the industry millions of dollars annually. In some cases, such as for cyanide sensors, errors can result in health hazards. Gross errors can be easily identified. When the calibration starts straying, however, it is impossible to tell unless one actually checks the calibration. In this paper, various methods that have been explored to characterize processes are presented. This is the first step to the research to determine if calibration related errors can actually be detected automatically.

3:05 pm

Automating haul trucks for small mines and quarries

J. Brown; Jaybridge Robotics, Cambridge, MA

While autonomous haul trucks are serving large, remote mines in ever-growing numbers, OEMs do not offer autonomous capabilities to smaller, less complex, more cost-sensitive operations. Jaybridge Robotics is developing a solution to automate haul trucks already owned by quarry and small mine operators — a solution which is designed to operate without complex infrastructure such as fleet management systems; to be cost-effective even for aggregates operations; and to work with operators' current fleets rather than requiring new purchases. In this talk, we will describe our technical approach, review the business case for operators, and outline the long-term technology roadmap.

3:25 PM

LWIR camera systems as reliable data source for mining automation and safety features

P. Mehnert, J. Berg, B. Eichentopf and K. Nienhaus; Department for Mining and Metallurgical Machinery, RWTH Aachen University, Aachen, Germany

Accurate and reliable data acquisition is important for the realization of automation and safety features in modern mining. Long wave infrared (LWIR) technologies have been used to acquire geometrical information in rough environments like shearer loader horizon control for years. Advancements in LWIR camera technology coupled with embedded system design tailored for the mining industry, now facilitates higher accuracy geometrical information together with contactless absolute temperature measurements for a broad range of applications. This paper describes the developed novel LWIR camera system for the mining industry as well as results from laboratory measurements and applications in mines.

3:45 pm

Safety Innovations in Mine Production Systems

M. Lewis; Modular Mining Systems, Tucson, AZ

Over the years, mine production systems have expanded to encompass a more safety-driven approach. As haulage equipment grows larger and faster, so does the need for collision avoidance (CA) systems capable of effectively alerting operators to nearby dangers. More important than the ability to warn of potential

danger, however, is the necessity to transmit real warnings; many CA systems available today produce an excessive number of false alarms, often conditioning operators to dismiss valid warnings when mistaken for false ones. In an effort to reduce nuisance alarms and improve overall safety, several technologies have evolved, including vehicle-to-vehicle communications akin to DSRC protocol, path prediction and scenario-based algorithms, and multi-layered approaches to technology. This paper will introduce the various methodologies common to CA systems, emphasizing the importance of safety in mine production systems. A case study will demonstrate that a scenario-based approach with path prediction can reduce the frequency of collisions through improved operator awareness and minimized false alarms.

4:05 pm

Thermo-Mechanical Stress Performance of Ultra-large Mining Truck Tires

W. Nyaaba, S. Frimpong and E. Gbadam; Mining Engineering, Missouri University of Science and Tech, Rolla, MO, Rolla, MO

Ultra-large radial tires are widely used in trucks employed in surface mining operations across the globe. These tires operate under extreme conditions: high grade, rolling and curve resistances; rigorous terrains; and high payloads in excess of 360 tons. Under these operating conditions and given the viscoelastic behavior of the rubber materials, the tires generate heat during operation. Excessive heat generation and retention in the tire's body reduces the strength of its structural components and may lead to the tire failing prematurely. Accurately predicting tire temperatures is key to avoiding any premature heat failure and thus forms the focus of the current paper. A fully coupled thermal-stress finite element analysis is conducted on a 27.00R49 radial tire adopted for Caterpillar Earthmover 777G Model deployed in an oil sand formation using the ABAQUS software. The mechanical and thermal properties are defined to vary with temperature in the range from -40 to 40 degrees celsius. The results of the study show that tire temperature rise depends on its speed and truck load. This study introduces a pioneering fundamental research to extend ultra-large truck tire service life.

ROOM: 129AB

2:00 pm

MPD Plenary Session

Sponsored by: Moly-Cop USA

Chairs: Robert Seitz
Garland Davis
Corale Brierley

Gaudin Lecturer: Dr. Ron Woods

Richards Lecturer: Robert Dunne

Wadsworth Lecturer: David Dreisinger

Monday, February 22 – Afternoon

ROOM: 122A

2:00 pm

Research: Geostatistics for Risk Management in the Mining Value Chain: Geology and Resources

Chairs: L.Allen, Newmont Mining Corp, Greenwood Village, CO A.Samal, GeoGlobal LLC, Riverton, UT

2:00 pm

Introduction

2:05 pm

The Impact of Declustering Technique Choice on the Outcome of Resource Model Uncertainty Quantification Using Conditional and Categorical Simulation

H. da Silva; Resource Modeling, Newmont Mining Company, Greenwood Village, CO

Sequential Gaussian conditional simulation is becoming more popular in the mining industry as a tool for quantifying resource model estimation risk. Financial decisions can be made on a project by comparing the resource model to conditional simulations and establishing the years where the project falls short of meeting predetermined, acceptable, limits of uncertainty. Years at risk can then be mitigated by additional drilling or proper engineering. This paper examines the impact of the parameter choices in the conditional simulation process, focusing especially on the declustering technique used and the impact of the choices made on the project life. Geological domains will also be categorically simulated to account for the uncertainty along the contact between domains. Models will be assessed based on yearly mine plans and conclusions will be drawn on the economic impact to the project. A complete dataset from a mined out deposit will be used and the results will be checked against production data (blastholes). Conclusions will be drawn.

2:25 pm

16-055

Spatial prediction of fracture intensity based on drill hole observations

A. Hekmatnejad¹, X. Emery² and A. Brzovic³; ¹Student, Santiago, Chile; ²Professor, Santiago, Chile and ³Geologist, Santiago, Chile

The objective of this work is to validate a methodology for spatially predicting the fracture intensity, defined as the average fracture surface per unit volume. Firstly, using the observations from drill holes, the fracture intensity is directly inferred at the support of drill hole composites based on a Terzaghi correction. Subsequently, the composite values are interpolated to larger blocks. The methodology is tested on sets of simulated fracture networks. For each of these simulated networks, one can calculate the actual fracture intensity within any region of space, based on geometric considerations. The study is applied to predict the global and local fracture intensity. The actual and predicted fracture intensities are finally compared, showing that predictions are unbiased, insofar as, on average, the prediction error is always close to zero. Also, the error dispersion increases when the support of the prediction decreases, which is consistent with the well-known support effect. In practice, the proposed methodology allows predicting fracture intensity based exclusively on drill hole information, without the need for simulating fracture networks in space, hence its interest.

2:45 pm

Selection of Categorical Simulations for use in Geological Uncertainty Analysis. A Case Study from the Merian Deposit.

L. Allen; Newmont Mining Corp, Greenwood Village, CO

Mineralization controls of the Merian deposit have been simulated using various techniques including Multiple Point Statistics and Sequential Indicator Simulation. In addition, implicit modeling methods have been used to generate a range of mineralization shells intended to reflect the uncertainty in the interpretation of geological controls. These different methods produce varying ranges of uncertainty. To select which set of results should be used in evaluation of geological uncertainty, various validation techniques have been applied to the results from each technique. The validation results for each techniques are then compared and conclusions drawn.

3:05 pm

Application of Localised Indicator Kriging at Long Canyon

C. Wilson and N. Kusuma; Resource Modeling, Newmont Mining Corporation, Carlin, NV

The Long Canyon deposit is a near surface, relatively high-grade oxide ore body that presents an opportunity to develop a new mining district in Elko County along the eastern flank of the Pequop Mountains. The deposit occurs as a series of sub parallel northeast-trending zones that extend for a strike length of almost three miles. Mineralization is hosted in Cambro-Ordovician platform margin facies carbonate rocks. The majority of the mineralization is hosted within the Notch Peak and Pogonip limestone units along the upper and lower margins of the massive Notch Peak dolomite with minor mineralization in dolomite and Mesozoic intrusive rocks. The mineralization is locally varying; hence, many attempts were made to use various estimation methods including Ordinary Kriging (OK) which over-smoothed the grade and Multiple Indicator Kriging (MIK) which created un-mineable slivers of low or high-grade when dealing with small tonnages. In 2012, Localised Indicator Kriging (LIK) was applied to estimate the gold and validated the best globally, against the Direct Gaussian Model, when compared to simulation and visually. This paper documents the application of LIK for estimating the gold.

3:25 pm

Confidence on the Grade Shells: Application to Exploration Projects

A. Samal; GeoGlobal LLC, Riverton, UT

Construction of grade shells in exploration project is a common practice. Grade shells are used for quantification of mineralization and planning for future drilling and sampling programs. Generally a deterministic grade shell is used for these purposes with limited exceptions, where a risk based grade-shell analysis is conducted. This paper and presentation uses anonymous exploration data for demonstrating the usefulness of risk based grade shell analysis using conditional simulation. Sequential Gaussian Simulation (SGS) is used. The results of this research project indicate that at 95% and 90% confidence intervals the volumetric differences between conservative and optimistic cases can be substantial. This result also shows the variability of the deterministic model. Similar analyses can be used for planning and prioritizing drilling campaigns in order to maximize the rate of return.

Monday, February 22 – Afternoon

ROOM: 131C

2:00 pm

SME Sections Sharing Success: Changing the Public Perception of Mining

2:00 pm

SME Sections Sharing Success: Changing the Public Perception of Mining

D. Scriven; Western States Mining Consultants, Casper, WY

The session will be a workshop to show other SME section members how their local sections can be more effective in getting the message to their communities and schools about the value of the extractive mineral industry. The session will show a few examples of what some of the other successful sections are doing as far as outreach is concerned, how to better communicate with schools and businesses and how to run effective fund raisers to provide scholarships to engineering students as well as school class rooms to buy equipment. The section will also have some in depth discussions on the Mining in Society Merit Badge. Julie Lucas – Minnesota Section of SME – Merit Badge Camporee Frank McAllister –

Mining in Society Merit Badge Dan Alexander – Pittsburg Section of SME – Public and Student Outreach from the Pittsburg Section Michael Lynn – Paradise Valley Unified School District – Business and School Partnerships Greg Kruse – Central Wyoming Section of SME – What makes a successful SME Chapter?

Tuesday, February 23 – Morning

ROOM: 132A

9:00 am

Accessing Capital Today: What Are the Latest Trends?
What Drives Success? Is M&A and/or Restructuring
an Option for You?

Chair: T. Alch, Vice Chair NY Section of SME and Co Chair of SME's
Mining Finance Conference, Edgewater, NJ

9:00 am

Accessing Capital Today: What Are the Latest Trends?
What Drives Success? Is M&A and/or Restructuring an
Option for You?

*T. Alch; Vice Chair NY Section of SME and Co Chair of SME's Mining Finance
Conference, New York, NY*

Join us to hear our group of experts talk about what you need to know re financings, valuations, M&A deals, restructuring trends and other issues impacting mining companies looking to raise capital for exploration, development, expansion, etc. including pros and cons of capital from different sources, financing structures, etc. Our Speakers will take your questions about: What are latest trends re equity, debt, private equity, streaming, and royalty financings? What sectors look 'best'? Are improving? Will 2016 – 2017 improve? How? Why? Who has provided capital in recent years? For what types of projects? Where? What is impact of non-technical issues, social license to operate, et. al. risks? What role does China, India, NGOs etc. have? Driver? Investor? etc..?

9:10 am

World Exploration and Financing Trends and Some Key
Issues Impacting New Mine Development in the USA

D. Cox; Sales, SNL Metals & Mining, Halifax, NS, Canada

This presentation will examine the major trends in metals exploration over the last 10 years, including the principal commodity targets, regional allocations, and stages of exploration. We will discuss the relative importance of junior exploration companies, those companies most dependent on equity financing or partnerships for their exploration activities, and the impact of the prolonged scarcity of equity financing on exploration in 2016. We will also look at financings over the last few years and the impact these have had on the global metals development pipeline. One of the key issues for the US is the dysfunctional permitting system for mining projects compared to other countries. We will examine how it has a demonstrable impact on the economics of new mine development in the country.

9:30 am

Hard Realities Management & Shareholders Need to Know
about Raising Money Today

B. Cox; Oreninc, Vancouver, WA

Benjamin Cox will discuss the chilling realities of today's fundraising market in the junior resources space. He will dive deep into the core issues surrounding

the current crisis that has overtaken our industry. Focusing on the perspective of shareholders and management, Mr. Cox will look at what actions stakeholders should take to survive this capital plague and live to see another day.

9:50 am

A Banker's View of Raising Capital in Mining Today: Two Case Studies

R. Reeves; Project Finance - Mining and Minerals, MUFG, Los Angeles, CA

The current market creates both problems and opportunities for mining finance. The problems stare us in the face: (i) weak commodity prices; (ii) weak macroeconomic activity every except North America; and (iii) concerns about long term supply and demand balances. The current situation makes new mine development and monetizing assets more difficult, particularly for juniors. This has resulted in the financial community looking to maximize returns versus risk. While a difficult time, it presents opportunities for lower risk and de-risked projects to move to the head of the pack by taking advantage of the lower risk nature of brownfield expansions and thoroughly de-risked projects

10:10 am

Mining Today: What Managements Know and Need to Know about the Capital and Funding Dilemmas

J. Miller; Ernst and Young, Denver, CO

Mr. Andrew Miller will discuss the capital dilemmas faced by the mining and metals companies today. There are significant and systemic limits on the amount and type of capital available to mining and metals companies depending upon the nature of the company - the majors have different capital sources available to them than the junior miners. What is driving the changes and what nontraditional sources are available today? Mining and metals companies must choose among competing projects - how will they choose and what factors impact those decisions?

10:30 am

Financing Options in the Current Market: Traditional Sources, Alternative Sources...and More?

C. Urda Kassis; Shearman and Sterling LLP, New York, NY

Despite the general improvement in the financial markets, liquidity to fund greenfield mining projects remains constrained. As a consequence, companies developing such projects continue to need to consider non-traditional debt and equity funding sources and structures. In doing so, it is important to consider the consequences which flow from the use of any such funding. Cynthia will discuss some of the key consequences such as the reduction of the borrowing capacity of a project, likely inter-creditor issues, and future consent requirements which give rise to options to renegotiate and limits on future growth activities. She will also focus on one alternative source which seems to be re-emerging in some jurisdictions as construction activity has slowed and consequently significant contractor capacity has opened up is the construction contractors themselves. Contractor funding can take a variety of forms, each with different implications on which Cynthia will provide some highlights.

10:50 am

Streaming and royalty financings and the importance of valuing assets today

E. Lee; Duff and Phelps, San Francisco, CA

This paper will present an update on the status of royalty and streaming financings in the industry. A comparison of the sources of funding and the types of projects financed will be presented. In this troubled market, the importance of asset valuation will also be discussed.

11:10 am

How Mining Projects Will Be Funded in the Future

C. Williams; Red Cloud, Toronto, ON, Canada

The past 4 years have been challenging for mining exploration or development stage companies seeking to raise capital. An overview of the current funding environment will be provided. Equity financing, the mining industry's historical mainstay for raising money, has fallen greatly in importance. Now, new, alternative forms of financing need to be considered by all public and private companies. Equity crowd funding has developed from the now-ubiquitous crowd funding activities created for non-profit activities. Klondike Strike is the world's first mining-only equity crowd funding portal. The outlook for mining equity crowd funding, opportunities and challenges will be discussed.

11:30 am

The Politics of Base Erosion and Profit Shifting – How Recent Trends re Limited Deductibility of Financing, Profit Based Taxation, etc. Drive Financing of New Projects & M&A

D. Henritze; International Tax, KPMG LLP, Denver, CO

This session will focus on the recent trend in international taxation to tighten rules and expand reporting requirements to stop the perceived erosion of tax base and “immoral” behaviors most specifically associated with financing global projects. We will provide you with an historic overview of the events that lead the politicization of tax policy, and will discuss the tools that governments are implementing to gain transparency into a company's finances, and stop the erosion of tax revenue from their jurisdictions through interest payments.

Tuesday, February 23 – Morning

ROOM: 224A

9:00 am

Coal & Energy: Coal Mine Methane

Chairs: N. Gupta, Virginia Tech, Blacksburg, VA

C. Long, Raven Ridge Resources, Incorporated, Grand Junction, CO

9:00 am

Introductions

9:05 am

Evolution of Coal Mine Methane Recovery and Use in the United States

C. Talkington¹ and F. Ruiz²; ¹Advanced Resources International, Arlington, VA and ²Climate Change Division, United States Environmental Protection Agency, Washington, DC

Methane degasification systems have evolved from relatively simple operations to highly integrated systems. Today U.S. coal mines employ surface gob wells, surface vertical pre-drainage wells, long-hole in-mine boreholes and surface directionally drilled boreholes. During that last 40 years, mining companies have also recognized the economic benefit of capturing the mine gas for a wide range of uses. This paper will review the history of coal mine methane recovery and use in the United States, including the roles of the Environmental Protection Agency's Coalbed Methane Outreach Program and the Global Methane Initiative in promoting methane recovery and use. The paper will also outline the most common options for using coal mine methane, the factors that determine which utilization options are most appropriate for a project, the steps in developing a project, and the reductions in greenhouse gas emissions resulting from project implementation.

Temperature-dependent Langmuir's model in the coal and methane sorption process: statistics relationship

X. Tang and N. Ripepi; Department of Mining & Minerals Engineering, Virginia Polytechnic Institute & State University, Blacksburg, VA

The Langmuir model has been widely used for the coal-methane sorption process via an isothermal test. However, even though the temperature-dependent Langmuir model were recognized theoretically and experimentally, the quantitative relationship between the Langmuir's constants and temperature have not been clarified and confirmed by the lab test data. This paper collects 158 methane-coal sorption data under different temperatures, which apply the Langmuir model to consider the relationship between Langmuir's constants and temperature. Even though Langmuir model cannot be used to show the physical state of methane adsorption on coal, it is widely used because of its simplicity and the reasonable explanation of its parameters. The results from these published tests confirm that 1) there is no consistent relationship between Langmuir's constant-a and temperature; 2) the Langmuir model is a temperature-dependent model, and the temperature-dependent feature is mainly shown by the relationship between Langmuir's constant-b and temperature; 3) The relationship between Langmuir's constant-b and temperature can be described by both the exponential and linear relationship with dried coal.

9:45 am

Development of Coalbed and Coal Mine Methane Resources in Mongolia— Breaching Barriers to Investment

R. Pilcher, C. Long and J. Marshall; Raven Ridge Resources, Incorporated, Grand Junction, CO

Mongolia, endowed with impressive mineral wealth, has been the focus of international mining and petroleum companies for many years. Aiming to attract additional investment, the Government of Mongolia revised its Petroleum Law in 2014. The law administered and enforced by the Ministry of Mining (MoM), designates coalbed (CBM) and coal mine methane (CMM) as unconventional petroleum resources. Changes to the law allow Mongolian coal companies to develop methane resources within their coal leases by amending their existing licenses. Erdenes Tavan Tolgoi JSC, a state-owned company located in the eastern Gobi, has joined with a Mongolian drilling company and Korea Gas Corporation to explore for CBM on its leases. Privately owned Mongolyn Alt Corporation, operating the Nahrn Sukhait Coal Mine in the central Gobi, will begin CBM/CMM exploration in the second half of 2015. Although the change in the Petroleum Law removed a legal barrier to CBM/CMM development, additional barriers to development exist. Mongolia lacks gas pipelines, additional power grid capacity, roads and rail needed for transport of LNG, and a trained workforce required for developing and producing the resource.

10:05 am

Study on Dynamic Character of Negative Pressure along Gas Drainage Bore

J. Liu; School of Safety Science And Technology, Henan Polytechnic University, Jiaozuo, Henan, China

Gas drainage is the most important method to raise the safety of coalmine. How to ensure the rational drainage negative is a factor to influent the drainage effect. This paper takes Jiulishan coalmine of Jiaozuo Energy Coal Group and Daning coalmine as research background and test site through theoretical analysis, laboratory test, numerical simulation, field test and other methods. Based on the systematic analysis of the distributing of negative pressure and many factors, including negative pressure at spot face, diameter of drilling, gas emission, etc. the distributing regular of negative pressure along the drilling hole is concluded.

The negative pressure along the drilling hole is not a constant value. It is reduced gradually along the drilling hole length. According to the application at Jiulishan coalmine, with the increase of the depth of drilling hole, the negative pressure along the drilling hole is decreased obviously, and the loss of per 100 meters is 19.73~22.64%. There are important theoretical and realistic significance for selecting the rational parameter, raising the gas drainage effect, eliminating blank zone of gas drainage and exploitation safety.

10:25 am

New Elk Coal Company – Coal Mining In an Established Gas Field

J. Marshall, R. Pilcher and C. Long; Raven Ridge Resources, Incorporated, Grand Junction, CO

The New Elk Mine is located in the Raton Basin in southeast Colorado in an area that has seen profitable coal mining, natural gas and coalbed methane (CBM) development for many years. The footprint of the mine's leases are overlain by the well-developed Purgatoire CBM field operated primarily by two companies— oil and gas development at this location has primacy over coal mining. This situation poses barriers to employing a comprehensive approach to optimizing economic recovery of both resources. Our investigations have shown that both coal and gas can be sustainably extracted while reducing greenhouse gas emissions. New Elk could face unplanned abandonment costs for wells that are completed in the same seams that are being extracted, and could pose hazards if gas from the wellbore leaks into the mine workings. Presently there are no mandated coordination efforts between the natural gas and CBM producers and the New Elk Mining operations. Coal miners may benefit from the pre-mine drainage that occurs due to the CBM production; however while gas production may not be interrupted by mining operations, ongoing gas production can have an undesirable impact on coal mining.

10:45 am

Monetizing Coal Mine Methane – You are Sitting On Your Own Fuel Supply

E. Woods; Dresser-Rand, A Siemens Business, Fort Collins, CO

Removal of methane from coal mines is required for safe operations. Monetization of coal mine methane is difficult due to proximity to pipelines and their available capacity. Recently commercialized modular gas liquefaction technologies present an opportunity for mine operators to manufacture onsite liquefied natural gas (LNG) to fuel surface equipment, or sell to the market.

11:05 am

The choice of extraction methods under the composite disasters of methane and fire in goaf

J. Guo; China Coal Research Institute, Beijing, China

In order to research the influence of methane extraction to spontaneous combustion under the composite disasters of methane and fire in goaf. With the No.101 working face in some coal mine as the research object, using numerical simulation software of FLUENT to analyze the methane concentration distribution, leakage air field and change of the oxidation zone width, which are caused by adopting the techniques of high drilling extraction, deep tail roadway extraction, drawing near extraction, buried pipe extraction and so on. The results shows that the techniques of high drilling extraction is the best way under the condition of same extraction volume, which have relatively small influence on leakage air field in the bottom of goaf and the change of oxidation zone width. The method can reduce the composite disasters of methane and fire in goaf, and provide effective guarantee for the working face of coal mine with safety and efficiency.

Tuesday, February 23 – Morning

ROOM: 224B

9:00 am

Coal & Energy: Dust Control I

Chairs: J. Colinet, NIOSH, Pittsburgh, PA
E. Sarver, Virginia Tech, Blacksburg, VA

9:00 am

Introductions

9:05 am

16-010

Examination of a Newly Developed Mobile Dry Scrubber (DS) for Coal Mine Dust Control Applications

J. Organiscak¹, J. Noll¹, D. Yantek¹ and W. Kendall²; ¹NIOSH, Pittsburgh, PA and ²J. H. Fletcher & Co., Huntington, WV

A self-tramming mobile dry scrubber (DS) was developed by J. H. Fletcher and Co. under a contract with the National Institute of Occupational Safety and Health's Office for Mine Safety and Health Research (NIOSH-OMSHR). NIOSH-OMSHR laboratory testing showed that the DS averaged greater than 95% respirable dust removal efficiency with the disposable filter cartridges and averaged 88% and 90%, respectively, for the optional washable filters in their pre-washed and post-washed test conditions. Laboratory sound level measurements of the DS also showed the outlet side of the scrubber was noisier and the loaded filters increased sound levels as compared to clean filters at the same airflow quantities. The scrubber with loaded filters reached the permissible exposure level (PEL) threshold of 90 dB(A) at 6000 cfm of scrubber airflow, indicating that miners should not be over exposed to hazardous noise levels at or below this airflow quantity. Field testing the DS with the disposable filters at an underground coal mine showed that it can clean a portion of the section return air and provide nearly a 50 % dust reduction at the face area downstream of the continuous miner operation.

9:25 am

Effects of Proper Drilling Control to Reduce Respirable Dust During Roof Bolting Operations

M. Li, Y. Luo and H. Jiang; WVU Mining Engineer, Morgantown, WV

The dust generated from bolt hole drilling in roof bolting can have high quartz content. As a dust control measure, vacuum drilling is employed on most of the roof bolters in US underground mines. However, fine rock particulates from the rock drilling can become airborne under a number of circumstances causing the roof bolter operators expose to quartz-rich respirable dust. A previous research shows that drilling can be controlled through properly selected penetration and rotational rates to reduce the specific energy of drilling. Less specific energy means less energy is wasted on generating noise, heat and over-breakage of rock. It implies that proper control of drilling has a great potential to generate significantly less fine rock dust during drilling. The drilling experiments have been conducted to study the effect of controlling drilling on reducing respirable dust. The preliminary results show that the size distributions of respirable dust were different when controlling drilling in different bite depths. Based on the theoretical and experimental studies, rational drilling control strategy will be developed for dust control while maintain a safe and productive roof bolting.

9:45 am

16-003

Development of a Roof Bolter Canopy Air Curtain for Respirable Dust Control

W. Reed¹, G. Joy¹, W. Kendall², A. Bailey² and Y. Zheng¹; ¹Dust Control, Ventilation, and Toxic Substances Branch, NIOSH, Pittsburgh, PA and ²J.H. Fletcher & Co., Huntington, WV

Testing of the roof bolter canopy air curtain (CAC) has gone through many iterations demonstrating successful dust control performance under controlled conditions. J.H. Fletcher & Co. (Fletcher) an original equipment manufacturer of mining equipment has further developed the CAC concept by incorporating it into the design of its roof bolter machines. A new CAC design has been developed incorporating the results of testing of the NIOSH design and the recent Fletcher design. Observations from smoke testing conducted on this new CAC design in a laboratory setting show promise for better performance.

10:05 am

16-161

CFD Modeling of a Novel Wet Scrubber for Capture of Respirable Dust in an Underground Coal Mine

S. Arya, W. Wedding, A. Kumar and T. Novak; Mining Engineering, University of Kentucky, Lexington, KY

Controlling dust generation and keeping it below permissible limits at the working face of a room and pillar mine is a challenge for mine operators. With the recent changes in the respirable-dust regulation, it has become increasingly difficult. The current most effective practice of dust control at a continuous miner face in an underground mine is the use of a flooded-bed scrubber. A study carried out by National Institute for Occupational Safety and Health (NIOSH) stated that a flooded-bed scrubber, under its optimum condition, can achieve cleaning efficiencies between 58 and 90 percent. The performance of such a system can be maintenance intensive. Other industries face similar dust control issues. The University of Kentucky partnered with Toyota Motor Manufacturing for the development of a novel wet scrubber for capturing paint overspray, with capture efficiencies in excess of 98 percent and minimal maintenance. The aim of this study is to assess the ability of this novel wet scrubber to capture respirable dust in an underground coal mine. This paper presents the conceptual design and the computational fluid dynamics (CFD) modeling of this novel wet scrubber.

10:25 am

16-118

Testing a Reduced Scale Model of a Flooded Bed Dust Scrubber Integrated With a Longwall Shearer for Dust Capture Efficacy

A. Kumar, W. Wedding, S. Arya and T. Novak; Department of Mining Engineering, University of Kentucky, Lexington, KY

Coal dust in the underground environment has always been a health and safety issue, especially on longwall mine faces. Efforts to integrate a flooded bed scrubber with a longwall shearer are underway at the University of Kentucky, in order to reduce worker exposure. Reduced scale modeling, along with numerical modeling and full-scale experimentation is a useful engineering tool to simulate operating conditions underground. Recent advances in affordable 3D printers offer means to get timely insight in advance of building larger, expensive test setups. When paired with a numerical modeling approach, such as computational fluid dynamics (CFD), it can offer confidence in a proposed design. The paper discusses reduced scale modeling of a flooded bed dust scrubber for a longwall shearer. A tracer gas was used in the model in lieu of dust to establish dust capture efficiency. Results from the scale modeling were compared to a CFD models, for both a 1:20 scaled model and for a full scale model. The reduced scale model

and the CFD model results demonstrated good agreement. Dust capture results show the usefulness of the approach at different scales, ahead of actual design implementation.

10:45 am

Designing Water Spray Systems for effective Dust Suppression at Conveyor Transfer Points

E. Clausen and A. Agasty; Institute of Mining, TU Clausthal, Clausthal-Zellerfeld, Germany

Mining of minerals from underground undeniably results in generation of pollutants, gaseous and particulate. The generation of dust at extraction face or re-suspension during the material handling process requires measures such as suppression or filtration techniques. The objective of this study was to provide an effective spray solution for conveyor transfer points with minimal water usage, for this a scale model was constructed. The setup was used to test variable parameters and for each configuration the concentration of dust could be measured. An analysis of the dust suppression capacity of tested configurations was performed with special consideration to nozzle type and location, spray pressure and water volume rate, droplet spectrum etc., consequently most suitable spray configurations for the tested scenario could be determined. The results show that as much as 90% of the total dust suppression is possible with a proper spray application, but at the same attention needs to be paid to the amount of water. The conducted research aided in designing of efficient configuration that would provide a safe and suitable working environment.

Tuesday, February 23 – Morning

ROOM: 229A

9:00 am

Coal & Energy: Refuge Alternatives for Underground Coal Mines I

Chairs: T. Lutz, DHHS/CDC/NIOSH, Pittsburgh, PA
D. Yantek, NIOSH OMSHR, Pittsburgh, PA

9:00 am

Introductions

9:05 am

16-025

Analysis of Heat Loss Mechanisms for Mobile Tent-type Refuge Alternatives

P. Bissert¹, D. Yantek¹, M. Klein² and L. Yan¹; ¹NIOSH, Pittsburgh, PA and ²ThermoAnalytics, Calumet, MI

Federal regulations require that refuge alternatives (RAs) are located throughout coal mines in the event that miners cannot escape during a disaster. The Mine Safety and Health Administration mandates that RAs provide safe shelter and livable conditions for a minimum of 96 hours while maintaining the apparent temperature below 95°F. Using a validated thermal simulation model, the National Institute for Occupational Safety and Health Office of Mine Safety and Health Research examined the heat loss mechanisms for mobile tent-type RAs, and the effect of mine strata composition on the final RA internal air temperature. The results of these studies show that most of the heat loss is from radiation (50%) and conduction (31%). Three mine width/height configurations and three mine strata compositions were examined. The final RA air temperature varied less than 1°C for the three mine width/height configurations and less than 2°C for the three mine strata compositions.

9:25 am

16-045

Validation of Thermal Simulation Model of 23-person Tent-type Mobile Refuge Alternative

L. Yan¹, D. Yantek¹, M. Klein² and P. Bissert¹; ¹CDC/NIOSH, Pittsburgh, PA and ²ThermoAnalytics, Inc., Calumet, MI

If an accident occurs in an underground coal mine, miners who fail to escape from the mine can enter the RA for protection from adverse conditions. One of the main concerns with the use of mobile RAs is the temperature rise inside the RA. Moreover, the humidity within the RA will increase. The accumulation of heat and humidity can result in miners suffering heat stress or even death. The heat transfer process within and surrounding a RA is very complex, and is not easily defined analytically or experimentally. Therefore, NIOSH conducted a 96 hour physical test on a 23-person tent-type RA in the Experimental Mine (EM). The test results showed that the average air temperature within the RA increased by 6.4°C (11.5°F) and the relative humidity approached 94 %RH. These test results were comparable to thermal simulations and indicate the need for research into occupancy ratings for tent-type RA.

9:45 am

16-070

Refuge Alternative Relief Valve Testing and Design

T. Lutz, P. Bissert, J. Yonkey and G. Homce; OMSHR, DHHS/CDC/NIOSH, Pittsburgh, PA

Since 2007, the National Institute for Occupational Safety and Health has been testing various refuge chambers with built-in relief valves. The Mine Safety and Health Administration (MSHA) requires that the valves vent the chamber when a specified pressure—0.18 psi or less, or as specified by the manufacturer—is reached inside the chamber. To facilitate relief valve testing, an instrumented benchtop test fixture was developed using an off-the-shelf centrifugal blower and ductwork. Relief pressures and flow characteristics were measured for production and newly designed relief valves. Newly designed relief valves are based on readily available PVC check valves and brass/cast iron units. Adjustments were made to the production valves and prototype valves to relieve at pressures consistent with MSHA regulations.

10:05 am

16-046

Effects of the Constant Mine Strata Temperature Assumption, and Initial Mine Air and Strata Temperatures on Refuge Alternative Internal Air Temperature

D. Yantek¹, L. Yan¹, P. Bissert¹ and M. Klein²; ¹NIOSH OMSHR, Pittsburgh, PA and ²ThermoAnalytics Incorporated, Calumet, MI

Federal regulations require the installation of refuge alternatives (RAs) in underground coal mines. Mobile RAs have a limited ability to dissipate heat, and heat buildup can lead to a life-threatening condition as the RA air temperature and relative humidity increase. NIOSH OMSHR performed heat testing on a 10-person tent-type training RA and contracted ThermoAnalytics, Inc. to develop a validated thermal simulation model (TSM) of the tested RA. The TSM was used to examine the effects of the constant mine strata temperature assumption, initial mine air temperature (MAT), initial mine strata surface temperature (MSST), initial mine strata temperature at depth (MSTD), and mine strata thermal behavior on RA air temperature using 117 W of sensible heat input per simulated miner. For the studied RA, when the mine strata temperature was treated as a constant, the final predicted RA air temperature was 12.8°F lower than it was when the mine strata thermal behavior was included in the model. A 10°F increase in the initial MSST resulted in a 7.1°F increase in the final RA air temperature, whereas a 10°F increase in the initial MSTD yielded a 2.5°F increase in the final RA air temperature.

10:25 am

16-072

Human Thermoregulation Model for Analyzing the Performance of Mine Refuge Alternatives

M. Klein and M. Hepokoski; ThermoAnalytics, Inc., Calumet, MI

Mine refuge shelters are designed to protect mine workers from hazardous environmental conditions after a mine disaster, but high temperature and humidity levels inside these shelters may pose a significant safety risk. Due to the safety risks associated with human testing, detailed thermal models of shelters and human occupants have been developed using TAItherm simulation software. These models are used to predict the temperature and humidity within the shelter resulting from metabolic heating, evaporation due to sweat and respiration, moisture and heat from the shelter's carbon dioxide scrubbing system, and heat transfer within the shelter. A detailed human thermoregulation model simulates the sensible and latent heat generated by the shelter occupants, and predicts the occupant's body core temperature and moisture lost due to sweating and respiration. This information is used to assess the safety of the shelter. In this paper we will review technical details of the human thermal model, validation comparing the human model to human subject test data, and results of a mine shelter analysis.

Tuesday, February 23 – Morning

ROOM: 229B

9:00 am

Coal & Energy: Ventilation Best Practices I

Chairs: G. Hartsog, Alpha Engineering Services Inc, Beckley, WV
K. Raj, University of Alaska Fairbanks, Spokane, WA

9:00 am

Introductions

9:25 am

Reduction of Noise Exposure in Underground Mines by Improving Auxiliary Ventilation Technologies

S. Bhattacharyya and F. Calizaya; Mining Engineering, University of Utah, Salt Lake City, UT

Noise is an inherent health hazard in the mining industry. It is produced by both mobile and stationary units viz. production machinery, conveyors, and auxiliary fans. In hard rock mines, auxiliary fans are used in development headings, stopes, fixed facilities, and underground crushers. In coal mines they are mainly used in development headings to reduce leakage and allow deeper cuts compared to brattice lines. These fans are equipped with high speed motors, and generate noise levels greater than 100 dB(A). Sound attenuating devices are sometimes used but often omitted for cost reduction purposes or not maintained properly. This study summarizes the results of sound attenuation tests carried out at the University of Utah's auxiliary fan system equipped with silencers, and flexible connectors. It describes the advantages and disadvantages of these fans, the risks involved and the control measures that should be available. It also includes a summary of basic requirements for the design, selection, operation, and maintenance of these fans and ways to minimize noise exposure by efficient auxiliary ventilation systems and improved mining layouts in underground coal and non-coal mines.

Optimization of Gob Ventilation Boreholes Completion Parameters

S. Saki¹, J. Brune¹, G. Bogin², J. Grubb¹, R. Gilmore² and S. Lolon¹; ¹Mining Engineering, Colorado School of Mines, Golden, CO and ²Mechanical Engineering, Colorado School of Mines, Golden, CO

Gob ventilation boreholes (GVBs) are widely used in underground coal mines for longwall gob degasification purposes. GVBs are generally drilled within 10 to 30 m above the top of the coal bed into the fractured zone, completed with 7-in. casing and 60 m of slotted pipe at the bottom. The purpose of this completion strategy is to create a pressure sink to capture the emissions before they can enter into the underground workplace. For GVBs to work effectively, they must be drilled close enough to the mine to capture methane from the fractured zone while the setting depth must be kept above the caved zone to minimize the amount of ventilation air that is drawn into the GVBs. Well completion parameters are important for creating safe working conditions. In this paper, computational fluid dynamics (CFD) studies will be presented to analyze the effect of different practices for GVBs completion parameters on methane extraction, formation of explosive gas zones in the gob and methane concentrations at the longwall face and tailgate. Authors have identified the optimum completion parameters for GVBs, which can maximize the benefit and minimize the fire and explosion risk.

Effect of Controlled Recirculation on Buildup of Methane Concentration in a Sample Booster Fan Network

M. Shriwas and F. Calizaya; Mining Engineering, University of Utah, Salt Lake City, UT

Controlled recirculation may be considered as a beneficial means in mines of cold climate, where heating of air is required, and in deep or extensive mines when the working areas are far from the surface connections, where cooling of air is required. Controlled recirculation can be designed by proper sizing of the booster fans with respect to main fan. Intuitively, it seems that the buildup of methane at the face will cease when a steady state condition is attained, and also that, at that same time, the maximum concentration at the face will remain same as in the return air. This supposition is proved by mathematical analysis that considers uniform mixing of methane in air in successive cycles of recirculation. This study includes two scenarios to show the effect of 10% controlled recirculation on methane concentration in a sample network. Firstly, when crosscut recirculation exist near the working face; secondly, when recirculation exists away from the working face. The later scenario result shows the less buildup of methane concentration than former scenario result.

Automation and Control of a Laboratory Mine Ventilation System

K. Mayfield, T. Novak and W. Wedding; Mining Engineering, University of Kentucky, Lexington, KY

The Department of Mining Engineering at the University of Kentucky uses its Mine Ventilation Laboratory for educational and research experimentation. Much of the laboratory equipment is undergoing significant modernization. The in-house design, implementation, and operation of a major upgrade related to automating an existing 25-hp vane-axial fan, connected to ductwork, along with its associated controls are described. This process is achieved through the use of a programmable logic controller (PLC), sensors, actuators, and a human machine interface (HMI) with a touch-screen display. This new system provides a convenient

means for student measurements and experiments, including demonstrations of fundamental ventilation principles. Furthermore, it affords a venue for sophisticated experimentation, such as the development of optimization algorithms for ventilation on demand.

Tuesday, February 23 – Morning

ROOM: 226A

9:00 am

Environmental: Creative Closure Approaches

Chairs: E. Bingham, AECOM, Los Angeles, CA
R. Furey, MWH, Broomfield, CO

9:00 am

Introductions

9:05 am

Copper Recovery Improves Water Quality of the Acidic Berkeley Pit Lake, Montana, U.S.A

N. Tucci; Mining, AECOM, Chico, CA

Pit lakes may become long-term environmental risks or long-term water resources depending upon management decision. The potential benefits of resource recovery in mine water are examined in this case study of an acidic pit lake. The Berkeley Pit Lake in Butte, Montana, is one of the world's largest accumulations of acidic, metal-rich water. Between 2003 and 2012, approximately 2×10^{11} L of pit water were pumped from the bottom of the lake to a copper recovery plant, where dissolved Cu^{2+} was precipitated on scrap iron, releasing Fe^{2+} back to solution in the pit lake. Artificial mixing caused by this continuous pumping changed the lake from a meromictic to holomictic state, induced oxidation of dissolved Fe^{2+} , and caused subsequent precipitation of more than 2×10^8 kg of secondary ferric compounds, mainly schwertmannite and jarosite, which settled to the bottom of the lake. A large mass of As, P, and sulfate was also lost from solution. These changes in chemistry resulted in a roughly 25–30% reduction in the lake's calculated and measured total acidity. This represents a significant potential savings in the cost of future lime treatment, scheduled to begin in 2023.

9:25 am

Managing Storm Water on Closed Dumps in High Seismic Areas

S. Taylor; EMC2 - Picacho, Phoenix, AZ

Draining storm water off the top surfaces and side slopes of waste dumps after closure presents a number of hydraulic, geotechnical and structural challenges; especially for large, tall, and steep facilities in high seismic zones. This paper explores the use of HPDE drain pipes in lieu of more conventional approaches such as riprap, articulating concrete blocks, gabions and other types of open channel down drains. In the presented solution we route HDPE drain pipes down angle of repose sideslopes. We use intermediate geomembrane/clay-lined benches for velocity breaks and for flood attenuation, and buried perforated pipe for water capture on the benches. We explore the hydraulics of the pipe system, robustness of the solution against earthquake induced slope failures/settlement, potential for blocking and sedimentation, capital and operational costs and overall functionality.

9:45 am

Innovative Repurposing of America's Last Lead Smelter

C. Neaville; Environmental, Doe Run, Maryland Heights, MO

In 2013, The Doe Run Company closed the last primary lead smelter in the United States under an agreement with EPA after 120 years of operation. Since that time Doe Run has been working with EPA and the state of Missouri Department of Natural Resources on an innovative Brownfield redevelopment approach to repurposing the property for a multi-modal port facility. The former smelter is situated within 300 acres on the Mississippi River in Hercules, Missouri. The property is accessed by interstate highway (I-55), Union Pacific mainline rail, and barge loading on the shipping channel. In 1892 the St. Joseph Lead Company constructed the lead smelter which became the largest in the United States producing approximately 225,000 tons of refined lead annually. Since the shut down in 2013, Doe Run has advanced the redevelopment with repurposing the barge loading facilities for shipping frac sand from nearby quarries. The site is now being remediated and developed by Riverview Commerce Park, LLC and Doe Run.

10:05 am

Role of Bioaccessibility in Developing Risk-Based Arsenic Soil Remediation Levels At A Historic Smelter Facility

D. Crawford; Environmental Science, Golder Associates Inc., Redmond, WA

Contamination from a historic copper smelter facility was evaluated to determine site-specific remediation levels for arsenic. Probabilistic risk-based, site-specific soil remediation levels (SSSRLs) were developed for arsenic to identify the volume of soils that could require remediation using arsenic oral bioavailability to support the computation SSSRLs. Soils were analyzed for arsenic bioaccessibility using the Relative Bioavailability Leaching Procedure (RBLP); and Electron Microprobe Analysis (EMPA) to provide an initial understanding of mineral species present and their relation, if any, to bioaccessibility. Bioaccessibility of arsenic differed across the site areas with the highest arsenic bioaccessibility, not surprisingly, identified in soils downwind from the smelter stack, and lower bioaccessibility in soils crosswind from the smelter. The EMPA data was useful in refining mine areas and as supporting evidence for observed differences in bioaccessibility observed. These site-specific bioaccessibility data resulted in the calculation of more site relevant remediation levels and their impact on remedial decision-making is discussed.

10:25 am

Panel Discussion: Creative Approaches to Water Management in Mine Closure

R. Furey; MWH, Broomfield, CO

The final time slot for the session will be a panel discussion focusing on creative approaches to water management for mine closure. Panelists – Mike Milczarek (Geo-Systems Analysis, Inc.), Stephen Taylor (EMC2) and Eve Bingham (AECOM) – will delve deeper into ‘what taking a creative closure approach means with project examples and outcomes. The discussion will include time for audience questions and participation. Does taking creative approach mean navigating down an unconventional path or simply defining an issue differently to access to a new path that will lead to a suitable outcome? What are the risks of creative closure in water management at closure? Examples of success and failures. Panel moderator: Resa Furey.

Tuesday, February 23 – Morning

ROOM: 226C

9:00 am

Environmental: Permitting and Compliance Strategies II – NEPA and Permitting

Chairs: D. Anderson, Haley and Aldrich Inc, Boise, ID
A. Williamson, Twin Metals Minnesota LLC, St Paul, MN

9:00 am

Introductions

9:05 am

Addressing Climate Change in Mine Permits and Planning

A. Lundin; HDR, Denver, CO

Over the past several years, a number of legal findings and events have led to regulatory actions by the Environmental Protection Agency (EPA) and the Council on Environmental Quality (CEQ) regarding climate change and how permits and NEPA documents should address the issue. The CEQ has determined that climate change is already within the scope of impacts that should be considered within NEPA documents. However, guidance on how to address climate change is murky at best, and federal agencies vary greatly in how they address climate change in permits and NEPA documents, leaving the agencies open to litigation and project proponents vulnerable to costly delays. This presentation examines a number of emerging regulations, and varying federal agency approaches to addressing climate change within permits and NEPA documents and offers a path forward on how to effectively and efficiently address climate change in mine permits and NEPA.

9:25 am

A Robust Multi-Disciplinary Approach to the Selection of Samples for Geochemical Testing in Support of Mine Permitting for Twin Metals Minnesota's (TMM) Maturi Deposit

K. Boerst², C. Ross¹, R. Verburg¹ and A. Williamson³; ¹Environmental, Golder Associates Inc., Redmond, WA; ²Geology, Twin Metals Minnesota LLC, Ely, MN and ³Environment & Sustainability, Twin Metals Minnesota LLC, St. Paul, MN

TMM is proposing to develop a Cu-Ni-PGE ore body in the Duluth Complex of Minnesota. The Giants Range Batholith (GRB) forms the footwall of the deposit. TMM anticipates that the majority of the underground infrastructure will be located in the GRB. The mine material geochemical characterization program is a fundamental component of the Environmental Impact Assessment for the proposed mine. Selection of representative samples for geochemical characterization is fundamental to the success of the laboratory testing program. TMM has collected numerous samples in the GRB; however, no lithologic units were defined during exploration. Using existing data from exploration, supplemented by additional geochemical characterization data, TMM was able to identify distinct lithologic units with the use of multivariate statistics. This presentation demonstrates the benefits of applying rigorous statistical methods to all available geochemical information for the development of a robust and defensible testing program. The evaluation resulted in the identification of three clear lithologic domains within the GRB, each with its own spatial, geochemical and environmental characteristics.

9:45 am

Is it Still Possible to Permit a Major New Mining Project in the United States?

D. Ewigleben; Energy, Environment & Natural Resources Practice Group, Holland & Hart LLP, Greenwood Village, CO

After 150 years of mining development in the United States and significant growth of the mining sector in the last two decades of the 20th century, industry observers have now raised the question of the likelihood of new mining projects being permitted based on the growth of regulation, Federal oversight and citizen involvement. Congressional, state and local statutory requirements in the last 35 years have proliferated along with the accompanying regulations enforced by various federal, state and local agencies. In particular the 2014 pre-emptive action by the Environmental Protection Agency (EPA) against an Alaska mine project which had not submitted a permit application has raised the bar for any would-be mine developer. Yet, a closer look at the recent history of projects developed or expanded in the last 15 years may portray a more positive picture than at first glance. Successfully permitted mining projects share common themes in conducting an adequate community assessment and public outreach which follow a systematic approach to sustainable development. New mining projects can be developed in the U.S. if properly planned and managed.

10:05 am

Endangered Species Act Listings – Understanding the Process and Tips for Effective Involvement

A. Aurora; SWCA Environmental Consultants, Austin, TX

Petitions to list species as threatened or endangered under the Endangered Species Act (ESA) have been on the rise in recent years, including a number of species with wide ranges and broad habitat associations with the potential to affect activities across large portions of the country. The presence of a listed species often has significant economic consequences for those operating within its range, requiring costly and time-consuming permitting and compliance measures. ESA listing decisions must be made on the basis of the best available science, but valuable information from landowners and industry is often underrepresented in the process. Understanding how the listing process works and what issues are on the horizon are critical to ensuring that the mining industry and its stakeholders have a voice in these critical regulatory decisions. This presentation gives an overview of the listing process, notes upcoming species of concern for the mining industry, identifies opportunities for involvement and tools that can help shape the outcome of a listing decision, and provides tips to help ensure that new listings are based on full consideration of the best information available.

10:25 am

Leveraging data acquisition, analytics and technology to drive successful sustainability reporting

R. Marrill and F. Mielli; Schneider Electric, Alpharetta, GA

The availability of corporate social responsibility (CSR) reports and inclusion of sustainability information on company websites, internal and external reports is on the rise and stakeholders are demanding more transparency regarding how miners are driving sustainability initiatives. As demand for transparency continues to grow, mining companies will require a higher degree of sophistication and detail around the data they gather and the information they report. The paper analyzes the current sustainability landscape and offers recommendations for company-wide integration of new thinking around sustainability strategy development and data management. We will also present software technologies that combines quality assurance and data capture capabilities into one energy and resource management solution.

10:45 am

Efficient Management of Large Volumes of Public Comment on Controversial Projects.

R. Vellacott; ERM, Saint Paul, MN

Increased accessibility to technology and social media channels has facilitated unprecedented global public awareness and expression. Stakeholders and interested parties increasingly promote their agendas through online platforms in an effort to influence public opinion. The consequence of this public influence on large mining and other capital projects is that these projects are becoming more controversial than ever. While this poses challenges for proponents striving for their 'social license to operate', it also presents procedural challenges for lead Government agencies as they manage and address an ever-increasing volume of public comment through formal processes. Recent US National Environmental Policy Act (NEPA) Environmental Impact Statements on the NorthMet Mining Project and Keystone XL Pipeline attracted high public interest, and generated tens of thousands to over a million public comments respectively. Efficient use of relationship databases as well as other methods to effectively manage these large volumes of public comment are presented through recent case studies.

11:05 am

Coordinated Permitting of Iron Mines with a Focus on Minnesota Regulation

J. Engstrom; Minnesota Department of Natural Resources, St. Paul, MN

Minnesota has an over 130 year history of mining in the Mesabi Iron Range. The original, direct shipping, underground operations have since given way to open pit taconite mining. Most of the active taconite operations started in the 1950's with the newly developed pelletizing process. With the advent of environmental protection regulation, essentially in the 1970's, those operations have since been permitted, connecting the legacy facilities with more recent expansions. Minnesota's set of environmental regulations are implemented alongside the federal and local regulations, which can lead to overlapping jurisdiction. Coordinating and integrating requirements for successful permitting and reclamation of new or expanded facilities is in the public's interest.

Tuesday, February 23 – Morning

ROOM: 225A

9:00 am

Environmental: Water Treatment

Chairs: A. Cooper, Freeport-McMoRan, Inc., Oro Valley, AZ
D. Graves, TREC, Inc., Bozeman, MT

9:00 am

Introductions

9:05 am

Challenges of Wet Test in Mining Wastewater

H. Tozer; Industrial Wastewater, Woodard & Curran Inc, Portland, ME

A change in polymer was the final step in helping a mine meet its discharge limits on metals and whole effluent toxicity (WET). The mine/mill produced lead, copper and zinc and discharged water generated by dewatering its underground operations. The design-build team of Woodard & Curran and Alberici drew upon jar tests and a pilot study to build a 3000 gpm physical-chemical water treatment plant. The plant has met the metal limits since startup in December 2013 at lower

than projected operating costs. There were, however, some difficulties with the initial chronic WET tests for *Ceriodaphnia dubia*. The tests passed only when the metal concentrations were much lower than required by the permit, and lower than typically observed to be toxic. The chemistry to achieve the low levels was expensive and formed scale. The team identified the emulsion anionic polymer used in flocculation as a likely source of WET. Though pilot testing had used a dry polymer, an emulsion polymer was initially used at full-scale due to its ease of operations. Since replacing the emulsion polymer with a dry feed system, the plant has passed over 10 WET tests, even with higher metal concentrations.

9:25 am

Removal of Selenate Ion from Mine Water by an Innovative Adsorption Media

K. Banerjee, C. Blumenschein and N. Percel; Veolia Water Solutions and Technologies, Moon Township, PA

Using a proprietary iron-based media, selenium in the mine water was reduced to $<5\mu\text{g/l}$. The treatment system utilizes a filtration and adsorption process. Bench and pilot studies were conducted at two coal mine sites. Several process parameters were investigated, including pH, ORP, adsorbent dosage, contact time, and the impact of co-occurring contaminants. Using an ICP-MS, selenium in water was analyzed. Results reveal that the adsorbent is capable of removing selenium to $\leq 5\mu\text{g/l}$. The average selenium in the untreated water was $25\mu\text{g/l}$. About 90,000 bed volumes of water were treated prior to reaching the target effluent selenium. The adsorption capacity of the media was not affected by the presence of co-occurring contaminants. Scaling or fouling was not observed within the column. No significant pressure drop was observed. The treated effluent contained between 2 and 5 mg/l of iron, and after aeration followed by direct filtration iron was reduced to $< 0.1\text{ mg/l}$. Since the selenium concentration in the TCLP extract was less than the regulatory limit of 1 mg/l, the spent media can be disposed as a non-hazardous material. Results from the studies will be presented and discussed.

9:45 am

High Recovery Membrane Systems for the Treatment of Mining Wastewater

P. Thoen; Industrial Water Management, Littleton, CO

Membrane technology has proven to be an effective method for treating mining wastewater in order to meet strict environmental discharge limits. However, many membrane technologies produce a concentrated waste stream that is becoming exceedingly challenging to manage or dispose of. Industrial Water Management (IWM) has developed High Recovery Membrane (HRM) water treatment systems to treat mining wastewater in order to meet strict environmental discharge standards, while minimizing or eliminating the liquid waste stream. Water recovery rates of over 99% have been demonstrated on bench, pilot and commercial-sized systems. A review of HRM technology and results will be presented.

10:05 am

Water Quality and Cost Considerations: Arsenic Removal from Mine Water

P. Pigeon; Water Treatment/Automation Division, Golder Associates Inc., Lakewood, CO

Mining projects and operations in the Western United States often encounter arsenic in mine water they must either reuse or release to land or a receiving water. Quality criteria are applied as limitations on the mine water discharge depending upon the water management plan. The standard treatment for arsenic in the mining industry has been iron coprecipitation (IC) with clarifiers, ponds and filters for separation of the arsenic-bearing solids. A variety of alternates to IC exist for arsenic removal. One alternate that is used for arsenic removal from drinking water

supplies is proprietary sorption media filtration (PSMF). While PSMF has not been widely used for mine water treatment, it may offer water quality and operational cost advantages over IC. This paper will provide a brief digest of arsenic removal processes and an analysis of the costs of treatment and attendant advantages for IC and PSMF over a range of arsenic concentrations, effluent criteria, mine water flow rates and treatment residual management options. The findings of this analysis should be helpful to mine operators faced with treatment requirements for discharge of arsenic-bearing mine water.

10:25 am

A Review of Zeolite Based Treatment Water Systems and Their Applicability in Hard Rock, Coal and Uranium Mining Applications

D. Eyde; St Cloud Mining, Tucson, AZ

The revisions to the Clean Water Act, ever lower NPDES water discharge standards and competition for scarce water resources have increased the need for cost-effective water treatment products and applications. Many water treatment sites are remote and lack infrastructure, others are passive or semi-passive wetlands and bioreactors whose effluent, while meeting discharge standards, still require additional treatment for turbidity, COD, BOD and pH adjustment. The use of natural zeolites, alone or in conjunction with other treatment technologies, have had success in mitigating amD/amR discharges, as well as heavy metals, turbidity, NH₄⁺, Al, Mn and silica in coal and hard rock mining impacted effluents. In uranium mining areas and NURE impacted waters, treatment systems initially designed more for problems like for Three Mile Island and Fukushima have been effective in capturing radionuclides in both passive and active treatment systems, most recently at the Homestake Uranium Tailings at Grants, NM. The applicability of the ion exchange and filtration capabilities of zeolites, their ability to be used in passive treatment systems and their limitations are reviewed.

10:45 am

16-012

Biological Sulfate Removal – A Case Study From Sierrita Pilot Plant Operations

V. Paruchuri; Freeport McMoRan Inc, Tucson, AZ

Freeport-McMoRan Inc. operated a water treatment test facility at Sierrita, AZ to evaluate and demonstrate water treatment technologies for sulfate removal. One of the technologies tested was SULFATEQ™, biological sulfate removal, with a target effluent sulfate concentration of the process below 500 ppm. Sulfate removal is achieved using two active biological reactors. In the first reactor, sulfate reducing bacteria convert sulfate to hydrogen sulfide. In the second reactor, sulfide oxidizing bacteria convert hydrogen sulfide to elemental sulfur. The pilot plant was successfully operated from August 2011 through April 2015 and treated 100 gpm of sulfate impacted water with average feed calcium and sulfate concentrations of 475 ppm and 1,490 ppm, respectively. Effluent concentrations of calcium and sulfate could be consistently maintained as low as 7 ppm and 296 ppm, respectively. Potential by-products in the form of calcium/sulfur cake and sulfide source for other water treatment have also been evaluated. The process technology, operational challenges and performance are presented.

11:05 am

Evaluation of Selenium in Process Water and Its Potential Effect on Doré Quality in Carbon in Leach Gold Recovery Plant

T. Sharp, C. Kennedy and M. Noel; SRK Consulting, Vancouver, BC, Canada

The effect of increasing selenium concentrations in process water on the selenium content of gold doré was investigated. A site used reverse osmosis (RO) to treat for selenium and added the reject to the process water. The investigation

integrated metallurgical processing and the site water and load balance. Selenium in the ore was the primary source of selenium loading to the mill. The RO reject contributed a lesser portion. Selenium in the ore formed selenocyanate during cyanidation and adsorbed to carbon in the leach circuit. Selenium in the RO reject and tailings reclaim water was present as selenite and selenate which are less likely to adsorb to the carbon. Selenium eluted from the carbon precipitates into the sponge gold during electrowinning. The site water and load balance also affect selenium in process water. Reclaim water from the tailings facility was the primary water source. Low selenium freshwater was used as makeup water as the volume in the tailings facility decreases. Selenium concentrations will decrease in process water despite the addition of RO reject. The results demonstrate how integrated water management can reduce and forecast operational risks.

Tuesday, February 23 – Morning

ROOM: 132B

9:00 am

Global Mining Education & Collaboration

Chairs: B. Hebblewhite, University of New South Wales, Sydney, NSW, Australia
V. Kecojovic, West Virginia University, Morgantown, WV

9:00 am

Introductions

9:05 am

16-026

Training and Insertion of Female Professionals in the Chilean Minerals Industry: Chile vs. USA

J. Botin¹, M. Poulton² and C. Gatica¹; ¹Ingenieria de Mineria, Pontificia Universidad Catolica de Chile, Santiago, Chile and ²Department of Mining and Geological Engineering, University of Arizona, Phoenix, AZ

The Chilean minerals industry foresees a shortage of 33,000 new skilled professional by 2023. Enhancing the integration of women into the workforce is a possible solution. This study analyzes the state of women in the mining workforce over the past decade. Several key indicators are presented: percent in the workforce, salaries, career profiles, presence at management level, and participation in academia are studied. The study also analyzes the accessibility of professional and skilled technical jobs for women and the strategies used by government, industry, and universities to improve the recruitment and retention of women in the mining workforce. The main results show women represent 7.4% of the mining workforce in Chile and less than 1% of senior positions with a salary gap of approximately 30%. Systematically, women prefer professional programs in geology, chemistry, and environmental areas. The Chilean statistics are compared to data from the United States mining industry.

9:25 am

Global Mining Education & Collaboration

B. Hebblewhite² and V. Kecojovic¹; ¹Mining Engineering, West Virginia University, Morgantown, WV and ²University New South Wales, Sydney, NSW, Australia

This session will be coordinated by the international Society of Mining Professors (SOMP), but is open to all mining academics and industry personnel with an active interest in mining engineering education and collaborative research. It will be an interactive session involving a number of brief keynote talks by international speakers, followed by an open forum discussion on the various keynote topic areas. The session will include the following topics: (i) An update on activities and

projects of SOMP; (ii) Collaborative education and research partnerships – pitfalls and opportunities!; (iii) Case studies of collaborative international mining research; (iv) Update on SOMP'S Mines of the Future Initiative; and (v) Distance education – Is it effective? What are some working models?

Tuesday, February 23 – Morning

ROOM: 131B

9:00 am

Health & Safety: Impacts of Leadership on Safety Culture and Change

Chairs: L. Guasta, Safety Solutions International, Inc., Parker, CO
M. Premo, Premo Consulting LLC, Parker, CO

9:00 am

Introductions

9:05 am

The Science of Fun

N. Measley; The Fun Dept, Wilmington, DE

The simple learning objective of “The Science of Fun” is to explore and understand the science and The Laws of Fun model behind what makes for successful fun work programs – employee engagement, team building and company events – as perfected by The Fun Dept.™ for more than a decade. “The Science of Fun” encourages participants to explore how they can create a Shared Experience to realize its power and potential and Explore The Laws of Fun – The Fun Dept. Model for Successful Engagement; having Leadership Buy-In when implementing fun programs; making fun a Consistent piece of your workplace fabric, organizing fun on Company-Time to encourage participation, ensure fun programs are Culture-Compliant for your people and your organization; and designing fun so it is built For All the Senses.

9:25 am

Driving Positive Safety Culture: An Introduction To A Practical Model Of Safety Leadership

M. Afton; Cognitive Change Concepts, Inc., Centennial, CO

With the best of intentions and an aim to motivate individual contributors to take on new safety initiatives or change protocols, leaders and middle managers continue to resort to interventions that tend to fall flat, instead of inspire. While ‘old school’ transactional styles of leadership may have worked in the past, increasingly leaders are seeking new ways to develop followers to be more self-directed and achieve buy-in for the organizational safety vision. Thankfully, with a better understanding of worker motivation, brain biases and transformational leadership styles, today's leaders can take better control of their leadership and their cultural change outcomes. In this session, we will explore the concepts of Transformational Leadership, and the impact these principles have on safety culture as a whole. We will introduce a simple model and strategy for influencing a positive and proactive safety culture with practical application tools. These will upgrade any leader's skill-set while charting a clear pathway that drives individual safety leadership forward with passion and purpose.

9:45 am

Leadership Development for Front-Line Supervisors in Western Mines: Initial Lessons Learned

L. Guasta; Safety Solutions International, Inc., Parker, CO

Based on Bureau of Labor Statistics, the mining industry is expected to grow and diversify its workforce over the next 10 years due to expanding opportunities for exploration and production, and the retirement of veteran miners. Significant and immediate labor needs will attract younger, inexperienced employees who represent a change in culture and increased risk in the safety and health environment. These challenges present the need for refined training approaches and the capture of veteran worker experience. The University of Texas at Arlington (UTA) and Safety Solutions International, Inc. has developed a NIOSH supported, two-day leadership development course for front-line supervisors in Western mines to address the immediate needs of supervisors facing a new dimension of workers. By incorporating best practice adult learning principles and a systems approach, the course focuses on the fundamental development of leaders in the mining workforce, strengthening existing on-the-job-training (OJT) practices with train-the-trainer (T3) concepts, and enabling the occupational culture to pursue a prevention practice that will move the industry closer to accomplishing “zero”.

10:05 am

16-059

Pseudo Leadership and Safety Culture

T. Camm; MONTANA TECH, Butte, MT

Search Amazon.com using the keyword “leadership,” and you are rewarded with a list of over 144,000 titles. There is no shortage of books and articles, many of them well written, with excellent ideas. So why is there still a constant cry for effective leadership in organizations? Often, the person in charge has personal blinders that prevent them from seeing or understanding how to implement the newest leadership idea or method. Either deliberately or subliminally, there is a disconnect from learning about leadership, and actually modelling and implementing what has been learned. Some current research in neuroscience and, yes, leadership theory can provide insight and tools to address this issue.

10:25 am

16-021

Vision Zero and the Seven Golden Rules – The Global Prevention Strategy of the ISSA for Mining and Beyond

H. Ehnes; Prevention, BG Rohstoffe und chemische Industrie, Langenhagen, Germany

340 million accidents at work happen worldwide every year, only counting those leading to more than four days absence. 360,000 end fatal. Two million people more die every year due to work-related diseases. To sum this up: around 2.4 million people die every year because of work conditions. While mining represents just 1% of employees globally, it represents 8% of all occupational fatalities. What does this mean? It means a tremendous loss of productivity and extremely high costs. It means enormous problems in quality. It means a lack of motivation due to unsafe work conditions. It means a disastrous public image And, most of all, it means human suffering, families losing their loved ones – and their suppliers! We can make mining sustainably safer, but we need a successful strategy to do so. A high potential lies in Vision Zero. Vision Zero is a prevention strategy for a safe future without fatal or serious occupational diseases, work accidents and traffic accidents. Vision Zero's holistic elements cover technology, workplaces, rules, and people as fields of action. By focussing on severe and fatal accidents, its application increases the level of safety and health overall.

Tuesday, February 23 – Morning

ROOM: 131A

Health & Safety: Risk Management Practices to Ensure Worker Safety I

9:00 am

Chairs: J. Burgess, University of Arizona, Tucson, AZ
E. Lutz, The University of Arizona, Tucson, AZ

9:00 am

Introductions

9:05 am

Advancing Safety Management: Are we Learning the Right Lessons

M. Pillay; School of Health Sciences, The University of Newcastle, Callaghan, NSW, Australia

The twenty-first century has seen an accelerating rate of technological advancements, with the mining industry being at the forefront of a number of these initiatives. The improvements in health and safety performance in the industry over the last decade are testimony that these developments are producing some level of tangible gains, at least in some segments of the industry. However, disasters still occur in mining, raising the question of whether any essential learnings from such disasters are informing health and safety risk management practices of the future. This paper, based on an analysis of findings from the Beaconsfield and Pike River Coal Mine Disasters, seeks to explore this very research question. This paper first discusses the above disasters. Next, high-reliability and resilience engineering as developments in organizational health and safety management are introduced, and used to critically analyse the two disasters. The paper concludes with a number of suggestions those charged with improving mining safety may wish to consider in seeking to advance safety management in the industry.

9:25 am

16-122

Improving Fluid Power System Risk Management – Proactively

T. Ley; Chemical Engineering, University of Waterloo, Freelon, ON, Canada
According to brutally honest mining executives “managing risks is job #1 but...money is also important”. When times are tough you feel the need to choose between safety and reliability. Excellence at both provides the best performance. Equipment hydraulic systems operate at extremely high pressures and contain great amounts of energy. Reliability is achieved at least cost by tackling failure signals (like leaks) early. Fluid injection injuries are devastating events; globally under-recognized. Production can be lost along with the worker’s livelihood. Australian miners tackled this issue in 2010 thru better risk management AND FluidSafe™ - a safety-formulated fluorescent dye that proactively improves identification and treatment of injection injuries from hydraulic systems while also reducing fluid use by up to 7%. For miners, reducing fluid power safety and reliability related risks in tandem generates strong economic returns. FluidSafe™ along with disciplined risk management and safety training, lowers costs, increases reliability, improves productivity, lessens environmental mishaps and saves workers.

9:45 am

Risk Management Best Practices to Reduce Injuries and Maximize Economic Benefits in U.S. Mining

S. Griffin; CEP, Assistant Professor, Tucson, AZ

Background RM is a cyclical process of identifying operations or activities that put miners at high risk for injuries, designing controls including engineering changes or standard operating procedures to reduce risks, implementing these controls and evaluating their effectiveness. **Methods** Four companies in the metal, aggregate and coal sectors with RM expertise participated in the study. Retrospective longitudinal analysis of company internal injury and compensation claims data and MSHA injury reports was completed to determine the effectiveness of RM programs. Among RM programs subjectively identified by mine employees as the most effective at reducing injury, costs of program implementation and in injury costs were evaluated, enabling an evaluation of return on investment (ROI). RM best practices were defined as those programs that led to a reduction in injury rates and positive ROI. **Results** Generally, reductions in injuries were observed following implementation of 14 RM programs at our partner mines, and lost-time injury rates were lower at our partner mines than comparison mines. Implementation costs ranged from \$43,000 to \$1.2M, with a positive ROI for several.

10:05 am

Risk Management of DPM: Use of Alternative Fuels

J. Burgess; Zuckerman College of Public Health, University of Arizona, Tucson, AZ

Background: Diesel Particulate Matter (DPM) is a known carcinogen and exposure also results in increased respiratory and cardiovascular morbidity. Alternative fuels have been employed to reduce miner exposure to DPM, but no previous studies have evaluated whether these interventions also reduce acute health effects. This study investigated exposures and acute health effects associated with exposures to diesel and 75% biodiesel/25% diesel (B75) blend fuel emissions. **Methods:** Exposure and health endpoints before and after exposures to diesel and B75 emissions were evaluated in an underground setting. **Results:** B75 reduced respirable diesel particulate matter (rDPM) by 20%. Lung function declined significantly following exposure to diesel emissions, and to a greater extent than with B75. Lung inflammatory cells and sputum and plasma inflammatory mediators increased with both exposures. Urinary 8-OHdG, a marker of oxidative stress, was significantly increased following diesel exposure. **Conclusions:** Compared with diesel, B75 use lowered rDPM exposure and some associated acute health effects. However, lung and systemic inflammation were not reduced compared with diesel use.

Tuesday, February 23 – Morning

ROOM: 221A

9:00 am

Industrial Minerals & Aggregates: Aggregate Operational Efficiencies

Chairs: K. Kosloski, Luck Stone, Richmond, VA

A. Parr, Oldcastle Materials, West Kingston, RI

9:00 am

Introductions

A Short Review of Blending Optimization Methods for Concrete Aggregates

D. Adiguzel, A. Bascetin and S. Tuylu; Istanbul University, Istanbul, Turkey

Optimization techniques are successfully used in many different fields such as engineering, physics, economy, and politics in order to enhance the performance of the systems. In concrete technology, Aggregates are prepared by mixing the water and cement in proportional quantities. In order to obtain desired quality control parameters, the determination of the ingredients ratios is one of the important problem for the optimization. Additionally, in the quarries where the aggregate quality constantly changes, blending optimization must be made to obtain a sustainable aggregate quality. Nowadays, in the solution of the blending optimization, various optimization techniques are being used such as linear programming, nonlinear programming, and genetic algorithm. In this study, optimization techniques especially used for concrete aggregates blending have been summarized, and the advantages and disadvantages of these techniques have been introduced. This study showed that linear programming, which is easy and which includes many aggregate properties, can not be used in terms of some aggregate properties. Therefore techniques such as nonlinear programming or genetic algorithm must be used.

9:25 am

Optimizing Throughput: How do Plant Production & Sales Balance, Demand Forecast, Performance Management, Performance Metrics & Trends, and AggFlow modeling drive Aggregate Best Performance? | Case Study – Oldcastle Materials

W. Aspinall; Oldcastle Materials, Wharton, NJ

There are a few critical components in optimizing throughput of the plant for the business. The first goal is to balance plant production to match sales. The second is to forecast sales demand by product that looks into the future. It is necessary to have a performance management culture that holds everyone accountable for their business results. Areas of improvement will become more noticeable as performance metrics and trends are analyzed. These performance metrics and trends are critical to the continuous improvement of the plant. Computer based modeling such as Aggflow can be used to optimize critical product yields, which in turn will help with balancing production with sales.

9:45 am

Environmental Blasting Impact – Addressing Perception

M. Osborne; Southeast LLC, Austin Powder Company, Greensboro, NC

Many quarrying owners and operators receive regular complaints regarding the blast impact of vibration and overpressure, despite being 100% compliant with the RI 8507 vibration Z curve and with the overpressure guidelines of RI 8485. Some simple tools exist to help such operations address impacts by changing the focus from compliance to personal perception, and these tools point to changes that can be made to blast designs and initiation timing, which can frequently be made at zero cost. This paper presents some of those tools along with actual field results to determine the extent to which impact levels and personal perception can be reduced. These tools are built to be used by Design Engineers, Blasters, and Shot Firers. They are simple and easy to use without a great deal of “difficult to get” input. It does still require a person that is familiar with blast design as it applies to layout, digital delays, and hole loads applicable to bench blasting. Lower impact levels mean greater community acceptance, improved sustainability of the extraction industry in urban environments, and a perception of a “green” industry aware of a delicate environmental balance with its neighbors.

10:05 am

Vertical Shaft Impact Shaping Advances

B. Junior; Process Management, Luck Stone, Richmond, VA

Program will focus on methods and configurations of Vertical Shaft Impactors and the use of them for shaping top size material without excessive increase of fines. Focus will be on machine types, internal configurations, and speeds. Supporting data will include case studies of recycled base top size materials ranging from 1 ½" to ¼" and typical compression crusher discharge ranging from 2" to #30 mesh.

10:25 am

Myths and Science in Conveyor Belt Cleaning

A. Marti¹ and D. Marshall²; ¹Corporate Marketing, Martin Engineering, Neponset, IL and ²Project Engineer, Martin Engineering, Neponset, IL

Fugitive material has been an area of concern since dry bulk material was first transported. These concerns must be addressed by any facility transporting dry bulk solids. Belt Cleaners are the principal means used to combat these issues. This paper addresses the theory and need for belt cleaners. It addresses the need, the principal of operation, and the material specific options available in the arena of belt cleaners. This is an informational paper that addresses each of these topics in an objective and thorough manner. All fact presented in this paper are based on years of experience in the bulk solids industry. By the conclusion of this paper, the audience will have a better understanding of the methodology and the available technologies for removing unwanted material from the surface of a conveyor belt.

10:45 am

Optimizing Truck Selection Using Discrete Event Simulation: A Case Study of P.J. Keating Co. Lunenburg, MA Quarry

R. Gagliano¹ and K. Awuah-Offe²; ¹Tilcon Connecticut, New Britain, CT and ²Missouri University of Science & Technology, Rolla, MO

Longer haul distances can reduce productivity of truck haulage operations as cycle times increase. Larger nominal payloads can be incorporated to remedy this. Proper sizing of equipment is critical to transport material at the lowest possible unit cost. Truck sizing should take into consideration other portions of the process so that bottlenecks are not introduced with the change in truck sizes. Computer simulation (like discrete event simulation) can assist in examining changes in operations at a low cost without any physical changes. This paper presents the use of Arena® to select optimal truck sizes at the P. J. Keating Co. Lunenburg MA Quarry Using Arena® simulation software while considering the impact of truck sizes on primary bin and feeder. A model of the mine's truck-shovel system was built and validated with real production data. The model is used to conduct simulation experiments to evaluate various production scenarios. The results show that operating four 75-ton haul trucks would be the best option as it meets the processing plant's productivity requirements with low wait times at the primary.

11:05 am

Evaluating Crusher Results Using Digital Photo Gradation Analysis

A. Bessen; Quarry Vision, Lexington, KY

Examining output gradation results substantially enhances evaluation of crusher performance variables including closed side setting, liner configuration, feed distribution and capacity as well as key product and by-product yield. Using photo gradation analysis, multiple samples can be acquired using almost any digital video camera, substantially enhancing data validity without stopping production.

Tuesday, February 23 – Morning

ROOM: 221B

9:00 am

Industrial Minerals & Aggregates: Innovation in Industrial Minerals I

Chairs: B. Li, Michigan Technological University, Houghton, MI
P. Macy, Kemira, Atlanta, GA

9:00 am

Introductions

9:05 am

Modification of Vermiculite Interlayer Regions

B. Li¹, M. Wang² and J. Wang³; ¹Michigan Technological University, Houghton, MI; ²Central South University, Changsha, China and ³Kunming Metallurgical Research Institute, Kunming, China

Vermiculite is a layer-structured natural mineral with potentially extensive applications. Recently, it has been used for synthesis of nanoscale composite materials by cation exchange. Pre-modification of vermiculite will improve the process of the composite materials. In this study, sodium and magnesium were employed to modify the interlayer regions of vermiculite. The results and mechanisms were discussed.

9:25 am

16-001

Feldspar Beneficiation: Tailoring Reagents to the Mineral

L. Moore, R. Xiong, A. Gorken and G. Wang; Mining, ArrMaz, Mulberry, FL

Feldspar may represent 60% of the earth's crust, but the mineral does not exist in a pure state. It is generally associated with quartz, iron containing minerals such as mica, and titanium containing minerals such as rutile. Feldspar itself can even exist in different lattices from those containing sodium to various divalent ions. As such, its beneficiation has become a process that is quite complicated, when comparing to the beneficiation of other minerals. It is this complexity that has made the success of feldspar beneficiation become dependent on tailor made reagents to successfully yield the industry specified feldspar products. This paper reviews the mineralogical variations found from two feldspar mines and the development of collectors to specifically target an Fe+Ti concentration of < 0.05%, while maximizing feldspar recovery.

9:45 am

16-016

A Breakthrough in the Mining Sector: Pre-concentration by Automatic Sorting.

C. Petter¹, R. Paranhos² and M. Veras¹; ¹UFRGS, Porto Alegre, Brazil and ²Mining Department, UNIPamPA, Caçapava, Brazil

The major challenges of the current mining are the energetic optimization, the lowest water consumption and minimizing environmental impact. One technique that eliminates much of the waste avoiding milling sterile, operating without water and to decrease the generation of waste at the end of the process, must be considered a major innovation. One of the most important developments in these past 10 years in the mining industry was expanding the use of high-tech sensors aimed at pre-concentration of ore. Among the mining areas where this type of technology is booming is the industrial minerals. The most common sensors are color sensors with Charge – Coupled Devices (CCD cameras) allowing through

the RGB colorimetric system, the separation of minerals with different hues, and in many cases, a difference in brightness. More recently, the development of the use of dual energy X-ray transmission (DE-XRT) Dual Zone allowed the separation by atomic density of the mineral constituents of the rock. This paper presents a review of these two techniques (CCD and DE – XRT) as well some examples showing the use of both for automatic sorting.

10:05 am

The Influence of System Variables on the Structure of Flocculated Kaolinite Particles

S. Sharma, C. Lin and J. Miller; Metallurgical Engineering, University of Utah, Salt Lake City, UT

The extent of interaction of kaolinite particles and their aggregation is revealed from size analysis which shows the transition from ~500 nm for primary kaolinite particles, to ~1-2 microns for self- aggregated particle clusters, to ~1 mm for polymer induced particle flocs. In the current study, we have tried to characterize the aggregates formed on addition of polymeric flocculants to kaolinite suspensions. The flocs were analyzed for their size, shape and microstructure using SEM, PVM, PCS and X-ray microtomography. The influence of cationic and anionic polymers on floc characteristics and structure was studied at different conditions of pH, ionic strength and polymer dosage.

10:25 am

Prospecting and Exploration of Hydraulic Fracturing Sand Sites

K. Anderson; Kraemer Mining & Materials Inc, Burnsville, MN

Prospecting for hydraulic fracturing sand sites has proliferated rapidly with the recent growth of the hydraulic fracturing industry. Viable deposits of hydraulic fracturing sand must be of pure quartz, minimally cemented and be highly rounded and spherical. Significant exploration and testing is required to insure that the deposits on a target site will meet all ISO specifications and be usable. Common exploration techniques include local geologic analysis of outcrops, structural analysis, microscope review and laboratory testing followed by air rotary and rota-sonic drilling. Economically viable sites must contain sand that meets all ISO requirements, are efficient to mine and process and be located at, or reasonably transport to, both a wet and dry plant with rail transportation. An overview of exploration techniques and specification issues as well as general economic viability assessments will be discussed from the presenters experience with the operation/development of 5 industrial sand mines and numerous exploration and drilling projects.

10:45 am

Aggregate Materials Response to High Strain Rate Testing

S. Vitton; Civil & Environmental Engineering, Michigan Technological University, Houghton, MI

High strain rate research was developed in the early 1900's to study the behavior of impact loading on metals by John Hopkinson and his son Bertram. In the 1940's Kolsky modified the device to allow for the determination of the dynamic stress-strain curve for the tested materials. The device is generally known today as a Split Hopkinson Pressure Bar (SHPB). High strain rate research using the SHPB was extended to brittle materials in the 1970's. In the past fifteen years, a series of research projects at Michigan Tech investigated the response of high strain rate testing on coarse aggregates used in concrete highways, which included igneous, carbonate and blast furnace slag aggregates. The primary purpose of this research was to investigate high strain rate behavior of the concrete's course

aggregate in transferring shear loads across concrete joints. Later research investigated the high strain rate response of wood, specifically oak and pine, to better understand the compliance of the SHPB to low modulus materials. The presentation will summarize the results of this research and its application to aggregates in the areas such as crushing, size distribution and potentially shape.

11:05 am

Characristics of Zonal Emerald from Malipo,Yunnan Province, China

X. Yu; School of Gemology, China University of Geosciences, Beijing, China

Emerald is the green gem variety of beryl. The color of emerald is due to trace amounts of chromium and/or vanadium replacing aluminum at the Y site; In most cases the Cr contents is much greater than that of V. Preliminary geological work on samples from Saxi mine of Malipo, Yunnan province indicate that emerald occurs in pegmatite and quartz veins that intrude deformed Proterozoic biotite-muscovite granofels and schist. The emerald-bearing vein minerals include quartz, albite, K-feldspar, tourmaline, scheelite, arsenopyrite, calcite, fluorite, biotite and muscovite. Characteristics of zonal emerald have been studied by using petrography, CL, LA-ICP-MS and EMPA. In this paper, the result reveals that the green color is caused by Cr³⁺, V³⁺. But the V contents (vary 0.12%~0.99%) is always greater than that of Cr (varies 0.01%~0.11%). In most cases trace element of zonal emerald also contain high vanadium and low chromium. But Cr content is higher than V at the edge of the sample, which causes the bright green color. Emerald is associated with V-rich muscovite and V-rich tourmaline. It suggests that the trace element not only affects the color but also should reflect the model of formation.

11:25 am

Data Treatment for Real Time Process Control

A. Baryshnikov; Laser Distance Spectrometry Ltd, Petach-Tikva, Israel

The crucial issue in data treatment is how fast their results may be implemented. "Uncertainty principle" of data treatment states that the more precise is the measurement, the bigger time of its implementation in process improvement. To find the golden mean is imperative. Rapid and automatic online process analysis, while less accurate than the laboratory one, enable industrial minerals producers not only to promptly detect changes in incoming materials, but take immediate appropriate action in the process streams. Our laser based standoff analyzers, using LIBS, Raman, Luminescence, are capable to work from 25-0.1 m distances, do not contain radioactive sources, and accurate enough for process control sake. All major and minor elements may be analyzed by LIBS, while combining it with Raman and Luminescence enable in certain cases to detect the minerals also. The connection of the analyzer with sorting or dosing mechanism allows to intervene in technological process in tens of seconds to several minutes time interval. Today Online Analyzers are implemented in phosphates, fertilizers, iron and refractory making industries, but any other branch is our potential customer.

Tuesday, February 23 – Morning

ROOM: 221C

9:00 am

Industrial Minerals & Aggregates: Innovations in Minerals for Agriculture

Chair: L. Moore, ArrMaz, Mulberry, FL

9:00 am

Introductions

9:05 am

Application of Classification and Fluidized-Bed Flotation at PCS Aurora

G. Piegols; Technical Services, PotashCorp, Washington, NC

Classification and coarse flotation circuits were added to the phosphate beneficiation plant at PotashCorp, Phosphate Division's, Aurora mine. The plant flow sheet was designed to treat 2,020 t/h (2,220 stph) of phosphate matrix ore and yielded an overall P_2O_5 recovery of 79% using conventional, mechanical flotation cells. Size-by-size results indicated that the recovery of the coarse component (+0.425 mm) was very poor. To improve the coarse particle recovery, a classification circuit was added to the plant which created both a fine and coarse feed. While the fine feed is now treated in the existing conventional cells, the coarse feed was routed to fluidized-bed flotation units (i.e., HydroFloat Separators). Laboratory- and pilot-scale tests had been carried out to determine the benefits of this approach which included higher recovery, reduced reagent consumption, and attractive return on investment. Current plant data indicate that the split-feed flotation circuit has increased recovery and provides results consistent with the earlier test work. In addition, this split feed flotation circuit provides added flexibility for plant personnel to meet various production requirements.

9:25 am

Steam Injection in Phosphate Fluid Bed Calciners

G. Piegols; Technical Services, PotashCorp, Washington, NC

PotashCorp's North Carolina phosphate ore deposit is buried in a reducing or septic zone. The phosphate ore is calcined to burn off organic materials adhering to rock. Calcination eliminates the need of defoamer in the phosphoric acid plant. The acid produced is a clean green acid. The Dorr Oliver Calciners are configured to burn either pulverized bituminous coal or #6 fuel oil with compressed air used to atomize the oil. In a major innovation, PotashCorp replaced the high price compressed air with low cost steam produced as a byproduct of sulfuric acid generation. Steam injection improves oil dispersion and combustion while reducing demand for plant air. Steam injection tempers hot spots in the calciners, significantly reducing scale build-up.

ROOM: 16-007

9:45 am

Blending Consistent and Predictable Feed to Achieve Improved Operational Efficiency with the Use of Nuclear Elemental Analyzers in the Phosphate Production Process

A. Montera; SABIA, Inc., San Diego, CA

A phosphate beneficiation plant in Utah is using isotope-based Prompt Gamma Neutron Activation (PGNA) technology to analyze the entire slurry streams of the incoming feed and final product in order to adjust the floatation circuits in near real time and optimize the plant output. A phosphate mining operation in Florida is using the same technology on a conveyor belt to by-pass low value feed before the storage silos. By analyzing the entire stream in both processes, the plants have gained greatly improved visibility/control and are able to reduce product variability for improved profitability and product quality. This paper takes a look at both the economics as well as application details and the difference this technology provides the phosphate operations.

10:05 am

Particle Shape Effect of Silica on Initial Attachment

G. Allan, Y. Han and H. Kim; Chonbuk National University, Jeonju, Korea (the Republic of)

Model silica rodlike and sphere particles were fabricated and their initial attachment in silica surfaces were measured using a QCM-D over a wide range of ionic strength. The classic DLVO profile was calculated for each condition in order to predict the initial attachment results. Three different approaches were used to calculate the DLVO; the conventional DLVO, the surface element integration (SEI) DLVO and the SEI DLVO for a rod-shaped particle. When an equivalent sphere was assumed, the prediction of the initial attachment of rodlike particles over a certain range of IS in NaCl and CaCl_2 failed. In NaCl, the initial attachment of the spheres was successfully predicted with the conventional DLVO or SEI DLVO. However, the SEI for an equivalent rod was necessary in order to correctly predict the initial attachment of the rods in NaCl and CaCl_2 . It was proved that the conventional DLVO failed to model the initial attachment of silica rodlike particles, therefore, the real particle shape and orientation must be considered for future modeling of particle attachment.

10:25 am

16-065

Effect of Clay Minerals on The Flotation of Malachite

S. Park, P. Seo, J. Choi, G. Hwang and H. Kim; Mineral Resources and Energy Engineering, Chonbuk National University, Jeonju, Korea (the Republic of)

Abstract In the mineral processing, clay minerals have negative effects on the flotation of valuable minerals. In this study, we investigated how the flotation recovery of malachite ($\text{CuCO}_3 \cdot \text{Cu}(\text{OH})_2$) is affected by presence of the clay minerals in the fundamental aspects. Flotation experiments were conducted by using Na_2S and PAX (potassium amyl xanthate), and the flotation recovery of malachite was compared between the cases in the presence and absence of clay minerals. The results showed that flotation recovery was greater in the absence of clay minerals than in the presence of clay mineral under same conditions applied. The enhanced Cu recovery in the absence of clay minerals was attributed to the increased amount of adsorbed Na_2S and PAX on the surface of malachite. Mechanistic discussion on this observation will be provided in this presentation.

10:45 am

16-024

Cleaner Tails Recycling to Minimize Phosphate Loss

A. Fallaw, L. Moore, G. Wang, Z. Gu, R. Xiong and S. Dobson; ArrMaz, Mulberry, FL

The decline of high grade ores has become an increasing problem in the global mining industry. Techniques and chemistries continue to change to meet market demand to maintain product quality. Even with new technologies the balance of recovery and grade is still a significant challenge. The most common beneficiation technique for phosphate ores is the Crago Process. A fatty acid collector is used to float the phosphate from the gangue materials; acid scrubbed to remove the fatty acid collector and prepare the ore for amine flotation where silica is selectively removed to obtain final product quality. Inefficiencies in the acid scrub and other interferences cause phosphate losses in the amine flotation step to bring the overall phosphate recovery down as much as 18%. Some phosphate producers have made attempts to recapture the phosphate lost in the amine flotation by piping the amine flotation tails to a point in the beginning of the beneficiation process, known as amine tail recycling. This paper will focus on the theory of amine tail recycling and the best methods to ensure the highest recovery of the phosphate lost in the amine flotation step.

Tuesday, February 23 – Morning

ROOM: 131C

9:00 am

International I

Chair: M. Gavrilovic, GR Engineering Services, Denver, CO

9:00 am

Introductions

9:05 am

Tailings Storage Facility Design: Preventing the next Mount Polley TSF Breach

D. van Zyl¹ and J. Easton²; ¹Mining, University of British Columbia, Vancouver, BC, Canada and ²Process Engineering, WesTech Engineering, Inc., Salt Lake City, UT

In the wake of the Mount Polley Tailings Storage Facility (TSF) breach, our industry will be called to find Best Available Technology (BAT) solutions for TSF design in many parts of the world. This is a daunting task because BAT varies from one location to another. In this paper we attempt to show a path to determine site specific BAT solutions. This requires an approach that covers site water management, tailings treatment, material transport and TSF design. Careful consideration of the constraints, interactions and costs of technology choices can produce a site specific BAT solution every time.

9:25 am

16-014

Artisanal Miners and Their Social and Environmental Situation in Colombia

O. Restrepo Baena; Materials and Minerals, Universidad Nacional de Colombia, Medellin, Antioquia, Colombia

Antioquia region, in Colombia, is considered one of the areas with the highest mercury contamination in the world due to its use in gold recovery through artisanal mining, emissions to the environment between 100 and 150 tons of mercury are estimated by year. Therefore it became necessary to develop a project in which it was proposed aim to empower traditional artisanal mining community, or in different areas, such as gold mining in the region of Antioquia, in the implementation of safe mining practices and environmentally sustainable, from the introduction of clean technologies, in order to prevent or mitigate the impacts generated by traditional mining on the environment and the communities involved. In order to achieve this training to traditional mining community developed and technical visits to artisanal mining were performed in order to optimize operating processes and promote safe mining practices. In the project more than 1500 artisanal miners were trained. Finally it was concluded that permanent support professional by the respective authorities (mining and environmental) and academic entities related to the work area can carry out responsible and sustainable mining.

9:45 am

16-039

Small scale gemstone mining in Sri Lanka

J. Weyer; TU Bergakademie Freiberg, Freiberg, Saxony, Germany

Gemologists differ between diamonds and colored stones. Most of the diamonds are mined with modern mining methods and huge modern equipment. But the majority of colored stones – that are all other gemstones – are artisanal mining op-

erations. Sri Lanka is a good example for such small scale gemstone mining. Similar operations one can find throughout the world. Gemstones are mines in surface operations, with shafts in underground operations and with river dredging operations. The gemstone bearing gravel is then washed in a basket and valuable gemstones are picked out by hand. Environmental protection is an issue in Sri Lanka and so bigger surface operations will not be allowed. The wealth from the gemstones should stay in the country. Therefore an export of uncut stones is not allowed or at least needs a special permission. Gemstones are behind textiles and tea the most important export source in Sri Lanka. The export volume is steadily increasing. At the turn of the century 650 000 persons worked in the gemstone industry. A lot of pictures will explain the mining technology and basics of the cutting process.

10:05 am

MINATURA 2020 – Mineral Resources for the European Union

*J. Cowley; Mineral & Resource Planning Associates Ltd, Blandford Forum,
United Kingdom*

MINATURA 2020 is an EU project with the objective of enabling the development and protection of the mineral resources of Europe, through a policy and land use framework common to all member states. The project will address the greater exploitation of the indigenous mineral resources of Europe and the prevention of sterilisation of those resources by development or environmental constraints, at both EU and member state level. Greater access to the mineral resources of Europe is seen as essential by the European Commission to support existing and new industrial opportunities. The project team consists of 24 partners from 16 EU member states. John is the UK partner on mineral development opportunities and he will describe the project background, draw out some of the contentious issues and consider the way forward.

10:25 am

Criteria for Tailings Dams Location in the South American-Pacific Region

*G. Barreda¹ and M. Villavisencio²; ¹Civil, CIP 56910, Lima, Lima, Peru and
²Lima, SME Member 4104221, Lima, Lima, Peru*

The extraction and processing of minerals in the South American Pacific Region has a long history, so it is not surprising that these countries concentrate some of the larger mining operations in South America. However, mining operations, in particular tailings dams, are associated not only with challenges related to site regional constraints such as diversity of topographical conditions, including high and steep mountainous terrain, diversity of weather and water management; but also to environmental and social matters related to the proximity of communities that generate the necessity to outline a clear strategy for the location of tailings dams in the region. The intention of this paper is to describe the critical points to consider for the location of tailings dams in the South American-Pacific Region, with a special emphasis on Perú. The critical points include not only technical and economic aspects, which are extensively discussed in international literature; but also a discussion on the environmental and social aspects that have impact on technical decisions for the location of the structure, such as ownership of the land, acquisition of the land for the facility and others.

10:45 am

The Cornish Mining Legacy: Technology, Chorals, Pasties and Wrestling

C. Anderson; Extractive Metallurgy, Colorado School of Mines, Golden, CO

When it comes to underground mining, the miners of Cornwall dominated the world with their skills. As they roamed the world from mining camp to mining camp, they spread their technology and culture as well. This presentation will provide a snapshot of the Cornish miners based on the recent venture of Dr. Corby Anderson to Cornwall.

The Sangan Iron Ore Mines: A Role Model for Sustainable Mining in Iran

J. Kretschmann; TFH Georg Agricola University, Bochum, Germany

Abstract: The Sangan iron-ore mines (SIOM) project in Iran is located in a remote area, near the Afghanistan border. The deposit of SIOM is containing a geological resource of 1.2 billion tons of mostly magnetite with a Fe grade ranging from 27 to 61 %. The Iranian government plans a stepwise development of SIOM in cooperation with private companies to satisfy the growing demand of the Iranian steel industry. Sustainable development (SD) is an influential ethical concept in mining all around the world. However, a successful realization of a SD is not possible without a foundation on the core values and regarding the specific circumstances of the individual mining country. This paper introduces SIOM and describes SD activities undertaken during its development. From the early stages these activities have been realized to secure the acceptance of the stakeholders in the region. To evaluate their effects fifteen indicators could be filtered as the ones with the highest priority for the stakeholders. Moreover Islamic values and Iranian regulations and their influences on SIOM have been analyzed. **Keywords:** Iran, Sustainable Mining, SIOM, Evaluation, Islamic Values.

Tuesday, February 23 – Morning

ROOM: 122C

9:00 am

Mineral Valuation I: Case Studies and Methodologies

Chairs: J. Manes, Mineral Valuation Specialists, Phoenix, AZ
M. Shumway, The Ohio State University, Worthington, OH

9:00 am

Introductions

9:05 am

Case Study: Quarry Impact on Ranch Land Market Value

T. Grote; IIMA, Austin, TX

A Comal County, Texas ranch is impacted by an intermittently operating limestone quarry. The market value appraisal considered: Limestone quality under county and TxDOT specifications Client's unwillingness to provide income-expense data and its impact on appraisal methodology Physical impact (quarry expansion or closure) of quarry to the property Economic impact on market value estimate in light of grazing and hunting income, and recreational enjoyment. For many mineral appraisers, an operating quarry is commonly assumed to continue unless the end-of-mine is near. In this case study, the continued operation of the quarry may not be a reasonable assumption.

9:25 am

Simplified Guide for Mineral Appraisers to Ore Reserve and Mineral Resource Classifications

R. Cameron; Robert Cameron Consulting, Black Hawk, CO

When conducting an appraisal or issuing an opinion of value, it is important to properly identify or verify the resource or reserve classification of the material within the framework of the valuation code being utilized. This paper will present a simple guide that can be used to help an appraiser to properly understand and evaluate the reported resource or reserve classification assumptions. Although the various resource and reserve reporting standards around the world are constantly

changing, most modifications in the last few years are refinements or tightening of definitions surround the basic confidence of the estimate. An understanding of the broad principles discussed will help the appraiser to better set a value on the mineralization being reviewed.

9:45 am

Conservation Easements and the Income

Approach to Value: Are You Kidding Me?

A. Stagg; Stagg Resource Consultants, Inc., Cross Lanes, WV

The use of conservation easements to create tax credits results in some interesting (i.e., creative) appraisals when the property involved allegedly has mineral development potential. Nowhere is this more evident than in the use of the Income Approach to Value for properties containing low-value commodities such as stone and sand and gravel for which development is not on anyone's planning horizon and in markets in which there is little or no demand for additional production. The appropriate application of the Income Approach to Value and examples from the author's experience of its misapplication in this type of appraisal are reviewed and the ultimate test of an opinion of market value is proffered.

10:05 am

Accruing for Mine Reclamation and Post-Reclamation Care Expenses: A DNPV Perspective

D. Espinoza; Geosyntec Consultants, Potomac, MD

Different from other business activities, mining is an activity that generates revenues during a finite period whereas its liabilities can last a very long time (in many cases in perpetuity). However, valuation of mining investment opportunities typically focuses on the revenue side (i.e., mineral grade, commodity prices) with less emphasis to expenditures associated with mine reclamation and the care that follows. The financial analysis of long-lived liabilities that are far in the future is particularly difficult, if not impossible, with standard valuation techniques such as Net Present Value along with risk adjusted discount rates. The problem stems from the widespread practice of increasing the discount rate to account for the riskiness of the project which reduces the effect of these liabilities. The Decoupled Net Present Value (DNPV) concept, developed for valuation of infrastructure investments, is introduced. DNPV is conceptually similar to Real Options but simpler to apply. DNPV decouples risks from the time value of money and treats risks as a real cost to the project. Revenue risks reduces the value of revenue whereas expense risks increases the overall expenses.

10:25 am

Appraiser Liability: A Case Study

K. Lang; Lang & Klain, P.C., Scottsdale, AZ

All appraisers face the threat of litigation stemming from a variety of circumstances. For instance, appraisers may be sued over disagreements arising from their valuations or the scope of the valuation. Additionally, appraisers may be sued because they overlooked or omitted items from a valuation. Given this reality, this paper will focus primarily on the main legal claims that may be brought against appraisers. These claims include, but are not limited to, negligence (negligent appraisals) and negligent misrepresentation. Through the examination of court decisions in this area, this paper will outline the legal elements that comprise each of these claims, and highlight and analyze the common factual scenarios that may give rise to legal action. Additionally, it will discuss when appraisers may be found liable to third parties for their valuations.

10:45 am

Capital Cost Overruns in the Mining Industry — Mistakes, Misjudgements or ?

A. Kuestermeyer; Tetra Tech Inc., Golden, CO

Escalating Capital Costs have been the runaway factor in the mining industry, plaguing both the international financial community and mining companies.

Traditionally associated with the junior market sector, now even the major mining companies are experiencing uncontrollable capital costs. This presentation examines the reasons behind these excessive cost overruns, suggesting solutions to better manage Capital Costs in the construction and development of new mines.

Tuesday, February 23 – Morning

ROOM: 128A

9:00 am

Mining & Exploration: Geology: Continuous Improvement through Geology, Geomet, Reconciliation

Chair: L. Smith, amEC E and
C. Services Inc, Phoenix, AZ

9:00 am

Introductions

9:05 am

Reducing Variance, Optimizing Mine Geology and Process Efficiency in Copper & Gold Operations with Ore Profiling and Integrated Lab Automation

W. Baum; Ore & Plant Mineralogy LLC, San Diego, CA

Ore characterization and process mineralogy use for Geo-Metallurgy are highlighted. Integrated Mineralogy Labs are essential in supporting mine geology and production. Geo-Metallurgy programs must include robust sampling and best-practice sample preparation. Ore profiling, modeling, and process diagnostics reduce ore routing errors, improve processing and plant trouble-shooting. Often reduced commissioning times have not been achieved partly due to lack of Geo-Metallurgy programs. Shortened start/ramp-up can represent savings close or equivalent to the capital cost of equipment. Future improvements for Geo-Metallurgy are foreseeable with on-line/down-hole mineralogy and chemistry. As such, ore characterization represents the best Risk Reduction in the mining tool box.

9:25 am

Utilizing the Geological Database and Resource Estimation Methods to Improve Metallurgical Models

G. Seibel; Amec Foster Wheeler, Divide, CO

Mineral resource models are usually estimated using an extensive geological database that is representative of the entire orebody. Metallurgical models on the other hand, are generally based on a few samples collected locally that are judged to be “representative” of the entire orebody. Although the metallurgical samples are analyzed in detail, interpolating these results into the resource model so all the pertinent information is representative of the entire deposit can be difficult and subjective. Metallurgical information is also available in the geological database that is commonly overlooked. Although this information is not as detailed as the metallurgical tests, the amount of data available is usually several orders of

magnitude larger and more representative of the orebody. This paper will give an overview of what data is commonly available in the geological databases and how that data can be estimated into the resource model. Utilization of this information is becoming more crucial as reporting guidelines now recommend that authors comment if the metallurgical data is understood and representative enough to support the mineral reserves.

9:45 am

Is it Actually Working? Case Studies in Geometallurgy

S. Leichter; Stacey Leichter Consulting LLC, Woodland Park, CO

Geometallurgy is a “buzz” word that has been used everywhere. Geometallurgy is a discipline that uses information from the different departments of the mine site, such as: exploration, geotechnical, mine engineering, ore control, comminution, processing, environmental, and management. Collaborating with all of these diverse departments, data is extracted from databases from each of their own testwork. This allows for the building of a base geometallurgical model. After seeing the results of the base model, the mine site or department allow for further geometallurgical specific testwork. This specific geometallurgical testwork is not too much different than from testwork done for other specific departments. All of the testwork and modelling identifies variability, mineralogically based, in areas like hardness, detrimental and identifier minerals for processing and recovery, geotechnical issues, and environmental issues, such as sulfides. Various mine sites use it and are found worldwide. By looking at how each different deposit approached Geometallurgy and the variability problems, it should be evident if Geometallurgy was actually beneficial to them.

10:05 am

The Role of Mine Geology for Improvement of Mineral Resource Estimates

R. Preece; Richard Preece Services LLC, Tucson, AZ

Exclusive of exploration, the major purpose of the geological science in the mining industry is to acquire and interpret data for estimating the spatial distribution of key orebody characteristics. A common organizational structure consists of a centralized team to support the long-term planning process and separate operational teams who focus on day-to-day ore body management. Improvements in the resource estimate at both scales are achieved by testing a given resource interpretation against independent data and interpretations, propose reasons for their differences, and implement actions to reconcile those differences. An effective improvement process must include aligned views by the mineral resource and mine geology teams on the geological framework, the key features selected for characterization, and criteria for operational decisions. Organizational structure can interrupt the reconciliation process by allowing independent teams to create multiple versions of the orebody as data and interpretation diverge. Maintaining parallel views of the deposit means that neither will improve over time. Methods to manage the risk of an ineffective improvement process will be discussed.

10:25 am

Using MineSight's Implicit Modeler to Create Short Range Geologic Model at FMI's Tenke Fungurume Mine, DRC

E. Orbock¹, R. Owen² and J. Kabulo³; ¹Mining & Metals Consulting, Amec Foster Wheeler, Reno, NV; ²Mine Geology, Tenke Fungurume Mining, Tenke Fungurume, Congo (the Democratic Republic of the) and ³Mine Geology, Tenke Fungurume Mining, Tenke Fungurume, Congo (the Democratic Republic of the)

At FMI's Tenke Fungurume Mine, new geological information is generated daily through pit mapping and logging of blastholes and/or trenches. Short range stratigraphy and grade shell models are continuously updated from this data. Timely and accurate modeling of stratigraphy widths and volumes are critical as

a large majority of the copper and cobalt metals are contained in two of the seven stratigraphy units that make up The Mine Series, the SDB and RSF. Updating short range geologic models using traditional cross sections and bench plans to create wireframe solids consumes a considerable amount of time. Recent development of new mine software that uses mathematical algorithms allows geologists to quickly construct accurate geologic contact surfaces directly from geologic data. Geologic surfaces are used to cut structural blocks to create stratigraphic solids which are then used to code stratigraphy to the block model. Copper and cobalt grades are interpolated into the short range block model using a one to one stratigraphy match between the mine blocks and blasthole assays.

10:45 am

Optimum Dig Line Design for Open Pit Grade Control

E. Isaaks; Earth Sciences, Isaaks & Co., Emerald Hills, CA

Open pit grade control is a series of tasks beginning with blast design and drill, followed by the sampling and laboratory analysis of drill cuttings, the estimation of block grades, and finally dig line design. As the name suggests “grade control” is critical to ensuring mined material is sent to the correct destination. However, a number of challenges bedevil the various tasks. Numerous papers have been written on the problems of blast hole sampling. In fact, careers have been made out of solving blast hole sampling and laboratory problems. Books have been written on how to best estimate ore control block grades. But relatively little attention has been paid to dig line design. Indeed, manual contouring of ore control block grades and/or sample assays appears to be the industry standard. It's very easy to show that a smart computer program designed to optimize dig line design will generally increase net revenue over manual designs by 2% to 7%. This is accomplished by minimizing the number of blocks sent to the wrong destination. An algorithm for the design of optimum dig lines constrained by a minimum mining width is presented together with examples from current mine operations.

11:05 am

Benefits from geological consistency throughout the entire life of mine

M. Evans; Research and Development, Endevea, Phoenix, AZ

Mining activities invest significantly in drilling, analysing, logging and photographing drillhole core. Unfortunately, drillhole core degrades with time, is bulky to manage and is expensive to store long term. Due to these issues, core photographs are usually the only reliable long term record of the geology supporting a mine's resource. Most operations understand the value of these photographs but generally only view them as an historical record. The authors suggest that in reality, they contain significant untapped value. Since the photographs are a point-in-time reference, day-to-day mining activities can use them to ensure geological consistency throughout the entire life of mine. Consistency assists predictability in planning and scheduling. This paper will describe these benefits and how to introduce them into an operating mine.

Tuesday, February 23 – Morning

ROOM: 128B

9:00 am

Mining & Exploration: Geology: Gold, Nevada, and Rare Metals

Chair: M. Barton, University of Arizona, Tucson, AZ

9:00 am

Introductions

9:05 am

16-004

Vanadium: Trends in Exploration, Markets and Future Demands

T. Hammond; Hammond Swayne LLC, San Manuel, AZ

The recent drop in iron ore prices has claimed an unwitting casualty in vanadium. Vanadium is dominantly produced as a by-product of steel production. The recent shutdown at EVRAZ's Mapochs steel-vanadium operations in South Africa has cut-off 10% of the world's vanadium output. This shortfall is expected to be partially filled by Largo Resources' Maracas vanadium operation in Brazil, a primary vanadium producer. The decoupling of vanadium production from integrated iron ore producers is manifested in the increasing number of pure-play vanadium ventures around the world. Hence, exploration interest is likely to favor single-product deposit; among them, the vanadiferous asphaltite deposits of Central Peru, site of the first and richest vanadium mine in history, and deposits in the Parana Magmatic Province of Brazil, Uruguay and Paraguay. This trend could be reinforced by the expected increase in vanadium demand from non-traditional uses in the form of batteries for the storage of energy generated from renewable sources. This paper summarizes the current state of vanadium exploration, briefly describes the vanadium market and lists sources of future demand for the metal.

9:05 am

Lithium Enriched Brine – Not a Typical Ore Deposit

D. Weber¹, M. Rosko² and W. Weinig³; ¹Montgomery & Associates, Denver, CO;

²Montgomery & Associates Consultores Limitada, Santiago, Chile and ³South Dakota Science and Technology Authority, Lead, SD

Unlike traditional, solid mineral resources, brine resources are fluid deposits of variable density and mobility. Mineral-enriched brines occur in porous- and fractured-rock aquifers, typically within closed hydrologic basins. The exploration of brine resources and definition of mineral reserves require understanding the variability of brine densities and mineral concentrations and the variability of flow and transport characteristics in the brine aquifer. Production wells or shallow trenches are generally the mining method for extraction of brine resources enriched in minerals such as lithium. Hydrogeologic assessments are thus critical to evaluating what portion of the total mass of lithium contained in the Mineral Resource is economically extractable and can be defined as a Mineral Reserve. Consistent with CIM and JORC guidelines, defining the Extractable Brine Mineral Resource is a critical modifying factor for the mining method and advancing from Mineral Resource to Mineral Reserve. The Extractable Resource category is supported by exploration results, aquifer testing, conceptual models, and numerical simulations of wellfields or trenches for mining the mineral-enriched brine.

9:25 am

Rhenium in Molybdenite as an Indicator of Metal Grade

C. Rathkopf², M. Barton² and I. Barton¹; ¹Lowell Institute for Mineral Resources, University of Arizona, Tucson, AZ and ²Geosciences, University of Arizona, Tucson, AZ

Compilation of more than 2300 measured Re concentrations in molybdenites from different ore deposit types worldwide found a wide variation in Re content. The data showed some distinct trends when compared to metal grade, genetically associated igneous rocks, and deposit model classification. Rhenium correlates positively with Cu and negatively with Mo and Au in porphyries and skarns – possibly related to a negative correlation observed between Re and high-silica intrusions. Rhenium also corresponds to lower Au in intrusion-related, IOCG, and volcanogenic deposits. These correlations affect deposit and byproduct modeling and provide context for a study of Re concentration as a vector to mineralization and grade in individual ore deposits.

9:45 am

Geology of the Marigold Deposit, Battle Mountain trend, Nevada: New Exploration Insights for Sedimentary-Rock Hosted Gold

E. Holley¹, M. Fithian³ and J. Carver²; ¹Department of Mining Engineering, Colorado School of Mines, Golden, CO; ²Silver Standard, Valmy, NV and

³Department of Geology and Geological Engineering, Golden, CO

The Marigold mine is located in the Battle Mountain mining district at the northern end of Nevada's Battle Mountain-Eureka trend. The trend contains in excess of 90 million ounces of gold, primarily in disseminated deposits hosted in sedimentary rocks. In the Battle Mountain district, many of these deposits are spatially associated with Jurassic, Cretaceous, or Eocene intrusions. Marigold is the second largest gold deposit in the district, with 3.7 million mined ounces of gold at an average grade of 0.67 g/t, hosted primarily in siliciclastic rocks above the Roberts Mountain thrust. Marigold has been previously described as a distal disseminated deposit based on an assumed genetic relationship between gold mineralization and a number of prominent felsic dikes exposed throughout the deposit area. New U-Pb ages reveal these dikes to be Cretaceous, associated with minor base metal mineralization. However, detailed studies of the ore and alteration reveal that the gold is a younger, Carlin-style overprint lacking a proximal magmatic signature. These data suggest that Carlin-type gold may be found in host rock packages that have traditionally been considered less favorable.

10:05 am

Structural Reconstruction of Extensional Deformation in the Maysville Summit-Hilltop-Park Saddle Area, Northern Shoshone Range, Nevada: Implications for Mineral Exploration Targeting

C. Richardson and E. Sedorff; Geosciences, University of Arizona, Tucson, AZ

The northern Shoshone Range, located between the Cortez and Battle Mountain districts, exposes rocks of the Roberts Mountains allochthon, windows into the autochthon, the Antler overlap sequence, and Tertiary igneous rocks. The Hilltop district consists of historic small vein mines (Ag ± Au-Cu-Pb-Zn), the structurally-controlled Hilltop gold deposit, and weak disseminated porphyry mineralization. This study documents a normal fault system in the center of the range that has dismembered and tilted the ore deposits and their host rocks. Structural reconstructions of this area shed light on the pre-faulting geometry of the ore systems during formation and suggest exploration targets.

10:25 am

Eocene Magmatism, Na-Ca Hydrothermal Alteration, and Gold Mineralization in NE Nevada

C. King and M. Barton; University of Arizona, Tucson, AZ

New geologic mapping in the Battle Mountain district, Nevada has revealed extensive sodic-calcic (Na-Ca) alteration is associated with Eocene magmatism and associated gold mineralization in some (but not all) of the ore-forming systems. Na-Ca alteration requires involvement of non-magmatic brines, and reflects a distinctive, potentially important source of ore-forming fluids. This has led to new investigations of other Eocene intrusive centers in northeastern Nevada wherein multiple examples of heretofore unrecognized Na-Ca alteration have been found. These results confirm that non-magmatic fluids with gold-transporting capacity were widespread in the Eocene, contemporaneous with early stages of crustal extension and magmatism. Their chemistry is consistent with gold transport; it is possible that they played a role in the genesis of this major gold province – a subject of ongoing investigation.

Tuesday, February 23 – Morning

ROOM: 127A

9:00 am

Mining & Exploration: Operations: Mine Planning and Development for Operational Excellence

Chair: M.Groulx, Amec Foster Wheeler, Mesa, AZ

9:00 am

Introduction

9:05 am

Rebuilding Lucky Friday

L. Radford; Hecla Mining Company, Coeur d Alene, ID

Lucky Friday has been an important silver, lead, zinc mine in the Silver Valley of northern Idaho since 1941. Hecla has had an interest in the mine since 1958 and full ownership since 1964. Following 25 years without a fatality, two fatal accidents occurred at Lucky Friday in 2011. A subsequent order by MSHA closed the Silver Shaft – the principal access to the mine. The mine has subsequently been rebuilt and returned to full production. Work included: Rehabilitating infrastructure Changing and broadening the management team Changing the culture of the mine Increasing emphasis on rock mechanics Planning for the future This will be a Presentation Only.

9:25 am

Modeling Maximum Ramp-Up and Production Rates Of Stoping Mining

P. Vergara; SME, Eden Prairie, MN

Benchmarking and empirical ratios are a common source of information when addressing one of the most important decisions of a new mine: its production rate. However, especially in underground mining projects, the lack of directly comparable cases due to particular geology, rock quality or other singular characteristics makes the comparison quite challenging. The paper discusses an analytical alternative for determining the maximum achievable production rate for underground stoping mining for a given set of parameters, by modeling production as a continuous process. Interestingly, the results show that long term maximum production depends exclusively on the development rate and the development intensity of the design. Extraction rate and stope size only impact the ramp-up rate. These findings allow shaping the maximum capacity profile of the project. Results compared favorably with some projects, mines in operation and were validated against scheduling exercises. They can be used as a tool for quick assessment of conceptual capacities, and sensitivities around mining rates.

9:45 am

Fleet Estimate Methodology for Underground Development Based on Crew Performance

B. Syers and P. Vergara; Project Development, Twin Metals Minnesota, Saint Paul, MN

Mobile equipment fleet estimation is an integral part of long term mine planning for both project and operation phases of a mine. Proper fleet estimation is essential to evaluate asset quantities to maintain efficiency and eliminate excessive capital required for the mine plan. Conversely, improper estimation can leave the operation with fewer or excessive (+/- 40%) resources than are needed. This presentation will explain the methodology of fleet estimation used by the Twin Metals Minnesota Mining Team that uses a crew's productivity with a given equip-

ment configuration to estimate the mobile fleet. The rationale behind this is that a measurable and relevant work (e.g. a round of advance) is attained by a crew, not by a single piece of equipment, and that utilization of equipment within a crew is a result of the process and determined by the bottleneck activity in its relation to the other parts of the cycle. This methodology differs from other common practices of evaluating equipment performance individually with assumed utilizations as inputs and estimating fleets based on the ratio of demanded work and achievable work by each single piece of equipment.

10:05 am

Getting More Out of Your Big Investments: Data is Only as Good as the People Who Handle It

Z. Savit; Vulcan Solutions, Maptek, Lakewood, CO

In a data driven environment, the people who control your data are crucial to the success of your operation. Engineers, Geologists and Surveyors translate data from the CEO's desk to the frontline miners who make it all happen. Why, then, do we not treat them with the same analytics and efficiency metrics that we use to ensure that expensive equipment works effectively? What happens when you look at the availability, downtime and UoFA of your technical services personnel? Are you asking them to perform the right tasks at the right time with the right tools? Along with examples of efficiency to be gained through better usage of personnel, the process through which Tech Service groups are built will be examined. Changes in practices will be presented for consideration. Utilization decisions and processes for change will be discussed.

10:25 am

Geometallurgy: From Purchase to Reserves

W. Tyler¹ and T. Logan²; ¹Coeur Mining, Inc, Hawthorn Woods, IL and ²Golden Metallurgical Group, Littleton, CO

The use of scoping-level geometallurgy at early-stage deposit in Mexico during the due diligence process allowed a mining company to more clearly see value. The deposit had only two prior tests which yielded inconsistent recoveries. Application of geometallurgy began with core photos and geologic logging, followed by mineralogy and bottle roll cyanidation testing to define metallurgical responses of discrete geometallurgical domains. Understanding the responses by domain, coupled with improved knowledge of the spatial dispersion of the geometallurgical domains de-risked the overall estimated recovery of metals and better estimate the value of the deposit.

10:45 am

16-164

Bottleneck Analysis for Single Source Mining Model Using Grids

S. Richards; Mining, Carlson Software, Maysville, KY

Classic engineering economics provides the mining engineer with a fundamental approach to choosing between capital spending alternatives. This approach has been heavily used over the years and is an accepted technique for most investment decisions. There is a real shortcoming however, that I have seen encountered when using the classic time value of money approaches such as Net Present Value, Return on Investment, and Internal Rate of Return. The number crunching process works fine, however, the input assumptions often fall short of describing the real material differences required by these analysis techniques. All too often there is an incomplete analysis conducted when the expected benefit of a capital productivity improvement is proposed. Whenever possible, productivity improvement based capital projects should be conducted in concert with a "bottleneck analysis". The author uses gridded surfaces to represent the system bottlenecks across the reserve to serve as a backdrop for mine capacity planning.

11:05 am

Sustainable Mine Planning: Creating a Positive Legacy

A. Trippel; ERM, Minneapolis, MN

Mine life cycles start with exploration, an ore reserve, engineering, and economic analyses—without those fundamentals, no mine could be justified. However, ERM's experience and research shows that viable large capital projects are often delayed by undermanaged environmental and social issues. Proactively addressing such issues early in the mine planning process is the best assurance that a project will be approved, operate smoothly, and close with a sustainable positive legacy. Sustainable mine planning (SMP) methods are key to assessing and resolving economic, engineering, environmental, and social issues while significantly decreasing mine development timelines and the need for subsequent plan revisions and permit approvals. This presentation will highlight successful mining projects that employ SMP approaches which have resulted in positive legacies for communities, the environment and the mining industry.

Tuesday, February 23 – Morning

ROOM: 127B

9:00 am

Mining & Exploration: Operations: New and Expansion Surface Operations Overview

Chair: J. Rahn, Newmont, Elko, NV

9:00 am

Introduction

9:05 am

The Full picture of IPCC System Implementation and the Reason Why So Many Fail

D. Morrison; Mining and Metals, Bechtel, Carindale, QLD, Australia

In the last few decades a number of attempts have been made to deliver a fully mechanised mine with the deployment of In Pit Crushing and Conveying Systems. The aim has always been to reduce or eliminate the deployment of truck fleets, which appears attractive as fuel prices increase, finding skilled labour becomes more challenging and the location of deposits become more remote. The challenge facing the mining industry is further exacerbated by the increasing global demand, falling grades and greater depth that mines extend to in order to maintain global consumption of resources. The installation of in pit crushing and conveying systems seems a logic development but these systems rarely operate for long enough to repay their capital burden and become marginalised by the developing mine. This paper sets out to debunk some of the myths that resulted in the investment decision in the first instance and to articulate some of the criteria that need to be met before a system of this type is viable.

9:25 am

Barrick and Premier's Arturo Mine JV Project: From Discovery to Production

P. Haarala; Barrick Goldstrike Mines, Inc., Elko, NV

The Arturo mine is located 4.5 miles NW of Barrick's Goldstrike operation in Northeastern Nevada. It was discovered in 2005 and began production in 2015. The Arturo mine is a combination of a new open pit and expansions of the

existing, closed Dee Gold open pit. We will cover a brief history and timeline of the project, permitting challenges and lessons learned, infrastructure construction, Carlin formation dewatering, and operational performance.

9:45 am

When All Haile Breaks Loose: The Reopening of a Gold Mine

C. Fleshman, S. Stenson, J. Townshend and C. Baldwin; Mine Technical Services, Romarco Minerals - Haile Gold Mine, Kershaw, SC

Haile Gold Mine, 100% owned by Romarco Minerals, is located within the Carolina Slate Belt of the Southeastern United States, which has hosted many gold deposits covering five states. The Carolinas were the site of the first gold rush in North America before California, dating back to the early 1800s and was explored and produced by many qualified gold companies throughout the 1980s. Haile is located near the town of Kershaw, SC which has necessary infrastructure in close proximity. Haile has received all major permits, including the Federal 404 permit and State mining permit. Construction began in May, 2015. Haile will be mined using traditional open pit methods, and will deliver ore to the process facility in the 4th quarter of 2016. This presentation will focus on development, challenges, and solutions of reopening a gold mine on the East Coast of the United States.

10:05 am

Mining-induced Seepage Instability of Karst Collapse Pillar: A Numerical Simulation for Groundwater Inrush

D. Ma and Y. Wu; China University of Mining & Technology, Xuzhou, Jiangsu, China

Groundwater inrush has an impartible relationship with geological structures such as karst collapse pillar (KCP), which is widely distributed in North China. A numerical fast Lagrangian analysis of continua in three dimensions (FLAC^{3D}) model was conducted to determine the pore groundwater pressure, seepage vectors and effect of plastic zone on seepage field development of a penetrated-type KCP and the surrounding rocks. The results indicate that: KCP formed by the overburden cave collapse, is shaped like a plug, the insides are irregular structures and mostly formed by crushed rocks. When KCP and the surrounding rocks show dislocation, shear failure may occur, which will lead to a sidewall channel for groundwater inrush. As mining advances, the plastic zone in the KCP and its crushed area develop gradually. Under the effect of the support pressure and unloading of the coal face, an obvious seepage concentrate channel with greater water head and seepage vectors will form within the edge of the KCP. Then, the channel will gradually move to the other side with the coal face near and away.

Tuesday, February 23 – Morning

ROOM: 127C

9:00 am

Mining & Exploration: Technology: Application of Discrete-Event Simulation in Mining Problems I

Chairs: K. Hindle, Hatch, Mississauga, ON, Canada
E. Tarshizi, Michigan Technological University, Houghton, MI

9:00 am

Introduction

Introducing Near To Face Sorting in an Underground Mine: A Case Study From Kristineberg Mine

B. Skawina¹, J. Greberg¹, A. Salama¹ and E. Novikov²; ¹Civil, Environmental and Natural resources engineering, Lulea Tekniska Universitet, Lulea, Sweden and ²Boliden Mineral AB, Boliden, Sweden

Mining of ore bodies that are located at great depths enforces long distances to move the excavated rock masses to the surface. The excavated rock mass contains not only ore that can be economically extracted from the face but also waste, which is usually discarded several steps further downstream in the process. As a result large amount of rock masses are transported to the surface, influencing the costs at which the ore is produced. Reducing the amount of waste being transported to the surface by introducing near to face sorting plant would improve the in many cases strained transport system in the deep mine. In this study, one of Boliden's cut and fill mines was analysed with respect to the challenges related to mass movement and increasing mining depth. The study aims to evaluate the use of the new near to face sorting system in the operating underground mine. Discrete event simulation was used to study and analyse the mass movement with and without the near to face sorting plant. The paper shows how the underground mass movement system and the production were influenced when a near to face sorting equipment was added into the current system.

Design of a Discrete-Event Model for Optimization of the Load-Haul-Dump Cycle

P. Vasquez and V. Tenorio; Engineer, Jesus maria, lima, Peru

The mining industry, as many other production activities, is always in search of new solutions for the optimization of its processes in order to achieve a sustainable operation flow. Improving safety for operators and maximize the utilization of equipment assets when facing the cost variability and fluctuation of commodity prices has become a priority for the majority of operations around the world. This paper explores the most recent advancements in information technology that were occurring in the field of surface mine production, helping to centralize, integrate, and analyze operational data. As a result, a Discrete-Event simulator has been developed as a specially designed tool for the maximizing the utilization of equipment, safety of operators, and productivity increase. The application combines the supervisory features of production monitoring with an analysis of delays.

Simulation and Animation of Marigold Mine with Dynamic Pit Operation (Phase II)

E. Tarshizi¹, D. Taylor², A. Achleithner³ and V. Ibarra²; ¹Department of Geological and Mining Engineering and Sciences, Michigan Technological University, Houghton, MI; ²Department of Mining and Metallurgical Engineering, University of Nevada, Reno, Reno, NV and ³Technical Services, Silver Standard Resources Inc., Valmy, NV

A discrete-event system simulation and animation model for the Silver Standard's Marigold Mine haulage operation in Nevada, USA, was developed during the first phase in 2014. This model was recently updated with new equipment and haulage routes to both waste dump locations and ore destinations according to the mine advancement and changes. After the calibration and verification, the model mimics and simulates the mine haulage and allows for "what-if?" scenarios to assist with long-range mine planning and determination of haul truck requirements. Marigold is somewhat land constrained and finding dump and leach pad space to place material mined is a top priority. Optimizing the mine haulage,

which is the greatest portion of the mining operating expenditure, is extremely important and the simulation tool can assist the engineers in this process. This program can also assist to determine if additional trucks are required to be purchased, when they will be needed and for what length of time period the truck requirements are increased. It may determine if a truck is leased or purchased depending if the requirements are long-term or just a short-term increase in haulage capacity needed.

10:05 am

Sensitivity Analyses of Rock Support Design Parameters in Numerical Models

R. Thareja and R. Kallu; Mining and Metallurgical Engineering, University of Nevada Reno, Reno, NV

Many Nevada gold deposits are found in highly fractured and faulted host rock with RMR ranging from 10 to 50. Various ground control design issues in weak rock masses are faced by most underground mines operating in Nevada. Numerical models complement field observations, instrumentation techniques, and testing by providing a better insight into the fundamental behavior and response of weak rock mass and its interaction with support systems. It facilitates development of a better design methodology and guidelines for excavation span and support design. MPBX arrays were installed in underground excavation and the displacements at MPBX nodes were observed for previous numerical model calibration. Numerical models were designed to take into consideration the effect of jointing using discrete fracture network (DFN) and rock bolts in 3DEC. Sensitivity studies were performed to understand the effect of various rock support design parameters. Rock bolt length and spacing was varied for numerical models to understand the effect of each parameter to the stability of underground excavations.

10:25 am

Development of a New 3-D Coal Mass Strength Criterion

P. He and P. Kulatilake; Rock Mass Modeling and Computational Rock Mechanics Laboratories, The University of Arizona, Tucson, AZ

Estimation of rock mass strength has been a difficult task for mining engineers. Because of the pre-existing complex fracture networks, rock mass strength shows obvious scale effect and anisotropic behavior. The current rock mass classification systems and strength criteria are insufficient to capture those important behaviors. In this research, a systematic procedure combining advanced laboratory testing techniques, fracture tensor based methodology and numerical analyses was used to investigate the influences of the pre-existing fracture networks and confining stresses on the jointed coal mass strength. The created data bank was finally used to develop a new 3-D coal mass strength criterion.

Tuesday, February 23 – Morning

ROOM: 125A

Mining & Exploration: Technology: Big Data in Mining

Sponsored by: Civil & Environmental Consultants, Inc.

9:00 am

Chair: R.Diaz, Maptek, Lakewood, CO

9:00 am

Introductions

9:05 am

Data Analytics for Productivity and Condition Monitoring of Surface Extraction Machines

B. Barnes, S. Jacque and D. Ghosh; Surface Extraction & Hauling, Caterpillar Global Mining, Inc., South Milwaukee, WI

Our customers expect the highest machine performance and availability to lower cost per ton from their surface extraction machines. They also expect predictable machine reliability so that the components, if necessary can be replaced or repaired during the scheduled downtime. In order to achieve the above business objectives, there is a need to monitor how our customers are using the machines, and develop data analytics which can generate alarms / warning so that preventive maintenance can be performed. This application data can also be utilized to optimize the future machine design. Caterpillar Surface Extraction product group has recently developed data analytics tools which can automatically extract the electronic data from the customer machines and generate productivity and condition monitoring reports. This system is currently being piloted at a number of customer sites on their Electric Rope Shovel fleets. The first phase of this development is limited to collecting the machine electronic data from the Electric Rope Shovels. The second phase of the project will collect additional data from strain gages and accelerometers located on critical structures and powertrain components.

9:25 am

Big Soil: Use of public soil geochemical datasets for exploration and geoenvironmental model development

D. Levitan; Barr Engineering, Minneapolis, MN

Soil geochemistry is used to identify exploration pathfinders and anticipate potential environmental issues at ore deposits. In this project, multi-element statistical methods are used to analyze soil geochemical data, and elemental compositions and relationships are compared between soils collected from a uranium deposit in the SE US and reference soil samples extracted from a regional subset of a national-scale survey. Results included anomalies in soil U/Th ratios and LREE enrichment factors in the deposit soils. These results are being used in genetic, weathering, and environmental models of the deposit and can also be applied to future prospecting for similar deposits.

9:45 am

Enabling Operational Excellence in Mining, Mineral and Metallurgical Processing Operations: New Ways of Using Data

O. Bascur, L. Garrigues and C. Hertler; OSIsoft, LLC., Houston, TX

Mining operations are faced with large variability of their ore types, escalating operating costs and environmental constraints. It is widely recognized that people, not systems, are the best way to deal with problems or exceptions. When data are recognized as a critical asset when management as part of an infrastructure it become a key enabler to help transform the entire operations. Applying the latest technologies has become a serious challenge to both management and technical teams due to their rapid change. The integration of data and process events in a context based model enables people to collaborate and drive improved results. An Operational Excellence program fueled by a data infrastructure enables collaboration of people at all locations using Cloud based technologies. This paper will share examples of how mining and mineral processors have adopted new data strategies based on an operational excellence program. These strategies include self-service business intelligence, cloud computing and internal/external collaboration. Examples from industrial implementations on Mine to Mill, Enterprise Energy reduction program and asset optimization case studies will be reviewed.

10:05 am

Geographic Information Systems (GIS) for “Big Data” Analysis at Longwall Mining Sites

M. Maguire and C. Cyprych; Civil & Environmental Consultants, Pittsburgh, PA

Geographic Information Systems (GIS) and relational database technology provide excellent toolsets for long-term environmental data storage and analysis. This presentation will illustrate the use of desktop and web-based GIS to store, analyze, and detect changes in natural resource data over time, focusing on longwall mining sites in Southwestern Pennsylvania (PA). Longwall mining operators must collect extensive biological and hydrologic data required for full extraction coal mining permits and post-mining compliance monitoring. For this project, four major underground coal mines covering over 60,000 acres, defined the study area. Due to the large volume of data collected at regular seasonal intervals, GIS relational database technology was employed to securely store and manage this enormous multi-year dataset. Currently, the GIS database for these sites contains nearly 3,000 wetland records, 500 acres of delineated wetlands, and 600 stream miles collected over a decade's time. Going beyond the creation of traditional maps, GIS and related technology provide the ultimate tool to manage this “big dataset” for mine managers, regulators, and other information consumers.

10:25 am

Big Data: A Cloud Computing Approach

S. Van Wegen; Modular Mining Systems, Tucson, AZ

“Big data” and predictive analytics are being used by more and more mining organizations as a means of better understanding their mobile equipment health. But managing overwhelming amounts of data and the infrastructure required to maintain it has proven to be an increasingly difficult endeavour. By integrating cloud computing technology with a maintenance management system, big data can be translated into actionable information, providing greater insight into asset health and helping to drive a more proactive approach to machine maintenance. In a heavily capital-constrained business climate, this approach can eliminate high up-front expenses and reduce support and maintenance requirements for mines across the globe. This paper will demonstrate that mining organizations large and small can increase their ROI by adopting a cloud-based solution to maintenance management. Case studies will be examined to show that, by connecting mobile equipment to the cloud via a site's Wi-Fi network, mines can collect enhanced data about their machine health, as well as optimize maintenance workflows, to truly maximize the value of their maintenance management system.

10:45 am

Real Big Data Applications using Hadoop and Cloud Services: Machine Health, Safety, and Productivity

S. Dessureault¹ and A. Kauf²; ¹Mining and Geological Engineering, University of Arizona, Tucson, AZ and ²Abosolutdata, Alameda, CA

Large contemporary mines have been generating both relational and process-based data for well over a decade. The significant investment mines have continued to make in these data-generating technologies has induced the need to create value from these large data repositories. Algorithm-driven productivity monitoring, predictive maintenance, and improved risk monitoring are opportunities that can be incorporated into contemporary mine management, using big data approaches, to create value. However, data preparation, processing, analytics, and interpretation, using big data approaches, are not part of a mine's typical workforce skill sets nor part of undergraduate mining engineering curriculum. A set-by-step example of big data analytics is presented using real coal and copper operations data and big data approaches using cloud-based resources. Specific skill sets and resources are described that can help identify training, education, and other resources necessary for mines to understand and then leverage this technological opportunity.

11:05 am

The Data Value Index (DVI): A Systematic Means of Quantifying the Current and Potential Value of Data

P. Rogers and S. Dessureault; University of Arizona, Marana, AZ

Most large contemporary mines already have considerable amounts of data, much of which goes largely unused. The key challenge in big data is increasing data utilization. Much of the data in the mine (not plant) come from a variety of systems, each with different databases and reporting environments. Standard technology deployments create a “silo-ification” of data leading to poor system usage. Through modern server monitoring, data utilization can quantifiably be measured. A host of other quantifiable, often automated approaches, to measuring data use and value can also be incorporated as a means of monitoring value generation. A data valuation tool is presented to measure the data assets at an operation. The Data Value Index (DVI) quantifies business intelligence best practices and user interaction considering managerial flexibility and data utilization rates. The DVI is built considering many case studies of data warehousing at various mining companies, some of which will be presented.

Tuesday, February 23 – Morning

ROOM: 228A

9:00 am

MPD: Chemical Separation: Leaching I

Chair: J. Lee, University of Arizona, Tucson, AZ

9:00 am

Introductions

9:05 am

A Conceptual Bromine/Bromide Circuit Development for Gold Processing

M. Melashvili; SGS Canada, Lakefield, ON, Canada

Development of a new hydrometallurgical flowsheet requires quantitative description and optimisation of all chemical processes in each step in the process, as well as mass and energy balances across a fully integrated circuit incorporating all the unit operations. This paper covers steps leading to early modelling of a gold processing plant based on a bromine/bromide lixiviant. Initially, this lixiviant was evaluated in leaching of a number of gold bearing ores and concentrates. Next, the recovery of gold by different types of resin and activated carbon was studied, along with various methods of stripping the gold from the extractant. The circuit is closed by electrolysing the spent leach liquor to oxidize some of the contained bromide back to bromine that would allow recycling the regenerated leach solution back to the leach step in the process.

9:25 am

Petrography Saves Money: a Case Study of Leaching in the Central African Copperbelt

I. Barton¹, H. Yang² and M. Barton¹; ¹Lowell Institute for Mineral Resources, University of Arizona, Tucson, AZ and ²Geosciences, University of Arizona, Tucson, AZ

Much of the supergene cobalt ore in the Central African Copperbelt stratiform Cu-Co deposits (D.R. Congo) is thought to consist of cobaltoan dolomite ($\text{CaMg}(\text{CO}_3)_2$), identified by core logging, hand sample identification, and geometallurgical testing. However, petrographic reexamination of samples from the Tenke-Fungurume district showed that in a significant fraction of samples, the supposed cobaltoan dolomite is actually $(\text{Co,Mg})\text{CO}_3$, a previously unknown solid solution between sphaerocobaltite and magnesite. It is indistinguishable from cobaltoan dolomite in

QEMSCAN and in hand sample, but distinct in petrography, electron microscopy, and Raman spectroscopy. Calculations indicate that the spherocobaltite-magnetite crystals are much less soluble in acid than cobaltian dolomite, so the misidentification will probably cause cobalt recoveries to be lower than predicted.

9:45 am

Leaching of Low Grade Chalcopyrite Ores and Implications for Field Implementation

J. Uhrig; RungePincockMinarco, Englewood, CO

Chalcopyrite leaching is dramatically enhanced by elevated temperature. Field scale heat balance includes sources due to rapid oxidation of ferrous iron and pyrite and sinks of radiation, evaporation, and convection. Significantly elevated temperature is only possible on supergene ores which are high in pyrite content or contain highly reactive pyrite. Best field results should be obtained through combined stockpile aeration, fine crushing, controlled irrigation rates, and regular rest cycles. The economics of primary sulfide leaching could be very favorable at properties where existing capital of excess SXEW, crushing plant, and pad space is available.

10:05 am

Chemical Oxidative Pretreatment and Cyanide Leaching Applied to a Gravimetric Concentrate of a Refractory Gold Ore

F. Lopez¹, G. MUNOZ², S. Morales¹, L. Tapia¹ and A. Alvarez¹; ¹Metallurgical Department, National Research Institute in Geology, Mining and Metallurgy, Quito, Pichincha, Ecuador and ²USFQ, Professor, Quito, Pichincha, Ecuador

A chemical oxidative pretreatment with hydrogen peroxide and nitric acid, followed by cyanide leaching was applied to a gravimetric concentrate with high sulfide content from the Portovelo mining zone in El Oro province, Ecuador. Assay results confirmed the refractory characteristics of the ore, with 15% of gold dissolution when direct cyanidation was applied. Mineralogical and chemical analysis, together with leaching tests suggest the oxidation of sulfides to sulfates after the chemical pretreatment, and the release of the encapsulated gold in the sulfide matrix. It was found that cyanide leaching after oxidative pretreatment achieves 98% of gold dissolution from the ore concentrate using a nitric acid and hydrogen peroxide mixture.

10:25 am

Economic Evaluation of the Gold Mine Tailing in Arizona

J. Lee¹ and L. Finman²; ¹University of Arizona, Tucson, AZ and ²Finman & Associates, Inc, Tucson, AZ

There are many small, closed gold mine operations around the state of Arizona and the tail reprocessing project was evaluated using chemical and mineralogical analysis. The processing conditions and the chemistry of the old process plants were not optimized and often higher grade of mine tailings were disposed into the tailing storage facility. The grade of the tailing and mineralogical information can be used to evaluate the values in the tailing and appropriate process can provide the beneficial method to recover the metal values from it. The process also can alleviate the environmental concerns such as acid rock drainage and other toxic element contained in the tailings.

10:45 am

A Billion Gallons of Experience: Results From a Long Term Subsurface Heap Leaching Program

D. Rucker; HydroGeophysics Inc, Tucson, AZ

Many studies have shown that surface leaching of low-grade rubblized ore is generally an effective means to extract nearly 70 to 90% of a heap's metal content. The last 10-30%, however, has significant economic impacts on

the operation, profitability, and eventual closure of the mine. Therefore, any inexpensive means to extract the last bit of metal from the heap can be of great value. Lately, we have been conducting targeted subsurface leaching on copper ore that has historically underperformed due to high fines and compaction. To this end, we recently hit a milestone in our experience: a billion gallons of barren solution injected through a number of wells that targets the underleached ore. Our experience in this endeavor has provided much insight into heap performance, effects of localized phenomena, and the importance of hydraulic and metallurgical monitoring to understand the economic impact of subsurface leaching. In this work, we will discuss many of these experiences and look towards the future as we expand the well field and prepare for closure.

11:05 am

Copper Leaching: 2014-2015 Global Operating Data

R. Washnock¹, R. Scheffe² and G. Zarate³; ¹Freeport McMoRan Inc, Safford, AZ; ²Consulting Metallurgist, Castle Rock, CO and ³AngloAmerican Chile, Santiago, Chile

The second survey of global copper leaching operations has been completed, the data published in 1998 has been updated. A questionnaire was sent out to 40 identified copper leach operations around the world including those leach properties still in operation that responded to the 1998 survey. The paper lists the results of 26 operations that responded to the survey. Selected information from the survey is represented in graphical form.

11:05 am

16-041

Leach Process Monitoring and Control Through Instrumentation

C. Wooten¹, C. Zenner³ and J. Dean²; ¹Leaching, Freeport-McMoRan, Morenci, AZ; ²TC, Freeport-McMoRan, Safford, AZ and ³Hydromet, Freeport-McMoRan, Silver City, NM

Raffinate solution distribution on a heap leach pad is an important part of metal recovery. This is especially critical at Freeport-McMoRan's Safford Mine where the acid-consuming nature of the ore requires a high level of raffinate flow precision. Prior to 2013, the raffinate system was flow-controlled at a single point for the Leach Pad with manual adjustments made at each ~8,000 m² module. This did not meet the precision needed, leading to the development of a state-of-the-art control and monitoring system. Many challenges had to be overcome, including materials of construction, portability, power requirements, wireless operation and cost/benefit. Taking these obstacles into consideration resulted in a portable self-contained unit consisting of a wireless pressure transducer, a wireless flow meter, and a pressure regulating valve. These devices allow the individual raffinate flows and pressures to be monitored and recorded on a real-time basis, with the regulator maintaining a consistent pressure to each module. This data has also provided data benefits for flushing efficiency and real-time drip emitter plugging rates. This new system has been greatly successful for Safford.

Tuesday, February 23 – Morning

ROOM: 228B

9:00 am

MPD: Comminution: Comminution I

Sponsored by: ThyssenKrupp Industrial Solutions (USA), Inc.

Chairs: A. Giblett, Newmont, Subiaco, WA, Australia
M. Larson, Glencore Technology, Ewen, MI

9:00 am

Introduction

9:05 am

Simulation of a pilot scale HPGR using DEM

G. Pantoja Barrios and L. Tavares; UFRJ/COPPE/LTM, Researcher, Rio de Janeiro, Rio de Janeiro, Brazil

The application of High Pressure grinding Rolls (HPGR) has been growing steadily in the mining industry for the last 10 years. The HPGR employs interparticle breakage as the primary crushing mechanism, by slow compression of a bed of particles between two counter-rotating rolls, one of which applies a compressive force using a pneumo hydraulic system. HPGRs are generally regarded as more efficient than ball mills, with less specific-grinding energy needed to produce the same degree of comminution. The DEM-based model of the HPGR of the present work considers the dynamics of the floating roll hydraulic system and the particle bed compressive behavior inside the crushing zone, to describe key performance parameters as working gap, compressive force, specific throughput and energy consumption. The paper describes the modelling approach, as well as the calibration of model parameters to simulate lab and pilot-scale HPGRs on the basis of data from piston-die tests of an Itabirite iron ore from Brazil. Comparison between simulation and pilot-scale test results suggest that the proposed model is the basis of a powerful tool for the simulation and scale up of industrial HPGR units.

9:25 am

Developing MillScanner, a mesh network enabled surface vibration sensor for real-time Sag mill control and optimization

M. Hales; KnowledgeScape, Salt Lake City, UT

Optimum Sag mill control is difficult to achieve because of the myriad unmeasured and changing variables that are extremely important to normal operation. Real-time measurements do not exist for ball charge, volumetric load, charge toe and shoulder angles etc. We do our best to infer some of these values from measurements we do have, such as bearing pressure, power, and mill sound. These are poor replacements for the real thing, however. In this paper we detail our work in developing a vibration sensor with accelerometer and telemetry components to pinpoint the toe and shoulder angles, allowing us to better understand the mill operation in real time, and thus come one step closer to optimum control. We will address issues of design, hardware and software that we faced in the development of this sensor.

9:45 am

The Importance of SAG Ball Quality and the Effect on Milling Performance

M. Meulendyke¹ and J. Purdue²; ¹Moly-Cop North America, Kansas City, MO and ²Moly-Cop USA, Mesa, AZ

The operating environment experienced by balls in SAG mills has continued to become more demanding over the years as mills have become bigger, discharge grate openings have become larger, and more aggressive milling practices to push throughput have become common. These drivers have significantly increased the impact conditions in mills, sometimes leading to high levels of ball breakage. As a result, SAG ball manufacturers have had to respond by developing balls that can withstand these higher impact environments while still providing high levels of abrasion resistance. Over the past 5 years, ball quality from the major SAG ball suppliers has significantly improved to meet these higher milling demands. The result is significant value to the milling process in terms of less

breakage and lower steel consumption. This paper will provide an overall review of SAG ball wear in hard rock milling, and will focus on the attributes of ball quality on ball wear performance.

10:05 am

Improving Hydrocyclone System Performance Using Smart-Cyclone™ Technology

B. Buttler; Product Development, FLSmidth Krebs, Tucson, AZ

Efficient separation processes are vital for maintaining effective grinding circuits in mineral processing plants. FLSmidth Krebs has developed a means to monitor the underflow from cyclones to detect an upset condition known as “roping”. In closed-circuit grinding applications, several control parameters must be balanced in order to produce the desired cyclone overflow product. These parameters include: the number of operating cyclones, cyclone inlet pressure, sump level, water addition, and pump speed. The open area of the cyclone apex can be a limiting factor in the operation of a cyclone. Apexes are sized to provide a high underflow density under a set of baseline conditions. When circuit conditions change and more solids report to the cyclone underflow, the apex can become overloaded, causing coarse particles to be misplaced to the cyclone overflow. This inhibited underflow discharge can be detected by measuring the sound produced as the underflow slurry impacts a specially designed splash skirt mounted under the apex. A patented ultrasonic sensor based solution attached to the splash skirt transmits data that identifies this “roping” condition so corrective actions can be taken.

10:25 am

Benefits of Continuous Data Acquisition From Critical Large Drives Systems in a Mine Operation

L. Galarza; Minerals, Siemens, Alpharetta, GA

To achieve higher productivity and energy efficiency, mining machinery has grown to the Gigawatt range in the last decades. Its sophisticated drives require skilled labor for its maintainance. Retaining this expertise has proven to be challenging; as mines are in remote areas and trained personnel in high demand. This challenge can be addressed through Asset Analytics for large drive systems, with continuous data acquisition & remote access to critical asset information, remote experts assist the local maintenance team ensuring prompt diagnosis, less downtime, & higher availability. Combining modern fast recording devices, large data storage along with safe data transmission affords flexibility in remote assist engineering services, prompt diagnosis, “just in time” parts ordering & contracting. In addition, operating improvements like extra throughput can be gained. A comparison of multiple condition monitoring systems for electrical & mechanical drive types in mining applications is provided. This comparison analyzes initial pros / cons and complexity for its implementation to enhance the plant reliability. An actual application of this technology at a mine site will be presented.

10:45 am

New Generation Variable Source Drives: Optimizing the Grinding Process in Comminution Circuits

I. Atutxa; Ingeteam, Zamudio, Spain

Comminution circuits have evolved from basic circuits consisting of simple crushing machines to the current multi-stage semi-autogenous (SAG) and ball mill circuits and more recently to the latest generation High Pressure Grinding Rolls (HPGR). All these evolutions share the same goal: to obtain the maximum possible efficiency in the whole process in order to maximize the productivity and the profitability of the grinding process. Therefore, in the different grinding systems, Variable Speed Drives (VSD) are becoming a main player, allowing the operator to meet the expected ore size target and to optimise the media utilization and wear. In fact, VSD systems offer the flexibility to maintain the process performance and product ore size between desired limits by simply adjusting the mill speed. In

addition, further advantages related to electrical grid and wear reduction like electrical friendliness, unitary power factor and load sharing in multi pinion systems and HPGRs are achievable by using modern VSD systems. This paper describes how INGEDRIVE VSD systems develop all these functionalities, upgrading the grinding process to a new level of productivity and profitability.

Tuesday, February 23 – Morning

ROOM: 232A

9:00 am

MPD: Plant Design I

Sponsored by: ThyssenKrupp Industrial Solutions (USA), Inc.

Chairs: A.Cole, Barrick Goldstrike Mines Inc, Elko, NV
D.Meadows, FLSmidth, Phoenix, AZ

9:00 am

Introductions

9:05 am

Developing a Great Process Control System

F. Zumwalt; Chapman College, Tucson, AZ

Developing a Great Process Control System The paper discusses the differences between a great process control system and a bad system. It also will describe the elements necessary to develop a great system, including: Model based logic Graphics Logic construction Alarming System criteria Historian specification Scope of work The paper discusses why these elements are essential to creating a great system and the consequences that follow for overlooking them. It requires less time to create a great system by using upfront planning and implementing the plan from the beginning, than it does to install a poor control system and deal with the problems it causes. Consequently, great systems cost less to implement and construct. They are less expensive, because model based systems use cut-and-paste methods and only require modifications to the model to accommodate individual equipment. Poor systems require individual programming and this requires many more man-hours to construct and troubleshoot. Contrary to popular opinion, a control system does not have to be expensive, complex, and unique to be great.

9:25 am

A Methodology to Assess Mineral Processing Circuit Design Under Uncertainty: A Linear Circuit Analysis Approach

S. Amini and A. Noble; Mining Engineering, West Virginia University, Morgantown, WV

Finding the optimal design of a mineral processing circuit is a complicated and open-ended design process. Several simulation and optimization techniques may be used to select a suitable circuit configuration on the basis of one or more techno-economic performance indicators. Despite the utility of these predictive tools, they often only consider static input values and do not consider the uncertainty inherent to the input factors such as predicted unit recovery and feed grade. To address these concerns, this paper describes a novel approach to analyze and predict the role of uncertainty in circuit design process. Monte Carlo simulations were first used to determine the distribution of predicted performance metrics when considering uncertain distributions for various input parameters. These simulations were conducted on 31 simple circuit configurations, and the results show that different configurations have a natural tendency to suppress or inhibit uncertainty in the predicted parameters. A parallel approach, based on linear circuit analysis, shows that this behavior can be predicted prior to simulation, even with limited a priori information beyond the circuit configuration.

9:45 am

Optimization of Flotation Plant Performance Using Micro-Price Analysis

G. Luttrell¹ and A. Noble²; ¹Mining & Minerals Engineering, Virginia Tech, Blacksburg, VA and ²Mining Engineering, West Virginia University, Morgantown, WV

Many flotation concentrators have installed complex control systems that are designed to optimize performance based on objective functions such as circuit yield, grade or other performance index. Unfortunately, field studies indicate that this generalized approach to optimization often does not provide a true financial optimum and, in fact, can often lead to worse performance in terms of overall profitability. This blind approach to optimization also provides little insight that can be used by plant operators on a day-to-day basis to improve concentrator performance. A better approach is to utilize “micro-price” analysis to identify and formulate optimization protocols for the concentrator. The micro-price concept assigns unit values to each particle passing through production units. Optimization occurs whenever all particles with positive value are generated, recovered and passed to market. This paper describes the micro-price concept as applied to the control and stabilization of froth flotation circuits in base metal concentrators. Case studies are also provided to demonstrate the economic gains that can be realized via the industrial application of this concept.

10:25 am

Plant Commissioning and Project Startups – Recent Experiences and Observations in the Base and Precious Metals Industries

D. Meadows; Mining and Metals, Bechtel, Phoenix, AZ

During the past fifteen years, a number of increasingly complex projects have come on line in the base and precious metal industries throughout the world. Some of the projects have come online and ramped up very quickly while others have had a prolonged and rather painful start up. This paper provides an assessment of some of the events seen in different parts of the world and investigates some of the project specifics. With the ever growing human resource challenge in the minerals industry careful preparation and mature management in the design phase all the way through to start up is essential. Similarly, the application of project tools and commissioning protocols has never been more important in this age of high tech computer software and largely office-based practicing engineers and project managers. This paper examines the subject from a number of different avenues and discusses some of the important themes and lessons learned. We hope these observations will provide guidance on minimizing the risk at the project startup phase, culminating in a successful and stimulating startup. **Keywords:** Commissioning, Ramp up, Project Planning, Project Management.

10:05 am

Optimization of Slurry Pumping Systems for Maximum Pump Performance and Minimum Pump Maintenance

K. Don, L. Echeverri and J. Frater; FLSmidth Krebs, Tucson, AZ

Slurry pumps are critical components in many applications in mineral processing plants. The successful operation of slurry pumps depends not only on having an optimal hydraulic pump design and adequate material selections, but also a proper design of the surrounding systems such as the sump and suction pipe. This paper discusses the application of the patented millMAX® Suction Side Sealing System and the use of modern computational engineering tools in combination with real life experience to optimize the design of slurry pump systems for maximum performance and wear life while making system maintenance convenient and safe. The recirculation on the suction of side of the impeller is discussed presenting measurements and flow predictions to illustrate its effects on pump

performance and wear. Finally, the effect of suction pipe design is discussed including practical examples and flow simulation results to point out frequent and unnecessary sources of suction head loss and recommend best practices.

10:45 am

Integrating Automated Mineral Analysis and Plant Metallurgy

P. Gottlieb¹ and R. Thorpe²; ¹TESCAN ORSAY HOLDING a.s., Brno, Czech Republic and ²Metrix Plant Technologies, Parksville, BC, Canada

Automated Mineralogy Technology has been very successful in diagnosing processing problems in concentrator operations. Detailed knowledge of mineral grades, recoveries and distributions are necessary, but not sufficient, for the optimization of mineral processing plants. Experienced plant metallurgists with comprehensive knowledge of plant operation are essential for implementing the changes in plant equipment, reagents and operation that are essential for the solution. Traditionally the mineralogical analysis has been limited to either static plant survey snap-shots or to average monthly composites of concentrates or tailings. The analysis of these “post mortem” studies is usually months after the event. This paper describes a new collaborative approach that combines experienced metallurgical and detailed process mineralogy knowledge to enable dynamic studies to be conducted on site on a much shorter time-scale. This approach creates a number of challenges such as regular plant monitoring, sampling and sizing; the routine preparation, measurement and analysis of size-by-size metallurgical samples; and the integration of the combined mineralogical & metallurgical information.

11:05 am

16-131

The cPlant: a Modular Approach to Flotation Plants

L. Rudolph², P. Tahkio² and B. Murphy¹; ¹Outotec Flotation USA, Denver, CO and ²Outotec Beneficiation, Espoo, Finland

The cPlant is a modular flotation plant which has been designed to minimize capital expenditure and risk. The plant is based on a number of standard modules, for both flotation and ancillary equipment, which can be configured to give the required flowsheet for the ore being treated. All of these modules can be rapidly deployed and erected onsite, minimizing not only engineering time and site preparation but reducing the time taken to get the plant up and generating revenue. Given the paradigm shift in flotation circuit design that has been employed in the cPlant it may allow smaller, previously uneconomic deposits to be exploited and create a more cost efficient upgrade route for existing plants. This paper introduces the cPlant and presents a case study comparing EPC cost and development timing of a cPlant against a traditional flotation circuit design.

11:25 AM

Optimizing Test Methodologies for Ceramic Reinforced Protective Coatings to Achieve Performance in Mining and Ore Processing Applications

S. Bowditch and M. Ramakrishnan; ARC Efficiency & Protective Coatings, A. W. Chesterton Company, Groveland, MA

Correlating laboratory evaluation techniques for abrasion and corrosion resistant ceramic reinforced protective coatings to real world conditions is difficult and often leads to disappointing results unless extensive field trials are involved. Current accepted physical test methods for establishing abrasion and corrosion resistance include dry abrasive testing at low and high velocities and pressures, low load dry testing, slurry based testing, and impact testing. Chemical resistance testing can include weight loss, physical property retention after immersion exposures, and permeation resistance. Additional testing may include pull off or scribed cut adhesion, flexibility, and compression resistance. This paper will review the some of

the more popular current test methods, identify the limitations of these tests where appropriate, provide examples where improvements can be made to tighten the coefficient of variation of test results achieved, and then provide correlating “real world” applications where operational reliability was improved and documented.

Tuesday, February 23 – Morning

ROOM: 232B

9:00 am

MPD: Reagents in Flotation: Flotation I

Chairs: R.Kappes, Newmont Mining Corp, Englewood, CO
T.Olson, FLSmidth, Midvale, UT

9:00 am

Introductions

9:05 am

Copper Sulfides Selectivity Utilizing Sulfur-Based Flotation Reagents

B. Ramos, D. Miller and C. Brown; Mining Chemicals, Chevron Phillips Chemical Company, The Woodlands, TX

Sulfide mineral flotation operations continuously strive for a balance between optimizing copper sulfide mineral recovery while rejecting iron sulfide minerals. Predominately the most effective, and economical, reagents for sulfide mineral recovery fall within the thiol collector family. Chevron Phillips Chemical Company has developed a family of reagents that have demonstrated the ability to keep copper sulfide mineral recovery, improve molybdenite recovery, while selectively minimizing recovery of iron sulfides; mainly pyrite, pyrrhotite, and arsenopyrite. This paper will provide examples of solutions of selectively rejecting iron. Discussions will include test data utilizing Orfom® MC Collectors in copper-molybdenum ores, copper-gold ores, and copper-molybdenum-zinc ores. The presentation/paper will also discuss flotation parameters including pH, retention time, percent of solids, and particle grind size.

9:25 am

Improving flotation recovery of Oxide Cu minerals

T. Bhambhani and D. Nagaraj; Cytec Industries Inc., Stamford, CT

Cu ore bodies commonly contain oxide Cu at the surface, with sulfide Cu content increasing with depth. The recovery of oxide Cu minerals by flotation is a long-standing challenge, especially for high acid-consuming ores which would not be economical for direct acid leaching. Current practice of oxide Cu flotation involves controlled potential sulfidization (CPS) using NaSH (or Na₂S), along with sulfide collectors. CPS has shown to improve recoveries but has the following limitations: a) SHE issues with NaSH, b) large doses of NaSH required, and c) certain oxide Cu minerals are refractory to sulfidization. The oxide Cu flotation is further complicated by the presence of certain non-sulfide gangue minerals which adversely impact recovery and selectivity. Several collectors have been evaluated for the direct flotation of oxide Cu minerals, i.e. without sulfidization. While promising at the lab scale, they have invariably failed at the plant scale due to various problems. This paper discusses the mineral occurrence of the various oxide Cu ores and the challenges associated with recovering these minerals while maintaining acceptable grade, using both sulfidization and direct flotation.

9:45 am

Xanthate Replacement Products - Designed for the Future

D. Canady; Mining, Clariant Corporation, Kingwood, TX

The hazards and difficulties of working with xanthates have long been an issue. It is a known problem but has been considered an acceptable risk at most mining operations. The issue of safety and the environmental impact of xanthates and their packaging disposal has led Clariant to develop chemistries to replace xanthates at a price point that is at, or below, existing xanthate pricing. The risk of spontaneous combustion is a known issue in the transoceanic shipping of xanthates. Because it is so hazardous, there are only two or three freight lines that are willing to ship this product. A cost effective option to xanthates is needed. In its commitment to Sustainability, Clariant has put focus on the areas of community, the environment, and sustainable business practices. Clariant now has several collectors that can replace xanthates and which are cost effective, with similar metallurgical results achieved for recovery and grade, and far less hazardous than the spontaneously combustible solid xanthate or the flammable liquid that results from dissolving xanthate pellets. This paper will outline the real-world application of this trend-setting chemistry.

10:05 am

16-124

An AFM Study of the Adsorption of Collector on Bornite

J. Zhang and W. Zhang; University of Arizona, Tucson, AZ

The adsorption of collector on bornite has been studied in situ in aqueous solutions by applying an atomic force microscopy (AFM). The AFM images show that xanthate, such as potassium ethyl xanthate (KEX) and potassium amyl xanthate (PAX), adsorbs strongly on bornite mainly in the form of insoluble metal xanthate, which binds strongly with the mineral surface without being removed by flushing with ethanol alcohol. This adsorption mechanism is very similar to the one obtained with chalcocite/xanthate system. However, the result also clearly shows that the adsorption of xanthate on bornite is totally different from its adsorption on chalcopyrite, during which oily dixanthogen is the main adsorption product on chalcopyrite surface. The obtained AFM images also showed that the adsorption increases with increasing the collector's concentration. When Cytec Aerofloat 238, a dialkyl dithiophosphate collector, is used, it adsorbs on bornite mainly in the form of an oily substance, which can be rinsed off mineral surface by flushing with ethanol alcohol. AFM images also show that the adsorption of Cytec Aerofloat 238 increases with increasing the adsorption time.

10:25 am

16-120

Reduction of NaSH Usage in Kennecott Molybdenum Plant Using AERO® 7260HFP Depressant

J. Mortensen², G. Castillo¹ and A. Lawrence¹; ¹Mineral Processing, Cytec, West Jordan, UT and ²Mineral Processing, Kennecott Utah Copper Corp., Bingham Canyon, UT

Molybdenite is often a co-product of copper in a bulk flotation circuit. In the subsequent Cu-Mo separation circuit, molybdenite is separated from copper sulfides and pyrite by depressing these using inorganic reagents such as sodium hydrosulfide (NaSH). Due to the strong binding of collectors on the surface of copper minerals, it is necessary to maintain a highly negative (reducing) oxidation-reduction potential (ORP) range. It was recently demonstrated that AERO® 7260HFP depressant is quite effective in a far less negative ORP range than that traditionally used for NaSH. This paper discusses the recent application of AERO® 7260HFP in the Cu-Mo separation circuit to significantly reduce NaSH usage. A reduction in NaSH consumption by 50% was observed at the Rio Tinto Kennecott Concentrator in Copperton, UT (RTKC). In particular, a NaSH:AERO® 7260HFP replacement ratio of ~40:1 was established. This translates into <100cc/min of AERO® 7260HFP

replacing about 4 L/min NaSH with no impact on molybdenite recovery or on the required <0.4% Cu grade in the final product sent to molybdenite roasters. Further, it translates into a reduced risk of H₂S generation/employee exposure.

10:45 am

Study on the Use of Hybrid Polymers in Sulfide Mineral Flotation

M. Hayat and L. Alagha; Mining & Nuclear Engineering, Missouri University of Science & Technology, Rolla, MO

Many industrial processes including enhanced heavy oil recovery and flotation are using polymers beside surfactants to achieve optimum performance. It is observed that in flotation, selectivity is affected through polymer surfactant interaction at different interfaces or in the bulk. Many polymers have found use in the flotation of minerals as depressants, dispersants and flocculants. The current study is carried out to investigate the effect of hybrid polymers on flotation performance of sulfide minerals in a column flotation cell. Column based Dell's simplified release analysis procedure was carried out to compare the ideal separation achieved with and without the use of hybrid polymers. Chemical and physical studies were carried out to model polymer effects on flotation performance.

11:05 am

A Critical Overview of Interactions of Dithiophosphinates with Base Metal Sulfides and Precious Metals

N. Tercero, D. Nagaraj and R. Farinato; In-Process Separations, Cytec Industries, Inc., Stamford, CT

Dialkyl dithiophosphinates are a unique class of collectors used in the flotation processing of Cu-Au, complex polymetallic, and precious metal ores. They are known to exhibit a remarkable selectivity and high flotation rates for Cu sulfides, galena, and precious metal values in the presence of other gangue sulfides, especially when compared with the closest analogues such as dialkyl dithiophosphate. Dialkyl dithiophosphinates also have an attractive SHE profile. Historically, for most reagents used in flotation, practical methods of chemical usage have preceded detailed scientific understanding of how they work; this applies also to dithiophosphinates. Recently, however, the research community has shown significant interest in this chemistry and numerous studies have been conducted to understand the fundamentals of interaction of dithiophosphinates with several base metal sulfides and precious metals. A critical overview of these studies is given in this paper, drawing on concepts and insights from coordination chemistry, fundamental studies, laboratory ore flotation, and plant practice.

11:25 am

Effects of Monovalent and Divalent Salts in Seawater Flotation

L. Pan and R. Yoon; Mining and Mineral, Virginia Tech, Blacksburg, VA

Sea water flotation is becoming a reality due to shortages of fresh water. To better understand the mechanisms involved, we have studied the effects of KCl and MgCl₂ on the surface forces present in the wetting films of water formed on hydrophobic surfaces. The measurements have been conducted using the force apparatus for deformable surface (FADS), which is capable of measuring both the surface and hydrodynamic forces responsible for bubble-particle interactions. The results obtained with the gold surfaces hydrophobized with butanethiol show that the wetting films of Ultrapure water do not rupture despite the relatively high water contact angle ($\theta = 80^\circ$). The film loses its metastability and ruptures in a 10⁻² M KCl solution by the presence of the hydrophobic force with its decay length of 23 nm. The effects of MgCl₂ has also been studied. It has been found that the film remains stable due to the decrease in the decay length of the hydrophobic force

in MgCl_2 solution. Thus, the results obtained in the present investigation support the view that the difficulties in sea water flotation may be due to the presence of MgCl_2 rather than the presence of NaCl in sea water.

Tuesday, February 23 – Morning

ROOM: 122A

9:00 am

Research: Geostatistics for Risk Management in the Mining Value Chain: Production and Reconciliation

Chairs: R. Dimitrakopoulos, COSMO Lab, McGill University, Montreal; QC, Canada
A. Samal, GeoGlobal LLC, Riverton, UT

9:00 am

Introductions

9:05 am

The Impact of “Acceptable” Levels of Blasthole Precision and Accuracy at Akyem

A. Jewballi; Newmont mining corporation, Greenwood Village, CO

Definition and delineation of ore and waste material in the pit is one of the key objectives of grade control. In most mines this process relies heavily on blasthole sampling. Blasthole sampling has a number of drawbacks namely issues with sample quality-blasthole samples in general have poor precision, in addition sample recovery from blastholes is generally poor with sample bias caused by particle size and density segregation. Like most mining companies, Newmont has internal guidelines which specify acceptable limits on blasthole precision and accuracy. This paper uses conditional simulation to assess the impact of acceptable blasthole sampling (i.e. blasthole samples within specified precision and accuracy limits) on ore and waste delineation and as a consequence on the financial returns of the operation.

9:25 am

Discussion of the Impact of Herco Parameters

R. Cooper; Newmont Mining, Colorado Springs, CO

The use of “Herco” software based on Hermitian polynomials for the calibration of grade tonnage curves is common across the industry. The details of the derivation of the parameters used in the “Herco” process have considerable influence on the outcome of the Herco results and thus the calibration process. This presentation uses case examples to examine the impact of differing Herco parameters and makes suggestions for optimal outcomes.

9:45 am

Updating Short-Term Material Flow Optimization in a Mining Complex With New Information

C. Paduraru and R. Dimitrakopoulos; COSMO Lab, McGill University, Montreal, QC, Canada

With the advent of inexpensive sensors and digital storage, increasing amounts of data about a mining complex can be collected. This can include camera imaging, mill sensors, blasthole analysis, GPS devices etc. This work shows how the reduction in uncertainty resulting from this data can be incorporated into stochastic short-term decision-making. This is done through the use of adaptive decision-making policies, which encode recipes for responding to new information

as it comes along. Focusing on short-term planning, we describe how adaptive policies for allocating the extracted material can be computed in conjunction with optimizing the schedule. The resulting plan can be applied across different short-term time scales, marking an important step towards simultaneously optimizing different time scales. An implementation of the proposed method for a copper-gold deposit shows that it can improve over heuristic simple heuristic approaches.

10:05 am

Risk Resilient Mine Production Schedules Yielding Favourable Product Blends for Rare Earth Element Deposit

M. Quigley and R. Dimitrakopoulos; Mining and Materials Engineering, McGill University, Montreal, QC, Canada

Conventional approaches for modelling rare earth element (REE) deposits often ignore the strong cross-element relationships and involve some deterministic estimate of ore quantity and quality. These models can be misleading and do not provide a mine planner with the necessary resolution to properly assess the inherent geological risk. Better representation of a REE deposits' spatial variability and uncertain characteristics coupled with advancements in the field of stochastic mine planning offer the tools to develop a mine design that will yield a higher NPV while ensuring a better performance in terms of achieving ore tonnage, ore quality and REE blend targets. The application herein consists of the joint conditional simulation of the 14 stable lanthanides and yttrium present in a monazitic REE deposit. Multiple realizations of this deposit are used to develop a risk resilient mine production schedule using a stochastic integer programming (SIP) framework that maximizes NPV while ensuring consistent ore characteristics at the head of the mill. The results of this approach are bench marked against the best known conventional practices to illustrate the numerous advantages.

10:25 am

Solving Stochastic Mine Production Scheduling Problem

K. Dagdelen, A. Van Dunem and C. Aras; Mining Engineering Department, Colorado School of Mines, Lakewood, CO

The stochastic mine production scheduling problem is a large scale optimization problem that is formulated as a mixed integer linear programming model (MILP). The stochastic MILP models require specially developed algorithms to obtain solutions in a reasonable amount of time. This paper will present the research work that is undertaking at the Colorado School of Mines for the development of a new algorithm to solve stochastic open pit mine production scheduling problems for large scale applications. The formulation and the solution methodologies will be discussed in an effort to solve problems coming from real world mining environments.

Tuesday, February 23 – Morning

ROOM: 132C

9:00 am

Three Years Later-An Update on Rio Tinto Kennecott's Manefay Landslide

Chair: B. Ross, Rio Tinto, Tucson, AZ

9:00 am

Introduction

9:05 am

Rise to the Occasion – Lessons From the Bingham Canyon Manefay Landslide

B. Ross; 90 Degree Consulting LLC, Tucson, AZ

The Manefay Landslide at the Rio Tinto Kennecott's Bingham Canyon Mine was the largest in mining history that created a crisis of epic proportion. The slide could have been deadly to the people that worked there and permanently close the historic mine, but no person was injured or killed and the mine was back in operation much sooner than just about anyone thought possible. Through the process of preparing for the Manefay – that kept people safe, and recovery from the Manefay that kept the mine in business, there were a number of lessons that are not only applicable to giant landslides, but business in general. This paper discusses some of the important lessons from the Manefay such as understanding risks, not waiting for perfect answers before acting, having a common goal that everyone understands and creating the environment and inspiration for others to achieve greatness.

9:25 am

Creating a Design Acceptance Criteria for Rio Tinto Kennecott's Bingham Canyon Mine

V. Pere; Rio Tinto Kennecott Copper, Salt Lake City, UT

The Manefay Landslide at Rio Tinto Kennecott's Bingham Canyon Mine was such a large event that it created a demand for a closer scrutiny of the way highwall slopes are designed and approved. A new method was required to ensure that the lessons from the Manefay were taken into account for future mine plans and operations to help prevent future mega-slides at the mine. To address this issue a new Design Acceptance Criteria was developed that takes in account the results from the geotechnical analysis, the veracity of the data used in the analysis as well as the location and risk to critical infrastructure and facilities. This paper discusses the factors used in the Design Acceptance Criteria and the outcomes from this work.

9:45 am

Comparing Strength Reduction Factors to Factor of Safety in Geotechnical Analysis

C. Williams; Rio Tinto, Greenwood Village, CO

Since the Manefay Slide at Rio Tinto Kennecott's Bingham Canyon Mine the Geotechnical Team has performed a multitude of different geotechnical analysis using a variety of modeling programs to create a comprehensive understanding of highwall stability at the mine. During this analytical work there was a requirement to understand and compare the resulting Strength Reduction Factor from numerical modeling methods to Factor of Safety from limit of equilibrium methods. This paper describes results of this comparison and the factors that influence these results.

Tuesday, February 23 – Morning

ROOM: 122B

9:00 am

UCA of SME I: Tunneling

Chairs: D. Kruse, Santa Ana, CA

J. Rostami, The Pennsylvania State University, University Park, PA

9:00 am

Adaptable TBMs for Efficient Mine Access Tunnels

D. Ofiara and G. Watson; The Robbins Company, Solon, OH

TBM's have been employed by mines since the 1970s, but their use has been rather limited overall, due to both perceived and actual difficulties in their

application. With new technology and recent success stories, this is changing. For both coal and metallurgical mining, deep ore bodies require long access tunnels, and an efficient method for excavating those reaches. Today, mining engineers are considering TBMs as part of the overall mine development plan. Planned TBM drifts are not only longer but also have more complex trajectories. Mine development TBMs may have to cope with varying geology, potential for high water inflows, steep gradients, and high temperatures. TBM systems are being planned to cope with such difficulties, and to do so with good efficiency. Even if commodity prices remain low, the paper authors believe TBM systems will be considered and increasingly deployed for mine development due to the need for increased productivity and safety. This paper will discuss the 2016 status of TBMs in mining applications, the special requirements, and adaptable features needed in order to make TBMs the tool of choice for mine access.

9:20 am

Influence of embankment loading on the hydro-mechanical response of a lined tunnel in saturated ground

S. PRASSETYO; Civil and Environmental Engineering, Colorado School of Mines, Golden, CO

According to Tunneling Journal in July 2015, about 80% of the U.S. population lives in urban areas. Underground constructions in these areas will have to account for embankment loads from surface infrastructure, such as residential or industrial buildings. This paper examines the influence of embankment loadings on the hydro-mechanical (H-M) response of a lined tunnel in saturated ground. Two tunnel models are created in FLAC. One is under highly permeable ground (i.e., sand) and the other one is under low permeable ground (i.e., clay), which are typical ground conditions commonly found in urban areas. The short-term and long-term H-M responses of the tunnels are investigated. These responses include the increase of pore pressure and ground deformation at the tunnel crown and the tunnel wall, which are monitored during the simulation. Axial forces and bending moment that are developed in the tunnel liner are also analyzed. Two different coupling techniques are used to simulate this H-M problem. One uses the built-in coupling technique in FLAC and the other one uses a newly developed sequential coupling technique. The accuracy and efficiency of the two techniques are then compared.

9:40 am

Applications of Rock Strength Borehole Probe (RSBP) in Underground Openings

A. Naeimipour¹, J. Rostami¹ and B. Sedat²; ¹Pennsylvania State University, University Park, PA and ²Afyon Kocatepe University, Afyonkarahisar, Turkey

Safe and cost-effective construction of tunnels/caverns is possible when ground is stabilized in a reasonable pace. Any ground instability imposes additional risks, costs and delays. This often results in very conservative ground support design due to insufficient geological data. Some measures are commonly taken to optimize the support system, such as monitoring the ground and support components (i.e. in SEM or NATM systems). However, understanding and improving ground support requires reliable data. One of the common support systems used in tunneling is rock-bolt. The rock-bolt holes can be used for probing and obtaining data from the ground, including rock strength and discontinuity pattern. This paper will introduce a recently developed probe (Rock Strength Borehole Probe or RSBP), which is designed to estimate the rock strength by scratching the borehole wall. In this tool the data from various sensors, namely the normal force, the scratching position and the scratch depth, is recorded on a mini SD card by a micro-controller. RSBP applications and design considerations will be discussed in this paper, along with the results of preliminary laboratory and field tests.

10:00 am

New Concepts/Developments in Mobile Cutting Equipment

S. Dube, Herrenknecht

Herrenknecht successfully developed and entered the market with the next generation of mobile cutting equipment with their strive to increased automation and safety. This session will outline further concepts and ideas which are being pursued by Herrenknecht using developed technology and adapting it to market requirements. Concepts will include usage of raise drill for horizontal cross cuts, boxhole back reaming for a combined approach of boxhole and raise drill and the reef boring machine.

10:20 am

Quality Management System on Sound Transit Underground Projects

M. Saleem, Sound Transit

On an underground construction projects, effective Quality management is essential to ensuring facility durability, life cycle performance and low maintainability. Furthermore, follow on contracts also rely on an effective Quality management system for interface congruency. For the past 15 plus years Central Puget Sound Regional Transit Authority's Link Light Rail extension has successfully completed over 10 miles of twin bore tunneling and associated underground features including cross passages, deep sump structures and shafts. After the completion of each segment, lessons learned have successfully been implemented to improve the quality of delivered projects. This paper presents the Sound Transit Quality Management System with regard to a number of project elements of tunnel construction projects, with specific focus on Quality performance of TBM boring, launch box excavation, segment construction, cross passages, slurry walls, and other associated construction features. A collaborated Total Quality Management System will be presented in this paper that will serve as a guide of successful Quality implementation.

10:40 am

Study of the Correlation Between RMR and TBM Downtimes

O. Frough and J. Rostami; Dept. of Energy & Mineral Engineering, Pennsylvania State University, State College, PA

Tunnel Boring Machines (TBM) is increasingly used in tunneling projects all over the world. In any operation, machine performance is very sensitive to ground conditions and can be substantially impacted by variations in rock type, strength, jointing, and rock mass classes. Adverse ground conditions such as mixed face, high water inflow, rock instability often have a great impact on TBM downtimes and can considerably reduce the machine utilization. In this paper, the influence of rock mass properties on machine utilization and downtimes were examined. The result of statistical analysis on available field data indicates that the geology and rock mass related downtime can be estimated from rock mass parameters. For this purpose data from three long mechanized tunnels recently completed by TBM was used to evaluate the relation between engineering geology information and daily machine utilization and downtime. Various regression equations were developed to offer empirical models for estimation of machine utilization and RMR. Results of this study showed that the relationship between RMR classification system and rock mass related downtimes can reach correlation coefficient (R^2) of 0.62.

10:20 am

The Impact of Approach Shallow Twin Tunnels on the Convergence

F. Jamshasb; Iranian Mining Engineering Organization (IMEO), Tehran, Iran (the Islamic Republic of)

Underground construction in all developed cities is all important for passenger transportation, Tunnels excavating in urban subway are usually in twin format. Most of the tunnel on the parallel excavation of twin tunnels had located near the surface. The twin tunnel excavation would influence through the convergence of each tunnel. In this article the author founded simplified relationships to help tunnel designers to find the optimum distance from center to center tunnels to minimize the effect of the twin tunnels convergence. The numerical investigation performed in this study, using the FLAC^{2D} finite difference element program, has made it possible to define five different scenarios to discuss the distance influence between center to center of the two tunnels. Finally the relationship between several variables based on data from the Matlab software fit has been obtained.

ROOM : 129AB

4:00 pm

Barrick North Americas OPERATORS SESSION Professionalism and Your Iron Ring

Corey Ciocchetti, an Associate Professor of Business Ethics and Legal Studies at the University of Denver, Corey Ciocchetti is one of the University's most popular and highest-rated professors. Corey joined DU after graduating with a law degree from Duke University School of Law, a Masters degree in Religious Studies and two Bachelors degrees in Finance and Economics—summa cum laude—from the University of Denver.

In this talk, Corey takes a look at historical examples of professionalism and compares them to the examples set by contemporary professionals such as professional athletes, lawyers and business executives. The story of the iron ring and the professional oath taken by Canadian engineers is recounted and audiences are encouraged to create their own version of an iron ring and act like professionals regardless of their chosen career. Corey also discusses the ways that society judges its professionals—especially by the way they speak, think, dress, listen—and what character attributes society expects of its professionals.

Tuesday, February 23 – Afternoon

ROOM: 224B

2:00 pm

Coal & Energy: Dust Control II

Chairs: T. Beck, NIOSH - Office of Mine Safety and Health Research, Pittsburgh, PA

W. Wedding, University of Kentucky, Lexington, KY

2:00 pm

Introductions

2:05 pm

Technical Measures for Dust Control in Underground Mines

K. Bartke; Engineer of Mining, M.Sc., Wiesbaden, Hesse, Germany

One of the most important tasks in order to guarantee the health and safety of miners in underground mines are measures for dust control. Overexposure to respirable dust can lead to deadly lung diseases. In coal mines dust can cause terrible coal dust explosions. At the Upper Big Branch Mine the death of 29 miners was caused by such an explosion in 2009. After explaining the basics for dust control the presentation focuses on the efficiency of the different technical measures and especially on the wet and dry dedusting systems. For the acceptance of underground mining in the future it is necessary to make new efforts in order to reduce the dangerous risks of dust in underground mines to an absolute minimum.

2:25 pm

Development of an Automated SEM-EDX Routine for Characterizing Respirable Coal Mine Dust

V. Johann and E. Sarver; Mining and Minerals Engineering, Virginia Tech, Blacksburg, VA

Incidence rates of coal workers' pneumoconiosis (CWP) and other related respiratory illnesses remain unacceptably high in Central Appalachia. Changes in specific dust characteristics, such as particle size, shape or chemical composition may offer a possible explanation. Automated SEM-EDX analysis of coal mine dust samples can be used to quantify these particle characteristics at a much faster rate than manual analysis. Automation also reduces user bias in interpretation of EDX spectra and allows for a more reproducible data collection method. In order to develop a reliable automated routine, the software must be programmed to consistently detect all particles in the size range of interest, properly "cut" agglomerated particles, and appropriately classify particles by chemical composition. In short, the automated routine must be able to characterize dust particles in the same manner a user would manually. This paper discusses the development of an automated SEM-EDX routine for coal mine dust characterization and compares results obtained using the automated routine versus those obtained manually for five dust sample fields.

2:45 pm

A TGA Method for Analysis of Respirable Dust from Underground Coal Mines

M. Scaggs, E. Sarver and C. Keles; Mining and Minerals Engineering, Virginia Polytechnic Institute and State University, Blacksburg, VA

The coal mining industry has worked for decades to lower the risk of Coal Miners' Pneumoconiosis (CWP) and silicosis. However, incidence of occupational lung disease amongst miners in Central Appalachia and elsewhere remains unacceptably high. Dust characteristics and the potential impact on health outcomes have yet to be fully explored. Mass concentration silica content of exposure are the basis for current compliance efforts, but thermogravimetric analysis (TGA) offers a means for gathering more information about respirable dust samples – including the total coal to total mineral mass ratio, which may be helpful in comparing conditions in different areas of a mine or between mines. TGA may also allow for estimation of the rock dust (i.e., carbonate) fraction, specifically. Here, we present a standard TGA method that approximates the mass fractions of coal, rock dust, and "other minerals." The method involves first removing dust particles from the collection filter by sonication. Results are presented with multiple filter types. Keywords: Thermogravimetric Analysis (TGA), Respirable Dust, Rock Dust, Occupational Lung Disease, CWP.

3:05 pm

16-017

Comparing the Air Quality Inside Enclosed Cabs of Two Pieces of Underground Mining Equipment with MERV 16 and HEPA Quality Filters

A. Cecala, J. Organiscak, J. Noll and J. Zimmer; DVTSB, NIOSH, Pittsburgh, PA

Significant strides have been made to optimize the design of filtration and pressurization systems used on enclosed cabs of mobile mining equipment to reduce respirable dust and protect equipment operators. Considering all the advances and strides made in this area, one area that still needed optimized was the quality of filters in filtration and pressurization systems. Researchers for NIOSH hypothesized that HEPA quality filters were not optimal for the mining industry and speculated that MERV16 rated filters would be a more appropriate choice in most cases. To test this, NIOSH performed a two year study evaluating both HEPA and MERV16 quality filters on two pieces of underground mining equipment, a roof-bolter and face drill. The results of this testing showed there was no statistical difference between the two filters on both pieces of equipment at the 95 pct. confidence level. Since the MERV16 filter is less restrictive, provides greater cab pressure, and since it did not have to be replaced as often, it was the optimal choice for both pieces of mining equipment in this case study comparative analysis.

3:25 pm

16-029

Computational Fluid Dynamic Modeling of a Medium-sized Surface Mine Blasthole Drill Shroud

Y. Zheng¹, W. Reed¹ and L. Zhou²; ¹Dust, Ventilation and Toxic Substances Branch, National Institute for Occupational Safety and Health, Pittsburgh, PA and ²Fires and Explosions Branch, NIOSH CDC, Pittsburgh, PA

The National Institute for Occupational Safety and Health (NIOSH), Office of Mine Safety and Health Research (OMSHR) has recently developed a series of models utilizing Computational Fluid Dynamics (CFD) to study airflows and respirable dust distribution around a model of a medium-sized surface blasthole drill shroud with a dry dust collector system. The dust flow input into the CFD models was calibrated using the case having 300 cfm bailing airflow with dust collector-to-bailing airflow ratio 2:1. The subsequent simulation models were then compared with experimental results for other scenarios, including 300 cfm bailing airflow with 3:1 and 500 cfm bailing airflow cases with 2:1 and 3:1 dust collector-to-bailing airflow ratios. The CFD calculated dust levels were within the 95% confidence intervals of the lab experimental dust concentrations. This paper describes the methodology used to develop the CFD models, to calibrate the model dust input, and to validate the models. Problem regions were identified and visualized by the simulation. The simulation results can be used for future development of dust control methods for the surface mine blasthole drill shroud.

3:45 pm

16-162

Reducing the Cost and Risk of Dust Collection in Coal Handling

A. Marti¹ and D. Marshall²; ¹Corporate Marketing, Martin Engineering, Neponset, IL and ²Product Engineering, Martin Engineering, Neponset, IL

Recent regulations, as well as a general aversion to central dust collectors within the coal community, have created a need for an alternate method for eliminating airborne dust. This paper addresses the capital expenditure as well as the cost of ownership of a point source air cleaning system in comparison to a central collection system. This assessment was conducted by comparing the cost to purchase and operate a central dust collection system and point specific air cleaners on a typical multiple transfer point application. The assessment yielded a 73% reduction in capital expenditure and a 24% reduction in operating costs for the same

application when using individual dust filters as opposed to a central system. In addition to the lowered cost, there are reductions in risk associated with the elimination of ductwork and the central containment enclosure for collected explosive dust. By the conclusion of this paper, the reader will have a better understanding of the quantifiable differences between a central dust collection system and a set of point specific air cleaners.

Tuesday, February 23 – Afternoon

ROOM: 224A

2:00 pm

Coal & Energy: Geologic Challenges in Underground and Surface Mining-Case Studies

Chairs: A. Iannacchione, University of Pittsburgh, Pittsburgh, PA
N. Iannacchione, Indiana University, Bloomington, IN

2:00 pm

Introductions

2:05 pm

Analyses of Pre-Driven Longwall Recovery-Room Stability for Challenging Geologic Conditions

H. Maleki; Maleki Technologies, Inc, Spokane, WA

Longwall recovery operations are generally accomplished by using either standard practices or alternative approaches adopting pre-driven recovery rooms supported by a variety of internal and external support systems. In this paper, a two prong approach is used for evaluation of ground response during longwall recovery operations. First, more elaborate multi-variable statistical analyses of 130 cases (reported by Niosh) is completed, highlighting significant geologic and mining factors affecting the stability of pre-driven recovery rooms. Second, ground reaction to the longwall load is analyzed using boundary-element and finite-difference analyses, including three mining steps, different cave conditions, and a variety of primary, secondary and standing support systems with and without backfill. While back fill support is shown to be effective in stabilizing ground conditions, analyzed internal and standing support are shown to be inadequate to control convergence for the weakest analyzed geologic conditions. Modeling results are in good agreement with successes and failures observed by the author in more recent investigations in the western U.S. operations.

2:25 pm

16-005

Updated Study of A Low Overburden Longwall Recovery with Pre-Developed Recovery Entry

B. Hanson³, R. Ochsner³, J. Stankus¹ and X. Li²; ¹Jennmar Corp., Pittsburgh, PA; ²Jennmar Corp., Pittsburgh, PA and ³Signal Peak Energy, Roundup, MT

Bull Mountains No. 1 mine of Signal Peak Energy made another success in its 4 Right pre-developed recovery entry on March 23 and 24, 2015, after the first successful cut-through and shield retrieval of 3 Right in 2014. Under the same geological conditions, the major difference of 4 Right and 3 Right is the 600 psi Unconfined Compressive Strength (UCS) value of light-weight concrete in 4 Right versus 800 psi in 3 Right. One more recovery chute was added in 4 Right. The unique geology in this mine includes: (1) low overburden of 200-250 ft, (2) prevalent roof joints, (3) proximity of the rider seam to the bench seam, and (4) prompt surface subsidence with face advancement. The 4 Right recovery entry was 42 ft

wide and developed in two stages, first reinforced with steel wire mesh/ recovery mesh, primary bolts, and high-capacity SUMO cables, then completely backfilled with low-density cement. It took about half time to cut through the concrete with less dust in 4 Right as compared in 3 Right. The updated study further explored the nature and mechanism of effective roof control in the pre-development recovery entry of this mine, providing the safest working environment for the miners.

2:45 pm

Collaborative Approaches to Solving Geotechnical Challenges in the Mining Environment

C. Lange; Engineering and Business Development, Nicholson Construction Company, Cuddy, PA

Geotechnical construction in the mining environment includes earth retention systems and deep foundation systems. The geotechnical contractor is an expert in a variety of techniques and construction means and methods that allow the geotechnical contractor to optimize solutions given the particulars of the site access constrains, ground conditions, performance criteria and geotechnical risk. Mining owner collaboration between the design team and geotechnical contractor allows selection of the optimum solution. Two case studies are discussed that showcase this collaboration; a contractor-designed earth retention system and a contractor-design deep foundation system each of which offered a price and schedule savings over the original solutions.

3:05 pm

Evaluating the Effect of Geology and Horizontal Stress on Pennsylvania's Underground Bituminous Coal Mines through Abandoned Mine Maps and ArcGIS

A. Iannacchione¹ and N. Iannacchione²; ¹Civil and Environmental Engineering, University of Pittsburgh, Pittsburgh, PA and ²Safety Science, Indiana University of Pennsylvania, Indiana, PA

Underground Bituminous coal mining has occurred in western Pennsylvania for over 150 years. During this time, thousands of mines have been worked out and their maps collected and digitized by a number of government and academic institutions. In the past, information about individual mining experiences resided only in publications or government/industry files. Today, many of these maps are available through government sponsored websites. The University of Pittsburgh has analyzed a portion of these maps, looking for examples of geologic and horizontal stress related features that affected mine layouts. Over twenty case study examples were entered into ArcGIS, inventoried, analyzed, and presented in this paper.

3:25 pm

Impacts of Unfavorable Geologic Conditions on Longwall Mining Operations, Case Histories

C. Stewart; Consultant, Farmington, NM

This paper reviews the impacts of unfavorable mine-site geology on mine operations based on the author's 30-plus years of experience as a mine-site mining and geotechnical engineer at longwall coal mines in Colorado, New Mexico and Wyoming. Three case histories are presented in summary form: the impact of faulting on face operations at a coal mine in northeast New Mexico; the impact of a highly disturbed, faulted, "shear" zone at a coal mine in southern Wyoming characterized by mining of a thick coal seam with very weak roof strata and weak overburden strata; and, the impacts of adverse geology on face mining and headgate and tailgate stability at a deep coal mine in Colorado. Each case study summarizes the basic mine plan, the site-specific geologic framework, the impacts of the negative geology on mine operations, tools used in the analysis and remediation of the negative geology and lessons learned from the case history. A

fourth case history is presented; the ongoing analysis of the long-term stability of 884 main entry intersections at a coal mine in New Mexico characterized by weak to very weak roof strata, weak overburden strata and deep overburden cover.

3:45 pm

16-090

Geological Conditions and Influences on Ground Control at San Juan Mine

D. Burkhard; Planning Services, BHP Billiton New Mexico Coal, Aztec, NM

Geologic structure and properties are the primary influences on ground control at San Juan Mine. Geotechnical properties of the coal seam and near seam strata, the presence of above seam sandstone paleochannels and water, are thought to be the leading contributors to ground control issues. It is the confluence of specific geologic conditions rather than isolated features that most often produce adverse conditions. Altering primary support installation and mining practices are done when unfavorable conditions appear during development. Installation of standing support is most often employed when adverse conditions develop at later dates.

4:05 pm

Spontaneous Combustion Problems and Treatments at one Lead and Zinc Underground Mine

F. Yang¹, J. Tien², E. Jong¹ and M. Thiruvengadam³; ¹Mining and Mineral Engineering Department, Virginia Tech, Blacksburg, VA; ²Monash University, Clayton, VIC, Australia and ³Mining and Nuclear Engineering Department, Missouri University of Science and Technology, Rolla, MO

Spontaneous combustion (SponCom) is an exothermic chemical reaction between sulfide ore constituents and oxidants. And the heat release rate by exothermic process exceeds that of heat loss or dissipated. Spontaneous oxidation of sulfides poses hazardous safety and health problems to miners, and causes economic losses to mineral properties. Once surrounding combustibles are ignited and there are few effective treatments to combat the fire disaster. The geological and crystal relationships of sulfide minerals (pyrite, marcasite, sphalerite and galena) in the original deposit was introduced. This paper discusses the problems of self-heating based on field observations and investigations of both underground sulfide ores and aboveground concentrates in the mineral processing plant. Carbonaceous shale and carbonaceous mudstone and their contributions to spontaneous combustion were also mentioned. And comparisons between several site-available treatment methods to prevent sulfide oxidation and combustion were made. A Computational Fluid Dynamic (CFD) model was made to attempt to simulate the interactions between airflow and heat released from the SponCom.

Tuesday, February 23 – Afternoon

ROOM: 229A

2:00 pm

Coal & Energy: Refuge Alternatives for Underground Coal Mines II

Chairs: T. Lutz, DHHS/CDC/NIOSH, Pittsburgh, PA
D. Yantek, NIOSH OMSHR, Pittsburgh, PA

2:00 pm

Introductions

2:05 pm

Refuge Alternative, Protecting the compressed air line

J. Silva-Castro and B. Lusk; Mining, Assistant Professor, Lexington, KY

Compressed air lines are used to supply breathable air to refuge alternative in underground mines. To guarantee the success of the system and maintain a safe atmosphere for the trapped miners, the integrity of the compressed air line must be kept all times. A NIOSH sponsored project is under development by the University of Kentucky, to explore in a practical way through laboratory testing, the design and construction considerations regarding compressed air lines to a refuge alternative. These considerations include among others: air lines materials, bending strength requirements, anchoring systems and protection of the compressed air lines against explosions and live loads. To date; several types of pipes of different materials like aluminum, cast iron, copper and high density polypropylene have been tested under static and dynamic conditions. To simulate an underground mine explosion, the compressed air lines has been tested in a shock tube in the explosive research facility at the University of Kentucky. This document shows the up to date results and data collected during the dynamic testing to evaluate the most adequate procedure to protect the compressed air lines.

2:25 pm

Universal thermal model of refuge shelters

D. Bahrami and G. Danko; Mining Engineering, University of Nevada, Reno, Reno, NV

The Mine Improvement and New Emergency Response Act of 2006 mandates the use of emergency rescue chambers in all US coal mines. One solution is the use of RA, emplaced within 1,000 feet from the workers. The results of a NIOSH measurement program have shown that the environment inside an occupied RA may exceed the threshold of 35 °C apparent temperature, T_a , within the required 96 hours of sheltering time. The criticality of deploying an RA depends on the pre-accident in-situ thermal and ventilation environment of a given mine at a given location. Underground coal mines in the US may have cold strata conditions at around 10 °C (50 °F), or as high as 30 °C (85 °F), (e.g., in Alabama in the summer). Seasonal variations in the air and strata temperatures may also affect the criticality of deploying an RA at a mine. A universal thermal model is being developed to evaluate the safe deployment of any RA specified by its manufacturer, in any underground mine in-situ conditions. An easy-to-use, interactive graphical interface is designed to define the RA model. The paper discusses the elements of the model and its application to match the measurement results in the NIOSH experimental RA.

2:45 pm

Movable Safe Haven wall for Built-In-Place Refuge Alternatives

B. Lusk and K. Perry; Mining Engineering, University of Kentucky, Lexington, KY

Problems exist with current refuge options for post incident response such as reluctance from miners to make use of refuge chambers (either steel box type or inflatable tent system), a finite supply of breathable air, search time for rescue teams tasked with clearing each refuge chamber, and also the lack of approval by MSHA for safe haven subsystems and structural components. The problem area is specific to any underground mine where refuge alternatives are required by law. This paper presents the design and development of a movable safe haven wall. The built-in-place (BIP) safe haven wall utilizes steel and polycarbonate as the primary materials and offers a slight adjustment in height (approx. 12 inches) to account for varying roof heights. Following the publication of NIOSH RI 9698 (Facilitating the Use of Built-in-place Refuge Alternatives in Mines), novel solutions for 15 PSI safe haven walls will be required. The paper also highlights the design recommendations within RI 9698 and how they correspond with MSHA policy on approval of safe haven walls and refuge alternatives.

3:05 pm

Built in Place (BIP) Refuge Alternative Testing with a Borehole Blower

J. Piercy² and E. Roscioli¹; ¹Exec, ChemBio Shelter, Inc., Allentown, PA and ²Engineering, ChemBio Shelter, Inc., Sophia, WV

This paper describes the testing that was done at the Bruceton Experimental Coal Mine using a Built In Place Refuge Alternative with a borehole and borehole blower. Descriptions of the equipment, test setup, test procedure, and the test results are presented. These tests were performed as part of ChemBio Shelter's Safe Air System application for Part 7 approval of the Safe Air System with the Mine Safety and Health Administration (MSHA).

3:25 pm

Overview of NIOSH Research on Built-in-Place Refuge Alternatives In Underground Coal Mines

R. Matetic¹, D. Yantek¹, A. Smith¹, E. Thimons² and J. Srednicki¹; ¹NIOSH OMSHR, Pittsburgh, PA and ²NIOSH OMSHR (Contractor), Pittsburgh, PA

In a 2007 report to Congress, The National Institute for Occupational Safety and Health Office of Mine Safety and Health Research stated that built-in-place (BIP) refuge alternatives (RAs) provided significant advantages over mobile RAs. At present, BIP RAs are impractical to use at the working face in coal mines. BIP RAs would be practical if three issues are addressed: (1) allowing BIP RAs at greater distances from the working face; (2) developing a reliable process for the design/approval of BIP RA stoppings meeting the 15-psi design criteria; and (3) developing systems that reliably deliver breathable air to the RA. For research purposes, OMSHR constructed a BIP RA in its Experimental Coal Mine in Pittsburgh and discovered several issues related to the delivery, distribution, and exhaust of ventilation air to the RA, and the design of stopping/door systems for BIP RAs. This paper will discuss these issues.

3:45 pm

16-128

Cryogenic Refuge Alternative Supply System (CryoRASS) tested in a Built-in-Place RA

D. Doerr¹, E. Blalock² and D. Bush³; ¹Engineering, Liquid Air Breathing Technology, Merritt Island, FL; ²President, BCS Life Support LLC, Titusville, FL and ³Biomedical Engineering, NASA, Kennedy Space Center, FL

A new technology Refuge Alternative supply based on a cryogenic gas was developed, tested, and reported to the 2015 SME. This prototype system has been re-designed to meet the needs of a 40 person BIP (built-in-place) Refuge Alternative. Two liquid air storage vessels fed two air-handler units that supply necessary oxygen and air circulation. Representative heat and moisture was added to the BIP while temperature, pressure, gas concentration, and flow data were digitally monitored. The major benefit of this new technology was the provision of heat stress relief by circulating refuge gases through air-handlers which contain the heat exchangers necessary to warm the very cold (-318°F) liquid air to a gas. Further, this process condenses water vapor thereby lowering humidity. The liquid air supply ran the required 96 hour test and demonstrated cooling. Other testing confirmed minimal stored liquid loss when power to the cryocooler was lost over an extended period. In summary, the liquid air supply provided the necessary oxygen (component in air), while providing heat stress relief via cooling and reduced humidity.

Tuesday, February 23 – Afternoon

ROOM: 229B

2:00 pm

Coal & Energy: Ventilation Best Practices II

Chairs: E. Jong, Virginia Tech, Arlington, VA

E. Zeglen, Alpha Natural Resources, Bristol, VA

2:00 pm

Introductions

2:05 pm

Mine Accident Data Analysis as Big Data Using Microsoft Visual Basic for Application (VBA)

F. Yang, K. Luxbacher, E. Jong, H. Dougherty and C. Brown; Mining and Minerals Engineering, Virginia Tech, Blacksburg, VA

Dataset collections of mining accidents, injuries, fatalities, employment, production, etc., are made by MSHA under Part 50 of the U.S. Code of Federal Regulations (CFR). And NIOSH has converted MSHA data to SPSS and dBase IV file formats for 31 years (1983 to 2013). The huge data of mining accidents during last decades can be considered as “big data”. The dBase IV file (the .dbf file) can be opened in the Microsoft Excel. The Microsoft Visual Basic for Application (VBA) routine can be coded to facilitate mine accident data analytics. Desired data can be captured, extracted and transferred automatically from a massive dataset based on the searching criteria such as mine fires and the work load of data analysis is reduced tremendously. All the customized and selected data during last decades can be integrated into a master file automatically. An example of mine fires in coal mines was discussed in the paper. VBA programming is a helpful and efficient tool to better take advantage of mine accident datasets collected by MSHA. Big data Analytics by VBA routine of mine accidents can find correlations, conclusions and prevent/eliminate accidents, injuries and fatalities.

2:25 pm

16-132

Face Ignitions in US Coal Mines and Prevention Technologies.

A. Verma and J. Brune; Mining Engineering, Colorado School of Mines, Golden, CO

Face ignitions in underground coal mines are a major risk for underground mine operations, as they can lead to a methane or coal dust explosions. The 2010 disaster at the Upper Big Branch Mine caused 29 fatalities due to a methane and coal dust explosion initiated from a face ignition. Much research has been conducted to mitigate the face ignition hazard, from water sprays to active, triggered explosion barriers. Despite the use of water sprays in underground mines there have been more than 50 cases of face ignition in U.S. mines since 2010. This paper will examine the statistics of face ignitions and gas explosion in US mines based on MSHA data. It will also include the brief summary of factors contributing towards these face ignitions. It will then outline best practices for the prevention of face ignitions, based on experience worldwide.

2:45 pm

Numerical Study on Blast-Wave Features of Methane Explosion in an Underground Airway Network

L. Wang; Resource and Environmental Science, Chongqing University, Chongqing, China

The space of constrained methane explosion can be divided into two segments, a driver section and a blast-wave section, according to their distinctive explosion features. This paper will focus on the numerical modeling for the blast-wave section, where turbulence and combustion phenomenon are ignored. The geometrical models of the blast-wave section can therefore be simplified into one-dimensional (1D), which could significantly reduce computational cost without compromising accuracy. Readily available explosion source data in the previous study can provide initial and boundary conditions for the 1D model here. The attenuation effect due to geometric changes is also considered in the analysis by modifying factors of specific components in the 1D network geometry. When analyzing blast-wave section, one dimensional CFD code Flowmaster is selected as the tool to perform network-based predictions. Experimental mine owned by Missouri University of Science and Technology will be used as the prototype of the explosion site. Explosion characteristics such as overpressure and temperature in varying regions of the mine will be investigated.

3:05 pm

Review of Auxiliary Ventilation in Mine Planning and Design

P. Rostami and L. Landon; Mining, Stantec Consulting Inc., Tempe, AZ

Auxiliary ventilation plays a key role in the development of underground mines and areas remote from the primary ventilation systems. Environmental conditions play a large role in the design and operation of an auxiliary ventilation system. Air density, wet/dry bulb air temperatures at the intake, geo-thermal gradient, virgin rock temperature (VRT), rock characteristics and properties, heat and emissions from equipment, air-born dust, water inflow and temperatures, and humidity effect the overall air quality and need to be reviewed and understood for better planning and design. The planning and design phase not only influences the efficiency but the effectiveness of ventilations systems and their ability to provide a safe working environment. This paper reviews the best practices for design and implementation of auxiliary ventilation systems in an underground mining environment. Various ventilation arrangements, development types, and input parameters were studied and pros and cons of each system were summarized with regards to mine economics, practicality, implementations, and the health and safety of personnel.

3:25 pm

16-037

Real-time Diesel Particulate Matter (Dpm) Monitoring in Mines a Review

M. Khan; Mining and Nuclear Engineering, Missouri S & T, Rolla, MO

Diesel exhaust is a major cause of large number of occupational diseases. Acute and continuous exposure to Dpm can cause numerous health issues including respiratory disease, reduced lung capacity, heart disease etc. The NIOSH and the IARC consider diesel engine exhaust as carcinogenic. In large underground metal and nonmetal mines, regulatory compliance regarding miner's exposure to airborne particles especially Dpm is a big challenge. Complex mine networks add more difficulties in controlling Dpm. MSHA relies on the NIOSH 5040 method for Dpm compliance. The NIOSH 5040 method is a shift average based method which inherits some limitations. Due to these inherent limitations of the NIOSH 5040 method the concept of real-time Dpm monitoring is promoted. Several real-time Dpm monitors have been used by the researchers and efforts still continues to improve their measuring techniques and understanding. Real-time monitoring of Dpm is vital to gain understanding of rapid changes in the mine atmosphere. The current study highlights the advancement in real-time Dpm monitoring and mainly covers a review of several studies in which Dpm concentrations were measured by real-time Dpm monitors.

Tuesday, February 23 – Afternoon

ROOM: 226A

2:00 pm

Environmental: Responsible Mining Environment and Social Risk I

Chair: M. Jarvie Eggart, Barr, Marquette, MI

2:00 pm

Introductions

2:05 pm

Renewable Heat For Mining

A. Dixon; Mining, Pontificia Universidad Católica de Chile, Santiago, Chile

Geothermal energy is safe, clean and renewable and has been used in many ways for several decades. Modern geothermal power plants are designed to re-inject the used water back into the reservoir so the only thing they mine is “heat”. Geothermal power generation technology commonly used today is well understood, but the geothermal resource assessment and deep drilling techniques are still evolving to be more accurate and efficient. As geothermal resources and underground orebodies are often located in their physical proximity, this paper describes how readily minable geothermal heat can help mining operations. The simplest way to harness heat from high enthalpy geothermal resources is to generate electricity to be used for mining operations. However, the focus of this paper is to introduce different types of usages of low enthalpy geothermal resources that are already assessed and do not require extensive drilling due to previous mining activities, share some examples of flooded abandoned mines, and finally give some detailed thoughts on innovative uses of mined heat in Chile.

2:25 pm

Beyond Tribal Consultation: Mining Educational Modules

C. Koch; Soil, Water, Environmental Science, University of Arizona, Tucson, AZ

Increasingly tribes are extending their scope of sovereignty to include resource development projects. Combined with past traumatic experiences of exploitation, tensions continue to heighten when resource developers do not use proper government-to-government consultation in proposing and negotiating mining sites. Tribes have an urgent and critical need for legislation and information that can protect them from further exploitation and understanding tribal consultation, negotiation, and mineral rights so they can make an informed decision about resource development on their lands and for their people. This tribal consultation mining module aims to increase tribal members' understanding of consultation, rights of indigenous peoples under the United Nation Declaration on the Rights of Indigenous Peoples and the difference between tribal sovereignty and government-to-government consultation. This module aspires to go beyond consultation to explore partnerships that exemplify positive relationships by providing case studies and best practice models from industry and tribal perspectives. This module can be modified to different learning scenarios and used for mining personnel training.

3:05 pm

Sustainability in a None Sustainable Industry

G. Walton; Endeavour Silver, Vancouver, BC, Canada

Sustainability is important in Endeavour Silver because it is how we do business, how we treat the communities around our operations, our employees and the responsibility that we have for the environment that we operate in. We have now

completed 2 full sustainability reports at a G4 level and gradually improve our reporting each year and our transparency in how we do our business. Sustainability has been an pillar in Endeavour's business model and core values for many years. Our sustainability report is available on our website and hard copies are available to anyone who is interested in obtaining one.

3:25 pm

Managing Risks from Artisanal Mining Through Industry-University Collaboration

N. Smith¹, J. Smith¹, B. Teschner² and Z. John³; ¹Colorado School of Mines, Golden, CO; ²Colorado School of Mines, Golden, CO and ³Chemonics International, Washington, DC

Artisanal and small-scale mining activities can pose significant environmental and social risks to large-scale mining projects. This paper examines an attempt to mitigate some of these risks through a collaboration between a mining company and the Colorado School of Mines. It demonstrates the ways in which graduate and undergraduate student projects can provide critical insights on environmental and social risk management. Furthermore, it proposes a model for constructive industry and academic partnerships that support corporate social responsibility initiatives and provide student learning opportunities.

Tuesday, February 23 – Afternoon

ROOM: 226B

2:00 pm

Environmental: Sustainable Outcomes of Effective Stakeholder Engagement

Chairs: S. Fecht, Ramboll ENVIRON, Westford, MA
L. Wrong, Lundin Mining, Toronto, Ontario, Canada

2:00 pm

Introductions

2:05 pm

16-081

Human Rights and Business Procedures: Grievance Mechanisms. Using Data To Improve the Relationship With Stakeholders: How Feedback Processes are Helping to Minimize and Avoid Conflicts While Reinforcing Engagement

C. Eddine; Public Admin, University of Victoria, Vancouver, BC, Canada

Can we use data to make communication effective? How does one successfully tackle the challenge of solving cultural differences and harmonizing the needs of diverse stakeholders while developing and maintaining a strong and reliable corporate image? Integrating social, environmental, and economic values plays an imperative purpose in preserving a productive and trustworthy relationship with stakeholders. We add value to a positive image of our industry by embracing responsibility for corporate actions and promoting their beneficial impact on the environment. The social context within communities, groups and organizations is dynamic and presents new challenges as the connections evolve. There are wildly diverse expectations which one may need to address during both the exploration and mining phases. Disagreements are an inevitable consequence of interactions due to the different needs and requirements of the parts involved. Nevertheless, balancing differences and solving conflicts can offer remarkable opportunities for improvement.

2:25 pm

Case Study: Fostering Renewable Energy in Arizona

K. Parameswaran; tfgMM Strategic Consulting, Scottsdale, AZ

Arizona has a mandate requiring certain utilities to obtain 15% of their electricity production from renewable energy sources by 2025. Mining companies generally have large land holdings. Moreover, mines represent large electricity loads and have the necessary critical infrastructure including transmission lines, roads and utilities. They also have access to heavy earthmoving equipment. Despite these advantages, siting a utility scale solar facility on disturbed or unutilized mine lands has proved quite difficult. The Pima Mine Road Solar Generating Facility, also known as the Avalon Solar Project, is a utility-scale 35-megawatt (MW) single-axis tracking solar power photovoltaic (PV) facility. This panelist will discuss the evolution of the Avalon Solar Project, a unique collaboration between ASARCO LLC, a primary integrated copper producer, the utility Tucson Electric Power and the solar energy developers Clenera, LLC, Panasonic EcoSolutions and Coronal Group. In particular, he will present the perspectives of the mining company, utility and solar developer in the context of stakeholder engagement and discuss what was involved in the successful implementation of the project.

2:45 pm

Sustainable Outcomes from Effective Stakeholder Engagement

R. Holmes; Energy Mines and Resources, Government of Yukon, Whitehorse, YT, Canada

Project success depends on effective engagement with stakeholders. Review processes are more “democratized” now as a result of social-media, allowing grass-roots support for causes/ideas & reducing reliance on government decision-makers. First Nation land rights are unclear & subject to court challenges, contributing to uncertainty. Increased socio-economic effects emphasis, not just environmental. “Social license” is a restructuring of industry’s engagement with the public, similar to other major industrial shifts seen over the last century (e.g. workplace health & labour and environmental protection). Effective engagement requires a number of actions, including: -Initiate engagement early & continued engagement; -Flexibility on processes/outcomes. -Determine real people’s concerns, not just focusing discussions on general societal benefits/technical plans. -Understand different risk perspectives and reconcile; -Timely engagement & application of the right skill sets to build common ground. -Failure to achieve common understanding can undermine a project forever, not just at the initial stages. -Government to set out clear public engagement expectations.

3:05 pm

Unravel Social Performance: the Case of Hecla’s Casa Berardi

J. Forget[†] and L. Russell[‡]; Hecla Mining, Coeur d’Alene, ID

There is an increasing need for proponents to measure and monitor their social performance, but many organizations put emphasis on guidelines and programs rather than outcomes. Social risks are heavy contributors to mining projects’ delays and costs and relevant social performance systems became paramount in anticipating and addressing those risks. The monitoring exercise is very important for learning organizations, but if the measurement system is inadequately designed, the actual social risks might not be captured and addressed. How to make this social monitoring relevant? How to make it credible to stakeholders? What should it entail? The exercise conducted at Casa Berardi was about developing a concrete, operational and efficient social performance system with sufficient participatory mechanisms to be meaningful to all stakeholders. We all know now that social performance is not only about measuring and monitoring publicly disclosed commitments, but it is also, and especially, about measuring and

monitoring ultimate outcomes: community well-being, levels of trust and levels of social acceptance. Measuring the outcomes of a process is more powerful than measuring the means.

3:25 pm

Resettlement and Economic Development in Guerrero, Mexico – Torex Gold's El Limón Guajes Mine

M. Thorpe and A. Mallen; Torex Gold Resources, Toronto, ON, Canada

Torex Gold Resources is constructing the El Limón Guajes open pit mine in Guerrero, Mexico. The six local stakeholder communities ranging in size from about 100 to 2,500. The mine development required the resettlement of two communities totalling 170 families. The resettlement negotiations were completed to the IFC PS5 for land acquisition and involuntary resettlement. Economic development for the stakeholder communities includes a local hiring policy and local contracts provided additional opportunities for local stakeholders. A broad-based community economic development initiative was (ranging from stocking fish to artificial insemination). Following the initial economic investment, community stakeholder meetings were completed and the value of the inputs to the local economy assessed allowing Torex to identify some options (farming and fishing) that would, over the long-term, provide for sustainable economic development not tied to the mining operation. By appropriately engaging stakeholders, Torex has been able to diversify the local economic, increase local wealth, provide direct and indirect employment opportunities, and improve local security.

Tuesday, February 23 – Afternoon

ROOM: 226C

2:00 pm

Environmental: Sustainable Remediation/Reclamation I – Water and Habitat

Chairs: D. Crawford, Golder Associates Inc., Redmond, WA
J. Pepe, Golder, Lake Oswego, OR

2:00 pm

Introductions

2:05 pm

16-110

Sustainable Restoration of Livestock Degraded Riparian Habitats

M. Birdsell; Environmental Assessment and Compliance, Golder Associates Inc., Coeur d'Alene, ID

Sustainable restoration requires adequate planning and preparation, implementation, and measurement of success to monitor goals associated with restoring sites to pre-disturbance levels of ecological health. The Buckhorn Mountain Mine procured mitigation lands during the permitting process to be set aside for long-term restoration. Properties were historically used for agriculture purposes and livestock grazing. Restoration efforts have included implementation of livestock exclusion, treatment of noxious weed species, and installation of locally sourced riparian plant species. A combination of methods has been employed to help aid restoration of native species within the riparian corridor, and increase survival of planted species. The ability to adapt management activities and the willingness to make changes to mechanisms for long-term restoration success are important when dealing with natural systems that can continue to prove difficult. Several

mechanisms have been employed over the course of the restoration process, and not all efforts have been successful. Learning and adapting from these undesired outcomes have given opportunity to modify and employ new methods for success.

2:25 pm

Recovery of a mining-damaged stream ecosystem

W. Adams; Legacy Management, Rio Tinto, South Jordan, UT

This paper presents a 30+ year record of changes in benthic macroinvertebrate communities and fish populations associated with changes in water quality in mining-influenced streams. Panther Creek, a tributary to the Salmon River in central Idaho, USA suffered intensive damage from mining and milling operations at the Blackbird Mine that released copper (Cu), arsenic (As), and cobalt (Co) into tributaries. From the 1960s through the 1980s, no fish and few aquatic insects could be found in up to 40 km of mine-affected reaches of Panther Creek downstream of the metals contaminated tributaries, Blackbird and Big Deer Creeks. Efforts to restore water quality began in 1995, and by 2002 Cu levels had been reduced by about 90%, with incremental declines since. Rainbow Trout (*Oncorhynchus mykiss*) were early colonizers, quickly expanding their range as areas became habitable when Cu concentrations dropped below about 3X the U.S. Environmental Protection chronic aquatic life criteria (~18-20 ug/L). Full recovery of salmonid populations occurred within about 10-years after the onset of restoration efforts (2012) and about 4-years after the Cu chronic criteria had mostly been met.

2:45 pm

Reclaiming Seiad Creek After 100+ Years of Placer Mining

J. Poulsen; Environmental/Natural Resources, GeoEngineers, Inc., Boise, ID

Siskiyou County California has been a source of gold and platinum for more than 100 years. More than 1,800,000 troy ounces of gold was produced in the county between 1880 and 1959, primarily from placer operations. In addition to mineral resources, Seiad Creek also is home to another valuable natural resource: Coho salmon. Seiad Creek currently is one of the most productive Coho salmon tributaries to the Middle Klamath sub-basin. In addition to negatively impacting Coho spawning and rearing habitat, these levees have breached multiple times during high flow events, flooding the small town of Seiad, and causing erosion and aggradation on neighboring properties. The Seiad Creek Habitat Enhancement Project was developed with initial funding provided from PacifiCorp and as a joint effort between the Karuk Indian Tribe (Karuk Tribe) and private property owners. The purpose of the project was to enhance and increase juvenile and adult Coho salmon habitat while at the same time reducing erosion and flooding events on Seiad Creek.

3:05 pm

A Review of the Successes and Methodology of the Forestry Reclamation Approach and its Applicability to All Mining Regions

R. Sweetwood; Burns & McDonnell, Downers Grove, IL

Until recently, the reclamation expectation for mines in the Appalachian Region was typically straight slopes, smooth surfaces, no surface rocks, and overabundance of grasses and forbs. The unintended consequence of this approach was the inhibition of growth for hardwood species and native bushes. For an area that depends on its forestry industry, this outcome is detrimental. A coalition of citizen groups, government agencies, and mining representatives formed the Appalachian Regional Reforestation Initiative and from this the Forestry Reclamation Approach (FRA) was created. Vindex Energy – Arch Coal Inc has made significant advances in the methodology within the FRA. This presentation will review the different methods attempted across multiple mine sites, their successes and failures, and its applicability to beyond the Appalachian Mountains. Some of the successes include reduced erosion, increased tree survival, increased tree growth,

greater plant diversity, increased habitat, and decreased overall cost and time for final reclamation release. Vindex Energy also performed a pilot study comparing different grass and forb mixes and their effect on tree growth and ground cover.

3:25 pm

16-147

Pilot Testing of a Permeable Reactive Barrier to Remediate Sulfate, Metals, and Low pH in Groundwater.

R. Legrand¹, R. Henry¹, K. Maestas¹, J. Bain², D. Blowes², J. Strunk³ and Y. Chai⁴; ¹AECOM, Highlands Ranch, CO; ²University of Waterloo, Waterloo, ON, Canada; ³Rohm and Haas Company, Bristol, PA and ⁴The Dow Chemical Company, Midland, MI

Groundwater with elevated sulfate and metals was treated using a sulfate-reducing pilot PRB consisting of a series of six 55-gallon drums filled with ZVI (Fe⁰), wood chips, brewer's grain, and vegetable oil (EVO). Sulfate was reduced from >3,000 to <250 mg/L and Cd, Cu, Mn, Ni, and Zn concentrations declined up to 3 orders of magnitude in 2 months. After 6 months of operation at a 7.5-day retention time, sulfate broke through. The system was then rejuvenated by injecting EVO in each drum and operated for 5 more months at a 9-day retention time. Sulfate-reducing bacteria in the pilot system grew by 3 to 4 orders of magnitude in 2 months. Some cementation of the PRB media was observed in the first 2 drums after processing 25 pore volumes of water, due to preferential upstream precipitation of sulfides; this can be avoided through operational modifications. Resulting permeability losses were estimated at 0.1% to 1% per year. Absorption/desorption was tested at bench scale to evaluate the use of various oil-soaked sorbents as a slow-release source of dissolved carbon. The tests show that oil sorbents can increase the useful life of a PRB between oil refills to over 100 pore volumes.

3:45 pm

16-139

Sustainable Mine Water Management at Remediated Uranium Mining Sites of the former Wismut Mining Operations

H. Mischo¹ and M. Pau²; ¹Mining Engineering, Technical University Bergakademie Freiberg, Freiberg, Saxony, Germany and ²Engineering & Radiation Protection, Water Management Department, Wismut GmbH, Chemnitz, Germany

From 1945 until 1990, highly intensive Uranium mining of the Wismut company took place in the ore mountains region in eastern German, resulting in a large number of underground and open cast mine sites with more than 1500 km of drifts and galleries, 311 km² waste dams and 160 mio. m³ of radioactive tailings to be taken care of and remediated after the re-unification of Germany in 1990. 25 years later, and after spending billions of Euros, the Wismut remediation project is almost complete, making it to one of the great success stories in environmental protection in German. Only the sustainable and long term stable mine water treatment will remain as an ongoing task for the upcoming decades. This paper provides an comprehensive overview over the complete remediation project, with a special focus on the installed mine water treatment operations, their development and continuous optimisation as well as the long term operational design for a sustainable and stable water management and treatment even after all other remediation activities have been concluded.

Tuesday, February 23 – Afternoon

ROOM: 131B

2:00 pm

Health & Safety: Health & Fatigue Related Issues in Mining

Chair: W. Shoff

2:00 pm

Introductions

2:05 pm

Results of a Predictive Fatigue Risk Monitoring System Using Circadian Principles in an Occupational Mining Environment

M. Wichmann; Engineering and Operations, Predictive Safety LLC, Centennial, CO

It is estimated that employee fatigue is a primary cause of 30% of all industrial accidents including fatalities. It is thought to be major contributor in as high as 60% of all accidents in 24/7 shiftwork operations. Effective fatigue management programs need to address human behavior through education and training. There has long been a need to predict fatigue risk and address the risk prior to the worker falling asleep. Despite the development of technological solutions to detect worker fatigue at the point of dozing off, effective fatigue management requires fatigue monitoring technologies. PRISM, (Predictive Risk Intelligent Safety Module), is an innovative software technology that uses Circadian principles and the worker's time on and off work to dynamically calculate fatigue risk based on each worker's individual work history and communicates the risk in real time. In a study of ~1000 workers, PRISM reduced man hours worked in high fatigue zones by 31% with ongoing improvement. Secondary benefits include 3% improvement in attendance and 35% reduction of accidents annually. Worker alertness testing shows positive statistical correlation with the fatigue risk set points.

2:25 pm

Holistic Assessment of Operator Fatigue, Distraction and Machine Performance

D. Edwards and T. Dawson; Caterpillar Inc., Dunlap, IL

Fatigue impacts employee vigilance and the decision-making process, which can lead to critical errors and accidents. Fatigue also affects jobsites in less tangible ways. A fatigued operator is more likely to make errors which can reduce mine productivity, consistency, quality and can lead to increased machine wear. Building the connection between machine performance and the operators' state (fatigued or vigilant) has not always been straightforward. To fully understand how machine and operator health are influenced by the operator's state, their jobsite, home, and in-the cab environments need to be evaluated objectively. This requires multiple data sources (machine, site, employee) using specialized equipment. This session will discuss case studies where in-cab operator fatigue and distraction data, wrist-worn actigraphy, and machine performance data were collected and assessed holistically to demonstrate the manner in which operator fatigue directly impacts employee health and safety and indirectly impacts mine performance.

2:45 pm

Putting the "Health" into Safety and Health

L. Evans and R. Jameson; Central Mine Services, Inc., Danville, KY

Employee safety and wellness programming typically operate in separate "silos" in most organizations. Safety programs are housed within safety departments and often focus on injury prevention and workers' compensation cost control. Wellness programs are often administered by Human Resource department and focus on employee health and managing health care costs. Research shows that employee health directly impacts overall safety. Progressive organizations are recognizing the importance of improving employee safety by focusing on improving employee health. For example, a review of employee health risk assessment data at Duke University showed that an employee's body mass index (BMI) is one

of the best indicators of workers' compensation claims frequency and severity. Unfortunately for employers, obesity rates have soared over the last two decades and have impacted overall safety programming and costs. Program attendees will learn about the components of a comprehensive wellness program and the benefits including improved overall safety, lower medical treatment costs, lower healthcare insurance costs, improved productivity, reduced absenteeism and improved morale.

3:05 pm

16-075

Detecting Diesel Particulate Matter Using Real Time Monitoring Under the Influence of an Exhaust Fan System

Y. Alghamdi and S. Gillies; Mining Engineering, Missouri University of Science and Technology, Rolla, MO

Diesel Particulate Matter (Dpm) is a complex mixture of diesel exhaust gas. It has become a significant health issue in underground mines where diesel engines are more active in confined areas. The studies have shown that exposure to Dpm is the main risk for lung cancer and other lung diseases. Providing an accurate underground ventilation plan can help to dilute Dpm concentrations. It should be monitored constantly to ensure it does not exceed MSHA's emission standards. This paper will show the behavior of diesel exhaust emission under the influence of an exhaust fan with different speeds, and how the Dpm can be detected by using a real-time personal sampler. It is shown that there is a variance of the concentration of elemental carbon depending on the type of diesel source and the speed of exhaust fan. Understanding the relationship between the source and the ventilation system can give a better understanding of what ventilation plan is appropriate to keep the emission concentration as low as possible while taking into account other affecting factors. Some of the tests have not shown a good dilution of Dpm, but other factors are recommended in this paper for more research.

Tuesday, February 23 – Afternoon

ROOM: 131A

2:00 pm

Health & Safety: Risk Management: Updates, Evaluation, and Health Outcomes II

Chair: R. Reed, University of Arizona, Tucson, AZ

2:00 pm

Introductions

2:05 pm

Bow-tie Analysis of a Coal Dust Explosion

M. Shriwas and A. Jha; Mining Engineering, University of Utah, Salt Lake City, UT

Coal dust explosion is a complex phenomenon, coal dust present at roof, rib and floor of the mine can be initiated by the firedamp explosion if the methane concentration is within explosive limit. The magnitude and severity of the explosion depends on availability of fuel, confinement and obstructions. Bow-tie analysis is a visual tool widely used in risk assessment. It is simple to use and communicates effectively the problem and corresponding consequences. It includes preventive controls and recovery measures in case the given hazard occurs. A bow-tie analysis of the explosion phenomena will help the management and miners to better understand the nuisance of the problem. Moreover, control measures can be decided and come up to mitigate effect of explosion on health and safety of miners.

2:25 pm

OTR Wheel & Rim Certification On-Site

T. Shumka; OTR Rim Certification, Inc., Kelowna, BC, Canada

Current method for examining OTR rims is Magnetic Particle or Visual Inspection. This is a slow process, can miss indications and wheels and rims have to be sandblasted before inspection. At best, this method can determine whether a flaw exists, but is unable to provide information on defect severity. Most OTR rims are shipped to a central facility for inspection and recertification. Numerous times mining customers are shipping rims with no defects adding a large expense for recertification. Other examples of wasted expense are rims being shipped that are scrap. This program provides on-site inspection services for OTR wheels and rims. With this program, the only wheels and rims shipped offsite are the ones for repair. This reduces costs to the end user and simplifies logistics for OTR wheel and rim inspection. OTR's third party on site rim inspection and certification program provides the end user with a qualified, independent assessment of their OTR wheels and rims separate from the OEM.

2:45 pm

Safety of Surveyors Near Open Pit Highwalls

N. Goncalves; Maptek, Lakewood, CO

Safety in the mining industry is a primary concern. At many sites, surveyors are using laser scanners to increase productivity while eliminating unsafe tasks from their daily routine. These tools provide many benefits for both open pit highwall and underground environments. One example is daily acquisition of data at the dig face. This typically requires equipment to halt production, slowing the very process the surveyor is there to streamline. Technologic advancements in laser scanning allows surveyors to collect data quickly and decrease risk of injury. Acquiring data remotely solves this concern while increasing speed, accuracy, and quality of the data.

3:05 pm

Some Like it Hot: Heat Strain Management in Mining

R. Reed; Community, Environment, and Policy, University of Arizona, Tucson, AZ

Objective: To disseminate and discuss heat strain management best practices, particularly those unique to the mining industry. Introduction: Heat kills more Americans than any other type of weather-related event. Heat strain is dependent upon environmental heat stressors, individual physiology and acclimation, job-specific factors such as work load, and PPE worn. Compared to coal, underground metal mining presents a particularly unique environment in which heat stress is exacerbated by deep mines that may introduce substantial geothermal heat, high humidity, relatively low ventilation rates, and heavy workloads. Discussion: A good heat strain management program consists of 1) engineering controls, where possible; 2) an acclimatization program for new workers or those returning from vacation; 3) work-rest regimens; 4) regular heat stress and heat strain monitoring; and 5) proper training and response programs. Conclusion: A proactive approach to heat strain management can effectively prevent heat-related illnesses.

3:25 pm

What is Best-In-Class in Contractor Management?

R. Cerenzio and J. Van Gundy; ISN, Dallas, TX

In this white paper, we outline 10 essential attributes we find in best-in-class contractor management systems. The list of attributes is not intended to be exhaustive, but it presents key items considered to be of strategic significance for establishing effective contractor management processes. Whether you are a Hiring Client who uses contractors or a General Contractor who hires subcontractors, you will find reference points for benchmarking your practices and identifying opportunities for reducing your risk exposure. We focus on the non-commercial and non-technical aspects of contractor management, though most of our points

would also apply to those considerations. In correlation with our white paper, ISN's analytics team has published industry specific benchmarking reports that allow companies to compare the safety statistics of their contractor base to their industry peers. ISN also provides safety benchmarking statistics for the contractors, allowing them to benchmark themselves against the 60,000 contractors that are members of ISN today.

Tuesday, February 23 – Afternoon

ROOM: 221A

2:00 pm

Industrial Minerals & Aggregates: Breaking Rock in Hot Sun

Chairs: V. McLemore, NMBGMR/NM Tech, Socorro, NM

N. Niemuth, Arizona Geological Survey, Phoenix, AZ

2:00 pm

Introductions

2:05 pm

16-023

Update of Industrial Minerals and Rocks in New Mexico

V. McLemore; NMBGMR/NM Tech, Socorro, NM

Production of industrial minerals remains important to the rural economy of New Mexico. In 2014, some 240 mines were registered in New Mexico, including 25 industrial mineral operations and 189 aggregate operations. New Mexico leads domestic production of potash, perlite, zeolite, and travertine. Other production includes aggregate, humate, pumice, gypsum, salt, common and fire clay, scoria, limestone, fly ash, cement, magnetite, silica, and decorative stone. New Mexico has potential for additional production of industrial minerals. One company is exploring for garnet. Cretaceous black sandstones in the San Juan Basin have drawn interest for titanium, rare earth elements (REE), and zircon. Other REE deposits are being explored. REE-Th-U veins are found in the Gallinas, Capitan, and Cornudas Mountains and Laughlin Peak-Chico Hills. Recent exploration has occurred for beryllium in the San Mateo Mountains, Iron Mountain, and Victorio districts. Companies also are examining High-Ca limestone and dolomite for potential development. Aggregate continues to be important in urban areas and along highways.

2:45 pm

16-080

Arizona Aggregates in the 21st Century

W. Langer¹ and S. Trussell²; ¹Bill Langer - Research Geologist, Anthem, AZ and

²Arizona Rock Products Association, Phoenix, AZ

Throughout most of the last half of the 20th century, aggregate (sand & gravel and crushed stone) production in Arizona generally increased at a steady rate. Just prior to 2000 Arizona ranked 2nd in population growth, 2nd in employment growth and 3rd in income growth. For the first five years of the 21st century aggregate production in Arizona increased erratically, reaching a high of 108.8 million metric tons during 2006. Four consecutive years following the start of the Great Recession aggregate production plummeted, reaching a low of 39,860,000 during 2011. The 240,000 construction jobs in 2006 dropped to 111,000 in 2010 and in 2008-2010 Arizona ranked 14th in population growth, 49th in employment growth and 45th in income growth. The recovery is progressing at an exceedingly slow and, by national comparison, disproportionate speed. The distribution of cement in Arizona experienced a prolonged downturn following the Great Recession. Distribution of cement peaked at 4,611,000 tons in 2006. Distribution steadily decreased for the next five years, dropping to a low of 1,476,000 tons in 2011. During 2012 distribution of cement in Arizona was just starting to recover.

Industrial Minerals on Arizona State Trust Land

K. Murray and J. Dixon; Minerals Section, Arizona State Land Department, Phoenix, AZ

The Arizona State Land Department (ASLD) manages the permitting and leasing of 9.2 million acres of State Trust Land, which represents about 13% of the total area of the state, for the exploration and development of mineral products. The ASLD is not a regulatory agency, but a department guided by its fiduciary responsibilities to the Trust. Our mineral programs include: Exploration Permits, Mineral Leases, Mineral Material Leases, Oil & Gas Leases, and Geothermal Leases. Industrial minerals play a significant role in the revenue generated for the Trust. The Arizona Geological Survey estimated there are 682 million to 2.27 billion metric tons of potash in the Holbrook Basin in northeastern Arizona. Approximately 24 to 157 million metric tons of that underlie 66,000 acres of State Trust on which multiple exploration permits and one Mineral Lease have been issued. Additionally, ASLD has several mineral leases for gypsum and limestone, and has a high potential for more. In 2014, Arizona produced approximately 35.6 million metric tons of construction sand and gravel with 1.5 million metric tons being produced on State Trust Land.

3:25 pm

Streamlined Environmental Compliance for Mining and Materials Operations Using Mobile Devices

T. Danaher; Haley & Aldrich, Inc., Costa Mesa, MA

Many mining and materials companies use a distributed compliance model that relies on busy onsite personnel to schedule, conduct and manage record keeping for numerous onsite environmental and safety compliance inspections. This compliance model struggles to perform inspections on-time, complete and maintain the required paperwork correctly, and give notice to corporate EHS personnel of compliance issues that require timely action and regulatory agency notifications. The convergence of inexpensive cloud-based services with ubiquity of mobile devices is presenting interesting opportunities for us to change this for the better by creating mobile-based streamlined compliance systems. Many workers already have access to smart-phones or tablets which can access these cloud-based services and tools. These new tools can automatically alert facility personnel when an inspection is due, collect and error-check inspections using smart electronic forms, save records to centralized repositories, and automatically flag and quickly distribute potential compliance issues to corporate EHS staff so they can effectively perform agency notifications, reporting, action item tracking and follow-up.

3:45 pm

pH Sensor Calibration and Maintenance in Alkaline Minerals Processing Circuits

M. Davis; Sales, Lhoist North America, Scottsdale, AZ

pH sensors are a critical but sometimes overlooked component of cost-effective minerals processing. In alkaline mineral processing environments, the calibration and maintenance of these probes needs to be handled with special care, or else significant waste of reagents can ensue. Lhoist North America's Margaret Thomson (Technical Director, Far West Region) has many years of experience with a wide variety of pH and process chemistry sensors. The different types of probes, common failure modes, and calibration methods are explored, along with suggestions for keeping sensors functioning at peak accuracy in difficult environments.

4:05 pm

Formation of Arizona Industrial Minerals through Geologic Time

J. Rasmussen² and S. Keith¹; ¹MagmaChem Exploration, Inc., Sonoita, AZ and ²Jan Rasmussen Consulting, Tucson, AZ

Older Precambrian deposits include Iron King tailings, gem amethyst, and feldspar. Chrysotile asbestos was formed by contact metamorphism where limestone was intruded by diabase dikes. Paleozoic limestones are the source of most of the calcite mined for use in cement at the Rillito, Clarkdale, and Drake cement plants. During the Permian, a large saline lake with hydrothermal springs deposited potash and salt in the Holbrook basin. Flagstone is mined from the Coconino Sandstone of Permian age. Mesozoic industrial minerals include metamorphic minerals, limestone, clay, and graphite. Cretaceous Mural Limestone was mined at Paul Spur for smelter flux. Kaolinitic underclay was mined near Pinedale from coal sequences. Tertiary industrial mineral deposits include those associated with Laramide metamorphism, mid-Tertiary basins, Pliocene volcanism, and more recent sand and gravel deposits. Laramide gem turquoise and marble deposits are associated with porphyry copper deposits. Oligocene to Miocene lakebeds were the site of several clay, evaporite, salt, and volcanic-related deposits. Pliocene deposits include volcanics and sediments, including stream and terrace aggregate.

4:25 pm

A Potential New Major Graphite-Graphene Deposit in West Central Arizona

S. Keith¹, T. Viehhaus³ and V. Spieth²; ¹MagmaChem Exploration, LLC, Sonoita, AZ; ²VS.GLOBALMETAL LLC, Tucson, AZ and ³AVISpectro Raman Spectroscopic Lab, Stuttgart, Germany

Exploration for porphyry copper mineralization on the Yuma King property about 20 km SW of Bouse in west-central Arizona has serendipitously revealed the presence of a large body of graphite-bearing rock that contains a significant graphene component. The graphite-graphene mineralization is inferred to have been formed by frictional heating and shearing associated with SW directed thrusting in early Laramide time circa 89-85 Ma. The graphite is contained in a relatively flat lying dark gray carbonaceous phyllitic meta-mudstone body about 1000 feet thick that occupies at least a square mile of area. The carbonaceous kerogen-rich mudrock protolith was deposited as part of the early to mid Cretaceous McCoy Mountains Formation. The best graphite-graphene (in terms of black color and 'magic tape' field testing for graphene) seems to be associated with shear fabrics presumably associated with the overlying McVay thrust. Raman Spectrometry has confirmed the presence of a significant disordered graphene component. Drillhole samples are currently being analyzed for graphite content/grade, kerogen, and related reduced carbonaceous polyaromatic hydrocarbon compounds.

Tuesday, February 23 – Afternoon

ROOM: 221B

2:00 pm

Industrial Minerals & Aggregates: Innovation in Industrial Minerals II

Chairs: B. Li, Michigan Technological University, Houghton, MI
P. Macy, Kemira, Atlanta, GA

2:00 pm

Introductions

2:05 pm

Gravity Aid Grinding Mill (GAGM)

B. Aksoy; Mining and Nuclear Eng, Missouri S&T, Rolla, MO

The search for energy savings either by controlling particle size distribution or using new technologies has been a major challenge for the industries. In this paper, a novel apparatus "Gravity Aid Grinding Mill" (GAGM) and a method are presented, which utilize the gravity force to grind ores. Initially, its functionality and potential applications were examined. The experiments were conducted with clay and phosphate ore. The major findings indicate that GAGM can be utilized as a grinding mill for clay and phosphate ore and the results were comparable to that reported in the literature for the traditional comminution equipment, (ball mills). In addition to controlled particle size of final products, having no moving parts; reduced energy and grinding media consumptions, dust problems, liner wearing, and maintenance are among the benefits of GAGM. The new experiments are suggested to examine its technical and practical applicability for grinding the other mineral ores and agricultural-food products. Further investigations will provide a deeper understanding of the grinding process of GAGM and justification of its functionality, inclusion in a grinding circuits and energy savings.

2:25 pm

Effectiveness of Mineral Characteristics and Rheological Property of Bentonite to Drilling Fluid Efficiency and Cost

Y. Song¹, F. Gao¹ and B. Li²; ¹BHDC, CNPC, China, Houghton, MI and ²Michigan Tech University, Houghton, MI

Bentonite is an essential mineral material for oil and gas drilling with millions tons of consumption annually. The quality and performance of drilling fluids mainly depend on the property of raw bentonite. This study investigated the mineral characteristics, barrel yields, rheological properties, and the drilling efficiencies of typical bentonite products from different mineral deposits in China. Methylene blue test, Fann viscometer, scanning electron microscope (SEM), and chemical analysis were employed to determine the physical, chemical, and rheological properties of the bentonite samples. The cost factor of bentonite in drilling operations based on bentonite quality and performance was also assessed. The results showed that the mineral type and characteristics of bentonite have a significant effect on the barrel yield and rheological property of the drilling fluid. Sodium bentonite has a better rheological performance and higher drilling efficiency than that of calcium-based bentonite, while reducing the overall cost of drilling project. The using tendency of bentonite in China was also discussed.

2:45 pm

Modification of Trim Shots Timing and Sequencing Utilizing an Improved Signature-Hole Technique: A Case Study at Cortez Gold Mines, northeast Nevada

J. Silva-Castro¹, P. Jenks² and B. Lusk¹; ¹Mining, Assistant Professor, Lexington, KY and ²Cortez Gold Mines, Chief Geotechnical Engineer, Crescent Valley, NV

It is commonly accepted that blasting has less influence on slope stability than geology and ground water. However, in some situations where geotechnical slope performance is of concern, blast design takes increased relevance as a variable to consider in the slope stability. Cortez Hills Open Pit mine (CHOP) is a Barrick operation in Nevada. Geological conditions and other factors influence slope performance in a key sector of the highwall. As consequence of the slope performance, more control of the vibration levels produced by trim shots was proposed in order to mitigate slope deformation. Modification in the traditional timing and sequencing of trim shots were recommended based on signature-hole analysis using the

Silva-Lusk equation. This paper presents the basics of the improved signature hole technique, the analysis performed for the implementation of the non-traditional timing and detonation sequence allowing the mine to control the vibrations levels of the trim shots without changes in the pattern or amount of explosive detonated.

3:05 pm

Technological Innovations That Shaped Smart Change in the Past Decade

A. Navarro; SGS North America, Tucson, AZ

Over the past decade we have witnessed a great deal of transformation in the way we use technology in the mining industry. This change has been driven by the industry mandates to improve performance, improve processes, reduce costs, reduce risk and enhance project value. This technical session discusses some of the most influential innovations adopted in the last ten years in the mining industry that have strengthened the whole value chain. More specifically, this session will overview technical solutions and innovations in a mine product from resource to market inclusive of exploration, surveying, geo-modeling, mine planning, mine operations, process engineering and process plant designs.

3:25 pm

Valuable Minerals from Waste Streams

T. Ji² and H. Wu¹; ¹Wayne State University, Detroit, MI and ²Fuzhou University, Fuzhou, China

Portland concrete is the most widely used building materials. However, the production of cement is energy intensive and one of the leading CO₂ producers. Therefore, the extensive use of concrete increases the consumptions of natural mineral resources, and impacts the ecological environments. Therefore, there is an urgent need for a new aggregate which can replace natural coarse aggregate. Many industrial wastes including fly ash, marble dust, and various slag have been found to be useful replacement for Portland cement, partially or completely. When the contents of Portland cement is reduced to be less than 20%, such new cement formulations can be called green cements, which possess very different hydration mechanisms and unique characteristics in addition to being sustainable. New opportunities and challenging issues will be highlighted and discussed.

3:45 pm

Interpretation and Application of Hydrogeological Concepts to Commercial-Scale Brine Extraction Projects

P. Cortegoso; SRK Consulting, Denver, CO

Brine extraction for surface process and recovery of potash, lithium and industrial salt requires the application of traditional hydrogeological theories to hyper-saline solutions. Such brines present additional technical challenges in comparison to fresh water due to density effects, density driven multichemical composition flow on a large scale, and interaction between brines and fresh water over the course of the production period. The hydrogeologist is tasked with balancing extraction rates from multiple production wells, locating the production wells in space (and time), predicting chemical composition of the pre-pumping and extracted brines and monitoring depletion of a “dynamic” resource. Each of these parameters can have a significant impact on project economics. Recent guidance from the Ontario Securities Commission provides an indication of how to disclose brine resource and reserve estimates according to the Standards of Disclosure for Mineral Projects, namely National Instrument 43-101. This paper examines the technical aspects of estimating extractable brine resources and reserves, and current public disclosure guidance.

Tuesday, February 23 – Afternoon

ROOM: 221C

2:00 pm

Industrial Minerals & Aggregates:

Part A – Pyro-processing of lime and cement

Part B – Drones, Stockpiles, and Emeralds

Chairs: W. Langer, Bill Langer - Research Geologist, Anthem, AZ
B. Pruett, Imerys Oilfield Solutions, Sandersville, GA

2:00 pm

Introductions

2:05 pm

A Powerful Tool for Pyro-Processing Analysis –
A CFD-Chemical Bed Coupling Approach

Y. Fu, B. Iancu, C. Manias and A. Greco; FCT INC, West Chester, PA

FCT approach recognizes that each kiln is unique. It is not rare to see two “identical” kilns operating differently. Several parameters (i.e., Momentum or Swirl Number) cannot fully determine burner performance. FCT’s unique modelling approach takes flow pattern, combustion, radiation, chemical bed reaction all into account. The chemical bed model, which accounts for bed calcination, sintering, etc., is coupled with CFD (Computational Fluid Dynamics) simulation, which accounts for the flow, combustion, radiation inside kiln. By combining all information, either from plant or FCT’s site survey, the coupled solution is a powerful tool that can be used by any plant.

2:25 pm

Features and Benefits of Modern Lime Shaft Kilns in the
Mining Industry

A. Baskette¹, B. Bissonnette² and H. Plath¹; ¹ThyssenKrupp Industrial Solutions (USA), Inc., Atlanta, GA and ²Barrick Gold Corporation, Toronto, ON, Canada

As ores become increasingly difficult to process, several projects are considering using pressure oxidation, where large quantities of lime are required for neutralization. This paper will provide an overview of the modern shaft kiln process, including the benefits of updated design, operational flexibility, performance parameters, and current trends in the technology. The inner workings and management for a modern shaft kiln project from an equipment supplier’s perspective will be examined. An examination of the project’s lifetime through design, fabrication, erection, startup, and normal operation of the shaft kilns will be conducted.

2:45 pm

Pyro Processing: More Than Just Rotary Kilns

M. Schiefer, A. Baskette and H. Plath; ThyssenKrupp Industrial Solutions (USA), Inc., Atlanta, GA

The rotary kiln is a proven and accepted form of technology having successfully been used in the processing of several different ores and minerals. There are, however, instances where the use of a rotary kiln may not be the ideal consideration for given applications. Material characteristics, process requirements, efficiency, available fuel source, and site parameters may indicate use of alternative pyro processing technologies in order to achieve project success. This presentation will provide a brief overview along with the features and benefits of select technologies which comprise the area of pyro processing. Gas suspension calciners, shaft kilns, and multiple hearth furnaces will be discussed.

3:05 pm

Achieving Survey-grade Accuracy with Mapping Drones

L. Graham; Engineering, GeoCue Group, Inc., Madison, AL

Nothing promises to change the entire approach to surface mine mapping so much as small Unmanned Aerial Systems (sUAS or drones). A confluence of technologies such as navigation systems, compact motors, dense energy batteries and especially revolutions in software has enabled low cost, owner-operator aerial mapping systems. While these systems promise to rapidly replace traditional mapping techniques such as GNSS and terrestrial LIDAR surveys, little has been published on the comparative accuracy of these approaches. This presentation will provide a review of a year of analytic study on the use of non-metric cameras flown on low cost sUAS for mapping and volumetric analysis. The focus has been on geometric accuracy using approaches including navigation grade positioning, ground control and survey grade sUAS deployed Real Time Kinematic positioning. The information from this presentation will provides a foundation for selecting the technology appropriate for the accuracy level required by the mapping task.

3:25 pm

Characteristics of Zonal Emerald from Malipo, Yunnan Province, China

X. Yu, X. Jiang, B. Guo and C. Xu; School of gemology, China University of Geosciences, Beijing, China

Emerald is the green gem variety of beryl. The color of emerald is due to trace amounts of chromium and/or vanadium replacing aluminum at the Y site; In most cases the Cr contents is much greater than that of V. Preliminary geological work on samples from Saxi mine of Malipo, Yunnan province indicate that emerald occurs in pegmatite and quartz veins that intrude deformed Proterozoic biotite-muscovite granofels and schist. The emerald-bearing vein minerals include quartz, albite, K-feldspar, tourmaline, scheelite, arsenopyrite, calcite, fluorite, biotite and muscovite. Characteristics of zonal emerald have been studied by using petrography, CL, LA-ICP-MS and EMPA In this paper. The result reveals that the green color is caused by Cr³⁺, V³⁺. But the V contents (vary 0.12%~0.99%) is always greater than that of Cr (varies 0.01%-0.11%). In most case trace element of zonal emerald also contain high vanadium and low chromium. But Cr content is higher than V at the edge of the sample, which causes the bright green color. Emerald is associated with V-rich muscovite and V-rich tourmaline. It suggests that the trace element not only affect the color but also should reflect the model of formation.

Tuesday, February 23 – Afternoon

ROOM: 131C

2:00 pm

International II

Chair: M. Gavrilovic, GR Engineering Services, Denver, CO

2:00 pm

Introduction

2:05 pm

The Economics of Social License

M. Upton; SRK Consulting, Denver, CO

How much is it costing mining companies to obtain, or to forego, social license to operate? To what extent does social license affect access to capital, from public securities markets, private equity or royalty investors? This session will consider not only the challenges of obtaining social license for mining projects, but the economics of this challenge from initial outlays to the rewards of stakeholder support.

2:15 pm

The Lithium Paradigm

I. Kunasz; Individual, Tucson, AZ

Until the late 1980's, lithium production was dominated by the United States and Australia. A major shift in lithium production from mineral-dominated deposits to brines took place with the discovery of lithium in the brines at Silver Peak Nevada in the late 1960's. In the late 1980's, South America became the new locus for lithium production with the development of the rich lithium deposit at the Salar de Atacama, Chile and, later, at the Salar del Hombre Muerto. From a non-producer of lithium, Chile in particular, and South America in general, has become the major supplier of lithium chemicals in the world. Under positive economic policies potential additional brine resources might be developed in Argentina and Bolivia.

2:35 pm

Project Due Diligence for Streaming

T. Bruington; Sandstorm Gold Ltd, Vancouver, BC, Canada

Due diligence of mining projects for metal stream financing share many similarities with due diligence for equity and debt financings. A comprehensive evaluation of geologic, ore reserve, mining, processing, marketing, capital and operating costs are just the larger among a multitude of area to be investigated. Understanding the operating and managerial capabilities of the mine operator represents a particular challenge in some cases. Stream financings present their own difficulties, and often the terms of the streaming agreement will need to be drafted to address particular risks identified during due diligence. International projects bring additional complexity to the effort.

2:35 pm

An Emerging New Silver Producer in Mexico

M. Barahona; Arian Silver Corporation, London, United Kingdom

ARIAN SILVER CORP, a London based company with its primary project San Jose in Zacatecas, Mexico, is turning into a silver producer despite the current market conditions, and is making the effort to become a sustainable operation. This is a challenge and the company understands that community relations are a key factor for success.

2:50 pm

New Paradigms in Resource Extraction

R. Furey; MWH Global, Broomfield, CO

As the use of alternative and renewable energy grows at mines, so too do the opportunities for miners. This presentation will show examples of alternative energy sources that have been developed at mines around the world and will advocate for new mine planning and business models to harness the mine infrastructure during operations and after closure.

3:10 pm

Anti-Mining Terrorism in Peru

M. Cedron; Mining Department, Pontificia Universidad Catolica del Peru, Lima, Peru

Recently, anti-mining activity in Peru has grown in the form of violence with riots, attacks to private and public property, threats to those in favor of mining projects, and fights with the police that have resulted in death people on both sides. All this activity is in response to a new strategy of the anti-mining groups with support from foreign institutions. This presentation reveals such a strategy, identifies its main actors, and their real intent.

Real-Time Cost Monitoring by continuous Sensor-Based Data Collection and Transmission

T. Lupek¹, H. Mischo¹, J. Benndorf², M. Buxton², K. Nienhaus³, L. Rattmann⁴, A. Korre⁵, A. Soares⁶, A. de Jong⁷, N. Jeanne⁸, P. Graham⁹, D. Buttgerit¹⁰, C. Gehlen¹¹, F. Eijkelkamp¹², M. Sandtke¹³ and T. Wilsnack¹⁴; ¹Institute of Mining and Special Civil Engineering, TU Bergakademie Freiberg, Freiberg, Germany; ²Geoscience and Engineering, Delft University of Technology, Delft, Netherlands; ³Department of Mining Machines, RWTH Aachen, Aachen, Germany; ⁴Department of Mining Engineering, RWTH Aachen, Aachen, Germany; ⁵Department of Earth Science and Engineering, Imperial College, London, United Kingdom; ⁶Center of Natural Resources and the Environment (CERENA), Instituto Superior Technico, Lisboa, Portugal; ⁷Nederlandse Organisatie voor Toegepast Natuurwetenschappelijk Onderzoek, Delft, Netherlands; ⁸Geovariances, Avon, France; ⁹Dassault Systemes GEOVIA Ltd., Coalville, United Kingdom; ¹⁰XGraphic Ingenieurgesellschaft mbH, Aachen, Germany; ¹¹LSA-Laser Analytical Systems @ Automation GmbH, Aachen, Germany; ¹²SonicSampDrill BV, Giesbeek, Netherlands; ¹³Spectral Industries BV, Delft, Netherlands and ¹⁴Ingenieurpartnerschaft für Bergbau, Wasser und Deponietechnik (IBEWA), Freiberg, Germany

With regard to the EU funded project 'Real-Time Mining' a sensor-based acquisition, collection and transmission of Data for the resource extraction process will be developed. The key concept promotes the change in paradigm from a discontinuous to a continuous process monitoring. Especially concerning material characterization, machine performance and underground positioning 'Real-Time Mining' will provide sensor solutions as well as the interfaces for integration, management and visualization of the collected data for a permanent updating process of the resource model with the aim of near real-time optimization of decisions. On the basis of 'Real-Time Mining'-Output a permanent monitoring of costs can be performed as well in both, the installation and the production process of a mine. Due to the collected data in terms of machine performance connected with the underground positioning information added with personnel tracking and mine surveys a comprehensive overview of process performance is available. By evaluating those information in a specific manner costs per unit will arise for monitoring and possibly controlling actions.

Resistance of Mine Stoppings and Construction Challenges in Reiche Zeche Mine

A. Mull¹, H. Mischo², J. Weyer² and J. Brune¹; ¹Colorado School of Mines, Golden, CO and ²Mining Engineering, TU-Freiberg, Freiberg, Saxony, Germany

Mining operations in Freiberg, Germany and the surrounding area are over 800 years old. The Reiche Zeche and Alte Elizabeth shafts are used by TU-Freiberg for research and educational purposes. The mine is connected to an unknown extent to other old mines in the area. Ventilation air leaking into abandoned areas leads to decreased airflow in areas of the mine that are used for research and teaching. To correct this issue, ventilation stoppings and seals must be constructed. Challenges arise constructing such ventilation controls in remote areas that lack material transportation infrastructure. In the past, wood has been the primary material used for stopping construction in these areas, yet wooden structures lack durability and fire resistance. Alternative materials, including concrete impregnated canvas, brattice, and expanding polymer foams, are considered for use in stopping construction. Stopping designs and factors affecting air leakage through stoppings are investigated. Finally, the costs of constructing stoppings using a variety of materials are estimated.

3:55 pm

A Practical Investigation into Measurement of Thermal Conductivity and Resistivity of Rocks

M. Hoveidafar¹ and M. Mousavi²; ¹Mining and Geological Engineering, PhD Student, Fairbanks, AK and ²School of Mining Engineering, Associate Professor, Tehran, Iran (the Islamic Republic of)

Thermal conductivity is the property of a material to conduct heat. Thermal conductivity of rocks and soils is an important property in many engineering projects such as design of buried electrical cables, gas and oil pipelines, ground improvement techniques by heating and cooling, disposal of radioactive waste in underground disposal sites, and schemes for energy storage. Methods of measuring thermal conductivity can be divided into two categories: steady-state and transient-state methods. In this paper, a device has been designed and fabricated for measuring thermal conductivity/resistance of rocks based on principles of a transient line heat source. Design process and the details of the device have been discussed. Calibration and verification of data accuracy of the device was conducted by testing on two materials with known thermal properties. Eventually, thermal conductivity and thermal resistance of some rock specimens were determined by using the device.

Tuesday, February 23 – Afternoon

ROOM: 122C

2:00 pm

Minerals Valuation II: Lessons Learned and Fundamental Issues

Chairs: D. Collins, DLC Productions, Inc., Littleton, CO
T. Knobloch, AIMA, Marietta, OH
J. Manes, Mineral Valuation Specialists

2:00 pm

Introductions

2:05 pm

Industrial Mineral Market Entry – A Bear Market or What the Market will Bear

M. Springer; Spanish Flat Mining Company, Garden Valley, CA

One of the most overlooked concepts of industrial mineral appraisal is market entry. Industrial minerals include low unit-value construction aggregate and fill material to high value fillers/extenders and chemical-grade mineral deposits containing unique or special properties suitable for end-users requirements. Mineral property owners commonly fail to consider, among other cost and timing related issues, realistic marketability and absorption rate attributes when valuing industrial mineral properties for sale. The dynamic relationship between mineral producers and consumers requires mineral property valuers to examine closely the supply/demand dynamics, matching a subject mineral deposit with end-use product requirements, and existing competitive contractual relationships for target markets. When large value disparities exist between industrial mineral property appraisals, the difference is often reconciled by a comprehensive feasibility analysis, which considers realistic market attributes. The Security Exchange Commission generally requires sales contracts, in addition to feasibility analyses, as reserve calculation criteria for U.S. industrial mineral property investments.

2:17 pm

Valuation Technique During High-Velocity Pricing Change

A. Schissler; Mining Engineering, Colorado School of Mines, Littleton, CO

Mines and their associated assets are valued using three industry accepted approaches; market-based, royalty, and discounted cash flow analysis. Usually in stable pricing environments, the three methods will result in equivalent value. When price, regulatory environment, inflation, weighted average cost of capital, and geo-political risk change with high velocity, the valuation methods return significantly different results. The purpose of this paper is to present experienced-based valuation tools that reduce variation and quantify business risk including options strategy. Valuation technique is pertinent in the 2016 timeframe as mineral assets offer unparalleled opportunity.

2:29 pm

Effects of Global Affairs on Valuation of Mineral Resources

S. Olmore; President, S D Olmore & Assoc Inc, Key Biscayne, FL

Global affairs and politics affect valuation of mineral resources. Latin American Republics are highlighted.

2:41 pm

Reliability of the Mineral Appraisal Report: The New World of Appraisal Review

R. Frahme; Mining, Gustavson Associates, Boulder, CO

After sinking many \$000s on an appraisal for decision making or litigation, how does the decision maker or legal counsel know that the report will withstand the scrutiny of litigation or negotiation? The recent re-writing of the Uniform Standards of Professional Appraisal Practice (USPAP), especially that part addressing "appraisal of the appraisal" (Standard Rule 3) is one recent sea-change in USPAP. It requires testing the underlying appraisal report against five newly clarified parameters: "Completeness, Accuracy, Adequacy, Relevance and Reasonableness". When tested by a qualified reviewer, the user of the report gains a clear picture of the reliability of the report without arcane references to alleged USPAP violations, as frequently done in the past. Beyond the extensive appraisal education and experience that should be required of the practicing appraiser, the reviewer must have additional education, experience, and a different mind-set. Comments will be provided on getting it right the first time (appraiser selection), and common structural errors the reviewer should find in determining whether the report is adequately supported before the opposition asserts that it is not.

2:53 pm

Acquisition of Economic Data for Appraisals in Different Commodity Markets

D. Collins; Collins Productions, Littleton, CO

Experience in obtaining data from the field on properties used for the Sales Comparison, the Income, and the Cost Approaches in the Appraisal of Mineral Properties has demonstrated that there are varying levels of difficulty with respect to the appraisal of construction materials and specialty/industrial mineral properties verses precious and base metal mineral properties. The over all market of the commodity seems to dictate the level of the proprietary nature of the mining company's data and the difficulty or ease in obtaining such data. This presentation on lessons learned reviews the various methods and strategies used in obtaining the necessary data that is applied in the three approaches: the Sales Comparison Approach, the Income Approach and the Cost Approach.

Mineral Valuation in a World of Volatile and Cyclical Commodities

B. Berhe¹, J. Hinzer² and R. Lawrence¹; ¹PEO, Toronto, ON, Canada and ²CIM APGO, Toronto, ON, Canada

The fortunes of mining companies and their implied value are tied to cycles - both economic and commodity – within which they operate. Hence the determination of appropriate future metal prices is one of the most critical factors faced by mineral valuers especially for advanced projects. Price, and hence revenue, is usually the most sensitive input to the valuation model. Empirical studies of past forecasts show that the success rate for commodity price forecasting is very poor. This paper explores various approaches and comments on their strengths and weaknesses.

We conclude that careful evaluation of long-term metal prices is a key element and is hardly a luxury that can be left to simple averages or rules of thumb.

3:17 pm

Reconciling AISC to Mineral Project Valuations

G. Malensek; SRK Consulting (U.S.), Inc., Denver, CO

Since establishing formal guidelines in 2013, the World Gold Council's (WGC) All-In Sustaining Cost (AISC) has been a frequently reported metric for comparing costs per payable metal unit sold for gold mining companies. Like most financial and economic metrics, it should not be a surprise to industry types since there are many interpretations of AISC within the industry, even with explicit WGC guidelines. While AISC appears to be driven by the needs of the investment community in ranking current producers, it is also often quoted by companies in valuations for mineral projects not yet in production. However, such technical-economic valuations using accepted best practices are invariably in conflict with several aspects of the AISC guidelines. This presentation attempts to highlight the discrepancies between AISC guidelines and standard technical-economic valuations to so that the reader can better understand what the numbers represent. To this end, for valuations of mineral projects not yet in production, SRK advocates a "Total Cash Cost" concept which reports costs per payable metal unit sold during life of mine commercial operations.

Tuesday, February 23 – Afternoon

ROOM: 128A

2:00 pm

Mining & Exploration: Geology: Copper, Old and New Opportunities

Chair: D. Briggs, Geomineinfo, Tucson, AZ

2:00 pm

Introductions

2:05 pm

Yerington District, Western Nevada: Brownfields Activity in the Midst of Diverse Jurassic Hydrothermal Systems

S. Runyon, M. Barton and E. Seedorff; Geosciences, University of Arizona, Tucson, AZ

The Yerington district has historic porphyry-copper and copper-skarn production and continues to be an important copper district. Historic mines produced ~2 billion lbs Cu from porphyry copper deposits (Anaconda's Yerington mine), and porphyry-re-

lated copper skarns (Bluestone, Douglas Hill, Casting Copper). Active exploration and development in the district includes Entrée Gold's Ann Mason porphyry copper system, Quaterra Resources' porphyry-related copper projects, and Nevada Copper's Pumpkin Hollow iron oxide copper gold deposit. Yerington provides the perfect setting to compare and contrast various hydrothermal systems because of the vertical range of exposure produced by Basin and Range normal faulting.

2:25 pm

Geology of the Lone Star porphyry copper deposit, Graham County, Arizona

D. Parker; Exploration, Freeport McMoRan Exploration Corp., Oro Valley, AZ

The Lone Star deposit is one the largest unmined copper oxide deposits in North America. Mineralization is hosted in Cretaceous andesite localized around a felsic vent complex. These rocks are intruded by felsic dikes and overlain by mid-Tertiary basalt. Copper oxide mineralization wraps around the leached core of the vent complex and is localized by major faults. Chrysocolla-dominant mineralization comprises the center of the oxidized zone whereas copper-manganese is dominant at the margins. Similar copper grades in the oxide zone and subjacent hypogene protore suggest that mineralization formed by in-situ oxidation of chalcopyrite.

2:45 pm

Hydrogeological Requirements for In-Situ Copper Recovery

G. Hoffmeyer, I. Ream and D. Johnson; Florence Copper, Florence, AZ

Several copper projects exclusively utilizing in-situ recovery methods are currently under development in Arizona. Ideal conditions for In-Situ Copper Recovery (ISCR) include a saturated orebody, fracture hosted mineralization, hydraulic conductivity sufficient to effectively inject and recover solutions using wells, and a relatively flat background hydraulic gradient. Safe operation of an ISCR project requires that the operator have the ability to induce and maintain localized hydraulic gradients, thereby controlling the movement of injected and recovered solutions. Benefits of ISCR include reduced initial capital, and a greatly reduced environmental footprint.

3:05 pm

The Exploration and Discovery of the Resolution Porphyry Copper System, Arizona

H. Martin; Resolution Copper, Gilbert, AZ

A 1989 exploration program developed by consultant Don Hammer to discover high-grade (~5% Cu) ores at the Magma Mine led to the discovery of the Magma Porphyry deposit. Surface hole MB-9 was cored in 1991 by the Magma Copper Company, and intersected sericite-pyrite altered Cretaceous volcanics as well as a modest chalcocite enrichment blanket. Although below 'ore grade', this intersection was recognized as clear evidence of proximity to a porphyry copper system. It wasn't until 1994 that S27E, an underground drill hole, cut long intervals of 0.5% Cu mineralization hosted by sericitized/advanced argillically altered and chalcocite/bornite mineralized Cretaceous volcanics. The following year another underground drill hole, S27H, was the first to intersect a significant continuous interval of +1% Cu mineralization. The last 140 ft of this hole averaged 1.94% Cu and 0.037% Mo in relict potassic alteration and chalcopyrite mineralization. By 1996 the mine was closed for the last time. Drilling by BHP continued in 1997 to test the porphyry copper deposit with a best intercept of 1,004 ft @ 1.75% Cu and 0.029% Mo recorded from surface hole MB-20A.

3:25 pm

Mineralization Characteristics of the El Abra Porphyry Copper Deposit, Chile

R. Stegen; Exploration, Freeport-McMoRan Inc., Oro Valley, AZ

The El Abra porphyry Cu-Mo deposit in Northern Chile is related to an Oligocene-aged composite granodioritic stock complex. Multiple generations of Cu-Mo veinlets produced two large and overlapping chalcopyrite-bornite-molybdenite orebodies situated within the intrusion complex. K-silicate alteration assemblages dominate with some admixtures of sericite. Copper veinlets in upper part of the system were oxidized in-situ to form a large oxide deposit currently being mined and processed. Recent exploration has delineated a large bornite-chalcopyrite sulfide deposit situated beneath that presents a future mining opportunity.

Tuesday, February 23 – Afternoon

ROOM: 128B

2:00 pm

Mining & Exploration: Geology: Putting the Tech in Geotech

Chair: R. Pratt, Call & Nicholas, Inc., Tucson, AZ

2:00 pm

Introductions

2:05 pm

Managing Risks to Production From Historical Underground Voids in an Open Pit Mining Environment – a Case Study From the Cripple Creek & Victor Gold Mining Company

E.A. Munroe AngloGold-Ashanti, Cripple Creek & Victor,

USA 1 and E.C.F Hamman AngloGold-Ashanti, Perth, Australia2

Many historical underground workings, mined between 1891 and 1941, exist in the Cripple Creek Mining District, which is located in central Colorado, USA. The historical shafts serviced underground workings that spanned an area of roughly 12km². The main types of underground voids likely to be intersected by open pit mining methods are shafts, drifts and stopes. Historical mining survey records are available and document the majority of the underground mining. However, unmapped or inaccurate underground voids, associated with contractor mining are present and interpretation is required between underground mining levels. These undocumented workings and details require additional hazard definition and mitigation to safely complete surface mining activities. In conjunction with the historical underground void database, CC&V uses geophysical methods, exploration, and production drilling data, to predict underground void locations. Probe drilling and downhole laser scanning is completed to validate and refine void geometry. The mine has established procedures and methods to mine safely and efficiently through the underground voids.

2:25 pm

16-135

Applications of Point Cloud Technology in Geomechanical Characterization, Analysis and Predictive Modeling

J. Lyons-Bara² and J. Kemeny¹; ¹Mining & Geological Engineering, University of Arizona, Tucson, AZ and ²Planning, Hexagon Mining, Tucson, AZ

Point cloud technology is now an indispensable tool in geological and geotechnical data collection, interpretation and analysis. Open pit and underground mines of all sizes are regularly collecting point cloud data as Laser Scanning (LiDAR) and Pho-

togrammetry surveying devices have finally become affordable and the workflows fast and efficient. Past challenges of large data processing and manipulation are gone with recent technological advancements in computer hardware and software. These innovations reduce file sizes, ease rendering requirements and allow for the implementation of real-time 3D viewers and surface meshing tools. With its ability to remotely (safely), rapidly and accurately extract large quantities of georeferenced and 3D-oriented data, point cloud technology provides numerous applications to the geomechanical field. The list of uses is continuously growing, so this paper specifically focuses on digital outcrop modeling and digital terrain engineering.

2:45 pm

Investigation of Rock Mass Stability Around Tunnels in an Underground Mine

Y. XING and P. Kulatilake; Rock Mass Modeling and Computational Rock Mechanics Laboratories, The University of Arizona, Tucson, AZ

Rock mass stability around excavations is an essential factor that determines the safe and efficient mining in underground mines. The purpose of this research is to understand the geomechanical behavior of the rock masses around tunnels in an underground mine in USA by using numerical modeling. First, a three-dimensional numerical model was built by 3DEC software according to the available information on stratigraphy and geological structures. Then, stress analyses were performed to study the effects of the lateral stress ratio (K_0), material constitutive models, boundary conditions and support system on the stability of rock masses around the tunnels. Results of the stress, displacement, failure zone, accumulated plastic shear strain and post-failure cohesion distributions were obtained for these cases. Finally, comparisons of the deformation were made between the field measurements and numerical simulations. Results show mixed boundary condition is more appropriate to apply; it is recommended to increase the length and yield capacity of rock bolts on the walls of tunnels. In addition, strain-softening model and K_0 between 0.5 and 1.0 are more applicable for this mine.

3:05 pm

Improved Geotechnical Data Management Using Electronic Field Data Collection

R. Post; Tucson Office, Golder Associates Inc., Tucson, AZ

Geotechnical investigations are both a critical part of the mine planning process, and a significant financial investment. This presentation discusses the benefits of improved management of geotechnical data, particularly a better return on investment for geotechnical investigations. The two primary means of accomplishing this are through improving access to historical data, and providing a better framework for collecting new geotechnical data, including electronic field data collection. By indexing the locations and basic metadata (elevation, investigation type, final depth, etc.) for past geotechnical investigations and providing an interface to search for specific types of information in a particular area of the mine, the owner may be able to find data they didn't know they had. Electronic field data collection, along with an intelligent data structure, can allow both expedient collection of new data, and ways of analyzing data not possible with less sophisticated methods. Examples from projects where these approaches have been successfully implemented will be presented along with a discussion of future trends in geotechnical data management.

3:25 pm

Applications of Satellite-Based Interferometry (InSAR) for the Mining Industry

K. Ferguson; Amec Foster Wheeler, Flagstaff, AZ

InSAR has the potential for measuring deformation of the earth's surface with very high accuracy. In addition, when archived (post-1992) raw data is available,

recent historic movement may be quantifiable. Future InSAR data can be utilized as a monitoring tool. InSAR utilizes satellite-based data acquired at two different times along orbits of a similar trajectory to detect changes in the ground surface elevation. InSAR can also be utilized to create high quality and repeatable digital elevation models (DEMs). The most important information that InSAR can provide is a direct observation of ground deformation as measured from the satellite's line of site. This presentation will show examples of the author's experience with and InSAR use and application to geologic and geotechnical investigations and monitoring as applied to the mining industry. Included are examples from mine infrastructure impacted by ground subsidence related to pit dewatering, potential ground subsidence due to groundwater pumping and treatment, DEM development and vegetation mapping, pit slope stability in large, open-pit mines, and a landslide hazard study for a tailings dam location.

3:45 pm

Ground Monitoring in Mines Using Interferometric Synthetic Aperture Radar (InSAR) Data

B. Panda; Environmental and Infrastructure, Amec Foster Wheeler, Phoenix, AZ

Interferometric synthetic aperture radar (InSAR) has the potential for measuring deformation of the earth's surface with very high accuracy. In addition, when archived raw data is available (post 1992), recent historic movement may be quantifiable. InSAR utilizes satellite-based data acquired at two different times along orbits of a similar trajectory to detect changes in the ground surface elevation. This technique can be used to monitor ground movement for rectangular areas as large as 100 kilometers on a side. The detection of ground surface deformation in terrain of high slope relief terrain is difficult. For ground deformation mapping by means of InSAR it is necessary to separate the motion-related and the topographic phase contributions. This is achieved by using a low resolution digital elevation model (DEM) during the processing of InSAR data. The presentation will show the application of this new technology to various mines. The ground movements adjacent to the mining areas can be successfully determined using this new technology which proves to be a great monitoring tool for the future environmental monitoring.

4:05 pm

Risk Assessment for a Shaft in a weak ground- case study

A. Rai¹ and R. Kallu²; ¹Barrick Turquoise Ridge Inc, Winnemucca, NV and ²Dept. of Mining & Metallurgical Engg, Univ. of Nevada, Reno, NV

A lot of work has been done to cover many of the risks for the ventilation and/or production shaft that would be common or similar in a competent ground. The challenges is defining these technical limits and physical constraint in the real SWOT numbers. The purpose of this paper is to determine what are current technical limits, physical constraints and address an appropriate risk assessment to produce a reasonable justification for each alternative.

Tuesday, February 23 – Afternoon

ROOM: 127A

2:00 pm

Mining & Exploration: Management: Agile Project Management

Chair: P. Rostami, Stantec Consulting Inc., Tempe, AZ

2:00 pm

Introductions

2:05 pm

Mastering the Five W's for a Successful Project

P. Stockburger and B. Crabb; Mining, Stantec, Tempe, AZ

Successful projects all share common elements, including a well-defined scope, a capable, motivated team, and clear expectations of all stakeholders. But successful projects don't occur by accident. They are the result of proper planning, setup, monitoring, and control. At its core, project execution is all about the who, what, where, when, how, and why. If you can't answer these questions, your project is either getting off to a bad start or it has already gotten way off track. This paper will focus on practical tools and methods to ensure a successful project. The focus will be from the perspective of an engineering services provider. Topics include: defining and freeze the scope of work, building a cohesive team with well-defined roles, implementing a logic-based, targeted schedule, monitoring and cost control (earned value system), proper communication protocol, robust change management, and communication protocol.

2:25 pm

An Integrated Uncertainty and Risk-Informed Decision Making Framework for Open Pit Strategic Mine Planning

P. Felli and V. Tenorio; Mining and Geological Engineering, University of Arizona, Tucson, AZ

Mine Planning is the heart of open pit operations. It is the strategy to follow in order to maximize the profitability of operations in a given time frame, with adequate equipment and personnel, constrained by geological, economic and environmental factors. The lack of a holistic understanding of the complexities in mine planning may obstruct the process of getting the permitting approval; and as a consequence, production startup and the generation of expected value for shareholders could be adversely impacted. The goal of this study is to incorporate uncertainty and risk analysis into mine planning in creating value by adopting a top-down systemic risk management approach in a distributed environment. Using a framework for categorizing key risk drivers, the mine planning tasks are grouped with its major objective. The critical drivers affecting the achievement of these objectives are then identified, until all the sub-sections work collaboratively. Risk-informed decision making principles are applied in a collaborative manner for direction-setting in the selection of the optimal mine planning options.

2:45 pm

16-111

Future of Mining: Views and Perspectives

M. Javier; EnviroMINE, Denver, CO

Mining makes civilization possible. It also creates socio-environmental liabilities forcing us to ask how much more of this mining can our planet support. It is clear that the future of mining differs from mining in the future. The laws of nature are being compromised by mining. This paper studies the problems at the core of the mining business which need to be addressed. What kind of mining will serve our existence with nature on this planet? What kind of mining perspectives are we able to formulate without having negative effects for future generations? Is mining technologically sustainable? The values of predictions, imagination, and creativity must be integrated to define what mining should be. Those values should be in the technologies necessary to restoring equilibrium of nature (Geomimic) as well as in complete extraction of metals, better utilization of the mineral reserves, and design the usage of metals to recycle. The purpose of this research is to examine many views and perspectives for future generations and to accelerate the pace of innovation of having mining without socio-environmental liabilities by design and by understanding nature.

3:05 pm

Automation: Is autonomy the real objective?

F. Gariepy; Peck Tech, Montreal, QC, Canada

The previous four decades, particularly the last, have seen many Research & Development efforts attempt to develop autonomous mining solutions. While autonomy is the ultimate level of automation, many other intermediate levels of automation exist. This paper discusses the relative values and costs associated with the various levels of automation. It compares the path taken by some of the key developers toward autonomous mining. It also highlights the major repercussions these divergent approaches dictate with regard to overall system safety, system robustness, industry acceptance and return on investment.

3:25 pm

A Mobile App for every employee: A new paradigm in production management

P. Rogers, D. Moore and S. Dessureault; MISOM Technologies, Tucson, AZ

Mines use many applications for operations management and engineering. A major component of these applications is data for decision making. The challenge for most sites is transmitting this information into the hands of the frontline supervisors and operators. Historic barriers to mobile applications for all employees is rooted in the challenges of cost, communications, security, and liability, when providing tablet devices with internet connection. The mobile application industry has changed dramatically in the last 18 months and many of the old barriers no longer exist or can be easily mitigated. Most companies are unaware of these changes which make mobile applications far more cost effective, secure, and flexible than the technologies that currently dominate the marketplace. Taking advantage of this change now will give companies of any size, a competitive advantage and will enable alignment of goals from top management to entry level employees. The role of mobile apps for data capture is examined along with the managerial role of using apps for business intelligence delivery. Specific case studies along with lessons learned are reviewed.

3:45 pm

Establishing a Reliability-focused Mining Organization

B. Wesner; Life Cycle Engineering, Charleston, SC

Today's mining organizations are tasked with creating more advanced strategies to effectively handle internal and external client expectations, competition and budget constraints. Focusing on reliability-based fundamentals is not only recommended, but essential for an organization's success. Organizations must develop tactics and tweak established practices to handle these competitive pressures. Learning Objectives: Define current reliability challenges and internal paradigms within the mining industry Develop a personalized plan to combat cultural resistance. Understand the multitude of benefits a reliability-based organization can deliver Create a plan for increasing reliability efforts in order to improve the bottom line Summary: This presentation is designed to deliver a high-level understanding of how various asset management strategies, lean concepts and reliability-centered practices should be leveraged in order to increase mining performance and deliver more value to an organization.

4:05 pm

Keys to Sustainable Change and Project Success

B. Wesner; Life Cycle Engineering, Charleston, SC

Many organizations rightfully assume that the key element for any project's success is sound project management. While this may be true, it fails to fully recognize the human components within the process. When this happens, significant organizational changes often come with a myriad of unforeseen consequences. Therefore, if an organization is going to commit to change, it must also carefully consider human

factors. This presentation will focus on the essential elements required to effectively manage organizational change initiatives and ensure sustainable change. Learning Objectives: Understand the key elements of successful projects Recognize the link between change management and business results Explore Case study review – why do projects fail? Summary: This presentation is designed to help leaders understand how to successfully implement change within an organization. The presentation will reference Life Cycle Engineering's industry experience along with Prosci's® Change Management process to address human factors, culture, process and equipment limitations that adversely impact project success.

Tuesday, February 23 – Afternoon

ROOM: 127B

2:00 pm

Mining & Exploration: Management: Research: Innovations in Mine Operations

Chairs: E.Fretheim, Freeport-McMoRan, Oro Valley, AZ
A.Samal, GeoGlobal LLC, Riverton, UT

2:00 pm

Introductions

2:05 pm

Six Steps to Creating An Innovation Mindset in Your Company

K. Gill; Clareo, Chicago, IL

The mining industry is in a critical state globally. Despite record profits and still above-average prices compared to the lows of 2000, the industry is struggling to make profits and provide the returns on capital that investors are seeking. Traditional cost-cutting methods are not enough to correct the course. It's clear that radical innovation is needed to return companies to greater profitability, but what exactly does "innovation" mean, and how do you make it a prerequisite for your corporate strategy? Kulvir Singh Gill will explain the industry's innovation deficit and its implications, provide examples of innovation at work, and he will discuss the six key principles your company must follow to implement a successful innovation strategy. Drawing on his experience at Clareo, where he works with some of the world's largest mining companies and juniors, Mr. Gill will share methods that work equally well at small and mid-size companies.

2:25 pm

Presenting the Truth - Calculating KPIs in a Data-driven Mining Company

T. Mattiske; Trimble Mining, Denver, CO

Key performance indicators (KPIs) are measurable values of how effectively an organization is achieving its objectives. Calculating accurate and meaningful KPIs depends upon KPI definition and correctness of the data from which the KPI is calculated. If the data used to calculate the KPI is several processes away from the original data source, then any transformations applied by each process in the data chain need to be identified and understood, otherwise the value drivers of the KPI will be obscured. This presentation discusses innovative approaches to how data is validated and integrated before generating KPIs, while maintaining data integrity.

2:45 pm

New design method for compressed air distribution system

G. Danko; Mining Engineering, University of Nevada, Reno, Reno, NV

All underground metal mines use compressed air power supply in addition to electrical power distribution. For safety and rescue operations, safe and accident-proof supply of compressed air has been suggested for coal mines. Studies have been completed on the advantages of simultaneous ventilation, power and cooling supply with the use of compressed air. It is timely to critically review and improve the design methods of the compressed air power distribution system as it has not been changed for several decades. A new method is described for distribution pipeline sizing, as well as for pressure and power loss or gain calculations with distance, elevation, and variable temperature effects. The new method simplifies the compensation for elevation differences and makes the compressed air pipeline design more accurate in hot and deep underground mines. The new method helps evaluating the actual power efficiency of a compressed air power distribution system under variable elevation and temperature conditions. Numerical examples are provided to demonstrate the advantage of the new design method and new numerical simulation tools.

3:05 pm

Trial Results of a Collision Avoidance System at Barrick's Bald Mountain Mine

T. Ruff¹ and J. Keyes²; ¹Hexagon Mining, Tucson, AZ and ²Barrick Gold Corp., Salt Lake City, UT

A trial of Hexagon Mining's SAFEmine Traffic Awareness and Collision Avoidance System was conducted on surface mining equipment and light vehicles at Barrick's Bald Mountain operation in Nevada. The SAFEmine system determines vehicle location and movement information using GPS, while peer-to-peer radios are used to communicate this information to surrounding vehicles. The addition of TrackingRadar on trucks and a loader enable detection of untagged objects such as people or vehicles without the GPS-based system. The SafetyCentre additionally provides an integrated system that combines the GPS-based vehicle tracking information with TrackingRadar and cameras to monitor blind spots. The trial was designed to evaluate the effectiveness of SAFEmine in increasing operator situational awareness and providing warnings of potential collisions. Another goal of the trial was to demonstrate the ability to share data and present SAFEmine collision avoidance and vehicle tracking information on the Leica Fleet Management System. Trial methodology and key performance indicators, along with results and recommendations, will be discussed.

3:25 pm

16-061

Producing Structural Concrete while Using Mine Tailings as a Substitute for Fine Aggregate

J. Bray; Civil and Environmental Engineering, Colorado School of Mines, Golden, CO

The objective of this bench scale study was to produce concrete containing mine tailings in place of aggregate while investigating the structural integrity and leaching of heavy metals from the resulting concrete. Compressive strength greater than 4350 psi (30 MPa) was achieved when 70% of the fine aggregate was substituted with mine tailings. The potential of leaching heavy metals was evaluated using a standard static leaching method, where Cd, Fe, Mn, and Zn, were shown to have been encapsulated in the concrete matrix by at least 2 orders of magnitude. The next step is creating a pilot scale structure utilizing this construction material.

3:45 pm

Comparison of Mineralogic and Metallurgical Quantitative predictions using hand-held and portable Near Infrared Reflectance Spectrometers

D. Shiley; ASD Inc., a PANalytical company, Boulder, CO

Near infrared reflectance (NIR) spectroscopy is an analytic technique that has been a commonly used in mine laboratories for the quantitative determination of mineralogic and metallurgical parameters. Spectrometers have continued to evolve, becoming smaller, lighter and faster. These changes have enabled next-generation spectrometers to move from the laboratory to the core shed and even to the pit providing real-time quantitative measurements when and where they are needed. Quantitative results from a new hand-held NIR spectrometer will be compared to results produced using standard portable NIR systems. Many of the minerals that cause problems with efficient extraction of ore can be effectively quantitatively measured using portable NIR devices. Point of use quantitative predictions can create new opportunities for optimization of mine operations.

4:05 pm

The Enterprise Control System:Using Big Data Systems and Distributed ControlSystems to measure and report Value Generated in the Mineral Processing Industry

R. Cook; Mining and Metals, Schneider-Electric, N. Dighton, MA

The engineering design of a mineral processing plant is based on the design criteria developed for the project. It evolves through preliminary studies and conceptual designs, and documents the assumptions, and governing standard design for the plant. As the plant evolves from conceptual to implementation phases a continuing upgrade of the design is undertaken. As project startup evolves, an issue to focus on is financial reporting. Each company has their own method for reporting financial results. Most have a corporate ERP system, functional groups(Mine development teams Accounting, purchasing and warehousing, IT, HR, Maintenance, operations, Control systems, Health and Safety, continuous improvement teams, etc.)and a Plant Superintendent. One dilemma the management team face is how to measure and report value generated. They need to be able to take raw data from their big data systems, and globally distributed control systems, and tie it into an information management system to provide an auditable representation of value generated.This paper deals with the diagnostic process involved in the measuring and reporting of value generated.

Tuesday, February 23 – Afternoon

ROOM: 125A

2:00 pm

Mining & Exploration: Operations: Rock Mechanics and Geotechnical Challenges and Solutions

Chair: R. Rojas, Freeport McMoran Inc., Morenci, AZ

2:00 pm

Introductions

2:05 pm

Increasing Operational Spans Underneath Cemented Rockfill at Barrick Cortez Hills

B. Gunn¹, J. Armstrong¹ and R. Langston²; ¹Underground Engineering, Barrick Gold Cortez Mines, Spring Creek, NV and ²Langston and Associates, Inc, Red Lodge, MT

Barrick Gold recently increased operational spans underneath cemented rockfill (CRF) from 30 feet to 35 feet at its Cortez Hills mine. This paper summarizes the engineering approach used to assess the feasibility of increasing CRF spans and the operational steps taken to ensure successful implementation and mitigation of hazards. Some of the specific topics discussed in this paper include: Closed-form, numerical, and empirical assessments; potential hazards and action items identified during a formal risk assessment; increased QA/QC measures; the development of trigger action response plans (TARPs) and standard operating procedures (SOPs) prior to implementation; operational challenges encountered during implementation; and, deformation measurements and numerical model reconciliation.

2:25 pm

16-084

Elliptical Shaft Excavation in Response to Depth Induced Ground Pressure

B. Strickland, M. Board, G. Sturgis and D. Berberick; Hecla Mining Company, Coeur d'Alene, ID

Hecla Limited is nearing completion of the Lucky Friday Mine No.4 shaft located in Mullan, ID. The shaft is collared at the 4940 level of the mine and will have a final mine level depth of 8620, or 9,590 feet below the surface. After reaching the 7400 mine level the shaft encountered ground pressure higher than allowed for in the design for a circular shaft excavation and concrete lining. This additional ground pressure required portions of the shaft concrete liner to be reinforced with frameless, steel liner plate. To eliminate the installation of the liner plate from the remaining shaft development, the design of the shaft excavation starting at the 7650 mine level was changed to an elliptical cross section based on the overall stress field orientation as well as the orientation of the structure of the host rock surrounding the shaft. The elliptical cross section was instrumented to confirm the shaft excavation and lining was performing as designed. This design change has allowed the shaft to continue to the planned 8620 mine level without the need to install liner plate in the shaft or change the overall functionality of the shaft or the Lucky Friday life of mine plan.

2:45 pm

Crown Pillar On Ventilation Drift At Deep Mill Level Zone (DMLZ) PT Freeport Indonesia

A. Parhusip¹, R. Nugroho² and W. Teweng³; ¹Underground Construction, PT Freeport Indonesia, Tembagapura, Papua, Indonesia; ²PT Freeport Indonesia, DMLZ Engineering, Tembagapura, Papua, Indonesia and ³Underground Geotechnical Engineering, PT Freeport Indonesia, Tembagapura, Papua, Indonesia

Crown pillar is a situation which two different levels of development tunnel overlaying with adjacent distance. This situation results small pillar between these two drift/tunnels. Many cases Crown pillar cannot be avoided due to designated ore body position and existing facility drift such as ventilation drift, haulage drift. Crown pillar also been a case on Deep Mill Level Zone (DMLZ) PT Freeport Indonesia. This paper will discussed a geotechnical decision to state a Crown pillar status on DMLZ, Consequence assessment start from Development phase, pre-production/ground support phase and steel set construction to fix Crown pillar issue on DMLZ, a calculation on economic/actual cost of all of these phases revealed on this paper.

3:05 pm

Update to Newmont's Leeville Mine Ground Model and it's Application to Ground Support Selection

W. Robertson; Engineering, Newmont Mining Corp., Elko, NV

A site specific approach to ground conditions modelling has been undertaken at Newmont's Leeville underground mine. Changing and significant variations in ground conditions have led to an alteration based ground classification model. The reconciliation of over 1 million linear feet of drill core has provided a ground conditions model that is a proactive system used for both mine planning and ground support selection. Alternative ground support testing is ongoing in order to compensate for heavily squeezing and potentially corrosive environments.

3:25 pm

Pillar Extraction Project at Nyrstar's Immel Zinc Mine

M. Mrugala, A. Eksteen, S. Konieczki, N. Pohrivchak, C. Yarnell and C. Travis; Nyrstar Tennessee Mines, Gordonsville, TN

Abstract In underground operations involving room and pillar extraction method, a substantial amount of ore reserves remain arrested in the remaining pillars. These pillars are easy targets for potential extraction as their ore content is already known and accessibility can be secured with modest effort. Safety and operational considerations are main deterrents in adopting pillar extraction as a part of routine mining operations. Nyrstar's management has decided to develop the method of pillar extraction in its Tennessee operations. Among the six Nyrstar's zinc mines three are located in middle and three in east Tennessee, in limestone deposits ranging in depth from 800ft to 2000ft, approximately. The Immel Mine located in east Tennessee was selected for the pilot Pillar Extraction Project. A multi-phase plan was developed to assure that both theoretical and operational requirements are addressed and documented. This paper presents the details related to planning and field implementation of the already completed rock mechanics instrumentation phase. Authors wish to share lessons learned, while always maintaining safety at the forefront of their activities.

3:45 pm

Application of Inverse Velocity method for small-scale and rapid movements- A back analysis case study

S. Ghaychi Afrouz, H. Tiruneh and K. McPhelimy; Slope stability, Mining/geotechnical, Morenci, AZ

Bench scale failures in large open pit mines are tolerable during mine operations as long as the catch benches below the failure area are not full and the potential for rolling rock is minimized. However, these types of failures can create greater risks if there are no catch benches to contain the failed material and especially if there is equipment or personnel working directly under them. Slope Stability Radars are commonly used in large open pit operations to monitor the movement of high walls. The inverse velocity method, introduced by Fukuzono (1985), has been widely used to predict the time of slope failures in open pit mines, although the method has difficulties in predicting small scale or rapid failures. Phase ambiguity and atmospheric corrections on the acquired radar data can limit the application of inverse velocity in small scale or rapid bench scale failures. The objective of this work is to study the rate of acceleration for different real case situations and back analyze them to understand how the inverse velocity method can be used for small scale and rapid movements, and whether it can be distinguished from atmospheric effects of the monitoring radars.

Tuesday, February 23 – Afternoon

ROOM: 127C

2:00 pm

Mining & Exploration: Technology: Application of Discrete-Event Simulation in Mining Problems II

Chair: E. Tarshizi, Michigan Technological University, Houghton, MI

2:00 pm

Introductions

2:05 pm

16-042

Effect of Changing Duty Cycles with a panel in CM-shuttle Car Matching: A Case Study

A. Anani and K. Awuah-Offei; Mining, Missouri University of Science and Technology, Rolla, MO

Accounting for changing duty cycles in equipment matching maximizes equipment utilization and productivity. The objective of this study is to investigate if the optimal number of shuttle cars for a particular panel width is optimal in different segments of the panel. In this study, discrete event simulation (DES) is used to determine the optimal number of cars that maximizes productivity in each segment. Data from a real-life mine is used to validate the model. The study shows that the optimal number of cars for the entire panel may not be optimal for some of the defined segments.

2:25 pm

Optimizing the operating costs of the transportation systems in open pit mines using discrete event simulation modeling

A. S. Hashemi² and J. Sattarvand¹; ¹Mining and Metallurgical Engineering, University of Nevada Reno, Reno, NV and ²The Robert M. Buchan Department of Mining, Kingston, ON, Canada

Maximizing the mining equipment utilization is considered as one of the most important operational objective functions which can be achieved using equipment managing systems. Advances in computer science and truck dispatching systems, which are enhanced significantly using GPSs, make it much easier to monitor the trucks and shovels inside the pit and make real time decisions in order to reach the maximum efficiency of the machinery and higher production rates. This paper focuses on comparing different fleet management strategies using delay time minimization. In this regard, difference of the operating costs associated with unnecessary waiting times of both trucks and shovels has been investigated. To this end, discrete event simulation model of the loading and haulage system of an open pit porphyry copper mine located in North West of Iran has been constructed. The model was then studied for minimizing the waiting times which occur at the loading points according to their associated costs. This resulted in improvement in production rate as well as reduction in unit cost of production due to the minimization of the idle times of the equipment.

2:45 pm

Using Dynamic Simulation to Support Mine Infrastructure Construction Supply Chain Planning and Vendor Selection

M. Franklin and S. Parakh; MOSIMTEC, LLC, Herndon, VA

For a multi-national metals and mining corporation in Europe, we developed a detailed global supply chain model to evaluate the feasibility of a new mine specifically related to supplying the material and infrastructure to construct the port, the roads, the railways, and the mine. The model was configured to utilize estimated material requirements as well as analyzing contractor bids with contractors providing their proposal of material scheduling. This paper provides more detail regarding approach, input parameters, model development, level of abstraction, metrics, and output analysis. Since the project is ongoing, the paper will also highlight current status, lessons learned, and planned next steps in utilizing modeling and simulation to support informed decision making for large infrastructure projects.

3:05 pm

Using Simulation to Better Predict Performance of New Equipment

C. Taylor and O. Wyberneit; RungePincockMinarco, Toronto, ON, Canada

Mines are more complex with greater numbers of production and support equipment and underperformance of new equipment is more common. The use of discrete event simulation allows for the mine to be viewed as a complete transport system instead of a series of individual haul routes. This allows for the impacts of new equipment to be more accurately estimated, allowing for more realistic benchmarks resulting in smaller variances between modelled and actual productivities. This paper looks at how clients have used this process and Rpm's product to evaluate changes to the load-haul system, analyzing different haul routes, rosters and equipment.

3:25 pm

16-035

Merits of discrete event simulation in modeling mining operations

S. Dindarloo¹ and E. Siami Irdemoosa²; ¹Mining and Nuclear engineering, Missouri University of Science and Technology, Rolla, MO and ²Department of Geosciences and Geological and Petroleum Engineering, Missouri University of Science and Technology, Rolla, MO

Discrete event simulation is a stochastic mathematical modeling tool with applications in queuing systems. Many mining operations, both surface and underground, can be simulated in the context of queuing theory e.g. open pit loading and haulage operation, underground level and vertical transportation, and mineral processing circuits. A computer simulation model of the operation is an invaluable tool to study both the system's dynamics and conducting sensitivity analysis on different effective elements on system performance. In this paper, merits of discrete event simulation in decision making in mining engineering is discussed. Moreover, a stochastic simulation framework for selection and sizing of shovels and dump trucks in surface mining is presented to elaborate one example for applicability of the method in mining operations.

3:45 pm

Model-experimental study on cemented rock-tailings backfilling process

L. Guo and X. Yang; Mining Department, Associate Prof., Beijing, Beijing, China

In order to solve the key technology problems of cemented rock-tailings filling (CRF) and discuss slurry sedimentation behavior, the model-experimental device of CRF was devised, experimental schemes of CRF were prepared according to the mining with backfill method and in-situ engineering project, and the estimation of quality of CRF were carried out using morphometry and cross-section cutting of filling, with giving the optimum backfill process. The research results show the backfilling quality is better when waste rock and tailings synchronously dump, be it waste rock even laid or tapered stacked; The feasible and optimum backfill process can effectively improve compressive strength of cemented rock-tailings filling, but also effectively reduce cement dosage, economize backfill cost, at the same time test results can afford scientific evidence for the optimization of backfill of test mine.

Tuesday, February 23 – Afternoon

ROOM: 125B

2:00 pm

Mining & Exploration: Technology: Underground Mining Methods, Technology and Innovation

Chair: A. Nieto, Penn State University, University Park, PA

2:00 pm

Introductions

2:05 pm

uGPS: Developing a mobile localization and 3D mapping technology for the underground mining industry

A. Chapman; Peck Tech Consulting Ltd., Montreal, QC, Canada

While the surface mining industry was greatly advanced with the introduction of global positioning systems (GPS) in the 1990s, no comparable technology yet exists underground. Similarly, 3D mapping underground is an emerging field but so far has been constrained to conventional, stationary surveying set-ups. This presentation covers the authors' work in developing a mobile underground positioning and mapping technology for the mining industry. This LIDAR-based approach has succeeded in its original goal of mine site-wide positioning with precision comparable to surface L1 GPS, and as a necessity has evolved an impressive capability for rapid volumetric mapping. The process of commercializing this technology from the initial research stage to the finished product is reviewed, including technical challenges, input from industrial partners, and results from real world use cases. Also highlighted are capabilities of the finished product's technology platform, and a few applications of the technology with the potential to revolutionize underground planning and production operations.

2:25 pm

16-063

Water Quality of Reiche Zeche Teaching Mine, Freiberg, Saxony, Germany

V. Zhiteneva¹, H. Mischo³, J. Brune², J. Weyer³ and A. Simon³; ¹Civil & Environmental Engineering, Colorado School of Mines, Denver, CO; ²Mining Engineering, Colorado School of Mines, Golden, CO and ³TU Bergakademie Freiberg, Freiberg, Germany

Reiche Zeche is a lead-zinc-silver deposit in Freiberg, Germany, that was mined for over 800 years. Since 1969, Reiche Zeche has been a teaching and research mine, with numerous adits for dewatering large amounts of inflowing water. Infrequent metal water quality monitoring in the 1980-1990s and flooding of the mine in 2002 led to a lack of relevant data. New measurements were taken at different level adits and ore veins for comparison to historical values, revealing pH levels as low as 1.95, conductivity as high as 22,000 $\mu\text{S}/\text{cm}$, and an overall trend towards less acidic waters.

2:45 pm

Increased safety and productivity through collision avoidance systems on mobile equipment

K. Winfield; Provix, Alliston, ON, Canada

One of the main issues when operating heavy equipment is the inability of the operator to see pedestrians and other equipment. This has led to many near misses, high potential incidents, equipment damage, injuries and fatalities in the industry. To correct these issues Provix can implement solutions to your exact industry needs with a combination of RFID proximity detection systems and Laurentian University's derived Blind spot detection technology. Laurentian University's LOS team and camera supplier Provix work together to have LOS studies developed identifying the "No Zone" or "Blind Spots" on mobile equipment. Dr. Tammy Eger and Dr. Alison Godwin from the "Center for Research in Occupational Safety & Health" at Laurentian University evaluate the equipment for blind spots based on the operator's line of sight on the equipment. A recommendation is provided for the number of cameras as well as the cameras installation locations. Camera systems provide operators with more situational awareness and enhanced vision through expanded sight lines. This leads to decreased trip times; increasing productivity with safer equipment operation around personnel.

3:05 pm

Mining and Exploration Underground Mining Methods Technology and Innovation

J. African GASORE; MINING, CONSULTANCY, Kicukiro, KIGALI, Rwanda

I would like to participate on this event to improve the knowledge and develop the way which one we operate our concessions because we still used the operating artisanal. It will also occasion for me to meet others professionals to reap and share some knowledge together. If I find the opportunity I held the first in our area of large of great lakes region to have this knowledge and I think that I will be the front door to share all that you will teach me to develop our capacity.

3:25 pm

A 3D numerical analysis on the propagation of 3.2kHz TTE signals along the rail in underground mines

C. Weiss², S. Schafrik¹ and E. Jong¹; ¹Mining and Minerals Engineering, Virginia Tech, Arlington, VA and ²Department of Geophysics and Atmospheric Sciences, Sandia National Laboratories, Albuquerque, NM

A fundamental question in assessing through-the-Earth (TTE) communication systems is the effect of subsurface geologic and anthropogenic complexity on signal propagation and strength. The following paper presents a focused and fully 3D numerical analysis about the impact of underground rail on the propagation of 3.2kHz TTE signals. Anecdotal and experimental evidence is consistent with the model results presented in this paper, which show enhanced signal propagation when the TTE transmitter is broadside to the rail. Limitations of this phenomenon, such as the lack of signal enhancement when the TTE transmitter is placed directly on the rail, is also discussed.

3:45 pm

Use of mine control in optimizing underground mining productivity

N. Harries; Operations, Hexagon Mining, Tucson, AZ

Mine control is a term used to describe the process used to manage and supervise the production that occurs in mining. In mine control, technology is increasingly playing an essential role in optimizing the productivity of mining but this has to be matched by developments in the business processes to achieve the best and most sustainable results. As well as providing productivity gains, mine control has now been widely used to reduce the mining costs of operations by increasing the utilization and availability of mining equipment. The technology environment of underground mines combined with the complex task schedule needed to execute the underground mining process can make the application of a mine control quite challenging. Hexagon Mining has developed and deployed a number of underground mine control systems over the last five years. In this paper we will discuss the success factors that have made mine control both a success and failure in the underground environment.

Tuesday, February 23 – Afternoon

ROOM: 130

2:00 pm

Mining & Exploration: Technology: Ventilation Technology in a Data-Driven Environment

Chair: G. Goodman, NIOSH, Pittsburgh, PA

2:00 pm

Introductions

2:05 pm

16-006

Extending Mine Ventilation Sensor Coverage With Real Time Model Simulation

C. Stewart; Mining Engineering, University of Queensland, Thornlands, QLD, Australia

The use of gas, temperature and airflow sensors to monitor mine ventilation atmospheres offers numerous safety and operational benefits to mines. Detection of dangerous gases, changes to airflows and temperature variations are some of the obvious benefits of using atmospheric sensors in mines. The prediction of atmospheric conditions between sensors however is potentially difficult, and gaining full coverage a mine will require either many sensors or a method of extrapolating and predicting atmospheric conditions between and downstream from a sparser array of sensors. A dynamic simulation computer model technique is demonstrated to predict time based changes to atmosphere conditions downstream from sensors. The dynamic model predicts the time based changes to conditions throughout a mine model by simulating the mixing, addition and dilution of gases and airflow changes in incremental time steps. The advantages of this method is that a real time overview of full mine atmospheric conditions can be viewed at all locations, even areas without sensors. In addition, with careful planning and consideration of potential contaminant sources, the number of required sensors can be minimized.

A new sensor for continuous tracking of diesel particulate matter in mines to optimize mine ventilation systems

J. Volkwein¹, A. Hansen² and J. Hilß³; ¹Consultant, Canonsburg, PA; ²Magee Scientific, Berkeley, CA and ³Mining Engineer, Mullan, ID

Hecla Limited has been investigating the potential benefits of using a Spendrup/ Compact Filter Technic (CFT) to remove diesel particulate matter (Dpm) from the mine atmosphere, to optimize use of the available air. NIOSH evaluated the scrubber efficiency for dust and Dpm (presented in another report). This paper reports on a new carbon particle sensor which can continually monitor mine Dpm levels, and was used in conjunction with the scrubber evaluation. Two Magee Scientific Aethalometers that measure ambient black carbon from combustion sources (off-the-shelf Model AE33) were installed underground to assess their ability to continuously monitor underground Dpm levels in the mine, at the intake and exhaust of the CFT scrubber system. Results showed that the Aethalometer data continuously indicated underground Dpm levels over the course of the six week trial. Data from 14 days of testing showed that Dpm filtration would be required for less than half of the time, in order to maintain Dpm levels at acceptable levels. If the Aethalometer data output was used to control a 200-HP in-mine scrubber to operate only when required, significant electrical cost savings could be realized.

2:45 pm

The Challenges in Assessing and Establishing an Appropriate Heat Stress Index which Protects the Workers in Underground Mines

P. Roghanchi, K. Carpenter and K. Kocsis; Mining Engineering, University of Nevada, Reno, Reno, NV

The evaluation of climatic condition of an underground environment requires extensive measurements and modeling work. Consequently, a simple indicator is needed to enable a quick, valid and acceptable evaluation of climatic conditions on a regular basis. Heat stress index integrates personal, physiological, and environmental parameters into a single number for a quantitative assessment of a thermal environment. Measuring and collecting a large number of physiological and environmental factors is rather complicated and usually not practical at the underground mines. Furthermore, the large number of available heat stress indices would make it difficult to choose an applicable "distinct" index for the underground mines. The aim of this study is to discuss the challenges in identifying and selecting a heat stress index for thermal planning and management purposes in an underground environment. We will demonstrate how the weights of the important parameters in an underground mine are critical for selecting an appropriate heat index. We will also disclose our method for selecting and recommending a heat stress index for various operating conditions in the underground mines in the USA.

3:05 pm

Modelling of Radon Gas Diffusion through Fractured Rock in Cave mines

P. Tukkaraja¹, K. Ajay², K. Shahbaz², K. Katzenstein³ and D. Loring⁴; ¹Mining Engineering and Management, South Dakota School of Mines and Technology, Rapid City, SD; ²Mechanical Engineering, South Dakota School of Mines and Technology, Rapid City, SD; ³Geology and Geological Engineering, South Dakota School of Mines and Technology, Rapid City, SD and ⁴Freeport-McMoRan Company, Chief Mine Engineer, Empire, CO

Both natural and induced fractures play a role in the diffusion of radon gas through the yield zone of cave mines. This study focuses on development of a discrete fracture network model which incorporates both natural and induced

fracture characteristics and a simple one dimensional diffusion model for radon gas transport. Results from this study will help develop a model used to estimate radon gas emission from the yield zone within cave mines.

3:25 pm

Development of a Real-Time, Predictive and Personal Heat Strain Monitor

R. Reed; Mining Safety and Health Program, University of Arizona, Tucson, AZ

Objective: To pilot development of a real-time heat strain monitor capable of predicting core body temperature and heat strain risk and VOD integration.

Introduction: Compared to coal, underground metal mining can present a unique environment in which heat stress is exacerbated by deeper mines with substantial geothermal heat, high humidity, lower ventilation rates, and heavy workloads.

Methods: A university maintenance crew will be recruited to participate. With a wearable prototype laden with several sensors, physiologic (heart rate, activity, skin temperature, hydration, oxygen saturation) and environmental (dry bulb temperature, relative humidity) measures will be collected for approximately ten subjects. Core body temperature (CBT) will be measured using ingestible temperature sensors, and will be used as a standard. Neural networks (NN) will be used to develop machine learning models predictive of core body temperature. Anticipated

Outcomes: We hope to successfully predict CBT in real-time in working individuals with a wearable monitor. This project lays the groundwork for a small, predictive, real-time heat strain monitor with alerting system and VOD integration.

Tuesday, February 23 – Afternoon

ROOM: 228A

2:00 pm

MPD: Chemical Separation: Pyrometallurgy

Chairs: D. Connor, Metso Minerals Industries Inc, Waukesha, WI
J. Grogan, Gopher Resource, Eagan, MN

2:00 pm

Introduction

2:05 pm

Selective sulfation roasting of rare earths from NdFeB magnet scrap

B. Carlson and P. Taylor; Kroll Institute for Extractive Metallurgy, Colorado School of Mines, Golden, CO

Rare earth magnets play an increasingly important role in high end technology and the manufacture of rare earth magnets, such as the NdFeB type, consume a large amount of the rare earths produced. As the US is highly dependent on foreign sources for rare earths, there is both a strategic and economic drive for developing a recycling program for this material. The selective sulfation and water leach (SSWL) technique has been developed as a way to recycle the contained rare earths in NdFeB waste. The central principle of this method is to take advantage of the higher thermal stabilities of the rare earth sulfates compared to those of iron. After being mixed with sulfuric acid, the magnet waste is heated, converting the rare earths into sulfates, while the less stable iron sulfate is decomposed into iron oxide. The roasted product is then leached with water, putting the soluble rare earth sulfates into solution, while leaving behind the insoluble iron oxide. After a solid liquid separation stage, the rare earth bearing solution can be sent to a purification and precipitation circuit, while the iron oxide leach residue can be sent to disposal or possible sale.

2:25 pm

Reduction of Silicon Oxide to Silicon in Thermal Plasma Reactor

R. Reddy; Met. Matls. Eng., The University of Alabama, Tuscaloosa, AL

The numerical simulations and experimental studies on reduction of metal oxide to metal in thermal plasma reactor (TPP) were investigated. CFD simulations in TPP on temperature and fluid flow distribution were investigated. Reduction of SiO_2 to Si experiments were conducted as a function of power input to the TPP and methane to SiO_2 ratios. From the results obtained temperature and fluid flow distribution in TPP, SiO_2 and methane gas properties, and experimental parameters, a reduction mechanism of SiO_2 to Si is proposed.

2:45 pm

Carbochlorination of Cerium and Neodymium Oxide

A. Anderson and B. Mishra; Metallurgy, Colorado School of Mines, Golden, CO

Rare earth oxides are the typical starting material for conversion into their metals because they are the most common products of ore processing and separation operations. The extreme chemical stability of the rare earth oxides is responsible for the rather complex methods used for rare earth metal production. Carbochlorination, a process in which metal oxides are converted into metal chlorides under the flow of dry chlorine gas in the presence of carbon, has been a proposed step in rare earth metal processing. The direct chlorination of cerium and neodymium oxide with chlorine gas is very energy intensive and thus it becomes beneficial to perform the chlorination of these oxides in the presence of a reducing agent such as carbon. The process parameters chosen for this investigation were temperature, time, chlorine gas concentration and carbon concentration. The effect of agitation was also studied. A rate curve as well as statistical modeling was generated for both the cerium oxide and neodymium oxide carbochlorination reactions.

3:05 pm

Effect of Reduction Roasting On Beneficiation of Low Grade Iron Ores by Magnetic Separation

V. Ravi Sankar, V. Rayasam and P. Kumari; Fuel and Mineral Engineering, Indian School of Mines, Dhanbad, Jharkand, India

Reduction roasting was carried out on samples of Gua mines from Jharkhand, containing 58.08%Fe, 7.82% SiO_2 , 4.26% Al_2O_3 and loss of Ignition (LOI) of 4.97% by varying time (10, 20 and 30 minutes), temperature (600°C, 700°C and 800°C) using coal as the reducing agent (2, 5 and 10 %). Drum Magnetic separation of roasted samples showed best results at 800 °C, 10 % C and 30 minutes. With maximum Recovery of 90.44 % with 66.58 % Fe. XRD and SEM, of roasted samples confirmed the results.

3:45 pm

Value Added Approach to Furnace Rebuilds – A Fit For Purpose Application Methodology

P. Lee; METALLURGY, U of T, Oakville, ON, Canada

The rebuilding and turn around process of a primary or secondary smelting vessel is a major undertaking defined by capital and schedule intensive activities that impact directly on bottom line production and cash flow. Exceedances of budget and schedule are not rare due to technical and executional challenges associated with infrastructure and vessel integrity which may only be discovered post shut-down and during demolition. Strict definition and control of project scope as well as execution plans are critical to ensure success. Additionally, rigorous planning of contingencies (technical and project management) are required in order to rapidly adjust whilst minimizing negative implications (cost and schedule). Combining fit-for-purpose technology application, engineering design, construction and project

management can add significant value minimizing cost and downtime. Judicious application of such principles and incorporation of early stage planning and execution by owners' teams, technology providers, engineers and construction management teams result in significant value creation. Examples presented are successful applications base metals smelting (nickel and copper).

4:05 pm

Campaign Life Extension and Continuous Improvements of the ASARCO Flash Furnace

P. Lee; Metallurgy, U of T, Oakville, ON, Canada

ASARCO's Hayden Smelter is a fully integrated copper miner producing ~400 million pounds of copper per annum. An original Inco Flash Furnace is employed treating copper concentrates, secondaries, fluxes and coke to produce an intermediate copper matte that is further refined in PS converters and Anode furnaces to Anode Copper. Over the past ten years ASARCO has carried out a continuous improvement program resulting in major improvements to the furnace integrity/campaign life. Following this approach, the furnace has achieved an overall campaign life >2x that of the original design. Recently, the furnace was completely rebuilt with advanced technology in copper coolers, refractory and cooling systems as well as complete upgrades to the structural and binding system, effectively providing for a "new" asset. Combination of a unique and fit-for-purpose mix of in-house and niche third party engineering, construction and project management knowledge and expertise gained from the improvement program has resulted in an asset with considerably improved capability at a significantly reduced schedule and cost as compared to recent and prior industry benchmarks.

4:25 pm

Laboratory Methods to Evaluate Double Refractory Gold Ore Roasting

P. Taylor, B. Fosu and J. Friesinger; Metallurgical and Materials Engineering, Colorado School of Mines, Golden, CO

Various laboratory techniques are presented and discussed that are being used in the evaluation of roasting of double refractory gold ores. Methods include: DSC-DTA, bomb calorimetry, X-ray diffraction, BET surface area analysis, QemScan, tube furnace tests, cyanide leach amenability tests, and lab scale fluidized bed tests. Results are presented that demonstrate the utility of the techniques.

Tuesday, February 23 – Afternoon

ROOM: 232C

2:00 pm

MPD: Chemical Separation: SX-IX-EW

Chairs: B. Hutzler, Cytec Industries, Tempe, AZ
B. Varela, Freeport McMoRan, Tyrone, NM

2:00 pm

Introductions

2:05 pm

Copper Solvent Extraction: Status, Operating Practices and Challenges in the African Copper Belt

O. Tinkler¹ and K. Sole²; ¹Cytec Industries, Phoenix, AZ and ²Consultant, Johannesburg, South Africa

Although the first large-scale application of copper recovery by solvent extraction (SX) took place in Zambia in the early 1970s, it is only in the last decade that this technology has become widely employed in this part of the world and is now a mainstay unit operation in most copper hydrometallurgical flowsheets. The mineralogy of the ores in the African Copper Belt, and hence the characteristics of the African leach liquors, differ significantly from those in Chile and the south-western USA, where copper SX has had a long and successful history. These differences provide operators, metallurgists, reagent vendors, and engineers with many challenges: new approaches are needed to adapt this technology for successful implementation in this region. This paper examines typical operating practice in the African Copper Belt, discusses differences compared with other parts of the world, and looks at some of the challenges and opportunities presented by these flowsheets.

2:25 pm

Manganese dioxide deposition on catalytic titanium anodes

M. Moats, P. Laforest and H. Westin; Materials Science and Engineering, Missouri S&T, Rolla, MO

Rising energy prices and concerns about sustainability will likely drive copper electrowinning operations to reduce energy consumption. Replacing lead alloy anodes with mixed metal oxide coated titanium could reduce electrical power consumption by 13-15%. Unfortunately, titanium anode surface life can be sensitive to deposits of foreign materials such as manganese dioxide. This presentation will review previous research on the effect of electrolyte and electrolysis parameters on the deposition of MnO_2 on crystalline mud-cracked IrO_2 - Ta_2O_5 coated titanium anodes from synthetic copper electrowinning electrolytes. The effects of common commercial smoothing agents and other polyacrylamides will also be presented.

2:45 pm

Extraction of Copper from NH_4Cl Leachate

T. Hymer¹, K. Summerfield¹ and M. Moats²; ¹Research and Technical Development, The Doe Run Resources Corporation, Viburnum, MO and ²Materials Science and Engineering, Missouri University of Science and Technology, Rolla, MO

The Doe Run Resources Corporation has undertaken the development of a process for recovery of copper from chalcopyrite concentrates. The process features a unique NH_4Cl leaching solution that copper is extracted into and then transferred from NH_4Cl into a H_2SO_4 based solution for electrowinning. Laboratory testing was performed to confirm that copper extraction can be accomplished using either atmospheric or pressure leaching and recovery is possible through commercially available technologies such as solvent extraction or ion exchange.

3:05 pm

16-160

The Impacts of Silica on Cadmium Cementation by Zinc SX/EW Plant

A. Janwong; Horsehead Metal Products Inc., Mooresboro, NC

The Horsehead Metal Products is a zinc refinery in Mooresboro NC treating crude Waelz Oxide (WOX) to produce Special High Grade® Zinc by a hydrometallurgical process, comprising leaching, zinc solvent extraction/electrowinning (SX/EW), melting and casting and bleed treatment. Cadmium removal by zinc dust cementation plays an essential role in the bleed treatment circuit to prevent a build-up of cadmium in the circuit. Silica, although not present at significant levels in the WOX feed material, had a significant impact on the efficiency of cadmium cementation with zinc dust, most likely due to the passivation of zinc dust particles with silica gel, and the subsequent solid/liquid separation by filter press. The silica levels were mapped throughout the circuit to identify the source of the silica and specific conditions promoting the formation of silica gel. Adjustments have been introduced to mitigate the silica levels in the circuit.

3:25 pm

Modeling and Validation of Electrowinning to Facilitate Operational Optimization

J. Werner and M. Free; Metallurgy, University of Utah, Layton, UT

Understanding the causes and effects of operational conditions in tank houses has a significant impact on electrowinning operating costs. To better predict these costs a model was developed to determine the cause and effect of various parameters such as temperature, concentration, bubble size, and current density on electrowinning performance. Straight cathodes and various defects were studied such as nodules, bent and tilted cathodes. Experiments were conducted to validate the model. Full-scale simulations were also compared to historic data. The objective of this work is to provide operators with a modeling tool that quantifies the impacts of operational settings on electrowinning performance and costs.

3:45 pm

Commissioning of Innovative and Fully Automated GEA Westfalia Three-Phase Crud-treatment Decanter at Asarco Silver Bell Mine

W. Mang; Leach and SXEW, Asarco Silver Bell, Marana, AZ

Asarco Silver Bell Copper Hydromet, together with GEA and TB Contractors, successfully commissioned and automated the GEA three-phase decanter crudMaster CF4000, the largest in North America copper industry. Initial startup was a success, but saw significant solids and varying 10% to 90% organic in crud, beyond conventional decanter design based on fixed %organic and %solids in crud. The decanter was subsequently power-up by doubling the torque and differential Rpm for the internal scroll, and sized-up with a smart open organic system sensing and matching decanter processing any crud. Afterwards the decanter automatically separated any complex crud of any composition into clean organic, solids and aqueous, achieving the ultimate goal in crud treatment for copper industry. A process breakthrough, such decanter realizes significant other benefits: upstream eliminating draining “aqueous” from crud separation tank, saving organic otherwise lost; and downstream providing dry organic for best clay treatment. Further upstream it minimizes draining organic from crud collection tank, with selective crud removal now planned, saving copper otherwise lost in electrolyte pumped with crud.

4:25 pm

16-134

SX Impurity Transfer and Wash Stage Considerations

A. McCallum, T. Bednarski and T. McCallum; Cytec Industries Inc., Tempe, AZ

Physical impurity transfer in solvent extraction (SX) has a significant impact on operating costs, electrowinning (EW) performance, and cathode quality. Some operations use a wash stage to limit impurity transfer by diluting the entrained pregnant leach solution (PLS) to prevent direct transfer to EW. Wash stage operating conditions vary impacting impurity transfer. A number of factors impact dilution efficiency including mixer continuity, wash aqueous acidity, and organic quality. The impact of these variables on dilution efficiency was studied and compared to current industry practice.

4:45 pm

An Alternative Approach to Masking Electrowinning Cathodes to Produce Rounds

T. Valentine; Metallurgist, Newport, WA

An alternative approach to masking electrowinning cathodes to produce rounds is to apply an adhesive plastic film to seal the cathode surface from the electrolyte in such a way so as to create an optimum pattern of bare areas exposed to electrolyte and DC current and thus produce deposits in any desired shape and size. The size, shape and pattern of plating areas are easily adjusted. Initial

testing indicates the potential of using the cathode blanks for several plating and harvest cycles before removal and reapplication of the masking is necessary. The material can be easily removed without generating hazardous waste. The cost of necessary capital equipment is minimal.

Tuesday, February 23 – Afternoon

ROOM: 228B

2:00 pm

MPD: Comminution: Comminution II

Sponsored by: ThyssenKrupp Industrial Solutions (USA), Inc.

Chair: M. Dennis, FLSmidth USA Inc., Midvale, UT

2:00 pm

Introduction

2:05 pm

Recent Experiences in the Design and Operation of Comminution Circuits

A. Giblett; Techinical Services - Processing, Newmont, Subiaco, WA, Australia

This paper will review a number of recent experiences in the design and operation of comminution circuits, with particular focus on circuits using SAG milling. This will include a review of experiences with HPGR/Ball and secondary crushed SAG feed configurations. These experiences will be leveraged to provide useful insights in the interpretation of ore characterisation databases in support of grinding circuit design. Practical methodologies for the statistical and critical review of ore hardness test results to provide a reliable basis for determining the appropriate number of samples for testing and the appropriate design basis for mill sizing will be discussed and supported by case studies. Operational performance benchmarking data will be discussed for use in support of mill design approaches and defining mill throughput model accuracy.

2:25 pm

16-166

Plant Site High Speed Tomography for 3D Coarse Particle Characterization

J. Miller, C. Lin and Y. Wang; Metallurgical Engineering, University of Utah, Salt Lake City, UT

The more efficient production and use of mineral resources is a major objective of our sustainability efforts. Resource characterization is a critical component for optimization of the mine-to-mill process and is now referred to as geometallurgy. Sampling and geometallurgical information is important for exploration, deposit evaluation, mine planning, mill control of recovery efficiency, etc. Improved sampling and geometallurgical analysis can save millions of dollars in the effective utilization of our mineral resources. It now seems possible to use 3D X-ray tomography analysis for plant site particle characterization at an expected sampling rate of 10-20 kg/min for particles which range in size from 150 mm to 1 mm at a voxel resolution of about 150 microns. This is quite a significant advance in X-ray tomography technology and should be useful for plant site particle characterization (size, shape, composition, density, texture, grain exposure, mineral liberation) with a response time of minutes after receiving the sample. Applications in the mineral industries are discussed including the coal industry, aggregate industry, metal mining, and industrial minerals.

2:45 pm

Dynamic Simulator Module of a Grinding Circuit

V. Srivastava, G. Akdogan and T. Ghosh; Mining Engineering, University of Alaska Fairbanks, Fairbanks, AK

Grinding is a primary unit operation in a mineral processing circuit. Grinding involves multiple input and output variables. The variations in input variables such as feed throughput, water addition to mill and sump, rpm of the mill and cyclone volumetric feed flow rate greatly affects the output variables such as product particle size distribution, circulating load and mill power draw. The intricate interactions among these variables and disturbances such as changes in feed particle size distribution and ore hardness makes the process complex in terms of operation and control. This paper presents an attempt to simulate the various unit operations in a Matlab/Simulink environment utilizing conventional population balance models to develop a dynamic module of a grinding circuit. The module includes the model predictive control (MPC) feature which co-relates the weighted response of the output based on the dynamic variabilities of the input.

3:05 pm

Exploring IsaMill Viscosity

M. Larson; Glencore Technology, Ewen, MI

Much has been written in the past regarding viscosity in stirred mills from a laboratory standpoint while running industrial minerals such as calcium carbonate. However the same body of knowledge when it comes to full scale hardrock applications is still a work in progress. This presentation will attempt to discuss in layman's terms some of the issues encountered in full scale and laboratory IsaMills. As exploitable ore bodies have become finer grained and including more exotic, ie miserable, components new challenges have arisen at both the pilot and industrial level that defy previous levels of understanding and have forced supplier and customer to adapt in more creative ways with how these mills are operated.

3:25 pm

Energy curve case study (AngloGold Ashanti)

G. Ballantyne¹, M. Powell¹ and N. Clarke²; ¹The University of Queensland, Sustainable Minerals Institute, Julius Kruttschnitt Mineral Research Centre, Brisbane, QLD, Australia and ²AngloGold Ashanti, Perth, WA, Australia

AngloGold Ashanti has been an early adopter of High Pressure Grinding Roll (HPGR) technology at Tropicana Mine and they have been assessed in the Gramalote Project. The increased energy efficiency achieved by HPGRs through confined bed breakage has been extensively researched in small scale tests, but slow industry uptake has resulted in fewer large-scale studies. This has resulted in a reluctance by operators to accept that small scale testwork is capable of replicating real energy reduction at industry scale. The first full survey of the Tropicana circuit has recently been conducted to assess its performance. These results are presented on CEEC's energy curves to benchmark the individual performance of each reduction stage down the circuit. In addition, the availability of lab-scale test work conducted during project development allows the investigation of scale-up effects in energy efficiency. The investigation of HPGR circuits during the development of the Gramalote project provides another opportunity to showcase the efficiency of HPGR circuits and the CEEC energy curve methodology.

Tuesday, February 23 – Afternoon

ROOM: 232B

2:00 pm

MPD: Industrial Minerals Flotation: Flotation II

Chairs: T. Bhambhani, Cytec Industries Inc., Stamford, CT
J. Gebhardt, FLSmidth Salt Lake City Inc, Midvale, UT

2:00 pm

Introductions

2:05 pm

Collectorless Flotation of oil shale

S. El-Mofty; Mining Engineering, Head of Mining Engineering Division, Cairo, Egypt

The impurities in oil shale prevent its direct usage as a source of energy. Removal of these impurities by physical treatment processes proved to reduce the cost of oil shale retorting. Pretreatment of oil shale by flotation represents one of the favorable solutions due to its simplicity and flexibility as well as its lower operating costs. Therefore, in this work the flotation of oil shale was used to separate the organic matter (kerogen) from associating gangue without adding a collector. Microscopic examinations were carried out to study the different mineralogical characteristics of oil shale sample. Floatability of oil shale was investigated under different conditions of flotation process. Results of oil shale characterization showed that kerogen content in the studied sample was 20% while the flotation results proved that possibility of oil shale upgrading with a recovery reached to more than 70 %. Kerogen morphology, grinding size and kinetics of flotation were detected to have a great effect.

2:25 pm

16-167

Surface Chemistry of Rare Earth Elements using Salicylhydroxamic Acid

R. LaDouceur, W. Nicholas, G. Galt, A. Das and C. Young; Metallurgy, Montana Tech, Butte, MT

Many of the RE Elements are on the DoD Strategic and Critical Materials list. In this regard, the Army Research Laboratory (ARL) has funded several projects at MT Tech focusing on RE recovery from natural resources. As part of rare earth processing by flotation using salicylhydroxamic acid, surface chemistry determinations, zeta potential and adsorption density, were performed. Zeta potential was used to experimentally determine point of zero charge for selected rare earth oxides and carbonates, with and without salicylhydroxamic acid, as a function of pH. The experimentally determined point of zero charge could then be compared to a theoretical value which can be determined using Eh-pH phase stability diagrams. Equilibrium studies were performed to determine the adsorption density of salicylhydroxamic acid on selected rare earth oxides and carbonates.

2:45 pm

Adsorption of Cationic Collector on Silica Surface in Presence of Iron Depressant

X. Yin; Kemira Chemicals, Atlanta, GA

Cationic reverse flotation is widely applied in iron ore beneficiation as an important separation technique. In this process, depressant, such as starch and dextrin, is commonly used to selectively adsorb on iron oxide and render its hydrophilicity, while ether amine is used as collector. Previous research in literature has been reported that overdosing depressant leads to an increase of silica content in the concentrate, which could be due to the depression of silica or the interaction between residue depressant and collector. However, the fundamental research on this topic is still limited. In this research, the adsorption of collector on silica will be studied by Quartz Crystal Microbalance with Dissipation (QCM-D). The effect of residue depressant will be discussed. It is expected that this research will provide a better understanding of the surface chemistry in iron ore flotation system.

3:05 pm

The effect of mixed cationic/anionic surfactants with different ratios on wetting and flotation of quartz

L. Wang, W. Sun and Y. Hu; Central South University, Changsha, China

The adsorption of mixed cationic/anionic surfactants with different molar ratios onto quartz was investigated. The cationic surfactant used was dodecylamine bromide (DDA), and the anionic surfactant was sodium oleate (NaOL). The critical micelle concentration values for the individual surfactants and their corresponding mixtures were determined using a platinum plate. The adsorption mechanisms of mixed surfactants on quartz were studied using contact angle measurements, flotation tests and adsorption amount measurements. At alkaline condition, NaOL depresses DDA flotation of quartz without depressing the adsorption of DDA. The molar ratio of mixed surfactants is found to be a key factor in the orientation of alkyl chains and thereby the flotation response of quartz. A mixture of 1/2 or 1/3 DDA/NaOL forms on the surface of quartz when the concentration of NaOL is higher than that of DDA. The adsorption of the mixture decreases the wetting of quartz since the alkyl chains are in chaotically orientation with a conceivable number of head groups directing towards the solution phase. These results provide important insights into the adsorption of mixed surfactants onto quartz surface.

3:25 pm

Amine Collectors for Silica Flotation in the Beneficiation of Phosphate

P. Dopico and B. Makin; Clariant Mining Solutions, The Woodlands, TX

Silica is a common contaminant which must be removed before phosphate concentrates are fed to the phosphoric acid process. While some silica is left in the concentrate to capture fluoride ions, excess silica takes up volume in the attack reactor and ultimately in the gypsum stack. Manufacturers balance the cost of removing silica versus the rate at which they fill their gypsum stack, often leaving up to 10% silica in the flotation concentrate. The flotation of silica in phosphate is unique in the large range of particles that must be floated, from coarse particles up to 1000 microns to finer particles smaller than 150 microns. The flotation schemes are also quite varied, including the reverse flotation of silica from a rougher concentrate, such as in the Crago process practiced in North America, and also the reverse flotation of silica from the main plant feed, which is useful in the flotation of carbonate-containing ores using a silica collector and a carbonate collector. In this paper, some of Clariant's global experiences with the flotation of silica in the beneficiation of phosphate will be described, including flotation results with some of Clariant's novel silica collectors.

3:45 pm

16-165

Novel alkyl aminodicarboxylate reagents for mineral specific flotation

T. Karlkvist¹, B. Pålsson¹, A. Fredriksson² and H. Kota³; ¹Minerals and Metallurgical Engineering, Luleå University of Technology, Luleå, Sweden; ²Mining Division, LKAB, Kiruna, Sweden and ³Dept. of Geology and Mineral Resources Engineering, Norwegian University of Science and Technology, Trondheim, Norway

Calcium mineral separation is investigated by microflotation, zeta potential measurement and adsorption using novel collectors having two functional groups instead of one. By varying the distance between the functional groups, it can be possible to preferentially target one calcium mineral by matching the geometrical distance on the surface. In this investigation two new surfactants have been tested to judge their ability to float apatite and/or calcite. Preliminary findings show that an increase in distance between the functional groups favors one mineral over the other which could be due to differences in the mineral structure.

Flotation and adsorption of muscovite using a quaternary phosphonium salt as collector

P. Chen¹, Y. Hu², W. Sun², R. Liu² and Z. Gao²; ¹School of Metallurgy and Environment, Central South University, Changsha, China and ²School of Minerals Processing and Bioengineering, Central South University, Changsha, China

A cationic surfactant, tetradecyl tributyl phosphonium chloride (TTPC), was first used as a collector. Flotation characteristics of muscovite using TTPC have been investigated through micro-flotation tests. And dodecyl trimethyl ammonium chloride (DTAC) was tested for comparison. Their adsorption mechanisms on muscovite and air/water interface were clarified using zeta potential measurement, molecular dynamics (MD) simulations and AFM observation. The flotation results indicate that the recovery of muscovite rapidly decreases when the pH increases in the presence of surfactants; however, when a maximum of recovery was reached, the dosage of TTPC was 2×10^{-5} mol/L which was half of that of DTAC. Zeta potential measurements confirm that the TTPC displays a stronger collecting power than DTAC and is a superior collector for the muscovite flotation. MD simulations show that TTPC interacts with the muscovite mainly through electrostatic attraction and hydrogen-bonding. AFM observation further confirms that a well-compacted monolayer is formed on the muscovite surface in the presence of TTPC compared with DTAC, indicating a much stronger hydrophobic character of muscovite.

Tuesday, February 23 – Afternoon

ROOM: 232A

2:00 pm

MPD: Plant Design II

Sponsored by: ThyssenKrupp Industrial Solutions (USA), Inc.

Chairs: D. Rose, Midvale, UT

A. House, Hatch, Lakewood, CO

2:00 pm

Introduction

2:00 pm

Newmont's Copper Leach-SX/EW Plant – Overcoming Design Challenges

K. Koiki; SME, Elko, NV

Newmont USA Limited commissioned its copper leach-SX/EW plant in September 2013, achieving commercial production in October. The plant is a modern design with promises of a very safe and low maintenance operation to produce two million pounds of copper per month. With an initial pregnant leach solution (PLS) grade of more than 8 grams per liter, and little or no ramp up period, Newmont proceeded to push the plant to deliver design production. Reality quickly set in after Newmont discovered limitations, which resulted in operational challenges. Newmont did not achieve its first two million pound production until October 2014, one year after commissioning. The goal of this paper is to discuss Newmont's design limitations and other challenges and how Newmont was able to solve these problems to achieve full production. The paper will also discuss opportunities for future improvement.

2:20 pm

SAG Pre-crush Circuit Design Considerations

K. Lee, P. Rosario and G. Schwab; Hatch, Vancouver, BC, Canada

SAG pre-crush is a capital effective method to increase or maintain production at SAG limited brownfield operations. This paper presents a review of design considerations for two recent SAG pre-crush circuits including process design, equipment selection, and layout development. Major discussion points revolve around changes to key performance indicators. The paper also touches on the design of tie-ins for major components of engineering disciplines. Finally, the paper discusses engineering considerations given to advancing concept design straight to detailed design/ construction.

2:40 pm

Grinding Circuit Design Improvements Through Improved Classification Efficiency

D. Perkins; Metallurgical Engineering, Derrick Engineering, Buffalo, NY

Classification of material in wet grinding circuits has gone through many changes in the last century. Today many mineral processing plants default to the hydrocyclone for classification of the milled product. This paper will present the next stage in classification evolution. The use of screening dates back to the early 20th century, but was not made practical until the early 21st century. The advent of high frequency and low amplitude screening coupled with non-blinding polyurethane surfaces has enabled comminution circuits to more than double the efficiency of the existing grinding mills. The data will show in many cases that utilizing highly efficient classification can enable a reduction in power consumption, increases in mineral recovery and significantly lower circulating loads.

3:00 pm

Plant Design Challenges of the Barrick Goldstrike TCM Leach Project

L. Enloe¹ and J. Langhans²; ¹SME Registered Member, Draper, UT and ²Process, Barrick Goldstrike Mines Inc., Elko, NV

Designing a new, first of its kind, gold recovery plant using thiosulfate chemistry for the Barrick Goldstrike Autoclave facility had many challenges. The design incorporated the addition of new processing circuits and replacement of the existing Carbon in Leach circuits while minimizing the impact to the existing Goldstrike Autoclave facility operation. The design of the Resin in Leach and Resin Elution circuits with the complex chemistry of the new technology required careful selection of materials of construction. Operator safety and environmental compliance were crucial considerations in the design of the facility. Aspects of the design were especially important in the construction, startup and operation of the facility.

3:20 pm

16-113

An update on the performance of the TankCell e500 at the Kevitsa mine

B. Murphy¹ and T. Mattsson²; ¹Flotation, Outotec, Denver, CO and

²Beneficiation, Outotec, Espoo, Finland

Outotec's TankCell® e500 flotation cell was commissioned during 2014 at the Kevitsa Mine in northern Finland. The TankCell® e500 is the first cell in this size class (500m³) to be run in an operational duty and it has been working as the first rougher in the copper flotation circuit. Treating around 850tph with an average grade of 0.3% Cu the TankCell® e500 has run with an average copper recovery of 71% and an average enrichment ratio of 50. In addition the cell has proved to be very energy efficient, operating with a specific energy of around 0.4kW/m³ under production conditions. This presentation will provide a review of the installation and operation of the TankCell® e500 at Kevitsa and will summarize the results found in the published literature from the various testing campaigns conducted around the cell.

3:40 pm

Durability and Economics of Materials Used in Design and Fabrication of Hydromet Equipment

K. Lambrych, D. Kelly and T. Johnson; Speciality Resins, Ashland Performance Materials, Dublin, OH

Hydrometallurgical equipment is exposed to extremely corrosive chemical environments. Materials of construction must be durable against corrosion, meet mechanical requirements, and perform economically over the life of the mineral processing plant. As a material of construction, fiber reinforced plastic (FRP) has been shown to provide equal if not improved durability relative to alternative materials such as corrosion resistant alloys. Remote fabrication and assembly of process equipment is also less complex for FRP versus alloys. This paper will compare corrosion performance and cost of plant equipment fabricated with stainless steel alloys and FRP made with Epoxy Vinyl Ester thermoset resins. Case histories for FRP piping, storage tanks, extraction vessels, and electrowinning cells combined with laboratory based corrosion studies will be reviewed to demonstrate how FRP materials are selected for hydrometallurgical equipment.

4:00 pm

The Teghout Copper-Molybdenum Project – Development and Implementation of Armenia's Newest Base Metal Greenfield Project

C. Adams⁴, D. Meadows², P. Thompson³ and G. Hall¹; ¹Process, FLSmidth SLC, Midvale, UT; ²Mining and Metals, Bechtel, Glendale, AZ; ³Process Consultant, FLSmidth SLC, Midvale, UT and ⁴Process Plant, Vallex Teghout Operations, Yerevan, Armenia

The Teghout project in Northern Armenia started out more than a decade ago, embedded in an historically rich mining area, it became the first major greenfield base metal mining project in the country for many years. The overall project, designed for an initial throughput of 7 million tpa with a planned expansion to 12 million tpa by year 5, was developed for approximately 400 million USD. This paper describes the project development from the original concept of a traditional former soviet style flowsheet to the final more streamlined and efficient, bulk sulphide, copper and molybdenum separation flotation circuits and aspects of the process plant design. The flowsheet was finalized in 2010 although equipment orders for the primary milling circuit were placed in 2008. Detailed design was completed with the Vallex Lermetin Institute for local compliance. Plant installation commenced in 2013 and commissioning started in late September 2014 with first concentrates shipped in December 2014. The plant is now processing at over 8 million tpa and producing a good quality bulk sulphide copper concentrate with the molybdenum separation plant due to start up during the autumn of 2015.

4:20 pm

Capital Cost Efficiency – What is it?; why we need it; how it can be achieved

D. Meadows; Mining and Metals, Bechtel, Phoenix, AZ

The development of a new mining project has become increasingly difficult, complex and expensive. Even brownfield expansions have a considerable share of these challenges. Faced with the prospect of prevailing lower metal prices and more complex orebodies the capital cost hurdle becomes even more significant. This paper addresses how capital efficiency can be defined, measured and achieved. Armed with appropriate capital intensity and commodity intensity metrics, together with use of forward-looking assessment of the overall project economics, the paper discusses how a desirable level of capital efficiency can be achieved to fulfil the mining owner's needs. Like plant design itself, there are bespoke requirements to consider for ensuring that project value comes with the

targeted capital efficiency and capital intensity. Successful results that are sustainable through project delivery, and accompanied by good ramp-up performance, require a measurable process; not a simple cost-cutting or quantities reduction exercise. The paper includes benchmark examples of trends and best practices.

Tuesday, February 23 – Afternoon

ROOM: 122B

2:00 pm

UCA of SME II: Shaft Construction

Chairs: B. Caro Vargas, MSCE, Centennial, CO

J. Rostami, The Pennsylvania State University, University Park, PA

2:00 pm

Introduction

2:05 PM

Update on Mechanized Shaft Sinking

S. Dube, Herrenknecht

Herrenknecht gained practical experience in mechanized deep shaft sinking solutions in the past years. This session will describe some of the problems which were faced and which solutions succeeded. Furthermore a outlook in future design solutions of such equipment will be described in the session.

2:25 pm

3D FE Seismic Analysis of Large Diameter Segmentally Lined Shafts

D. Kruse² and M. Sanaei¹; ¹R&D, Cobalt Construction Company, Santa Ana, CA and ²President, Cobalt Construction Company, Santa Ana, CA

A three dimensional nonlinear finite element model is simulated to analyze the behavior of large diameter segmentally lined shafts when subjected to seismic waves. A transient excitation is applied to the supported nodes at the base of the shaft with a time-function representing the 1994 Northridge earthquake. The model is developed at the end of an original phased construction-stage analysis of the shaft. Displacements, forces and moments are monitored during the analysis steps. During the initial 15 seconds of the earthquake, the top and bottom of the shaft show similar displacements. The maximum horizontal displacement within the shaft is approximately 3.5 inches.

3:25 pm

16-138

Access shafts for tunnels – comparison between Diaphragm Wall and Secant Piles: lessons learned through recent case studies

B. Caro Vargas; MSCE, Centennial, CO

The list of construction method to build a vertically supported excavation in the ground is endless. A non-exclusive list of the techniques would include, from most to less commonly used: Soldier beam and lagging Sheetpiles, Shaft caissons, Diaphragm wall, Secant piles, Vertical boring machine, Jet grouting, Ground freezing Obviously before talking about techniques a detailed analysis of the site has to be done as all these techniques have limitations. Three of the most

important characteristics to consider are: Hydrogeology and site environment (external constraints) Shape, depth and Use of the shaft (internal constraints) Cost and schedule (both internal and external constraints) None of the techniques presented above fit all, there is no magic solution and there is usually more than one technique that can be used. This paper will mainly discuss two of the techniques widely used for access shaft or launch pit on tunnel projects when typical challenges have to be overcome, such as high water table in urban or semi urban environments: diaphragm wall and secant piles. This article will discuss the application of these techniques on recent or on-going projects.

2:45 pm

The Largest Raise Drilled Shaft In North America

F. Stevens¹ and R. Sidwell²; ¹Cowin & Company, Inc., Birmingham, AL and ²Raisebor, Inc., Aztec, NM

The increasing demand for larger and deeper mine shafts, as well as the requirement to develop these shafts by the most economic and safest means available, has pushed the shaft construction industry to expand the range of what is feasible for a raise drilled shaft. A recently completed project in Alabama demonstrated the capability of one large raise drilling system on a 26' shaft x 1,440' deep shaft. It also exposed some of the additional challenges associated with the raise drilling process in very large diameter shafts.

3:05 pm

Finite Element Analysis of the Effect of Circumferential Ground Modification on Shaft Performance

D. Kruse² and M. Sanaei¹; ¹R&D, Cobalt Construction Company, Santa Ana, CA and ²President, Cobalt Construction Company, Santa Ana, CA

3D finite element models of the ShorWall structure are simulated as means of numerical analyses of the system's structural behavior. Constructed from a top-down arrangement of precast concrete segments, ShorWall consists of large diameter, relatively shallow underground spaces that can be utilized for various applications. To further investigate the effects of soil conditions and different loadings on the shaft structure, the FE model is run under specific boundary conditions. Simulation include a) effects of various soil layers on ShorWall, including a circumferential layer of ground modification, b) effects of various soil layers on ShorWall without any ground modifications, c) Seismic analysis of ShorWall with ground modification and d) Seismic analysis of ShorWall without any ground modification. Comparing the analyses outcomes emphasizes the significance of the inclusion of the ground modification layer in the structural performance of ShorWall.

Wednesday, February 24 – Morning

ROOM: 224A

9:00 am

Coal & Energy: Breathing Air Supplies

Chairs: R. Fernando, NIOSH-OMSHR, Pittsburgh, PA
K. Pan, Virginia Tech, Blacksburg, VA

9:00 am

Introductions

9:05 am

Virginia Tech Mine Rescue CCBA Experience

K. Pan; Mining and Minerals Engineering, Virginia Tech, Blacksburg, VA

In order to stay competitive between our collegiate and industry peers the Virginia Tech Mine Rescue Team uses a variety of training exercises and education sessions to strengthen and enhance skills on an off the field. Practices ensure all competition teams are physically able to compete with the challenges that a CCBA presents during intense physical exertion and mental pressure. Training courses led by both student leaders and professional coaches educate new and existing members on using CCBA's safely and effectively. This presentation will cover training regimens, classroom education, and typical team training to give an overview of collegiate level use of closed circuit breathing apparatuses.

9:25 am

The impact of the Revised CCER Rules on the Mining Sector

J. Kravitz; USDOL, MSHA, Pittsburgh, PA

NIOSH announced final rules on March 8, 2012 that revised and updated the agency's requirements for testing and certification of closed-circuit escape respirators (CCERs). The revised rules were designed to strengthen emergency respiratory protection for workers in escaping from toxic concentrations of fumes, gases, or smoke, or from confined areas where there is insufficient oxygen, posing immediate dangers to life or health. The rules became effective on April 8, 2012. This presentation delineates the changes in testing and certification requirements, and the impact of these revised requirements on the mining sector. The approved CCERs will be also be discussed.

9:50 am

Constant Inspired Air Temperature Cooling Technology for 4-Hour Rebreathers

G. Srinivas, R. Copeland and S. Gebhard; TDA Research Inc., Golden, CO

TDA Research Inc. is developing a 4-hour cooling system for use with mine rescue reentry rebreathers that maintains the return air at a constant temperature regardless of the level of exertion of the miner, or time-on-stream. If the miner's level of exertion increases, more CO₂ and heat are produced, and TDA's system increases the cooling rate. When the miner is at rest, less cooling is required and TDA's system self-adjusts for this condition. This is in contrast to ice packs, which overcool at first, and undercool later. Since no ice packs are used, no freezer is required, which simplifies logistics.

10:15 am

Self-Contained Self-Rescuer Breathing Apparatus Improvement

J. Comman and B. Toole; Diving and Life Support Systems Branch, Naval Surface Warfare Center Panama City Division, Panama City, FL

The Office of Mine Safety and Health Research in conjunction with the Naval Surface Warfare Center Panama City Division is identifying and adopting technologies for improvement of a self-contained self-rescuer (SCSR) breathing apparatus for underground mine emergencies. This work covers the development of closed-circuit oxygen breathing apparatus (CCBA) prototypes that incorporate technologies used in other fields such as diving. Current SCSRs used in the coal mining industry were evaluated for baseline performance. It was found that the largest areas for improvement are in heat transfer, ergonomics, and in deployment methods. The ergonomic effort addresses potential areas for improvement to minimize the overall footprint and weight load on the user while making the units comfortable to wear. The heat transfer work addresses removing unwanted

heat, which has two main benefits: increasing the CO₂ absorbent efficiency and reducing the user's inspired gas temperature. The work on deployment methods addresses the ability to decrease the time and increase the ease at which the apparatus is deployed. The presentation focuses on updating the project status and future design improvements.

10:35 am

Mine Rescue Breathing Apparatus Improvement

B. Toole and J. Cornman; NAVSEA, NAVY, Panama City, FL

The Office of Mine Safety and Health Research in conjunction with the Naval Surface Warfare Center Panama City Division is identifying and adopting technologies for improvement of rescue breathing apparatus for underground mine search and rescue. This work covers the development of closed-circuit oxygen breathing apparatus (CCBA) prototypes that incorporate technologies used in other fields such as diving and aerospace. Current CCBA's used in the coal mining industry were evaluated for baseline performance. It was found that the largest area for improvement is in heat transfer. Removing unwanted heat has two main benefits: increasing the CO₂ absorbent efficiency and reducing the user's inspired gas temperature. This work also addresses potential areas for improvement to minimize the overall footprint and weight load on the user. The presentation focuses on updating the project status, the manned evaluation at the Naval Experimental Diving Unit, and future design improvements.

10:55 am

Liquid Oxygen Retrofit Kit for Advanced Navy Rescue Rebreather

D. Bush¹, E. Blalock³ and D. Doerr²; ¹Biomedical Engineering, NASA, Kennedy Space Center, FL; ²Liquid Air Breathing Technology, Inc, Merritt Island, FL and ³BCS Life Support, Titusville, FL

Under contract to the Office of Mine Safety and Health Research (OMSHR), The Naval Surface Warfare Center, Panama City Division developed a novel rebreather technology that is very light and reduces breathing temperatures without consumables (ice or phase change materials). The four hour rebreather is designed as an alternative to traditional mine rescue rebreathers. Taking advantage of NASA's long history and expertise with cryogenic life support, OMSHR has partnered with NASA to explore the advantages of using liquid oxygen, rather than the traditional high pressure gaseous oxygen that drives conventional rebreathers, using the Navy prototype rebreather as a starting point. The liquid oxygen based system should help reduce the breathing gas temperatures further, reduce weight, and size. The initial prototype has been developed is currently undergoing testing, both machine and human. The theory of operation and test results will be discussed.

11:15 am

16-116

Advanced Cryogenic Breathing Apparatus for Emergency Mine Egress & Production of Liquid Air from Commercially Available Products

D. Bush¹, E. Blalock³ and D. Doerr²; ¹Biomedical Engineering, NASA, Kennedy Space Center, FL; ²Liquid Air Breathing Technology, Inc, Merritt Island, FL and ³BCS Life Support, LLC, Titusville, FL

The Office of Mine Safety and Health Research (OMSHR) has partnered with NASA to explore the potential of cryogenic (liquid) air based Self Contained Breathing Apparatus (SCBA). The project is now in its second phase. The original Cryogenic Breathing Apparatus (CryoBA) was designed for emergency mine egress using liquid air rather than compressed air. As a prototype, it worked and proved the concept of extended duration, attitude independence, and quick simple refilling without doffing. However, it was heavy, had issues with excessive venting due to

heating, and no quantity sensor. The Advanced Cryogenic Breathing Apparatus (ACryoBA) builds upon the lessons learned from the CryoBA and hopes to resolve the shortcomings. Two versions (one and two hour) are being built and tested. The specific improvements and test results will be discussed. Additionally, a simple device for mixing liquid air from commercially available liquid nitrogen and liquid oxygen has been developed that will help increase the availability of liquid air and pave the way for liquid air based life support equipment. The capabilities, process, and results of the device will be discussed.

11:35 am

16-074

OMSHR's Effort on the Next Generation Closed-Circuit Mine Escape Respirator

R. Fernando; NIOSH-OMSHR, Pittsburgh, PA

The NIOSH Office of Mine Safety and Health Research (OMSHR) currently is leading an effort in the development of the next generation self-escape apparatus as part of the research imperative directed by the MINER Act of 2006. A multifaceted contract program over the past 3 years delivered key components and base breathing modules to form the basis for developing backpack and vest style versions of Dockable Self-Contained (Closed Circuit) Self-Escape Respirators with Hoods (CCMER). This paper outlines the current status in developing the CCMER that incorporates a docking & switch-over valve (DSOV) for seamless transfer from one breathing device to another and hood with inner masks & speech diaphragm (HMC) for ease of donning, use and communication ability. Two versions of the CCMER are being pursued, namely; CCMER – V, which attaches to a miner's belt and worn similar to a miner's vest and CCMER – B that can be worn as a Backpack and incorporates the features of a miner's belt. The CCMERs are designed to be capable of being certified to 42CFR84 standards including sub-part O for mine use and to meet MSHA permissibility regulations for use in underground mines.

Wednesday, February 24 – Morning

ROOM: 224B

9:00 am

Coal & Energy: Mine Environmental Issues

Chairs: J. Craynon, Virginia Polytechnic Institute and State University, Blacksburg, VA

H. Trexler, Tetra Tech Inc, Pittsburgh, PA

9:00 am

Introductions

9:05 am

16-115

Assessing the Feasibility of Automated Data Monitoring and Control Strategies for the Chemical Treatment of NPDES Outlets: Bench-Scale Studies

C. Vass and A. Noble; Mining Engineering, West Virginia University, Morgantown, WV

The chemical treatment of mine influenced waters is a longstanding environmental challenge for many coal operators, particularly in Central Appalachia. Mining conditions in this region present several unique obstacles to meeting NPDES effluent limits. Outlets are often located in remote areas with challeng-

ing terrain where conditions do not facilitate the implementation of large-scale commercial treatment systems. Furthermore, maintenance of these systems is often laborious, expensive, and time consuming. Many large mining complexes discharge water from numerous outlets, while using environmental technicians to assess the water quality and treatment regime multiple times per day. As an alternative solution, this paper describes the ongoing research and development of automated chemical treatment systems for mine water discharges. The current work explains the development of a bench-scale prototype that has been used to evaluate various monitoring, notification, and control strategies. Results from this testing are compared to present day practices to show the costs and benefits of implementing an automated treatment and monitoring program.

9:25 am

Predicting TDS Release Dynamics from Appalachian Coal Surface Mines

W. Daniels; Crop & Soil Environmental Sciences, Virginia Tech, Blacksburg, VA

Appalachian USA surface coal mines face significant regulatory pressure to reduce total dissolved solids (TDS) discharges. Low levels of TDS (300 to 500 $\mu\text{S cm}^{-1}$) have been proposed as benchmarks, but most mines discharge higher (500 to > 2000 $\mu\text{S cm}^{-1}$) TDS due to spoil weathering reactions and leaching, even though discharges are > pH 6.0. We focused on four areas to develop new strategies to reduce TDS release: (1) Rapid lab prediction of TDS release potentials; (2) Development of reliable field indicators to identify low vs. high TDS risk materials; (3) Determination of the actual long-term pattern of TDS release from historic valley fills; (4) Implementation and verification of new valley fill construction procedures to minimize TDS production. We correlated laboratory column leaching results for over 60 regional overburden materials with simple lab analyses (e.g. Total-S, saturated paste EC) and produced regression models that reliably predict ($p < 0.01$; $R^2 > 0.80$) peak TDS potential for most common spoil types. Several new generation low TDS fills are being actively constructed and monitoring to date indicates much lower TDS release than older conventional designs.

9:45 am

Coal Mining Employment and its Relationship to Income Inequality: Appalachia and the United States, 1990-2010

M. Betz², L. Lobao¹, M. Partridge³ and M. Zhou⁴; ¹School of Environment and Natural Resources, The Ohio State University, Columbus, OH; ²Human Sciences Administration, The Ohio State University, Columbus, OH; ³Agricultural, Environmental, and Development Economics, The Ohio State University, Columbus, OH and ⁴Discover Financial Services, Chicago, IL

In this study, we question the degree to which employment in coal mining is related to income inequality. Income inequality, a major public policy concern, is often attributed to shifts in employment sectors. However, studies of income inequality rarely analyze mining as an employment sector. Research derived from economics on the natural resource curse suggests that mining sectors may generate income gaps among affected populations. However, some empirical work suggests that any natural resource curse for coal mining may have applied more to the past. We evaluate the mining-inequality relationship by analyzing two periods, 1990-2000 and 2000-2010 for the Appalachian Regional Commission (ARC) counties (N=420) and for all U.S. counties (N=3,072). Coal employment is related to greater income inequality during the 1990-2000 decade for both ARC counties and the U.S. However, no statistically significant relationship is found in the post-2000 period. By contrast, oil/gas employment—rather than coal employment—are more likely to contribute to the nation's contemporary inequality gap.

10:05 am

Economic Impact of Fluctuating Coal Production in Counties in Appalachian Southwest Virginia

S. Meacham; Preventive Medicine, Via College of Osteopathic Medicine, Blacksburg, VA

Coal mining, the economic base in southwest (VA), has been scrutinized for its relationship to poor health. No publications have investigated declining coal production from 1990 to 2013 on economic variables in the region. Coal production, poverty, children in poverty and unemployment were compared for the state of VA, the six coal producing (CP) and one non-coal producing county (Scott, SC). Coal production declined by 36%. A difference in poverty between SC, CP, and VA was reported ($p = 0.007$) with no change in poverty rates over time. The percent of children in poverty declined ($p = 0.001$). Children in poverty rates were unaltered ($p = 0.5$). Unemployment declined with the lowest rates constant until 2008 followed by an upturn. From 2008 to 2012 SC had a higher rate of unemployment than CP and VA and a significant regional interaction reported ($p = 0.0001$). Unexpected was the downturn in coal production, poverty and unemployment from 1990 to 2008 suggesting a lesser-than-expected influence of the coal mining industry on the economy of the region in recent years. A more extensive approach is needed to gain a better understanding of coal production on the economy in Southwest VA.

10:25 am

Dust Characterization and Source Apportionment at an Active Surface Mine in West Virginia

N. Basta¹, S. Whitacre¹, V. Kecojovic², A. Lashgari⁴ and B. Lusk³; ¹School of Environment and Natural Resources, Ohio State University, Columbus, OH;

²Department of Mining Engineering, West Virginia University, Morgantown, WV;

³Mining Engineering, University of Kentucky, Lexington, KY and ⁴Energy and Mineral Engineering, Pennsylvania State University, University Park, PA

The objective of this study is to characterize potential health risk associated with exposure to the dust collected from an active surface mine in West Virginia. Dust monitoring was conducted for overburden and coal loading operations, and trucks at the haul roads. Dust samples collected from the mine underwent particle size analysis and collection of ingestible and respirable size fractions followed by elemental analysis. Chemical data and dust was used to calculate potential exposure using standard risk equations. Background soil and dust was calculated in order to estimate risk of disease incident in non-coal mining communities. The 95th percentile pm_{10} concentrations at 9-11m from the various mining practices were 0.12, 0.084, 0.62 and 0.43 mg/m^3 for coal road trucking, wheel loader, overburden trucking, and rope shovel operations respectively. Results indicate that even with an extreme scenario; 95th percentile air particulate concentrations 9-11 m from the mining operation, 365 days/year for 70 years, exposure to constituents via inhalation accounts for a relatively small portion of total exposure when everyday incidental ingestion of native soil is considered.

10:45 am

16-112

Minimizing impacts on stream due to underground mining by predicting surface ground movements

Z. Agioutantis¹, C. Newman¹, G. Boede Jimenez Leon¹ and M. Karmis²; ¹Mining Engineering, University of Kentucky, Lexington, KY and ²Mining and Minerals Engineering, Virginia Tech, Blacksburg, VT

Underground mining may affect the form and function of streams on the surface. Prediction of ground movements in the vicinity of linear water bodies can be used to establish an optimum extraction sequence while the type and magnitude of anticipated movements can be used to evaluate alternate mitigation plans when such bodies are undermined. This paper will present the enhanced features of a

well-established methodology for calculating surface deformations due to underground mining. The Surface Deformation Prediction System, which was originally developed at Virginia Tech in the 1980s, is currently updated to include enhanced subsidence, tilt and ground strain calculations for streams and linear waterbodies. Examples and case studies will be presented validating the new tools and procedures which are under development. This research was partially sponsored by the Appalachian Research Initiative for Environmental Science (ARIES).

Wednesday, February 24 – Morning

ROOM: 229A

9:00 am

Coal & Energy: Mine Gas Analysis

Chair: N. LaBranche, Self, Brisbane, QLD, Australia

9:00 am

Introductions

9:05 am

16-040

Using Mine Site Gas Chromatography for Accurate and Reliable Gas Analysis

S. Abbott, R. Taylor and S. Dagit; PHOENIX First Response, Glassport, PA

Using gas chromatographs at mine sites to monitor toxicity, explosive gas mixtures, and to detect smoldering in remote areas and guide fire extinguishment efforts has traditionally been problematic and expensive. Recent developments in GC equipment technology and a change in the analytical paradigm offer a new, practical and cost-effective way to successfully analyze gases at mine sites by utilizing existing staff. This approach will be presented, along with supporting data. Background: Gas chromatographs appear simple, but are sophisticated, highly sensitive instruments that should be overseen by an analytical chemist to ensure reliable data. GC analysis is not a straightforward test in which an injected sample automatically delivers a true result. Unrecognized errors can be costly or disastrous. Instrument vendors tout the units' simplicity, but do not guarantee they will perform with the necessary reliability, sensitivity and accuracy. Several mining companies have purchased GCs underestimating the high cost and difficulties, and how to prove unbiased accuracy in critical situations. For these & other reasons, most mines that purchase a GC have eventually abandoned using it.

9:25 am

MRAS - Managing Information for Decision Making in a Mine Emergency

D. Carey; Queensland Mines Rescue Service, Dysart, QLD, Australia

The development of risk management based guidelines for the deployment of Queensland mines rescue personnel in emergency rescue activities requires the assessment of information relevant to the potential hazards that may confront the rescue teams to determine if they can be safely deployed. Mine Re-Entry Assessment System (MRAS) is a computer based system for gathering the critical information necessary to be considered by those in control of a mine emergency when considering the deployment of mines rescue personnel. MRAS has a reporting capability that allows the status of information to be quickly assessed to determine what is currently known or unknown at any point in time during the progress of a mine emergency. This allows decision makers to prioritise the gathering of required information to efficiently manage available resources. The program provides for the formal consideration and acknowledgment of the explosibility risk that may be

present in the mine and a formal process for approval of entry into the mine during or after an incident. The tool aims to assist decision makers make informed and considered risk based decisions founded on reliable information.

9:45 am

Pike River Gas analysis implications

D. Cliff; Minerals Industry Safety and Health Centre, University of Queensland, University of Queensland, QLD, Australia

The mine disaster at Pike River underground coal mine in New Zealand in November 2010 has again highlighted the need for high quality gas monitoring information in order to allow safe mines rescue. High quality gas monitoring information could have also prevented the first explosion from occurring. Reentry into the mine was not able to be effected due to the uncertainty in the state of the mine atmosphere. This uncertainty was reinforced by the series of explosions that racked the mine over the following ten day period. This disaster will be contrasted with the management of the spontaneous combustion incident at Carborough Downs mine where safe reentry was possible and the mine was able to return to operation within weeks of the evacuating the mine.

10:05 am

Operational experiences with Tube Bundles in the USA

F. Johnson; Farmington, NM, Pillar Innovations, LLC, Farmington, NM

The “Big, Bad, Intimidating” Tube Bundle system. This system can be intimidating at first sight, however, when broken down these are technologies, we are all familiar with. Networked servers & PLC, solenoids, pumps, regulators, flow switches, & gas analyzers are just meshed together in one big system. Proper training to essential personnel, maintenance schedules with proper documentation, and communication between operations & maintenance turn the Tube Bundle system into an easily managed unit.

10:25 am

16-088

Tube Bundle Installations Overseas experience Suppliers perspective

G. Robson; no affiliations, Seven Hills, NSW, Australia

Underground mining Underground coal mines contain dangerous gases, which must be monitored and controlled in order to allow productive mining operations to take place and to minimize the risk of explosion. Underground mines are also a potentially dangerous place for mine workers. SICK manufacture solutions to monitor mine atmospheres and control underground mine equipment in these hazardous applications. Whilst most of SICK activity with underground Coal Mining is located in Australia there have been a number of locations World wide which have taken up the TUBE BUNDLE SYSTEM technology in order to better understand and manage the underground Atmosphere, control ventilation and fully understand the situation behind sealed and mined out areas of the mine. The world mining industry has relied on Real Time Sensors to monitor CH₄, CO, CO₂ and O₂ in the mine, The big advantage with Tube Bundle is that it allows the Mine to measure the levels of these potentially harmful gases in sealed areas of the mine allowing the mine a full understanding of the situation underground. Today I would like to present the overseas experiences with Tube Bundle Installations in New Zealand USA and China.

Wednesday, February 24 – Morning

ROOM: 229B

9:00 am

Coal & Energy: Underground Processes and Practices I

Chairs: G. Buchan, Norwest Corp., Pittsburgh, PA
P. Conrad, Montana Tech, Butte, MT

9:00 am

Introductions

9:05 am

Guidelines of Using Cable Bolts and Truss Systems as Supplemental Roof Supports for Ground Control

J. Chen; DSI, Morgantown, WV

Cable bolts and truss systems have been widely used as supplemental roof supports to control difficult roof conditions in coal mines. Compared with all the standing supports, cable bolts or trusses as supplemental roof supports have three obvious advantages. Firstly, cable bolts or trusses can utilize the inherent strength of rock mass above the coal seam to prevent entry roof failure or falls. Secondly, they don't take up significant entry space to interfere with mine ventilation and transportation. Thirdly, the overall roof control cost is usually much less than those of standing supports due to easier installation and material transportation. However, due to the lack of studies and research, the method of trial-and-error is often employed to determine the supporting pattern and spacing. The author in this study tries to propose some guidelines to design the pattern of cable bolts or the spacing of trusses when they are used as supplemental roof supports for entry roof control at coal mines. These guidelines are proposed in lieu of the principles of rock mechanics, structural strengths of cable bolts and truss systems.

9:25 am

16-018

Investigation of the potential lightning impacts on underground coal mines

D. Cliff¹, P. Henderson², M. Morris³ and W. Johnson³; ¹Minerals Industry Safety and Health Centre, University of Queensland, University of Queensland, QLD, Australia; ²Underground, Glencore Coal, Singleton, NSW, Australia and ³Consultant, Albuquerque, NM

The objective of this research was to develop and apply computer models to evaluate the potential lightning impacts on underground coal-mining. These models can then be utilised to assist in the design of effective controls. If successful this project will provide a significantly improved level of knowledge and control over current lightning abatement techniques. The direct potential for harm from lightning has long been recognised for the surface facilities of coal mines. However recent event at Blakefield South in NSW on January 5, 2011 and more definitively at Sago mine in the USA in 2006 have suggested that there is potential for lightning to cause significant damage to the underground workings of a coal mine. A very detailed analysis carried out by as part of the MSHA investigation into the SAGO disaster by Sandia Laboratories identified at least ten other incidents over the past thirteen years where lightning had probably caused the ignition of a sealed goaf area of a mine. In addition there is a long history of lightning related incidents in South African coal mines. Fortunately in those cases no lives were lost.

9:45 am

16-008

Use of Subsidence to Estimate Secondary Extraction of Trona

N. West¹, P. Conrad¹, R. Kramer² and C. Todd¹; ¹Montana Tech, Butte, MT and ²Tonox, Green River, WY

Surface subsidence caused by both underground room-and-pillar mining operations and solution mining operations have each been studied separately, but never combined. In 2008, FMC Minerals began using solution mining at its Westvaco Mine as a secondary extraction method in an area that had been previously mined using the room-and-pillar mining method. Mining regulations require that subsidence associated with underground mining activities be monitored and measured annually. Researchers at Montana Tech were able to develop a relationship between measured surface mine subsidence and solution mining that can be used at the Westvaco Mine to estimate the production of trona from solution mining operations.

10:05 am

Ground Control Tools in Underground Coal Mining – Conveniences and Precautions – ARMPS

S. Bhattacharyya and M. Nelson; Mining Engineering, University of Utah, Salt Lake City, UT

Among the ground control design tools available from the National Institute for Occupational Safety and Health, Analysis of Retreat Mining Pillar Stability (ARMPS) is often used to size pillars in room and pillar mines. The tool is convenient to design both production and barrier pillars. Achieving adequate Stability Factor is aimed to prevent squeezes, collapses, and bursts. Geotechnical databases are used when not enough input information is available. Databases are not representative of coal mines in the western United States and Canada. Not enough case studies are available to calibrate outputs. Use of inappropriate inputs runs the risk of unsafe designs. ARMPS is convenient but thorough understanding of the inputs, calibration with local test results, and operating experience are important. In very deep mines and in multiple seam workings additional design verifications are necessary. The authors' experience in designing pillars in two deep coal mine projects is described. Both projects suffered delays partly because of inconclusive output from design tools. Additional exploration was recommended.

10:25 am

16-109

Application of Borehole Imaging for Detection of Rock Fracture Zone and Improvement of Roadway Supports

X. SONG¹, G. Chen² and L. WANG¹; ¹Mining Engineering, Heilongjiang University of Technology, Jixi, China and ²Mining & Geological Eng, University of Alaska Fairbanks, Fairbanks, AK

The development of fracture zones in surrounding rock mass has significant impact on the stability of underground mine roadways. Detection of the fracture zones is of compelling importance for maintaining roadway stability as well as for safe and speedy excavation of the roadways. This paper presents a study conducted at Dong Bao Wei underground coal mine, where the roadways were developed in diabase rock mass. The roadways suffered severe damages, including sloughing and excessive floor heaving. The borehole imaging technique was applied in the study to observe and detect fracture zone development surrounding the roadway openings. Based on the borehole imaging studies, new roadway support systems were proposed to improve the stability. Furthermore, numerical modeling studies were performed for in-depth analysis of the roadway stability.

10:45 am

Underground selective crushing separation effect evaluation of coal and gangue in green mining based on X-Ray Technology

K. Zheng, Y. Wang, J. Dong, C. Lin and J. Miller; Metallurgical Engineering, university of utah, Salt lake city, UT

Coal gangue separation is of key importance for green mining. Underground selective crushing separation experiments are carried out under different crushing conditions and quantification description of coal and gangue damage is discussed by using X-Ray techniques. Particle size distribution of crusher products are measured to establish the relationship between crushing rate of coal and gangue and different crushing factors. The micro-structure of coal and gangue are described in 3D using X-Ray microtomography. The number, the size and shape of cracks generated by coal and gangue are analyzed by using X-Ray techniques to evaluate the particle weakening and energy saving ability under different crushing conditions.

11:05 am

Implementing new algorithms into LaModel in order to increase the efficiency of the calculation for multiple seams mines

M. Rajaeibaygi and K. Heasley; Mining engineering, West Virginia University, Morgantown, WV

In LaModel, the finite-difference solution method has proven to be very fast when solving single seam problems; however, when solving multiple-seam problems, the solution times increase by several orders of magnitude. For multiple seam scenarios, calculating and projecting stress influences between the seams is very time consuming. In this paper, three new algorithms have been implemented to improve the efficiency of the program in modeling multiple seams mines. These algorithms include: a new kernel integral formulation, an optimized influence distance algorithm and an optimized method for lumping elements in both local and remote seams. These new algorithms are implemented into the most recent version of LaModel and the code has been verified by four cases histories. Implementing these algorithms results in individual reductions in calculation times by approximately 30%, 70% and 40% respectively, and the combination of these algorithms represents an average 80% time savings, with no loss in accuracy. In the future, these new algorithms should greatly speed the analysis and design of multiple seams mines.

Wednesday, February 24 – Morning

ROOM: 226A

9:00 am

Environmental: Responsible Mining Environment and Social Risk II

Chairs: M. Jarvie Eggart, Barr, Marquette, MI

M. Martinie, Krech Ojard & Associates, Inc, Duluth, MN

9:00 am

Introductions

9:05 am

Community, Communication, and Context; Correlations With the Required Environmental Analysis and Obtaining a Social License

L. Watson; Merjent, Minneapolis, MN

The relationships with the project proponent and perceptions about how the impact assessment reflects concerns raised by the community (stakeholders) correlates to obtaining a “social license to operate”. The communication with stakeholders raises the following questions: What is the process for communication with the community and what validates consideration their concerns? Concerns raised are reflected in the issues addressed in the required environmental analysis, and the environmental and social management plans developed by the mine operator, or exploration company. These documents and the communication with the community helps set the context for obtaining the social license to operate. This presentation will discuss how communication during mine exploration and development and the correlates with required environmental analysis for permits and the agency decision process.

9:25 am

Using Collaboration to Build Sustainable Outcomes in the NEPA Process

H. Levine; ERM, Milwaukee, WI

Proposed mines that require federal approvals evaluated under the National Environmental Policy Act (NEPA) require tremendous amounts of environmental and other data. The decision to choose which data are used rests with the lead federal agency; external stakeholders have begun to demand increased involvement in this activity. Many government and industry players in the NEPA process have begun to consider alternative means to gather data in the NEPA process. Examples of increased collaboration, such as those examined in this presentation, can range from informal work groups to formal advisory committees facilitated by professionals trained in conflict management techniques.

9:45 am

Carlota Mine Monitoring System

G. Heath¹, M. Smith², M. Poulton¹ and J. Haynes²; ¹Mining and Geological Engineering, University of Arizona, Tucson, AZ and ²Carlota Copper Company, Globe Arizona, AZ

With an increase in tailings dam failures and mine closure activities, the industry is faced with a greater need for thorough, inexpensive, procedures. The approach for the Carlota Mine project is predicated on developing a low cost, integrated, autonomous system that includes networked geophysical, hydrological, and self-calibrating general and ion specific chemical sensors backed by a secure, integrated web-based data storage and retrieval software system. This approach includes the following attributes: Automated self-calibrating water/gas chemistry monitoring, Remote control of data acquisition systems, Secure web-based data accessibility, Complementary multi-sensor monitoring networks, and Critical-event alarm capabilities. Advantages of an integrated monitoring system are that the sensors are self-calibrating continuous data, allowing for the system dynamics to be understood. The remediation system optimization performed with these data reduces the operational cost of the effort and highlights improvements needed in future designs. The capability gained with continuous real time results is appropriate action can be taken before catastrophic failure results.

10:05 am

16-048

Legislation, Challenges and Policy Strategies: In Search for a Regulatory Framework for Sustainable Development in the Rare Earths Mining Industry

G. Barakos¹, J. Gutzmer³ and H. Mischo²; ¹Department of Extraction, Helmholtz Institute Freiberg for Resource Technology, Freiberg, Saxony, Germany; ²Underground Mining, TU Bergakademie Freiberg, Freiberg, Germany and ³Institute for Mineralogy, TU Bergakademie Freiberg, Freiberg, Germany

One of the major issues that the Rare Earth Elements Mining Industry has to deal with is the legislation vacuum that exists in many countries around the world. Among these, are countries which have long history and tradition in mining. In many cases the lack of direct legislation for REE mine management as well as for other potentially polluting industries can be a barrier to sustainable development. Moreover, the case of lax legislation in China has led to environmental pollution problems and extended smuggling of rare earth elements. This paper attempts to look into the current regulatory status on the mining of rare earths, identify the loopholes and suggest some elements for a new global legislation framework for sustainable development in the REE mining industry. The setting of this regulatory framework will be in line with the present and future challenges of the rare earths market as well as with the policy strategies that are defined internationally. The aim of such a legislative framework will be to strengthen the global rare earth elements supply chain, appease social concerns and ensure the preservation and conservation of the environment.

10:25 am

16-076

Project organization and management challenges of interdisciplinary large scale projects using the example of the pump storage plant Nant de Drance

J. Herhold¹, H. Mischo¹ and S. Plaum²; ¹TU Bergakademie, Freiberg, Sachsen, Germany and ²Hochschule RheinMain, Wiesbaden, Germany

As part of the demand for clean energy and a simultaneously fast growing energy demand the call for new and reliable energies becomes louder. Strongly weather-dependent energy sources, e.g. solar and wind energy, are unable to provide a constant control energy to withstand the fluctuation of the extensive power systems during peak hours. The pump storage plant Nant de Drance in Switzerland will not only have the capacity of a nuclear power plant, with 900 MW, but also combines the environmental aspect and the demand for control energy. For future projects in the sector of pump storage plants Nant de Drance can be seen as one of the pioneer projects for upcoming energy challenges. This paper focusses on the planning process and the project execution of interdisciplinary large-scale projects such as Nant de Drance including project related data handling, communication systems and project handling skills. Furthermore the paper discusses the field of mining excavation in the context of large scale projects and their environmental challenges due to the location, e.g. high alpine rock mass on the site of Nant de Drance.

11:05 am

Measuring Performance in Social Responsibility

J. Render; Merjent Inc., Binghamton, NY

Mining companies, industry associations, and external stakeholders have worked exhaustively over the past 10-15 years to develop policy frameworks that define social responsibility expectations. Good practice guides from the ICMM and IFC, among others, have moved the peg farther forward by helping to translate those high-level commitments into practical implementation. However, there still remains a fairly significant gap in translating implementation guidance, standards, and procedures into an agreed and relatively easy to use performance assurance

framework that speaks to the needs of both internal and external stakeholders. This presentation will provide an overview of the key elements of a social responsibility management system and the fundamentals of measuring performance across the full range of metrics, from inputs, to outputs, to outcomes, to impacts. The author will also discuss the most common challenges faced by companies in undertaking an audit program and some lessons learned in maximizing the value of your internal social responsibility spend.

Wednesday, February 24 – Morning

ROOM: 226C

9:00 am

Environmental: Sustainable Remediation/Reclamation II – Mine Water Remediation/Reclamation

Chairs: D. Crawford, Golder Associates Inc., Redmond, WA
J. Pepe, Golder, Lake Oswego, OR

9:00 am

Introductions

9:05 am

The University of Arizona Center for Environmentally Sustainable Mining

R. Maier¹ and M. Poulton²; ¹Soil, Water and Environmental Science, University of Arizona, Tucson, AZ and ²Department of Geosciences, The University of Arizona, Tucson, AZ

The Center for Environmentally Sustainable Mining (CESM) is the environmental pillar of the University of Arizona Lowell Institute for Mineral Resources. The CESM was created to address the complex environmental stewardship issues involved both in siting and opening new mines and in dealing with our mining legacy. The CESM is an industry- academic partnership that is working to prioritize and address industry research needs. As a result of this partnership, CESM is seeking to innovate development of technologies to: create sustainable mine waste caps; model and minimize dust generation in mining operations; develop remote real-time water quality monitoring systems to facilitate monitoring and closure; treat groundwater plumes at depth through biosequestration of contaminants; prevent and treat acid rock drainage; and develop educational and specialized professional training initiatives that address environmental issues related to mining activities in arid and semi-arid urban environments. The CESM is supported by a combination of federal research grants and funds from the State of Arizona and the mining industry.

9:25 am

Abandoned Mines Rehabilitation - A New Future?

S. Longo; Paste Engineering and Design, Golder Associates Ltd, Calgary, AB, Canada

Orphaned and abandoned mines can be challenges or even impediments to urban or recreational development. Typically communities will fence off the affected areas to restrict access however the public risk and safety issues associated with these sites are bringing alternative remediation programs to the forefront. These sites have typically been inherited by local, regional and/or federal governments or are legacy sites for active mining companies. Lack of resources from a financial and technical perspective are preventing communities from actively mitigating the risks that these sites pose. The technical challenges of early century mine plans, no current underground access, logistics and proximity to local communities

associated with these orphaned sites makes mobile paste backfill a viable option. This application of paste technology has not to date been widely utilized but is steadily growing. This paper will discuss three case studies from the past decade of work on mobile paste backfill applications ranging from a resort development program to a crown pillar stability remediation program.

9:45 am

Developing Biogeochemical Indicators to Enhance Revegetation Success of Mine Tailings and Waste Rock: An Industry-Academic Research Cooperative Approach

J. Neilson, L. Jennings and R. Maier; Soil, Water and Environmental Science, University of Arizona, Tucson, AZ

Current reclamation standards for modern hard rock mines require revegetation of tailings storage facilities (TSF) and waste rock stockpiles (WRS) in many locations. Revegetation in semiarid regions presents unique challenges that can be most efficiently addressed through collaborative research efforts between industry and academia. The University of Arizona (UA) has formed a unique partnership with four copper companies in Arizona to develop biogeochemical indicators to 1) assess the revegetation potential of individual TSF and WRS materials, 2) evaluate potential sources of borrow material used as amendment caps, and 3) correlate revegetation success with the reclamation strategies implemented. The indicators evaluated include pH, salinity, organic carbon and nitrogen and assessment of the biological potential of substrate microbial communities to support plant establishment. These assessments help inform decisions regarding amendment requirements and seeding strategies. The cooperative facilitates a comprehensive assessment of multiple revegetation strategies under diverse conditions and results are shared by the UA with all industry partners in annual reports and meetings.

10:05 am

Sustainable Remediation Practices for Mine and Mill Reclamation Projects

P. Lear; Envirocon, Inc, Missoula, MT

Sustainability is an important aspect of mine and mill reclamation projects. In-situ stabilization (ISS), a common remedial technology utilized to solidify mill tailings and sludge, can easily incorporate sustainability best management practices (BMP). The primary way for an ISS project team to minimize energy use and emissions is by incorporating alternate reagents as part of the mix design. Each ton of Portland cement substituted with an alternative solidification reagent results in the reduction of almost a ton of CO₂ emissions. To reduce air pollutants and greenhouse gas emissions, ISS project teams can utilize biodiesel and ultra-low sulfur diesel in heavy equipment equipped with Tier-2 and Tier-3 engines. An ISS reagent batch plant can consume more than 20,000 gallons of water per day. By using graywater from decontamination pads, treated waste water, and stormwater, clean water usage can be substantially minimized. This presentation will discuss sustainability practices related to the remediation of mines and mills and provide carbon footprint calculations for at least one ISS remediation project.

10:25 am

McKinley Mine: A Commitment to Stable Land Forms utilizing Geomorphic Principles

K. Kutter and S. Motyka; Golder Associates, Inc., Ballwin, MO

McKinley Mine was a surface coal mine located in western New Mexico. Coal production began in 1962 and ceased in 2009, with significant lengths of final pits and highwalls, areas of ungraded spoil, areas where reclamation had been performed using conventional reconstruction methods, and large areas of undisturbed watersheds that contributed stormwater runoff to the disturbed area. Conventional reclamation at the mine had utilized terraces and down drains to create stable

landforms which have traditionally required long term maintenance. A move to geomorphic reclamation was made to introduce topography during the final grading that resembled that of pre-mining topography in order to create a final landform with more long term stability and sustainability, requiring minimal long term maintenance. An added benefit is that the final reclaimed land conforms to the look of the pre-mine land and is aesthetically pleasing. The reclaimed areas are showing great results and should require minimal maintenance during the extended responsibility time frame, leaving a world class product for future generations to enjoy.

10:45 am

16-106

Applying the mixture of mine tailings and fly ash as construction materials

J. Zhang and Q. Feng; University of Arizona, Tucson, AZ

Efforts have been tried to apply the mixture of copper mine tailings and fly ash as construction materials. Through the present investigation, a protocol to make construction materials using the mixture of mine tailings and fly ash has been set up. The experiment results of the present work also help set up the working conditions such as activation temperature and time, the concentration of NaOH, the addition of Ca(OH)_2 , forming pressure, mine tailing to fly ash weight ratio, curing temperature and curing time. The findings of the present work provide a novel method for the geopolymerization of the mixture of copper mine tailings and fly ash as construction materials, such as bricks for construction and road pavement.

11:05 am

16-057

Determination of Optimum Mixture Ratios of Paste Backfill Materials for Disposal of Mineral Processing Tailings

A. Bascetin, S. Tuylu, D. Adiguzel and O. Ozdemir; Mining Engineering, Istanbul University, Istanbul, Avcilar, Turkey

In recent years, use of mineral processing tailings as a paste backfill has been significantly increased due to the environmental problems occurred during the disposal of the tailings. The strength of the paste material is completely related to ratios of tailings and cement in mixture. Temporary strength value of the paste material is a great importance for stability of the backfill. The paste backfill material must compensate the minimum 4 MPa strength value in 28 days curing time in order to procure the permanent fortification. In this study, the Pb-Zn tailings were used to prepare for the paste backfill material using cement in order to perform the uniaxial compressive strength tests. Additionally, a statistical experimental design and linear programming techniques was used to find the optimum mixture in terms of strength and cost. The results obtained from this study showed that the paste prepared by using cement and the solid ratio at 7% and 83%, respectively gave the best strength as 4.15 MPa after 28 days of curing period. This study clearly indicated that the paste material prepared at the optimum conditions can successfully and effectively be used in underground mines.

Wednesday, February 24 – Morning

ROOM: 225A

9:00 am

Environmental: Water Geochemistry

Chairs: J. Gillow, ARCADIS U.S., Inc., Highlands Ranch, CO
J. Kerstiens, ARCADIS US Inc, Highlands Ranch, CO

9:00 am

Introductions

9:05 am

The effect of site conditions on scaling factors calculated from sulfide oxidation rates

S. Doyle, A. Nicholson and S. Helgen; Integral Consulting Inc., Lakewood, CO

Scaling of analytical laboratory results to full scale is often a necessary, yet poorly constrained step in predicting mine-site drainage water quality. Many authors have suggested that sulfide oxidation rates may be used to scale up laboratory results for predicating leachate chemistry from waste rock piles. However, scaling factors estimated from comparisons of field and laboratory testing vary widely from site to site, often by an order of magnitude or more. Variations in site conditions such as precipitation, in-situ temperature, availability of oxidant, and water-to-rock ratios make estimating scaling factors difficult. This paper will show how these factors have affected the relationship between laboratory and field leachate water quality for a variety of mine sites.

9:25 am

Radionuclides Reporting to Water Treatment Systems: Characteristics and Management of Residuals

J. Kerstiens, J. Gillow, J. Jackson and D. Carpenter; ARCADIS U.S., Inc., Highlands Ranch, CO

Geochemical conditions dictate the identity and chemical form radionuclides in water systems; reducing groundwater systems often contain radium due to reductive dissolution of iron and/or the dissolution of alkaline earth sulfate, such as barite [BaSO₄]. Surface waters discharging through uranium-enriched mineralized zones may contain dissolved uranium in its highest oxidation state. Water and wastewater treatment concentrates the radionuclides through both oxidation and co-precipitation reactions resulting in treatment residuals elevated in radionuclide content. More advanced treatment processes (such as ion-exchange) may concentrate these radionuclides to the extent that the potential exists for treatment vessels to become significant sources of external radiation. Water conveyances may also accumulate and concentrate radium-bearing mineral precipitates from mixing of diverse water chemistries leading to similar source conditions. Here we describe the geochemical conditions leading to concentration of uranium or radium in residuals, means of predicting their accumulation, and options for managing these residuals in terms of both source control and waste disposal strategies.

9:45 am

Uncovering Confounding Factors that Affect Successful Mine Water Treatment

S. Rogers and P. Moran; ARCADIS U.S. Inc, Highlands Ranch, CO

Mine water treatment facilities are typically designed to achieve performance standards based on limited water quality information modeled from the pre-mining and laboratory data describing a mine site. These data may cover a relatively short time period, be based on sparsely sampled regions, and include other data gaps. As a mine evolves, across the span of decades or longer, from pre-mining to production to reclamation and closure, influent water quality changes need to be considered for successful mine water treatment. Some confounding factors that can influence water quality and therefore water treatment performance include unanticipated changes in geological/mineralogical conditions and hydraulic inputs, shifts in meteorological conditions over the life of mine (such as prolonged drought or a prolonged wet period), and ever more restrictive water quality discharge limitations (such as aquatic toxicity in the receiving system). In this paper, mine water treatment at typical open-pit and underground mines and some confounding factors that were uncovered and addressed are examined.

10:05 am

Importance of carbon dynamics during acetate stimulation of uranium bioremediation

L. Figueroa and M. Dangelmayr; Civil and Environmental Engineering, Colorado School of Mines, Golden, CO

Contamination of groundwater by uranium is an ubiquitous environmental challenge that exists in all areas that are host to uranium resources. The injection of a soluble carbon based electron donor into the contaminated saturated zones, can stimulate bacteria to use U(VI) as an electron acceptor with a concurrent reduction in soluble uranium. Solid phase organic matter produced by the utilization of soluble carbon may provide a long-term carbon source for the removal of solution uranium. Groundwater samples were collected from the Integrated Field Research Challenge (IFRC) site in Rifle Colorado before, during and after stimulation with acetate. Carbon characteristics in conjunction with geochemistry of the field bio-stimulation experiment were assessed. Soluble uranium concentrations in the bio-stimulated region of the aquifer were still reduced to below the background level at 210 days post-stimulation. Understanding the dynamics of microbial produced organic matter is crucial to the long-term success of uranium bioremediation.

10:25 am

Assessment of Environmental Impacts Associated with Artisanal and Small-Scale Mining in Suriname

T. Borrillo-Hutter; Colorado School of Mines, Denver, CO

Although global mineral holdings have become increasingly concentrated among a few large mining corporations (LMC), artisanal and small-scale mining (ASM) are ubiquitous in rural areas of developing countries. It is estimated that up to 100 million individuals directly and indirectly depend on ASM as part of their livelihoods. Small-scale miners regularly engage in environmentally detrimental activities. This presentation will present the findings of an environmental impact campaign conducted in the interior forest of Suriname where ASM activity is conducted illegally on the concession of a LMC. Topics will include fate and transport of pollutants (including mercury) associated with ASM activity.

10:45 am

Designing and Constructing a Mine Water Treatment Facility to Remove Multiple Contaminants

H. Liang¹, J. Tamburini², F. Johns³ and B. Willis²; ¹Water Chemistry, Tetra Tech, Denver, CO; ²Tetra Tech, Denver, CO and ³Industrial Water Management Group, Tetra Tech, Denver, CO

The design and construction of a full-scale mine water treatment facility to remove multiple contaminants, including sulfate, fluoride, aluminum, iron, manganese, molybdenum, and total dissolved solids (TDS), at the Chevron Questa molybdenum mine in New Mexico, United States, will be presented. The design flowrate of the mine water treatment facility is approximately 5 million gallons per day (MGD), where certain waste streams with greater than 5,000 mg/L sulfate concentrations would be treated to below 600 mg/L sulfate and below 1,000 mg/L TDS for discharge, along with meeting discharge limits for other contaminants-of-concern. The evaluation of treatment technologies and decision-making processes utilized to develop the final design will be discussed. Besides discussing details of the relevant process chemistry and engineering, construction of the mine water treatment facility, which is expected to be completed by 2016, will also be discussed.

Wednesday, February 24 – Morning

ROOM: 131B

9:00 am

Health & Safety: Best Practices in Training for Safe Production

Chairs: R. Hill, University of Arizona, Phoenix, AZ
M. Lutz, Freeport McMoRan, Sahuarita, AZ

9:00 am

Introductions

9:05 am

Building a Workforce of Professional Miners to Sustain Safe Production

E. Lutz; College of Public Health, The University of Arizona, Tucson, AZ

Mining operations throughout the globe continue to be plagued by injuries and fatalities. Further adding to the challenge of achieving and sustaining zero health and safety incidents, even in high performing operations, the historic Heinrich Triangle of incidents and Behavior-based safety models fail to provide contemporary operators and contractors the needed predictive indices to address gaps. The Institute for Mineral Resources (IMR) at the University of Arizona has hosted the Mining Institute for Supervisor Leadership (MISL) program since 2011 and trained over 125 mining supervisors. Based on operational trends, the MISL program continues to mature in breadth and depth, including expansion internationally. This presentation will review the MISL programs, discussing associated impacts and challenges from the past five years, and the future directions reflecting operational realities and trends.

9:25 am

Distraction: The Elephant in the Mine – Strengthening Your First Line of Defense

D. Johnson; Eco-Edge, Chandler, AZ

Experts state that technologies that monitor distraction and fatigue only capture 50-70% of incidents and that a multilevel approach is needed. Furthermore, attention is often overlooked in that multilevel approach since it has been easier to address the root causes of fatigue than of distraction. How do you address this “elephant” in your mine? Your first line of defense is right under your hard hat – since your brain is where distraction and fatigue happen. In addition to familiar technologies such as proximity detection & fatigue monitoring, we’ll tackle these challenges from a different direction, including new ways to adapt training to individual miners, since no two people are the same. This session will also provide a better understanding of underlying root causes such as “automaticity” and “decision fatigue.” By understanding underlying issues and available technologies, participants can better protect their employees as well as decide what solutions are right for their site and if different solutions are needed for different positions (e.g. haul truck driver vs. shovel operator vs. explosives technician). This session will help participants improve safety and save lives.

Preparing the Next Generation of Operators for Advances in Leaching

Z. Sample; Projects Department, MYNAH Technologies, Chesterfield, MO

In reaction to dwindling deposits of high grade ore, modern process and automation technology has become vital to the success of mineral processing facilities, causing plants to become increasingly complex and sophisticated. As a result plant personnel are presented with new operational challenges, making plant operation more difficult than ever. In order to effectively train operators on real-world challenges, it is imperative for the simulation to represent the actual process. The use of a real-time, dynamic simulator with rigorous, first-principle models integrated with a virtual copy of the production control system provides a reliable, hands-on experience with 100% physical fidelity to the real plant experience. From this, operators can be trained on operational procedures, process upsets and equipment failures without the risks and stresses associated with on-the-job training. Through a case study of a recent gold extraction and recovery project, we see how operators can be successfully trained in an engaging and safe environment through the use of lifecycle dynamic simulation.

10:05 am

Translating Training to Competency: new approaches to mine safety training

M. Poulton, E. Lutz, L. Wilson and S. Gravley; Lowell Institute for Mineral Resources, University of Arizona, Tucson, AZ

We discuss methods to translate training into improved safety and health competencies, specifically including : 1) network the best mine safety trainers to create a high-performing technical advisory committee to assist in writing training materials that use active learning and are based on competencies that will improve transfer of safety learning from the training room to the workplace; 2) run a high performance training clinic to train trainers to use these best practices; 3) measure the effectiveness of the transfer of training knowledge to practice with an adult learning instrument; 4) apply our computer simulation software platform to measure safety competencies; and 5) continue offering our Mine Institute for Supervisor Leadership (MISL), which includes competency training. We will outline what effectiveness of improved training methods and motivations to improve training effectiveness looks like at a work crew, department, mine operation, and corporate level.

10:25 am

The Future of Training in a Data-Driven Mining Industry

M. Lutz¹ and E. Lutz²; ¹Custos Fratrís, L3C, Tucson, AZ and ²Environmental and Occupational Health, University of Arizona, Tucson, AZ

The Future of Training in a Data-Driven Mining Industry Many researchers and experts in the industry have noted the need for more opportunities for and effectiveness of workforce training (NRC, 2013; Kowalski-Trakofler et al, 2004; Alexander et al, 2010). However, it's unclear exactly what type of training is needed most. More mandated safety training? More technical skills training? More formal education experiences such as K-12, college and university programs? Additionally, it's unclear who is in most need of this training; i.e., engineers, equipment operators, maintenance workers, frontline supervisors? Using the National Survey of the Mining Population (McWilliams, Lancaster & Zeiner, 2012), this study attempts to discern what training is most urgently needed in the mining industry and looks not only at the aggregated data, but also identifies variability among the commodity sectors of coal, metal, non-metal, stone, and sand and gravel.

Wednesday, February 24 – Morning

ROOM: 131A

9:00 am

Health & Safety: Big Data Analytics: What about Leading Indicators?

Chairs: R. Reed, University of Arizona, Tucson, AZ
M. Savit, Jackson Lewis LLP, Denver, CO

9:00 am

Introductions

9:05 am

Data Science's Place at the Mine Safety and Health Table

R. Reed; Mining Safety and Health Program, University of Arizona, Tucson, AZ

Objective: To broaden understanding of the role that data science does and will have in mine safety and health. **Introduction:** Humans have become expert at collecting and storing data. Sufficient data currently exist to provide significant information on our world, including mining safety and health. We are limited by our methods of integration and analysis. The future of sensing and communication technologies will allow for exponentially larger amounts of various types of data to be conveniently and inexpensively collected. **Discussion:** Once the integration and analytical hurdles we face have been overcome, data science will use enormous amounts of data to predict and forecast mining injuries and illnesses before they happen. This flow will consist of: 1) sensors/kiosks that collect real-time, continuous, and/or categorical data; 2) digital warehouses that store and integrate data; 3) complex analytical programs and algorithms that automatically sift, filter and model data; and 4) a communication or warning system that will alert mining employees and supervisors of unsafe thresholds. **Conclusion:** Understanding and adapting with data science can optimize mine safety and health.

9:25 am

Leading indicators for mining safety through resilience engineering

M. Pillay¹ and M. Tuck²; ¹School of Health Sciences, The University of Newcastle, Callaghan, NSW, Australia and ²School of Engineering and Information Technology, Federation University, Ballarat, VIC, Australia

Mining health and safety academics, practitioners and researchers have traditionally relied on traditional, lag-type indicators for managing risks associated with mine health and safety hazards and risks. This is largely due to the way in which safety has been defined and understood in the industry. In the last decade, however, there have been attempts to re-define safety, the way it is managed, and how the concept of human error is seen, and how traditional data can be used in more innovative ways. This paper introduces commonly used indicators for measuring health and safety performance, reviews traditional views and definitions of safety, human error, events and/or threats, and safety management that arises from such definition(s), followed by an exploration of resilience engineering as an alternative approach to health and safety management. Following a re-definition of safety as learning from success under the the resilience engineering approach, the paper concludes with ideas those responsible for managing safety in mining may wish to think about in seeking to use existing data to in more innovative ways.

9:45 am

Predicting Trends: Using Analytics to Promote Safety in High Hazard Industries

D. Lauriski; Predictive Safety LLC, Centennial, CO

According to The Bureau of Labor Statistics more than 3.3 million men and women have suffered a serious workplace injury or illness. The annual economic impact is over \$53 billion in just workers' compensation costs. Lost productivity, employee training and replacement, time spent on investigations, and the emotional and psychological effects are other indirect costs to employers. Both leading and lagging safety indicators are collected in mining and other high hazard industries, but leading indicators are rarely used to predict future safety behaviors and trends in performance. Predictive Safety, LLC is working to produce and distribute a proactive software model focusing on leading indicators to predict and prevent operational incidents and worker injuries. The intent is to assemble leading indicator data from existing data collection systems and utilize analytics to enable employers to pinpoint behaviors and demographic data to determine and address factors likely to lead to incidents resulting in injury or damage.

10:05 am

Predictive Compliance: A Strategic Data Approach to Regulatory Compliance Management

J. Savit; Predictive Safety, Denver, CO

Predictive Compliance provides services that allow mine owners and operators to evaluate and manage potential compliance issues proactively, prior to MSHA, or other regulatory, both internal and external assessment. Their propriety analytics and penalty, and cost calculation engine offers insight into the financial impact of receiving additional citations or actions, as well as disputing current citations, or actions. The software is user friendly and provides a platform for citation management. It also allows for the prediction of the impact of future citations, or actions with regard to costs, resources, and operations, allowing for the allocation of resources to safer, more efficient operations. The ability to quantify safety bridges the gap between safety, compliance, and production. This presentation will highlight the benefits that this software offers companies to manage MSHA, or other regulatory compliance and subsequently improve operational safety performance.

10:25 am

Using Big Data Approaches on Large Unstructured and Structured, Highly Varying Mine Safety Data to Gain Insights

S. Dessureault¹ and R. Reed²; ¹Mining and Geological Engineering, University of Arizona / MISOM Technologies Inc., Tucson, AZ and ²Public Health, University of Arizona, Tucson, AZ

The large volume of highly variable data sources both directly and indirectly related to mine safety is so large and complex, traditional spreadsheet and simplistic reports are unable to extract the full value of the Big Data assets. This trend will only increase with the incoming use of tablets to collect the currently paper-bound safety forms, and the ability to track miner movements through Internet of Things beacons and accelerometers. It will become ever more important to understand how to use Big Data approaches if the full value of this new data is to be achieved. A case study is presented of an integration and cleansing of currently available data sources including observations, incidents, violations, every machine production movement, down events, and machine health monitoring alarms (abuse), from several large mines in the United States. Visualization approaches and data mining algorithms are applied to identify correlations, clusters, and other patterns. Identification of these nonlinear relationships between these variables could lead to the development of real-time leading indicators.

10:45 am

Caterpillar and Tyco using Teamwork and Technology to enhance Fire Safety on mobile equipment through a complete data driven system and solution

K. Carver; Global Accounts, Tyco, Evansville, IN

Together, the international marketplace leaders - Caterpillar Global Mining and Tyco/Ansul - have utilized their technology and Teamwork core value in a data-driven approach to improve fire safety on mobile equipment. Utilizing a six sigma approach from Fire Risk Analysis through early engineering design through 3d design/simulation through live testing on pilot machines, the overall safety and dependability of the mobile machine is enhanced. Operator safety and asset protection are foremost at each step of the process. Through computer modeling, the machine is designed for the optimal application of a well designed fire suppression system. Through the 3D design process, serviceability and reliability are improved by integrating the fire protection components with the machine. Off site analytics and service schedule integration are possible, with the benefit of enhanced uptime for the end user.

Wednesday, February 24 – Morning

ROOM: 221A

9:00 am

Industrial Minerals & Aggregates:

Computer Aided Mine Planning and Development

Chairs: A.Brickey, South Dakota School of Mines and Technology,
Rapid City, SD

S.Chatterjee, Michigan Technological University, Houghton, MI

9:00 am

Introductions

9:05 am

Forecasting time-to-failure of a Mining Machine using Hybrid Neuro-genetic algorithm: An application from aggregate industry

A. Paithankar; Department of Geological and Mining Engineering and Sciences, Michigan Technological University, Houghton, MI

Forecasting of next time-to-failure is an important aspects of mining machine for the performance assessment, schedule maintenance, and fault detection. The knowledge of time-to-failure allows more defined arrangement of preventive maintenance. Traditional methods including lifetime distribution models, fault tree analysis, and Markov models have limitation of assuming a specific statistical distribution function to fit the time-to-failure data. In this study, a hybrid data driven method using neural network and genetic algorithm is proposed. The developed model was validated by a benchmark data set. A comparative study reveals that the proposed method performs better than existing methods on benchmark data sets. A case study was conducted investigating a dumper operated at a limestone quarry. Time-to-failure historical data for the dumper were collected, and cumulative time to failure was calculated for time-to-failure forecasting. Study results demonstrate that the developed model performs satisfactory in the prediction of next time-to-failure.

9:25 am

Incorporating uncertainty in Long-term Production Planning of Multiple Limestone Quarries

D. Joshi; Mining Engineering, Nit Rourkela, Rourkela, Orissa, India

To supply consistent quantity and quality of raw materials to cement plant, raw materials are generally brought from multiple limestone quarries. Therefore, production planning of multiple quarries together provides more robust solution for consistent raw materials supply. In this paper, a long-term production planning of multiple quarries is proposed. The uncertainty of lime saturation factor (LSF), silica ratio (SR), and alumina ratio (AR) are considered while solving the production planning problem. The sequential Gaussian simulation was used to generate multiple realization maps of LSF, SR, and AR. The sequential branch-and-cut algorithm was applied to generate initial feasible solution. The initial feasible solution was improved using longest path algorithm. A case study from Indian cement industry is presented. The results demonstrated that the proposed approach can efficiently solve the multiple quarries production planning while maintaining the smooth quantity and quality of the raw materials to the cement plant.

9:45 am

Optimizing Feeder Movements at a Quarry

A. Newman; Mechanical Engineering, Colorado School of Mines, Golden, CO

As mining progresses, the frontier in an aggregate mine moves farther away from the feeder; this increases loader cycle time, meaning that loaders must be added to the operation to maintain production rates. Eventually, the feeder must be moved closer to the mining frontier. If a feeder movement occurs when all loaders are in operation, it can overtax the loaders and lack advance warning. We present a mathematical model to determine how often the feeder should be moved to the mining frontier to combat these problems.

10:05 am

6-170

Using Gridded Surfaces to Estimate Blasting Delay Cost Near Protected Structures

S. Richards; Mining, Carlson Software, Maysville, KY

Abstract The Scale-Distance formula is one of the primary means of determining the maximum amount of explosives that can be detonated at one time by a single delay. This paper describes a method of applying the Scale-Distance formula to the entire mining area using gridded surfaces. Using this technique, the operator can determine the economic impact of the presence of nearby structures on the cost of blasting delays.

10:25 am

Open Pit Mine Scheduling with Variants on Inventory Considerations

M. Rezakhah and A. Newman; Mechanical Department, Colorado School of Mines, Golden, CO

We present several ways of modeling stockpiling (with and without considering degradation) in open pit mine production scheduling, including (i) individual stockpiles for each block and (ii) binned stockpiles with pessimistic grade estimates. These models are formulated for a currently operational mine and compared to results without stockpiling in order to assess the benefits of stockpiling and to analyze the relationship between milling capacity and stockpiling value.

Wednesday, February 24 – Morning

ROOM: 221B

9:00 am

Industrial Minerals & Aggregates: Talc, Pyrophyllite and Other Lammellar Minerals I

Chairs: J. Childs, Childs Geoscience Inc, Bozeman, MT
G. Tomaino, Minerals Technologies Inc, Easton, PA

9:00 am

Introductions

9:05 am

Talc Resources of the World; A Historical to Modern Day Perspective

E. McCarthy; Imerys, San Jose, CA

Talc occurs in every continent and it was used in the early Chinese dynasties and in Roman times as a cosmetic as well as by the Vikings and West Coast US Indians for cookware. The modern industry began in the Northeast US in the 1870s to serve local paper and paint markets and talc deposits were exploited in other parts of North America, Europe and Asia for local use; some of these grew into more regional markets with growth in ceramics in the 1930s and regional ceramics, paint and paper applications still predominated until the 1980s; then new automotive applications in technical ceramics and polymers placed a high technical requirement for products with a carefully targeted particle size and controlled mineralogy; since then talc has become a more global business with growing intercontinental trade, significant industry consolidation; four major multinational producers now supply most of the product in the western hemisphere, while smaller, mostly local enterprises still predominate in East Asia.

9:25 am

An overview of the talc industry in the United States

D. Flanagan; National Minerals Information Center, U.S. Geological Survey, Reston, VA

This presentation will provide a current and historical overview of the domestic and global talc industry with an emphasis on end uses and import sources. After increasing throughout much of the 20th century and peaking in the late 1970s, talc production in the United States steadily decreased from 1990 to 2014. Since 2005, the percentages of domestic talc sold for plastics, paper, and cosmetic applications have increased and the percentages sold to ceramics, paint, and roofing markets have decreased. Prior to the 1980s, yearly imports of talc were low relative to production and predominantly originated in Italy, Canada, and France. Imports have increased by more than 17-fold since 1980 and China has been the primary source of imported talc since the early 1990s.

9:45 am

16-140

The Talc Deposits of Southwestern Montana: An overview

J. Childs; Childs Geoscience Inc, Bozeman, MT

The talc deposits of southwestern Montana are hosted by Archean to early Proterozoic(?) dolomitic marbles. Three major deposits are presently being mined and a fourth is reclaimed in the Ruby Range and Gravelly Ranges east of Dillon, MT. Several smaller deposits have produced minor amounts of talc. The talc is a co-product of hydrothermal processes that have also produced chlorite and

sericite in the adjacent gneiss and schist. A hydrothermal origin for the talc is supported by the restricted areal extent and relatively sharp borders between talc/chlorite and high-grade metamorphic host rock assemblages and by fluid inclusion and other geochemical data. Radiometric dating on sericite indicates a mid-Proterozoic age for talc formation. Controls on mineralization recognized to date include a source of fluids enriched in magnesium, conduits such as fault zones, and receptive carbonate host rocks. Exploration methods have consisted primarily of geologic mapping, and outcrop and soil sampling. Some experimentation has been done on the use of geochemical and geophysical exploration methods but these remain largely untested.

10:05 am

Hydrothermal Talc Deposits in Pre-Belt Carbonates of Southwest Montana: An Updated Model

S. Underwood; Childs Geoscience Inc, Bozeman, MT

Voluminous talc ($\text{Mg}_3\text{Si}_4\text{O}_{10}(\text{OH})_2$) deposits in pre-Belt marbles are mined in the Ruby Range by Barretts Minerals Inc. and in the Gravelly Range by Imerys Talc in southwest Montana. These large talc deposits and numerous smaller talc occurrences in the southern Tobacco Root Mountains, Greenhorn Range, and Ruby Range are thought to result from Proterozoic hydrothermal activity. A new model of talc formation invokes a time-transgressive, regional fluid-rich greenschist facies environment with active Proterozoic tectonism. The present work reevaluates the results of several stable isotope studies of talc and carbonate samples in the Ruby Range and fluid inclusion studies from the Gravelly Range combined with new $\delta^{18}\text{O}$ and δD values for talc collected from other localities across this region. Preliminary data interpretation: Over time, talc formation processes within the Dillon Block of tectonically active crust were likely intermittent reflecting changing fluid permeabilities and fluid compositions (i.e., shifting proportions of brines, sea water, and meteoric waters, with occasional magmatic fluids).

10:25 am

Physical Chemistry Features of Bubble Attachment at a Talc Surface

V. Atluri, X. Wang and J. Miller; Metallurgical Engineering, University of Utah, Salt Lake City, UT

The surface chemistry of talc is of interest in order to develop improved strategies for control in flotation systems. The wetting characteristics of talc in aqueous systems are described from both experimental, and molecular-dynamics-simulated, contact angle determinations. These sessile drop contact angle results are presented with respect to drop size which varied from nanometers in size (molecular dynamic simulations, MDS) to millimeters in size (experimental). In addition, the interfacial water structure and characteristic features are discussed based on MDS results. Finally, bubble attachment time measurements suggest that talc depression by polysaccharides during flotation is achieved by decreasing the rate of film rupture/displacement, and is explained based on the surface state of talc after bubble attachment as revealed by microscopic examination.

10:45 am

Pyrophyllite – That Other “Talc” Mineral

J. Harkins; Vanderbilt Minerals, LLC - Standard Mineral Division, Robbins, NC

Pyrophyllite is a layered hydrous aluminum silicate mineral, with similar physical properties as talc, the mineral that gets most of the attention between the two industrial minerals. Vanderbilt Minerals, LLC – Standard Mineral Division (owned by R.T. Vanderbilt Holding Company, Inc.), located in Robbins, NC, is the primary producer of pyrophyllite products with worldwide distribution in the refractory industry. Standard Mineral has a rich history, with the initial usage of pyrophyllite produced as “talc” pencils which were sold for steel marking and tailor’s chalk in the early 1920’s. This presentation will review Standard Mineral’s mining and processing operations throughout the years along with today’s marketing applications of pyrophyllite.

11:05 am

Trinity Resources - Building value with the brightest Pyrophyllite source in the NAFTA and EU region

J. Hurley; Trinity Resources, Conception Bay South, NL, Canada

From the initial business plan through to FDA approval. With a Pyrophyllite mineral long used in ceramics, Trinity Resources has successfully completed process and product development for diverse applications in both the EU and NAFTA region. The hurdles were difficult - the challenges rewarding.

11:25 am

The Graphite Creek Flake Graphite Deposit, Seward Peninsula, Alaska

D. Hembree; American Institute of Professional Geologists, Sunny Valley, OR

First discovered in 1900, the Graphite Creek graphite deposit lies in the Kigluaik Mountains 58 km northwest of Nome, Alaska. The deposit is hosted by Precambrian biotite-schist and quartz-garnet-biotite-sillimanite schist striking 70 degrees west dipping 60 degrees northeast. The host rocks have been subjected to granulite facies metamorphism during emplacement of the Kigluaik granite. The northern boundary of the deposits is the NE trending Kigluaik fault. Graphite One Resources has conducted airborne geophysics, mapping, sampling and core drilling over three field seasons. In April 2015, Graphite One announced an Indicated resource totalling 17.95 Mt at 6.3% Graphite within an inferred resource of 154.36 Mt averaging 5.7% Graphite. Metallurgical studies are ongoing for production of spherical graphite for the Li-ion and storage battery market.

Wednesday, February 24 – Morning

ROOM: 128A

9:00 am

Mining & Exploration: Geology: Mine Geology

Chairs: D. Applebee, ASARCO, Green Valley, AZ

G. Tomaino, Minerals Technologies, Inc., Easton, PA

J. Childs, Childs Geoscience Inc., Bozeman, MT

9:00 am

Introduction

9:05 am

How to Integrate Geometallurgy Easily into a Mine Site

S. Leichter; Stacey Leichter Consulting LLC, Woodland Park, CO

Geometallurgy is a discipline that has been used for a long time in mining. It can be known also as process mineralogy, process engineering, or mineralogy. The key to all these titles is that it is mineralogy based. Geometallurgy aids in identifying the variability in the mineralogy of the geology, which could cause problems and losses. Geometallurgy incorporates the many different disciplines found at a mine site: exploration, geotechnics, blasting, ore control, crushing, grinding, processing, environmental, and management. Each of these departments has their own unique testwork performed for needed information. This data is usually kept in separate databases and audited. Once it has been used to illustrate the particular trait, it sits in the database for quite a while. Instead of having this expensive, important data just sit, it can be used as a basis for different geometallurgical models. These base geometallurgical models are great to use to reiterate with new geometallurgical specific testwork.

9:25 am

Calc-silicate Alteration and Ore Characterization, ASARCO Mission Complex, Pima County, Arizona: Implication for the Optimization of Molybdenum Recovery

S. Baxter; Mining Engineering - Mineral Processing & Extractive Metallurgy, The University of Arizona, Oro Valley, AZ

This study sought to better understand and characterize the skarns and associated Mo mineralization at ASARCO's Mission Complex. High grade Mo mineralization generally occurs in three modes: 1) disseminated masses in Clinopyroxene-Tremolite (\pm calcite, anhydrite) hornfels, 2) trace amounts in Garnet \pm Clinopyroxene skarn locally closely associated with scheelite, and 3) as fracture controlled mineralization. Vein paragenesis plays an important role in ore characterization, which varies considerably throughout the deposit. Understanding the relationships between mineral assemblages in specific lithologies associated with Mo is the key to predicting and mitigating potential processing issues.

9:45 am

Taylor's Rule Revisited

K. Long; U.S. Geological Survey, Tucson, AZ

In 1977, H.K. Taylor proposed an empirical relationship between mine capacity and reserves, known as Taylor's Rule, for use in determining installed mining and processing capacity in mines. Long (2009) re-estimated the relationship using a sample of 539 open pit and underground mines, proposing two new equations, one for bulk (open pit and block cave) mining and another for selective underground mining. Since that time a number of feasibility studies have been released which consider the effects of a range of mine capacities on project economics. These new data are an opportunity to test the new equations and look at reasons for the observed relationship between reserves and mine capacity.

10:05 am

16-052

Dynamic Unfolding – Complex geology case study of Tenke-Fungurume mining district deposits

J. Cardwell² and A. Cartwright¹; ¹Hexagon Mining, Tucson, AZ and ²Freeport-McMoRan Inc., Oro Valley, AZ

Complex geology requires innovative approaches to confidently and appropriately model grade and geologic trends. Local Anisotropy Kriging (LAK) and MineSight® Dynamic Unfolding (MSDU) from Hexagon Mining are advanced exploration interpolation methods designed to best estimate grade along deformed three-dimensional grade trends at sediment-hosted deposits. While LAK works in Euclidean space for the construction of variograms, kriging weight assignment, and stationary local interpolation search ellipses, MSDU is far more dynamic and can utilize a modeled three-dimensional undulating surface representing a folded grade trend to construct the above mentioned. MSDU was implemented at the sediment-hosted, stratabound Tenke-Fungurume mining district and revealed major block-to-block differences in interpolated copper and cobalt grades compared to LAK.

10:25 am

Contribution of Remote Sensing Radar to analyse fracturing and identify new drilling targets from Oumé license

A. Mahizan; Metalogeny and Basement Complex Laboratory, University of Abidjan Cocody, Abidjan, Côte d'Ivoire

Oumé license (PR105) is located in Central West Côte d'Ivoire (West Africa) on the Birimian greenstone belt of Fetekro. In this license, the gold deposit Bonikro was highlighted by survey on soil geochemical anomaly. Around the deposit, within a radius of about 15 km, there is a dozen of targets highlighted by ground geophysics and geochemistry. These targets are currently tested by drilling in order

to find any additional resources. That is why this work is find strategic; location of new targets. To achieve this goal, we used another approach which is airborne satellite images; SOR combined with magnetic, gravimetric and radiometric. This study aims also to contribute to the structural knowledge of Oumé-Hiré gold district. The first step was to use directional filters of Sobel (NS, EW, NE-SW and NW-SE) and Yesou's gradient filter that allowed the image enhancement so the trace of lineaments on screen is used for realizing detailed map of fracturation. The second step was to establish a relationship between the lineament map and the geochemical signature map. This correlation allowed us to identified four (4) potential targets in the Oumé license.

10:45 am

16-062

Trace Element Analysis of Placer Gold Samples from New Mexico

T. Luterbach¹ and V. McLemore²; ¹Mineral Engineering, New Mexico Institute of Mining and Technology, Socorro, NM and ²Bureau of Geology, New Mexico Institute of Mining and Technology, Socorro, NM

Trace element analysis of placer gold can be used as a valuable exploration tool in order to determine the original deposit source and locating lode gold deposits. Placer gold collected from multiple districts in New Mexico and Alaska, coupled with a broad database of other analyzed placer gold samples indicate correlations between chemical signatures (especially gold, silver, and copper) and type of deposits (i.e., Au-rich copper porphyry deposits, Au porphyry deposits, and epithermal deposits). By completing a chemical analysis and determining the particle morphology of placer gold collected from these districts using an electron microprobe, patterns in the chemical signatures from each location can be used to examine chemical variability (1) within the individual placer gold particles, (2) within the same district and (3) among different districts.

Wednesday, February 24 – Morning

ROOM: 128B

9:00 am

Mining & Exploration: Management: Getting Bold: Case Studies of Opportunities and Challenges in Managing Mines of The Future

Chair: C. Osborn, Stantec Inc, Higley, AZ

9:00 am

Introductions

9:05 am

Dealing with Challenges to Workforce Development for Modern Mining: Innovative Partnerships

R. Ganguli; University of Alaska Fairbanks, Fairbanks, AK

Dwindling state and federal budgets have had a negative impact on mining related education and training, and therefore, industry vacancies & turnover. A creative partnership was formed between a research institution, the mining industry, and community colleges to address mining workforce needs in Alaska. The partnership, led by the University of Alaska Fairbanks, received a \$8.1M grant from the US Department of Labor for various mining workforce development initiatives. The grant funds training programs for mine operators (underground and surface), mine mechanics, and mill process operators. It also funds the creation of a mill process simulator, that will be utilized to train mill operators. This paper presents information on the grant activities, including creative aspects of the partnership.

9:25 am

Case studies of 3D printing as an effective communication tool

W. Blattman and M. Blattman; Blattman Brothers Consulting, Cypress, TX

3D printing in industrial settings is becoming common place, but until recently its application in the mining industry was limited. As 3D printing technology advances, so will its value as a tool for mining engineers, geologists, and technical professionals. This presentation discusses case studies where 3D printing was used as a communication tool in various mining environments including: permit applications, investor relations, public and regulatory consultations, and long- and short-term mine planning.

9:45 am

The Whole Nine Yards – Barrick's Implementation of KPI Reporting Across 10 Operations

D. Prance¹ and A. Scott²; ¹Trimble Mining, Denver, CO

and ²Barrick Gold, Toronto, ON, Canada

Barrick Gold selected the Trimble Mine Management Reporting System to standardize on one central data source of KPIs and business metrics used across 10 operations and its Toronto head office. This case study will review the goals, developing requirements, designing to specification, consensus building to accelerate adoption, implementation milestones, and initial results. Attendees will learn about real-world examples of an enterprise-wide mine information system implementation, gain an awareness of the benefits of an enterprise MMRS system, and managing the key considerations for a successful implementation.

10:05 am

Eagle Mine: Developing an Effective Operating Partnership

C. Connors¹ and J. Larsen²; ¹Lundin Mining - Eagle Mine, Champion, MI and

²Cementation USA, Salt Lake City, UT

Eagle Mine was purchased by Lundin Mining in the summer of 2013 and was brought into production in the Fall of 2014. In late 2013, Cementation (USA) was selected as the mining contractor to perform all underground operations and underground maintenance functions. The presentation will discuss the concept of a "One Eagle" team, the development of this operating strategy and the learnings that have occurred by both organizations in effectively building the operating teams and structure.

Wednesday, February 24 – Morning

ROOM: 127A

9:00 am

Mining & Exploration: Management: Project Strategies

Chairs: K. Hanson, CH2M HILL, Eagle, ID
S. Newman, Barrick, Layton, UT

9:00 am

Introductions

Strategic Decisions based on the Cost Model Analysis for Mines Transitioning from Surface to Underground

A. Sanzana¹ and V. Tenorio²; ¹Departamento de Ingenieria de Minería, Pontificia Universidad Católica de Chile, Santiago, Santiago, Chile and ²Department of Mining and Geological Engineering, University of Arizona, Tucson, AZ

There is a current trend in transitioning from Open-Pit (OP) to Underground (UG) mines, as it becomes more difficult to find new, easily accessible ore deposits. It is necessary to find a method that will assure the optimum extraction of deeper and more complex orebodies and extend the life of the mine. In addition, there is the economic incentive of reducing the extraction cost per unit of ore. Several major OP-to-UG transition projects were compared in function of ore production for both methods, stripping ratio for the OP stage, and type of access to the deposit for the UG stage. Cost charts of every stage are presented and applied in a case study, providing a guide for making strategic decisions in the transition process. Keywords: capital cost, cost analysis, decision making, operating cost, production, surface, transition, underground.

9:25 am

Optimizing Mine Performance to Improve Output and Financial Returns

B. Wesner; Life Cycle Engineering, Charleston, SC

Combining Lean, Asset Management Solutions and Organizational Change Management Today's leaders are increasingly asked to do more with less. As a result, many are forced to oversee operations with fewer resources and mitigate resulting risks with less time and money. Given these constraints, how can we expect decision-makers to continue to drive improvement, achieve success and deliver value? One solution is to develop strategies that drive improvement and eliminate issues that impact our ability to perform. Chronic and persistent issues in the mining industry can be solved by using a targeted Mining Performance Optimization approach that integrates best practices in change management, lean and asset management solutions. This session will focus on the tactical, hands-on changes necessary to remove issues and waste that stand in the way of improving mine output and financial sustainability. Learning Objectives Understand what a focused improvement effort should look like Learn the fundamentals of the Mining Performance Optimization process Create several loss elimination strategies to reduce waste and risk Develop a plan to manage change and culture during process improvement efforts.

9:45 am

Running With Scissors; How Self Inflicted Wounds can Damage a Mining Application

C. Hopkins; Politics of Mine Permitting, The Saint Consulting Group, Franklin, TN

It is hard enough to permit a mineral mine today without the difficulties of making mistakes along the way. Most mistakes can be avoided if your the producer's process is planned throughly, well thought out and carefully executed. Many times, producers take shortcuts during the process and it typically damages their application. Politics plays a major role in any development applicaiton regardless of the industry but in mining when you may have to go through a local, state and federal process, politics is a good 75% of your efforts. Working with elected officials, residents of your community and environmental orgnizations takes great skill, must be done carefully and virtually without error. This session will explore how to avoid common mistakes that are made during the permitting process including making the initial public announcement of your application, introducing

yourself to residents and how you engage NGO's. We will cover techniques on how best to successfully navigate these stages of the application process through the public hearings and the final votes. We will review case studies of applications that went terribly wrong and what could have been done to avoid the outcome.

10:05 am

Strategic Mine Planning to Maximize Project Value

A. Peralta; Amec Foster Wheeler, Vancouver, BC, Canada

Finding the mine plan that maximizes the value of a mining project requires the analysis of many complex scenarios which involve multiple constraints. The process involves determining the ultimate pit limit, the operating phases, selecting the mining capacity, determining the cut-off strategy, finding the stockpile management strategy and identifying the improvements generated by the interactions between all these items. In this presentation, the practical application of the methodology to develop a strategic mine plan that maximizes the project value is discussed. The applicability of this methodology is demonstrated using a case study of a gold-copper project.

10:25 am

Collaboration in Strategic Planning: Client Interaction and Involvement During Project Development

M. Erickson; Member, Denver, CO

Having spent most of my career in vendor supply, process and project engineering and design, and in client projects involvement, I wanted to share my thoughts on stages/phases of project development and how a technology supplier can interface either with the client and/or engineering contractor during the early phases of a project. This client/engineering contractor/technology supplier interfacing is much more than just supplying prices and designs during the early study phases and waiting for the RFQ/RFP to be released for bidding and/or purchase. Early involvement of the technology supplier with the client/engineering contractor can contribute to options analyses in the mine design, ore/waste transport, process design and process plant, tailings/waste transport and storage, infrastructure and general arrangement and facilities locations. The technology supplier is provider of up-to-date technologies, equipment and systems in the options analyses for the projects advancement and development.

10:45 am

Collaborative Approaches to solving Geotechnical Challenges in the Mining Environment

C. Lange; Nicholson Construction Company, Centennial, CO

Geotechnical construction in the mining environment includes earth retention systems and deep foundation systems. The geotechnical contractor is an expert in a variety of techniques and construction means and methods that allow the geotechnical contractor to optimize solutions given the particulars of the site access constraints, ground conditions, performance criteria and geotechnical risk. Mining owner collaboration between the design team and geotechnical contractor allows selection of the optimum solution. Two case studies are discussed that showcase this collaboration; a contractor-designed earth retention system and a contractor-design deep foundation system each of which offered a price and schedule savings over the original solutions.

Wednesday, February 24 – Morning

ROOM: 127B

9:00 am

Mining & Exploration: Operations: Continuous Improvement in Underground Operations

Chair: M. Tilley, Cementation USA Inc, Sandy, UT

9:00 am

Intorduction

9:05 am

A Value Driven Cost Management Method for Continuous Improvement of Efficiency and Cost Reduction in Mining Operations

J. Botin and M. Vergara; Ingenieria de Mineria, Pontificia Universidad Catolica de Chile, Santiago, Santiago, Chile

The end of the “super cycle” has placed an end to a decade of production focused strategies, with operating cost growing at rates higher than production. Today, the sector is placed on a tough ride and forced to shift focus to cash preservation and efficient cost management. However, most cost management systems in the minerals industry are not conceived as value driving tools but to meet financial accounting and reporting needs. This paper draws from a research project aiming to develop an innovative cost management methodology that applies Activity-Based Bottom-Up cost budgeting and continuous improvement tools to develop a value-driven cost management system for sustainable improvement of operational efficiency and cost reduction. The methodology was successfully tested in the Andina underground mine III Panel sector of Corporation del Cobre (CODELCO), in Chile. The results of this test and its potential are also discussed.

9:25 am

Drawpoint Construction Improvement At Deep Mill Level Zone (DMLZ) PT Freeport Indonesia Using Six Sigma Method

A. Parhusip, R. Mulyanto and F. Hartono; Underground Construction, PT Freeport Indonesia, Tembagapura, Papua, Indonesia

PT Freeport Indonesia is preparing the Deep Mill Level Zone (DMLZ) mine to be the successor of the currently operating Deep Ore Zone (DOZ) mine. The DMLZ is block cave mine situated 500 m below the DOZ mine and approximately 1600 m depth from surface. These block caving mines require draw point construction in the extraction level to extract the ore from caved area above. Learning from the experience in DOZ, the construction of draw points in the production panels is a significant challenge in supporting consistent production. The average DOZ draw point construction duration is approximately 46 shifts per draw point. The time frame for construction is dependent on several variables; availability of the conventional forming system, material availability, and development tolerances. The repair of concrete floors and lintel sets causes production downtime. Reviewing the old DOZ draw point design, there is an opportunity to increase constructability, durability, and reliability of DMLZ draw points. This paper discusses how the DMLZ has improved draw point construction productivity and is on track to significantly reduce costs whilst increasing the quality by using the Six Sigma Method

9:45 am

Increasing Productivity and Equipment Utilization in Underground Operations

N. Ferreira; Marketing, Modular Mining Systems, Tucson, AZ

One of the most prevalent challenges in underground mining is a lack of operational visibility. By implementing a fleet management system (FMS) designed for the underground environment, mines can know where their mobile equipment is, what it is doing, and how it is performing, at all times. An effective FMS addresses all major aspects of the development and production processes and provides a solution that manages the numerous ongoing sequential, concurrent, and parallel efforts, present in underground mining. With the right FMS, mines can realize increased equipment utilization and productivity, maximized material movement, reduced waste and operational costs, and enhanced operator safety. This presentation will demonstrate how an underground operation in Mexico, utilized an FMS to automate their development and production workflows and gain valuable insight into activities occurring below the surface. The presentation will also discuss how FMS utilization enabled the mine to transition from manual task assignments, personnel management, equipment tracking and record keeping methods; to more accurate and reliable automated tracking and data collection practices.

10:05 am

Room and Pillar Training: Achieving a 12% improvement in production using advanced Continuous Miner Simulation

A. Norris; Immersive Technologies, Sandy, UT

Steep declines in the price of coal have created an emphasis for existing operators to boost their productivity. A recent simulator based training initiative by an underground coal mine in the eastern region of the United States aimed at Continuous Miner Operators led to nearly one million dollars in production improvements in just 90 days. The training program targeted 16 Continuous Miner operators from eight different room and pillar mines. An experienced operator/trainer first observed the operators in the field and then operated the Continuous Miner to observe the unique conditions present at each of the mines. The trainer then developed a tailored curriculum within simulation, replicating coal tensile strength, rock bands, top height and other significant operational characteristics. Real world performance was measured as Feet Per Shift (FPS) with an average improvement of 12% on Continuous Miner Operator productivity.

10:25 am

Investigation of Current Underground Mine Industry Practice For Safe Design of Mobile Equipment Entries, Adits, Drifts and Haulageways

S. Rosenthal; Mining Engineering, Montana Tech, Butte, MT

Underground haulageways should be designed to provide safe, efficient and economically feasible layouts yet there are currently no industry standards for how this is to be designed by a mining engineer. To increase the knowledge for underground mine haulage safe design practice, benchmarking current underground mine industry practice, combined with input from underground mine equipment manufacturers, has been undertaken. Outcomes of this study would aid practicing mine engineers in designing safe underground openings and improve materials available for universities teaching underground mine design. The benchmarking used an innovative application to underground mining practice using a proven surface mining benchmarking technique. This paper will present the survey methodology and results of the underground industry benchmarking undertaken.

10:45 am

Electrical System Implementation: Get 'er done (the right way)

N. Schroeder and P. Vrcelj; Mining, Stantec, Tempe, AZ

Proper specification and installation of electrical equipment are essential to a safe and functional electrical system. Production, shutdown, and construction schedules can unwittingly turn what would otherwise be a safe system into one that is beset with problems. These problems can be as small as nuisance trips and alarms, or at the extreme, they can result in injuries to personnel and property damage. Equipment specification must consider all of the conditions under which the equipment is to operate. But a proper specification alone doesn't guarantee success. This paper will examine the importance of proper equipment specification, procurement, installation, and quality control. This paper will also address considerations for older electrical equipment where replacement parts may not be available.

Wednesday, February 24 – Morning

ROOM: 127C

9:00 am

Mining & Exploration: Operations: Innovative Information Mining & Equipment Reliability II

Chair: L. Walker, Freeport-McMoRan Inc, Morenci, AZ

9:00 am

Introduction

9:05 am

Applying Predictive Asset Analytics to Prevent Equipment Failure

F. Mielli and S. Gregerson; Schneider Electric, Alpharetta, FL

With the amount of data-transmitting sensors and smart devices growing exponentially, the Industrial Internet of Things (IIoT) is enabling opportunities for mining companies to improve productivity and efficiencies. Organizations can leverage predictive analytics solutions to provide early warning detection of equipment issues – days, weeks or months ahead of standard alarm set points. This allows companies to move from reactive maintenance to predictive maintenance, a more efficient, proactive and cost-conscious strategy for critical assets. Predictive analytics solutions help operators and engineers increase equipment availability, optimize throughput and recovery, and reduce unplanned downtime. Case studies from industrial organizations across industries will be examined

9:25 am

Expediting the Identification of Reasons for Downs across the Mine through interconnected software platforms

A. Bonillas and S. Dessureault; IT, MISOM Technologies, Tucson, AZ

There is an underlying new technology for the monitoring and measure of key process components at mines, in this case we made use of OPC to automatically extract plant data in near-real time into a central data warehouse and use an interface built on Web 2.0 technology to allow users to supplement plant data. OPC is a compound acronym for Object Linking and Embedding (OLE) for Process Control. The plant data with additional operator input, was fed into a larger data warehouse that had additional data, such as safety and production data from the mine. All of this near-real-time data was available through simple to use Excel spreadsheets, where reports and analyses could be automatically updated by sim-

ply refreshing the workbook. Mining operations have key process data which needs much more detailed monitoring (mine and plant). Most have completely different data structures, processes, equipment, people, and procedures. Since these processes are different, the information being recorded is stored often at different times in different data bases. This may impose a difficulty when trying to generate reports and statistics that serve as a feedback mechanism to managers and operators.

9:45 am

Data Mining for Mining Data – A Case Study similar to others

A. Agasty and E. Clausen; Institute of Mining, University of Technology Clausthal, Clausthal-Zellerfeld, Germany

The mining of minerals is highly competitive and the product prices are generally set at international level, whereas the costs vary subject to number of factors. The complexity of the extraction process at great depths and need for suitable and effective working conditions have led to advances in automation. In the mining industry around the world different levels of automation have been tested and implemented, starting from remote control, tele operation, semi & full automation. The basic demand for any of this to function is a sound data collection and interpretation system, the level of which depends on the stage of automation. A semi and full automation system, for example, would require data collection from different mining processes/equipment, such as support system, extraction and material transport machinery, ventilation and climatization devices etc., and interpretation & action plan on the basis of data analysis. This paper presents a model for such a system on the basis of an example for a specific operation. An algorithm for processing and pattern identification from the raw data collected from the continuous monitoring systems is presented.

10:05 am

Predictive Analytics for Mobile Equipment, Remote Monitoring and Diagnostics Increase Asset Utilization

M. Mills, C. Toro and B. Nieman; Intelligent Platform-Mine Performance, General Electric, Lisle, IL

ABSTRACT In mining operations, it is well known that cost of removing overburden waste material and moving ore from mine to process has high influence on business profitability. Strategies to drive operational improvement must revolve around asset reliability, and utilization as well as operations planning and control. Mobile equipment health and performance data are available from periodic and real-time systems. Periodic methods for measuring and analyzing particular equipment elements include handheld vibration-spectra analyzers, oil analysis and thermography. Such solutions can provide a great deal of information about important equipment elements susceptible to functional failure, but they are time-consuming and intermittent by nature. In this paper, a real-time, model-based solution for increasing reliability by reducing unexpected failures is discussed in the context of mobile equipment in open pit mines. Real time systems are capable of creating actionable intelligence from large quantities of currently available data from diverse sources for many key mobile assets. **KEYWORDS** Predictive analytics, mobile equipment, preventing failures, real-time.

10:25 am

Virtual Prototype Modeling and Simulation of an Electric Shovel for Efficient Excavation

M. Wardeh and S. Frimpong; Mining and Nuclear Engineering, Missouri University of Science and Technology, Rolla, MO

Electric shovels provide efficient excavation and loading of dump trucks in surface mining operations. These shovels are characterized by their complex design and operating conditions variability. Effective and safe operations require rigorous simulation of shovel kinematics and dynamics. In this paper, a 3D

multi-body kinematic model of the P&H 4800-XPC cable shovel was simulated in MSC.ADAmS. The shovel is modelled as a robot with 6 degrees of freedom for the spatial motion of 6-bar links using appropriate joints. Model validation is achieved in ADAmS by applying precise angular and translational displacements with proper time functions. The model was refined by optimizing the numerical analysis and simulation of the swinging, digging, and dumping processes in a complete cycle. Motion combinations were analyzed using superimposed displays to evaluate model robustness. The model was simulated in ADAmS using data for a complete cycle. The results of the angular displacements, velocities, accelerations and traced trajectories of the model are in agreement with real world-data. This work provides a solid platform for stress and fatigue modeling for life cycle component evaluation.

Wednesday, February 24 – Morning

ROOM: 125A

9:00 am

Mining & Exploration: Technology:

Mining Innovations & Big Data

Sponsored by ThyssenKrupp Industrial Solutions (USA), Inc.

Chair: M. Armstrong, Caterpillar

9:00 am

Introductions

9:05 am

Effective Finite Element Modeling of Ultra-large Mining Truck Tires

W. Nyaaba and S. Frimpong; Mining Engineering, Missouri University of Science and Tech, Rolla, MO, Rolla, MO

The advent of high performance computers has necessitated the use of virtual models to simulate and predict responses of mining systems in real time. Significant advances in the use of virtual tire models for predicting tire response to external loads have been presented by several researchers in the past few decades. However, most of these previous attempts have not accurately represented tire reinforcement and tread pattern in their models making results of their models questionable. It is worth noting that accurate prediction of tire response can only be made possible when all the structural components (belts, plies, beads, cap-ply) and tread pattern are included in the model. This paper presents an enhanced approach to modeling a 3D finite element model of the 27.00R49 treaded tire in ABAQUS environment. The resulting model allows a full scale visualization and assessment of tire response to mechanical loads in order to accurately predict possible failure regions in the tire. This fundamental research effort is key to developing a more accurate virtual prototype model which serve as a basis for tire durability studies in order to extend its service life.

9:25 am

Precision surface mining, the next steps

G. Hutchins and S. Oppelaar; Engineering, Vermeer Corporation, Pella, IA

Precision surface mining is gaining traction in the phosphate, iron ore, copper, iodine, limestone, bauxite, coal and gypsum markets. Precision surface mining allows following an ore body in three dimensions to increase ore quality over that possible from drill and blast techniques by keeping the ore separate from the waste. In addition to eliminating the need for a primary crusher, precision surface mining allows for production of a uniform material with a tight particle size distribution. In this study, we present case studies in Chile (iodine) and South Africa (coal) to illustrate these results. The second section of the paper is focused on a

new dust containment capability not involved with using water. The remainder of the paper describes step-by-step developments of the Vermeer “road to autonomy.” These steps include a remote control capability to allow mining next to walls, an operating system (SmartTEC) which teaches the operator how to more efficiently run the machine – along with presenting operational data for management purposes. In addition this section includes a description of automatic steering using GPS techniques – both in a straight line and turning.

9:45 am

We have big data, but who is asking the big questions?

B. Reynolds; TSG Consulting, Perth, WA, Australia

The current marketing buzz for data-driven industry transformation pitches software as a panacea. It suggests that your organisation can be transformed by investing appropriately in the right algorithmic widgets and tools. The reality however, is that this is half the story. The efficacy of a sophisticated data-driven approach to decision making relies on people with the right skills and traits working effectively within the organisation. This paper examines the characteristics of effective data-driven organisations, some of the particular challenges to achieving this in mining and looks at some options for organisational structures to achieve this.

10:05 am

Data Analytics in the Mine: Getting Past the Hype

L. Van Latum; Technology & Innovation, Modular Mining Systems, Tucson, AZ

The modern organization collects vast amounts of data. In the relentless pursuit of continuous improvement, data analytics software and techniques have become key components of the modern engineering toolset. With all the statistical modeling and analysis techniques available, ranging from basic to highly sophisticated, any large-scale dataset will yield very interesting, but not necessarily useful, results. Statistics do not lie, but when used inappropriately, statistics can certainly mislead. If you are looking for meaning in a massive dataset, your data scientists will certainly deliver something. However, the value of the discovery depends on how much domain expertise and rigour is applied to the analysis. This presentation will discuss the practical use of large-scale data analysis of the massive volume of data today's mining operations generate. Examples will be provided to demonstrate how data analytics can improve operator safety or predict equipment failures.

10:25 am

Big Data challenges in Mining Industry

S. Kalarickal; Mining, Siemens, Alpharetta, GA

In modern industry, to survive and to stay ahead of the competitive market, data is an indispensable resource. Data can be used to drive performance, profitability and simplify maintenance. The data collected across multiple systems address different demands. As data collection sensors and techniques becomes inexpensive and wide spread, the volume of monitored data grows explosively. The complexity comes with dealing with this ‘big’ data that is coming from diverse environment at different sample rate – how to integrate the data coming from different computing environment, how and when to store or move data from these data elements to data centers and/or to cloud and back, how to get real time information or feedback that is needed to optimize the resources and ensure higher productivity, how does this data and the data management system aid with failure analysis, how to ensure the security among data, etc. In this paper, though all the aspects are not addressed, it attempts to give some insights on some technologies available to deal with these challenges.

10:45 am

Smart Drives for Conveyor Applications

C. Dirscherl; Minerals, Siemens Industry Inc., Littleton, CO

Each and every day mines around the world are pressured to produce more with less. How can they, with the noticeable decline in ore grades and incline of energy

and labor costs? In order to select the ideal drive system for a belt conveyor, many requirements must be economically weighed; such as the type of material being transported, surrounding landscape, behavior of the drive, and network characteristics. Drive systems for belt conveyor applications can be divided into two groups: fixed speed or speed controlled. Fixed speed drives systems include methods such as starting resistors or fluid couplings. While these methods have served their worth, smart drives are able to offset many of the downfalls found with traditional applications. Smart drives (realized with VFD's) are speed controlled drives which are able to control speed and torque from zero to the rated motor speed, under all load conditions. The latest technology in variable frequency drives and motors allow highly reliable and efficient drive applications for all kind of conveyors while also reducing labor costs and spare part requirements. For larger power requirements, gearless conveyor drives can also be installed.

Wednesday, February 24 – Morning

ROOM: 228A

9:00 am

MPD: Chemical Separation: Leaching II: POX

Chairs: R. Frischmuth, Hatch, Mississauga, ON, Canada
T. Kahl, Barrick

9:00 am

Introduction

9:05 am

Pressure Leaching – coming of age or has it been here for a long time?

J. Uhrig; Runge Pincock Minarco, Greenwood Village, CO

The use of pressure oxidation technology is becoming more prevalent as ores are becoming increasingly complex, but it's interesting to note that this technology has been used successfully for 75 years, in a number of different applications, and on every continent. This robust process has been adapted to operate in acid, neutral and alkaline pH as well as under strongly oxidizing, neutral or reducing conditions.

9:25 am

A Review of the Pueblo Viejo Project Autoclave Design

W. McCombe; Autoclave Technology/Non-Ferrous, Hatch Ltd., Georgetown, ON, Canada

The Pueblo Viejo gold mine is located in the the Dominican Republic and is operated by Pueblo Viejo Dominicana Corporation, a company owned by Barrick (60%) and Goldcorp (40%). The poly-metallic ore contains gold, silver, copper and zinc associated with pyrite, sphalerite and enargite and preg-robbing carbonaceous matter in certain ore types. The Pueblo Viejo process plant utilizes whole ore pressure oxidation to liberate gold and silver and leach copper from refractory gold ore (zinc is currently not recovered). The circuit is required to completely oxidize the sulphides and partially oxidize the carbonaceous matter to maximize metal recovery. To achieve the required oxidation extent and autoclave throughput, the autoclaves are designed to operate at high temperature (230°C) and pressure (3350 kPa.g) with high oxidation per unit volume in the first compartment. This paper describes the design process for the Pueblo Viejo autoclaves and outlines the key design aspects which may be applicable to other poly-metallic gold ores.

9:45 am

Copper Concentrate Leach Plant Restart at Freeport-McMoRan Morenci

C. Green, B. Mota and J. Alexander; SME, Safford, AZ

Freeport-McMoRan's Morenci Concentrate Leach Plant (MCLP) was originally commissioned and functional by October of 2007. The plant operated for a total of 17 months and was placed on care and maintenance due to the world economic downturn. While several restart scenarios were conducted since the plant shutdown in 2009, capital could not be justified until concentrate shipping costs, foreign smelting and refining costs and the demand for sulfuric acid (FMI U.S. sites) increased. Comparatively speaking processing copper concentrate in a domestic smelter which has excess capacity is always the most positive economic outcome compared to the processing through the Morenci CLP. However the company had achieved significant sales overseas and the plant restart had become a viable option. The project was approved late October of 2014 and the first vessel was re-commissioned and started up by May 14, 2015. Full production has been achieved during the 3rd quarter of 2015. The plant is expected to process 150,000 tons of copper concentrate and produce 141,000 tons of sulfuric acid per year.

10:05 am

Continuous Improvements Over the Life of the Twin Creeks Autoclaves

G. Thies; Metallurgy, Newmont, Winnemucca, NV

Newmont has been operating two whole ore Autoclaves at the Twin Creeks mine since 1997 and has achieved a steady increase in annual throughput through continuous improvement efforts. Since startup throughput has increased by over 13% and raised availability by 6% utilizing incremental improvements to various components within the Autoclave process. Some of the systems that have been improved are: Slurry Feed density, pumping capacity, agitator design, and Autoclave discharge pressure let down system. Original designed throughput was 204 tons per hour per Autoclave and has now reached a sustainable 235 tons per hour. Original Availability was listed to be 85% and now 91% is achievable with current asset management.

ROOM: 16-104

10:25 am

Autoclave Overpressure Control in Pressure Oxidation Operations: Reducing Titanium Ignition Risk in Autoclave Vent Systems

R. Frischmuth, L. Zunti and T. Krumins; Hatch, Mississauga, ON, Canada

Titanium and titanium alloys are commonly selected for pressure oxidation autoclave vent piping and pressure control valve components, as well as autoclave internals and other process piping. In the autoclave vent application, titanium ignition risk is controlled by limiting oxygen concentration, and preventing high gas velocity gas impingement on surfaces. Oxygen concentration is dependent on the autoclave pressure and temperature operating conditions and therefore oxygen concentration and the associated titanium ignition risk is dependent on standard operating procedures, process control interlocks and permissive conditions. It is not uncommon for these standard controls to be deficient during atypical operating conditions, or for operations to deviate from the operating procedures, increasing the potential for titanium ignition incident. Titanium ignition risk caused by elevated oxygen concentration in autoclave vent systems can be reduced with the introduction of an online autoclave overpressure calculation and the configuration of associated interlocks and permissive conditions.

10:45 am

DEMET Technology Application to POx – New Potential For Savings and Revenue

P. James; Blue Planet Strategies, Madison, WI

Application of new electrolytic DEMET technology to POx leaching is examined. An example operation process flow for gold mining is considered. Processing points for potentially replacing conventional processes with DEMET are discussed. The possibilities for lowering OPEX costs, lessening sludge creation, and capturing various valuable byproducts and residuals are examined. Financial life cycle benefit estimates of the principal gains provided by DEMET application to the example operation are noted. Extension and generalization of the analyses to a wider range of scenarios is explored.

11:05 am

Ambient Alkaline Oxidation At Hycroft Mine: Results Of Bench And Pilot Plant Tests

W. Pennstrom², A. Ibrado¹, B. Bermudez¹, R. Chaudoin⁴, D. Gertenbach³, J. Burton³ and R. Griffith³; ¹M3 Engineering & Technology, Tucson, AZ; ²Pennstrom Consulting, Highlands Ranch, CO; ³Hazen Research Corporation, Golden, CO and ⁴Allied Nevada Gold Corp., Reno, NV

About 70 to 90% of the gold associated with Hycroft sulfide ore is refractory. The general processing scheme to recover this gold is to oxidize a sulfide concentrate prior to cyanidation. Several oxidation tests were conducted, including acid pressure oxidation and ambient alkaline oxidation (AAO), using a number of reagents to neutralize the acid produced. AAO was further explored using trona (sodium sesquicarbonate) as the neutralizer because of its cost and abundant supply. More importantly, it does not produce calcium sulfate, which forms a passivating layer on the sulfide mineral surface. Several bench-scale and continuous pilot plant-scale AAO tests were conducted on three ore types and a master composite. A continuous 10-tpd demonstration plant will also be operated. The completed tests indicate that target oxidations can be achieved in less than 24 hours, resulting in the release of refractory gold for cyanidation. The reaction kinetics were enhanced by higher temperatures up to 75 °C and higher dissolved oxygen levels achieved at 16 to 30 psi. Such pressures are present where air or oxygen are injected at the bottom of a tall process tank (30 to 60 feet).

Wednesday, February 24 – Morning

ROOM: 232B

9:00 am

MPD: Flotation Equipment: Flotation III

Chairs: S. Miskovic, Salt Lake City, UT

T. Bhambhani, Cytec Industries Inc., Stamford, CT

9:00 am

Introductions

Optimization of Air-Injection Spargers for Column Flotation Applications

V. Ramirez Coterio¹, G. Luttrell¹, T. Valle² and M. Mankosa²; ¹Mining & Minerals Engineering, Virginia Tech, Blacksburg, VA and ²Eriez Flotation Division, Erie, PA

The performance of flotation columns primarily depend on the effectiveness of the gas sparging system. Unfortunately, field studies suggest that the gas injector systems used for column sparging are often not optimized. This unfavorable condition can create a number of issues within the concentrator including lower recoveries, poorer metallurgical upgrading, decreased throughput capacities, increased circulating loads, higher reagent consumption and inefficient energy usage. To help overcome these problems, techniques have been developed that can be adopted by plant operators to improve gas dispersion performance. These techniques include (i) design modifications to sparger components such as nozzles, distributors and internal parts and (ii) operational improvements such as proper balancing of gas and water flows, elimination of unnecessary pressure drops, and staged injection of frothing agents. This article reviews the important criteria that govern sparger operation and provides case studies showing how these simple low-cost improvements can positively impact column performance.

High Intensity Ultrafine Sulfide Flotation Using Eriez StackCell Technology

L. Christodoulou², E. Yan², A. Hobert², J. Kohmuench², M. Mankosa² and G. Luttrell¹; ¹Mining & Minerals Engineering, Virginia Tech, Blacksburg, VA and ²Eriez Flotation Division, Erie, PA

During the past decade, column flotation cells have become widely accepted for upgrading ultrafine sulfide ores. However, the use of columns has been widely relegated to cleaner circuits due to their comparatively high selectivity derived from the use of wash water dispersed over a deep froth. High tonnage rates and low feed grades make using column technology in roughing and scavenger stages challenging due to the resulting size of the needed equipment. To specifically address this challenge, a new high-intensity flotation system known as the StackCell™ was developed. This technology makes use of a novel pre-aeration method coupled with froth washing to simultaneously provide improved flotation kinetics and selectivity. The novel aeration system provides efficient bubble-particle contacting; thereby substantially shortening the residence time required for particle collection and substantially reducing the column height. This article reviews the technical design features and presents recent data from in-plant pilot testing in copper-sulfide applications.

Determination of the Maximum Recoverable Particle Size in Fluidized-Bed Flotation

G. Luttrell¹, J. Hilsen¹, M. Mankosa² and J. Kohmuench²; ¹Mining & Minerals Engineering, Virginia Tech, Blacksburg, VA and ²Eriez Flotation Division, Erie, PA

The inefficient recovery of coarse particles by conventional flotation has been a longstanding problem in the minerals industry. Fundamental studies suggest that this limitation can be attributed to froth phase and pulp turbulence effects that are inherent to the design of existing mechanical flotation machines. To overcome these constraints, a new advanced flotation technology called the HydroFloat Separator has recently been developed and commercially deployed. This unique fluidized-bed flotation system is capable of dramatically increasing the upper particle size limit that can be successfully treated by froth flotation. In the current study, a series of laboratory tests were conducted to establish the upper size of particles that can be effectively concentrated using this new technology. The experimental data show that the maximum grain size that can be recovered using this technology is more than four times larger than that attainable using conven-

tional flotation. The data also show that the recoverable grain size, which is a strong function of both particle size and density, is predictable based bubble-particle buoyancy limits established from a theoretical analysis.

10:05 am

Data mining for exploration and process control of ores using Partial Least Square Regression (PLSR) in combination with X-ray diffraction (XRD)

U. König; Product Marketing, PANalytical B.V., Muenster, NRW, Germany

Decreasing ore qualities and increasing prices for raw materials require a better control of processed ore and a more efficient use of energy. Traditionally quality control in mining industries has relied on time consuming wet chemistry or the analysis of the elemental composition. The mineralogy that defines the physical properties is often monitored infrequently, if at all. The use of high speed detectors has turned X-ray diffraction (XRD) into an important tool for fast and accurate process control. XRD data and their interpretation do make the difference in the identification of minerals, in describing their distribution in ore bodies and in their beneficiation during processing. The use of modern techniques such Partial Least Square Regression (PLSR), Principal Component Analysis (PCA) or full pattern Rietveld quantification will be discussed during the presentation as well as the importance of adequate sampling and the correlation with sample chemistry. The practical use will be illustrated on case studies.

10:25 am

Industrial Application of the 660 m³ SuperCell™ D. Lelinski(*), Y. Yang, K. Caldwell, K. Rahal, S. Reddick, T. Olson and M. Jespersen FLSmidth Salt Lake City, USA

D. Lelinski, Y. Yang, K. Caldwell, K. Rahal, T. Olson and M. Jespersen; FLSmidth, Midvale, UT

Flotation cells are getting bigger and more efficient. Until recently, the FLSmidth 300 Series SuperCell™, developed in 2009, was the largest in the world with a capacity of 300-350m³. In 2011 FLSmidth started the development process of the new generation of flotation cells and the final result is the 600 Series SuperCells™ with volume from 600 to 660m³. Other than new, large throughput plants, these cells are especially attractive in a situation when there is limited room for expansion in existing large capacity plants. The 600 Series SuperCells™ uses the whole range of newly developed FLSmidth mechanisms: self-aspirated WEMCO® and the Dorr-Oliver® forced air mechanisms designed to float wide range of particle sizes. Hydrodynamic and metallurgical response of the Dorr-Oliver® forced air cell will be presented with the emphasis on the recently introduced nextSTEP™ rotor/stator combination.

10:45 am

nextSTEP™ flotation mechanism development, scale up and testing K. Caldwell, Y. Yang, K. Rahal, T. Olson, M. Jespersen and D. Lelinski(*) FLSmidth Salt Lake City, USA.

K. Caldwell, Y. Yang, K. Rahal, T. Olson, M. Jespersen and D. Lelinski; FLSmidth, Midvale, UT

FLSmidth introduces the patent pending nextSTEP™ flotation mechanism; the newest design for forced air flotation technology with the lowest power consumption on the market. The exceptional performance of the nextSTEP mechanism comes from the rotor and stator being perfectly matched which delivers the best energy dissipation, thus maximizing the probability of attachment and flotation. Wide flow jets produced by the nextSTEP rotor and increased eddy formation behind the patented slotted nextSTEP stator increase the probability of bubble

- particle attachment. In addition to the increased performance derived by the FLSmidth nextSTEP mechanism, it provides better wear distribution for increased rotor and stator life. This will have a positive impact on the long term operating costs and will benefit both new and existing installations. Results of laboratory, pilot and industrial scale testing will be presented including both hydrodynamic and metallurgical evaluation.

11:05 am

A Real-Time Dynamic Simulation of Selective Molybdenum Flotation, Thickening and Filtering Processes

A. TRIPATHI¹, M. Jara², C. Carvajal² and F. Gomez Araya²; ¹Automation Solutions, ANDRITZ Chile Ltda., Santiago, Chile and ²CMDIC, Iquique, Chile

Separating and enriching Molybdenum from the Copper (Cu) – Molybdenum (Mo) sulfide ore deposits in a conventional way involves a bulk flotation process where molybdenum sulfide is recovered together with copper sulfides followed by a selective flotation process to separate molybdenum sulfide from the depressed copper sulfides. A real-time dynamic simulation is used to model the selective Mo Flotation, Thickening and Drying processes for the Puerto Collahuasi of CMDIC, Chile. Subsequently, the simulator is connected to an emulated control system of the real plant to train the operators of the Puerto Patache plant on operating scenarios such as Start-Up, Shut-Down and several external perturbations to the processes. This paper discusses the effects of dynamically changing process variables such as feed grade of Mo and Cu, solids percentage in the feed, pH and Oxidation-Reduction Potential (ORP), flocculant dosages, and pressure to the filters on product quality. Lastly, the paper briefly presents the Operator Training System that turns out to be the most effective tool for learning the operation of a plant, enhancing troubleshooting skills and standardizing the operating procedures.

Wednesday, February 24 – Morning

ROOM: 228B

9:00 am

MPD: Innovations and Development I

Chair: E. Spiller, Colorado School of Mines, Golden, CO

9:00 am

Introductions

9:05 am

A Different Source for Rare Earth Elements – Deep Sea Sediments

D. Maxwell; Process, Deep Reach Technology, Arvada, CO

Rare Earth elements (REE) have unique physical and chemical properties that have proven useful in numerous commercial and military applications. Heavy rare earth elements (HREEs) in particular have recently found increased uses in high technology applications. Currently the supply of HREEs is a collection of relatively small deposits in China. A significant amount of venture capital has been expended in recent years to locate alternative sources and develop processes to extract REEs in general and HREEs in particular from those sources. Deep Reach Technology has been examining the possibility of extracting REEs from deep sea sediment resources. These resources have particularly high concentrations of HREEs relative to other resources. Practical tools and system have been developed for exploration to find candidate deposits. Team members who are very experienced in deep ocean operations are evaluating collection methods for mining the sediment and transporting it to the ocean surface. Experienced engineers are developing practical processes for extracting the REEs and producing benign residues.

9:25 am

Selective Reduction and Separation of Europium from Mixed Rare-earth Oxides from Waste Fluorescent Lamp Phosphors

M. Strauss; Metallurgical and Materials Engineering, Colorado School of Mines, Golden, CO

Europium is a critical material required for LED, florescent lamps, and flat panel display production. The recycling of europium from waste lamp phosphors is an innovative method to supply europium for high technology applications. Phosphor powder from recycled lamps is retorted, sieved, and leached to produce a europium/yttrium leach solution. The separation of europium/yttrium rare earth oxides from the pregnant leach solution is conducted by selectively reducing Eu^{+3} to Eu^{+2} via zinc powder and precipitating EuSO_4 from solution using sulfuric acid as the precipitating agent. The optimal conditions for the reaction were optimized by varying the europium input concentration, pH, reaction time, and feed flow rate. After two stages of selective reduction and precipitation, the purity and recovery of europium oxide were greater than 95% and 90%, respectively.

9:45 am

Synthesis & Characterization of Zinc Borates from Secondary Zinc Sources

S. Gostu; Metallurgical and Materials Engineering, Graduate Student, Golden, CO

This paper explores the possibility of synthesizing zinc borates ($3\text{ZnO} \cdot 3\text{B}_2\text{O}_3 \cdot 3.5\text{H}_2\text{O}$) from a typical waste material having high zinc content such as zinc ash. Zinc ash collected from an Indian secondary zinc processing plant found to contain 71% Zn, 0.6% Fe, 28% Cl, 0.2% Pb, 0.3% Si and other trace elements such as Cu, Cd, As etc. in ppm level. This material was leached in sulfuric acid to dissolve most of the metallic elements followed by separation of impurities by pH controlled precipitation route. The purified leach solutions were taken for precipitation of zinc borates under various conditions. It was observed that, the phase composition, morphology, particle sizes etc. of precipitated zinc borates are sensitive to B/Zn molar ration, solution pH, temperature and ageing time. Precipitation of particular zinc borate phase of interest ($3\text{ZnO} \cdot 3\text{B}_2\text{O}_3 \cdot 3.5\text{H}_2\text{O}$) was found to be facilitated at higher precipitation temperature (95°C), low solution pH (5.5 – 6.0) & B/Zn molar ratio >4.0 .

10:05 am

16-142

Study on the Recovery of Rare Earth Metals using Stimuli-Responsive Macromolecules

M. Khodakarami and L. Alagha; Mining and Nuclear Engineering Department, University of Missouri, S&T, Rolla, MO

This work focuses on the extraction of rare earth metals (REE) from aqueous solutions using stimuli responsive polymers. Various parameters affecting the adsorption capacity of the polymer, including pH, temperature, REE concentration, and contact time were studied. The interfacial behavior of REE in aqueous phase before and after polymer addition was systematically examined using electrokinetic measurements. The mechanism of the formation of metal-polymer complexes and their properties were investigated using different analytical techniques including FR-IR, UV/VIS, XRD, etc. The extraction equilibrium and the adsorption isotherms of REE were established using ICP-MS. Results obtained would help to test the feasibility of employing stimuli responsive polymers in pre-concentration of rare earth elements associated with other elements in mineral aqueous streams prior to solvent extraction. The pre-concentration step would reduce the amount of organic solvents used for extraction and stripping compared to conventional extraction processes. **Keywords:** Rare earth elements; adsorption; ICP-MS, Stimuli-responsive polymers; Zeta potential.

10:25 am

Sustainable Iron Production by Electrowinning

T. Eisele; Chemical Engineering, Michigan Technological University, Houghton, MI

The use of an electrowinning method for metallic iron production would make it possible to greatly reduce the dependence of the ironmaking industry on fossil fuels. From a sustainability point of view, this reduces fuel use by greatly reducing the need for process heating, or for the direct use of fossil fuels as chemical reductants. While electrowinning of iron is more difficult than for more noble metals like copper, it is possible, and electrolytic refining of metallic iron is a well-developed technology for converting metallic iron into high-purity iron for specialty applications. This paper considers the issues in iron electrowinning, particularly the preparation of solutions, elements of electrowinning cell design, and necessary conditions to produce a high-quality metal deposit.

10:45 am

16-094

Heap Leach Recovery Efficiency based on Crushed Ore Particle Size and Compaction Degree

S. Lee and F. Campero; Engineering, Braun Intertec, Cedar Rapids, IA

Most of heap leach designs do not take into account ore grain size distribution of which is closely related to unsaturated and preferential flow behaviors within heap leach material. A probabilistic model enabling to reasonably simulate preferential flow behaviors within crushed ore materials was invented based on the ore grain size distribution after agglomeration and relative density required during heap stacking. Unsaturated and transient flow behavior within heap leach material is dependent on the model parameters such as particle size distribution, porosity, initial saturation degree and unsaturated hydraulic conductivity which are susceptible to time dependent variation until the transient flows are converged to steady state. Proposed one-dimensional model does not require additional laboratory test to decide model input parameters such as soil water characterization curve (SWCC), needed for unsaturated flow simulation. If grain size distribution of crushed ore and relative compaction degree are available as a table format, program can automatically estimate the SWCC parameters based on Brooks-Corey model as known best fitting to non-cohesive materials.

Wednesday, February 24 – Morning

ROOM: 232A

9:00 am

MPD: Student Poster Session

Chairs: E. Sarver, Virginia Tech, Blacksburg, VA

L. Schlink, Freeport-McMoRan Copper & Gold, Oro Valley, AZ

9:00 am

Introductions

9:05 am

Development Study of Industrial Road Map for Copper Industries in Indonesia: Maximizing the Potential of Indonesia to Become World Primary Copper Producer

M. Arinanda; Georesources Engineering, University of Liege, Balikpapan, Kalimantan Timur, Indonesia

Indonesia is one of the countries with biggest mineral resources and reserves in the world, especially copper. To support the development of focused and sustainable copper processing and refining industries in Indonesia, it needs to

create a road map as a strategic planning. To avoid difficulties, simulation called Supply Chain Value Simulation is introduced. This simulation approach combines several concepts, such as supply chain management, material balance, economic and finance of industry, industrial tree, and supply chain value push-pull strategy. Simulations were conducted based on push-pull strategy to obtain the best conditions with success criteria, namely: Return on Investment (ROI), state revenue, and employment which is limited by the availability of energy and absorption of sulfuric acid. Of 8 simulations, 2 simulations were chosen with total of 6 new smelters in 2025. Simulation #2 take an investment of USD 19.06 billion with 21% ROI and generate state revenue potential of USD 2.65 billion/year, while Simulation #6 take an investment of USD 21.37 billion with 20% ROI and generate state revenue potential of USD 2.48 billion/year.

9:25 am

Development Study of Industrial Road Map for Alumina Industries in Indonesia: Maximizing the Bauxite Potential of Indonesia to Fulfill Domestic Needs of Aluminum

M. Arinanda; Georesources Engineering, University of Liege, Balikpapan, Kalimantan Timur, Indonesia

Indonesia is ranked seventh as countries with biggest bauxite resources in the world, and ranked third as biggest bauxite producer country. To support the development of focused and sustainable alumina processing and refining industries in Indonesia, it needs to create a road map as a strategic planning. To avoid these difficulties, simulation called Supply Chain Value Simulation is introduced. This simulation approach combines several concepts, such as supply chain management, material balance, economic and finance of industry, industrial tree, and supply chain value pull strategy. From the simulation, it is known that 6 new smelters need to be built in 2025 with capacity of 800,000 tons per annum per smelter, with details 2 new smelters start producing in 2018, 1 new smelters each year in 2020, 2022, 2024, and 2025. This simulation takes 93,630,996 tons of bauxite ores, 168,536 tons of diesel, 9,512,909 tons of oil, 5,880,027 tons of natural gas, 742,493,799 m³ of water, 14,044,649 m³ of sea water, 177,899 mWh of electricity, 8,333,159 tons of NaOH, and 3,745,240 ton of CaO.

9:45 am

Acid-Bake-Leaching of Samarium-Cobalt Manufacturing Waste

C. Stanton and B. Mishra; Metallurgical Engineering, Colorado School of Mines, Golden, CO

Manufacturing waste accounts for more than 30% of base material in the production of Sm-Co magnets. This material is usually sent to smelting operations for cobalt recovery while samarium is not recovered. The goal of this research is to develop a process for the recovery of rare earth content from magnet manufacturing waste. Acid-bake-leaching is a process that is used in this research to separate rare earth elements from base metals through selective thermal decomposition of metal sulfates at high temperatures. Acidic slurries containing magnet swarf are inserted into a rotary kiln where they are baked at temperatures between 700-800°C. Thermal decomposition is complete in less than 1.5 hours and selective dissolution of rare earth sulfates from metal oxides results in high grade leach solutions. Precipitation with oxalic acid is followed by calcination to produce a high-grade samarium oxide, which can either be sold or recycled for magnet production. In several experiments utilizing acid-bake-leaching, samarium is recovered with over 90% recovery and 99% grade. This process is protected under a provisional patent and is currently being advertised for commercial application.

10:05 am

Self-assembly effect of benzohydroxamic acid and octanol in cassiterite flotation

L. Sun, Y. Hu and W. Sun; School of Minerals Processing and Bio-engineering, Central South University, Changsha, Hunan, China

Tin ore from the southeast of Yunnan in China is a complex polymetallic low-grade ore. Because of the highly disseminated extent ore, cassiterite flotation was applied in industrial production instead of the low efficient gravitational separation. Benzohydroxamic acid (BHA) was widely used as a collector in cassiterite flotation, but the consumption of BHA was large. In this study, the representative cassiterite sample was taken from the southeast of Yunnan, China. The influence of octanol in cassiterite flotation using BHA as the collector was investigated. The results indicated that the addition of octanol improved the flotation capability of BHA to cassiterite and reduce the consumption of BHA significantly. But octanol showed almost no flotation capability to cassiterite alone without BHA. Infrared spectra analysis indicated that the single octanol adsorbed on the surface of cassiterite was unsteady adsorption, and a new entity assembled of BHA and octanol in a well manner was able to adsorb on the surface of cassiterite steadily. The probable self-assembly structure model of BHA and octanol existing on the surface of cassiterite was analyzed.

10:25 am

Fundamentals of Monazite Flotation with Hydroxamic Acid

J. Nduwa Mushidi and C. Anderson; MME, Colorado School of Mines, Lakewood, CO

Technological advancement has led to a rise in the demand of rare earth elements, which is also reflected in increasing research on the concentration and recovery of rare earth minerals. Monazite is the second most important rare earth mineral after bastnaesite. Monazite can be concentrated either gravity separation to take advantage of its relatively high specific gravity, or by froth flotation to ensure recovery of small particles. The fundamental of froth flotation includes the zeta potential on the surface of particles, the adsorption density of reagents on the surface of particles, the contact angle, and micro flotation which combines all three. This presentation outline the fundamentals of monazite flotation with hydroxamic acid as collector. In addition, it includes the fundamental research on monazite gangue minerals including apatite, ilmenite, quartz, rutile, and zircon.

10:45 am

Fundamentals of flotation with quebracho tannin

J. Rutledge and C. Anderson; Metallurgical and Materials Engineering, Colorado School of Mines, Golden, CO

This study provides an up to date review of tannins, specifically quebracho, in the flotation of fluorite and polymetallic sulfides. Quebracho is a highly useful reagent in many flotation applications, acting as both a depressant and a dispersant. Quebracho is most commonly used in industry as a method to separate fluorite from calcite, which is traditionally quite challenging as both minerals share a common ion—calcium. In sulfide systems, quebracho is a key reagent in differential flotation of copper, lead, zinc circuits. Further development of the surface chemistry measurements including zeta potential and adsorption density were explored for both fluoroite and copper ores. Microfloatation was also observed to show the application of the knowledge gained from the surface chemistry results.

Wednesday, February 24 – Morning

ROOM: 122A

9:00 am

Research: Focus on Innovation in the Mining Industry

Chairs: E. Fretheim, Freeport-McMoRan, Oro Valley, AZ
A. Samal, GeoGlobal LLC, Riverton, UT

9:00 am

Introduction

9:05 am

The Future of Product Documentation

*R. Schlei and L. Griffin; Product Training & Publications,
Joy Global, Milwaukee, WI*

If the future of mining is data, then the future of product documentation is easy digital access to the most up-to-date content and media. Recognizing that paper manuals are cumbersome and quickly outdated, Joy Global is piloting a new format for delivering product documentation through ProManual, a mobile application that houses manuals and training materials. ProManual offers the following key features: Multilingual, portable, and up-to-date manuals An annotation feature designed to provide feedback directly to Joy Global Data collection to understand how documentation is being used in the field Expanded, tailored access to information traditionally restricted to select groups Joy Global is learning how a digital application like ProManual can help mining enter the data-driven age. This presentation will share what Joy Global has learned about those documentation needs, offering valuable insights into how the world of technical documentation can keep pace with mining equipment and the people who service it.

9:21 am

How to assess the ‘bio’ in bioprocesses – examples for remediation, heap leaching, process optimization, and acid rock drainage.

V. Pittet and M. Haakensen; Contango Strategies, Saskatoon, SK, Canada

Microbes are the driving force in many processes, acting as catalysts to facilitate biogeochemical reactions that influence mining operations and remediation efforts. Historically, an issue with employing biological processes was the inability to effectively assess the microbial populations present, and interpret their potential functions. To address this issue, genetic microbial profiling is now being applied at mines globally to aid in remediation, water treatment, consultation on acid rock drainage, and process optimization. We will discuss the current state of technology for assessing microbial populations that influence bioprocesses related to mining operations.

9:37 am

Robotic Technologies in the Mining Industry

C. Campbell; Machinery Automation and Robotics, Silverwater, NSW, Australia

The mining industry is transitioning from a capital intensive expansion phase to a productivity driven operational improvement future. To stay competitive, the industry is in need of innovations to boost efficiency, safety, and overall productivity. The objective of this paper is to present developed automated robotic systems that can address major operational issues in the mining industry. Technology solutions for material handling, heavy vehicle, and primary crusher maintenances are discussed. With robotic technologies, maintenance can be performed on

conveyors while they are loaded and operational, thus increasing productivity and operational safety. With growing haul truck fleets, tyre maintenance and fuel costs are proving to be the highest expense factors. Significant gains can be made with robotics by decreasing the time to complete the tasks and increasing utilisation of haul trucks. GET on shovels & other excavating equipment is critical to production and can lead to costly downtime if broken from the shovel without detection. A smart technology solution can provide condition monitoring which will deliver new levels of control over components of heavy mining shovels.

9:53 am

Surface Miner Technology and its impact to the entire process

R. Bauer¹ and H. Volk²; ¹Wirtgen America, Antioch, TN and ²Wirtgen GmbH, Windhagen, Germany

Cutting, crushing and loading cleaner minerals in a single operational step is more efficient than conventional mining methods. This idea triggered the development of a new, economically efficient opencast mining method known as Surface Miner (SM) Technology. 1980 marked the birth of the new and innovative surface mining process – Wirtgen developed a SM prototype, the 3000SM. Wirtgen continued to develop different machines for different applications and performance rates. SM technology takes account on an increasing demand for economical, efficient and environmentally gentle solutions. Almost 500 units have been put into application in various locations, minerals and rock properties. Wirtgen Surface Miner are not just another excavator or loader in the pit: Benefits of the SM mining method are beside the cleaner run-of-mine (ROM) material seen as well in the ROM transport and in the different process steps within the sizing-, classification- and beneficiation process. Latest concepts are connecting the 4200SM to conveyor belt lines either indirect via mobile feeder or directly by feeding belt wagons or belt bridges.

10:09 am

Current and Future Examples of Replacing Steel Wire Rope with High Performance Synthetics in Mining Applications

J. Smoak; Samson Rope, Ferndale, WA

High performance synthetic ropes offer numerous advantages over steel wire rope in mining applications. This paper describes the synthetic rope material properties that make the case for conversion from steel wire. These include better bend fatigue life, higher strength-to-weight ratio and non-rotational construction. The paper then details mining applications where conversion to synthetics has been widely accepted, such as winch lines and longwall shield haulers. Next, the paper introduces the latest applications with synthetic solutions, namely dragline dump rope and shovel trip ropes. Finally, the paper concludes by evaluating future applications, including mine hoist ropes, slushers, and shovel or dragline ropes.

10:25 am

Configuration of energy storage system for optimized operation of mining trucks

J. Mazumdar; Siemens Industry Inc, Alpharetta, GA

The main objective of haul trucks is to achieve the lowest cost per ton of hauled material. In general terms, this can be achieved by improving the overall system efficiency and reducing the maintenance for any given payload. A diesel electric haul truck will have these advantages over a mechanical haul truck due to elimination of the mechanical conversion stages and lower mechanical parts count. The efficiency can be further improved by introducing energy storage devices to reduce fuel consumption. A suitably configured energy storage system could store portion of the regenerative energy and feed the auxiliary systems, making 100% of the engine capacity available for propulsion without consuming additional fuel.

The speed of a truck is directly proportional to the available power; hence if the energy storage could provide 10% additional power, speed of the truck would increase by 10% resulting in reduced cycle time and increased productivity. The paper will discuss potential Li-ion battery chemistries and present a specific design with feasibility analysis for an ultraclass truck. Successful implementation of this technology will reduce environmental liability and enhance safety.

10:41 am

We Need a Dam Sensor Reading

C. Bellusci; GeoEngineers, Inc., Bend, OR

GeoEngineers' Earth Analytics for Tailing Dams is a technology and science platform built to manage critical-asset sensor data, and meet the demanding state and local compliance reporting requirements. This online, hosted solution allows your O&M staff to access and store dam sensor readings from both traditional data loggers and wireless sensors using a user-role-based security model. The application allows staff to define advanced "listening" triggers or alarms to notify users of exceedances or potential thresholds. Your staff can now visualize and analyze data in ways that have traditionally required a high degree of subject-matter expertise and additional time to produce.

ROOM: 16-130

10:57 am

Mining on the Moon and Asteroids: Yes – It's Really Going to Happen!

D. Peacock; Peacock Myers, P.C., Albuquerque, NM

Outer space technology and exploration have reached a tipping point so that mining in outer space is now a certainty and not a dream. Several competing companies, worldwide, are well on the way to building spaceships to land on the Moon and eventually mine the Moon and asteroids for rare earth metals and Helium-3. The Google Lunar X-Prize offers a \$30 million prize for the first private company to successfully land on the Moon's surface, and have a robot that travels at least 500 meters transmit images back to Earth. China has recently landed a spacecraft on the Moon. The European Space Agency, with cooperation from the United States, has landed a spacecraft on a comet. And, Mars One is planning a one-way trip to establish a settlement of humans on Mars. The Author, Deborah Peacock, P.E., is a Metallurgical Engineer and Registered Patent Attorney, who represents several of these future-thinking aerospace/mining companies to achieve their goal of mining the moon and other celestial bodies. How will facilities be built and staffed? What new technologies will be required? What is the business model and what are the costs? What are the laws regarding mining claims in outer space?

Wednesday, February 24 – Afternoon

ROOM: 224B

2:00 pm

Coal & Energy: Coal Preparation

Chairs: T. Ghosh, University of Alaska Fairbanks, Fairbanks, AK
A. Noble, West Virginia University, Morgantown, WV

2:00 pm

Introductions

Characterizing REEs in Alaskan Coal and ash

T. Gupta, T. Ghosh and G. Akdogan; Mining Engineering, University of Alaska Fairbanks, Fairbanks, AK

In recent years, the demand for Rare Earth Elements have grown rapidly due to increasing demand and global supply shortage. The supply deficit of these critical elements has encouraged the search for new sources of REEs, possibly Coal and coal byproducts. Coals from certain parts of the world can be rich in REEs, approaching a total concentration of 1000 ppm. Two Alaskan coal samples were investigated for the effect of size and density on the concentration of REEs on three selected size fractions. Flotation tests were conducted for finer fractions. Additionally Bottom ash and Fly Ash samples from a power plant have been examined for REE concentration. The results show that the upgrade potential for REEs on ash basis from whole coal basis ranges from 2:1 to 4:1 for Wishbone Hill and Healy coal samples respectively. Flotation of the finer fraction for both coal samples, conducted under similar conditions, reveal higher concentration of REE's in the tailings. Both coal samples have a comparatively higher LREE content than HREE. Trends of REE content of the power plant products on ash basis revealed that Fly Ash has a slightly higher concentration of both LREE and HREE than Bottom Ash.

Micro-Pricing: The Value of Trace Rare Earth Elements in Coal and Coal Byproducts

A. Noble¹ and G. Luttrell²; ¹Mining Engineering, West Virginia University, Morgantown, WV and ²Mining & Minerals Engineering, Virginia Tech, Blacksburg, VA

A supply of sustainably sourced rare earth elements (REEs) is critical for several high-tech industries, renewable energy technologies, and defense applications. Recent studies have shown that REEs exist in coal and coal combustion byproducts at elevated concentrations and in quantities that could meet domestic demand. Despite these promising findings, declines in rare earth prices, volatile commodity markets, and challenging geo-metallurgical conditions have jeopardized this potentially valuable REE resource. While the dilute REE concentrations inherently necessitate low-cost separation technologies, the ultimately operating cost threshold for economic extraction must be based on commodity price projections and market demand. In this paper, the micro-pricing principle is used to develop a rigorous economic model assessing the inherent value of REEs in coal materials. This model is based upon basket pricing of individual elemental oxides, and elemental distributions of coal samples from various basins. These results may be used to assess the economic viability of potential REE concentration and refining technologies.

Separation and Dewatering of Ultrafine Particles Using the Hydrophobic-Hydrophilic Separation (HHS) Process

N. Gupta¹, B. Li¹, R. Bratton¹, G. Luttrell¹, R. Yoon¹ and J. Reyher²; ¹Mining & Minerals Engineering, Virginia Tech, Blacksburg, VA and ²Minerals Refining Company, Richmond, VA

Flotation is regarded as the best available method of upgrading minerals and coal fines. However, its efficiency deteriorates rapidly with decreasing particle size. Further, ultrafine concentrates are difficult to be dewatered economically. Due to these difficulties, some companies choose to discard part of the ultrafine materials to impoundments. To overcome these problems, a new method of separating ultrafine particles and simultaneously dewatering the concentrates has been developed. Following extensive laboratory-scale test work, the process, known as hydrophobic-hydrophilic separation (HHS), has been tested successfully in continuous operations at proof-of-concept (POC) and pilot-scales in an operating coal cleaning plant. The results show that the HHS process is capable of producing high quality concentrates with high recoveries and low product moistures.

3:05 pm

Enhancing Profitability through Efficient Coal Processing and Blend Optimization

P. Bethell; Cardno, Bluefield, VA

Abstract Significant profitability enhancements can be achieved by optimizing: plant performance, coal blending and coal market suitability. Monetizing the contribution optimized plant blending and maximized efficiency at the plant is also vital. The following areas will be discussed in the paper to provide major economic benefits: Matching coal sales quality specifications to the coal resource quality available. Monitoring and optimizing processing circuit efficiency. Establishing, implementing and auditing plant best practices. Using incremental ash and incremental inerts (ash + moisture) to optimize plant circuit cutpoints. Defining plant blending optimization and circuit efficiency on monetary opportunity basis. Continually evaluating circuit alternatives. Match plant circuitry to resource washing characteristics and coal market quality specifications

3:25 pm

Improving Coal Production Profitability through Middlings and Re-processing

R. Honaker; Mining Engineering, University of Kentucky, Lexington, KY

The typical preparation plant producing coal for the utility market targets a relative separation density in the plant of around 1.60 whereas plants generating metallurgical coal use relative cutpoint density values approaching 1.50. In some cases, achieving the specified coal quality requires operating at lower cutpoint values which results in a significant loss of valuable coal. In these situations, a middlings stream can be produced using a secondary separator or a three-product unit which would allow crushing of the middlings for liberation purposes and re-introduction into the plant feed. In this manner, higher quality coal can be produced while maximizing plant yield. The results of a current study investigating the economic benefits of middlings liberation and re-treatment will be presented and discussed.

3:45 pm

16-144

Characterization of Rare Earth Element Concentrations in the Product Streams of Coal Preparation Plants in the Eastern United States

G. Luttrell¹, M. Kiser¹, R. Yoon¹, A. Bhagavatula², M. Rezaee² and R. Honaker²;

¹Mining & Minerals Engineering, Virginia Tech, Blacksburg, VA and ²Mining Engineering, University of Kentucky, Lexington, KY

A field study of the coal preparation plant fleet in the eastern United States was undertaken to determine if quantity of rare earth elements (REEs) present in the product streams are large enough to justify further concentration. Representative composite samples were taken from the clean product, coarse refuse, and fine refuse streams from 20 coal preparation plants. Each stream was then separated into various size and density classes and analyzed for ash and REE contents. The large database showed that coarse refuse contained the largest amount of REEs, although the ratio of heavy to light REEs was greater for the clean coal products. The concentration of REEs were also compared to that typically seen in the Earth's crust. This enrichment ratio ranged from approximately 1.5 to more than 4.0 as the ash content varied. The database also shows that a linear correlation exists between La and Ce for many REEs of interest, although there are several notable exceptions for some of the high-value REEs. This article summarizes the findings of this detailed plant fleet study and, based on this data set, provides recommendations for how this resource may be best recovered.

Wednesday, February 24 – Afternoon

ROOM: 229A

2:00 pm

Coal & Energy: Mine Emergency Response

Chairs: S. Bealko, GMS Mine Repair, Oakland, MD
E. Zeglen, Alpha Natural Resources, Bristol, VA

2:00 pm

Introductions

2:05 pm

16-043

An evaluation of an E-field Through-the-Earth (TTE) communications system at an underground longwall mine in West Virginia

E. Jong and S. Schafrik; Mining and Minerals Engineering, Virginia Tech, Arlington, VA

A commercially available Through-the-Earth (TTE) communications system was evaluated at an active underground longwall mine in West Virginia. This TTE system utilizes electric field (E-field) sensing to establish text based communications through two separate antenna arrays each composed of interconnected, grounded metallic rods. Two-way communication between the surface and the subsurface and between only subsurface locations was investigated in this study using both the manufacturer's recommended procedures and alternative configurations for the antenna arrays. This field study was conducted as a part of a larger multi-site evaluation of available TTE systems in an effort to determine their operational sensitivity.

2:25 pm

16-159

Explosive Gas Zone Formation in Underground Coal Longwall Bleeder Ventilated Gobs with an Adjacent Panel using CFD Modeling

R. Gilmore¹, J. Brune², S. Lolon², A. Juganda², S. Sak², G. Bogin¹, R. Zipf² and J. Grubb²; ¹Mechanical, Colorado School of Mines, Denver, CO and ²Mining, Colorado School of Mines, Golden, CO

The formation of methane-air mixtures in underground coal longwall mine ventilation systems into explosive gas zones (EGZs) is a hazardous condition that may cause mine fires and explosions. Researchers at the Colorado School of Mines, with funding by NIOSH, have studied and predicted EGZ locations using Computational Fluid Dynamics (CFD) modeling. This model of a bleeder ventilated gob system includes an active panel with an adjacent, mined-out panel. The simulations are matched to statutory ventilation conditions for methane concentration and air flow rates at common measurement points throughout the mine. The model results predict the persistence of EGZs in the gob, which may indicate that the bleeder ventilated gob system is ineffective in protecting miners from explosion hazards.

2:45 pm

Early-warning safety hazard predictor for preventive ventilation management

W. Asante, D. Bahrami and G. Danko; Mining Engineering, University of Nevada, Reno, Reno, NV

Recognition of safety hazard is difficult because of the complex nature of information from atmospheric and other conditions underground. Large amount of monitored data may be available from measurement by sensors such as air velocity, pressure, hazardous gas contaminants, temperature, and roof stability. In addition, the combined effects of various signal trends must be interpreted simultaneously with their cross-effects. Safety hazard recognition and prediction algorithms are needed to foresee the possible outcomes of various problems by continuous observation. A future increase of hazardous contaminant concentrations can be predicted by a computer algorithm extrapolating the possible outcomes from real-time monitored data. Such a forward-in-time and forward-in-space prediction then may trigger a safety warning message to mine management to prevent the accident from happening. This paper discusses various environmental and working conditions and how they may affect the future hazardous conditions in underground mine environment.

3:05 pm

Challenges in data acquisition for modeling sub surface coal fires

V. Srivastava and S. Sharma; Mining Engineering, Indian Institute Of Technology (Banaras Hindu University), Varanasi, Uttar Pradesh, India

A large amount of coal is lost worldwide each year, due to the development of the uncontrolled coal seam fires. China and India are most affected. The convective transfer of minor steam of fire through the surface that is associated with the heat flux component creates heat stress regime. The factors influencing Coal Seam Fires (CSFs) may be clubbed under geological causes, mining methods related impacts and seam statuses. Researchers are working on data acquired by each of these influencing factors. Jharia coalfield results show that factors like shallow depth working, contiguous panel multi seam working and thick seam mining had created very complex situations.. Failures to model and map the development of such fire and real time quantification of the extent and the location of the problem have severely affected the performance of mitigation measures. This paper reviews the technical advances in data acquisition the world over for the modeling and mapping of the CSFs. The field experiences have been critically analyzed to identify the strength, limitations, scope for further improvement and for the prediction of the CSFs for the reliable modeling and mapping of the CSFs.

3:25 pm

Evaluation of Detection and Response Times of Fire Sensors Using an Atmosphere Monitoring System

J. Rowland, C. Litton and R. Thomas; Fires & Explosions Branch, NIOSH, Pittsburgh, PA

Atmospheric Monitoring Systems (amS) are required when using air from conveyor or belt entries to ventilate the working section in underground coal mines in the United States (U.S.). amS technology has the potential to increase safety mine-wide, but research is needed to determine the detection and response times for other types of materials. To evaluate the performance of an amS for potential use in other areas of the coal mine, a series of fire experiment were conducted using different combustible materials including conveyor belt, brattice, different wood types, diesel fuel and other materials that would be found in an U.S. underground coal mine to evaluate their detection and response times. Full-scale fire experiments were conducted in the Safety Research Coal Mine (SCRM) at the National Institute for Occupational Safety and Health (NIOSH) in Pittsburgh Pennsylvania

using the various mine materials and sensor types to determine the optimum sensor type and location for the earliest detection of fires. The results showed that the proper selection of sensors and location utilized as a mine-wide amS can provide earlier warning times and improve the health and safety of the miners.

Wednesday, February 24 – Afternoon

ROOM: 224A

2:00 pm

Coal & Energy: Research and Development

Chair: M. Trevits, Pittsburgh, PA

2:00 pm

Introductions

2:05 pm

Estimating the Ground Response Curve using Two-Scale Modeling of Retreat Mining

B. Fahrman and D. Westman; Mining Engineering, Virginia Tech, Blacksburg, VA

The goal of this research is to gain a better understanding of the response of overlying strata to room-and-pillar retreat mining. To measure the overburden response, a seismic array of eight sensors was installed at an underground room-and-pillar coal mine in the eastern US. Passive, mining-induced seismic data was collected while the panel was being retreated. A two-stage modeling process in FLAC3D was used to estimate the ground response curve for this panel. First, pillar-scale models were created. To do this, distinct pillar patterns were identified and loaded in FLAC3D until failure to determine their stress-strain response. These stress-strain curves were then used in a panel-scale model to estimate the ground response of the entire panel. This two-stage, two-scale approach allows for localized pillar and roof performance to be effectively modeled on the panel-scale efficiently. These models, which were calibrated with the passive seismic data, will help gauge the ability of the overburden to form a stable pressure arch and show the caving process.

2:25 pm

Fiberglass Reinforced Plastic Asset Condition Management System

G. Clarkson; UTComp, Cambridge, ON, Canada

Fiberglass reinforced plastic (FRP) is used extensively in leach, sulphuric acid, hydrometallurgical and other mineral processing facilities because of its corrosion resistance to many acidic environments. Many of these facilities are built to take feedstock from several mines so that, overall, the facility should outlive any one mine and requires long-term reliability. Mechanical integrity programs are implemented for many of the metal assets so that changes in condition can be monitored and corrective action planned in a deliberate manner. Monitoring the condition is done using non-destructive, and often non-intrusive, inspections that provide quantitative information about the asset. Ordinarily, inspection of in-service FRP assets is limited to qualitative and intrusive assessments that usually require shutdowns and confined space entries. Techniques have been used since 2008 that provide quantitative information about the condition of FRP to calculate remaining service life and maintenance needs. The quantitative results also contribute to a database that tracks performance of thousands of other FRP assets.

2:45 pm

16-123

Improving Productivity, Cost and Safety with Fluid Power Systems

T. Ley; Chemical Engineering, University of Waterloo, Freelon, ON, Canada

Brutally honest mining executives tell you that "safety is job #1 but...costs are also important". When times are tough it can feel like you need to choose between safety and productivity. Excellence at both provides the best performance. Mining equipment fluid power systems operate at extremely high pressures and contain great amounts of energy. Productivity is achieved at least cost by tackling failure signals (like leaks) early - saving money, diminishing the potential for in-mine breakdowns, minimizing environmental liabilities and reducing injuries. High pressure fluid injection injuries are devastating events; globally under-recognized. :Production and worker's livelihood can be lost. Australian miners tackled this issue in 2010 with better risk management AND FluidSafe™ - a safety-formulated fluorescent dye that improves identification and treatment of injection injuries from hydraulic systems - also reducing fluid use by up to 7%. For miners, addressing fluid power safety and uptime in tandem generates strong economic returns. FluidSafe™ along with safety training, lowers costs, increases reliability, improves productivity, lessens environmental mishaps and saves workers.

3:05 pm

Every mine deserves lowest total cost of ownership of their high-wear consumables

J. Miller; Business, Pivot Industries Limited, Littleton, CO

Mission Statement Shrink the supply chain in mining consumables, and share in the savings. Vision Pivot Industries Limited (PI) vision is to ensure that every maintenance foreman/manager in the global mining industry is confident that the equipment they install is fit-for-purpose, and meets the objective of lowest total cost of ownership (LTCO). PI intention is to build a proven platform model where infomine.com meets about.com meets Wikipedia.com meets upwork.com meets stackoverflow.com to achieve LTCO and fit-for-purpose. How do we do it? Leverage two trends: 1) High value technical mining expertise available due to the contraction of our global market 2) Mobile technology is enabling feature rich detail to allow domain experts to leverage their skills/experience to make prescriptive recommendations regardless of location.

3:25 pm

A Sodium Oleate Concentration Study for Modifying Rock Dust to Improve Particle Dispersion in Underground Coal Applications

Q. Huang and R. Honaker; Mining Department, University of Kentucky, Lexington, KY

An earlier investigation found that sodium oleate was effective in rendering the surfaces of rock dust particles hydrophobic which enhanced their dispersive properties. Subsequent research work has shown that increasing the sodium oleate concentration above a specific value reverses the positive impact on dispersion by inducing particle agglomeration through hydrophobic particle-particle interactions. A detailed investigation found that monolayer adsorption of sodium oleate occurs most likely within the reagent concentration range of 0.1% and 0.15% by weight. A further increase in the reagent concentration resulted in a corresponding rise in the surface contact angle to a maximum of 126°. As a result, the inter-particle interactions become dominated by the attractive hydrophobic interaction force which results in spontaneous particle agglomeration upon contact between the rock dust particles. As a result, the benefits of hydrophobizing rock dust particles are limited to lower reagent dosages to maintain the desired dispersion characteristics.

3:45 pm

16-121

Development of a Web-platform for Ground Control Applications

Z. Agioutantis and C. Newman; Mining Engineering, University of Kentucky, Lexington, KY

Over the last 20 years, NIOSH has developed and validated a number of software tools addressing safe coal mine design with respect to ground control. These tools are available free of charge to the mining industry to help design safer mining environments with respect to pillar stability in longwall and room and pillar mines, formation characterization, support requirements, etc. These tools are available as stand-alone PC based software packages. As cloud computing gains momentum, there is a definite need to develop internet based applications for mine design that would be easily accessible at all times, even underground where permitted. This new web-based product will allow for faster and easier access to existing ground control designs, on-the-fly calculations in the field if needed, and instant online collaboration between planning personnel and operations engineers. It is expected that the industry will rapidly embrace this product and, as it is common with all new innovative technologies, it will be a new paradigm for mining engineering computer applications.

4:05 pm

Improving Void Detection Capabilities of Instrumented Roof Bolter by Using a New Algorithm For Analysis of Drilling Parameters

W. Liu¹ and J. Rostam²; ¹Department of Energy and Mineral Engineering, Pennsylvania State University, 110 Hosler Building, State College, PA and

²Department of Energy and Mineral Engineering, Pennsylvania State University, 102 Hosler Building, State College, PA

Roof instability is one of important issues in underground mining. Roof falls cause many injuries, deaths and damages to equipment every year. In order to optimize roof support design and enhance ground stability, it is essential to have an accurate understanding on roof conditions, such as the location of voids, cracks and discontinuities as well as rock types and strength. Currently several manufacturers of roof bolters including JH Fletcher offer smart roof bolters with limited capabilities for void detection. This paper briefly reviews the existing equipment and introduces ongoing research on void detection by using roof bolter drilling parameters (feed pressure, rotation pressure, vibration, and acoustic). The goal of the project is to improve the sensitivity of the detection program to locate smaller joints and reduce the number of false alarms. Results of preliminary laboratory and field tests along with statistical comparison of the analysis of four drilling parameters used for void detection will be discussed. The new algorithm that has been developed is self-adjusting and have improved the capabilities of the existing systems for locating joints and bed separations.

Wednesday, February 24 – Afternoon

ROOM: 229B

2:00 pm

Coal & Energy: Underground Processes and Practices II

Chairs: J. Chlopek, GCC Energy LLC, Hesperus, CO

J. Zelanko, Rosebud Mining Company, Kittanning, PA

2:00 pm

Introductions

2:05 pm

Microseismic Monitoring of a Room and Pillar Retreat Coal Mine Panel

W. Conrad and D. Westman; Mining and Minerals Engineering, Virginia Tech, Lexington, NC

Room and pillar retreat coal mining is one of the most hazardous mining methods currently under practice. In order to better understand the rockmass behavior associated with the mining process and ultimately reduce risk to miners, an array of geophones was placed underground along a single panel of a retreat mine in SW Virginia. The geophones recorded microseismic events surrounding the active panel that resulted from failures due to stress redistribution. These events were located and their moment magnitudes were found. An analysis was completed, observing the redistribution of stress and the associated gob formation throughout the panel's retreat. The distribution of the events was consistent with expectations for gob formation. Overburden of the panel ranged from 200-300 m (650-1,000 ft), with the immediate roof consisting of shale, sandy shale, and a sandstone channel. Monitoring lasted 1.5 months through one full panel of retreat, resulting in over 13,000 located events. Approximately 3,000 of these events were located well enough to provide analysis of the changing stress conditions. The average recorded event had a moment magnitude of -0.9, with no events exceeding 2.0.

2:25 pm

Direct-fired Intake Air Heating at Pennsylvania Coal Mines

J. Krenze^P and J. Zelanko¹; ¹Engineering, Rosebud Mining Company, Kittanning, PA and ²Mechanical Engineer, Monongahela, PA

Rosebud Mining Company has developed slopes into five mines in western Pennsylvania since 2013. Several slopes are used both as air intakes and travelways. Water infiltration through surrounding strata requires some method to prevent ice formation during winter. Ice accumulation can result in slipping hazards, restrictions to airflow or travel, and freeze-thaw damage to roof/rib strata. Two strategies for ice prevention were considered. Water management techniques used in the mine pit and on the slopes included well pumping and strata sealing to remove or redirect groundwater in the slope areas. If groundwater was too pervasive or difficult to control, conditioning of the air entering the mine was utilized to prevent the air from dropping below the freezing temperature of water. Direct-fired air heating was considered along with radiant overhead and in-floor heating. This paper will describe different methods of water management and ice prevention considered and ultimately utilized in the recent slope construction projects. Additionally, experience with equipment installation, regulatory approval, commissioning, and operation through two abnormally cold winters will be presented.

2:45 pm

Quantitative Study of the Mechanism of Rock Dust in Controlling Coal Mine Explosives

H. Jiang, M. Li and Y. Luo; Mining Engineering, West Virginia University, Morgantown, WV

Methane explosion in underground coal mines can suspend the settled coal dust in mine air creating a condition for coal dust to participate in the explosion process and greatly increases its intensity. Even though rock dusting has been widely used as a primary explosion control measure in many major coal producing countries, its functional mechanism has not been fully studied quantitatively. The mechanism and effectiveness of three major functions for rock dust to control coal mine explosions (i.e., isolator, physical heat sink and chemical energy absorber) have been further explored and quantified. First, the mechanism of re-entrainment of dust has been analyzed and the critical air velocity for rock dust to isolate the underlying coal dust is determined through fluid dynamic analysis. When isolator function fails to prevent coal dust from becoming airborne, the

effect of physical heat sink is assessed by a mathematical model derived based on the heat equation. When condition is met for coal dust to burn in the explosion process, the rock dust's thermal energy absorber function in the chemical calcination process is also quantitatively evaluated.

3:05 pm

Underground Coal Mining Case Histories – Unanticipated Multiple Seam Stresses from Pillar Systems Forming “Pseudo Gob”

M. Gauna; Dept of Labor; MSHA-Technical Support, Pittsburgh, PA

Underground coal mining in the U.S. is conducted in numerous regions where previous workings exist above and/or below the actively mined seam. It is widely recognized that abutment stresses from overlying or underlying extracted coal areas, also known as gob regions, can affect the active mining. However, situations arise where there has been sufficient yielding of pillar systems in overlying or underlying workings to allow stress transfer to the active workings by acting as “pseudo gob”. This situation in the overlying or underlying coal seam(s) is often unanticipated. Case histories are presented illustrating how pillar systems unexpectedly acting as pseudo gob generate sufficient multiple seam stress resulting in hazardous roof and rib degradation, pillar failure, and coal burst in the active seam. The consequences shown in the case histories are presented so that operations that begin to encounter evidence of such multiple seam stress interaction can mitigate the impact rather than proceeding with no understanding of the mechanism encountered.

3:25 pm

Determination of Creep Parameters from Relaxation Tests

Y. XUE and B. MISHRA; Mining Engineering, WVU, Morgantown, WV

Determination of parameters for creep models, widely used to describe the time-dependent deformation in underground coal mine roof, is time-consuming in laboratory. If these parameters can be obtained from relaxation tests, much time can be saved. This was investigated with theoretical analysis, numerical simulation and laboratory test. The stress-time relation for a rock specimen following Burger's model was theoretically and numerically calculated under relaxation condition. In laboratory, each specimen of four groups of different rocks was tested under creep and relaxation condition. Comparison of creep parameters determined from creep and relaxation tests was made, which demonstrated the feasibility of determining creep parameters from relaxation tests.

3:45 pm

16-105

Ventilation airflow around a continuous miner and its effect on methane concentrations at the face

H. Dougherty; Fires and Explosions Branch, Office of Mine Safety and Health Research, Pittsburgh, PA

Attaining an accurate understanding of airflow distribution at the continuous miner face is instrumental in maintaining a safe mining environment. Currently, continuous miner face air readings can be taken in the last open crosscut and at the curtain mouth. By measuring airflow in a pre-determined area it is accepted that an adequate quantity of that air exists to sweep the face of harmful dust and gasses. Unfortunately, due to the location inaccessibility, precise face velocity readings can only be determined in a laboratory setting or through computer-simulated programs verified by laboratory models. The NIOSH OMSHR ventilation gallery was used to simulate common ventilation scenarios and measure air velocities utilizing ultrasonic anemometers. The ventilation gallery simulates a full-scale mining face similar to a CM room and pillar operation and provides a

means to obtain representative air velocities in areas typically inaccessible on an actual CM face. Methane gas was also released from pipes located at the face to simulate realistic face gas emissions.

4:05 pm

An application of 5S to the King II Coal Mine which increases overall efficiency and reduces operating cost

J. Chlopek and T. Peterson; GCC Energy LLC, Hesperus, CO

5S is an industrial systems-management process that is primarily used in the manufacturing industry. GCC Energy has adopted the practice of 5S at its King 2 coal mine with alterations for use in an underground room and pillar coal mine. The King II mine produces close to 1 million tons a year with 3 continuous miners in a super section and pillaring section. The mine employees about 140 people, the majority of whom work underground. In an effort to reduce cost (OpEx and CapEx), a system of organizational management and culture change was applied. GCC Energy's parent company had successfully utilized 5S for its cement and Redi-Mix divisions and wanted to do the same for its King II Mine. However, applying 5S to an underground mine required changing the criteria but keeping the main principals of 5S (Sort, Straighten, Sweep, Standardize, and Sustains) intact. To achieve 5S application, an out-of-the-box approach was defined with resulting operational efficiencies obtained. Examples of this included: set up of power centers, routing of trailing cables and utilities, equipment staging, supplies staging, roof bolter preload trays, Emergency Response trailers, etc.

Wednesday, February 24 – Afternoon

ROOM: 225A

2:00 pm

Coal & Energy: Ventilation Innovations

Chairs: A. Leeper, BHP Billiton, Farmington, NM

P. Tukkaraja, South Dakota School of Mines and Technology,
Rapid City, SD

2:00 pm

Introductions

2:05 pm

CFD Studies on the Phenomenon of Gob Breathing Induced by Barometric Pressure Fluctuation

S. Lolon¹, J. Brune¹, R. Gilmore², G. Bogin², J. Grubb¹, S. Saki¹ and A. Juganda¹;

¹Mining Engineering, Colorado School of Mines, Golden, CO and ²Mechanical Engineering, Colorado School of Mines, Golden, CO

In longwall mines, barometric pressure fluctuations can disturb the pressure balance between the gob and the ventilated working area of a mine, resulting in a phenomenon known as "gob breathing". Gob breathing triggers a gas flow across the gob and the working areas, resulting in a condition where a methane accumulation in the gob flows into the face area forming an explosive mixture. This paper discusses results of Computational Fluid Dynamics (CFD) modeling carried out to analyze this phenomenon and its impact on the explosive mixture development under a bleeder-ventilated longwall gob panel scheme. Modeling results indicate that the gas flows across the gob and the formation of Explosive Gas Zones (EGZs) are directly affected by the barometric pressure changes. Methane gas and EGZs in the gob expand out toward the face and bleeder entries during the falling barometric pressure. EGZ fringes may form along the face and in the bleeder entries.

When the atmospheric pressure increases, an ingress of oxygen into the gob is observed, increasing EGZs volume. The findings from this study help assess the methane explosion risks associated with fluctuating barometric pressures.

2:25 pm

16-067

Validation of a CFD Pollutant Transport Model of an Open Pit Mine under Air Inversion

K. Raj and S. Bandopadhyay; Mining Engineering, University of Alaska Fairbanks, Fairbanks, AK

The development and advancement of computational fluid dynamics (CFD) has made it possible to better understand pollutant flow and pollution distribution in deep open pit mines. This paper is based on the air inversion problem in Arctic open pit mines and a three-dimensional CFD model that was developed of an actual open pit mine to analyze the problem of pollutant growth in an open pit during inversion, its understanding and solution through improved ventilation schemes. This paper presents a comparison of the model simulated values for pollutant concentration with values obtained by monitoring actual mine concentrations. Due to the availability of mine-specific data, such as exact sampling locations, contaminant concentration values at those locations, and the coordinate values of these locations for validating the simulation model, the 2013 pit geometry was used for the validation purposes. For validation of the model, the realizable ϵ - ϵ model was selected. Pollutant concentration values at selected locations showed differences, but remained within the same order of magnitude in most cases.

2:45 pm

Distributed Air Properties Sensors for Underground Mine

M. Momayez; Mining and Geological Engineering, University of Arizona, Tucson, AZ

For nearly two decades, the uses of the fiber optic sensor technology have been in static long-term structural health monitoring due to the time required to obtain the data and its poor precision. However, advances in optical sensing, in the past few years, have produced sensors that provide greater precision and faster analysis times. We report on advances made to develop an optical fiber based distributed sensing technology for the mining industry. Fiber optic distributed sensing does not use in-situ type sensors but instead utilizes the sensing fiber itself, thereby eliminating cold spots along the structure to be monitored. More importantly, distributed sensing allows unprecedented coverage over long distances (up to 100 km) with no need for additional circuitry.

3:05 pm

Mechanically Robust, Thermally Insulating Alumino-silicate Lining For Underground Mines

K. Muralidharan² and M. Momayez¹; ¹Mining and Geological Engineering, University of Arizona, Tucson, AZ and ²The University of Arizona, Tucson, AZ

The ability to significantly lower heat transmission in hot underground mines has profound implications for optimizing mine ventilation systems. Using computational materials science paradigms, we investigate the feasibility of using amorphous alumino-silicate (AS) based polymeric lining as thermal insulating barriers. AS materials have excellent mechanical properties and low thermal conductivity: these properties are a direct consequence of their low density, 3D network open non-crystalline structure. AS materials exhibit mixed covalent-ionic bonding, resulting in high elastic modulus, while the polymeric structure enables high mechanical resilience and toughness. Further, the amorphous structure inhibits phonon transport, thereby resulting in low thermal conductivity. When used as additives, they retain their mechanical and thermal properties, enabling the pos-

sibility of using AS-based shotcrete lining. Employing molecular dynamics (MD) simulations and finite element modeling, we report for the first time, the interplay between structure, ensuing properties of AS based lining, and optimal composition that maximizes mechanical strength with diminished thermal transport properties.

3:25 pm

Comparisons Of Novel Fiber Optic to Standard Heat of Combustion Methane Sensors in a Coal Mine

H. Dougherty¹, A. Behera², D. Wang², A. Wang², K. Luxbacher¹, N. Ripepi¹, M. Karmis¹ and Z. Agioutantis³; ¹Mining and Minerals Engineering, Virginia Tech, Newport, VA; ²Electrical and Computer Engineering, Virginia Polytechnic Institute, Blacksburg, VA and ³Mining Engineering, University of Kentucky, Lexington, KY

A novel sensor using fiber optic technology has been developed for use in underground mines. Fiber optic sensing technology has been around and applied for many uses in all industries including mining. The practice of using this technology in underground mine atmosphere sensing applications is a relatively recent occurrence. Fiber optic sensing in underground mines is expected to be superior due to its intrinsic safety, large detection range, and high sensitivity. A robust methane sensor using fiber optic technology has been developed to sense concentrations from 0.1% up to a maximum of 100%. To validate this technology, a test is performed to verify sensor sensitivity, response time, and agreement with current proven heat of combustion methane sensors. These two sensing technologies are placed in a return entry for a prolonged period of time, data is collected and a comparison and verification of the data are presented.

3:45 pm

16-148

Designing a CFD Model for the Development of a Dust Sampling Device (DSD)

V. Duddempudi, B. Goertz, J. Brune and G. Bogin; Mining Engineering, Colorado School of Mines, Golden, CO

In designing a new pneumatic Dust Sampling Device (DSD) for coal mines, it was essential to analyze the air and particle flow inside the device in detail using Computational Fluid Dynamics (CFD) modeling. Several CFD models were developed to simulate the sampling air flow and sample collecting process of the DSD. Various CFD designs were considered to develop instrument prototypes for laboratory testing. Parameters like air velocity, pressure, size and geometry of the nozzles were controlled in wide ranges to obtain the optimum parameters. Accordingly, these parameters were used as support for the design of the device and to verify the dust scouring action, which represents the dust entrainment during an actual methane or coal dust explosion.

Wednesday, February 24 – Afternoon

ROOM: 226A

2:00 pm

Environmental: Alternative Treatment of Mine Impacted Water

Chairs: T. Sharp, SRK Consulting, Vancouver, BC, Canada
B. Waterman, Freeport-McMoRan, Oro Valley, AZ

2:00 pm

Introductions

2:05 pm

Field Push-Pull Test Investigation of In Situ Neutralization of Acid Sediment

J. Villinski; Clear Creek Associates, Tucson, AZ

Past mining activities potentially released acidity and heavy metals into natural systems and consumed the acid-neutralizing potential of the sediment. Subsequent metal sorption and hydroxysulfate precipitation resulted in acidity and metals stored with the sediment. Pump-and-treat (P&T) has been used to remediate aquifers impacted by amD. However, P&T relies on passive migration of affected groundwater to a wellfield, protracting the remediation since solid phase reactions pose kinetic limitations on the release of stored acidity and metals to groundwater. In situ alkali application is a potential alternative method to neutralize sediment acidity and sequester metals. Previous testing indicated that NaHCO_3 , Sesqui and lime are potential in situ remediation reagents. Testing indicated that if the treatment pH increased above 8.5, metals were remobilized, resulting in exceedances of remedial action objectives. A field-scale, push-pull test (PPT) was performed with NaHCO_3 to evaluate the effectiveness and implementability of the in situ neutralization of an aquifer impacted by amD. NaHCO_3 was chosen for the PPT as it has a high solubility and has a treatment pH near 8.5.

2:25 pm

Pilot Testing of In-situ Biostimulation for Biosequestration of Uranium in Groundwater

M. Brusseau; University of Arizona, Tucson, AZ

Enhanced natural attenuation is one of the few potential alternatives to pump and treat for management of large groundwater contaminant plumes comprising constituents such as uranium, selenium, chromium, and similar species. Pilot tests were conducted at the Monument Valley UMTRA site to evaluate the efficacy of electron-donor amendment for promoting biosequestration of U. Geochemical and stable-isotope data collected for groundwater and sediment before, during, and after the test were analyzed to evaluate the sustainability of sulfate reducing conditions induced by the test, the fate of hydrogen sulfide, and the impact on aqueous U concentrations. The results of site characterization activities conducted prior to the test indicated the absence of measurable bacterial sulfate reduction. The injection of the electron donor (ethanol) induced bacterial sulfate reduction, as confirmed by an exponential decrease of sulfate concentration in concert with changes in oxidation-reduction potential, redox species, alkalinity, production of hydrogen sulfide, and fractionation of ^{34}S -sulfate. Concentrations of U in groundwater decreased in parallel with decreased sulfate concentrations.

2:45 pm

Using Manganese for Trace Metal Removal

P. Eger; global minerals engineering, Hibbing, MN

Limestone beds are an effective method for passively removing manganese from mine drainage and are generally placed at the end of the treatment system, since iron must be oxidized before substantial amounts of manganese can be removed. Manganese removal occurs primarily through a variety of biological mechanisms under oxidizing conditions. Manganese oxides, primarily Birnessite and Todorokite, accumulate on the surface of the limestone. The ability of manganese oxides to remove trace metals is well documented in the literature but there is little quantitative data from operating passive treatment systems. Manganese solids recovered from several limestone beds contained up to 0.3% nickel and 0.6% cobalt. For these systems, trace metal removal rates ranged from around 50 – 90 mg/m²/day comparable to previously published rates for metal removal in constructed treatment wetlands. Laboratory experiments using a dispersed alkaline substrate and a limestone bed to treat acid mine drainage have removed over 90% of the iron, aluminum and copper but the limestone bed component has not yet been successful in removing manganese and cobalt.

3:05 pm

Development a peat based products for industrial wastewater remediation: increased selectivity for adsorption of Cd^{2+} in the presence of Zn^{2+}

R. Hallak², G. Browning², R. Uetrecht² and I. Kolomitsyn¹; ¹Center for Applied Research and Technology Development, Natural Resources Research Institute, UMD, Duluth, MN and ²American Peat Technology, LLC, Aitkin, MN

Peat, partially decayed vegetation that accumulates in wetland bogs, is a well-known natural sorbent of heavy metals. The utilization of peat and other biomass materials for the treatment of waste water containing heavy metals is gaining more attention as a simple, effective and economical means of pollution remediation. Recently, we reported the development of new peat granular media, APTsorb III, which effectively absorbs up to 16 mg of Cd^{2+} per 1 g of peat media at an equilibrium concentration of 50 ppb. However, the presence of Zn^{2+} ions decreases the capacity to adsorb Cd^{2+} , and in some instances can be as low as 0.5 mg per 1g of APTsorb III peat media at an equilibrium concentration of 50 ppb. This study presents an effective technology using reed-sedge peat to produce a modified peat media, APTsorb II*Na. APTsorb II*Na showed a dramatic increase in selectivity for Cd^{2+} in the presence of Zn^{2+} . The breakthrough capacity of Cd^{2+} in the presence of Zn^{2+} was measured using column tests at different flow rates and reached 3 mg per 1 g of APTsorb II*Na. This capacity is six times higher compared to APTsorb III peat media. The mechanism for increased selectivity will be discussed.

3:25 pm

Green Technologies for Acid Mine Drainage (amD) Remediation

L. Ackah, M. Mohanty, R. Guru, G. Cordeiro, M. Peiravi and X. Yang; Southern Illinois University Carbondale, Carbondale, IL

The main goal of this study is to develop lower cost green alternatives for passive treatment of (amD) water and affected soil at the abandoned mine sites. The metal binding and acid-neutralizing capability of water treatment residues, a waste material generating from drinking water treatment facilities, and metal uptake potential of some of the known grass/plants were used to develop a green, cost-effective amD remediation technology. An abandoned coal mine site generating nearly 20 gallon per minute (average) of amD in Illinois was selected as the host-site. The amD generating from this site has a pH of 2.86, and Al, Mn and Fe contents of 409 ppm, 80 ppm and 1,423 ppm against the EPA approved limits of 720 ppb, 180 ppb, 2.4 ppm, respectively. Laboratory tests conducted using three different types of water treatment residues (WTR) have been found to effectively neutralize and adsorb most of the metal ion dissolved in the amD water except Mn. The best Mn reduction observed so far is only 34%. Currently we are examining the phytoremediation technique using plants which are known to be hyperaccumulator of Mn to improve Mn reduction efficiency.

3:45 pm

Biochemical Reactor Treatment of Low Sulfate and Hard Rock Mining-Influenced Water

N. Anton, K. Saller, M. Fischer, N. Smith, A. Frandsen and D. Reisman; Environmental Services Group, CDM Smith, Helena, MT

CDM Smith completed bench-scale treatability testing to evaluate biochemical reactor (BCR) treatment of two mining-influenced waters (MIWs) that were near-neutral, low-sulfate (approximately 40 mg/L), and variable concentrations of metals. Column studies were completed with and without sulfate addition, pre-treatment oxidation and settling, and within a simulated cold environment. Pre-treatment using a gypsum column and a magnesium sulfate solution to raise sulfate concentrations were evaluated. For one of the MIWs, an additional column

was operated inside a refrigerator for a portion of the study. Columns were operated continuously for approximately three to four months, with weekly sampling and analysis. The testing indicates that sulfate addition by either method generated strong sulfate reducing conditions and high metals removal efficiency, whereas the non-sulfate pre-treated column did not generate strongly reducing conditions and had limited metal removal related to organic sorption. The cold operated BCR column illustrated slower sulfate reduction rates and metal removal efficiency compared to room temperature columns with equivalent sulfate amendment.

Wednesday, February 24 – Afternoon

ROOM: 226B

2:00 pm

Environmental: ARD - Passive Treatment

Chairs: I. Lee, Freeport-McMoRan Inc, Oro Valley, AZ
G. Savci, Brown and Caldwell, Phoenix, AZ

2:00 pm

Introductions

2:05 pm

Review of Passive Systems for Mine Drainage Treatment

J. Skousen; West Virginia University, Morgantown, WV

Mine drainage results from the exposure and oxidation of sulfide minerals, which release iron, sulfate and acidity, thereby producing acid mine drainage (amD) or alkaline mine drainage. amD contains acid-soluble metals and other ions at concentrations that are toxic to aquatic life and make it unsafe for domestic, recreation, and agricultural uses. amD treatment is distinguished between active and passive approaches. Active amD treatment relies on addition of chemicals with frequent re-supply and maintenance. Passive amD treatment relies on natural biological, chemical, and physical processes to neutralize acidity, and to oxidize and precipitate metal contaminants. Passive technologies can be separated into biological and geochemical types. Biological systems include constructed wetlands, vertical flow wetlands and bioreactors. Geochemical systems rely on an inorganic alkaline source and include anoxic limestone drains, open limestone channels and alkaline leach beds. Flow, acidity and alkalinity, metal, and dissolved oxygen concentrations are critical parameters for selection. When appropriately designed and maintained, passive treatment systems can be efficient and effective.

2:25 pm

Biochemical Reactors for Treating Mining-Influenced Water

D. Bacon; Dept. of Environmental Quality, State of Utah, Salt Lake City, UT

Innovative approaches and technologies are needed to solve environmental issues and remove existing regulatory barriers. The Interstate Technology and Regulatory Council (ITRC) is a state-led, national coalition helping regulatory agencies, site owners, and technology developers achieve better environmental protection through the use of innovative technologies. ITRC research teams demonstrate and provide methods to streamline and standardize regulatory review processes to ensure implementation of better, more cost effective, environmental technologies. The ITRC Mine Waste team was formed in 2008 to address solid mine waste and mining influenced water, and produced a web-based guidance to help selected technologies that address a wide variety of mine waste issues. Afterwards the Team felt bio-chemical reactors (BCRs) were a promising technology, but more information on their design and use was needed. In 2013 the Team completed a second web-based guidance on BCRs. This second guidance contains more detailed information on the applicability, design, construction, monitoring and maintenance, related regulatory and public stakeholder issues concerning the use of BCRs.

2:45 pm

Passive Limestone Treatment of MIW with Low pH and High Iron

L. Figueroa; Civil and Environmental Engineering, Colorado School of Mines, Golden, CO

Mining influenced water (MIW) with low pH and high ferric iron concentrations is typically treated in active systems by hydroxide addition. Limestone is an attractive reagent for neutralization and iron precipitation because it equilibrates at a neutral pH and thus is more amenable to lower operation and maintenance treatment systems. Existing design guidance is limited to passive limestone treatment of MIW with low ferric iron concentration or active limestone treatment of MIW with high ferric iron concentration. Extrapolation of current passive limestone bed design guidance has led to design failure for high ferric iron concentrations. Preliminary laboratory experiments suggested that an additional volume component needs to be included into the oxic limestone design model to account for the accumulation of precipitates. An oxic limestone drain model developed for low Fe and Al MIW was modified to include the increased volume associated with the collection of hydroxide precipitates. MIW from the Tiger Tunnel Adit in Colorado was used for the analysis. The size predicted by the modified model was compared to a system installed at the Tiger Tunnel site.

3:05 pm

Proof of Concept Bio-Terrace Aluminum Removal at an Abandoned Metal Mine, Idaho

J. Gusek; Sovereign Consulting Inc., Lakewood, CO

Low-pH (3.5) acid rock drainage (ARD) from an adit at an abandoned metal mine in southcentral Idaho exhibits a dissolved aluminum concentration of about 800 mg/L as well as other ARD constituents (Fe, Mn, Cu, and Zn). A “volunteer” terraced formation at the adit portal appears to be comprised of iron and aluminum precipitates; cyanobacteria appear to be facilitating aluminum precipitate deposition. Four stainless steel troughs (6m long x 460mm wide) were configured to receive equal flows of ARD at rates of about 3 L/min. Each gently-sloped trough was fitted with different media. Within two weeks, iron and aluminum precipitates were observed in the troughs in varying amounts, replicating the “volunteer” terraces that first prompted the proof of concept (POC) experiment. Static microcosm trays were also tested in parallel to evaluate long-term bioremediation potential including the effects of reduced sunlight and lower temperatures on metals precipitation rates. To gather sizing data for the design of a larger scale passive treatment system, the POC results were used to retrofit the troughs into a single 24m long train with the media that exhibited the best aluminum removal.

3:25 pm

Optimization of Passive Treatment for Sulfate Removal in a Biochemical Reactor

N. Gallagher, T. Rutkowski and E. Blumenstein; Golder Associates Inc., Lakewood, CO

A passive treatment system (PTS), designed to achieve a 50 percent reduction in sulfate from mining influenced water (MIW), has been operation at an underground coal mine in British Columbia since 2012. The PTS consists of four unit processes: anaerobic bioreactor (BCR), sulfide polishing cell (SPC), aerobic lagoon, and settling pond. In 2014 and 2015, field-scale testing was performed to study the effectiveness of several methods of improving the sulfate removal performance of the PTS, to allow more flow through the system without expansion, and evaluate the replacement of sulfide polishing cell media with other mechanisms of sulfide sequestration. Testing evaluated the effect of carbon and nutrient amendment of field-scale BCRs on sulfate reduction, ferrous chloride amendment in BCR influent and BCR effluent on sequestration of sulfide, and multiple variations of acidification, aeration, and oxidation of BCR effluent on sulfide removal.

3:45 pm

Performance testing results for passive treatment of manganese, iron, and arsenic to meet part-per-billion discharge limits

W. Oehmig, N. Gallagher and T. Rutkowski; Water Treatment, Golder Associates Inc., Lakewood, CO

Since 2011, passive treatment of impacted water at a closed mine site has shown effective removal of Fe, Mn, and As to meet interim water quality limits; however, limits effective June 2015 are stringent: Fe (300 µg/L), Mn (50 µg/L), and As (10 µg/L) as the system is still maturing. A lack of high influent flow rates to date has prevented evaluation of the system under low HRT conditions. A scaled testing system, using materials gathered from the full-scale system, was operated for several months to assess effects of HRT and oxidation on the removal of Fe, As, and Mn. The system consisted of three units: settling basin, aerobic wetland, and limestone based manganese removal bed (MBR). Controlled operation allowed for increased Mn loading to the limestone MBR. Results show that oxidation of the influent water has little effect on Fe, As, or Mn removal. Decreased HRT resulted in lower Fe, As, and Mn removal. Mn removal kinetics MBR are believed to follow first-order reaction rates. At higher HRT (11-12 hours), effluent Mn was consistently below 50 µg/L. A first-order rate constant (k) was calculated (8.5×10^{-3} m/hr) and is used to predict Mn removal at full-scale under peak flow.

4:05 pm

Application and Management of Passive Biochemical Reactors for Selenium Treatment

J. Bays and R. Thomas; CH2MHILL, Tampa, FL

Mining, power, water treatment and agricultural industries wastewaters may include selenium, a regulated contaminant with unique biogeochemistry and ecotoxicological properties. Treatment advances over the past thirty years have demonstrated that biologically-mediated transformation of oxidized selenium to reduced inorganic selenium offers effective treatment. As one such approach to biological treatment, passive biochemical reactors implemented in the past five years have demonstrated selenium reduction from 10-1000 µg/L to 1-10 µg/L for a wide range of flows (10-1000 gallons per minute), water quality (e.g., <-20 to +50°C; 100 to 25,000 mg/L total dissolved solids, and 1 to 55 mg/L nitrate-nitrogen and 100 to 4000 mg/L sulfate). In West Virginia, a dozen full-scale (0.1 to 1.0 acre) biochemical reactors passively reduce selenium in mine-influenced water. Operational conditions vary widely but converge on the need to manage hydraulics, monitor process indicators (e.g., oxidation reduction potential, selenium species), and control nuisance byproducts (e.g., biochemical oxygen demand). This paper summarizes performance findings, management needs, and solutions to common challenges.

Wednesday, February 24 – Afternoon

ROOM: 226C

2:00 pm

Environmental: Groundwater Management

Chairs: C. Cottingham, MWH Global, Salt Lake City, UT

R. Vanlandingham, Twin Metals Minnesota, St Paul, MN

2:00 pm

Introductions

2:05 pm

Optimization of Exploration Drilling Programs to Include Hydrogeologic and Geotechnical Data Collection

M. Birch and D. Bandon; Golder Associates Inc., Tucson, AZ

During the development of new mining projects, often times hundreds of boreholes are drilled across the mineral exploration area. Further, condemnation boreholes are often drilled outside of the ore zone to ensure that proposed mine facilities will not be placed over ore-rich areas. The primary purpose of these boreholes is to assess ore grades and geologic conceptual model development. However, with some planning, these drilling projects can be used to “piggy back” the collection of hydrogeologic and geotechnical data. These data, in turn, can provide valuable insights into the site hydrogeology and geotechnical conditions, ideally significantly reducing the cost of later hydrogeologic and geotechnical investigations. This paper outlines the types of data that can be collected early on during the exploration phases of a project, along with how these data can be used for hydrogeologic and geotechnical characterization. Examples are presented from several hydrogeological environments of efficient data collection programs as well as lessons learned. In addition, some examples of operational mine use of “multi-purpose” wells will be presented.

2:25 pm

Improved Characterization of Fractured and Faulted Rock by Passive Microseismic Monitoring

W. Dershowitz¹, W. deBeer² and J. Mercier²; ¹FracMan Technology Group, Golder Associates Inc, Redmond, WA and ²Golder Associates Ltd., Vancouver, BC, Canada

Fractures and faults provide important flow pathways for flow and transport at mine sites. Mine hydrogeologic characterization must therefore include the geometry, connectivity, and hydraulic properties of fractures and faults. This paper presents the development and application of a microseismic fault and fracture characterization approach. This approach combines passive seismic tomography with analysis of event magnitude and focal mechanisms. The approach relies on the emission of seismic energy when shear stress exceeds shear strength, including the effects of changes in fluid pressure. Microseismic fracture characterization for environmental groundwater management is demonstrated based on data collected at a block caving mine. This data was collected primarily for rock mass pre-conditioning. Fracture and fault geometry to a resolution of tens of meters was obtained for a 200 m scale oreblock at 600 m depth. These microseismically identified fractures form the basis of a conditioned 3D discrete fracture network (DFN) hydrogeologic model. The DFN model can be used to model groundwater flow and contaminate transport, considering the effect of discrete pathways.

2:45 pm

Hydrogeology Key to Niocorp's Elk Creek Project

P. Williams; SRK, Evergreen, CO

Beneath the cornfields of Johnson County in southeastern Nebraska lies the highest grade Niobium deposit in North America. The carbonatite-hosted deposit is located on the Nemaha Uplift within the Precambrian granitic basement, overlain by 180 m of Pennsylvanian limestone, and capped by 30 m of till. Results of 12 months of data collection confirm challenging groundwater conditions at this advanced exploration project. The hydrogeologic investigation has revealed consistently low water levels, downward hydraulic gradients, relatively high bulk hydraulic conductivities, laterally-connected faults and fractures, and warm brackish water. All of these factors impacted the original conceptual mine plan and forced an extension of the schedule to gather confirmatory data. The mine planning effort for the deep underground mine is being tailored to accommodate a manageable mine dewatering scheme, and a feasible mine water management plan.

3:05 pm

Multi-scale groundwater flow model simulations for embankment dam and tailing storage facility assessment during mine closure investigations

T. Goode; MWH, Gilbert, AZ

As part of a confidential mine site's closure activities, an evaluation of groundwater flow conditions within the tailing storage facility (TSF) and embankment dam is being completed. The evaluation includes two modeling phases; the first phase simulated regional groundwater flow and streamflow interactions near the TSF using MODFLOW. The second phase uses FEFLOW to simulate variably saturated conditions within the TSF impoundment and embankment dam. Transient simulations have been used to evaluate the viability of the conceptual model of streamflow moving through the tailing and out of the embankment dam underdrain system. The transient modeling analysis evaluated changes in head within and beneath the embankment dam as well as flow through the underdrain system resulting from seasonal changes in impoundment water levels and wetted perimeter. Additionally, transient simulations have been used to evaluate potential flow bypassing the tailing and entering the embankment dam via remnant mine infrastructure (e.g. inadequately abandoned decant lines). Current modeling results are being used in conjunction with field investigations to evaluate embankment dam and underdrain function.

3:25 pm

Evaluating and Mitigating Potential Groundwater Impacts from Phosphate Mining in Southeast Idaho

M. Steinprss¹, B. Hart¹ and K. Bergholm²; ¹Brown and Caldwell, Walnut Creek, CA and ²Agrium, Inc., Soda Springs, CA

Groundwater and surface water contamination from selenium and other metals from mine waste backfill in open pit phosphate mines of the Southeast Idaho Phosphate Mining District has been a significant concern since the late 1990s. The North Rasmussen Ridge Mine Model Validation Study included geologic mapping, hydrogeologic conceptual model development, monitoring well installation and testing, and groundwater flow and solute transport modeling to predict water resources impacts. Anomalously high groundwater elevations in one Wells Formation monitoring well were interpreted to be related to structural compartmentalization of the aquifer. Equilibrium-based geochemical modeling of chemical reactions using the USGS PHREEQC model was essential to accurate simulations of source term concentrations. Low-seleniferous wedges of backfill (wings) over alluvium in the pit walls and an associated waste materials segregation program were demonstrated to be an effective and innovative mitigation measure.

3:45 pm

Dewatering & Aquifer Modelling at Barrick Cortez Hills Underground Mine, Lander County, Nevada

M. Travis; Hydro-Geology, Barrick Cortez, Elko, NV

The Lower Zone (LZ) Carlin-style gold deposit is situated within a different hydrologic regime than the rest of Cortez Hills with artesian high temperature and high pressure water. The Breccia and Middle Zone ores are confined aquifers that dewatered relatively easily with underground wells. The application of surface wells to dewater the LZ aquifer is a function of volumes. The LZ aquifer is an unconfined aquifer that is recharged by the fault-block alluvial basin directly west of the mine; the Crescent Valley basin. Certain confining controls on groundwater in LZ consist of lithology, structure, and cross-cutting intrusives. Very little primary porosity remains except where hydrothermal fluids have decalcified the host rock, therefore groundwater flow relies upon fractures and faulting within the carbonate formations. Modelling of the LZ aquifer with geophysical, hydrophysical, and hydrological data will assist in locating underground well locations to supplement

dewatering efforts that are usually accomplished by more expensive surface wells. These underground wells will in turn provide a certain level of assurance and risk control as mining of the LZ ore approaches.

4:05 pm

High Density Instrumentation in Rotary Boreholes

C. Humphrey, M. Crouter and J. Weigel; Hydrogeologist, South Jordan, UT

The installation of multiple Geokon vibrating wire piezometers, up to eleven, within a single borehole presents challenges in the physical installation and data management. In a sedimentary rock environment, each unit has the potential to have a different water level. With the multiple piezometers, we are able to gain an increased understanding of the pore pressures with in specific units that are a key input into the geotechnical models. Vertical gradients become more apparent, with a high density installation of piezometers due to the increased resolution. In addition to piezometers, we include the installation the of TDR cables for geotechnical monitoring. If the geotechnical TDR cable shears off, there is the potential to utilize the piezometer cables to see if they also break at the same location.

Wednesday, February 24 – Afternoon

ROOM: 131A

2:00 pm

Health & Safety: International Perspectives on Mine Safety & Health

Chairs: M. Anderson, Colorado School of Mines, Golden, CO

E. Clausen, TU Clausthal, Clausthal-Zellerfeld, Germany

2:00 pm

Introductions

2:05 pm

Permit-to-work systems as a risk control strategy in mine health and safety: a prospective study in resilience engineering

M. Pillay¹ and M. Tuck²; ¹School of Health Sciences, The University of Newcastle, Callaghan, NSW, Australia and ²School of Engineering and Information Technology, Federation University, Ballarat, VIC, Australia

Mining is an important contributor to the the social and economic fabric of our society. However, it is also considered to be one of the most dangerous industries. Compared to manufacturing, however, mining is generally a more complex industry to work in, creating additional challenges for policy makers, researchers and practitioners. This calls for more innovation solutions for managing safety in the industry. Many practitioners, however, have continued to rely on contemporary approaches for managing some of the risks inherent in the industry. This paper first discusses the state of mining safety in Australia and outlines some of the complexities that characterizes the industry. Next one contemporary approach, permit-to-work systems, is introduced, followed by a review of the literature relating to its use as a risk control strategy. Resilience engineering is then introduced as an innovation in health and safety management, and a case for researching resilience engineering using permit-to-work systems presented. The paper concludes with a discussion on pragmatism as a research framework and two organizational theories upon which such research can be advanced.

2:25 pm

Dust=Dust?!

E. Clausen, N. Fietz and T. Bartnitzki; Department of Underground Mining Methods and Machinery, TU Clausthal, Clausthal, Germany

Dust is one of the major concerns in underground (hardcoal) mining operations regarding mine health and safety. Liberated during friction processes between the rock mass and the excavation tool dust is a major hazard for lung diseases and dust explosions. In order to master these hazards the focus of international researchers and developers has been attended to measures for dust suppression, ventilation and other activities within the last decades. Despite the hazardous potential, however, dust retrieves also a high potential for utilization. One application for instance, is the material analysis during hardcoal excavation for supporting the automation of excavation processes, e.g. as an instrument for horizon control. In their presentation the authors will outline the current status of development in German health and safety measures for dust control. Additionally, they will give an overview on future potential areas of application for the utilization of dust.

2:45 pm

16-141

Mine Ventilation Monitoring – Comparing Best Practices in Australia, Germany and the United States

J. Brune; Colorado School of Mines, Golden, CO

The mine air in underground coal mines needs to be monitored for quality parameters – sufficient oxygen and toxic gases below allowable limits, for explosibility – methane, hydrogen and other combustible gases, and for fire gases indicating a potential fire. Monitors must also confirm that sufficient quantities of air are available. Monitoring may be accomplished through manual spot readings or by means of fully automated, continuous atmospheric monitoring systems. In this comparison, the author discussed current practices in Australian, German and U.S. underground coal mines and makes recommendations for improvements and best practices.

3:05 pm

16-028

Numerical Model Calibration for Simulating Coal Ribs

K. Mohamed; NIOSH, CDC, Pittsburgh, PA

Rib-failure related accidents in underground coal mines continue to cause injuries and fatalities. Numerical modeling could be an applicable approach for rib design if a calibrated coal-rib model is achieved based on an understanding of the mechanistic behavior of coal mine ribs. The paper presents a framework to simulate the mechanism of rib deformation and the effect of rib bolts in controlling rib sloughing. The coal-rib model used in this study simulates the mine induced fracture (MIF) planes with ubiquitous-joint material model, in which fracture planes activated after a critical plastic shear strain. The critical plastic shear strain of the rib model was defined by calibrating the proposed rib model using a published data of instrumented rib at longwall gateroad of West Cliff Colliery in NSW, Australia. A critical plastic strain of 2.8% was sufficient to develop a fracture plane in the simulated rib. Accordingly, a discontinuous rib deformation was achieved and it was well compared with the instrumented case study.

3:25 pm

Policy changes in coal mining: Comparison and effectiveness on reducing accidents in United States and Australia

S. Agrawal and J. Germand; Energy and Mineral Engineering, Pennsylvania State University, University Park, PA

Ascertaining the effectiveness of policy changes is difficult because no control group exists to compare against, so any effects that do occur may be due to the change or to the natural course of events. In recent years, jurisdictions in both the United States and Australia have made changes in policy to regulate mining

operations with the intent of reducing accidents and worker injuries. This study was conducted to analyze the effect of policy changes on incidences of fatalities and lost-time injuries (LTI) for coal mines in United States (US), Queensland (QLD) and New South Wales (NSW), Australia for a period from 2003 to 2013. A select population of similar mines in US, QLD and NSW with respect to production quantities, geology, methods of mining, and other factors were grouped together to serve as control groups for one another's' policy changes. Then, trends in accidents, fatalities, and LTI before and after regulatory changes were examined. Fatalities and LTI in US mines were higher as compared to QLD and NSW though the group of similar mines displayed much more similar outcomes. Some small trend changes in both locations appear to be policy related based on timing.

3:45 pm

Bionics – a New Approach for Facing Challenges in Mine Health and Safety

E. Clausen and J. Rechner; Institute of Mining, TU Clausthal, Clausthal-Zellerfeld, Germany

As mining activities will be facing future challenges due to deeper and more complex deposit structures, it is necessary to find new and innovative solutions for guaranteeing safe, environmental-friendly and economic feasible mining operations. Especially regarding mine ventilation and climatisation, which is essential for underground Mine Health and Safety, bionics might be the key for more efficient and effective solutions. The presentation will outline the basic concept of biomimetics and present examples of organisms which have adapted to different hostile environments followed by a discussion of main mechanism and concepts, which will lead to the presentation of potential ideas for future inventions and solutions in underground mining.

Wednesday, February 24 – Afternoon

ROOM: 131B

2:00 pm

Health & Safety: NORA: Needs in Data-driven Research in Health and Safety

Chairs: S. Moore, NIOSH, Pittsburgh, PA

L. Saperstein, Missouri University of Science and Technology,
Nantucket, MA

2:00 pm

Introductions

ROOM: 16-044

2:05 pm

Jackleg-Drill Usage and Accidents

C. Clark, D. Benton, J. Seymour and L. Martin; NIOSH, Spokane, WA

NIOSH is conducting research concerning jackleg use and accidents in underground metal mines. This paper is based on information from injury reports, legacy research, stakeholder input, and published literature. It includes an analysis and overview of jackleg drill usage, accidents, operational characteristics and alternatives. The jackleg is a handheld rotary-percussive rock drill with integrated thrust leg used in the mining industry for drilling and ground support installation. Its use is concentrated in western underground metal mines with narrow profiles that do not allow for large openings and the use of mechanized drilling and ground support installation equipment. Jackleg drills were involved in 46% of the injuries associated with falls of ground while drilling and bolting in underground metal mines

in the US during 2006-2012. These ground falls are most prevalent at the face in the course of installing initial support. Alternatives to jackleg use for drilling and bolting under incomplete support are not fully-developed, although prototypes are underway. This is an important gap that needs to be filled to improve safety at these mines.

2:25 pm

Research Driven Safety and Health Gains for the Mining Industry

J. Kohler; Energy and Mineral Engineering, Penn State University, University Park, PA

Safety and health has improved consistently over the decades, although not always as quickly as we would like, and occasionally interrupted by catastrophic events. The mining industry has committed to eliminate fatalities and to reduce injuries within the decade. The success of this effort will depend in part on the availability of enabling knowledge, technology, and practices; and while the incremental gains characteristic of past improvements will remain important into the future, broader and more impactful changes will be essential. This paper identifies research that will be required to achieve the aggressive targets established for mine safety and health.

2:45 pm

Statistical Model Study to Analyze Non-fatal Injury Rate for Coal Mines

S. Jung; Civil, University of Idaho, Moscow, ID

Coal mine accidents and injuries are complex and generally related to personal and work-environmental characteristics. Work-environmental characteristics should be addressed as the majority of accidents were attributed to a relatively small percentage of the work-environmental errors. In this study, work-environmental characteristics such as mining height, average number of employees, productivity and mine type were considered. Although both Poisson and negative binomial regression are designed for counted base data, negative binomial regression was better suited for non-fatal injuries in coal mines. The results of negative binomial regression indicated that all variables, except mining height, were significantly affected coal mine safety. Mines with more employees were more prone to non-fatal injuries than the smaller mines. Mines with low productivity suffered more dangers. Extreme attention should be given to those underground anthracite coal mines. From these results, a safety rating system was built by using a prediction interval from the negative binomial regression. This system might be used to compare mines with similar characteristics for further evaluation.

3:05 pm

Update on the Health Effects of Diesel Exhaust

E. Green; Crowell & Moring LLP, Washington, DC

With the 2012 publication of the NIOSH/NCI Diesel Exhaust in Miners Study (DEMS) and the International Agency for Research on Cancer (IARC) finding that diesel exhaust is a human carcinogen, these controversial determinations have led to a flurry of activity as follows: (1) a decision by NIOSH to prepare a new diesel exhaust risk assessment; (2) a request for information on diesel exhaust by MSHA; (to be published in the Federal Register for public comment; and (3) a study of the key scientific literature by an expert panel appointed by the Health Effects Institute. This presentation will explore how all of these activities portend tougher regulation for exposure to diesel exhaust of underground and surface coal and metal/nonmetal miners, as well as increased attention by state and local governments and the private plaintiffs' bar.

Wednesday, February 24 – Afternoon

ROOM: 221A

2:00 pm

Industrial Minerals & Aggregates: Minerals and Oilfields: Common Chemistries and Practices

Chairs: H. Kim, Chonbuk National University, Jeonju, Korea (the Republic of)
H. Kolla, ChemEOR, Covina, CA

2:00 pm

Introductions

2:05 pm

At Line Particle Size Analysis of Drilling Mud with Auto Sampling and Dilution

P. Obrien and T. Canty; Engineering, JM Canty Inc, Lockport, NY

Monitoring the particle size distribution of drilling mud is critical to its performance. The mud must be efficient at lubricating and cleaning the drill string and bit, transport cuttings away from the bit and form a filter cake to stabilize the well bore as primary examples. The particle size of the solid constituents that make up the mud are critical factors affecting the performance. Current particle analysis of mud is done off line and is a labor intensive function. Capability now exists to sample the mud, prepare the sample and analyze for particle size and shape using vision technology equipped with auto sampling and auto dilution. This patent pending technology diverts a full diameter sampling of the mud line into a reservoir where water or oil, depending on mud base fluid, is used to dilute the slurry. Software controls the dilution by assessing the particle density flowing from the reservoir through the vision analyzer where size and shape of the particles are determined. Vision provides the capability to determine size and shape which is critical for mud particle analysis. The analysis can be done as often as desired, and consumed diluent can be separated and reused.

2:25 pm

Next Generation Water Soluble Dry Polymers for Oilfield and Mining Applications

C. Aften; R&D, ChemEOR Inc., Covina, CA

A new class of dry acrylamide (DPam) based polymers have been designed and synthesized which have changed the way friction reducers (FRs) and flocculants are used in the oil and mining industries. These novel polymers are in a class of their own, they are ultra-fast hydrating compared to traditional dry polymers (15 minutes vs. 2 hours), this technology can be utilized to manufacture a wide range of DPams including anionic, cationic, amphoteric, high and low molecular weight polymers. In this paper, we describe the use of these new polymers as friction reducers in oilfield stimulation using a variety of brines. With varying the backbone/functional group(s), we can tailor this to act as flocculants for any specific mineral type, especially for thickening and dewatering.

2:45 pm

Study of Novel Temporary and Permanent Clay Stabilizers in Oilfield Stimulation

C. Aften; R&D, ChemEOR Inc., Covina, CA

Various clay stabilizers are employed when stimulation requiring aqueous based fluids is necessary in water sensitive formations. Typically, if swelling or migrating

clays are present, temporary or permanent stabilizers are utilized. Temporary clay stabilizers, usually low molecular weight, as a rule perform above a critical level concentration, but as the stabilizers concentration diminishes in the fracturing fluid due to flowback, formation fluid displacement, or other mechanisms, the clay can swell reducing porosity and permeability. Permanent stabilizers are generally higher molecular weight and can adhere to single or multiple clay platelets thus dissolution of the stabilizer into the fluid is not favored and the beneficial anti-swelling effect is of higher duration. In this paper, we present the performance results from a systematic study of novel and contemporary clay stabilizers. These interactions range from synergistic to antagonistic and are presented on a response surface with good correlation. Both organic and inorganic permanent and temporary clay stabilizers are studied.

3:05 pm

16-071

Choosing a Defoamer and a Defoamer Type and the Role of Defoamer in Operation of Industrial Processes

R. Wilson; R&D, SIXIN North America, Marietta, GA

Abstract for Industrial Minerals and Aggregates: Minerals and Oilfields – Common Chemistries and Practices Seccession Author – Robert Wilson Sixin North America Foam, unless intentionally needed, in any industrial process presents operational problems or at a minimum a nuisance. Some of the foam problems are unique to a given industry and others are common across many industries. Some of the typical problems foam presents to any particular industry are: 1) Poor Housekeeping 2) Environmental impact 3) Safety Hazards 4) Slower Production Rates and 5) Reduced quality of the product. Defoamers address these issues. The assumption in most industries is all defoamers are alike in reality, a lot of chemistry is involved in the manufacture of even the simplest defoamer sold today and rarely are any two defoamer “just alike”. Today’s defoamers can include polymer chemistry, alkoxyated alcohols and esters, silicone chemistry, ethoxyated and propoxyated block polymers, and emulsion chemistry just to name a few. This paper will discuss the various types of defoamers, the mechanisms, advantages and disadvantages of defoamer selections, and how to choose the proper defoamer for your application.

3:25 pm

16-068

Productivity analysis of oil in accordance with the dissolution characteristics of carbonate rocks

D. Kwak, Y. Lee and J. Kim; Mineral Resource & Energy Engineering, Chonbuk National University, Jeonju-City, Korea (the Republic of)

In carbonate rocks, it is difficult to characterize due to the high degree of heterogeneity in pore geometry. Carbonate rocks have various types of pore systems such as fractures and vugs, and this heterogeneity should be considered for more realistic prediction of oil production in carbonate reservoirs. This study carried out water flooding experiments using five carbonate rock samples in order to observe the change of physical properties. Firstly, qualitative and quantitative analysis were conducted for each carbonate samples by use of XRD and XRF to evaluate the mineral content. All samples are mainly composed of CaCO_3 and after that, the ICP experiments were carried out for the water passing through the carbonate. As a result, it was possible to measure the quantity of CaCO_3 , MgO , SrO component in water and due to this effect, the permeability of carbonate was altered especially at the front part of the core. Finally, after the carbonate was saturated by 30 API crude oil, water injection to enhance the oil recovery was repeated and it was confirmed that the oil-producing characteristics are different depending on the dissolution characteristics of carbonate rock samples.

A study for the AGIP estimation by using adsorption experiments in Horn river shale

J. Kim, H. Jung, Y. Seo and Y. Lee; Resources and Energy Engineering, Chonbuk National University, Jeonju-si, Jeollabuk-do, Korea (the Republic of)

It is believed that gas in shale reservoirs is mainly composed of free gas within fractures/pores and adsorbed gas in organic matter. An important component of hydrocarbon storage in coalbed methane and organic-rich shales is sorption within organic matter. It is generally assumed in the literature that the Langmuir isotherm describes gas adsorption behavior in shale gas reservoirs. In this work, shale samples from Kiwigana field in Horn river basin were used. The adsorption amount was measured using Belsorp-hp measuring system by applying volumetric method. The adsorption amount was calculated by subtracting gas amount remaining after adsorption equilibrium for the various depth. More than 6g of shale sample is needed to get valid measurement results due to the low TOC (Total organic carbon) of shale comparing with coal. Finally, the adsorbed gas content for various depth were allocated to each layers of shale formation for the AGIP (Adsorbed gas in place) calculation.

4:05 pm

Shale and Scale Inhibitors for Oilfield and Mining Applications

L. Wang, W. Watson and W. Goss; Oilfield Chemicals, Ingevity, North Charleston, SC

Two problems shared by both oil and mining applications are scale deposition and swelling clays. In the oilfield, Ca, Ba, Sr, and silica scales can block piping in an oil or gas well, leading to lost production time. Swelling clays can cause fractures to shut or proppant to embed into fractures, negating the benefits of a frac job. In mineral processing, slurry pipelines and pumps can become compromised by scale, and clays can impede flotation and the movement of slurry in pipelines. Standard treatments for these oilfield issues have drawbacks. Specialized equipment is required to know the amount of residual scale inhibitor in a well, and if the amount of scale inhibitor falls below the MIC, scale forms. Clay inhibitors can desorb from the particle surface, allowing swelling to occur, or negatively interact with other stimulation chemistries. This paper discusses new chemistries for scale and clay inhibition. The scale inhibitor is detectable by a simple field titration, instead of costly lab equipment. The clay inhibitor tightly adsorbs onto clay surfaces, is compatible with a range of additives, and does not change the wettability of the mineral surface.

Wednesday, February 24 – Afternoon

ROOM: 221B

2:00 pm

Industrial Minerals & Aggregates: Talc, Pyrophyllite and Other Lammellar Minerals II

Chairs: J. Childs, Childs Geoscience Inc, Bozeman, MT
G. Tomaino, Minerals Technologies Inc, Easton, PA

2:00 pm

Introductions

2:05 pm

Is Talc becoming the new “asbestos”?

M. Rutstein; ECMS, Inc., New City, NY

Talc’s relatively unregulated usage in human society is now being impacted by environmental and legal efforts to: 1) find “asbestos” contamination in present and past products and correlating this with disease because only “presence” is believed to matter; and 2) develop state-of-the art analytical methods to characterize present ores and products. For past products, the question often put forth is “but can you be absolutely sure that NO asbestos was ever present”? Currently, attention focuses on characterizing products mined from geological environments essentially free of amphiboles in the primary ore where it is argued that asbestos contamination is not a legal and health problem. However, even for such deposits, localized geologic processes can produce minor amounts of amphiboles and serpentine, sometimes of asbestiform habit. As lawyers troll for the possible occurrence of “asbestos” in products, we must deal with the issue of public perceptions of a product in an increasingly chemophobic and litigious society. How can we do this and still mine talc? Or do we succumb to the pressures and cease mining talc, perhaps turning instead to synthetic phases or other platy minerals.

2:25 pm

Casting Talc as Hamlet: To Regulate or Not to Regulate?

M. Ellis; Industrial Mineral Association NA, Washington, DC

Talc is an industrial mineral that has been used commercially around the globe for hundreds of years. It is considered to be safe for its intended uses. However, because of its chemical composition and mineralogy, talc sometimes is associated other minerals that may occur in the same ore body. Some of these co-located minerals do not share talc’s reputation for safe use. Such negative associations have led some regulatory authorities to consider regulating talc the same as these other unnamed minerals. This presentation explores the product stewardship challenges attending this regulatory guilt by association.

2:45 pm

16-129

Current issues with purported “asbestos” content of talc: Part 1, Introduction and examples in metamorphic and ultramafic hosted talc ores.

M. Gunter¹, M. Buzon¹ and B. McNamee²; ¹Geology, University of Idaho, Moscow, ID and ²University of North Carolina, Asheville, NC

A Google search on talc asbestos will yield over 500,000 hits – the reason being the growing number of civil lawsuits in this area. Historically the litigation was centered on amphibole-containing industrial talc. There was no debate these talcs contained amphiboles, but the issue was the definition of asbestos. Ultramafic hosted talcs, however, are formed in such a way as to not favor the formation of amphiboles in the talc; they can occur in the surrounding black-wall, also the serpentinite host rock is in direct contact with the talc. Thus allegations can be made non-asbestiform amphiboles or non-regulated serpentine group minerals can occur in the final products. (M.E. Gunter is currently working with past and current producers of talc.)

3:05 pm

16-100

Current issues with purported “asbestos” content of talc: Part 2, Examples in hydrothermal hosted talc ores

M. Buzon; Geological Sciences, University of Idaho, Moscow, ID

Talc formed by hydrothermal alteration of preexisting carbonate rocks is known to be nearly mono-mineralic, and lacking in amphiboles. In southwest Montana, talc formed from hydrothermally altered dolomitic marbles, and is still actively mined. These talc deposits are typically in contact with quartzo-feldspathic gneiss and marble. Accessory minerals vary between these rocks and the ore producing

body; the identification and characterization of such minerals requires carefully selected analytical methods. Recent litigation and ensuing confusion over the petrology and asbestos content of these deposits challenges the talc mining industry in Montana, and elsewhere in the world. (M.E. Gunter is currently working with past and current producers of talc.)

3:25 pm

USP and ASTM Method Development for the Analysis of Talc for Contaminant Asbestos

J. Pier; Analytical Laboratory, Imerys, San Jose, CA

The United States Pharmacopeia organization formed a Talc Expert Panel in 2010 to address a request submitted from the USFDA to modernize the USP-NF Talc monograph and ensure the “Absence of Asbestos” test has adequate specificity. The 2010-2015 Talc Expert Panel published a background document that includes recommendations with a focus on improving detection limits and including updated microscopy techniques (polarizing light microscopy and electron microscopy). Appointment of a 2015-2020 Talc Expert Panel will continue this work and will include investigating analyte concentration techniques to improve detection limits. Spiked standards with known concentration will be developed to aid in this effort. ASTM International is also developing a similar method following claims that asbestos was found in off-the-shelf cosmetics in Korea and China in 2009. The FDA sponsored a survey of US off-the-shelf cosmetics and personal care products as well as talc raw materials obtained from US talc suppliers. Testing in 2010 confirmed no asbestos was found in any of the materials. Collaboration of standards organizations with industry, academia, and government agencies will be discussed.

3:45 pm

Defensible XRD Evaluations – Talc

G. Tomaino; Minerals Technologies Inc, Easton, PA

This talk will cover ISO 17025:2008 quality system, general and specific test method(s) and associated work instructions for instrument acceptance and analyst competency in the realm of defensible XRD evaluations and within the confines of XRD evaluations specific to talc. NIST traceable references, primary and secondary talc references, in-house talc references, spiked talc references (amphibole and serpentine), and relative detection limits prior to pre-concentration techniques by XRD will be reviewed in the talk. Two pre-concentration techniques, selective sieving and heavy liquid media, alone or in combination will also be reviewed where concentrates would aid in lowering relative detection limits of amphibole and serpentine in talc by XRD. These concentrates can be used for various microscopic evaluations PLM or TEM, or SEM/FESEM or combinations thereof.

4:05 pm

Serpentine and amphibole group mineral characterization in talc ores and talc based products by contract laboratories, accurate and defensible TEM evaluations

M. Sanchez, M. McGrath and R. Lee; RJ Lee Group, Monroeville, PA

Allegations of asbestos contaminating talcum powder products increase the need for scientifically accurate testing with legally defensible data. This is paramount in the evaluations of known and prospective talc sources. The majority of asbestos laboratories utilize methods promulgated by OSHA or USEPA. While TEM methods employed are based on scientific principles, over the past two decades asbestos analysis has become commodity-based. For the mining and manufacturing industries it has created asbestos testing with limited understanding of the fundamentals of mineralogy and crystallography. For correct and defensible data an understanding of these subjects specific to amphiboles are required. The goal of this presentation is to educate those in the mining industry on what the minimum standard of data reporting that can be independently verified and thus can be defended. Examples of type I errors will illustrate this need.

4:25 pm

Serpentine and amphibole group mineral characterization in talc ores and finished products by contract laboratories, accurate and defensible PLM evaluations

M. Sanchez, M. McGrath and R. Lee; RJ Lee Group, Monroeville, PA

Allegations of asbestos contaminating talcum powder products increase the need for scientifically accurate testing with legally defensible data. This is paramount in the evaluations of known and prospective talc sources. The majority of asbestos laboratories utilize methods promulgated by OSHA or USEPA. While PLM methods employed are based on scientific principles, over the past two decades asbestos analysis has become a commodity-based. For the mining and manufacturing industries it has created an environment of asbestos testing with limited understanding of the fundamentals of minerals and their optical properties. The goal of this presentation is to educate those in the mining industry on what the minimum standard of data reporting that can be independently verified and thus can be defended. Examples of type I errors by asbestos labs misidentify elongated talc particles as amphibole asbestos by PLM will illustrate this need.

Wednesday, February 24 – Afternoon

ROOM: 128A

2:00 pm

Mining & Exploration: Geology: Larmide Geology

Chair: I. Barton, UA Lowell Institute for Mineral Resources, Tucson, AZ

2:00 pm

Introductions

2:05 pm

Cordilleran Fe oxide(-copper-gold) “IOCG” mineralization: synthesis and opportunities

M. Barton; University of Arizona, Tucson, AZ

Variable amounts of copper and gold accompany hydrothermal iron mineralization in the Cordillera of North and South America. These deposits belong to the overall IOCG (iron oxide-copper-gold) clan, of which Olympic Dam, South Australia, and the Carajas Province of Brazil are global examples. In the Cordillera, the best known Cu(-Au)-rich deposits include Candelaria and Mantoverde in South America and Pumpkin Hollow in North America. These deposits are parts of huge but heretofore largely unrecognized hydrothermal Na-Ca-K alteration systems. Alteration was dominated by non-magmatic (evaporitic) brines and affected tens of percent of the upper Mesozoic arc crust over large regions. Economically mineralized Fe and Cu(-Au) occurs in the upper 1-3 km of the crust, with Cu(-Au) ores shallow and overlying Fe(-P) ores. The preponderance of “barren” (Cu < 0.2 wt%) Fe oxide ores points to the importance (and rarity) of an independent source of sulfur for precipitating Cu. These results point to prospective areas (shallow settings, evaporitic fluids, marine-influenced sulfur sources) throughout the Cordillera of the Americas.

2:25 pm

U-Pb Dating of and implications for Laramide porphyry copper systems

R. Stegen², J. Mizer¹, M. Barton¹ and E. Seedorff¹; ¹University of Arizona, Tucson, AZ and ²Freeport-McMoRan, Oro Valley, AZ

In spite of the economic importance of the Laramide (80-50 Ma) porphyry copper province of the southwestern North America, there have relatively few absolute ages produced by U-Pb methods. Zircon U-Pb provides robust ages of igneous activity and, by virtue of cross-cutting relationships, associated mineralization. Over 100 new U-Pb dates on Laramide porphyry systems reveal that patterns are complex, even within single districts, and that simple notions of eastward migration of magmatism and mineralization should be reconsidered. These results point to the importance of multiple intrusive and mineralizing events in the same district. Some, but not all igneous centers are long-lived; in these cases, multiple variable superimposed hydrothermal centers (and Cu(-Mo) deposits) were produced over a span of a few millions of years. Examples of the latter include the Pima, Morenci, Safford, and Globe-Miami district.

2:45 pm

Contractional deformation, magmatism, and hydrothermal systems in the southern Tortilla Mountains, Laramide porphyry copper province, Arizona

D. Favorito and E. Seedorff; Geosciences, University of Arizona, Tucson, AZ

Porphyry copper systems form in magmatic arc settings, but the space-time relationship of magmatism and mineralization to periods of reverse faulting remains elusive. The geometry of Laramide contraction also is unclear along much of the porphyry belt in Arizona (e.g., low-angle thrusts vs. higher angle reverse faults) because porphyry systems have been dismembered and tilted by superimposed Tertiary normal faults. The Romero Wash area between Ray and San Manuel exposes reverse faults and a sequence of variably altered intrusions, where the effects of normal faulting are relatively straightforward. New mapping and structural reconstructions provide constraints on geometries and space-time relationships.

3:05 pm

Vein-hosted Ag in the Cerro Colorado District, Pima County, Arizona

J. Mizer¹, M. Barton¹, E. Seedorff¹ and R. Metz²; ¹Geosciences, University of Arizona, Tucson, AZ and ²Professional Minerals Development, LLC, Tucson, AZ

The Cerro Colorado District has produced silver, lead, zinc, and copper but has been the subject of only limited study since the early works of Davis (1955) and Jones (1957). New U-Pb ages in the district show extensive andesite and local granitic rocks hosting Ag mineralization in quartz-calcite-barite veins to be Laramide in age. These veins display polymetallic mineralization with Ag, Pb, Zn, and Cu in galena, tetrahedrite, balkanite, and imiterite. Locally, host rocks adjacent to veins display only weak hydrolytic alteration. Pervasive propylitic alteration in widespread Cretaceous andesite accompanies disseminated sulfide and native copper mineralization and does not appear to be associated with the vein systems in the district. This suggests a different mechanism is responsible for copper mineralization and propylitic alteration in the district. The possible relationship of this and other Ag vein systems with porphyry copper centers across Arizona has yet to be thoroughly investigated. Proximity of the Cerro Colorado District to the vastly mineralized Laramide arc, specifically, the Pima Mining District, should be considered when evaluating Ag-base metal systems in the area.

New investigations of the mineralogy of silver in the world-class porphyry-lode deposits of Butte, Montana

C. Gammons and J. Szarkowski; Montana Tech, Butte, MT

The Butte mining district, a famous porphyry-lode copper deposit, has produced over 750 million ounces of silver. Archived samples of Ag-rich ore specimens from the Anaconda Collection, as well as new samples from the active open pit mine, are being examined by ore microscopy, SEM-EDX, and electron microprobe analysis (EMPA). Silver mineralization in Butte falls into three categories: 1) as an impurity within Cu-sulfide minerals; 2) as discrete, primary, Ag-bearing sulfide and sulfosalt minerals; and 3) as Ag-rich minerals formed during supergene enrichment. Sulfide minerals in which Ag appears as a significant impurity include chalcocite, covellite, bornite, enargite, tetrahedrite, and tennantite, as well as less common minerals such as wittichenite, colusite, and betekhtinite. Common primary Ag-bearing minerals include pearceite, argentite, and stromeyerite. Less common minerals (some reported from Butte for the first time in this study) include stephanite, furutobeite, larosite, jalpaite, and electrum. In the supergene enrichment zone, acanthite and/or stromeyerite has replaced pre-existing sulfide minerals, or silver may precipitate as the native metal.

3:45 pm

New models of exploration potential within the Boulder Batholith, southwest, Montana

S. Korzeb¹, K. Scarberry¹ and J. Zimmerman²; ¹Montana Bureau of Mines and Geology, Butte, MT and ²Montana Tech, Butte, MT

The Boulder batholith is located in southwestern Montana extending from Butte to Helena. A program was started at the Montana Bureau of Mines and Geology to examine the Boulder batholith for future exploration targets. Studies on stable isotopes, fluid inclusions, alteration types, trace element and whole rock geochemistry, mineralogy, geophysical studies by the USGS, and vein geochronology are ongoing in the Emery, Oro Fino, Lowland, and Big Foot districts. Preliminary-study results, particularly the Emery district, share geologic attributes in common with the world-class Butte district, indicating a potential for future exploration. Trace element geochemistry and alteration types from the Emery district fit the porphyry system model for an overlying lithocap. Sulfur isotope data from Emery district veins are similar to Butte veins and suggests a Belt-Supergroup source for the sulfur in both ore systems. Isotope and fluid inclusion data indicates the Emery veins developed from hydrothermal fluids with a magmatic source. In summary, the ongoing study suggests a potential exploration target for a deep porphyry deposit at Emery, and possibly elsewhere in the Boulder batholith.

4:05 pm

Hydrothermal Alteration and Mineralization at the Chukaru Peki Project, Timok Cu-Au district, Serbia

M. Wetzel², V. Canby² and M. Barton¹; ¹Geosciences, University of Arizona, Tucson, AZ and ²Freeport McMoRan, Oro Valley, AZ

Chukaru Peki is a recently discovered, concealed, high-grade Cu-Au deposit near Bor and within the Timok Cu-Au metallogenic belt, Serbia. High-grade Cu and Au mineralization (see Chen and Canby, this meeting) is a part of zoned high-sulfidation-porphyry system hosted in Upper Cretaceous andesitic rocks which are cut by intermediate composition porphyritic dikes. Mineralization is overlain by ~500m of post-mineral sedimentary rocks. An upper zone consists of high-grade, brecciated to massive Py-Cv-Dg-Bn-En mineralization and associated advanced argillic (Pyroph-Alun-Kaol-Qz) alteration. Upper zone mineralization partially overprints underlying potassic (Bi-Kf-Anh) to sericitic alteration and Cpy(-Bn-Mt)

mineralization typical of many Cu-Au porphyry deposits. The two likely share a common origin, but the extent to which they are linked is uncertain. These results are based on logging of >5000m of core, petrographic examination of >100 samples, and geochemical sampling. This information has been used to characterize rock types, mineral assemblages, petrogenesis, and the overall time-space development of the hydrothermal system.

Wednesday, February 24 – Afternoon

ROOM: 128B

2:00 pm

Mining & Exploration: Management: Utilizing Optimization Effectively

Chair: A. Brickey, South Dakota School of Mines and Technology,
Rapid City, SD

2:00 pm

Introductions

2:25 pm

Return on Investment (ROI) Benefits of FMS Investment vs. Haul Truck Purchase

N. Ferreira; Marketing, Modular Mining Systems, Tucson, AZ

In 2013, an open-pit copper mining operation in British Columbia, Canada, made the decision to invest in a fleet management system (FMS). After the purchase, the mine compared the potential ROI of implementing the FMS vs. buying an additional haul truck. The ROI calculation was based solely on additional tonnage that could be moved if both shovel hang times and truck queue times were decreased. Baseline data was collected three months after FMS installation, with the FMS's optimization algorithm disabled. The process was repeated three months later with the optimization algorithm enabled. In this phase, hourly production increased by nearly four percent, which equates to an annual production increase of just over \$2,000,000 or the volume of material moved by an additional 1.04 haul trucks. By implementing an FMS and utilizing its optimization capabilities, as opposed to buying an additional truck, the mine experienced a first-year cost savings of more than \$4,200,000. The ten-year savings were calculated at almost \$5,200,000. This presentation will discuss the mine's decision-making process, the improvements realized from FMS usage and the ROI from investing in an FMS vs. a truck.

2:45 pm

Integrated Optimization of the Life-of-Mine Schedule and Phase 2 Infrastructure Expansion at Freeport-McMoRan's Tenke Fungurume Mine, DRC

*J. Kraft¹ and J. Hawley²; ¹Minimax, Highlands Ranch, CO
and ²Freeport McMoRan, Oro Valley, AZ*

Freeport-McMoRan's majority-owned Tenke Fungurume operation is the largest copper-cobalt producing complex in the Democratic Republic of Congo. This study was performed for the optimization of an oxide processing capacity expansion that was undertaken by Tenke Fungurume and completed in 2014. The timing and magnitude of expansion/investment was determined while leveraging the availability and development of existing and new surface mining reserves, existing oxide processing capacity and other associated constraints.

The decision of optimum capital investment given this framework was achieved through concurrent consideration of the financial impacts of each of the possible expansion alternatives and the mining sequence derivation within a single optimization, not through traditional scenario analysis. This integrated problem was mathematically modeled and optimized through commercially available technology in order to determine the maximum value strategy given this important expansion/investment decision.

3:05 pm

16-038

Using Lean Six Sigma Techniques to Prioritize and Define Business Value for Projects at a Mature Uranium Mine and Mill

S. Britton; Cameco Corporation, Saskatoon, SK, Canada

This paper discusses the use of both lean six sigma and operational reliability techniques to improve operating management's understanding of the business value (i.e. reduction in operating costs) derived from improving process controls, data collection and ultimately, operations in both the underground mine and processing plant of a mature uranium facility in northern Saskatchewan. The discussion will focus on several specific projects completed as well as underway and include the analysis of their expected business value and payback. The results will demonstrate the importance of continuous operating improvement through the collection and analysis of operating data.

3:25 pm

Implementing Mine Scheduling Optimization at an Underground Mine

B. King¹ and A. Brickey²; ¹Mechanical Engineering, Colorado School of Mines, Golden, CO and ²Mining Engineering, South Dakota School of Mines, Rapid City, SD

With current technological gains it is now possible to schedule large, and complex underground mines using deterministic optimization techniques. We present a practical methodology for scheduling a large-scale underground mine using integer programming. Mine planners can use these techniques to improve value, identify production limiting resources, and quickly adapt to changing market conditions. By using current industry software and recently developed solution techniques, our methodology is able to efficiently and quickly schedule a two-year time horizon. Additionally, the underlying formulation is robust enough to be applied to many different underground operations.

3:45 pm

Harmonizing multiple schedules for a smoother, more productive workflow

A. Moharana¹, J. Quispel², Z. Huang³ and G. Wylde³; ¹Client Services, Hexagon Mining, Tucson, AZ; ²Morenci Operations, Freeport McMoran, Morenci, AZ and ³Software Development, Hexagon Mining, Tucson, AZ

Mining plans at multiple resolution levels are an integral part of every operating mine. Plans are continuously generated to ensure optimal and practical schedules across scheduling horizons. To achieve this objective a two-way update is required across the scheduling horizons. The longer horizon schedule should guide the shorter horizon, while the shorter horizon updates the longer for the overlapping time periods. Linking portions of different resolution schedules is difficult due to different time frames and planning assumptions used during the scheduling processes. Mines have typically relied on spreadsheets to transfer results from one scheduling horizon to another. This is time-consuming and difficult to manage

and control. This process becomes sub-optimal for leach operations as the mining schedules interact with the destination schedules and SXEW schedules. The paper shows how the direct integration of scheduling products (MineSight Schedule Optimizer for long-term schedules and MineSight Atlas for short term) addresses this issue with a better way to share scheduling results between different mine planning departments while striving for an optimal and practical schedule.

Wednesday, February 24 – Afternoon

ROOM: 125A

2:00 pm

Mining & Exploration: Operation: Continuous Improvement in Surface Operations II

Chair: M. Harman, Summit Materials, Denver, CO

2:00 pm

Introductions

2:05 pm

Understanding the “Why” of Continuous Improvement in Mining Productivity Environments

Z. Saufley; Application Engineering, Joy Global, Milwaukee, WI

In a tough global mining economy, Continuous Improvement (CI) projects become high priority for many mine operators. The standard CI projects focus on the “what” of the improvement, but what about the “why”? Information is in over-abundance on many surface operations – you can get overwhelmed by the ‘what’ of production goals and metrics. Getting back to the basics of operating can be a huge, yet simple, CI effort. Identifying the “what” of loading area bottlenecks from metrics like truck exchange time, spot time, truck wait time, and cycle time can help with the “why” of it for help in operator best practices, supervisor training and managerial goals.

2:25 pm

16-127

A Step Change in Dragline Performance is Possible Safer. Greener. Lower Operating Cost

R. Adsero; Current Power Solutions Inc, Houston, TX

In view of the decade long decline in worldwide mine equipment productivity and with heavy economic pressures and survival at risk, improvements for those remaining in the game are essential. The latest Multifactor Productivity data for the US mining industry indicates a continuing descent with Australia on a similar course. The world’s mining industry has a fleet of over 400 large draglines moving billions of tons of overburden annually. The most efficient use of this equipment resource will provide a competitive advantage to those companies who are committed to improving performance. A dragline monitoring system is a requirement for optimum operations. The monitor reports the facts. Focused actions can change the facts and create improved performance. Analyzing monitor data to build knowledge and create understanding is a beginning. Understanding the key productivity indicators for dragline operations and an effective benchmarking process are the basis for improvement. There is overwhelming evidence that adopting new technologies and concepts including AC drive technology can and will bring about a step change in dragline operating cost with improved production performance.

2:45 pm

Focusing the Company – Selecting KPIs in a Data-driven Mining Company

T. Matiske¹ and H. Greeff²; ¹Trimble Mining, Denver, CO and ²OPTRON, Centurion, South Africa

Key performance indicators (KPIs) are defined as measurable values which demonstrate how effectively an organization is achieving its key business objectives. The choice of a suite of KPIs which measures the full spectrum of an organization's activities and objectives is not a trivial undertaking. It requires an understanding of the organization's processes, the relationships between those processes, and the underlying drivers for each of the selected KPIs. This presentation discusses the development of the value driver trees which support KPIs and which lead to the selection of appropriate KPIs for an organization.

3:05 pm

Modeling Blast Movement for Grade Control

E. Isaaks; Earth Sciences, Isaaks & Co., Emerald Hills, CA

The mining industry has focused a great deal of attention recently on the impact of blast movement on grade control. Although the problem of blast movement and its contribution to dilution and ore loss is well known, solutions to the problem are less than satisfactory. One common solution is to displace pre-blast dig line polygons by distances and directions indicated by blast movement monitoring (BMM) data. However, studies show that blast movement not only displaces material laterally but also mixes material within the bench. This paper presents a method for modeling the post-blast muck pile that accounts for displacement and internal dilution using simulated annealing. The pre-blast ore control block model is re-blocked to unit sub-blocks. Each sub-block is displaced by simulated BMM vectors conditional to post-blast surface topography, blast initiation sequence data and BMM vector data. The displaced sub-blocks are aggregated into new ore control model blocks whose grades are calculated from the contained sub-blocks. New dig lines are then designed on the post-blast muck pile model using the new ore control block model grades. A case study based on actual data is provided.

3:25 pm

Overcoming Barriers to Innovation in Ancillary Mining Operations such as Environmental and Fleet Operation

D. Johnson; Eco-Edge, Chandler, AZ

Innovation in traditionally "ancillary areas" of a mine such as environmental and fleet operations has often been hard to implement. Reasons can include things like mine culture, perception of relative cost/benefit/risk, and that few operations can truly dedicate sufficient resources to all the options in these ancillary functions. Relying on equipment dealers or what other mines are doing can leave a mine behind the curve. In today's market, mines can't afford to overlook opportunities for cost reduction and efficiency within ancillary operations. How does management take the leap of faith, integrating innovation into areas in which they aren't a current expert or have the time or resources to hire or become one? We will examine barriers to innovation and ways to eliminate them or mitigate their impact. Using real examples, including participant experiences and presenter case studies, we'll explore how challenges can be avoided. Participants will also learn of innovative solutions that they can use to get the operational improvement ball rolling within their own companies and channel their excitement about ideas they get from SME sessions and exhibits into their own operations.

4:05 pm

How Proximity Awareness improves safety by expanding operator awareness at an open pit copper mine

M. Yildirim¹ and N. Légaré²; ¹Global Mining, Caterpillar Inc, Chandler, AZ and ²Drill & Blast Engineer, Miami, AZ

Most accidents that involve product operation, maintenance and repair are caused by failure to observe basic safety rules or precautions. An accident can often be avoided by recognizing potentially hazardous situations before an accident occurs. A person must be alert to potential hazards, including human factors that can affect safety. Proximity Awareness brings this level of safety to surface mines by expanding machine operator awareness of the working environment. The author will review the best practices of a Proximity Awareness system, and its capabilities built on a Radar based Vision augmented system. The paper has a case study which is an open pit copper mine in Arizona with 30 machines.

Wednesday, February 24 – Afternoon

ROOM: 127B

2:00 pm

Mining & Exploration: Operations: Practical Mine Ventilation

Chair: G. Goodman, NIOSH, Pittsburgh, PA

2:00 pm

Introductions

2:05 pm

16-049

Surmaoja main fan noise evaluation at the Kemi Mine

A. Martikainen¹ and H. Dougherty²; ¹Kemi Mine, Outokumpu Chrome, Kemi, Finland and ²Mining, Virginia Polytechnic Institute and State University, Blacksburg, VA

At the Kemi Mine, a recent expansion into the Surmaoja orebody required an increase in ventilation capacity. A new ventilation shaft was built with two main fans. The installation is near the entrance gate and only 1.7 kilometres from the nearest permanent dwelling. The main fans were first taken into use as exhaust fans in October 2014. Shortly after the fan installation, comments concerning fan noise were received from the neighbours. The first noise measurements were taken at the main fan installation site by Outokumpu personnel in March 2015. Due to higher than expected recorded values, during late June, 2015, a two-week environmental noise study was planned by the engineers and executed by a consultant specialized in noise measurement. The measurement results were analysed and compared to the requirements of the environmental permit and Outokumpu's factory standards. While the measured values at the nearest dwelling were within the environmental permit limits, high noise values were recorded at the fan station. A second two-week study will be performed after construction of the main-fan heating station has been completed. Actions taken will depend on the outcome.

Investigating Diesel Particulate Matter Reduction Using Local Ventilation Changes in a U.S. Industrial Commodity Mine – Case Study

A. Habibi¹, R. Kramer¹ and S. Gillies²; ¹Tronox Corporation, Green River, WY and ²Missouri University of S&T, Rolla, MO

Diesel Particulate Matter (Dpm) measurements were undertaken at Tronox's Westvaco Trona mine in Wyoming. Both shift average and real time monitoring using Elf pumps and Airtec analyzers were used. The mine's underground transportation fleet consists of over 250 diesel-powered vehicles. A vehicle monitoring log was undertaken consisting of vehicle type, direction of travel and time. The log was then used in analysis to determine the Dpm spread rate, of normally operating equipment, in the different entries with respect to vehicle location. Airflow velocity measurements at the stations were taken during the survey. The survey results also identified vehicles with higher emission rates. An ECOM gas and MAHA Dpm analyzers, located in the mine's underground emission shop were used to obtain various vehicle emission rates. The correlation of the workshop and field measurements was investigated with regard to the machine activity, fuel usage and atmospheric conditions. The results were used to identify and execute a ventilation project to reroute 45% of diesel shop air back to intake entries, by interlocking an automated door and a regulator. The result is reduced Dpm downstream.

2:45 pm

Blast pressure monitoring method developed at the Henderson Mine

R. Brokering, D. Loring, A. Rogers, B. Dhyne and C. Rutter; Engineering, Freeport McMoRAN, Empire, CO

ABSTRACT: Climax Molybdenum Company's Henderson Mine, owned by Freeport McMoRan Inc., is a 32,000 tonne per day panel caving molybdenum mine located about 69 km west of Denver, Colorado. As the mine continues to expand and grow new production panels are being developed and initiated. As new infrastructure is designed and installed it has become necessary for Henderson Mine to understand and measure the blast pressures created from development and production blasting. This paper reviews a case study of ventilation controls that were impacted by these production and development shots, which in a panel cave mine can be significantly larger than typical blasting seen in some other mining methods. It explains how the engineering department identified a method to measure the pressures that infrastructure was seeing from blasts, and apply that data to engineer a possible solution. In addition, this paper reviews how this data has laid the ground work for more advanced predictive ventilation modeling utilizing blast modeling for design of the ventilation system and its components.

3:05 pm

16-015

Reduction in diesel particulate matter through advanced filtration and monitoring techniques

C. Pritchard¹, J. Hilp², J. Volkwein³, J. Noll⁴ and A. Miller¹; ¹SMRD, NIOSH, Spokane, WA; ²Lucky Friday Mine, Hecla Limited, Wallace, ID; ³Science Consultant, Canonsburg, PA and ⁴Dust Control, Ventilation and Toxic Substances, NIOSH, Pittsburgh, PA

Hecla Limited, Spendrup Fans, Magee Scientific, and NIOSH combined efforts to evaluate an in-situ air filtration system for reducing the concentration of Dpm in mines. The evaluation included introduction of rock dust at the filter inlet to improve capture of the smaller Dpm particles. The filtration efficiency was assessed by measuring Dpm at the inlet and outlet using both an Aethalometer and filter samples analyzed by the NIOSH 5040 method. Calculated efficiencies

were similar for the two measurement methods, and in the range of 82-89%. The Dpm levels reported by the Aethalometer were higher than for the 5040 method, possibly due to differences in the size-selectors used (impactors versus cyclones). More research is required to develop a robust correlation between the two methods. Ideally such data could be used to initiate the startup of the filtration system, should Dpm concentrations reach an action level. This work demonstrated that in-situ filtration systems, modified to collect Dpm and coupled with real-time monitoring, show promise at reducing Dpm concentrations in a mine environment.

3:25 pm

Ventilation Planning for adding a New Shaft – Key matrices!

A. Rai, D. Powell, J. Poor and T. Weatherwax; Barrick Turquoise Ridge Inc, Winnemucca, NV

Its always a great challenges to close the gap between a operating mine and adding the a new shaft. The current understanding of physical operating points, and cost in order to maintain the appropriate dedicated ventilation is critical with additional sensitivity to primary and secondary escapes with risk mitigatin in the event of fire. The paper will discuss the system operating points, and models were determined mitigating re-circulation use of bulkheads around the intake and exhaust shaft, and critical infrastructure to be added for smooth transition. The paper will cover technical operational readiness process, operations commissioning and explain benefits on various matrices used. This work include economics, modelling, operational readiness process map.

3:45 pm

Sizing Auxiliary Ventilation Systems Using Measured Data

M. Florence¹, F. Calizaya² and M. McFarland¹; ¹Mine Technical Services, Nyrstar Tennessee Mines, Gordonsville, TN and ²Mining Engineering, University of Utah, Salt Lake City, UT

A series of large, highly mechanized hard rock mines encountered increasing difficulty with maintaining sufficient airflow with available auxiliary ventilation systems. Longer system lengths (greater than 300 m) and higher airflows were desired. Pressure and airflow measurements were taken in multiple existing auxiliary ventilation installations in stopes and development headings in order to determine representative resistance and leakage values. Issues with duct installation and maintenance were addressed in order maximize the potential of existing and future systems. Charts showing expected airflows at various total system lengths were developed using VnetPC models for use in selecting fan and duct combinations. Pressure loss and leakage calculation methods employed by duct and fan manufacturers are compared and discussed.

Wednesday, February 24 – Afternoon

ROOM: 127C

2:00 pm

Mining & Exploration: Technology: Advancements in Rock Mechanics and Ground Control

Chair: K. Perry, University of Kentucky, Lexington, KY

2:00 pm

Introductions

2:05 pm

16-036

Assessing the Mechanical Behavior of Large-Scale Shotcrete Panels

M. Raffaldi, D. Benton, L. Martin, J. Johnson and M. Stepan; NIOSH, OMSHR, SMRD, Spokane, WA

The Office of Mine Safety and Health Research, Spokane Mining Research Division, is continuing its High-Energy High-Displacement (HEHD) testing of field scale shotcrete panels. A test program was developed to determine the relationship between applied force, displacement, and energy for both unreinforced and reinforced shotcrete panels. Reinforcement consisted of polysynthetic fibers, sprayed polyurea liners, chain-link fence, welded-wire mesh, and combinations of these products. During testing, photogrammetry was used to determine the geometric changes of the panels, including volume changes and panel cracking. These measurements were correlated with the load and displacement data, allowing visual observation to be related to the applied force and displacement. The test results provide comparison of the mechanical performance of the various panel types and can be used by the practicing engineer to evaluate installed support based on visual observation of cracking and deformation. Visual assessment of the loading cycle and strength capacity of shotcrete in underground excavations will improve mine safety by providing a means to quantify the stability of installed shotcrete support.

2:25 pm

Paste Backfill Strength Properties: A case study from the Lucky Friday Mine, Mullan, Idaho

J. Seymour¹, J. Johnson¹, M. Stepan¹, L. Martin¹, A. Arkoosh¹, M. Board² and T. Emery²; ¹OMSHR SMRD, NIOSH, Spokane, WA and ²Hecla Mining Company, Coeur d'Alene, ID

At underground mines where cemented backfill is used for ground support, backfill strength properties are an important design consideration, particularly for underhand cut-and-fill mining methods where employees work directly beneath the placed fill. In response to a backfill roof fall in a deep underground silver mine, Hecla engineers identified the likely cause of the failure, re-assessed their backfill processes and procedures, and developed an improved cemented paste fill mix to eliminate horizontal layering and the formation of flat-lying cold joints within the placed backfill beam. A study was also conducted with NIOSH researchers to independently confirm the strength properties of the collapsed material. Although the tensile strength, Young's modulus, and Poisson's ratio of paste backfill are usually needed for mine design purposes (analytical equations or numeric modeling), values for these key properties are generally assumed rather than directly measured. This paper presents the results of these studies, provides information about Hecla's successful solution to the problem, and reports much needed, measured values for the strength and elastic properties of paste backfill.

2:45 pm

16-125

Nondestructive Methods to Estimate Rock Strength at Low Temperature: Applications for Asteroid Capture Technologies

K. Savage¹, A. Noble¹, B. MISHRA¹ and T. Evans²; ¹Mining Engineering, West Virginia University, Morgantown, WV and ²Mechanical and Aerospace Engineering, West Virginia University, Morgantown, WV

Recent government initiatives and commercial activities have targeted asteroids for in-situ characterization, manipulation, and possible resource extraction. Though emergent technologies may be effective for such undertakings, uncertainties remain concerning the effects a space environment may have on the

mechanical behavior of rocks. Various non-destructive rock characterization techniques can empirically predict in-situ rock strength on Earth; however, these techniques must be adapted to account for unique space conditions. In order to mimic one element of a space environment, various rock samples were evaluated after prolonged exposure to low temperatures ranging from -75 to 0°C. Tests included uniaxial compressive strength, Schmidt hammer, and ultrasonic pulse velocity, while rock types included shale, limestone, and chalk. This data was used to generate a temperature correction for the non-destructive methods and evaluate the accuracy of these methods in predicting strength values. Overall, these results provide insight on the mechanical behavior of rocks at low temperatures and may be used to design robust systems needed for asteroid rock characterization.

3:05 pm

Performance Evaluation of a High-Strength and Adjustable Standing Support System

W. Dolsak¹, J. Chen² and I. Ossenbüh³; ¹Director Corporate Development Underground Construction, DSI Underground Systems, Inc., West Jordan, UT; ²Director of Rock Mechanics / Tech Support, DSI Underground Systems, Inc., Martinsburg, WV and ³General Manager, BuM Beton- und Monierbau GmbH, Herten, Germany

The BULLFLEX® System is used globally as ground control element in various fields of underground construction. Following the first introduction of BULLFLEX® pumpable cribs to the US mining industry in the early 1990s, the system has recently been improved and modified to meet the requirements with regards to state-of-the-art standing support systems. Main performance criteria for standing support systems are their stiffness, the ultimate load-bearing capacity, as well as the post-failure behavior within a certain displacement range. Hence, it is quite difficult to design a support element which provides an ideal support performance for all three beforehand mentioned criteria. Recent investigations lead towards the development of two different pumpable crib systems, depending on the respective field of application. In hard rock mining, stiffness and ultimate load-bearing capacity are governing performance parameters, whereas in coal mining stiffness and the post-failure behavior are relevant. This paper describes the concept of BULLFLEX® pumpable cribs and performance characteristics of two different versions which have recently been tested at the NIOSH ground control laboratories.

3:25 pm

Improved Deterministic and Probabilistic Kinematic Analyses to an Open-Pit Mine

P. Kulatilake and J. Zheng; University of Arizona, Tucson, AZ

Improved deterministic and probabilistic kinematic analyses procedures are suggested in the paper incorporating the following new steps: (a) A procedure to generate 3-D discontinuity networks based on finite size joint geometry parameter properties; (b) A new methodology to calculate the intersection probability of any two finite size discontinuities coming from two discontinuity sets to form possible wedges; (c) Consideration of the 4 possible scenarios related to formation or non-formation of different wedges resulting from intersection of two discontinuities; (d) An algorithm to calculate instability probability for the rock slope by combining the instability probabilities obtained for each mode of failure. Both deterministic and probabilistic kinematic analyses are performed for a part of an open pit mine in USA. The results showed clearly the superiority of the probabilistic kinematic analysis over the deterministic kinematic analysis in obtaining additional information in designing rock slopes. The probabilistic kinematic and block theory analyses results are compared. The calculated values agree very well with the existing bench face angles reported by the mining company.

3:45 pm

Empirical Support Design Recommendations for Weak Rock Masses at Underground Gold Mines in Nevada

S. Warren and R. Kallu; Mining Engineering, Univ of Nevada-Reno, Reno, NV

Underground gold mines in Nevada are exploiting increasingly deeper ore bodies comprised of weak to very weak rock masses. Existing empirical support design methods are derived predominantly from experience in tunneling situations or more competent ground making them less applicable to underground gold mining in Nevada. This paper presents empirically derived support guidelines from experience at 5 underground gold mines in Nevada including: 400+ case-studies documented by the authors, discussions with engineers and miners, and review of ground control management plans and consulting documents. Support design recommendations are based on a modified Rock Mass Rating (RMR) classification that incorporates engineering soil classification where applicable, and reports recommended rockbolt support pressure, surface support, and excavation strategy.

Wednesday, February 24 – Afternoon

ROOM: 228A

2:00 pm

MPD: Comminution III: Energy Efficiency

Sponsored by: Moly-Cop USA

Chairs: O. Arafat, Metcom Technologies, Hamilton, ON, Canada
T. Braden, amIRA International Ltd, Melbourne, VIC, Australia

2:00 pm

Introduction

2:05 pm

Using Our Orebodies to Improve Comminution Efficiency

J. Pease; CRC-Ore, Melbourne, VIC, Australia

The mining industry has long sought to use a manufacturing approach to integrate operations, in search of a step change in productivity. There are some excellent examples of Mine-to-Mill integration, but as an industry we do not apply it often enough, and don't always sustain the benefits. CRC ORE is challenging that approach. Rather than considering ore heterogeneity as the "enemy" of integrated operations, it may be a solution to improving productivity. Liberation of gangue at coarse sizes may be exploited early in handling; or low grade zones in a mining bench may be able to be diverted from mill feed. CRC ORE has developed a set of tools to assess and exploit heterogeneity. These concepts are as old as hand sorting and dense medium separation; what is needed are tools to apply them to a wider range of orebodies; using methods that support large scale mass mining. CRC ORE is working with partner sites to demonstrate new analytical tools, new sensors for coarse ore quality, and robust equipment to allow early diversion of waste streams. The vision is to make every ore handling step an opportunity for upgrading and efficiency improvement.

2:25 pm

16-119

Introducing the GMSG Comminution Circuit Sampling and Surveying Guideline

A. Giblett; Technical Services - Processing, Newmont, Subiaco, WA, Australia

The GMSG Industrial Comminution Efficiency has facilitated the development of three guidelines for the simple and effective quantification of industrial scale grinding circuit efficiency. The techniques presented in these guidelines are based on the published methods for power based analysis of grinding circuits provided by Bond and Morrell. These methods have the advantage of requiring only basic characterisation of grinding circuit feed and product streams, supporting simple survey procedures. The direct comparison of predicted vs actual energy consumption allows an immediate assessment of circuit efficiency, while providing a baseline reference against which future optimisation efforts can be compared. This approach is an excellent alternative to full grinding circuit surveys when testwork budgets are limited and production downtime must be minimised. This paper will specifically discuss the GMSG guideline that has been developed for the surveying and sampling of comminution circuits, as the foundation for power based efficiency analysis. The guideline encompasses planning and preparing for the survey, survey execution, survey data collection, sample processing and data analysis.

2:45 pm

16-033

The GMSG Guideline for Determining the Bond Efficiency of Industrial Grinding Circuits

R. McIvor; Metcom Technologies Inc., Marquette, MI

Use of the Bond Work Index to size industrial grinding equipment was widely known. Bond also described its application for measuring grinding circuit efficiency. Bond Work Index efficiency has been widely used by industry, but until now without concise standard methods, or a formal guideline, for doing so. The Bond Efficiency Sub-Committee of the Industrial Comminution Efficiency work group of GMSG has produced such a guideline. It covers the methods and provides examples of how to calculate the Bond Work Index Efficiency of most industrial grinding circuits. Bond Work Index testing equipment and methods are also provided. The next steps are: (1) to establish standard reference testing materials and one or more laboratories to serve as bases for reference testing; (2) to establish the accuracy of relative circuit Work Index Efficiency determinations; and (3), to develop and provide a public data base of industrial comminution circuit Bond Work Index Efficiencies.

3:05 pm

Measuring Mill Efficiency as a Function of Lifter Configuration and Operating Parameters in a 1 Meter Diameter Batch Tumbling Mill

P. Taylor; Metallurgical and Materials Engineering, Colorado School of Mines, Golden, CO

A one meter diameter batch mill that facilitates changeable lifters and is equipped with a load cell for force measurements was custom-built and used to study the effects of different lifter shapes and operating parameters on mill efficiency and performance. For the mill with higher mill load and lower speed, rail lifters drew higher mill power than the for Hi-Lo lifters. The Hi-Lo lifters indicated improvement in the energy efficiency of the mill of approximately 22%. For the mill with lower mill load and higher speed, the Hi lifters showed improvement in the energy efficiency of the mill approximately 6.7%. The Hi lifter, under certain operating conditions, improves both the mill efficiency and breakage rate. Trajectory simulations were performed at various operating conditions, results at higher mill speeds showed that mill charges of at least 31% and/or lifters with higher face-angles should be applied to direct trajectories impacting on the toe of the charge for more effective milling and lower mill shell/liner wear.

Wednesday, February 24 – Afternoon

ROOM: 232B

2:00 pm

MPD: Flotation Plants: Flotation IV

Chair: D. Laney, Newmont Mining Corp, Elko, NV

2:00 pm

Introductions

2:05 pm

16-107

Molybdenite Polytypism and Its Implications for Processing and Recovery: A Geometallurgical-Based Case Study from the Bingham Canyon Mine, Utah

C. McClung; Rio Tinto Kennecott, South Jordan, UT

A geometallurgical study of molybdenite from the Bingham Canyon deposit, Utah, identified two types. A review of the published literature has assisted in identifying these as polytypes: hexagonal (2H); and rhombohedral (3R). The 2H polytype occurs as textbook-shaped particles in quartz-molybdenite veins located in the core of the deposit. The 3R polytype occurs as disseminated ball-shaped particles with a frosted appearance along the margins of the core. The metallurgical behavior of each type exhibits unique properties. The 2H polytype is easily ground and kinetically fast-floating with surface attributes that are amenable to higher rates of recovery. This results in the production of a high quality product under routine operating conditions. In contrast, the 3R polytype is difficult to grind and kinetically slow-floating with surface attributes that are not amenable to recovery. Hence, in deposits with higher amounts of the 3R polytype, modifications to the operating parameters may be necessary to improve recovery. This investigation highlights the necessity of understanding the mineralogical characteristics of the metal sulfides as these can have an impact on the performance.

2:25 pm

16-089

Carbon Dioxide pH Performance at Greens Creek Mill

T. Martin and D. Tahija; Hecla Greens Creek Mining, Juneau, AK

Hecla's Greens Creek silver-lead zinc mill began using carbon dioxide rather than sulphuric acid to control pH in April, 2015. High pH levels in the grinding and lead flotation circuits are caused by the presence of re-mined cemented paste backfill in mill feed and need to be lowered to achieve good flotation response. Carbon dioxide has proven to be quite effective at controlling pH in the lead circuit with greatly improved pH target attainment. The allowable amount of carbon dioxide used is not limited by effects on lead-zinc selectivity and by poor froth characteristics, as was the case with sulphuric acid. Startup and implementation went smoothly, with few operational issues needing to be resolved. Early results from implementation of the system and its effects on mill performance will be presented.

2:45 pm

Stabilizing Flotation Cell Pulp Level for Improved Copper Recovery

M. Ferra; REXA, West Bridgewater, MA

Having a stable flotation cell pulp level is critical to effective copper recovery. Controlling pulp levels in flotation cells is a complex task that includes modulating dart valves with each cell. The use of electrohydraulic actuators will decrease the process dead time and maintain froth height in a controlled manner, especially from slurry volume fluctuations from neighboring cells. By improving control of

the flotation level cell height, mine operators can realize a 25% increase in the capture of copper content in a scavenger cell circuit. This paper will examine the significance of ensuring proper control of the froth level, with particular focus on the actuator modulating action of the dart valves in maintaining process consistency at a mine in Arizona, USA. The electrohydraulic actuators can accurately position the dart valves to maintain the tank froth level set point, resulting in an increase in copper recovery by an estimated 33,000 lbs./yr.

3:25 pm

Variability Flotation Testing and Residence – Time Determination For The Hycroft Mill Project

A. Ibrado and B. Bermudez; M3 Engineering & Technology, Tucson, AZ

About 70 to 90% of the gold and silver associated with Hycroft sulfide ore is refractory. Partial oxidation of the sulfide is required to liberate gold and silver for cyanidation. Gold and silver floats well from this ore, making flotation a viable pre-concentration option to reduce the volume of material to be oxidized. Extensive flotation investigations were conducted at Hazen, G&T, Kappes Cassiday, and SGS to determine the optimum reagent scheme and dosages. The optimum scheme was implemented on 73 individual samples (not composites) taken at various locations in the orebody form a set of recovery variability tests. Flotation kinetics analysis was performed on 15 tests results from G&T. For each of these tests, timed concentrates were collected, which allowed kinetics information to be extracted. The timed recoveries obtained were fitted to an asymptotic equation to determine the maximum recovery predicted for the test. The time to reach 95% of this maximum recovery was taken as the required laboratory flotation time for the test. This resulted in a distribution of laboratory flotation times, with an average of 19 minutes for gold and 17 minutes for silver.

3:25 pm

On-stream measuring of mineral concentrations in slurries from elemental LIBS results

N. Khajehzadeh; Electrical Engineering and Automation, Aalto University, Espoo, Finland

Controlling and optimizing the recovery while preserving the grade of the concentrate is extremely important. This development requires new technological solutions and has given rise to the multitude of application areas for lasers. X-ray Fluorescence (XRF) and Laser-Induced Breakdown Spectroscopy (LIBS) are currently two of the predominant non-contact and direct surface-analyzing methods in industry. LIBS has a very simple and easy-to-implement spectroscopic setup, wider range of elements can be detected with online LIBS and measuring light elements is simpler by LIBS compared with XRF. It is of great interest to extract mineralogical information from the elemental results with no modification on the measurement setup. Therefore, the major focus of this research is about measuring mineral concentrations from the elemental contents of LIBS technique using advanced statistical methods. This accomplishment provides knowledge about both elemental and mineral concentrations from the real-time assay data of the slurry LIBS analyzer. This brings many benefits such as rapid control of concentrate quality, enhanced recovery, saving time, energy and manpower.

3:25 pm

The Simulation and Preliminary Studies on Bear Lodge Ore Flotation

H. Cui and C. Anderson; MME, Colorado School of Mines, Golden, CO

Rapid technological development causes an increase of demand of rare earth. Ancyilite, a strontianite rare earth carbonate, is a significant source of rare earth bearing minerals. In this research, based on an optimization of the variables and flotation simulation, a flowsheet is proposed. Furthermore, the economic feasibility for obtained processing conditions is analyzed.

Tungsten minerals recovery by flotation techniques in China: flotation collectors, depressant, and tail water treatment

Y. Hu, W. Sun and S. Han; School of Mineral Processing and Bioengineering, Central South University, Changsha, Hunan, China

China is rich in tungsten resource, but they are mainly associated minerals. The similar flotability of scheelite, fluorite, and calcite resulted in the difficult separation by flotation. This work summarized the current situation and the development of tungsten minerals flotation in China. Fatty acid served as the collector and sodium silicate was the depressant to expand the flotability differences in traditional flotation technology. However the sodium silicate inevitably influenced the flotation of tungsten minerals to a large extent, and the suppressed fluorite was difficult to recover by flotation. Abundant sodium silicate lead to the bad settleability of the tailings and the tail water was difficult to circulate, resulted in serious environmental problems. Recent study proved that the selectivity of benzene armour hydroxyl oxime acid salts was adequate for the separation of tungsten minerals from fluorite, calcite and most silicate minerals without any depressant. By this way, sodium silicate was canceled completely in tungsten flotation, greatly improving the recovery of tungsten and the environmental problems caused by tail water treatment would be solved fundamentally.

Wednesday, February 24 – Afternoon

ROOM: 228B

2:00 pm

MPD: Innovations and Development II

Chair: J. Miller, University of Utah, Salt Lake City, UT

2:00 pm

Introductions

2:05 pm

Iron ore sedimentation and iron ore pelletization: Is there a relationship?

J. Halt and S. Kawatra; Chemical Engineering, Michigan Tech University, Houghton, MI

The effects of common coagulants and dispersants on the zeta potential and sedimentation and pelletization behaviors of a finely ground iron ore concentrate will be shown. The dispersants stabilized the particle-water system, as indicated by high zeta potential (>40 mV), high total suspended solids (>500 mg/L) and strong pellets (>70 N/pellet). Conversely, the coagulants destabilized the particle-water system, shown by low zeta potential (<20 mV), low total suspended solids (<20 mg/L) and weak pellets (<40 N/pellet). These results suggest that (a) sedimentation tests and zeta potential measurements can be used to design binders for iron ore pellets; (b) organic dispersants are attractive alternatives to bentonite for fine balling feeds; and (c) understanding surface properties of the balling feed is necessary to understand its agglomeration behavior.

2:25 pm

Sedimentation and Consolidation of Flocculated Kaolinite Suspensions Using X-ray Technology

J. Dong, S. Sharma, Y. Wang, C. Lin and J. Miller; Metallurgical Engineering, University of Utah, Salt Lake City, UT

Clay mineral particles such as kaolinite (< 2 microns in size), can cause significant problems in flotation processes and in tailings disposal, including the processing

of Florida phosphate rock and Canadian oil sands. The sedimentation/consolidation of flocculated kaolinite suspensions is being studied using X-ray techniques to describe the settling rate, the structure of the consolidated sediment, permeability, and water recovery. The sedimentation rates are measured by X-ray radiography to establish the relationship between the particle flux and the kaolinite particle concentration. The structures of the consolidated sediment are described in 3D using X-ray microtomography. With this tomographic information, the complex geometry of the pore network structure for the consolidated flocs is used to determine permeability and water recovery by lattice Boltzmann simulation.

2:45 pm

Role of Starches for the Pelletization of Iron Ores

J. McDonald and S. Kawatra; Chemical Engineering, Michigan Technological University, Hancock, MI

The replacement of bentonite as the standard iron ore binder is an important factor in the future of iron processing. Bentonite replacement requires an in-depth understanding of how alternative binders affect the agglomeration process. One such alternative binder is starch, which can be modified in a multitude of ways. It has been observed in this study that the use of a highly soluble starch can greatly increase the dry compressive strength of a hematite concentrate pellet. By heating a starch solution or extruding a starch, its solubility can be altered. When using starch along with bentonite, a suitable pellet can be produced that can withstand all aspects of pellet handling. It was observed that at the highest solubility of starch there was a strength increase of approximately 15 lb_r. Seen with the high solubility starch, though, was the greatest decrease in compressive strength when the dry ball was heated to 500°C as the organic portion of the binder had been combusted. By investigating the binding mechanism of starch it has been proposed that only the soluble portion of starch plays a role in the binding of iron ore concentrates.

3:05 pm

Concentration of REEs in Alaskan coal ash by physical beneficiation techniques

T. Gupta, G. Akdogan and T. Ghosh; Mining Engineering, University of Alaska Fairbanks, Fairbanks, AK

In the last decade, the prices of REEs and critical elements has risen dramatically pertaining to the global deficit in demand and supply. This has led to a renewed focus on development of technologies to extract REEs and critical elements from alternate sources such as Coal Ash. Coal ash rich in REE requires an ecofriendly and cost effective technique for initial concentration of REEs from the coal ash. The concentrate subsequently can be used to extract REEs. The paper details the concentration of REEs from coal ash by exploiting physical properties such as difference in density, magnetic properties and surface properties. The specific gravity of lanthanides varies from 5.2 g/cm³ (Europium) to 9.8 g/cm³ (Lutetium), while specific gravity of mineral matter in ash is about 2.6 g/cm³ (Rock). Therefore, the possible separation of REEs and mineral matter has been tested by using standard equipment's used for gravity separation. The coal ash was separated according to the size for testing with equipment best suited for the size fraction. The results obtained by each separation technique are presented proving the potential of physical beneficiation of REEs from coal ash.

3:25 pm

Beneficiation of Phosphate Flotation Concentrate Using a Rotary Triboelectrostatic Separator

J. Chen and R. Honaker; Department of Mining Engineering, University of Kentucky, Lexington, KY

The processing of phosphate typically involves the use of sizing and concentration processes that uses water as a medium. In a recent study, the feasibility of enhancing the quality of a phosphate flotation concentrate containing 73.9% bone

phosphate of lime (BPL) was investigated using a Rotary Triboelectrostatic Separator (RTS). The RTS is a dry separation process that offers high capacity and low operating cost. Five operating parameters were studied to assess their influence on phosphate beneficiation. Two stages of electrostatic separation resulted in a significant increase of the phosphate quality to values as high as 82.4% BPL. Phosphate products containing 78.0% BPL was also attained with relatively high recovery values in the range of 70.0%. The results of the experimental program reflect potential of producing high quality phosphate using a dry triboelectric separator.

3:45 pm

Wetting Characteristics of Mineral Surfaces as Revealed by MDS Contact Angle Measurements

J. Jin, X. Wang and J. Miller; Metallurgical Engineering, University of Utah, Salt Lake City, UT

The wetting characteristics of mineral surfaces are described based on contact angles determined from molecular dynamics simulations (MDS), which results are compared to experimental measurements. Both advancing and receding sessile drop contact angles are considered. MDS analysis of captive bubble contact angles is reported for the first time including details of film thinning, rupture, and film displacement from the simulation of bubble attachment at a hydrophobic surface. In the case of sulfide minerals, the advancing contact angles generally exceed 60°, reaching 80° in the case of the basal plane surface of molybdenite. In the case of nonsulfide minerals the advancing contact angle for talc was found to be 70°, whereas most nonsulfide minerals were found to be hydrophilic with smaller sessile drop contact angles which generally varied from 20° to 0°. Of particular importance, in the case of oxide minerals, is the extent of hydroxylation in the wetting of such surfaces.

3:45 pm

Alkyl Phosphates for the Flotation of Nonsulfide Minerals

W. Liu, Z. Wang, V. Truong, X. Wang and J. Miller; Metallurgical Engineering, University of Utah, Salt Lake City, UT

Little attention has been given to the use of alkyl phosphates as collectors for the flotation of nonsulfide minerals. The chemistry of alkyl phosphates is reviewed and corresponding solution chemistry features discussed. Recent microflotation results with potassium lauryl phosphate show its effectiveness as a collector for bastnaesite ((Ce,La) FCO₃), smithsonite (ZnCO₃), and halite (NaCl). The experimental results are discussed with respect to possible applications.

Wednesday, February 24 – Afternoon

ROOM: 232A

2:00 pm

MPD: Physical Separation

Chairs: D. Perkins, Derrick Engineering, Buffalo, NY
T. Rauch, Jacobs, Venetia, PA

2:00 pm

Introductions

2:05 pm

Increased Attrition Resistance for Activated Carbon used in Hydrometallurgical Gold Extraction

W. Dickinson and S. Kofsky Wofford; R&D, Kemira Chemical, Atlanta, GA

The effect of a polyamine flocculent on the attrition of activated carbon used in gold processing was evaluated. The treatment lowered the amount of suspended carbon fines by 15% based on AARL bottle-roll attrition tests and by 30-50% under more aggressive agitation conditions. Turbidity caused by fines generation was significantly reduced for the treated carbon compared to untreated controls. The percent carbon passing a 1.7 mm screen was reduced by 17-35% with greater reduction achieved at higher molecular weight of the polyamine. Improvement in attrition resistance was most evident for the lowest of three grades of carbon covering a range of hardness and abrasion resistance. Percent of carbon passing a 1.7mm screen varied by a factor of two for the different carbon grades with the highest grade showed the most uniform performance. Electrochemical analysis confirmed that the treatment had no effect on the rate of gold adsorption onto the carbon.

2:20 pm

Potential Recovery of Rare Earth Minerals from Bituminous Coal

*R. Honaker, M. Rezaee, A. bhagavatula, W. Zhang and J. Groppo;
Mining Engineering, University of Kentucky, Lexington, KY*

A recent investigation focused on the potential of concentrating rare earth elements (REEs) found in the Hazard No. 4 (Fireclay) coal seam. A mineralogical study found REEs existing as 1) mineral species including monazite, xenotime and bastnaesite and 2) as an elemental substitute in clays. Systematic sampling conducted at a preparation plant revealed concentration in the coarse and fine reject streams and also very high REE concentrations in the finely dispersed mineral material in the low gravity fractions of all process streams. The plant samples were subjected to a number of separation techniques which indicated the potential to significantly concentrate the RE minerals.

2:50 pm

Flowsheet Development for Making Lunar Soil Simulant from Geomaterials

C. Young; Met & Mat Eng, MT Tech, Butte, MT

To make so-called "simulant," global research has concentrated on using single natural resources of volcanic rock but, at MT Tech, our approach has been different. We use multiple resources to extract the geomaterials of interest to form concentrates using traditional mineral processing techniques. These "separates" are combined in appropriate ratios to produce simulant. In this research, we continued to use the dry outcrop material from Stillwater Mining Company (SMC); however, another geomaterial from Olivine Corporation's mine in Bellingham WA (courtesy of AFFCO in Anaconda, MT) was used to produce an Olivine separate. We modify the flowsheet that was previously developed (Rickman et al., 2014) by modeling the unit operations and performing mass balances around them. Based on the analyses obtained by XRD and MLA, a simulant was prepared by mixing the three separates in a particular ratio and given to NASA and USGS to see how well it was made. The results compare well and show that the geomaterials can be used to make adequate separates for eventual bulk-scale production of simulant.

3:05 pm

Controlling thickener operation using novel bed profiling sensors

J. Johnson, J. Holindrake and M. Biesinger; Industrial, WesTech Engineering, Salt Lake City, UT

The control of thickeners and clarifiers has been a topic for years with some success coming with monitoring the input and output with some estimation of the bed level. The success of these strategies unfortunately can sometimes only be measured after a delay of the solids residence time as a minimum. Then once an action has been taken there is about the same period waiting to know if your correction was proper. Run of mine changes as well as normal process plant variations can cause a never ending cycling of performance. This paper is a follow up article to the introduction of a new level sensor presented last year in Denver at SME conference. The sensors ability to profile a thickener bed providing radial, horizontal and vertical profiles greatly increased the understanding of the inner workings of a thickener. This paper provides the full-scale tests results of new prototypes. The control of a thickener using real time profiles, detecting thickener ailments and quicker response to remedy the problem. The profiles now become the measure as well as the target to control the operating parameters. This paper discusses the control philosophy using the unique sensors.

3:20 pm

Metallurgical Sample Selection: How to Reinforce the Weakest Link in Mining Project Derisking

G. Desharnais; Geological Services, SGS Canada Inc., Blainville, QC, Canada

Many metallurgical programs suffer from samples that are not representative of the “rock recipe” that will eventually see the inside of a processing facility. Unfortunately this often introduces a bias; even before the samples have been received at the testing facility. The most common blunders include selection that is limited to the richest ore type, to a single host rock, to rocks excluded from the mine plan, or the lack of consideration for diluting rock types. The lack of consideration given to appropriate sample selection directly impacts the forecasts for hardness/recovery, flowsheet design and ultimately profitability of mining projects.

3:35 pm

Vibrating Screen Performance Evaluations

M. Garrison; Product Support, Polydeck Screen Corporation, Spartanburg, SC

The paper and presentation will provide an in-depth introduction into modern, electronic evaluations of screens used in mining operations worldwide. Screen Performance Evaluations – a system that records and presents data that guides customers as follows: 1. Vibrating screen movement and deflections – provides data to prevent failures 2. Quantifies performance – provides data to improve actual efficiency of vibrating screens. The screen's supporting structure and ore delivery is considered as parts of a ‘system’ that are evaluated to insure optimal performance and efficiency.

3:50 pm

Vibrating Feeders for Enhanced Recovery

A. Donahue; Marketing, General Kinematics, Crystal Lake, IL

Mineral processors around the world are making serious investments into sensor sorting systems to open up new opportunities in processing. These technologies increase mine yield and provide precise and efficient processing. In conjunction with these optical sorters is an often overlooked feeder in front of the sorter. GK's High Stroke Feeder technology is more than just a place holder. It enhances the presentation of the materials to achieve over 3% additional recovery rates. Learn the physics behind how we've taken the feeder to a whole new level to increase material purity and profits for our customers.

Wednesday, February 24 – Afternoon

ROOM: 122A

2:00 pm

Research: Geostatistics for Risk Management in the Mining Value Chain: Reserve and Mine Planning

Chairs: L. Allen, Newmont Mining Corp, Greenwood Village, CO
R. Dimitrakopoulos, COSMO Lab, McGill University,
Montreal; QC, Canada

2:00 pm

Introductions

2:05 pm

Stochastic Open Pit Mine Production Scheduling

K. Dagdelen; Mining Engineering Department, Colorado School of Mines, Lakewood, CO

During the last decades considerable effort is spent on developing open pit scheduling methods to characterize risks associated with geologic grade uncertainties. These methods are usually based on developing pit limits and production schedules using realizations coming from geostatistical conditional simulations. Due to the size of the optimization problems, the current uncertainty based scheduling methods are difficult to solve as such have not been implemented in commercial settings. In this paper we will review the state of art in stochastic production scheduling optimization methods to evaluate economic risks due to geologic grade uncertainties related to resource estimation. The shortcomings of the existing stochastic techniques will be discussed. A new stochastic production scheduling methodology will be introduced and demonstrated on a small case study.

2:25 pm

Optimizing Infill Drilling Decisions using Multi-Armed Bandits: Application in a Long-term, Multi-element Stockpile

R. Dirks and R. Dimitrakopoulos; Mining and Materials Engineering, McGill University, Montreal, QC, Canada

Every mining operation faces decisions on additional drilling during its lifetime. Two questions that always arise are if more drilling adds value and, if so, where the additional drill holes should be located. The method presented in this paper addresses both of these questions through Multi-Armed Bandits (MAB), a machine-learning framework often used for the optimization of exploration-exploitation problems. The proposed approach takes geological variability and uncertainty into account by considering multiple simulated orebody scenarios for the deposit under study. MAB selects the optimal infill drilling pattern and evaluates the added value of this pattern to the understanding of the orebody. Subsequently, the information generated supports decisions on additional drilling. The method is applied to a multi-element, long-term stockpile and the results show that the method is able to provide the desired answers to the two questions above.

2:45 pm

Determining the optimal open-pit to underground mining transition depth at a gold mine using stochastic planning techniques

J. MacNeil and R. Dimitrakopoulos; COSMO Lab - McGill University, Toronto, ON, Canada

Several of the world's open pit mines are expected to consider a transition to underground mining because of increasing operating costs and the opportunity to extend a mine's life. A method to determine the optimal transition depth from open pit to underground mining is applied at a large gold mine whose current ore production forecasts show a concerning deficit below the mill production target. The developed approach decomposes the problem by calculating the value of a set of candidate transition depths which have been identified as viable opportunities to begin underground mining. The analysis shows that the most profitable decision involves forgoing underground mine development and continuing to produce through solely open pit mining for the foreseeable future. Our results also show benefit of a 23% NPV increase for the stochastic mine plans when compared to the conventional deterministic equivalent.

3:05 pm

Joint Stochastic Simulation of Correlated Variables Using High-order Spatial Statistics for Uncertainty Quantifying

I. Minniakhmetov and R. Dimitrakopoulos; Mining and Materials Engineering, Cosmo Lab. McGill University, Montreal, QC, Canada

Geostatistical simulation techniques are used to quantify uncertainty of spatial attributes of interest describing mineral deposits, petroleum reservoirs, environmental contaminants and so on. The majority of existing methods consider second-order spatial statistics and Gaussian processes, while the more advanced multiple point based simulation approaches are algorithmic and do not consistently account for the high-order spatial relations in data. Recently, simulation techniques for complex and non-Gaussian, spatially distributed variables have been developed, based on high-order spatial cumulants. In this paper, the previous developments are extended and a new approach for the joint simulation of multiple correlated variables using high-order spatial statistics is proposed. The technique is based on a new algorithm described here for the decorrelation of correlated variables into factors, using the so-termed diagonal domination condition of high-order cumulants. The decorrelated factors are then simulated using high-order simulation and back-transformed into the initial correlated variables. The technique is tested with a dataset from a multi-element iron ore deposit.

3:25 pm

Stochastic Mine Planning at Twin Creeks Mining Complex

L. Montiel Petro¹, R. Dimitrakopoulos¹ and K. Kawahata²; ¹Mining and Materials Engineering, COSMO lab - McGill University, Montreal, QC, Canada and ²Newmont Mining, Winnemucca, NV

A mineral value chain is comprised of multiple sources of material, several processing streams and transportation systems which combine to generate various sellable products. These sources of material can be open pits, underground mines, stockpiles or external sources. Typically, there is a high level of geological uncertainty associated with these sources of material, which propagates through mineral reserve value chain. Uncertainty in material types and grades can be modelled and used in the risk assessment of mining plans but can also be incorporated during optimization in stochastic frameworks. This paper presents an approach which first utilizes a set of scenarios derived from stochastic simulations of the different sources of material to perform risk analysis and then applies a simultaneous stochastic optimization framework to develop a robust mine plan for Twin Creeks Mine, a gold mining complex in Northern Nevada. The analysis allows for potential risks associated with mine plans to be clearly quantified. The implementation of a stochastic optimization framework generates a mine plan that manages and mitigates geological risk while increasing value.

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