TECHNICAL SESSIONS

Technical program as of December 17, 2024. For the most current information please refer to the conference app.

MONDAY, FEBRUARY 24 AFTERNOON

DREYER LECTURE

Room 711

1:20 PM • Monday, February 24

Chairs: ***W. Wilkinson****, Phoenix, AZ*
D. Bryan

1:20 PM

Introduction

1:25 PM

High-grade Hypogene Porphyry Copper Deposit

J. Perello; BHP Billiton Minerals, San Francisco, CA

With the inevitable depletion of shallow, high-grade supergene copper ore from porphyry copper orebodies, future large-scale production will necessarily have to come from deeper, hypogene sources. Hypogene copper mineralization in porphyry copper deposits, normally perceived as low grade, can vary greatly in large systems (<0.3–>2% Cu), with exceptionally high-grade (>3% Cu) components in some. The following features are identified as conducive to development of large (>100–1800 million metric tons), high-grade (>1% Cu) mineralization in entire deposits or parts thereof: intense quartz-veinlet stockworks; magmatic-hydrothermal breccias; proximal skarns; carbonate replacement bodies; vuggy residual quartz or vein systems in telescoped deposits; presence of lithologic barriers and reactive mafic host rocks. Consideration of these features in exploration programs can assist in maximizing the chances of high-grade hypogene porphyry copper discovery.

Monday, February 24 Afternoon

BULK MATERIAL HANDLING: PLANT DESIGN AND RELIABILITY

Sponsored by: WOLONG Power your future

Room 610/612

2:00 PM • Monday, February 24

Chairs: ***S. Maldonado****, Freeport-McMoRan, Morenci, AZ*
M. Rubalcava*, Morenci, AZ*

2:00 PM

Introduction

2:05 PM

Gearbox Inspections: Boosting Reliability, Lifespan, and Reducing Downtime

M. Clark; Sumitomo Drive Technologies, Goodyear, AZ

Conducting regular inspections on gearboxes offers numerous benefits, including enhanced reliability, extended service life, and reduced downtime. Inspections allow for early detection of wear, misalignment, and lubrication issues, preventing catastrophic failures and costly repairs. Additionally, identifying minor problems before they escalate ensures optimal performance and efficiency. Regular maintenance also aids in understanding wear patterns, which can inform predictive maintenance strategies, leading to better resource allocation and operational planning. By maintaining gearbox health, the mining industry producers can achieve consistent production quality and lower the overall cost of ownership.

2:25 PM

Critical Considerations for Successful Bulk Solids Handling Projects: Case Studies

J. Chavez Sagarnaga; Jenike & Johanson, Tyngsboro, MA

Many projects are executed yearly for handling bulks solids in industries such as mining, cement, power generation, etc. Studies show that the average startup time for plants handling bulk solids was 18 months versus 3 months for plants handling liquids and 80% of those plants experienced bulk solids handling problems linked to physics and mechanics of processes rather than to chemistry. Part of the problem lies on the lack of training in critical considerations for designing and implementing projects for bulk solids handling. This presentation will discuss considerations that may range from obstructions of bulk solids flow to variations in geometry of the handling equipment. Case studies will be discussed to emphasize where critical considerations, even if minor, could be the culprits for a successful or failed project. Engineers in charge of the design, fabrication, construction and erection of bulk solids handling equipment will benefit from this presentation as they will be able to better understand the consequences of several considerations made during the life of bulk solids projects from conception to operation.

2:45 PM

Why Bins Plug: Selective Discharge—How Your Feeder May be Inducing Hang-ups

J. Bundalli and D. Vaile; Kamengo, Vancouver, BC, Canada

How material flows and discharges from a storage bin is critical to achieving a reliable feed system without hang-ups. To achieve the desired flow pattern, one must consider both the bin geometry and Feeder discharge area. For many difficult flowing bulk solids, it is often necessary that the material discharges in a first-in, first-out flow pattern. Achieving this starts by making decisions on the geometry of the bin, informed by the flow properties of the bulk solid. But what happens if the feeder discharges selectively from the bin outlet? In these cases, the feeder can induce an undesirable first-in, last-out discharge pattern. The result is unplanned consequences that lead to chronic bin hang-ups and costly operations. Understanding why feeders selectively withdraw material from the bin outlet is the first step to understanding how it can be resolved. This presentation will review the basics of bin geometry and look at how a Feeder must work in unison with the bin to achieve reliable discharge without hang-ups. Using case studies, the presentation will demonstrate how a fully effective feeder may be a missing piece to resolve a problem bin.

3:05 PM

Successful installation of a Phosphate Mine Dryer Drum with a Direct Hydraulic Drive Gearless System. One Retrofit and One New installation

A. Amin; Marketing, Bosch Rexroth Corporation, Dublin, OH

This paper describes the installation and operation of a success story for a retrofit of a Dryer Drum dual pinion drive replacing Electromechanical drive 2 x 250 HP with a direct Electro-Hydraulic drive using gearless Low Speed High Torque drive. This installation reduces the maintenance required and improved reliability and resistance to shock loads and faster response to torque fluctuation. Stabilize the challenge of nip adjustments and better consistency of finished product. This drive was commissioned during 2021 at Nutrien Mine, Aurora Mine, USA. Also 2nd installation of a new Dryer Drum single pinion with a more modern Electro-Hydraulic drive with 2 x 200 hp. This drive includes a new LSHT motor with more ports and reduced pressure drop and better efficiency. This incorporates lessons learned during 1st retrofit and additional improvements available to increase reliability. This drive was commissioned during July 2024 at

Nutrien Mine, Aurora Mine, USA. This paper provides details of drive configuration and steps involved and key factors considered and result of the performance improvement and productivity for grinding Clinker.

3:25 PM

FLS Rail-Running Conveyors: New Applications in IPCC, Steep and Long-distance Conveying

M. Lurie; High Performance Conveyors, FL Smidth Mining, Greenwood Village, CO

The FLS Rail-Running Belt Conveyor™ technology is a breakthrough in bulk haulage, offering the widest capacity range at the lowest energy losses or carbon footprint of any mine-class system on the market. The product line achieves OPEX savings of 30% to 80% in addition to significant as-erected CAPEX savings compared to conventional trough and pipe conveyors, depending on the application. The first full-scale installation for an IPCC customer is on track for commissioning in Africa in mid-2025, while many paid studies in response to robust customer interest have put the spotlight on the particular Rail-Running Conveyor ("RRC" capabilities covered in this talk. The four particular applications are: • IPCC—the ability for an RRC trough conveyor to spiral up out of an open pit from a semi-mobile crushing plant; • Steep conveying: RRC can carry material up or down inclines at angles around 15 degrees below the material's angle of repose, subject to testing. • Ultra-long distance conveying: examples of RRC energy and project CAPEX savings that can make or break the economics of a remote deposit.

MONDAY, FEBRUARY 24 AFTERNOON

COAL & ENERGY: BEST OF GROUND CONTROL

Room 702

2:00 PM • Monday, February 24

Chairs: ***M. Murphy****, National Institute for Occupational Safety and Health, Pittsburgh, PA*
T. Klemetti*, NIOSH, Pittsburgh, PA*

2:00 PM

Introductions

2:05 PM

Blasting Induced Ground Stress Evolution and its Effect on Pillar Stability

C. Spellman; Pennsy Supply, Inc., Harrisburg, PA

Large opening mines account for roughly half of the metal/non-metal mines in the United States. These mines produce aggregates and other industrial minerals that are utilized throughout the supply chain of consumer products from roads and builds to smart phones and computers. When deposits are flat lying-in nature, many mines utilize a room and pillar extraction method for production. Ground control is a vital aspect to the safety and productivity of stone mines. The objective of this research is to analyze mine induced stresses of underground workings through both time dependent static strain and blasting induced dynamic strain. A comprehensive field monitoring strategy has been developed to monitor the stress/strain relationship. Research of this caliber can offer baseline data for developing pillar stability factors based on dynamic peak stress, rather than the tributary area method. The influence of the expected success of this analysis will provide the mining community better tools for the design of pillars under various conditions.

2:25 PM

Lessons from Recent Pillar "Squeezes" in US Coal Mines

C. Mark; Mine Safety and Health Administration, Pittsburgh, PA

Area wide pillar failures, or "squeezes," were once fairly common in underground coal mines. While rare today, they do occur. This paper describes seven case histories that were investigated by MSHA Technical Support. They occurred across the range of US coalfields, in both longwall and room-and-pillar mines, and involved development mining, pillar recovery, longwall panel extraction, and multiple seam interactions. Significant lessons from each are discussed.

2:45 PM

Application of Analysis of Coal Pillar Stability (ACPS) Software for Assessment of Pillar Stability in Underground Lignite Mining—A Case Study

K. Andrews[1] and Z. Agioutantis[2]; [1]Marshall Miller & Associates, Blacksburg, VA and [2]Department of Mining Engineering, University of Kentucky, Lexington, KY

The Analysis of Coal Pillar Stability (ACPS) pillar design software is a standard in the coalfields of the United States. The user-friendly program allows mine personnel to complete pillar design in an efficient manner, ultimately resulting in increased mine stability and safety. The empirical nature of the methodology of the program makes it most applicable for mine design in regions from which case studies were collected. However, recent industry experience indicates that inputs to the ACPS program can be modified to allow the program to be used for pillar design in alternative regions. Application of the SDPS program for pillar design in regions outside of the base case study areas is favorable if conducted carefully. The case study presented in this paper describes the application of ACPS to pillar design in Eastern Europe and outlines the recommended process of using ACPS in alternative mining situations.

3:05 PM

Research on Microseismic Passive Velocity Tomography Based on Template Matching Technology

E. Westman; Department of Mining & Minerals Engineering, Virginia Tech, Blacksburg, VA

Microseismic passive velocity tomography has become an effective technology for large-scale mining-induced stress monitoring in underground mines, especially in the field of early warning of mining-induced hazards. Aiming at the problems of missing low-magnitude events in traditional microseismic monitoring, as well as the potential to increase the resolution of the tomograms in both time and space, a microseismic passive velocity tomography analysis method based on the template matching method was proposed. The results show that the selected templates can identify more microseismic events than the traditional microseismic analysis, and the variation trend of events in each day is consistent with the data from the traditional analysis. Using microseismic event locations, travel times and travel distance can effectively complete microseismic passive velocity tomography analysis in each day during the study period and can effectively identify the front abutment pressure zone and side abutment pressure zones of that longwall panel. This study can provide a reference for realizing the identification of mine-induced high stress zones and mining-induced hazard early warning.

3:25 PM

Investigating the Influence of Lateral Loading on the Vertical Capacity of Coal Mine Standing Supports

K. Mohamed; Pittsburgh Mining Research Division, CDC/NIOSH, Pittsburgh, PA

The National Institute for Occupational Safety and Health (NIOSH) initiated a testing program to evaluate various standing supports' lateral loading capacities, focusing on props commonly used in mining applications. The study aims to quantify the lateral loading capacity of standing supports and assess its influence on their vertical loading capacity and yielding mechanisms. This study uses the Mine Roof Simulator (MRS) at NIOSH Pittsburgh to test two types of standing supports: Type-1 with telescopic tubes made from ASTM A-513 steel with a designed locking mechanism and Type-2, comprising a singular component made from ASTM A500 Welded Grade C pipe. The findings provide valuable insights into the behavior of these props under different loading conditions, aiding in their efficient use and design in underground mining operations.

MONDAY, FEBRUARY 24 AFTERNOON

COAL & ENERGY: COAL AND RELATED ENERGY INDUSTRY MARKETS-FINANCE IN THE 2020S

Room 706

2:00 PM • Monday, February 24

Chairs: ***T. Alch****, NY Section of SME, Edgewater, NJ*
R. Bishop*, Virginia Tech, Blacksburg, VA*

2:00 PM

Introduction

2:05 PM

Can You Spare a Dime? We Want to Finance a Coal Mine

R. Reeves; KCR Capital, LLC, La Verne, CA

This presentation briefly lays out at a high level the issues that impact and shape the environment for coal industry finance today. The macro-economic environment and trends with respect to both demand and supply of energy would seem to favor expansion and capital availability for the US coal industry. However, the US coal industry has been steadily contracting for 16 years, shrinking by 50% from the high in 2008 of 1.17 billion tons sold. All of which raises the question of what are the drivers of that contraction (e.g. competing fuels and environmental issues) and are things moving back into the US coal industry's favor? With these issues in mind, the following presenters will put forth their views on prospects for financing growth in the US coal industry, and I will present some of my expectations and perspectives.

2:25 PM

Coal Mining Due Diligence and Valuation: an Ever-Changing Effort

P. Christensen; RESPEC, Littleton, CO

The basic tenets of technical due diligence have not really changed, but when considering coal assets, the subject business is changing rapidly. This is perhaps nowhere more evident than here in the United States where coal production has halved since peaking in 2008 with bankruptcy affecting companies responsible for two thirds of 2008 production. Disruption in the form of climate change and the new energy economy and substitution by natural gas is not abating leaving the question less one of the quality of the underlying asset but rather who are the customers of the business and will they still be customers in years to come. To different degrees, other countries are facing similar challenges. This presentation will explore various factors affecting the underlying value of coal assets.

2:45 PM

Global Financing and Thermal Coal Supply—A Perspective In 2025

M. Oommen; WSP USA Inc., Creve Coeur, MO

Local energy markets, domestic electricity demand and national energy and natural resource policies continue to dominate the use of coal in power generation. However, external financing in the form of large development financing institutions in Japan, South Korea and Europe has been significantly curtailed in the shift toward financing of cleaner energy sources all parts of the world. US thermal coal consumption is expected to be about 430 million short tonnes (Mt) in 2023 as stated by U.S. EIA. This is a decrease of about 9% from 470 Mt seen in 2022. Meanwhile, China is building 50GW of new capacity in 2023. India and Indonesia are building 97GW and 15GW of coal power capacity, respectively. Given current political and social views, How many of these projects will be commissioned? Given these many projects now in the pipeline, it is hard to see demand for coal completely dying out in the next few decades with coal supplies expected to last at least through the financial tenor of the loans associated with projects.

3:05 PM

Funding Options for the Fossil Fuel Industry

R. McCormick; Capstone Partners, Dallas, TX

Raymond McCormick will present an overview of the funding options for the fossil fuel industry. It has been recognized by major utilities that the electric growth requirements are significantly larger than was just estimated a couple years ago. This is due to the newly revised increased power demands required for AI, manufacturing, ev/hybrid, etc. As a result, fossil fuels are going to run longer and harder to meet the future power demand. Some analysts estimate that our electric grids will need to double in size.

3:25 PM

Restoring Mineral Security will Include Satellite Monitoring for Transparency and Trust

R. Weaver; Orbital Sidekick, San Francisco, CA

Not before in our lifetime has reliable access to mineral production posed the level of national security exposure that we face today. A critical obstacle to new production in friendly locations is resistance from community leaders and policymakers, largely due to an industry trust deficit. While supply reliability, and critical mineral supply, is a problem that demands an "all hands on deck" solution, any functional solution will require a wholesale restoration of trust in the mining sector. Trust, in general, cannot be restored without transparency, and only now is real-time transparency of physical commercial mining operations possible using the latest generation of inexpensive satellite systems. This session will discuss current satellite platforms and how they are able to deliver operational insights and how monitoring technology, and targeted sharing with communities and leaders, can bridge today's trust gap and accelerate mineral supply resilience.

3:45 PM

What Options are Available to Fund the Coal Mining Business

C. Urda Kassis; AO Shearman, New York, NY

This presentation will examine the landscape for raising funding for the coal business (whether the business is metallurgical coal, thermal coal, or a mixture of both). What challenges does the industry face in raising funding and what are the underlying causes of those challenges? Are the challenges increasing, decreasing, or remaining constant? What sources and structures are currently available to the industry? What have the consequences to the industry of such challenges been thus far and what additional consequences are likely to develop?

MONDAY, FEBRUARY 24 AFTERNOON

COAL & ENERGY: INNOVATIONS IN DUST CONTROL AND RESEARCH I

Room 703

2:00 PM • Monday, February 24

Chairs: ***F. Animah****, Virginia Polytechnic Institute and State University, Blacksburg, VA*
A. Greth*, Virginia Polytechnic Institute and State University, Blacksburg, VA*

2:00 PM

Introductions

2:05 PM

Innovative Filtration Solutions: MXene-Enhanced PET Membranes for Coal Mine Dust Mitigation

M. Zaid, A. Kakoria and G. Xu; Mining Engineering, Missouri University of Science and Technology, Rolla, MO

The coal mining industry is essential for energy and steel production but poses significant health risks to workers, notably from coal mine dust, leading to diseases like pneumoconiosis. Current dust control measures are inadequate, often failing to meet safety thresholds. This research explores a novel filtration membrane made from polyethylene terephthalate polymer and MXene titanium carbide (Ti3C2Tx). By analyzing the synergistic interactions between MXene and PET, this study aims to enhance the capture and retention of fine particulate matter, improving air quality and health in coal mines. The innovative approach leverages MXene's unique properties to develop advanced, efficient filtration solutions.

2:25 PM

Development of a Real-Time Silica Sensor with Graphene-MXene Nanosheet

M. Moradi[1], C. Wu[2] and G. Xu[1]; [1]Mining and Explosives Engineering, Missouri University of Science and Technology, Rolla, MO and [2]Zachry Department of Civil and Environmental Engineering, College of Engineering | Texas A&M University, College Station, TX

Respirable crystalline silica (RCS) in mine dust poses a significant health risk to miners, leading to severe conditions like pneumoconiosis and silicosis. Current methods for monitoring silica content delay action and lack an approved real-time silica measurement, necessitating the development of a real-time monitor. This study explores a micro-fluidic sensor embedded with Graphene-MXene for detecting and identifying RCS. The compact, affordable, and user-friendly sensor detects changes in voltage after absorbing silica dust. Initial results demonstrated the sensor's excellent sensitivity and accuracy in detecting real-time silica exposure. This capability can be considered to enhance equipment for real-time silica monitoring.

2:45 PM

Investigating Lung Deposition Mechanisms of Respirable Coal Mine Dust Using Experimental and Computational Approaches

A. Aboelezz[2], W. Su[3], M. Rezaee[4] and P. Roghanchi[1]; [1]Mining Engineering, University of Kentucky, Lexington, KY; [2]Mechanical Engineering, University of Maine, Orono, ME; [3]Public Health, Baylor University, Waco, TX and [4]Penn State University, State College, PA

This study combines experimental and computational approaches to investigate the lung deposition mechanisms of respirable coal mine dust (RCMD). A custom-designed dust wind tunnel with artificial lung airways was developed for experimental studies. Computational fluid dynamics (CFD) simulations were performed using ANSYS Fluent and real human lung geometries. By validating CFD results against experimental data, this research aims to enhance our understanding of respirable dust lung deposition and inform future investigations and miner health interventions. The experimental results obtained from the proposed setup are instrumental in delineating key zones within the lungs where particles tend to accumulate. By varying particle sizes and compositions in our tests, we gained valuable insights into how different types of particles interact with lung tissues, which has significant implications for understanding the health effects of various airborne contaminants. This combined approach provides a comprehensive analysis of RCMD behavior in the respiratory system, contributing to improved miner health and safety protocols.

3:05 PM

Investigating the Relative Agglomeration of Respirable Silica in Coal Mine Dust Using Advanced SEM-EDX Tools

M. Uluer, M. Jaramillo Taborda, C. Keles, D. Sweeney and E. Sarver; Mining and Mineral Engineering, Virginia Polytechnic Institute and State University, Blacksburg, VA

The content of respirable silica (RS) in coal mine dust is an important determinant of severe occupational lung disease. While RS content is typically measured based on mass, dust characteristics at the particle level (e.g., size, surface chemistry) are increasingly of interest. One underexplored characteristic is the relative agglomeration of RS—i.e., are the particles independent or joined with other particles?—which might have important implications for exposure assessment and health outcomes. Using scanning electron microscopy with energy-dispersive X-ray spectroscopy (SEM-EDX), this research demonstrates that RS agglomerates commonly occur in the mine atmosphere but may be easily dispersed with typical respirable sampling or sample preparation procedures. The research also evaluates application of advanced SEM-EDX tools for agglomerates analysis. Systems with capabilities for integrated mineral grain analysis may provide greater efficiency and less user bias than manual SEM-EDX analysis.

3:25 PM

25-047

Influence of Cutting Geometry and Wear Conditions on Dust Concentration and Performance of Conical Pick Cutters

A. Mohanty[1], J. Rostami[1], S. Slouka[2] and M. Sesay[1]; [1]Mining Engineering, Colorado School of Mines, Golden, CO and [2]Civil & Environmental Engineering, Colorado School of Mines, Golden, CO

The lack of progress in controlling pulmonary diseases such as pneumoconiosis cases in recent years necessitates additional studies on dust generation and the characterization of airborne dust. Studies are underway by a NIOSH-sponsored project to observe the characteristics of the dust generated by pick cutters under various wear levels. This research performed a full-scale linear-cutting-test matrix on eight coal samples with various bit penetrations, spacing, and wear conditions. The specific energy and resulting PSD (particle size distribution) of airborne dust and material left at the cutting surface were measured and analyzed. The dust concentration was determined using the NMAM (NIOSH Manual of Analytical Methods) 0600 method. For fines, the PSD was characterized using Laser Diffraction, measuring percent channel and aerodynamic diameter, while Imagej, a virtual sieving application, was used for larger particles. The results show that for a new bit, as the cutting depth and spacing increase, the specific energy and dust generation decrease. The size and shape of the dust particles have been analyzed, and the observed trends are discussed in this paper.

MONDAY, FEBRUARY 24 AFTERNOON

COAL & ENERGY: MINING MACHINES AND EQUIPMENT

Sponsored by: BARR

Room 704

2:00 PM • Monday, February 24

Chairs: ***J. Haughey****, Komatsu, Warrendale, PA*
C. Nyikos

2:00 PM

Introductions

2:05 PM

Enhancing Material Handling and Equipment Efficiency: Reliability-Based Maintenance Policies for Haul Trucks in Surface Coal Mines

S. Sahiner[1], M. Sarigul[2] and O. Golbasi[1]; [1]Mining Engineering, Middle East Technical University, Ankara, Turkey and [2]Mineral Resource Engineering, RWTH Aachen University, Aachen, Germany

In the mining industry, the efficiency of material handling and the reliability of haul trucks are crucial for maintaining production rates and controlling operating costs. This study presents the development of reliability-based maintenance policies for a fleet of haul trucks in a surface coal mine using Fault Tree Analysis (FTA) and Monte Carlo simulation. By analyzing maintenance records and uptime data, we identified key failure modes and

evaluated the effectiveness of seven different maintenance policies. Our findings indicate that optimized maintenance strategies can significantly enhance fleet availability and material handling efficiency, with potential improvements ranging from 59% to 66%. This research underscores the interdependence between effective material handling and equipment reliability, providing actionable insights into maintenance planning to support higher operational efficiency and reduced downtime in the mining industry. Keywords: Material Handling, Mining Equipment Efficiency, Fault Tree Analysis, Monte Carlo Simulation, Haul Truck, Maintenance & Reliability

2:25 PM

Operating Techniques to Improve Wheel Loader Efficiency

J. Marek; Resource Industries, Caterpillar, St. Charles, IL

Whether a wheel loader is used as a primary or supplementary loading tool, the savings that can be gained by improving efficiency can be significant. This discussion will include examples of how decisions at the system level and how operational techniques can affect the amount of material moved per unit of fuel consumed. Recognizing that the wheel loader is not typically the bottleneck in the mine system, we'll look at the value of the savings that can be gained in equal production scenarios by focusing on using a given machine more efficiently.

2:45 PM

Wheel Tractor-Scrapers: Versatility in Bulk Material Handling

J. Gerhold; Caterpillar, Assumption, IL

The Wheel Tractor-Scraper (WTS) has been an industry staple in moving bulk material. These versatile machines can extract pocket or thin seam material, support haul road development and maintenance, as well as perform drainage and reclamation activities. This presentation will explore the Cat® Wheel Tractor-Scraper product offering, the strength of those products in today's mine applications, and how Caterpillar can help customers succeed through application of Wheel Tractor Scrapers in their sites. The Wheel Tractor-Scraper can offer great versatility to the miner, from efficiently extracting the hard-to-get commodity to supporting operations that keep primary production tools working at their top efficiencies.

3:05 PM

Optimizing Rotary Drill Settings for Performance and Cost

J. Bollini; Application Engineering, Komatsu, Milwaukee, WI

Efficient production via a rotary blast hole drill requires a keen understanding of drilling conditions and the ability to determine optimal drill settings to maximize productivity and minimize cost. This paper will review an interpretation of a Komatsu—Mining Application Engineering case study reviewing an iterative process to determine optimal drill settings within a standard mining production environment utilizing Komatsu rotary blast hole drilling products.

3:25 PM

Advancements in Coal Mine Shuttle Car Automation

M. Long, S. Schafrik, J. Sottile and Z. Agioutantis; Mining Engineering, University of Kentucky, Winchester, KY

The mining industry has embarked on a broad effort to research and develop new automated technologies aimed at addressing the complex safety and efficiency challenges unique to mining operations. Coal mining, in particular, faces obstacles in implementing these technologies due to its complex environmental conditions and regulatory concerns. Traditional shuttle cars, critical for hauling coal from the face to conveyor belts, are now a main focus of automation research in coal mining. This presentation will discuss the current state of shuttle car automation research and development. Recently, significant progress has been made in sensor technology, such as underground equipment positioning and LiDAR applications. These advancements have the potential to provide critical spatial and positional data to navigation systems that have paved the way for autonomous operation. Additionally, research into the application of machine learning for shuttle cars has shown promise in allowing for real-time analysis of sensor data and decision-making.

MONDAY, FEBRUARY 24 AFTERNOON

COLORADO MINING ASSOCIATION

Room 710/712

2:00 PM - 3:35 PM

The Outlook for Commodities in the Current Global, Geopolitical and Economic Environment

Moderator: Adam Eckman, President & CEO, Colorado Mining Association

Panelists: Dave Sferra, Manager, Market Intel & Commodity Trading, Freeport McMoRan

Kevin Pritchett, Director of Marketing, Climax Molybdenum

Tom Brady, Professor of Practice, Colorado School of Mines

Rachel Rogier, Lead Federal Affairs Representative, Arch Resources

Paul Goranson, Chief Executive Officer, enCore Energy Corp.

Hear from leading international experts from the precious metal, base metal, and coal industry discuss their views on the future supply/demand, strengths and challenges of the mineral industry and global factors that enhance or threaten the future of the mineral industry.

MONDAY, FEBRUARY 24 AFTERNOON

EDUCATION INNOVATION FOR THE MINERALS INDUSTRY I

Room 501

2:00 PM • Monday, February 24

*Chair: **A. Brickey**, South Dakota School of Mines and Technology, Rapid City, SD*

2:00 PM

Introductions

2:05 PM

Mining and Mineral Engineering Programs of the United States: Enrollment and Trends

K. Luxbacher[1], A. Noble[2], R. Hall[3], Z. Agioutantis[4], B. Arnold[5], K. Awuah-Offei[6], M. Free[7], T. Ghosh[8], Q. Huang[9], C. Kocsis[10], M. Moats[11], N. Mojtabai[12], S. Rosenthal[13], J. Sattarvand[14], A. Smirnov[15] and B. Zisch[16]; [1]Mining and Geological Engineering, University of Arizona, Tucson, AZ; [2]Mining and Minerals Engineering, Virginia Tech, Blacksburg, VA; [3]Mining Engineering and Management, South Dakota School of Mines and Technology, Rapid City, SD; [4]Mining Engineering, University of Kentucky, Lexington, KY; [5]Mining Engineering, Pennsylvania State University, State College, PA; [6]Mining and Explosives Engineering, Missouri S&T, Rolla, MO; [7]Materials Science and Engineering, University of Utah, Salt Lake City, UT; [8]Mining Engineering, University of Alaska - Fairbanks, Fairbanks, AK; [9]Mining Engineering, West Virginia University, Morgantown, WV; [10]Mining Engineering, University of Utah, Salt Lake City, UT; [11]Materials Science and Engineering, Missouri S&T, Rolla, MO; [12]Mineral Engineering, New Mexico Tech, Socorro, NM; [13]Mining Engineering, Montana Tech, Butte, MT; [14]Mining Engineering, University of Nevada Reno, Reno, NV; [15]Geological and Mining Engineering and Sciences, Michigan Tech, Houghton, MI and [16]Mining Engineering, Colorado School of Mines, Golden, CO

The mineral programs of the United States are reviewed including the 14 ABET-accredited mining engineering and mineral engineering programs. Additionally, select extractive metallurgy programs are reviewed. Both include enrollment, degrees awarded, and historic trends, as well as national developments that impact programs. These data serve to address the workforce needs of the United States, particularly as domestic production and associated workforce have reached a critical inflection point as demand increases exponentially.

2:35 PM

Panel—The Future of Mining Education: Challenges, Opportunities and Potential Solutions

R. Mitra[1], J. Kellar[2], H. Wang[3], B. Valdes[4], K. Luxbacher[5] and K. Doran[6]; [1]Mining Engineering & Management, South Dakota Mines, Rapid City, SD; [2]Materials and Metallurgical Engineering, South Dakota Mines, Rapid City, SD; [3]Newmont, Denver, CO; [4]Deswick, Calgary, AB, Canada; [5]University of Arizona, Tucson, AZ and [6]NTS Technical Services; Mineral Education Coalition Chair, Virginia, MN

The US faces a significant challenge due to rising demand for critical minerals (CM) driven by cleaner energy and battery-powered vehicles. The International Energy Agency and US Department of Energy predict a massive demand increase for minerals like lithium, nickel, cobalt, manganese, and graphite. Geopolitical instability has triggered severe supply disruptions and sanctions on several metals, revealing the risks of import dependence. Despite these issues, China remains a dominant leader in CM mining and processing, especially in Africa. Currently, mining companies are facing a looming challenge with a mass exodus of experienced workforce, leading to loss of critical knowledge and skills. This is further exacerbated with reduced enrollment in the mining engineering programs resulting in fewer graduates. In response to this challenge, universities, mining companies and service providers have forged partnerships to design innovative educational programs and implement practical training initiatives. A panel of representatives from industry and academia will discuss the challenges along with the various opportunities and potential solutions.

MONDAY, FEBRUARY 24 AFTERNOON

ENVIRONMENTAL: ESG & SUSTAINABILITY DISCLOSURES

Sponsored by: ARCADIS

Room 104

2:00 PM • Monday, February 24

Chairs: ***K. Brantingham****, ARCADIS, Phoenix, AZ*
K. Awuah-Offei*, Missouri University of Science & Technology, Rolla, MO*

2:00 PM

Introductions

2:05 PM

Bridging the Gap: Aligning Corporate Sustainability Commitments in support of Site-Based Regulatory and Stakeholder Needs

A. Hood, T. Dillon and W. Leavitt; Sustainable Mining, ERM, Mesa, AZ

The gap between corporate commitments and mine operations often challenges the realization of strategic sustainability objectives. We discuss how site-level engagement and reporting can drive corporate sustainability initiatives. This presentation explores synchronizing corporate and site-level strategies, emphasizing how site-specific needs can drive global commitments. We will explore the complexities of translating high-level commitments into actionable, site-specific strategies to meet regulatory obligations and enhance operational efficiency, stakeholder relations, and long-term profitability. Key insights include methodologies for effective communication between corporate and site teams, strategies for leveraging regulatory frameworks to advance sustainability goals, and examples of successful integration leading to measurable business benefits.

2:25 PM

Developing a Path Forward for Nature+ Investments at Resolution Copper

C. Vynne[3], S. Fernando[2] and C. McKeon[1]; [1]Rio Tinto, Superior, AZ; [2]RESOLVE, Washington, DC and [3]RESOLVE and Regeneration Enterprises, Washington, DC

RESOLVE and Regeneration Enterprises conducted a third-party assessment of the proposed Resolution Copper project, and its impacts to biodiversity. The assessment focused on the project's impacts, proposed mitigation efforts and whether the project would result in a net negative, neutral, or positive effect on these resources, thereby guiding a path to a Nature Positive (Nature+) outcome. The report evaluates two key areas: the biodiversity value of the Land Exchange parcels and the net impact on biodiversity resources against mitigation measures outlined in the 2021 Final Environmental Impact Statement. The assessment ultimately informed and guided the development of Nature+ investments.

2:45 PM

Estimating Credits Associated With Nature Based Products

A. Thatcher and J. Tallis; Arcadis, Highlands Ranch, CO

Estimating ecosystem gains (credits) associated with nature-based projects can determine habitat restoration options and environmental credit and funding opportunities. Some of the opportunities for credits and enhancement include wetland banking, biodiversity accounting, retiring water rights/instream flow credits, carbon credits, and other strategies. Some states, such as Nevada, have specific systems which create incentives for private landowners to preserve, enhance, and restore greater sage-grouse habitat. The development of credit projects consists of enhancement and/or restoration of habitat, quantification of credits that will be generated by the project, development of a management plan, securing of financial assurances, and signing a participant contract. The restoration approach may result in no net loss to biodiversity during future work or could result in a nature positive outcome that could meet or exceed sustainability targets. The Arcadis Biodiversity Net Gain Calculator can be used to create a biodiversity baseline and then determine future scenarios that may result in no net loss or a net gain of biodiversity and summarize options for estimating credits.

3:05 PM

NEPA and Climate Change: Implications of Phase 2 NEPA Revisions for Mining Projects

K. Hanley and W. Merz; Trinity Consultants, Boise, ID

Navigating the latest NEPA requirements, particularly the Phase 2 NEPA rulemaking effective June 30, 2024, and the 2023 CEQ greenhouse gas guidance, is crucial for modern mining projects. This presentation highlights the new GHG emissions and climate change evaluation requirements and their implications for project evaluations. It presents innovative strategies that align with the regulation's purpose of addressing climate change impacts, focusing on robust methodologies for accurately assessing GHG emissions. These approaches benefit industry stakeholders by supporting thorough NEPA reviews and addressing new environmental sustainability considerations beyond other regulatory requirements, thereby increasing the chances of project approval.

3:25 PM

The Role Transition Plans Play in Value Creation for the Mining Industry

G. Wallingford; Stantec, Denver, CO

Once faced with defining Environmental, Social and Governance (ESG) for their companies, ESG leaders at are now faced with a different challenge: how to align current ESG programs with developing regulatory expectations, respond to climate associated risks, implement risk mitigation measures, all while taking advantage of burgeoning financial incentives. Alignment with the former Taskforce on Climate Related Financial Disclosure (TCFD) is no longer for advanced ESG programs and is now considered an essential starting point to meet the growing list of obligations. Contained within the TCFD (now IFRS) is an essential element useful to mature any ESG program: development of a transition plan. However, developing a transition plan, quantifying financial risk, and developing risk mitigating targets is extremely nuanced. This presentation will bring insight into the value of transition plan development, regardless of the current program's maturity. The presentation will offer a process for developing a credible and bankable transition plan, cross link transition plan value to include

biodiversity, and present data demonstrating the financial, compliance, and risk-mitigating value.

3:45 PM

Mining Sustainability Assessment Options: Strengths, Weaknesses, and Emerging Data Sources

J. Trost[1], J. Dunn[1], M. O'Connell[1], R. Bullock[2], N. Wight[3] and R. Sankaran[4]; [1]Chemical and Biological Engineering, Northwestern University, Evanston, IL; [2]Department of Environmental Engineering, Montana Technological University, Butte, MT; [3]Sustainable Minerals Institute Center of International Excellence, Las Condes, Chile and [4]Argonne National Laboratory, Lemont, IL

Government regulations and customer demands are driving interest in quantifying mining's environmental effects including greenhouse gas emissions and energy and water consumption. Analyses generated during permitting processes and reports issued through participation in standards like the Initiative for Responsible Mining Assurance can serve in this role. Another framework increasingly used in policies to drive down greenhouse gas emissions is life cycle assessment (LCA). We explore these three options, their strengths and weaknesses, how they interrelate, and how their data needs might be met with emerging low-cost and rapid data gathering technologies.

MONDAY, FEBRUARY 24 AFTERNOON

ENVIRONMENTAL: GREEN MINING

Room 103

2:00 PM • Monday, February 24

Chairs: ***E. Vahidi****, University of Nevada Reno, Reno, NV*
D. Reed*, Idaho National Laboratory Research Library, Idaho Falls, ID*

2:00 PM

Introductions

2:05 PM

Glycolipid-Functionalized Organosilica for the Recovery of Rare Earth Elements From Aqueous Systems

D. Hogan[1], K. Graves[1], C. Boxley[2], R. Maier[1] and T. Dittrich[3]; [1]Environmental Science, University of Arizona, Tucson, AZ; [2]GlycoSurf, Inc., Salt Lake City, UT and [3]Wayne State University, Detroit, MI

Critical materials such as the rare earth elements (REE) and uranium are vital for economic security and the advancement of the green economy. Aqueous mining of such metals in an economical, green, and selective manner is a major hurdle for the valorization of metals from resources typically viewed as waste streams within the mining industry. Glycolipid surfactants are promising materials for industrial and remediation applications because they are non-toxic, biodegradable, and exhibit selectivity for REE and other metals of environmental concern. This project describes the first use of glycolipids in solid-state adsorbents for the recovery of REE and uranium from an aqueous system and lays the foundation for these novel materials as an alternative, green mining approach to valorize metals from mining "wastes" and mitigate environmental risks from traditional mining approaches.

2:25 PM

The Sustainable Extraction of Copper From Chalcopyrite Concentrate Using Ferric Sulfate Bio Acid

E. Owusu-Fordjour, J. P Burke, M. Free and X. Yang; Materials Science and Engineering, The University of Utah College of Engineering, Salt Lake City, UT

The use of microorganisms in the leaching of copper from chalcopyrite is an emerging technology that has the potential to revolutionize the mining industry by encouraging the practice of sustainable mining (green engineering). Carbon dioxide is an essential carbon source for autotropic microorganisms such as Acidithiobacillus ferrooxidans, where their metabolic activity can be boosted, leading to an improvement on leaching kinetics and efficiency. The role of carbon dioxide in bioleaching operation is important to extract energy-relevant minerals from sulfides. This study focuses on the use of CO_2 to optimize bio acid production and to investigate the leaching behavior of chalcopyrite concentrate in ferric sulfate bio acid under varying process parameters. Various leaching techniques and different reagents were employed to optimize chalcopyrite leaching in ferric sulfate bio acid. Characterization and leaching kinetics studies were also studied accordingly.

2:45 PM

Comparison of Different Pretreatment Methods for Lithium-Ion Battery Recycling, and Life Cycle Assessment

U. Kar[1], A. Fahimi[1], T. Suponik[2], M. Kaya[3] and P. Chu[1]; [1]Mining and Metallurgical Engineering, University of Nevada, Reno, Reno, NV;[2]Faculty of Mining, Safety Engineering and Industrial Automation, Silesian University of Technology, Glwice, Poland and [3]Mining Engineering Department, Eskisehir Osmangazi University, Eskisehir, Turkey

The primary objective of this study is to develop an effective and eco-friendly pretreatment process for lithium-ion battery recycling. Based on experimental work and life cycle assessment, four pretreatment process options were evaluated, including discharge, solvent treatment, and grinding methodologies. Of these process options, cryogenic discharge and cryogenic grinding without solvent treatment (Option 3) proved the most effective for obtaining black mass, due to processing time and ease of implementation. Discharging with a 10% NaCl solution and dry (traditional) grinding without solvent treatment (Option 1) was identified as the most environmentally friendly approach, followed by Option 3.

3:05 PM

Evaluating the Carbon Footprint of Nickel Sulfate Production from Global Sources

F. MUTHONI, M. Rabbani, A. Fahimi and E. Vahidi; MINING AND METALLURGICAL ENGINEERING, UNIVERSITY OF NEVADA RENO, Reno, NV

The demand for battery-grade nickel sulfate hexahydrate has surged to meet clean energy goals. Upstream processes from mining, processing, refining, and metal sulfate synthesis have a significant carbon footprint due to energy demands. This study employs an LCA to investigate the environmental impact of nickel sulfate production from hydrometallurgical intermediates: mixed sulfide precipitate in Brazil and mixed hydroxide precipitate in Australia, pyrometallurgical intermediates: nickel pig iron in Indonesia, pure nickel metal in Canada, and basic nickel carbonate in Cuba. The results indicate that the lowest carbon footprint was from the pyrometallurgical pathway mining and processing in Canada, with refining in Norway, which produced 6.7 kg CO_{2eq} per kg of nickel sulfate hexahydrate. The Direct Nickel process in Australia generated 5.0kg CO_{2eq} per kg of product without considering electricity consumption. Our hotspot analysis identifies energy consumption in Indonesia's Rotary Kiln-Electric-Furnace process as a critical factor, with electricity from coal significantly contributing to GWP; transitioning to 50% hydropower could reduce GWP from 86.4 to 45 kg CO_2eq per kg of product.

3:25 PM

25-017

Blue Mining: Advancing Circular Economy Practices in Mining for Sustainability and Resource Efficiency

A. Binder, M. Schubert, Y. Jiang, S. Nowosad and O. Langefeld; Department of Underground Mining Methods and Machinery, Clausthal University of Technology, Clausthal-Zellerfeld, Germany

Transitioning towards a circular economy, mines' role extends beyond resource supply. They can embody circular principles through sustainable practices, optimizing asset multi-use, enhancing resource efficiency. Central to this is Blue Mining, a concept driving sustainability across the industry. With special consideration for ergonomics, Blue Mining integrates multiuse aspects of energy, water, and other resources into planning. It

features components like energy efficiency initiatives, integrated water-management, and circular business practices. Blue Mining unlocks the potential for mines to become more sustainable and resource-efficient. This presentation introduces the concept of Blue Mining, underscoring its role in fostering sustainable development within the mining sector. It explores initiatives geared towards the creation of energy-efficient and resource-smart mines, thereby elucidating the pathway to circularity in mining operations. The presentation emphasizes the opportunities for resource and asset re-utilization in mining, underlining the transformative impact of Blue Mining in shaping a sustainable and resource-efficient circular economy within the mining industry.

3:45 PM

Modification and Evaluation of Biochar for Green Extraction of Critical Minerals

W. Tugume[1], o. Famobuwa[1], D. Talan[1], O. Sanyal[3] and S. Grushecky[2]; [1]Mining Engineering, West Virginia University, Morgantown, WV; [2]Energy Land Management, Davis College of Agriculture and Natural Resources, West Virginia University, Morgantown, WV and [3]Department of Chemical and Biomedical Engineering, West Virginia University, Morgantown, WV

The demand for rare earth elements (REE) has increased much more than the current global production, necessitating innovative and sustainable methods to boost supply. Biochar, a low-cost adsorbent with unique properties, has emerged as an eco-friendly material to address this challenge. This study explores modification methods to enhance biochar's surface functionalities and aims to develop a process flowsheet for the recovery of REEs from acid mine drainage using modified biochar. The presentation will detail the characterization studies for modified biochar, including Zeta potential analysis, Scanning Electron Microscopy (SEM), Fourier Transform Infrared Spectroscopy (FTIR), and Brunauer-Emmett-Teller (BET) analysis. Additionally, the results of adsorption tests and key adsorption mechanisms will be discussed. By leveraging biochar's distinctive properties and improving its adsorption efficiency through surface modification, this study contributes to the advancement of green mining practices, offering a sustainable solution to meet the growing demand for critical minerals.

MONDAY, FEBRUARY 24 AFTERNOON

ENVIRONMENTAL: MINE WASTEWATER TREATMENT

Room 105

2:00 PM • Monday, February 24

Chairs: ***J. Schmidt****, Jacobs, Tempe, AZ*
T. Graham*, Freeport McMoRan, Mesa, AZ*

2:00 PM

Introductions

2:05 PM

Optimization of a High Density Sludge and Filtration Water Treatment System at a Remote Mine in Yukon, Canada—A Pilot-Scale Study

A. Campbell[1], B. Holzbauer-Schweitzer[1], J. Stefanoff[1] and M. Hughes[2]; [1]Federal and Environmental Solutions, Jacobs Engineering, Greenwood Village, CO and [2]Northern Contaminated Sites Branch, Crown-Indigenous Relations and Northern Affairs Canada, Gatineau, QC, Canada

A pilot-scale study was performed at the Faro mine in Yukon, Canada, to evaluate the future performance of a permanent water treatment plant. Treatment technologies included high density sludge lime treatment, aeration, gravity clarification, sludge thickening, and media filtration. Three waters were tested to assess performance under a range of chemistries. Pilot effluent met the draft discharge guidelines for all samples and tested conditions, except when operated at a pH lower than 9.7 and hydraulic loading much greater than the design. The results provide valuable data to enhance operability and performance, reinforcing the expectation that effluent guidelines will be met.

2:25 PM

Maximizing Reverse Osmosis Recovery of High-Sulfate Waters in Mining Pond Dewatering

w. mchale; wastewater engineer, Centennial, CO

With tailings and gypsum ponds filling up globally, and with the increased need to make available reuse-quality water on operational mine sites, the need to process high-sulfate waters at much higher recovery rates than has been acceptable previously, has been a technical pursuit for nearly all mining companies and their wastewater equipment suppliers. This paper presents pilot data acquired in 2024 that shows the performance of newly developed high-sulfate membranes in combination with new chemistries designed to mitigate sulfate issues, where recoveries were improved from 3x—4x as we observed saturation for $CaSO_4$ improve from about 6x—7x, and for $BaSO_4$ improve from ~250x—450x saturation. We will review data and discuss comprehensive treatment systems that can be designed to provide overall RO recoveries in excess of 80% for high gypsum waters.

2:45 PM

Nevada Mine Exploration Project: A Mobile Approach to Water Treatment and Beyond

M. De Ladurantaye-Noel and J. Dallaire; Technologies, Veolia Water Technologies Canada, Saint-Laurent, QC, Canada

Mine operations generate wastewater, even during exploration. At early stages, capital is best invested on revenue generating infrastructure, while environmental protection remains crucial for social acceptance. Mobile assets for wastewater treatment offer a flexible and cost-effective approach, allowing for rapid deployment in addition to proving adaptation to changing site conditions. This case study presents a Nevada mining project, where a mobile unit was deployed to restart an historical mine. Following a positive exploration outcome, and satisfying performances treating various water sources, the operation is poised to transition to a permanent unit, to ensure continued environmental protection while staying cost effective.

3:05 PM

Strategies for Reducing Metals Loading to a Legacy Mine's Water Treatment Plant Through Clean Water Diversion

E. Apostol[1], J. Willis[2], S. Walker[1], J. Kurtz[1], J. Sisson[3] and D. Gosen[3]; [1]Geosyntec Consultants, Lakewood, CO; [2]Trout Unlimited, Inc., Arlington, VA and [3]Freeport-McMoRan, Phoenix, AZ

A historical underground lead-silver-zinc mine (Site) in central Colorado is located between 9,500 and 12,400 foot elevation and is characterized by rugged and steep terrain with a series of fault and fracture systems that allow surface water to infiltrate into various levels of the existing mine workings. Active reclamation is ongoing and includes water treatment operations, management of four tailings dams, adit rehabilitation, in-situ treatment and revegetation of mine wastes, tailings recontouring, and cover studies. Over the past six years, several thousand feet of surface water diversions have been installed to redirect precipitation and snowmelt away from fracture zones above that align with historical underground workings. This presentation describes the adapation of the surface water diversions to a complex hydrogeological system to target a reduction in metals loading to the water treatment plant. The presentation will also explore the challenges of mine water treatment and design and construction of Site infrastructure in a high altitude environment and during various phases of active reclamation.

3:25 PM

The Value Proposition for Investing in R&D for Post-Closure Water Treatment Technologies—Building an R&D Portfolio Focused on Bring Novel Technologies for Selective Metal Recovery From Mining Influenced Water

N. Gurieff, T. Heaton and S. Barrera Ramirez; Rio Tinto, Brisbane, QLD, Australia

Rio Tinto Closure is responsible for >90 sites worldwide, with mining influenced water (MIW) requiring treatment at most sites. Recognising that MIW has an impact on the environment, local communities and the long-term cost of asset closure, Rio Tinto Closure invested in an R&D portfolio to identify, support and develop sustainable MIW treatment technologies. Specifically, the portfolio was designed to focus on technologies to selectively recover metals from MIW, including acid mine drainage (AMD) and alkaline leachates. Selective recovery technologies were chosen as the focus after conducting a detailed technology mapping exercise and consultation with internal and external SMEs to identify five key Areas of Interest (AoI), which were then prioritised based on potential for adding value to closure sites. Selective recovery of metals was prioritised as these can potentially add value directly through the metals recovered, but also indirectly by reducing the intensity of other unit processes in the treatment system. This presentation presents the value proposition for this R&D investment and how it is aiming to transform the approach to MIW treatment at Rio Tinto's closed assets.

3:45 PM

Microbiological Recovery of High-Value Metals From Mining-Influenced Waters

B. Rittmann and C. Ray; Biodesign Swette Center for Environmental Biotechnology, Arizona State University, Tempe, AZ

The Hydrogen-based Membrane Biofilm Reactor (MBfR) is able to recover many valuable metals from mining-influenced waters. Prominent examples of recoverable metals include gold and the Platinum Group Metals (PGM). The MBfR delivers hydrogen gas (H2) to a biofilm of bacteria that reduce the oxidized forms of these metals to elemental nanoparticles that are retained in the the biofilm. Periodic harvesting of biofilm removes the nanoparticles from the MBfR and makes them available for downstream refining. The biogenic nanoparticles have excellent catalytic activity. Being biological, the MBfR operates at ambient conditions and does not require the input of hazardous materials or intense energy. The high value of recovered gold and PGM can lead to a payback period shorter than one year. The MBfR also can remove common co-contaminants, such as nitrate and sulfate. Thus, the MBfR minimizes pollution liability while generating economic profit.

MONDAY, FEBRUARY 24 AFTERNOON

HEALTH & SAFETY: HEALTH AND SAFETY CASE STUDIES HIGHLIGHTED FROM THE SME HANDBOOK

Room 109

2:00 PM • Monday, February 24

Chairs: ***J. Monsalve****, Freeport McMoRan, Blacksburg, VA*
E. Haas*, National Institute for Occupational Safety and Health, Pittsburgh, PA*

2:00 PM

Introduction

2:05 PM

Heat Stress Management Plans

K. Yeoman; CDC/NIOSH, Spokane, WA, WA

Heat stress is a major cause for concern among many mineworkers in the United States. In the coming years, mineworkers will likely experience an increase in adverse health effects from heat exposure as underground mines get deeper and surface mines are affected by more severe heat waves. Therefore, understanding effective methods to manage heat exposure is of utmost importance in mines. To effectively minimize and manage mineworker exposure to heat, mines should assess heat exposure risk and develop a heat stress management plan. To assist mines in developing heat stress management plans, NIOSH researchers wrote a chapter "Managing Heat Stress in a Mining Environment" published in the SME Health & Safety Handbook. In the technical session "Best Practices—Health and Safety Case Studies," we will discuss important aspects of heat stress management plans. We will also include a group discussion with health and safety managers focused on gaps in knowledge and resources that need to be addressed to improve heat stress management in mines.

2:25 PM

Machine Learning the Language of Safety

R. Ganguli; Mining Engineering, Professor of Mining Engineering, Salt Lake City, UT

This talk presents the chapter "Machine Learning the Language of Safety" in the new SME Health & Safety Handbook. Additionally, it demonstrates the natural language processing (NLP) techniques introduced in the chapter through case studies. The mining industry generates a siginificant amount of textual data in the form of accident incident reports. This data could be used to gain useful insights. The chapter introduces the reader to basic concepts of NLP. Additionally, it also presents the capabilities of generative artificial intelligence (genAI), particularly chatGPT, at the time of writing. Since then, our research team has made significant advances in the use of genAI, ensuring the "language of safety" is leveraged while large amount of narratives are summarized. Results show that without introducing domain expertise, genAI may be lacking and miss the mark.

2:45 PM

Bringing Together Health and Safety Management Systems, Risk Management and Critical Control Management

L. Humphries; Minerals Industry Safety and Health Centre, University of Queensland, Brisbane, QLD, Australia

Working in the high hazard, risk management training space I see many professionals with a degree of confusion regarding how health and safety management systems, risk management processes and critical control management fit together. At times with organisations running these areas as independent systems under the misunderstanding that is the only way to achieve compliance with the each area. By understanding how these areas interact and leverage off each other allows us to simplify and integrate our health and safety system to include effective, auditable risk and critical control management within a compliant health and safety management system. It also can be straightforward to identify how our health and safety risk management system and critical controls can be effectively facilitated within an integrated operational risk management system.

3:05 PM

CORESafety: A Refreshed Safety and Health Management System for the Mining Industry

D. Gee[1], P. Krivokuca[2] and E. Haas[3]; [1]Legal, National Mining Association, Washington D.C., DC; [2]Office of the President—Health and Safety, National Mining Association, Washington D.C., DC and [3]Division of Safety Research, NIOSH/CDC, Pittsburgh, PA

CORESafety is a Safety Health and Management System (SHMS) originally developed by the National Mining Association (NMA) in 2011. The only SHMS created specifically for the mining industry, CORESafety's mission is to give mining operations the system, tools, and expertise necessary to consistently improve safety outcomes and achieve excellence in safety, health, and well-being. To reflect ever-changing standards in the industry, the NMA embarked on a CORESafety refresh beginning in 2023. With the help of the CORESafety Advisory Group (CSAG), made up of safety and health professionals from various NMA member companies, and the National Institute of Occupational Safety and Health (NIOSH), the NMA added in mental health and substance abuse considerations, process safety risk management protocols, and consolidated the system from twenty modules down to ten for simplicity. Additionally, the NMA's engagement with TDi Sustainability has them on track to be an internationally recognized SHMS. The NMA looks forward to sharing more about their unique SHMS and their efforts to keep CORESafety at the forefront of industry standards.

3:25 PM

An Introduction to the Mine Safety & Health Handbook

E. Haas[1] and M. Savit[2]; [1]Division of Safety Research, National Institute for Occupational Safety and Health, Pittsburgh, PA and [2]Predictive Compliance LLC, Denver, CO

SME's Health and Safety Division recently completed the Mine Safety & Health Handbook: Approaches from the Field. This presentation provides an overview of the new handbook and reviews the four parts used to accomplish the book's mission. Part 1 introduces safety, health, and risk management frameworks to identify and mitigate hazards. Part 2 contains knowledge around hazard identification and mitigation from industrial safety engineering to health hygiene perspectives. Part 3 advances a concrete understanding of these topics by providing case studies and experiences from mine professionals. Finally, Part 4 provides an overview of SME's Certified Mine Safety Professional credentialing program and connects topics covered in the handbook to the program's Body of Knowledge. Following this overview, the first chapter is discussed, which highlights the roles that regulations play in safety and health practice from one context to another. This presentation sets the stage for the subsequent presentations, which provide a sample of chapters and case studies published in the handbook.

3:45 PM

Emerging and Intersecting Aspects in Environmental Health and Safety in the Mining Sector: Total Worker Health® and Environmental, Social, and Governance

J. Barua and N. Wilk; WSP Canada Inc., Woodbridge, ON, Canada

The mining sector is keen to identify and implement sustainable practices. Environment, Social, and Governance (ESG) reporting is important as it improves transparency, risk management, and trust with stakeholders. It showcases commitment to responsible business conduct and investment and mitigates potential environmental and social risks. The ESG movement including capital markets is challenging organizations to deliver on their environmental and social obligations and economic commitments while mitigating risks of injury and illness for workers. The Total Worker Health® (TWH®) approach provides a framework and content that overlaps with ESG and this presents opportunities to collaborate, pool resources, and advance both areas. Occupational Environmental Safety and Health is a driver for ESG, and Human Capital is an important element as is disease prevention and well-being. Several TWH aspects align with ESG efforts including Sustainable Development and Corporate and Social Responsibility. This session will examine the intersection of TWH and ESG and potential partnerships to be explored. An overview of TWH will be provided along with available useful references and tools.

4:05 PM

Interpersonal Engagement and Psychological Safety for Occupational Well-Being

L. Sims and E. Geller; Health and Safety, Professional, Yerington, NV

When it comes to health and safety in the work environment there are several critical human dynamics to consider when cultivating a positive health and safety culture. A focus on appreciating the complexity of human nature when applying humanistic behaviorism to assessing the role of human behavior in injury occurrence and injury prevention, to improving human behavior with interpersonal behavioral feedback, recognition, and gratitude. This includes setting safe examples daily through work behavior and supporting the safe behavior of their coworkers with interpersonal behavioral coaching and sincere expressions of gratitude for their safety-related efforts.

4:25 PM

Air Quality Solution for Heavy Equipment Cabs

N. Kimball; Heidelberg Materials, Coppell, TX

Heidelberg Materials supplies cement, aggregates, ready-mixed concrete, asphalt, and other building materials to satisfy the needs of construction customers throughout North America. To operate in a safe and responsible manner, the company identifies potential hazards and mitigates risks in the workplace through its safety and health programs. In Heidelberg Materials' Lowrys Quarry (South Carolina, United States), the company instituted dust control measures for its equipment operators. This new technology was shown to reduce potential dust exposure in their working environments, in this case, heavy equipment cabs. What is notable about the process that Heidelberg Materials took to reduce dust accumulation and manage carbon dioxide levels is its use of ISO 23875 to guide its decision-making and evaluation processes. Additionally, the retrofit solution discussed in this case study not only improved the air quality of the cab but also supported driver alertness.

MONDAY, FEBRUARY 24 AFTERNOON

HEALTH & SAFETY: TECHNOLOGY AND INNOVATION IN HEALTH AND SAFETY

Room 108

2:00 PM • Monday, February 24

Chairs: ***S. Han****, The Pennsylvania State University, University Park, PA*
D. Curry*, Allegheny Metallurgical*

2:00 PM

Introduction

2:05 PM

Detection and Mitigation Strategies for Thermal Runaway of Lithium-Ion Batteries in Underground Mines

K. Said[1], S. Dey[2], S. Bhattacharyya[1] and A. Kumar[1]; [1]Energy and Mineral Engineering, Pennsylvania State University, State College, PA and [2]Mechanical Engineering, The Pennsylvania State University, State College, PA

Lithium-ion batteries (LIBs) in underground mines present a hazard due to the potential of rapid failure through thermal runaway (TR). These failures are characterized by elevated heat, noxious gases, projectiles, and burnt particles compromising safety. It is crucial to establish a comprehensive management framework for early prediction, detection, and eventual mitigation of TR. This study presents a novel approach for the prediction and detection of TR using gases from LIBs by combining high-fidelity mathematical models and estimation theory. A widely successful estimation algorithm, viz. linear Kalman filter, will be utilized in this approach, followed by proportional-integral-derivative (PID) controller for potential actuation mechanisms.

2:25 PM

25-035

An Assessment of the Performance and Reliability of Wireless Communication Links Subjected to Electromagnetic Interference in an Underground Coal Mine

Y. Zhang, M. Girman and C. Zhou; NIOSH, Centers for Disease Control and Prevention, Atlanta, GA

Wireless technologies are increasingly used in underground mines for communication, tracking, and remote operations but face challenges due to use of the unlicensed Industrial, Scientific, and Medical band, leading to potential device interference and reliability issues. This study introduced two wireless communication evaluation boards to assess communication performance amid electromagnetic interferences (EMI). Parameters such as signal and noise power, personnel movement, and packet size were adjusted. Results show that EMI source power and personnel movement can impact performance, with smaller packet sizes improving transmission success. These findings can guide the design of more resilient wireless systems in underground mining environments.

2:45 PM

How A.I Improves the Safety in Mining

K. KHERAIS[1] and S. Algharbi[2]; [1]J Tayba Design, Jeddah, Saudi Arabia and [2]Ma'aden, Riyadh, Saudi Arabia

In the mining sector, where operations involve complex, hazardous tasks under severe conditions, adherence to safety procedures is crucial but challenging due to the time-consuming process of identifying the correct protocols. This paper explores how AI, specifically Large Language Models (LLMs), can revolutionize safety compliance by processing vast quantities of safety documents to function as real-time expert safety assistants, offering advice and recommendations. The paper shade light on the development journey of an AI-driven safety model, including challenges faced and potential future advancements. This approach not only enhances immediate safety practices but also sets the stage for broader AI applications in mining, promising significant improvements in operational safety and efficiency. The paper will also provide touch on how the future will be when leveraging A.I specifically to assure the people and environment's safety.

3:05 PM

MIMO Wireless Communication Efficiencies and Reliability for Mine Rescue and Self-Evacuation in Underground Mine Emergencies

E. Antwi, S. Frimpong and M. Raza; Missouri University of Science and Technology, Rolla, MO

Underground mine emergencies can severely obstruct wireless communication. These emergencies may stem from roof and wall collapse and suspended particulate matter from possible explosions. Humidity, coupled with particulate matter, can severely reduce communication efficiency for both emergency self- and assisted evacuation. Increasing the signal power, as a solution alternative, is also limited by the allowable transmit signal power due to the risk of explosions from high methane and coal dust concentrations. Previous research has proposed Multiple-Input Multiple Output (MIMO) communication techniques as suitable solution approach within the allowable transmit power. However, they are limited due to their efficiencies and reliability in dusty and humid mines. In this study, the MIMO technique is employed to maintain signal power for efficient communication in highly humid and dusty underground environments. The system will be tested at Missouri S&T's Experimental Mine under controlled conditions to evaluate MIMO technology's efficiency and reliability. The main novelty of the study is the improvements in wireless communication efficiency and reliability during mining emergencies.

3:25 PM

Automated Post-Disaster Monitoring in Underground Mines Using Image and Point Cloud Analysis

A. Tejada Peralta[2], K. Joao[2], V. Androulakis[1], H. Khaniani[1], M. Hassanalian[3], S. Shao[3] and P. Roghanchi[2]; [1]Mineral Engineering, New Mexico Institute of Mining and Technology, Socorro, NM; [2]Mining Engineering, University of Kentucky, Lexington, KY and [3]New Mexico Institute of Mining and Technology, Socorro, NM

Ensuring safety in underground mines is critical, especially post-disasters. This project uses LiDAR and 360-degree cameras on Unmanned Ground Vehicles (UGVs) and Unmanned Aerial Vehicles (UAVs) to remotely monitor changes in mine environments. The system detects environmental changes using image processing and machine learning techniques. Iterative Closest Point (ICP) methods align point clouds to match images pre- and post-accidents. An object detection algorithm identifies changes in objects of interest. This automated approach aids in the prompt identification of potential hazards, ensuring the safety of first responders and mine rescuers.

MONDAY, FEBRUARY 24 AFTERNOON

INDUSTRIAL MINERALS & AGGREGATES: ADVANCED PROCESSING OF INDUSTRIAL MINERALS, TAILINGS, AND MINING WASTE

Room 106

2:00 PM • Monday, February 24

Chairs: ***H. Patel****, FLSmidth, Midvale, UT*
A. Kumar*, Martin Marietta, Clive, IA*

2:00 PM

Introduction

2:05 PM

Up-Hill Mining Backfill Challenges: When Gravity Is Not On Your Side

E. Charbonneau; Project Engineering, Coeur Alaska - Kensington, Juneau, AK

Backfill is an essential step in mining. Each mine adopts its own backfill method based on cost, rock composition, orebody location, mine life and mining method. When it comes to paste backfill, industry best practice is to build the paste plant above the orebody and use gravity as the primary force. The Kensington site, located in south-east Alaska, doesn't have this option. The mine entrance is at 900ft above sea level with most of the paste being placed up-ramp from the paste plant—as high as 2,795ft above sea level. To accommodate this unconventional approach, positive displacement (PD) pumps are used to deliver the paste up-ramp. With one main pump and two booster stations, the backfilling activities at Kensington are complex and have faced multiple challenges. Pipe improvements, pressure surges, pump reprogramming, water hammer and flushing challenges have been tackled to increase the reliability, performance and overall reach of the system. By investigating the hydraulic system, pipe geometry, pigging and admixture, we have been able to reduce the pressure by 20% and prevent a large capital investment on a 3rd booster station.

2:25 PM

Best Practices for Extending the Life of Industrial Equipment

M. Miner; Application Engineering, Henkel Corporation, Rocky Hill, CT

Industrial equipment over time will corrode or experience wear that will force the equipment to be replaced. Proper preparation and coating can eliminate replacing costly equipment with a simple service on a proper PM schedule. The ultimate goal is to avoid costly unplanned down time and maximize equipment throughput. There are many different protective coatings available and this will highlight when to chose one type of coating versus another. Also, this will highlight industry standards required for proper surface preparation to ensure optimal coating adhesion and maximize coating life. This will extend the life of your equipment, decrease cost and increase throughput.

2:45 PM

Comprehensive Evaluation of Processed Quarry Dust as a Sustainable Replacement for River Sand in Cement Wall Plastering with Optimization of Particle Size Distribution and Cost-Effectiveness

M. Ravanan; Earth Resources Engineering, University of Moratuwa, Hatton, Sri Lanka

The rising demand for sand in construction and the resulting river sand scarcity have led to illegal mining and environmental damage. To address this, finding an alternative is essential. Quarry dust, a byproduct of stone crushing, is being studied as a partial replacement for river sand in wall plaster. Initially, quarry dust did not meet the required particle size for plastering. However, after processing, it achieved a suitable size

distribution. The study created five types of cement-sand-quarry dust wall plaster mortars with sand-to-quarry dust ratios of 1:0, 4:1, 2:1, 3:2, and 0:1, while keeping the cement constant. These mixtures were tested for strength and durability and compared with plaster made from 100% sand. Results showed that a 2:1 sand-to-quarry dust ratio provided the best balance of strength, durability, and workability. Additionally, this mixture reduced plastering costs by 6%. Thus, replacing one-third of sand with quarry dust is recommended as a cost-effective and environmentally friendly alternative.

3:05 PM

Assessing Handling of Filtered Tailings and Mining Waste Using Bulk Solids Virtual Simulations to Match Real World Performance

C. Hartford; Jenike & Johanson, San Luis Obispo, CA

The consideration of handling filtered tailings, mining waste or a combination of those materials, requires an analysis of the flowability of the materials and the mixtures to assess for mixing, segregation, conveyability and flowability to reliably design new handling equipment for those material or consider using existing equipment for transfer and storage. Often transfer chutes handling waste rock suffer from excessive wear, unacceptable dust generation, high belt wear, and product spillage. With the high moisture content of filtered tailings, there may be a concern of liquification on the belt conveyor and plugging of transfer chutes. Flowability test results can then be used to calibrate simulation tools, such as calibrated Discrete Element Method (DEM) models to build a virtual model of material flow through the plant such as bins, stockpiles, and transfer chutes. Changes can be made in these virtual numerical models, such as flowrate and material characteristics (e.g. higher clay/fines/moisture), to evaluate how the changes will respond in the real world so that design or operational changes can be planned for to ensure a successful change.

3:25 PM

Industrial Mineral Flotation Using Novel Coarse Particle Flotation System: coarseAIR™

J. Bowden, H. Patel and L. Christodoulou; Mining R&D, FLSmidth, Bethlehem, PA

Froth flotation is typically constrained by the feed size due to the various probabilities involved in the flotation of minerals. In industrial minerals applications, this size range can extend up to 1000µm or larger. In this study, coarse flotation of industrial mineral was investigated using the novel coarseAIR™ coarse particle flotation technology. The coarseAIR™ is an innovative hybrid-gravity-flotation system that exploits the hydrodynamic advantages of the REFLUX™ Classifier. The coarseAIR™ consists of an aerated fluidized bed utilizing a system of inclined channels to maximize mineral recovery while rejecting fine gangue minerals. The project aimed to maximize the mineral recovery at a much higher particle size range than the current plant practice. Multiple tests were conducted to optimize the performance. Various parameters like feed sizes, fluidization water, flotation air, and throughput was tested. The results demonstrated significantly higher recovery at a coarser grind than the plant flotation performance. The scope for additional testing and plans for future testing were discussed.

3:45 PM

25-095

Unlocking Optimal Flotation Outcomes: Leveraging AI to Enhance Phosphate Recovery

A. Alghamdi, N. Almuhaisen, A. AlHarbi, S. Al Gharbi and O. Morton; mining, Riyadh, Saudi Arabia

Despite the complex nature of mining processes, flotation presents unique challenges, akin to cracking a safe by finding the right combination to achieve optimal results. Flotation involves managing around 20 dynamic parameters, each with a broad scope. The addition of human factors complicates this further, heightening the complexity significantly. This complexity suggests substantial potential for enhancing flotation outputs through precise parameter management. This paper highlights experiences in applying AI to optimize phosphate recovery from the flotation process. By analyzing critical parameters, it develops a predictive model that forecasts outcomes and guides operational teams in adjusting these parameters proactively. This approach not only improves the final product but also lays the groundwork for an advanced advisory model, potentially leading to a fully automated closed-loop flotation system.

4:05 PM

Cellulose Additive for Improved Processing and Performance of Ceramics from Belle Fourche Shale

C. Thrift[2], A. Sheehy[1], S. Gebes[1], B. Stuber[1], J. Petersen[3] and J. Kellar[1]; [1]Materials Engineering and Science, SD School of Mines and Technology, Rapid City, SD; [2]Arconic, Alcoa, TN and [3]Engineering and Mining Experiment Station, South Dakota School of Mines and Technology, Rapid City, SD

Belle Fourche Shale (BFS) is a bentonite-rich shale that is prevalent in the central portion of the United States. In addition to smectite clays BFS also contains small-grained quartz and mica as predominant mineral components. The swelling of smectite clay makes use of BFS for clay-based ceramics from a cracking and distortion perspective. This research focused on the use of cellulose additive to mitigate the negative effects of the smectite clay. A variety of characterization methods (e.g., SEM, DSC, TGA, XRD) and mechanical property tests (e.g., 3-pt bend, compression) have been used to determine the effect of the cellulose addition on shale for use as a low-cost method for processing and production of ceramics.

MONDAY, FEBRUARY 24 AFTERNOON

INDUSTRIAL MINERALS & AGGREGATES: DIGITALIZATION AND AUTOMATION IN INDUSTRIAL MINERALS

Room 107

2:00 PM • Monday, February 24

Chairs: ***D. Johnson****, Stantec, Phoenix, AZ*
K. Costner*, Intrepid Potash Inc, Carlsbad, NM*

2:00 PM

Introduction

2:05 PM

Optimizing Aggregate Quality Control with CNN-Driven Size Analysis

R. Nunes, N. Risso and M. Momayez; Mining Engineering, University of Arizona, Tucson, AZ

In mining operations, particularly in the production of aggregates, ensuring optimal grain size is crucial for maintaining quality standards. This paper presents the development of a convolutional neural network (CNN) model designed to identify oversized rock grains in aggregate images. Traditional methods, such as manual sieving, are labor-intensive and prone to human error. Our study introduces a machine-learning approach for continuous grain size measurement under supervised crushing operation conditions. By refining and optimizing these CNN models, we can accurately detect oversized grains, ensuring adherence to particle size standards and significantly enhancing production efficiency. This computer vision approach offers a practical, cost-effective solution for real-time quality control, with potential applications across various mining operations.

2:25 PM

St. Genevieve Case Study—Improving Crushing Throughput From AI Fragmentation Analysis

E. Williams and R. Sahu; Non-Member, Highlands Ranch, CO

Located just south of St. Louis, Missouri, the Holcim—St. Genevieve Plant encompasses a 100-year Limestone supply. In 2023, Holcim announced a $100 million expansion project where capital improvements will reduce net CO2 emissions, increase circularity, and accelerate decarbonization. Along with this, the adoption of UAV surveys to conduct updated pit topography maps, calculate reserves, 3D blast design, and post-blast fragmentation analysis became a standardized workflow for quarry operations. By leveraging post-blast AI fragmentation analysis, immediate improvements were seen downstream. Savings at the primary crusher, increasing throughput, and reduction of energy consumption all were impacts of adjusting the primary crusher settings, backed by the fragmentation data. The rapid results from the aerial surveys provided the plant operators to analyze the data to drive decisions at the primary crusher. This paper will dive into the ongoing work taken by Holcim to improve its overall operations, starting with its D&B performance.

2:45 PM

Should You Use Drone in Your Mining operation? Or Not?

Z. Al-Tuwaijri, F. Basakran, S. Al Gharbi and F. AlMatrafi; mining, Riyadh, Saudi Arabia

The primary goal of this paper is to assess the necessity of drone technology in mining. It guides teams on whether drones are crucial for enhancing operations or just an additional Nice to have tool. It also helps stakeholders decide between integrating drones directly in their operation or outsourcing drones services. Drones have transformed mining operations, enhancing efficiency and safety with advanced imaging for tasks like surveying and mapping. They speed up data collection, improve monitoring of inaccessible areas, and support environmental compliance, pushing the industry towards automation and increased safety. The critical question is whether to adopt drones and how to manage them. Answering this involves considering business needs and impacts like costs and benefits, essential for informed decision-making. This streamlined evaluation helps mining teams define their needs and enables drone providers to offer tailored services that meet these demands, benefiting all parties involved.

3:05 PM

3D Printing In Mining, A Use-Case

Z. Al-Tuwaijri, F. AlMatrafi, F. Basakran and S. Al Gharbi; mining, Riyadh, Saudi Arabia

In the mining industry, equipment reliability is crucial as unexpected failures can disrupt operations and cause financial losses. Traditionally, companies maintain extensive spare parts inventories, which incurs high costs and logistical challenges. Innovatively, 3D printing offers local, on-demand spare part production, potentially transforming maintenance strategies. 3D printing reduces the need for large inventories, cuts costs, and simplifies logistics. It allows for immediate part production, cutting lead time by over 90%, enhancing maintenance efficiency and reliability. Despite challenges to achieve precise designs, once designed 3D-printed parts often exceed traditional ones in durability, potentially extending equipment lifespans. While reduced initial costs can achieve 60% is attractive, the decreased downtime and improved equipment reliability remain the main consideration to adopt the technology leading to more robust operational strategies, pushing equipment harder and boosting production. The future of 3D printing in mining looks promising, aiming to fundamentally overhaul maintenance and production strategies and enhance efficiency in challenging environments.

3:25 PM

Real-Time P80 Measurement in Hydrocyclones for Enhanced Mineral Processing Efficiency

K. Baah[2] and K. Soni[1]; [1]Application Engineering PCV, FLSmidth, Johannesburg, Gauteng, South Africa and [2]Global Product Manager, FLSmidth, Tucson, AZ

In mineral processing, comminution and separation are critical for extracting valuable minerals. Hydrocyclones play a key role in the separation stage, especially in primary mill applications, by classifying particles based on size using centrifugal force. Achieving the optimal P80 size is crucial for maximizing mineral recovery and efficiency in downstream processes like flotation & leaching. Traditional P80 measurement methods are labor-intensive and risky, involving manual sampling and lab analysis. The Krebs PSA system offers a safer, real-time solution by measuring particle size distribution and P80 directly from the cyclone overflow stream, enabling better process control, enhanced recovery rates and reduced operational costs.

3:45 PM

Digitalization and Automation in Industrial Minerals

S. Datta; Mining, Rockwell Automation Inc, Milwaukee, WI

Digitization and automation are co-related. IoT-enabled devices, such as instrumentation, sensors, and data collection, enhance data visibility and efficiency for optimized operations. Electric motors consume around 40% of the world's energy, mostly from mining and minerals. Optimizing motor control and using intelligent devices can save significant energy. A simple solution is a variable-frequency drive that optimizes motor control to ensure efficient process control. VFD-controlled fans in industrial operations have been found to drastically cut energy usage by up to 70%. Intelligent devices offer energy usage data (cost per KW), enabling streamlined operations and reduced carbon emissions. Emerging automation & digitization technologies predict equipment failures (bearings, pumps, fans) through electrical signal analysis, enabling predictive maintenance. In summary, powered by data-driven models, dynamic optimization enhances efficiency and resource conservation across mining and minerals operations. IoT-enabled products optimize the efficiency of the assets, leading to more productive and sustainable operations.

4:05 PM

Decentralized Autonomous Haulage System Architecture

B. Miller; Autonomous Correct, LLC, Littleton, CO

Autonomous haulage systems (AHS) have been commercially deployed within the mining industry for 17 years. Worldwide over 1,500 fully autonomous haul trucks (AHTs) represent the first, largest, and most profitable application of autonomous vehicles in any industry. However, the commercial AHSs utilize a rigid centralized architecture that is highly reliant on the control rooms and low latency, high reliability communications. The rise of the autonomous "Driver" utilized by on-road autonomous vehicles (AVs) provides an opportunity for an alternative archiecture leveraging on-road AVs' next generation technology as compared to the AHTs from current commercial AHSs. The rigid nature of the current AHSs has limited their application to Tier 1 mines, which are large, long lasting, and low operating cost. Also, current AHSs utilize only ultra-class (>250-ton capacity) trucks with fleet sizes typically exceeding 50 trucks. A more flexible decentralize AHS must be developed to utilize emerging technologies from adjacent industries for sustainable and competitive mining within the United States.

MONDAY, FEBRUARY 24 AFTERNOON

MINING & EXPLORATION: GEOSCIENCES: GEOMETALLURGY- ITS IMPORTANCE IN ROBUST MINING OPERATIONS OF THE FUTURE (PANEL DISCUSSION)

Room 507

2:00 PM • Monday, February 24

Chairs: ***A. Dance****, SRK Worldwide, Vancouver, BC, Canada*
I. Penaloza*, Rio Tinto, West Valley, UT*

2:00 PM

Introduction

MINING & EXPLORATION: GEOSCIENCES: SME/AIPG: PURE GEOLOGY: DISCOVERIES FROM GEOLOGIC EXPLORATION PROGRAMS

Sponsored by: BARR

Room 601

2:00 PM • Monday, February 24

Chairs: ***D. Wolfe****, NACCO Natural REsources, Plano, TX*
J. Brinton*, Agapito Associates, Grand Junction, CO*

2:00 PM

Introduction

2:05 PM

Critical Minerals Mapping Across the United States Under the USGS Earth Mapping Resources Initiative (Earth MRI)

J. Jones, W. Day, P. Loferski, D. McPhee and C. Williams; Mineral Resources Program, U.S. Geological Survey, Anchorage, AK

The USGS Earth Mapping Resources Initiative (Earth MRI) acquires modern geologic, geochemical, hyperspectral, lidar, and geophysical data across the Nation in partnership with State geological surveys and others. Funding from the 2021 Bipartisan Infrastructure Law accelerated and expanded data collection, helping the USGS meet a Congressional mandate to map the Nation's below- and above-ground critical mineral resources. Earth MRI is also developing a national mine waste inventory and conducting site-specific characterization activities. This presentation will highlight Earth MRI research, outcomes, and planned directions and will describe opportunities for industry engagement. Data and reports can be found at https://usgs.gov/special-topic/earthmri.

2:25 PM

Fluid Inclusion Analysis of Auriferous Type 2 and Type 3 Veins Across the Estelle Pluton Complex

E. Freeman Hobler; University of Alaska Anchorage, Anchorage, AK

The Estelle Gold Project is located approximately 150 km (93 miles) northwest of Anchorage in the Alaska Range. The current project is classified as a reduced intrusive related gold system (RIRGS), and it hosts auriferous sheeted quartz veining. Mineralization is primarily low grade and follows a north/south trend across the property. The reported results suggest that two main vein types contain the bulk of Au mineralization, and three fluid inclusions assemblages (FIAs) were identified (Flagg, 2014). The objective of this study is to gather additional information by collecting samples from new high-grade prospects on the Estelle property and determine if a correlation exists between fluid inclusion assemblages and gold grade using petrography, microthermometry, and Laser Ablation ICPMS (LAICPMS) methods. Fluid inclusions (FIs) are small droplets of fluid trapped in minerals during their growth or along fractures that develop and heal after the crystal has formed. (Randive et al.,2014). The 2022 Estelle drill program focused on increasing and proving the resource located on the Korbel portion of the property and the further exploration of RPM North/South, and Train prospects.

2:45 PM

ACME Lithium's Clayton Valley (NV) Project Discovery: Expanding the Valley's Potential

W. Feyerabend; Geology, University of Southern California, Los Angeles, CA

ACME Lithium's Clayton Valley Project's claims adjoin Albemarle Corp's producing operations to the northwest. The USGS drilled two holes in northwestern Clayton Valley in 1979 to depths of 395 feet. Although they took scattered water samples with results up to 55 ppm lithium, that was not enough to stir interest and most exploration activity was in other parts of the valley. The open ground was staked by GeoXplor in 2016 and a block optioned by ACME Lithium in 2021. ACME conducted gravity and HSAMT surveys in 2022 and drilled three holes (one twin) in 2023 to calculate an inferred resource of 302,900 metric tons of lithium carbonate equivalent (LCE) in the basal lower gravel stratigraphic unit. Additionally, the program intersected lithium brines in the basal Campito formation, showed evidence for connectivity to pumping in other parts of the basin and geochemical and isotopic evidence that the brines have hot springs or geothermal affinities.

3:05 PM

The Putnam Anticline; A Complex Laramide Fold With An Interesting Story

M. Rhoades; Rhoades Associates, Overland Park, KS

The Putnam Anticline is a well-known structural high that plunges eastward into the Jornada Del Muerto basin from the north-south trending Caballo Mountain range. The range is located along the eastern flank of the Rio Grande Rift in southern New Mexico. The anticline is flanked to the east, north and south by Permian red beds of the Abo Formation. At the surface, the anticline is cored with Pennsylvanian limestones of the Magdalena Group, a very thick carbonate sequence in the region. Thrust faulting at-depth has created the surface expression in the form of a large fold. In this case, it is an anticline. In 1953, a wildcat well was drilled from the summit of the subject anticline. The drillhole penetrated more than 5800 feet of Paleozoic sediments and did not encounter Precambrian basement rock. This, even though the Paleozoic stratigraphic sequence in this area is only 2400 feet thick. The depth of thrusting may well be considerably deeper than previous investigators concluded. Furthermore, a Laramide 'structural bench' to the southwest, interpreted by previous investigators as a Precambrian basement high, may actually be a large-scale thrust duplex structure.

3:25 PM

25-022

Critical Minerals in Laramide and Paleogene Porphyry, Polymetallic Vein, and Skarn Deposits in Southern New Mexico

S. Moses[1] and V. McLemore[2]; [1]Earth and Environmental Science, Department of Earth and Environmental Science, New Mexico Institute of Mining and Technology, Socorro, NM 87801, Socorro, NM and [2]Economic Geology, New Mexico Bureau of Geology and Mineral Resources, New Mexico Institute of Mining and Technology, Socorro, NM 87801, Socorro, NM

New Mexico lies at the eastern edge of one of the world's great metal-bearing provinces hosting numerous Laramide and Paleogene mineral deposits. Southern New Mexico contains Laramide porphyry Cu (±Mo, Au) and Paleogene Mo-W deposits. Porphyry deposits are generally large, low-grade deposits containing metal sulfides related to porphyritic intrusions with characteristic alteration styles. Porphyry deposits can also be spatially and temporally associated with skarn deposits and polymetallic veins. All of these deposits have the potential to host various critical minerals, including Cu, Zn, Bi, Co, Ni, rare earth elements (REE), Te, and W. Critical minerals may be found as substitutions within ore minerals or as separate mineral phases. New $^{40}Ar/^{39}Ar$ dating and historic geochronology has constrained these deposits into three ore-producing magmatic pulses: 1) ~78-71 Ma Laramide pulse, 2) ~59-50 Ma, Laramide pulse, and 3) ~40-30 Ma Paleogene pulse. New and historic whole-rock geochemical data have highlighted areas with critical mineral potential (e.g. Zn >1%, Bi >1000 ppm, Co to 1026 ppm, and Te to 13 ppm in drill core from Piños Altos, Grant Co., NM) that require further study.

3:45 PM

Subsurface Geological Modeling of Missa? Keswal Area Potwar Plateau, Upper Indus Basin, Pakistan

I. Ullah; Earth Science, QAU, Islamabad, Pakistan, Islamabad, Pakistan

Salt tectonics shape structural geometries in foreland fold and thrust belts, complicating hydrocarbon exploration due to mismatches between surface and subsurface structures. Pakistan's Salt Range and Potwar Plateau is present the impact of the Precambrian Salt Range Formation's low-density evaporites under a Cambrian to Holocene cover during the Himalayan Orogeny. This interaction forms multiple salt-cored anticlines in the Potwar Plateau, hosting hydrocarbon deposits. Seismic and well data from Missa Keswal in the Potwar Plateau show Cambrian strata overlain by Paleocene strata, indicating a major unconformity. Seismic data reveal normal faults in the basement and northwest-dipping fore-thrusts that steepen near the surface. Southeast-dipping back-thrusts form a pop-up anticlinal structure above basement normal faults. Neo-Tethys uplift opening and Himalayan tectonics mobilized Salt Range evaporites, juxtaposing Precambrian-Holocene strata against Punjab Plain, forming steep reverse faults and salt-cored anticlines. Structural modeling using seismic and borehole data is key to understanding subsurface structures and guiding exploration in similar salt-dominated basins globally

4:05 PM

Impactful Due Diligence from Exploration to Resource for the Energy Transition

B. Atkinson and M. Kartick; Stantec, Denver, CO

Mineral exploration is an integral contributor to advancing the global energy transition by sourcing raw materials for technology and manufacturing needs. Our industry will face numerous opportunities and challenges to meet new and sustaining demand as we strive to expand production of critical minerals. Meeting this capacity and demand growth will also require exploration geologists to carefully focus on the quality and type of exploration targets and generation of resource estimates that inspire investor confidence. This presentation will explore the importance of maintaining first principles in exploration and mineral resource management for the energy transition.

MONDAY, FEBRUARY 24 AFTERNOON

MINING & EXPLORATION: INNOVATION & TECHNOLOGY: INTEGRATED TECHNOLOGY SOLUTIONS IN MINING

Room 504

2:00 PM • Monday, February 24

Chair: ***E. Rouleau****, Schnabel Engineering*

2:00 PM

Introduction

2:05 PM

Looking to the Future of Underground Rock Reinforcement: Epiroc's Path to Live Work Elimination & Improved Safety at the Face

L. O'Connor; Epiroc, Absarokee, MT

Underground rock reinforcement methods have been continually advancing with technology progressing over the last 20+ years. The mining industry has come far from the days of the jackleg drill. Epiroc's bolting technologies have moved forward with the goal of live work elimination and improved safety at the face. The Boltec Auto Bolt Reload (ABR) system is the culmination of several years of product development that had the aim to alleviate the bottle neck that rock reinforcement had become. The marriage of bolt type, injection resin, mechanized bolt reloading and smart software control has resulted in a solution that promises to become a game changer in the mining industry. The Boltec ABR is designed to increase productivity and bolt installation quality while significantly improving operator safety. With the ABR function there is no need for the operator to exit the cabin and manually reload the feed carousel--this is all done automatically from a magazine located on the side of the machine. This presentation aims to detail the progress that Epiroc has made with ground support tools and rock reinforcement technology, all while keeping safety the number one priority.

2:25 PM

25-048

Integrating a Drill Rig into the Digital Mine 4.0 Ecosystem

M. Friedemann and H. Mischo; Institute of Mining and Special Civil Engineering, Technische Universitat Bergakademie Freiberg, Freiberg, Sachsen, Germany

Many devices used in mining are not monitored by sensors or do not have their own intelligence. By retrofitting sensors and real-time data processing, machines can be integrated into an existing digital infrastructure. Within the European funded project Mine.io a Sandvik DE110 exploration drill rig is being digitized using various AI algorithms at Research and Education Mine of TU Freiberg. The aim is to increase the productivity of drilling with real-time evaluation of the current rock to be drilled and the current maintenance status of the drill rig. The drill rig is equipped with a speed sensor, pressure sensors in the hydraulics, 3-axis vibration sensor, borehole length measurement and temperature sensor. The sensors are additionally attached to the drilling rig and no structural changes on the drill rig are necessary. All data are processed real-time at a server structure outside of the mine using AI algorithms to analyze which rock (ore or host rock) is being drilled and to perform predictive maintenance. Processed Data are visualized for the operator to optimize the workflow and the productivity.

2:45 PM

Datatwin: DigitalTwin to Increase Productivity in Mine Operations

F. Sagastegui and J. Mansilla; Astay, Lima, Lima/Lima, Peru

DataTwin is a revolutionary platform that transforms mining operations management by enabling real-time supervision, analysis, control, monitoring, and simulation from mine to crusher. Its primary aim is to enhance operational efficiency, increase production, reduce costs, and ensure the product meets plant requirements, thereby boosting metallurgical recovery. Implementing a digital twin in mining starts with importing and centralizing data from geology, operations, plant, and maintenance systems on a single cloud platform. With this data, the mining operation is visualized in 3D, accompanied by the KPIs of the different processes with dashboards (BI), and business analytics (BA) models are generated for production forecasts. Proper training ensures personnel can manage the digital twin data. Applying the solution through DataTwin algorithms in a copper mine increased truck productivity by approximately 5%, reduced haulage fleet congestion by 4% through equipment reallocation, and improved mining plan fulfillment by 9%, guaranteeing plant feed under process area recommendations.

3:05 PM

Real-Time LoRa Based Control of Temperature of Concrete Cylinders During the Construction of the Shaft Liners of a Potash Mine

V. Le Borgne, A. Dulmage and A. Cosentino; GKM Consultants, Sainte-Julie, QC, Canada

The construction and sustained operation of potash mines in Saskathewan is challenging due to flooding risks as the beds are located under water-bearing formations. For the shaft-sinking project at BHP's Jansen mine, the unique construction method of the waterproof liner requires custom-formulated high-strength concrete to ensure long-term structural integrity. In order to obtain the most accurate maturity curves of the liner's high-strength concrete, break cylinders should to cured and tested in real-time at exactly the temperatures they are subjected to during construction. A new method was developed to monitor concrete temperatures in real-time, and transmit the readings to the surface over a LoRa radio link where the readings are used. The LoRa gateway distributes the readings to several programmable logic controllers (PLC) as setpoints for curing baths. Each batch of samples had to undergo controlled cure for a schedule of at least one month. The system scales in order to accommodate up 24 sections

at once in each of the two shafts. This approach can be extendd to any large linear structures such as tunnesl or bridges were running instrument cables is not feasible.

3:25 PM

Underwater Visualization for Tailings Monitoring and Management

J. Daignault[1], A. Zimmerman[3], H. Staton[2], R. Beranek[2] and D. Porter[2]; [1]Kongsberg Discovery, Marquette, MI; [2]Eagle Mine, LLC, Champion, MI and [3]Northwest Hydraulic Consultants, North Vancouver, BC, Canada

Tailings are a by-product generated during mineral processing after extraction. This by-product needs to be stored in a contained facility as it cannot be disposed of in conventional landfills. Tailings facilities are constructed to contain a permitted amount of waste material, with the safety of downstream users in mind. Tailings containment facilities can be constructed dams or impoundments, as well as natural terrain features or abandoned mines with storage capacity. Multiple notable disasters such as the Vale-owned tailings dam collapse in Brazil have drawn attention to the appropriate monitoring and management of tailings. SONAR, which stands for Sound Navigation and Ranging, can be used to not only monitor tailings deposition, migration, and accumulation, but also perform structural integrity inspections, monitor deposition volumes, and provide a holistic understanding of what is happening below the water line. This paper presents the potential for real-time monitoring of tailings impoundments, using the single beam dual-axis single beam scanning sonar deployed at Eagle Mine's Humboldt Mill Tailings Impoundment, in Michigan's Upper Peninsula, as a case study.

3:45 PM

HaulControl: Real-time Earthmoving Monitoring and Control System

J. Uribe, J. Mansilla and F. Sagastegui; Astay, Lima, Lima, Peru

In mining construction projects, supervisory personnel spend significant time manually recording and analyzing earth-moving data, which reduces operational efficiency. The implementation of technologies such as GPS, telemetry, and IoT in mining equipment fleets has shown improvements in the operational efficiency of earth-moving tasks by digitalizing and automating the process. The process starts with configuring IoT devices on earth-moving equipment to collect and send real-time data to the cloud, including location, speed, status, and other operational parameters. Routes are designed using CAD tools, and supervisors monitor and analyze compliance with the earth-moving plan in real-time using Business Intelligence (BI) tools, identifying areas for improvement. If operational deviations in haul cycles are detected, immediate decisions can be made to reconcile this information within the plan automatically. Tests were conducted at a model mine, and the results showed that adopting an IoT-haulage control system improved operational efficiency by 10% in the first year. The system meets technical and operational requirements for effective earth-moving management in mining environments.

4:05 PM

Optimizing Ore Control at Capstone Copper Pinto Valley Mine Through Blast Movement Modelling with OrePro3D

J. Adu; Capstone Copper, Miami, AZ

The Pinto Valley Mine has implemented a cutting-edge approach to optimize ore control and address the challenges of blast-induced ore movement. This case study highlights the innovative use of blast movement modeling to enhance grade control, reduce ore loss, and minimize dilution, thus improving operational efficiency and profitability. By utilizing comprehensive mine data, including in-situ block models, blast designs, pre-blast topo surface, and post-blast muckpile surface, the mine accurately simulates blast dynamics with SmartVectors in OrePro3D. This method transforms in-situ grade control models into precise post-blast models, accounting for differential movement and swell in all dimensions. Optimized dig polygons are calculated, considering dig direction, angle, and bench elevations, ensuring accurate ore boundary definitions and reduced ore loss and dilution. This approach also improves operational efficiency through rapid scenario analysis and real-time adjustments while enhancing safety by eliminating unsafe muckpile surveys. The case study demonstrates the transformative impact of advanced blast movement modeling on ore control.

4:25 PM

Komatsu—Reducing Fueling-Related Delays in Open-Pit Operations

A. Chowdu; Applied Sciences, Komatsu MTS, Tucson, AZ

Truck refueling is a core operational requirement for any open-pit haulage fleet. Based on the fleet size, mines utilize different refueling strategies while attempting to minimize delays and fulfil ancillary objectives, e.g., managing shift changes and operator breaks. A common strategy, especially for larger fleets, is to refuel during the shift when trucks reach a minimum fuel threshold. Komatsu combines the fueling threshold with near-real time data to predictively model a truck's duty cycle and fuel consumption in the future to optimize the refueling schedule for the available fleet. This approach is more responsive to changing operational conditions and opens opportunities for reducing fueling-related non-productive time. A direct consequence of this approach allows operations to safely reduce their minimum fuel thresholds by 5-10%, in turn improving truck productivity. In this analysis, we reduce the fueling threshold by 10% at a large open-pit operation to identify the potential benefits and explore alternative fueling strategies that are made possible by the optimization model.

MONDAY, FEBRUARY 24 AFTERNOON

MINING & EXPLORATION: MANAGEMENT: VENTILATION MANAGEMENT—CASE STUDIES

Room 505

2:00 PM • Monday, February 24

Chairs: ***R. Brokering****, Freeport McMoRan, Littleton, CO*
P. Tukkaraja*, South Dakota School of Mines and Technology, Rapid City, SD*

2:00 PM

Introduction

2:05 PM

Spatial Statistics for Airborne Contamination Estimation: Case Study in the San Xavier Mine

K. Brown Requist and M. Momayez; Mining and Geological Engineering, University of Arizona, Tucson, AZ

Current methods for the real-time monitoring of airborne contamination distributions are severely lacking. No formalized framework for air quality monitoring exists for underground metal/nonmetal mines, and atmospheric monitoring systems for underground coal mines are limited in their ability to provide a holistic understanding of contamination dynamics. A statistical basis for air quality monitoring is desirable, especially one that provides better spatial resolution than ventilation network simulation or atmospheric monitoring systems while remaining suitable for real-time monitoring. With real-time air quality monitoring and spatial statistical methods, we present a case study monitoring airborne contamination in the San Xavier Underground Mining Laboratory.

2:25 PM

Implementing Ventilation on Demand (VOD) at Turquoise Ridge—A Case Study

S. AVANE[1], R. Dayal[2], T. Wharton[2], A. Anani[1] and S. Adewuyi[1]; [1]Mining and Geological Engineering, University of Arizona, Tucson, AZ and [2]Nevada Gold Mines, Winnemucca, NV

Optimizing ventilation in underground mines is crucial to safe mine operations and economics. Ventilation on-Demand (VOD) adjusts the ventilation system to balance overall primary airflow: providing quality air to active mining levels, and accommodating equipment demands leading to overall production efficiency. This study presents a case study of a VOD system at Nevada Gold Mines, to enhance underground safety/health, improve efficiency and economics. Findings indicate that VOD may reduce energy consumption up to 50%, equivalent to annual energy cost savings of approximately $1.1M, with a 3.2-year payback period and an NPV of $4M over 15 years.

2:45 PM

Effective Shaft Ice-Plug Management and Mitigation at Henderson Operations

K. Kolobe, N. Shea, C. Rutter, D. Febiawan and A. Cable; Mining, Freeport McMoran, Broomfield, CO

There is limited published material pertaining to mitigation of ice occurrence in intake shafts in the mining industry. In the winter of 2024, the team at the Henderson Mine identified an ice plug in the #3 intake shaft. This plug was identified through analysis of changes in airflow and confirmed visually to be a significant blockage. Upon identification of the blockage, the Henderson team mobilized engineering, operations, and support resources to safely mitigate the ice without exposing personnel to hazards, while minimizing impact to operations. Workers were removed from all areas potentially exposed to potentially hazardous air velocities. Multiple methods were then used to reduce the size of the ice plug until it was safely dislodged. The mitigation process was achieved through analyzing data to determine the most effective melting methods and coordinating safe deployment of those methods. Teamwork, communication, collaboration, and good planning played a pivotal role in the successful removal of the ice.

3:05 PM

Review of the Diesel Engine Ventilation Bases with Historical and Current Perspective

I. Loomis; Worley, Englewood, CO

Diesel-powered equipment has been employed in underground mining applications for nearly 100 years and ventilation recommendations were established to meet the needs of that equipment. Those early airflow requirements are still, largely, with us today; however, the early bases appear to be lost. This paper considers the historic and current diesel-powered-equipment ventilation requirements, how those requirements were established and maintained. This approach considers the impact of direct pollutants, such as gases, diesel particulates, and sensible and latent heat, as well as indirect pollutants, such as dust, and the ability to manage an encompassing equipment fire. As clean diesel engines the presence of the equipment may be a more important driver of the ventilation demand than the nature of the power plant.

3:25 PM

From Concept to Savings: Lake Cowal's Ventilation Automation Journey

P. Bartak; Engineering, Chart Industries Howden Ventsim Solutions, Saint-Bruno-de-Montarville, QC, Canada

The widespread adoption of broadband data communications in underground mines has enabled the application of many new technologies such as vehicle tracking, remote operation, condition monitoring and ventilation automation. Higher power costs and constraints in ventilation capacity for deeper or more extensive mines make the efficient use of ventilation through automation increasingly attractive. In early 2024, Lake Cowal Mine in New South Wales started implementing Ventsim CONTROL for the automation of auxiliary fans, main fans and regulators. The presentation will focus on the steps taken to roll out an automated ventilation system highlighting its requirements, stakeholders, design, configuration, and commissioning. The installed system operational results shall be presented along with an indication of a variety of possible future optimization options with an automated ventilation system.

MONDAY, FEBRUARY 24 AFTERNOON

MINING & EXPLORATION: OPERATIONS: MINE PLANNING & OPTIMIZATION I (SURFACE FOCUSED)

Room 506

2:00 PM • Monday, February 24

Chairs: ***B. Perez****, KGHM, Centennial, CO*
J. Kraft*, Datamine Software, Littleton, CO*

2:00 PM

Introduction

2:05 PM

Sustainability in Long-Term Surface Mine Planning: A Systematic Review of Operations Research Applications

M. Aghdamigargari, S. AVANE, A. Anani and S. Adewuyi; Mining and Geological Engineering, University of Engineering, Tucson, AZ

The mining industry, crucial for global resource supply, has long faced environmental and social challenges, such as habitat disruption and fatalities. Recently, the industry has been transitioning to meet sustainable development expectations. Operations Research plays a crucial role in this regard by providing techniques to optimize decision-making processes. This research reviews various Operations Research methods and their applications in balancing economic, social, and environmental aspects in surface mine planning. By assessing the strengths and weaknesses of these techniques, the review provides valuable insights for researchers and practitioners aiming to improve production efficiency and sustainability through advanced planning strategies.

2:25 PM

Evaluating the Long- and Short-Term Production Mismatches in Surface Mining: An Expert-Based Unified Approach for Uncertainty Assessment

O. Golbasi[1] and T. Tekbey[2]; [1]Mining Engineering, Orta Dogu Teknik Universitesi, Ankara, Ankara, Turkey and [2]Mine Planning Department, Boliden Aitik Mine, Gällivare, Sweden

Production planning in surface mining is essential for long- and short-term timeframes. Long-term plans generally maximize NPV or final throughput and schedule ore and waste excavation annually, while short-term plans ensure the daily execution of these objectives. Long-term plans often face operational stochastic variability. Misunderstanding aleatory (natural) or epistemic (knowledge-based) uncertainties can cause significant deviations between these planning types, leading to production shortfalls, budget mismatches, supply issues, market losses, planning disruptions, and reduced productivity, affecting downstream industries. Current literature typically separates long- and short-term planning, neglecting a unified uncertainty assessment. This study identifies twenty-one key uncertainty factors—classified into geology, economics, operations, and external groups—that impact planning alignment. A survey of senior planning experts and managers from various surface mines worldwide, analyzed using fuzzy-fault tree analysis, revealed grade variation as the most critical factor (~14%) and communication efficiency as the least critical (~0.5%) in causing production plan mismatches.

2:45 PM

Incorporating Sustainability Principles into Mine Planning: A Novel MILP for Carbon-Conscious Short-Term Production Scheduling

M. Rahnema[2], M. Grenon[2] and A. Moradi[1]; [1]University of Kentucky, Lexington, KY and [2]Mining Engineering, Laval University, Quebec, QC, Canada

The mining industry is a notable contributor to global greenhouse gas (GHG) emissions, posing challenges to achieving the Paris Agreement's goal of capping emissions at 30 Gt CO_2-equivalent annually by 2030. This study introduces a novel Mixed Integer Linear Programming (MILP) model tailored for short-term open-pit mine planning that integrates environmental considerations alongside economic objectives. The model handles complex operational challenges, including block sequencing, multiple transport destinations, and stockpile management, and provides the opportunity to examine the adoption of In-Pit Crushing and Conveying systems, an innovative approach aimed at reducing emissions from haulage—which accounts for over 35% of GHG emissions in open-pit mining. Applied to a case study in an iron ore mine, the model considers the environmental benefits of IPCC systems compared to traditional truck and shovel operations and highlights significant reductions in haulage costs and carbon tax liabilities. The findings demonstrate that fixed IPCC systems, in particular, offer substantial decreases in GHG emissions, presenting a compelling case for their broader adoption in the industry.

3:05 PM

25-057

Mine Plan Risk Assessment and Grade Uncertainty Characterization Using Geostatistical Conditional Simulation: Gold Mine Case Study

S. Hoerger[1] and K. Dağdelen[2]; [1]Peak View Mine Planning, Englewood, CO and [2]Mining Engineering, Colorado School of Mines, Golden, CO

For gold mines, orebody variability is one of the leading causes of differences between planned and actual production. Geostatistical conditional simulations can be used to assess the likely range of production variability for a given mine plan based on the current amount of drilling information. For the McLaughlin gold mine, risk profiles are demonstrated to show how different mine, cutoff and stockpile strategies can reduce risk and improve expected value. Risk profiles for plans created with and without stochastic mine plan optimization are also compared.

3:25 PM

Design, Development and Implementation of Operational Fleet Management Systems Using Adaptative Artificial Intelligence Techniques

L. Zamalloa[2] and K. Dağdelen[1]; [1]Mining Engineering, Colorado School of Mines, Golden, CO and [2]COSMO Stochastic Mine Planning Laboratory, McGill University, Montréal, QC, Canada

In the mining industry, a Fleet Management System (FMS) is a complex framework of integrated routines responsible for calculating, deciding, and registering the best possible arrangement of trucks, shovels and service equipment to achieve the production targets while meeting the operational constraints in a mine. Due to the nature of the problem, the quantity of live data involved, the uniqueness of each mining site, the computational limitations, and the uncertainties related to the mining activity, the system relies on a person called dispatcher for most of the parameters' adjusting and decision-making process. However, since the dispatcher is a human being, the decisions may result in suboptimal solutions due to human-related factors. To provide a solution for this problem, an alternative methodology is presented to discuss a process that involves the combination of Operations Research and machine learning techniques to evaluate best decision parameters, and to predict optimal decision-making for a variety of uncertain scenarios, providing the dispatch operator an optimal course of action for a set of operational conditions, and a potential outcome for a given decision made.

3:45 PM

Capturing Value at Pena Colorada (Adding ESG to the Value Formula)

R. Vivas; Technical Services, Hexagon Mining, Tucson, AZ

Life of Mine Plans and Budget forecasts are supposed to predict the value of a mining operation for a determined mine planning horizon. These predictions look forward into the future and make assumptions which may be governed by ESG constraints. Sometimes, these assumptions change (e.g. did not get an environmental permit) and so the plans have to be updated and alternatives must be evaluated. This presentation looks at how Pena Colorada has included ESG factors into the value formula to provide forecasts that account for ESG variables. Similarly, this presentation shows how Pena Colorada has optimized their haulage and dumping plans to minimize the truck hours and associated carbon footprint.

4:05 PM

Simultaneous Stochastic Optimization of Mining Complexes: Integrating Waste Management and Progressive Reclamation with Encapsulation

V. Guimaraes and R. Dimitrakopoulos; Department of Mining and Materials Engineering, McGill University, Montréal, QC, Canada

Effective waste rock management is a crucial aspect of long-term mining planning. Ignoring the role of potentially acid-generating (PAG) waste rock requites significant treatment costs incurred to prevent acid rock drainage (ARD). Encapsulation of the PAG material can prevent or mitigate ARD by limiting exposure. Traditional practices don't optimize production schedules while addressing this risk. This presentation integrates waste management and progressive reclamation using encapsulation into a simultaneous stochastic optimization framework. Uncertainties in acid generation are addressed using geostatistical simulations of the rock's geochemical properties. A case study at a copper-gold mining complex demonstrates successful encapsulation with minimal financial impact.

MONDAY, FEBRUARY 24 AFTERNOON

MPD PLENARY SESSION

Sponsored by: FLS

Room 705

2:00 PM • Monday, February 24

Chair: ***T. Bhambhani****, Syensqo, Stamford, CT*

2:00 PM

Introductions

2:05 PM

Robert H. Richards Award and Lecturer

J. Kohmuench; Eriez Manufacturing Co, Erie, PA

For contributions made toward advancing the state-of-the-art in fine and ultrafine particle separation technologies that have been commercially successful and used in processing operations worldwide.

2:25 PM

Antoine M. Gaudin Award and Lecturer

Z. Xu; University of Alberta, Edmonton, AB, Canada

For outstanding contributions in applying rigorous science to oil sands extraction systems, leading to significantly improved production and reduced carbon footprint.

2:45 PM

Milton E. Wadsworth Award and Lecturer

M. Free; University of Utah, Salt Lake City, UT

For his contributions to the understanding of transport, kinetics, and interfacial phenomena associated with metal electrolysis, corrosion inhibition, and metal extraction.

MONDAY, FEBRUARY 24 AFTERNOON

RISK MANAGEMENT, RISK TRANSFER AND INSURANCE

Sponsored by: SOMERSET INTERNATIONAL

Room 110

2:00 PM • Monday, February 24

Chairs: ***C. Pecora****, Hawcroft, Venetia, PA*
K. Ward*, McGriff, Denver, CO*

2:00 PM

Introduction

2:05 PM

Introduction of Insurance

D. Zochowski; USI Insurance, Bristol, TN

From a Broker perspective, what a mining client should know about structing an effective insurance program. Embrace Insurance Inspections The ever-changing Insurance Markets Why do I get quotes at the last minute What to expect from your Broker

2:25 PM

Applying Loss Analysis in Loss Control Engineering Programs for Mining Sites

J. Wolgram and D. Landers; Swiss Re, Reno, NV

Loss control engineering programs support property damage and business interruption risk reduction programs through identification and communication of risks to enterprise stakeholders from the board level to front line operators. Through analysis of mining client claim data over the last two decades, Swiss Re tailors their risk engineering program to focus on inherent risks and loss scenarios correlated to large industry losses. The loss analysis framework includes a review of layers of protection related to the loss type and lessons learned to improve the implementation of protection systems and programs.

2:45 PM

Critical Controls—Are Yours Effective?

C. Pecora; Hawcroft, Venetia, PA

We spend a lot of time managing risk. We have numerous controls in place. Sometimes, we are crystal clear on the most critical controls to our operation or organization. Sometimes not. Undoubtedly, there are controls that are 'critical' to limiting the likelihood or consequences of a particular risk. Are these 'Critical Controls' in place? Are they working? Is the performance of the controls clear? In this paper, we aim to share some of the good practices on this subject. After all, we are all managing risk in one way, shape or form. Shouldn't our risk management program be effective?

3:05 PM

Sentrisk—Take Control of Your Supply Chain Risk

S. Maxwell and A. Gregg; Marsh USA, Cincinnati, OH

Marsh built Sentrisk so it's easier to stop disruption. Managing supply chain risk is hard. You can't manage what you can't see, disruption is more frequent, and regulators demand more. Companies have no or limited visibiility to risk exposure beyond direct suppliers and disruptions are causing significant downtime and losses. There are growing pressures from regulators, investors, and customers to operate efficiently. However, businesses that take control of their supply chain risk can gain significant advantage over the comeptition by preventing losses, recovering faster, reporting with confidence, and accessing cost efficiencies. Marsh's Sentrisk platform helps companies achieve these advantages.

3:25 PM

Risk Avoidance Using Tailings Valorization and Dewatering Technology

M. Barish and J. Fisher; Somerset International, Sewickley, PA

Tailings Storage Facilities (TSF) have been an integral part of mining throughout the world since the advent of aqueous processing. In recent years there has been a slow a movement away from these massive ponds due to high cost of construction, increasingly effective technology, and advances in ultra-fine particle recovery. One factor that is rarely considered, but could have great value for community relations and the bottom line, is risk avoidance. The risk associated with a TSF is not in the construction, though there is some, it is not in the cost, as it is known and can be budgeted for, but it lies in the devastation from a catastrophic failure. Lives lost, towns destroyed, and millions of dollars in damages can all be avoided by the proper application of dewatering technology and comingled disposal. This presentation will explore the various technologies available for tailings dewatering and the associated risks with each as it relates to cost and community.

3:45 PM

Insurance Program Impacts Related to Tailings Storage Facilities

K. Ward; McGriff, Denver, CO

Tailings storage facilities (TSFs) represent a major source of operatonal risk for any mine. We typically envision that risk in terms of potential loss of life, environmental devastation, and economic disruption to downstream communities. Tailings stewardship programs and other governance models are used to help manage these risks, but mine owners also utilize insurance programs as a financial risk management tool. In this presentation, we will:—Identify basic insurance coverages and structures related to TSFs - Review wider market impacts after historic TSF failures - Discuss strategies to maximize affected insurance coverages

MONDAY, FEBRUARY 24 AFTERNOON

TAILINGS: TECHNOLOGIES FOR MINE WASTE STEWARDSHIP

Sponsored by: Newmont

Room 607

2:00 PM • Monday, February 24

Chairs: ***J. Bindner****, Conetec Investigations Ltd., Seattle, WA*
C. Priscu*, Priscu and Associates Consulting Engineers Inc., West Vancouver, BC, Canada*

2:00 PM

Introduction

2:05 PM

Reducing Environmental Impact by Anomalies Detection on Pipelines to Tailing Dams

V. Mwaba; SME, Shorewood, IL

Leak detection systems are based on the possibility of performing a mass balance and simulating fluid conditions throughout the system, and identifying anomalies in stable and transient states. In tailings slurry, it is impossible to simulate the fluid due to its high solids content, since they will present indeterminate patterns as a result of the solids. The communication of the instruments along the pipeline poses a challenge in terms of communication and energy autonomy. Flowmeters suitable for high solids content, and monitoring of the pressure model by wireless transmitters, indicate possible anomalies that trigger verification and possible mitigations tasks. Limiting the risk of enviromental accidents.

2:25 PM

25-025

Digital Twins: The Future of Tailings Management

A. Veizaga and S. Cuellar; Arcadis, Santiago, Chile

A digital twin (DT) is an effective tool for monitoring and optimizing various production processes, including mining. In this context, it is important to analyze its application to tailings storage facilities (TSFs) considering their physical characteristics, the availability of data, quantity of variables involved, and the potential benefits expected as a result. TSFs require simulation tools to optimize design, construction, and operation, both in current conditions and future or extreme scenarios. DTs make it possible to integrate online data, historical data, state-of-the-art simulation software, and human expertise to generate a digital copy of the physical infrastructure and processes. This proposed applicability of a DT in a TSF should not be understood as an automatically operating system, but rather as an advanced simulation tool for decision making. In addition, since the implementation of Global Industry Standard on Tailings Management, the mining industry has raised its standards for information management and decision-making. In that sense, use of Digital Twins is a powerful instrument for warehouse management.

2:45 PM

Safeguarding Tailings Dams from Space using L-band SAR Soil Moisture Analysis

J. Perry; ASTERRA, San Diego, CA

Recent commercial uses of L-Band SAR in the water industry for the detection of leaks has led to further developments in its application within the ground engineering industry to determine the concentrations of sub surface soil moisture which can be indicative of potential problems within earthwork assets, road pavements and rail beds. L-Band SAR has also been explored for use in tailings storage facilities (TSF) safety. Internal erosion of TSF and earth dams is one of the major causes of failure, the consequences of which are far reaching including loss of life, environmental disaster, loss of reputation and significant financial penalties. L-Band SAR has the ability to detect moisture below the ground surface and determine the presence of high soil moisture concentrations which may be indicative of areas of internal seepage, in advance of this manifesting itself at the surface. L-Band SAR can assist asset owners to address their responsibilities in terms of dam safety, enabling appropriate direction of resources and funding to the areas needed, and targeted interventions and maintenance for the prevention future failures and the increase in safety.

3:05 PM

Predicting Tailings Properties from Multiple Mine Sites using Hyperspectral Sensing

C. Brockett, J. Scalia and C. Bareither; Civil & Environmental Engineering, Colorado State University, Fort Collins, CO

Technologies that rapidly characterize tailings properties are essential for advancing tailings practice. However, current methods, including the SPT and CPT, do not characterize all relevant tailings properties at the rate and resolution needed for geotechnical analysis and design. Recent studies have shown promise for the use of hyperspectral sensing and machine learning for the prediction of tailings properties. However, there is a poor understanding of how machine learning models perform when simultaneously predicting tailings properties from multiple mines. The objective of this study is to explore how neural networks can be used to predict tailings properties from multiple operations including particle size distribution parameters, solids content, and moisture metrics. Tailings from different mines were artificially prepared to have varying particle size distributions, moisture contents, and densities. Hyperspectral sensing was conducted on the tailings samples and used to compile a tailings-hyperspectral dataset. Neural networks were then used to investigate how various training and testing datasets impact the predictive performance of the neural network.

3:25 PM

Characterisation of In Situ Saturation Profile Through Tube Measurements and SCPTu

E. Coyle; Mining, Working Engineer, Denver, CO

As more scrutiny is given to upstream tailings facility's liquefaction potential and resulting strengths around the world, saturation of the tailings becomes an important question for tailings practitioners, especially in conditions of near, but not fully saturated tailings. The difference in seismic behaviour between near, but not fully saturated and fully saturated tailings can have significant implications in the stability outcomes and design configurations for tailings storage facilities. This paper presents a unique and extensive site investigation performed at an Australian gold mine upstream tailings facility, in predominantly near (but not fully) saturated tailings. The paper presents the method and results obtained by direct measurement of Sr through the collection of 100 high quality piston tubes to full depth of the tailings column, that were then used to determine void and saturation ratios. The tubes were supplemented with adjacent SCPTu dynamic Pore Water Pressure (PwP) and profiles of Compression wave velocity (Vp) and shear wave velocity (Vs) that will be presented for comparison and correlations.

3:45 PM

Revolutionizing Mining, Minerals, and Exploration: The Transformative Power of Generative AI

L. Bachu; Tetra Tech Inc, Saskatoon, SK, Canada

Mining, minerals, and exploration are crucial for global economic development, supplying essential materials for various industries. However, the sector faces challenges such as high costs, environmental concerns, and safety risks. Generative Artificial Intelligence (GenAI) has the potential to address these issues by enhancing efficiency, safety, and sustainability. Current technologies often struggle with data quality and integration. GenAI excels in processing diverse data types, enhancing project management, training, real-time monitoring, and resource optimization. Adopting GenAI presents challenges, including ensuring data quality, mitigating biases, ethics, securing data, and integrating AI systems. This paper provides an overview of GenAI's strengths and weaknesses and offers a roadmap for successful implementation. By leveraging GenAI, the mining industry can drive innovation and sustainability, positioning itself for a future of enhanced efficiency and reduced environmental impact. This paper offers insights for professionals, regulators, and researchers aiming to advance mining, minerals, and exploration practices

MONDAY, FEBRUARY 24 AFTERNOON

UCA: TUNNELS & SHAFTS

Room 111

2:00 PM • Monday, February 24

Chairs: ***B. Meyer****, Frontier-Kemper Constructors, Toluca Lake, CA*
R. O'Connell

2:00 PM

Introduction

2:05 PM

Mechanized Cutting in Mining

B. Grothen; Robbins, Kent, WA

Raise boring machines and road headers are a common fixture of underground mining operations worldwide, but there are limitations to their use. As the geology gets harder and face area or raise diameters get larger the effects on advance rate and tooling costs begin to limit where these technologies can be applied. These issues are especially notable in longer raises or tunnels. In addition, there are limited ways to install ground support in challenging rock conditions. In this presentation, we will look at new

technologies that are pushing the boundaries of what is possible in these conditions, including new tunneling and modular box hole boring machines. These and other machine setups offer the possibility to make long distance, large diameter boring in challenging hard rock an efficient process.

2:25 PM

Novel Methodology for Analysis of Tunnel's Wall Accidental Fire Load For Megaprojects

A. Haghighat; Fire Life Safety, Tunnel Ventilation, AECOM, Walnut Creek, CA

The fiber-reinforced concrete (FRC) tunnels' lining of the transit systems is designed based on accidental fire load during fire incidents. The conventional approach which results in overestimation of the fire loading and lining's thickness is the use of one of the standard temperature-time curves. The research presented in this paper developed a methodology using CFD analysis to analyze the tunnel's wall temperature during a 15 MW train car fire incident in the tunnel for an active megaproject. Convection, conduction, and radiation heat transfers were considered in this numerical analysis. The detailed numerical analysis procedure was discussed and the maximum temperature on the tunnel's wall at full fire was calculated. The maximum temperature point at full fire was considered as the base point to develop the temperature-time graph for FRC tunnel's lining design. The maximum temperature on the tunnel's lining at full fire was calculated at 735.6 ˚C. The calculated results were verified to the similar full scale fire tests in the tunnel. The outcome of this research can be applied to the tunnel and mine design effectively and cost efficiently.

2:45 PM

Improving Efficiency in Rock Cutting: Machine Learning Analysis of Force Signals and Power/Time Trade-Offs

A. Morshedlou[1], I. Dagli[2], J. Rostami[1] and M. Belviranli[3]; [1]Mining Engineering, Colorado School of Mines, Arvada, CO; [2]Computer Science, PhD Student at Colorado School of Mines, Golden, CO and [3]Computer Science, Assistant Professor at Colorado School of Mines, Golden, CO

In this study, the classification of rock types and wear conditions of pick cutters are investigated using force signals collected during rock cutting experiments. Various rock samples were cut using a linear cutting machine (LCM) at the Earth Mechanics Institute (EMI). Two different pick cutters, U85 and U92, were employed, each in three distinct wear conditions: new, moderately worn, and worn out. Cutting force data, represented as force signals, were collected and subsequently analyzed using machine learning classification algorithms alongside signal processing techniques. The objective was to discern the wear condition of the pick cutters and identify the rock types from the force signals. Following the classification analysis, the performance of different algorithms was evaluated to determine those yielding the most accurate results. Further analysis was conducted to balance energy consumption and execution time, providing insights into the trade-offs involved in the application of these machine learning algorithms. The outcomes of this research contribute to the optimization of rock cutting processes and the enhancement of tool life and performance.

3:05 PM

Pushing the Limits of Raise Boring in the Americas

R. Lyle and B. Jones; Cementation Americas, North Bay, ON, Canada

The demands for ventilation shafts are ever increasing as mines expand and go deeper. Accordingly, the commonly employed raise boring method for excavating ventilation shafts is being asked to push its limits. This presentation explores two recent projects that really pushed the limits and were completed with zero harm. The first project consisted of twin surface vent raises in hard rock of the Canadian Shield. These 3530 ft deep raises are the longest single pass raises ever completed in the Americas. The second project, located in a western sedimentary basin, really pushed the limits for diameter. It used an innovative approach to achieve a variable diameter to optimize the shaft liner dimensions. The reamer was initially configured at 26.6 ft diameter—one of the largest raises ever completed—and modified to finish at 24.6 ft. This presentation provides a summary of these groundbreaking projects including ground conditions, pilot drilling and reaming considerations—along with the challenges overcome along the way. Best of all, these demanding projects were successfully completed with zero harm.

3:25 PM

Pleasure Bay Interceptor—Shaft and Tunnel Design Considerations and Construction Challenges

T. Kilduff; Kilduff Underground.com, Tinton Falls, NJ

The Pleasure Bay Interceptor Project consists of the construction of a new 50 MGD pumping station in Monmouth Beach, NJ and interceptor sewer. The new interceptor sewer extends 3,300 linear feet under Pleasure Bay to an existing sanitary system in Oceanport. The pumping station required an 80-foot diameter compositely supported shaft sunk approximately 120 feet within stiff to hard marine deposits. The tunnel was advanced with a Lovat earth pressure balance machine (EPBM) through the stiff marine clays to reach another compositely supported reception shaft that was approximately 100 feet deep. The Project encountered a significant differing site conditions (DSC) that required quick attention and response with changes to means and methods and engineering design. This paper details the project challenges and team decisions made to overcome significant challenges.

3:45 PM

Master Drilling's Shaft Boring System: A Breakthrough in Blind Shaft Sinking

K. Jordaan and T. Janse van Vuuren; Business Development, Master Drilling Group, Fochville, Gauteng, South Africa

Master Drilling Group, a global leader in underground mining solutions, is proud to introduce its innovative Shaft Boring System (SBS). This groundbreaking technology is designed to revolutionize blind shaft sinking operations, offering unparalleled efficiency, safety, and precision. The SBS has been rigorously tested at Master Drilling's experimental site in Fochville, South Africa, where it successfully drilled through 320 MPa Norite, a particularly hard rock formation. This demonstrates the system's exceptional capabilities in challenging geological conditions. The initial testing phase of the SBS is focused on sinking blind shafts between 50 and 100 meters in depth with a diameter of 4.3 meters. However, future iterations of the technology are expected to accommodate larger diameters, with the potential to drill shafts up to 11.5 meters. By eliminating the need for traditional blasting methods, the SBS offers significant advantages in terms of safety, speed, and cost-effectiveness. This innovative technology has the potential to transform the underground mining industry, enabling safer, more efficient, and more sustainable operations.

4:05 PM

Master Drilling's MTB: A Revolutionary Advance in Tunnel Boring

K. Jordaan and T. Janse van Vuuren; Business Development, Master Drilling Group, Fochville, Gauteng, South Africa

Master Drilling Group, a pioneer in underground mining solutions, is proud to introduce its innovative Mobile Tunnel Borer (MTB). The MTB boasts a diameter of 5.5 meters, enabling it to excavate large-scale tunnels in challenging geological conditions. Its robust construction allows for drilling through hard rock formations, making it ideal for a wide range of mining and infrastructure projects. The MTB's modular design facilitates faster commissioning and de-commissioning, reducing downtime and minimizing project costs. Additionally, the machine is capable of operating at inclines and declines of up to 9 degrees, expanding its applications to a variety of tunnel configurations. A unique feature of the MTB is its ability to perform tunnel equipping tasks simultaneously with drilling. This integrated approach streamlines the tunneling process, reducing the need for additional equipment and personnel. The MTB represents a significant

advancement in tunnel boring technology, offering enhanced productivity, safety, and cost-effectiveness. It is poised to become a valuable asset for mining companies and infrastructure developers seeking efficient and reliable tunneling solutions.

TUESDAY, FEBRUARY 25 MORNING

BULK MATERIAL HANDLING: SAFETY AND DUST MANAGEMENT AND PLANT DESIGN

Sponsored by: WOLONG Power your future

Room 610/612

9:00 AM • Tuesday, February 25

Chair: ***G. Bierie****, Benetech USA, Aurora, IL*

9:00 AM

Introduction

9:05 AM

Reducing Dust and Respirable Crystalline Silica Near Conveyors Using a Hybrid Dust Control System

D. Parks[1], A. Miller[1], B. Koski[1] and G. Bierie[2]; [1]CDC NIOSH, Spokane, WA and [2]Benetech, Aurora, IL

Respirable crystalline silica (RCS) is a common airborne hazard in many industries including mining. Researchers at the National Institute for Safety and Health (NIOSH) have regularly conducted research into novel approaches for dust and RCS reduction at industrial sites. We present the development of a prototype system for reducing dust emissions with a focus on transfer points. The passive portion of the prototype included modular sections of shrouding with internal baffles mounted on the conveyor frame directly beneath two cone crushers. The active portion of the system consisted of a powered blower baghouse on a transfer point downstream of the cone crushers. The backpressure inside the baghouse filters was monitored and used to trigger a jet of compressed air to dislodge the collected dust. The dislodged dust was prevented from being re-entrained by way of a synchronized spray surfactant. Air sampling showed that area airborne respirable dust was reduced 93% ($p < 0.0001$) when the full hybrid system was installed. This type of system has the potential to reduce airborne respirable dust and silica in many mining environments.

9:25 AM

Improving Belt Maintenance Effectiveness by Design

R. Lezius[2], G. Graber[1], D. Pfister[2] and V. Hamilton[1]; [1]Business Development, Virta Inc, Carlsbad, CA and [2]Engineering, Carlsbad, CA

Effective and efficient maintenance of belt conveyors is as critical for its safety, reliability and efficiency as its functional design. While design principles for functional operation are well established, effective design for safe and efficient maintenance can often be overlooked. The availability and reliability of belt conveyors depend on minimizing unplanned downtime and reducing preventive maintenance efforts. Reducing unplanned downtime can be achieved with use of technologies like condition monitoring, which can be used to prevent premature component failure and to develop effective preventative maintenance programs. Routine maintenance activities can be made safer, more efficient and less costly with attention to rapid component replacement, modular chute design, clever maintenance tools (e.g., pulley C-frames, spreader beams, belt pulling bars, idler removal tools, etc.), improved inspection areas and effective spares management. This paper examines the design and implantation of effective maintenance techniques for improving overall system availability and reliability, while reducing the time and labor for maintenance tasks.

9:45 AM

Engineering the Second Longest (67.8km) Overland Conveyor System in the World

A. Jennings; Conveyor Dynamics, Inc., Bellingham, WA

At 67.8km Atlas Energy Solutions, Dune Express Overland Conveyor system is the second longest chain of conveyors ever built and the longest built in 50 years. The conveyor system transports 2,100 short tph of frac sand across the Permian Basin and into New Mexico where it supplies remote distribution facilities. Dune Express negotiates countless existing infrastructure obstacles including highways, railway corridors, service roads, flood plains, powerline and pipeline easements and oil wells on its way from the existing Kermit sand plant in West Texas to New Mexico. The horizontally curved conveyor system comprises of 4 main overland conveyor flights with the longest of which is 26.3 km. Conveyor Dynamics was responsible for the detailed mechanical design and control of this system. We present here, three new products we invented to meet Atlas Energy Solutions' requirements: a tool that removes idlers on a running conveyor, a device that is inserted into a running conveyor to temporarily offload the sand at any location along the route, and a belt tension sensor that does not require loadcells. This paper also describes the advanced array of smart sensors monitoring the system.

10:05 AM

Advanced Drive Technology for Atlas Energy Solutions' "Dune Express" Overland Conveyor System

R. Hoet; Sales & Applications Engineering, Voith USA Inc, York, PA

Atlas Energy Solutions will complete the commissioning of the historic "Dune Express" (DE) overland conveyor system in 4Q-2024, the longest conveyor system built in the last 45 years worldwide. The 4 overland conveyors transport fracking sand 67 km across western Texas into New Mexico. It is the 2nd longest conveyor system in operation worldwide, and the longest overland system in the Americas. Two of the conveyors, CV02 (24.05 km) and CV04 (26.55 km), surpassed the previous world record for the longest single flight conveyor without an intermediate drive station (Sasol—Shondoni @ 20.5 km). Like the Sasol conveyor, both CV02 and CV04 have several horizontal curves which require precise torque control from the drives. The DE uses many advanced technologies which were applied to the belt, the idlers, the pulleys, and the drive system. This paper focuses on the collaboration and design efforts of Atlas Energy Solutions, Conveyor Dynamics Inc, and Voith in the design, development, and control logic of the Voith supplied fluid coupling drive packages that power the 3 longest conveyors, providing a 10 minute controlled acceleration and load sharing control from the drive system.

10:25 AM

25-080

Silo Inspection and Repair

D. Blauser; Management, Marietta Silos, LLC, Marietta, OH

In this presentation, we will cover storage silo material flow patterns, including funnel flow, mass flow, and fluidizing flow. There will also be a discussion on the negative attributes of asymmetric flow. We will then go into a discussion of the different types of storage silos including jump form, slip form concrete, and steel silos. Then we will cover a description of the different areas and structures of a storage silo to be observed, and what to look for to determine if there are any potential structural problems. This will allow a silo operator to do a brief inspection and then know when to alert management or a silo specialist. We will also include a description of the different types of Silo inspections by professional experts to include descriptions of level one, two, and three inspection procedures. The presentation will include a discussion on the different types of silo repair procedures available in the market. We will also explain how to select the correct Silo professional to inspect further or design repairs.

TUESDAY, FEBRUARY 25 MORNING

COAL & ENERGY: CORE-CM/RARE EARTHS

Room 702

9:00 AM • Tuesday, February 25

Chairs: ***D. Palo****, Barr Engineering, Murrieta, CA*
B. Arnold*, The Pennsylvania State University, Apollo, PA*

9:00 AM

Introductions

9:05 AM

25-076

Rare Earth Elements (REE) and Other Critical Minerals in Late Cretaceous Coal Beds in the San Juan and Raton Basins, New Mexico

V. McLemore and E. Owen; NMBGMR/NM Tech, Socorro, NM

Rare earth elements (REE) and critical minerals are increasingly becoming more important in our technological society and are used in many of our electronic devices (such as cell phones, computer monitors, wind turbines, etc.), batteries, and magnets. Measuring REE and critical minerals in ashed coal approximates the REE and critical minerals in the fly or bottom ash remaining after coal is burned at a power plant, where REE and other critical minerals could be leached. In New Mexico, there are 23 coal fields in Late Cretaceous rocks in the San Juan and Raton Basins. These rocks are being characterized as part of the DOE's CORE-CM (Carbon Ore, Rare Earth, and Critical Minerals) program. Higher concentrations of REE (as much as 2103 ppm total REE) are found locally in ashed coals from the basins. More chemical and mineralogical analyses are required to fully understand the distribution and origin of REE in these deposits. As the demand for REE increases because of increased need and short supplies, the dollar value per ton of ore rises, enhancing deposit economics, perhaps even from coal.

9:25 AM

A Survey of Rare Earth Elements and Other Critical Minerals in Coal Ash

D. Levitan; U.S. Geological Survey, Reston, VA

When coal is burned for power generation, the residual ash can be enriched in critical minerals (as defined by the U.S. Geological Survey's 2022 list), including rare earth elements (REEs), compared to other geologic materials. This study evaluated a geochemical dataset compiled from over 700 coal ash samples that have been published in reports, government databases, and scientific literature. We examine the distribution of REEs in coal ash, the relationship between REEs and other critical minerals in coal ash, and the factors that may influence the concentrations of these elements. The results show that coal ash is generally enriched in REEs relative to typical crustal levels, with around 70% of samples exhibiting total REE concentrations over 300 ppm. However, the concentrations are variable, and the proportion of critical REEs was not correlated with total REE concentrations, suggesting that both factors may need to be considered when evaluating coal ash as a source material. Total REE concentrations were strongly directly correlated with the concentrations of individual REEs and thorium, a potential indicator parameter.

9:45 AM

CORE-CM Highlights from the CANARY (Northern Appalachia) Project

B. Arnold and S. Pisupati; The Pennsylvania State University, University Park, PA

Since 2021, Penn State's Center for Critical Minerals has assessed the carbon ore, rare earth elements, and other critical mineral contents of various target materials in the Northern Appalachian basin. Carbon products' potential is significant in this basin as coal reserves are prevalent and represent coal ranks from high-volatile bituminous through anthracite. Many waste products from current and historic mining and power generation activity are also found in the basin, including acid mine drainage/sludge, tailings related to ash from fluidized bed combustors utilizing coal refuse, coal mining, and metal mines), metal slags, coal underclays, and produced waters from the oil and gas industry. This paper will provide an overview of these targeted resources. It will identify samples that contain some of the highest concentrations of rare earth elements and other critical elements of interest.

10:05 AM

A National Critical Minerals and Materials Prospectus and Resource Assessment Methodology

A. Wendt, G. Creason, D. Justman, R. Yesenchak, N. Cordero Rodriguez, S. Nakacwa, J. Mackey, T. Vactor, T. Childress, C. Conwell, T. Tarka, B. Thomas and G. Guthrie; U.S. Department of Energy National Energy Technology Laboratory, Pittsburgh, PA

Since 2014, the U.S. Department of Energy (DOE) Office of Fossil Energy and Carbon Management (FECM) and the National Energy Technology Laboratory (NETL) have been developing technologies to diversify the domestic supply of critical minerals and materials (CMM) from unconventional prospects. It has been shown that unconventional CMM resources, including coal refuse, coal byproducts, and other coal-related waste streams such as acid mine drainage, contain usable concentrations of CMM that are, in some cases, ore-grade or greater. To fully understand and reflect how CMM contained in unconventional prospects vary across the United States, FECM/NETL is developing a National CMM Prospectus. The Prospectus, which leverages data collected by Carbon Ore, Rare Earth, and Critical Minerals (CORE-CM) Initiative for U.S. Basins awardees as well as other publicly available datasets, will present grade, tonnage, and constrained uncertainty of potential prospects. To that end, FECM/NETL is developing a prospectivity analysis methodology for unconventional CMM feedstocks, including coal, coal refuse, coal fly ash, acid mine drainage, and fossil-energy-related produced waters.

10:25 AM

Critical Minerals & Materials from Secondary and Unconventional Feedstocks: Best Practices from the CORE-CM Initiative

T. Childress, A. Wendt, J. Mullen and S. Montross; U.S. DOE National Energy Technology Laboratory, Pittsburgh, PA

The Carbon Ore, Rare Earth, and Critical Minerals (CORE-CM) Initiative for U.S. Basins is a Department of Energy (DOE) effort aimed at catalyzing economic growth and job creation by developing more stable domestic supplies of critical minerals and materials (CMM), including novel high-value, nonfuel, carbon-based products from secondary and unconventional feedstocks. DOE formed collaborative working groups with the CORE-CM awardees and their partners consisting of industry; universities; local, state, and federal government personnel; and tribal governments. These working groups collaborated over a series of virtual meetings and in-person workshops in 2023 and 2024. Drawing on the experience of technical experts, including the U.S. Geological Survey, DOE has developed a suite of best practices guidance documents regarding CMM resource characterization of secondary and unconventional feedstocks such as coal and coal refuse, coal fly ash, and acid mine drainage; assessing available infrastructure and gaps needed to support CMM supply chains; and environmental justice centered on community outreach and engagement.

10:45 AM

Integrated Treatment of Acid Mine Drainage and Rare Earth Element-Critical Materials Production

A. Noble[1], T. Larochelle[2] and P. Ziemkiewicz[3]; [1]Virginia Tech, Blacksburg, VA; [2]L3 Process Development, Bent Mountain, VA and [3]Water Research Institute, West Virginia University, Morgantown, WV

Rare Earth Elements (REEs) are considered critical minerals essential for several technology and defense applications. Terbium and Dysprosium are particularly important given their necessity in high-temperature magnets, their projected supply shortfall and the lack of domestic resource. Over the last 10 years, researchers at West Virginia University, Virginia Tech, and L3 Process Development have developed enabling technologies for the extraction, recovery, and separation of REEs, particularly Terbium and Dysprosium, from acid mine drainage (AMD). This presentation will describe how these technologies have been integrated into a national AMD-based REE supply chain using the Front End Loading (FEL) Framework, how this project is being leveraged to develop new technologies and training opportunities.

11:05 AM

Expanding the Search for Critical Minerals in Appalachia

R. Bishop[1], A. Noble[1], B. Arnold[2], K. Andrews[5], Z. Agioutantis[3], S. Schafrik[3] and D. Talan[4]; [1]Virginia Tech, Blacksburg, VA; [2]Penn State, State College, PA; [3]University of Kentucky, Blacksburg, KY; [4]West Virginia University, Morgantown, WV and [5]Marshall Miller & Associates, Blacksburg, VA

Over the past few years, extensive research has focused on assessing the mineral endowment of the Appalachian coalfields and its potential to be a source of critical minerals for the United States. Through the Department of Energy's CORE-CM (Carbon Ore, Rare Earth, and Critical Minerals) initiative, several teams have been examining this region's mineral resource potential beyond coal, with the goal of discovering materials that can be used to advance clean energy technologies and sustainable industries vital to job creation and national security. These efforts aim to stimulate downstream value-added industries that can bring economic growth back to the area. This presentation will highlight the latest technologies being used for rare earth and critical minerals exploration in the Appalachian region and plans to accelerate the next phase of characterization work.

TUESDAY, FEBRUARY 25 MORNING

COAL & ENERGY: DEPLOYMENT OF MINE EMISSIONS REDUCTION TECHNOLOGIES- MINE METHANE MANAGEMENT

Room105

9:00 AM • Tuesday, February 25

Chairs: ***M. Karmis****, Virginia Tech, Blacksburg, VA*
J. Fidler*, Consol Energy Inc, Canonsburg, PA*

9:00 AM

Introductions

9:05 AM

Field Test Unit Demonstration for the Catalytic Oxidation of Ventilation Air Methane (VAM)

A. Palermo[1], K. Gray[3], J. Fedeyko[1], Y. Lugo-Jose[1] and P. Flynn[2]; [1]Johnson Matthey, Wayne, PA; [2]CONSOL Energy, Canonsburg, PA and [3]Johnson Matthey UK, Stockton-Tees, UK

As Part of the DOE funded REMEDY project (DE-AR0001532), Johnson Matthey, Oak Ridge National Laboratory and CONSOL Energy have developed, designed, and implemented a catalytic oxidation technology to demonstrate the abatement potential for VAM sources from underground coal mining. The demonstration equipment successfully abates methane, by catalytically converting it to carbon dioxide, in a range of 0.1-1.2%v/v from 1000scfm from coal mine ventilated air. Lab scale results successfully validated performance >99.5% methane destruction over long periods (>1000h on stream). The design and performance of the system will be discussed, covering areas of performance and control across variable methane concentration. Also discussed is a proof of methane abatement in line with the California air Resources Board Protocol of April 2014, and applying carbon credits for income resource. An updated modular commercial design will also be presented and discussed alongside the CO2e Levelized Cost of Carbon Abatement (LCCA) for the system.

9:25 AM

A Modular Catalytic System for Methane Mitigation from Mining Operations

H. Hawa, T. LaBreche and S. Roychoudhury; Microlith Products & Applications Development, Precision Combustion, Inc., North Haven, CT

Precision Combustion, Inc. (PCI) is developing a modular catalytic system for methane mitigation from ventilation air methane (VAM) exhaust of underground coal and metallurgical mines. Unlike state of the art thermal oxidizers, PCI's system is based on proprietary contaminant-tolerant catalyst and system designs that enable operating at temperatures of <600°C, while maintaining methane destruction and removal efficiency (DRE) of >99.9%. Our system is based on short contact time, low thermal mass reactor design to achieve maximal total conversion in a small volume. Furthermore, the overall methane mitigation system is designed to maximize the degree to which released heat is retained and recirculated to minimize heating requirements. Long term durability and contaminant tolerance were demonstrated for 1000's of hours for methane concentrations ranging from <100 ppm_v to 1% (by vol.) in air. In this talk, we will report performance data, levelized cost of carbon abatement (LCCA), and life cycle impact analysis findings of methane mitigation from mining operations. Applications to other sectors, including oil and gas, agricultural, and atmospheric methane removal will also be discussed.

9:45 AM

Durability of a Low-cost Copper Zeolite Catalyst for Ventilation Air Methane Abatement

D. Plata[1], A. Parker[1], W. Sawyer[2] and E. Martin[1]; [1]Civil and Environmental Eng., MIT, Boston, MA and [2]Methanosynthesis Group, MIT, Boston, MA

Catalytic ventilation air methane abatement has been limited in application by high overall lifetime cost, where both the primary investment and durability of the catalyst compound to drive up operating expenses and prohibit useful application of the technology. Previous demonstrations have illustrated that low-cost, Earth abundant copper-doped zeolites can destroy methane at relatively low temperatures over short timescales in simulated air. Here, we illustrate that these catalysts can survive long-term exposure to temperature, hydrogen sulfide, ammonia, nitrous oxide, and water vapor. In particular, we illustrate that monolithic and pelletized catalysts can survive up to four months in active use with modest deactivation. Chemical and thermal deactivation mechanisms are detailed and technoeconomic implications are presented.

10:05 AM

Mine Methane Management in Germany

A. Preusse; Institute for Mine Surveying, Mining Subsidence Engineering and Geophysics in Mining, Rheinisch-Westfalische Technische Hochschule Aachen, Aachen, Nordrhein-Westfalen, Germany

Mine methane was always an important issue in german coal mining. Due to its ability to form an explosive mixture with contents of 5 to 15 % CH4 methane is harmful to underground working and a severe mine safety issue and has to be diluted and/or degasified prior or simultaneously to coal mining. On the other hand methane is a climate emission gas and 25 times more harmful than CO2. Moreover, the extraction of mine gas from active and abandoned coal mines is favorable due to its energy content. In german legislation mine gas by definition is part of the renewable energies, such as among others wind, solar or geothermal energy. Due to its effects on climate change in Germany since 2000 the conversion of mine gas in active and abandoned mines became a seperate industrial discipline. Beside its positive impact on the climate with significant savings of CO2-emissions, the extraction of mine gas improved mine safety. Even after mines have been shut down mine gas utilization has a positive impact

on the protection of the environment. The paper gives an overview of the achievements and challenges of the last 25 years in German mine gas industry and research.

10:25 AM

Improving Safety and Efficacy of Gob Gas Extraction Systems

B. Apple; Environmental Commodities Corporation, Boulder, CO

Incorporating remote monitoring and control functionality into mine methane drainage systems enables ventilation engineers to maximize safety and efficacy while reducing operating costs. Traditional gob gas extraction systems operate unsupervised and cannot adjust to operating conditions affected by underground operations or weather. ECC's new gob gas extraction system, the VORTECS, is revolutionizing gob gas extraction with semi-autonomous operation, remotely monitored process and environmental sensors, safety mechanisms, and remote-control capability. Additionally, the functionality of the VORTECS enables simpler integration with leading mine methane incineration systems that are becoming more common on active underground mines.

TUESDAY, FEBRUARY 25 MORNING

COAL & ENERGY: LONGWALL OPERATIONS AND PROJECTS

Sponsored by: BARR

Room 704

9:00 AM • Tuesday, February 25

Chairs: ***M. Robb****, Alliance Coal, LLC*
G. Howe*, Alliance Coal, LLC—Tunnel Ridge Mine, Moundsville, WV*

9:00 AM

Introductions

9:05 AM

Supplemental Support Design and the Fallacy of Chasing Sandstone and Fractures

B. Mirabile; Jennmar, Morgantown, WV

Many longwall operations employ geologic hazard mapping of longwall gateroads as part of their ground control progam. Both core logs and borescope data are often used as source data for these hazard maps. Locations of roof fractures and intervals and thicknesses of competent strata are very often included as major elements of these maps. However, many operations are encountering strata where no thick, competent rock exists within a reasoable interval to the mine roof horizon. In many instances, laminated strata is present throughout the primary and supplemental bolting horizons. The traditional focus of ultimate capacity and overall length of supplemental support is not sufficient to control these types of roof conditions. Re-focusing attention to stiffness and the support's interaction with the strata is a more effective means of controlling roof stability in these condtions. Additionally, by optimizing the support interaction with the ground, laminated conditions can often be controlled with lower supplemental support density compared to a design based on dead-weight capacity alone

9:25 AM

25-044

Improving Gas Management and Ventilation Performance at Longwall Mines with Potentially High Gas Emission Rates

S. Schatzel, B. Tulu, K. Raj and J. Addis; PMRD/MSSB/VEP, National Institute for Occupational Safety and Health, Pittsburgh, PA

The National Institute for Occupational Safety and Health is conducting research to enhance methane control and mine ventilation practices, at coal mines, as a method to mitigate hazardous work conditions. NIOSH researchers conducted case studies to investigate the effectiveness of existing systems and improve performance to decrease the potential for unplanned or excessive emissions. At one mine, drainage was influenced by hydrofracking inefficiencies where two of six wells showed good frack development. Methane content was variable, from 9.4 cm3/g to 19 cm3/g. This paper also summarizes overburden movement during undermining and the estimated quantities of gas transported to the mine using FLAC and CFD modeling. The findings from this research effort highlight considerations based on specific mine conditions that may also be applicable to longwall mines utilizing methane control systems.

9:45 AM

The Near-Term Outlook for the US Met Coal Industry

W. WOLF; Market Analysis, John T. Boyd Company, Canonsburg, PA

US met production is sourced from mining complexes that are established in the marketplace. Historically, the US has acted as a swing supplier into the international met market, opportunistically selling into the market during periods of high demand and strong pricing. Conversely, in periods of soft demand, US producers have typically reduced output. International pricing currently remains robust, thus enabling US producers to continue to generate financial gains on met coal shipped abroad. But there is no certainty this will continue. Going forward, the US met industry will have to answer a number of questions regarding their capability to be a major supplier, including: What is the competitive position of US met coal be in the international market? Where will long-term capacity of the US met coal industry come from? How will the growth of EAF steelmaking capacity impact domestic markets? What are the key drivers impacting future US met coal production? Who will be the participants going forward? Given the US industry's important role in the international market, this paper will investigation these and other factors, and their influence on future US coking coal production performance.

10:05 AM

Jennchem Pumpable Cribs: A 15-Year Journey

M. Castagnero; Jennchem, Pittsburgh, PA

"Jennchem Pumpable Cribs: A 15-Year Journey" explores the evolution and impact of Jennchem's innovative pumpable cribs over the past decade and a half. The presentation will highlight key milestones, technological advancements, and the visionaries behind these developments. Join us as we delve into the challenges faced and the successes achieved in enhancing mine safety and stability through this groundbreaking technology.

10:25 AM

Shaft Sinking Methodogies In the Varying Longwall Mining Regions

M. Miller, R. Cherry and J. Welch; Miller Contracting, Carrier Mills, IL

Shaft sinking methods and processes significantly vary in the three longwall mining regions. The three regions consist of the Appalachian, Interior, and Western coal regions. Each of these bring their own engineering and construction challenges. This paper will discuss the methods and processes used for successful shaft construction based on experience in each of the three regions.

10:45 AM

An In-depth Overview of the West Virginia based Friends of Coal Organization

C. Hamilton[1] and E. Midler[2]; [1]WV Coal Association, Charleston, WV and [2]Alliance Resource Partners—Tunnel Ridge, LLC, Valley Grove, WV

This paper provides an overview of the West Virginia based Friends of Coal organization; its objectives and how the loosely structured organization has evolved over the past 20 years. Friends of Coal was established in 2002 by the West Virginia Coal Association following the merger of WVCA and the WVMRA. The purpose was to create a public relations program on the grassroots level to give miners and their families support and public encouragement for their important work and contribution to West Virginia's economy. During this period, there was a conscience effort to keep politics removed from the Friends of Coal program. Fast forward 20+ years and a new paradigm shift in political and political policy driven in large measure by extreme liberal forces, the Friends of Coal program became a landing place for miners to voice their displeasure against the continued support of Democrat office holders and national or federal administrations ie EPA. Friends of Coal has emerged dynamic voice for working miners and their families and today accounts for over 40,000 strong engaged in a social media campaign.

11:05 AM

25-031

Enhancing Pillar Stability in a Deep-Cover Longwall Mine Using the LaModel Program: A Comparative Analysis

M. Sears; CDC/NIOSH, Pittsburgh, PA

This paper compares gateroad pillar stability in a deep-cover longwall mine in Southwestern Virginia, transitioning from a 700-foot panel layout to a 1000-foot layout with an inter-panel barrier. Using the LaModel program, the study evaluates three pillar configurations. It begins by analyzing the previous layout's stability and then explores the complex challenges posed by the wider layout, such as pillar, roof, and floor stability. An innovative three-entry yield pillar layout is then proposed to enhance overall stability. This research offers insights for optimizing gateroad pillar stability to improve safety and effectiveness in longwall mining under deep-cover conditions.

11:25 AM

Analysis of Floor Heave at an Underground Longwall Operation in the Eastern US

Z. Wedding[1], Z. Agioutantis[1] and S. Hicks[2]; [1]Mining Engineering, University of Kentucky, Lexington, KY and [2]Coronado, Raven, VA

The case study will discuss the factors driving floor heave in the headgate of a longwall operation. A new design of a longwall panel district has been implemented and has experienced floor heave in the gateroad after mining. The design is comprised of a one panel district, with a three-entry pillar system and a barrier panel between each district. Floor heave is observed in the second and third entries, rarely in the first entry, and there are a few occurrences in the cross-cuts. The coal mine is characterized by the strong overburden strata, high depth of cover, and the presence of soft floor strata. Roof and floor convergence was measured at various points in the gateroad and factors such as high horizontal stress were taken into consideration in the analysis. A numerical model of the longwall panel and entry system is presented.

TUESDAY, FEBRUARY 25 MORNING

COAL & ENERGY: TECHNOLOGY, INNOVATION AND AI/ML

Room 703

9:00 AM • Tuesday, February 25

Chairs: ***E. Shereda****, Consol Energy Inc, Canonsburg, PA*
M. Keener*, Mine Engineer*

9:00 AM

Introductions

9:05 AM

Predictive Platform for Mitigating Future Mine Incidents Using Machine Learning Techniques

N. Kelley and P. Roghanchi; Mining Engineering, University of Kentucky, Lexington, KY

This research developed a platform to assist mine operators by predicting possible future incidents and providing applicable solutions to help mitigate their effects. The program achieves this by first having the user input their mine information. It then uses MSHA's mine retrieval system to download the mine inspections, accidents, violations, and various other aspects of the mine. The program runs the mine data through its machine learning algorithm to predict future accidents by comparing them to other accidents with similar trends. The possible accident and solution are then proposed.

9:25 AM

UteAnalytics: Allowing the non-AI Expert to Use AI

R. Ganguli; Mining Engineering, Professor of Mining Engineering, Salt Lake City, UT

Downloaded so far from 27 countries, UteAnalytics, our free, easy to use, Windows based software has allowed domain experts, who may otherwise not know programming or artificial intelligence (AI), apply AI to their data and gain insights. Downloaders have included professionals, students, engineers, scientists and social scientists. In the mining industry, users are in mining companies, exploration companies and academia. This talk presents some of the features of the software. Features include data handling (cleaning etc), exploratory data analysis, model development and what-if scenarios. A mining and non-mining case study is presented to demonstrate the benefits of using the software.

9:45 AM

Leveraging Artificial Intelligence for Precision-Based Coal Quality Monitoring

T. Chimbwanda, N. Risso and A. Anani; Department of Mining and Geological Engineering, University of Arizona, Harare, Harare, Zimbabwe

Maintaining efficiency and precision in coal quality control can be challenging due to the inherent limitations of manual assaying. This study uses computer vision and machine learning to monitor coal quality in real-time. The methodology involves (i) collecting images of coal samples and corresponding assay information, (ii) training a machine learning model and (iii) evaluating model performance against existing approaches. The integration of machine learning contributes to the efforts to create a sustainable value proposition for clean coal. The anticipated result is improved efficiency and precision in coal quality monitoring, providing an accurate alternative to traditional methods.

10:05 AM

Fletcher CHDDR with Indexing Mast Feed System

F. Meintjes; Sales, J.H. Fletcher & Co., Huntington, WV

J.H. Fletcher & Co. designed and implemented an Indexing Feed System on a twin-boom Man-Up CHDDR for South Africa. The purpose of this design was to reduce fatigue experienced by all roof bolter operators, especially those of smaller stature, by reducing the total net mass of drilling tools & consumables lifted during a full shift. In addition, the Indexing Feed System was intended to eliminate certain hazard related actions taken by an operator, ultimately reducing total hazard exposure. Various other reliability and bolt installation improvements were observed during testing.

10:25 AM

Open-Source AI and Time-Series Data for Mining Operations: Overcoming Challenges with Gamification and Data Management

S. Dessureault[1] and E. Shereda[2]; [1]Dr Data Mining, Tampa, FL and [2]CONSOL Energy, Canonsburg, PA

The hype cycle for AI in mining has likely peaked, pushing practitioners to focus on tangible benefits to productivity and safety rather than just AI for AI's sake. While much hype currently surrounds Large Language Models (LLMs) like ChatGPT, a majority of mining data is time-series based, such as tonnage rates or grade blends, with few open-source LLMs trained on such data. Key challenges in AI applications start with managing time-series datasets, both in volume and tag conceptualization. Recent innovations have led to powerful open-source time-series databases, but identifying events within these datasets, like changes in blend or plant settings, remains a hurdle. Even if AI detects underperformance or optimization opportunities, getting decision-makers to act upon the information is an ongoing challenge. This presentation delves into the use of open-source time-series databases and gamification to manage data, drive user engagement, and foster continuous improvement. A case study from a large coal mining complex in southwestern Pennsylvania will highlight practical applications and lessons learned in AI and gamification deployment.

10:45 AM

Advancing Mine Safety Through Real-Time Atmospheric Monitoring and Data Analytics presented by Swathi Prabhu, Kermitt Melvin and James Jarrett Lewis

S. Prabhu[1], K. Melvin[2] and J. Lewis[2]; [1]Engineering, IWT, Lynchburg, VA and [2]Leer Mining Complex, Grafton, WV

Innovative Wireless Technologies (IWT) has developed the Wireless Gas Monitor (WGM), a cutting-edge multi-sensor platform for real-time atmospheric monitoring at Arch Leer's mine. Designed to meet regulatory standards, the WGM ensures the health and safety of mining personnel. The WGM utilizes infrared and catalyst-based sensors for accurate gas detection and is easily portable and battery-operated. It integrates seamlessly into Leer's large-scale mesh communication and tracking system, eliminating the need for additional infrastructure and speeding up deployment. By integrating gas and atmospheric sensors into C&T and FactoryTalk systems with IWT's ServerLink OPC interface, IWT leverages its technological innovation alongside Leer's mining expertise to identify additional data that enhances safety. Advanced data analytics on atmospheric readings are then used to develop actionable insights and advanced algorithms. IWT continues to advance technology with AI and machine learning algorithms for ventilation monitoring, further enhancing mining safety and operational efficiency through their joint efforts with Leer Mine.

11:05 AM

Redefining Collision Prevention for Underground Mining With Proximity Systems Using Next-Generation Radio Technology

P. May; Innovative Wireless Technologies, Lynchburg, VA

Underground mining environments contain many factors that unfortunately lead to accidents involving mining personnel and moving equipment. First generation proximity detection systems have improved the location of miners sharing travelways with moving equipment but the electomagnetic technology used by those systems is prone to interference from high voltage AC lines, other electrical equipment, and even co-located personal dust monitors. Next generation proximity systems based on Radio Frequency (RF) transmissions have exhibited much better interference protection and provides improved location accuracy. The RF-based system can identify personnel tags at distances exceeding 100 ft and tracks numerous devices simultaneously with multiple location updates per second. This allows the system to make intelligent decisions on throttle reduction and breaking well before emergency stops are required. The result is a gentle reduction in vehicular speed with simulaneous warnings to mining personnel to avoid the stoppage of vehicles and production. This presentation will provide details on the performance of the RF-based proximity system and with short videos of real-world performance.

11:25 AM

Critical Elements of Automation and Robotics in Future Mines

G. Danko; Mining and Metallurgical Engineering, Univ. of Nevada, Reno, Reno, NV

Automated and/or telerobotic machinery (ATM) will allow to exclude humans from the hazardous on-site environments for safer and cheaper operation than using engineering controls of atmospheric and site stability conditions for safety and health. ATM in future mine design are expected to improve safety, cost, and efficiency by a large margin. As only ATM will be used at hazardous locations but no humans, far higher temperatures than of today's regulations may be allowed, reducing ventilation and cooling demands as well as the total energy consumption of the mine. Autonomous and remote-controlled operations may be established by the mines if the original equipment manufacturers (OEM) supply ATM equipment and the mines buy and operate them. One critical element is to establish champions at both the mining industry and the OEM to work together in industrial-scale operation with ATM in example mines. The critical risks elements for the operations and machinery may be reduced using simulation techniques in the design for faster implementation of ATM than experimenting with mining tryouts.

TUESDAY, FEBRUARY 25 MORNING

COLORADO MINING ASSOCIATION

Rom 710/712

9:00 AM - 9:45 AM

Rare Earth Elements and the New Minerals Economy

Scott Bakken, Vice President, Regulatory Affairs, Energy Fuels Inc.

Energy Fuels is at the forefront not only of rare earth element (REE) production, but is also moving the U.S. forward with REE processing for the first time. These operations position Energy Fuels as a significant leader in providing a domestic source of necessary components for clean energy technology, aerospace, and national defense applications, among others.

9:50 AM - 10:35 AM

BLM's Role in Minerals Resources Management and Opportunities for Engagement

Stephanie Carter, Branch Chief, Solid Minerals, U.S. Bureau of Land Management

The U.S. Bureau of Land Management manages more than 8.3 million acres of public lands and more than 27 million acres of mineral estate in Colorado—mostly concentrated in the western part of the state. This presentation will provide an introduction to the Bureau of Land Management's solid minerals programs, determining what federal minerals are open to exploration and mining, and navigating the regulatory frameworks for conducting these operations.

10:40 AM-11:20 AM

The Aerospace Industry in Colorado and the Need for Reliable Minerals Supply Chains

Chad Vorthmann, Government Relations, Lockheed Martin

Colorado is the largest aerospace industry employment base of any state in the nation. With over 2,000 aerospace businesses employing over 55,000 employees directly and another 184,000 indirectly, and with significant contributions to the state's advanced technology industry, artificial intelligence, cyber security, advanced manufacturing, as well as government and university programs, the aerospace industry has become a driving force of Colorado's economy. The work of Lockheed Martin and other aerospace companies relies on a secure and reliable minerals supply chain for advanced technology applications and will benefit from increase domestic production from Colorado and throughout the Nation.

EDUCATION INNOVATION FOR THE MINERALS INDUSTRY II

Room 501

9:00 AM • Tuesday, February 25

Chair: ***J. Kellar****, SD School of Mines and Technology, Rapid City, SD*

9:00 AM

Introductions

9:05 AM

Attracting, Developing, and Retaining Gen Z Talent to Mining Through Empowerment

M. Miyoshi; Talent Acquisition, Teck Resources Ltd., Vancouver, BC, Canada

Attracting young talent to mining is a significant challenge and will continue to be so unless public opinion changes. According to a 2020 poll conducted by the Mining Industry Human Resources Council (MiHR), young Canadians view mining as the least desirable industry in which to work. These negative views are often reinforced by parents, teachers, academic and community leaders, and the media, who may themselves hold an unfavorable opinion of the industry. The majority of Gen Z have grown up in a world far removed from mines. Most know nothing about today's mining industry and what little they do know is incorrect. However, the increase in focus on critical minerals in recent years has provided industry and academia with an invaluable opportunity to change the narrative, increase awareness, and in doing so attract the critical talent required to deliver on critical minerals strategies. In this presentation find out how Teck influences influencers. Learn how Teck's campus attraction strategy of empowerment generates hundreds of brand ambassadors who provide the critical authentic messaging to resonate best with young people today, all the while developing and retaining top talent.

9:25 AM

Utilizing Local Mineral Resources to Recruit, Retain and Train STEM Professionals for the Mineral Industry

K. Donovan[1], M. West[1], C. Birrenkott[3], M. Whitehead[2] and J. Kellar[1]; [1]Materials Engineering and Science, SD School of Mines and Technology, Rapid City, SD; [2]Humanities, Arts and Social Sciences, South Dakota School of Mines and Technology, Rapid City, SD and [3]Mechanical Engineering, South Dakota School of Mines and Technology, Rapid City, SD

Creation of pottery and clay-based ceramics is as ancient as human development, and presents an opportunity for development of unique programming to help recruit STEM professionals for the mineral industry. Toward this end, the minerals found in the Black Hills (South Dakota) have been used to make ceramics for hundreds of years. This presentation will focus on leveraging local resources to develop hands-on curriculum for K-12 educators, high school students and undergraduate STEM students. A rigorous external assessment of the program will be offered as part of the presentation.

9:45 AM

Enhancing Active Learning with Artificial Intelligence and Generative AI

N. Risso and J. He; Mining and Geological Engineering, The University of Arizona, Tucson, AZ

Artificial Intelligence (AI) and in particular Large Language Models (LLMs) are fundamentally changing work practices and the way in which humans interact with technology. Current educational practices in mining engineering need to empower students with the skills needed to become an effective workforce in a technology-driven world. This work focuses on the study, development, and validation of active learning practices by integrating LLMs into the educational experience of students in mining programs. We present here findings on 1) the adaptation and development of active learning experiences that use LLMs as a key component, 2) Identifying strategies that work across different engineering subjects will inform best practices, and 3) evaluating the impacts of LLMs in the learning experience of students.

10:05 AM

25-087

Teaching Kids Project: A Bet for New Generations in Mining

M. Salgado Cabeza[1], J. Carmona Perez[1], O. Restrepo Baena[1] and J. Diaz Martinez[2]; [1]Materials and Minerals, Universidad Nacional de Colombia, Medellín, Antioquia, Colombia and [2]Engineering, Martin Marietta, Lexington, KY

The "Teaching Kids" project is an educational initiative aimed at young people and children from elementary schools, carried out by students of Mining Engineering, Geological Engineering and Environmental Engineering. This project is led by the SME Student Chapter of the Universidad Nacional de Colombia, Medellin. The purpose is to share knowledge about geosciences in a didactic and attractive way, emphasizing the importance of identifying the use of minerals in daily life and responsible and sustainable mining in our society. We use methodologies related to early childhood education such as Gamification, which we adapt dynamics of different games during the development of the workshops to create learning in a motivating way; also, the Montessori Method using primers, sensory mineral box and presentation, to allow learning through experimentation itself.

10:25 AM

25-060

Mining's Next Frontier: Perspectives and Transformations

S. Anderson[2], A. Binder[1], S. Nowosad[1], S. Raval[3] and O. Restrepo Baena[4]; [1]Institut of Mining, Technische Universitat Clausthal, Clausthal-Zellerfeld, Lower Saxony, Germany; [2]Curtin University, Perth, WA, Australia; [3]University of New South Wales, Sydney, NSW, Australia and [4]Universidad Nacional de Colomba, Medellín, Colombia

Driven by the rising demand for raw materials and the need for greater social acceptance, the mining industry is rapidly adapting to modern requirements. Academia is aware of these challenges and is addressing them by updating curricula, enhancing teaching practices, incorporating e-learning, and improving industry-academia and inter-university collaboration. This study highlights the outcomes of recent activities by the Education Committee (EC) of the Society of Mining Professors (SOMP) over the past three years, including expert exchanges, workshops, and live surveys. These efforts have identified emerging topics in mining engineering research and education, outlined the necessary technical and interpersonal skills for future professionals, and supported the development of a joint definition of the mining engineer of the future. Additionally, this study presents global perspectives from universities, contextualising them within SOMP's EC initiatives, and showcases best practices conducted in the involved universities highlighting country-specific demands and major challenges.

10:45 AM

Revolutionizing Mining Education: Leveraging AI-Supported Training Material Development to Enhance Professional Development in the Mining Industry

A. Siamaki[1], M. Yahyaei[2] and A. Bani[3]; [1]GKM Consultants, Richmond Hill, ON, Canada; [2]Julius Kruttschnitt Mineral Research Centre, The University of Queensland, Brisbane, QLD, Australia and [3]DevCraft Solutions, Toronto, ON, Canada

The mining industry faces a shortage of skilled workers, needing 128,000 new professionals by 2025. This is due to declining enrollment in mining education programs and a gap between university education and workplace needs. Traditional training methods struggle to keep pace with the industry's rapid technological advancements. AI-supported training material development offers a solution, allowing domain experts to create personalized, up-to-date, and engaging content faster and at a lower cost. Investing in training yields significant returns, yet AI-supported training material development in mining is still in its early stages. Challenges

include gaps in Learning Management Systems (LMS) platforms and technological limitations. Despite these challenges, a new workflow for AI-supported training material development by domain experts has shown promising results, with a 30% reduction in content development time and cost. This highlights the potential of AI to revolutionize professional development in the mining industry.

11:05 AM

University, Mining Industry and the ESG Criteria—Sustainability

C. SOTO; Universidad Nacional Micaela Bastidas, Apurimac - Peru, Cuzco, Peru

Mining activity is very important for the development of humanity. This development must be understood from the Academy where it allows showing alternatives for the performance of the industry. Likewise, this mining corporation needs to continue improving its activities to achieve correct results. Historically, a few years ago the application of the ESG (Environmental, Social and Governance) criterion was verified, which is positioned as a factor/regulator in the design of the performance of industries in general. ESG as an integral part of the concept of sustainability serves as a tool to conceive mining without conflicts and with a reputation based on trust in the interrelation of the university, industry and society. Therefore, the academy must be a forger of new knowledge in such a way that it is allowed to continue with the virtuous circle of constantly feeding it. In this context, the best mining practices are implemented in constant questioning of their activities. The scientific essence of the industry supported by the academy developed in an operational dynamic is addressed. This allows for an additional understanding of mining in the future with new mental attention.

TUESDAY, FEBRUARY 25 MORNING

ENVIRONMENTAL: CREATIVE APPROACHES TO MINE CLOSURE

Room 103

9:00 AM • Tuesday, February 25

Chairs: ***R. Furey****, Stantec, Broomfield, CO*
H. Lammers*, Colorado School of Mines, Hatch Ltd*

9:00 AM

Introductions

9:05 AM

Good Sam-I-am: What is "Good Samaritan" Legislation, and Why Does it Matter to Me?

S. Smith; American Exploration & Mining Association, Spokane Valley, WA

Dr. Seuss' classic "Green Eggs and Ham" tells a story about persistence. The American Exploration & Mining Association (AEMA) has been working with allies to pass "Good Samaritan" legislation to address hardrock AMLs for nearly three decades. Great, but what is Good Sam legislation? Sid Smith, Government Affairs Manager for AEMA, will help us answer this question and more, such as: What's in the bill? Don't we already have an AML cleanup program? Will Sid's presentation match the "Green Eggs & Ham" format? (No.) Come get answers to these questions, or bring your own!

9:25 AM

From Concept to Implementation: Indigenous Education and Ecosystem Offsetting

W. Brunham, A. Hood and D. Abranovic; Sustainable Mining, ERM, Mesa, AZ

This presentation will present a case study from Canada of Seabridge working with regulators and local indigenous communities to design a biological offset program that includes 6 ponds, channels and wetland/riparian communities. ERM began revegetation of culturally important plants identified by the Tahltan Nation and partnered with Tahltan Businesses to revegetate while incorporating training and capacity development values in the Project. We hired Tahltan youth, Tahltan University Students, and other First Nation members to transplant native vegetation and plant plugs from native plant supply nurseries. We taught vegetation identification skills and successfully planted 1000's of native aquatic, wetland, and riparian plants. The Tahltan Central Government (TCG) is the administrative governing body of the Tahltan Nation. This means the TCG is responsible for the ecosystem and natural resources of Tahltan Territory, for managing sustainable economic development, and for strengthening the cultural wellness of the Tahltan Nation.

9:45 AM

Remediated Soil Highlights the Potential of Temperate Grasslands to Sequester Carbon

I. Montero[1], J. Burke[2], K. Lewis[2] and S. Dunlap[1]; [1]Remediation Management Services Company, Houston, TX and [2]Texas A&M AgriLife Research, Lubbock, TX

Vegetated soil caps used to remediate historic mining impacts provide a unique opportunity to observe carbon sequestration in temperate grasslands. Soil caps can reestablish a diverse vegetation cover that protects against erosion and particulate transport whilst improving soil quality through nutrient and soil organic matter (SOM) increases. Four successfully vegetated soil caps, built 10-20 years ago with more than 30 cm on unimpacted colluvium over tailings, were selected for this study based on readily available design and construction records that show the starting colluvium material had <0.5% SOM. A grid of boreholes was installed to the bottom of the soil caps and cores were sampled every 10 cm. Samples were analyzed for density, geochemistry, inorganics, nutrients, and carbon fractionation. Samples of live herbage and plant litter were collected and analyzed for fiber characterization, total carbon, and nutrients. Results from this study highlight the potential of remediated temperate grasslands to sequester carbon. All results indicate significant increases in carbon in unamended soil strata, ranging from 277 to 26,700 Kg C/acre or 740 to 71,300 Kg CO_2 equivalent per acre.

10:05 AM

25-090

The Party's Over, Now What?

P. Werner; US Department of Agriculture, Washington, DC

Consider the time a mine will be in a "closed" state is far, far longer than the time it was ever in operation, but mine components still need to function to maintain reclamation integrity: underdrains need to drain, reclaimed slopes need to remain stable, diversion ditches need to convey water. So, when can a mine be considered truly reclaimed? Federal mine regulations fall short in addressing this question, yet mining companies have a vested interest in retiring their mine permits once mining is complete so as to remove this liability from their balance sheet. What can be done to move closer to a condition that provides adequate environmental safeguards, sufficient financial resources, and equitable treatment for all parties? The Forest Service recently concluded a risk evaluation of liabilities associated with a closed mining operation. It wasn't the extreme events that drove risk, rather it was the small, seemingly innocuous care and maintenance items that if left unaddressed could escalate and eventually compromise reclamation. Care and maintenance does not have to be financially onerous even when extended over long time horizons if one uses the time value of money concept.

10:25 AM

Enhancing Mine Closure Resiliency in a Wildfire Prone West

E. Sportsman; Stantec, Golden, CO

The western United States is a hub for both mining and wildfires. In 2020, this region accounted for 78% of the total U.S. mineral production and 76% of the total acreage burned in wildfires. Combining the ICMM Integrated Mine Closure principles with wildfire impact mitigation can significantly strengthen closure objectives like safety, physical stability, chemical stability, ecological stability and risk. By considering wildfires impacts and evaluating site-specific wildfire risks, miners can take mitigation and

management actions that improve site resilience while reducing the risk of critical infrastructure failure and secondary environmental impacts. 'Easy wins' for site-specific closure objectives could include burying HDPE piping to reduce the risk of mine water release to the environment, or modifying mine waste cover design to provide thermal buffering of HDPE or GCL if the cover vegetation burns. The known and documented impacts of wildfires on power utilities, municipal water supplies, transportation infrastructure, and communities should prompt our industry to learn from and adapt engineering and environmental practices to mitigate wildfire impacts.

10:45 AM

Post-Mining in Colombia: A Path Towards Sustainable and Responsible Mining

S. Nowosad[1], O. Restrepo Baena[2], T. Vallejo Lopez[2] and O. Langefeld[1]; [1]Institut of Mining, Technische Universitat Clausthal, Clausthal-Zellerfeld, Lower Saxony, Germany and [2]Universidad Nacional de Colomba, Medellín, Colombia

Mine closure is a topic of great importance both in Colombia's mining industry and globally due to the significant social, ethical, economic, technical, and environmental implications. As a relevant phase in the exploitation of mineral resources, along post-mining, an effective conduction must be guaranteed to ensure environmental, social, and economic stability. This article summarizes the results of the collaborative project "Pkture," between Colombia and Germany. Preventive and progressive planning for mine closure and post-mining are a complex process involving multiple interests, groups, and institutions. Therefore, this article evaluates the state of the art of mine closure in Colombia, identifies and examines the challenges the country faces, and discusses further closure and post-mining opportunities through an in-depth evaluation of exemplary projects conducted and planned in Germany. Moreover, the project revealed that for effective post-mining practices, long-term planning and anticipation are crucial as well as the coordination between different governmental institutions and the active participation from all stakeholders.

TUESDAY, FEBRUARY 25 MORNING

ENVIRONMENTAL: DECARBONIZATION METRICS: WHAT, WHERE, AND HOW

Room 104

9:00 AM • Tuesday, February 25

Chairs: ***H. Kim****, AtkinsRealis, Highlands Ranch, CO*
L. Watson*, Watson Environmental, Tucson, AZ*

9:00 AM

Introductions

9:05 AM

Climate Change Impacts for Tailings Management

H. Kim and L. Josic; AtkinsRealis, Highlands Ranch, CO

Climate change will cause a significant increase in the intensity and frequency of extreme precipitation events. These intense rainfall events could potentially affect the performance and integrity of mining infrastructures, such as embankments and dams, by increasing the risk of failure. Although different regions have adapted several approaches to tailings management including the Global Industry Standard on Tailings Management (GISTM), potential climate change impacts on extreme rainfall and floods were considered in very few regions. The frequency analysis and estimation of scaling factors based on the ratio of the rainfall depths of future period to those of the current period were conducted to assess scaling factor for the 24-hour annual probable maximum precipitation corresponding to the future period in Western Quebec, Canada. Through this example, adaptions to assess the changing extremes floods can be planned to include review of the closure landform to address future risks. In addition, changes in tailings management considering the climate change will most readily be achieved at new mining projects.

9:25 AM

A Comparative Evaluation of Operational Impacts of Mining Practices on Climate Change

Z. Uzundurukan, H. Soydan and M. Diler; Mining Engineering Department, Hacettepe University, Ankara, Çankaya, Turkey

The energy-intensive nature of mineral extraction and processing result in significant greenhouse gasses (GHGs) emissions. This study investigates the role of operational activities in the mining industry on climate change by utilizing the United Nation's Climate Change data inventory, with a focus on mining operations in Turkey. We implement temporal analysis to evaluate the change in total GHGs and/or and carbon dioxide emissions [depending on data availability] in relation to the total mineral production by generating emission indices for major mineral-producing countries, namely Australia, Canada, Turkey, and the US. Through analyzing and comparing these operational emission indices, the study provides insights into the gaps in operational improvement in the mining industry and required environmental policies for green mining practices.

9:45 AM

Mining's Water / Energy Nexus— The Next Frontier for Major Impact

D. Johnson; Stantec, Phoenix, AZ

Mining and processing use, move, treat, and recycle significant amounts of water for everything from dewatering, refining, leaching, brine processing through mine tailings. Most operations have water issues: too much, too little, contaminated or in the wrong place. Many are also in water scarce regions. These issues require a lot of energy to address, often representing one of your biggest energy drivers. More efficient methods are needed to achieve environmental goals for clean water and carbon reduction, as well as to transform host community impact. Global trends, including from ICMM and corporate goals, are increasing pressure on mining companies to improve performance. Focusing on the intersection of water and energy will identify improvements and changes that have a strong ROI and environmental impact. This facilitates your achieving commitments relative to energy, CO2, and fresh water. This session will help you identify your site's highest energy and water impact opportunities, understand tools available such as pumped storage hydro, micro-hydro, tailings alternatives, or water recycling, and work through challenges as you embark on these transformational projects.

10:05 AM

Optimizing Supply Chains for Reduced Greenhouse Gas Emissions: A Novel Methodology

K. Aydogdu and S. Duzgun; Mining Engineering, Colorado School of Mines, Golden, CO

Greenhouse gas emissions exacerbate global warming and environmental pollution, impacting humans, nature, and wildlife. The primary cause is the expanding material production industry, which requires extensive supply, leading to significant GHG emissions. Consequently, governments are implementing measures like carbon taxation regulations to compel industries to manage their emissions. To effectively control and reduce emissions, organizations must analyze their material supply chains and identify the most emission-efficient routes. This study introduces a novel methodology to trace end-products back to their raw materials, enabling stakeholders to map complete supply chains and select routes with the lowest emissions.

10:25 AM

The Road to Net Zero: Is the Mining Industry Positioned to Achieve Net Zero Commitments?

M. OWUSU TWENEBOAH[1], B. Kansake[2] and K. Awuah-Offei[1]; [1]Mining and Explosives Department, Missouri University of Science and Technology, Rolla, MO and [2]SSR Mining Inc, Denver, CO, Denver, CO

Most mining companies, including ICMM members, have made public commitments to achieve net zero carbon emissions by 2050. The miners have disclosed a variety of pathways to achieve their net zero targets with various probabilities of success with existing technology. It will be difficult, without technological breakthroughs, for most mining companies to implement their strategies at scale. This creates liability issues for companies with disclosures that are unlikely to be achieved. This study evaluates ICMM members' net zero strategies and existing technologies, identifies their current state, strengths and weaknesses, and estimates how this impacts the feasibility of achieving the stated goals. The work evaluates all ICMM members' disclosures around net zero commitments to assess the target and plans to achieve them. The work shows some disclosures are ambitious and unlikely to be achieved without significant technological breakthroughs. These pose risks to the companies from a liability standpoint. We propose some modifications to the existing strategies to make them more suitable for mining application.

TUESDAY, FEBRUARY 25 MORNING

HEALTH & SAFETY: IMPAIRMENT AT WORK: FATIGUE, SUBSTANCE USE AND MENTAL HEALTH

Room 109

9:00 AM • Tuesday, February 25

*Chairs: **T. Bauerle**, National Institute for Occupational Safety and Health, Spokane, WA*
***L. Sims**, Professional*

9:00 AM

Introduction

9:05 AM

Evaluating Impairment Detection Technology to Keep Miners Safe at Work & Promote Total Worker Health

L. Guasta; Naional Safety Council, Parker, CO

Impairment from chemical substances, fatigue, medical conditions, mental distress and other factors can present a fitness for duty concern as well as impact employee wellbeing. The broad range of signs and symptoms presented by all of these underlying causes of impairment makes impairment detection technology (IDT) an attractive safety solution for employers. IDT can also be used to promote concepts like Total Worker Health in the workplace. This presentation will feature research conducted by the National Safety Council to explore IDT with the potential to screen for multiple forms of impairment and to aid in fitness for work assessments. The many potential benefits of IDTs will be presented, including the ability for real-time assessment and the potential to detect impairment from diverse causes. However, there are barriers to implementing this technology, including validation concerns, cost and employee buy-in, which will also be explored in this presentation.

9:25 AM

Sleep Like a Rock to Rise and Mine: An Emerging Intervention Framework to Mitigate Fatigue-Related Risk in Mining

T. Bauerle; Spokane Mining Research Division, National Institute for Occupational Safety and Health, Washington, DC

While many fatigue risk management recommendations may be relevant to mineworkers and the mining industry, what is missing is a comprehensive synthesis of existing information that matches evidence-based expert recommended solutions to industry-specific fatigue-related hazards. To this end, we have developed an Intervention Framework (IF) which represents high-level information on different sensible strategies to mitigate fatigue in a mining context grounded on industry input, data, and existing guidelines. The IF will provide a general description of practical, viable mitigation methods for industry decision-makers seeking to develop action plans and make informed choices for managing fatigue risk. Given the complexity of measuring and managing fatigue, reliable and actionable information is needed about fatigue in mining. Although there is no one single solution, the IF will present an array of intervention choices stratified based on numerous criteria, such as upfront resources needed, factors targeted, and level of intervention so that practitioners will be able to select approaches that best suit their needs.

9:45 AM

Exploring Hazard Recognition and Risk Perception in Mining and Trade Industries: Results from a Mapping Review

Z. Dugdale[1] and B. Eiter[2]; [1]Spokane Mining Research Division, National Institute for Occupational Safety and Health, Washington, DC and [2]NIOSH Associate Director for Science Office, Pittsburgh, PA

Understanding how workers perceive and recognize hazards is essential for developing effective preventive measures and improving workplace health and safety practices. A mapping review was conducted to characterize existing literature on risk perception and hazard recognition in industrial sectors, and to identify gaps in research. 102 studies published between 2012 and 2023 were identified. Safety hazards were more frequently studied than health hazards, and most studies utilized visual search tasks to measure workers' hazard recognition. Age, work experience, safety knowledge, training, past injury exposure, awareness of occupational health risks, risk normalization and operational familiarity, attentional factors (e.g., distraction), task familiarity, fatigue and sleep patterns, working hours, cultural factors, working conditions, hazard characteristics (e.g., latent or visually unperceivable), hazard communication materials (e.g., signage), visual clutter, and workplace safety climate influenced workers' ability to recognize hazards and perceive risks. This review provides valuable insights to enhance workplace health and safety practices across industries like mining.

10:05 AM

Innovative Technologies for Enhancing Safety in the Mining Industry: A Case Study of Smart Watches for Fatigue Prevention

s. caururo norabuena[1] and G. Romani Navarro[2]; [1]sme, Huaraz, Peru and [2]Independent, Lima, Peru

This abstract presents a groundbreaking approach to enhancing safety in the mining industry through the implementation of smart watches for fatigue prevention among drivers. The case study conducted at Peruvian mine showcases the effectiveness of this technology in reducing the risks associated with driver fatigue and somnolence. By monitoring and analyzing sleep patterns, the smart watches provide real-time data to identify and mitigate potential fatigue-related incidents. This innovative solution not only improves safety standards but also sets a new precedent for leveraging technology to address critical safety concerns in mining operations. The findings from this study offer valuable insights and practical applications for enhancing safety protocols in the mining and minerals profession

10:25 AM

20 Years of Fatigue Technology: A Critical Review and Path Forward

D. Bongers; Director, Wenco International Mining Systems Ltd, Eight Mile Plains, QLD, Australia

Despite nearly two decades of sophisticated fatigue monitoring technologies being available to the mining industry, we see modest-at-best uptake of these tools. Real and perceived workforce resistance are commonplace, and the very personal nature of fatigue risk factors tests our skills of change management. This presentation will transcend brands and technology types, embracing a neutral but expert perspective to update on the current state of technology and the best practice elements that are consistent across successful projects. We will also discuss the policy nuances that have proven to help or hinder fatigue management initiatives.

10:45 AM

Preventing Suicide in the Mining Community

S. McCraren[2] and G. Smith[1]; [1]University of Arizona, Tucson, AZ and [2]McCraren, TUCSON, AZ

As miners, we are in an industry with one of the highest rates of suicide. Specifically extraction jobs, such as mining, experience rates compared to the general civilian working population* Although as a nation we have made progress towards de-stigmatizing mental health, suicide is still a difficult subject to talk about, especially with a workforce that self-identifies as strong and resilient. This presentation covers: -Scope of the problem using the latest available data on suicides in the mining industry -Which of us is most vulnerable. -General and mining specific health, historical, and environmental factors that put individuals at risk. -Intervention Strategies to support someone in crisis. -Prevention strategies for managing mental health and being proactive about self-care -Warnings signs, behaviors and the appropriate support matched to the potential risk. - Resources to support someone is crisis or prevent a situation from escalating to this point. *(based on 2021 data reported by the CDC)

11:05 AM

Controlling Fatigue on a Drilling Rig: The Lessons We Have Learned

J. Fowler; National Exploration, Wells and Pumps, Elko, NV

Fatigue is one of the biggest hazards we face in the mineral exploration drilling industry. It impacts our crews because, regardless of whether we are working on a mine site or an exploration project, we work 12-hour shifts in the heat, cold, rain or shine. In addition, we often have up to a 2-hour drive just to get out to the drill site. With current project locations ranging from the desert surrounding Death Valley to 8,000 ft. on top of a mountain in Utah, we are constantly looking for ways to keep our crews safe. Over the years we have implemented controls ranging from fatigue training in our new miner class to changing our work schedules reducing our exposure to temperature extremes. We have even rolled out hydration testing for our crews that can be done on the rigs by the onsite supervisors. When it comes to combating fatigue, the work is never done. We are constantly looking to improve and for new ways to keep our crews safe. This presentation will go through the controls that we have put in place over the years and the lessons that we have learned along the way.

11:25 AM

Investigating Job Satisfaction, Work Environment, Occupational Health, and Sleep Quality Among Female Dumper Operators in Indian Mines

A. Sharma, A. Kumar and B. Mandal; Mining Engineering, IIT Kharagpur, Kharagpur, West Bengal, India

Historically, the mining industry in India has been male-dominated, but recent years have seen an increase in women taking on roles like Heavy Earth Moving Machinery (HEMM) operators. There is a lack of studies on women's social comfort and integration in mining, as well as the unique challenges they face in hazardous environments. To address this, a cross-sectional study assessed self-reported musculoskeletal disorder(MSD) among women dumper operators (n=41) using the Nordic questionnaire. Individual characteristics and work-related risk factors were investigated through structured interviews. Chi-square test results revealed significant associations between job satisfaction and poor occupational health (OR = 4.27, p = 0.03), poor working environment (OR = 3.80, p = 0.04), and sleep quality (OR = 5.9, p = 0.01). The study recommends interventions to enhance job satisfaction and productivity. Future research should delve deeper into the social aspects to improve working conditions and job satisfaction for women in mining.

TUESDAY, FEBRUARY 25 MORNING

HEALTH & SAFETY: TECHNOLOGY AND INNOVATION IN HEALTH AND SAFETY II

Sponsored by: ERM

Room 108

9:00 AM • Tuesday, February 25

Chairs: ***C. Zhou****, National Institute for Occupational Safety and Health, Pittsburgh, PA*
A. Moradi*, University of Kentucky*

9:00 AM

Introduction

9:05 AM

25-024

Advanced Diesel Powertrains for Underground Mining Mobile Equipment

A. Bugarski; PMRD, NIOSH, Pittsburgh, PA

The results of laboratory evaluation of three EPA Tier 4f engines were used to discuss the effectiveness of those as a control technology for reducing exposures of underground miners to diesel aerosol and criteria gases. Only the engines fitted with viable filtration systems could provide reductions in aerosol emissions, in terms of both mass and number concentrations. The engines equipped with alternative exhaust aftertreatment systems would be suitable to control exposures to aerosol in terms of mass, but not in terms of number concentrations. The substantial nitrogen dioxide emissions limit usability of selected EPA Tier 4f engines in underground mining applications.

9:25 AM

Direct-On-Filter Characterization of Coal Mine Respirable Dusty Particles Using Micro-XRF

X. Wang[1], L. Pan[2], J. Miller[1], J. Jin[1] and M. Lun[3]; [1]Materials Science and Engineering, University of Utah, Salt Lake City, UT; [2]Chemical Engineering, Michigan Technological University, Houghton, MI and [3]Sigray, Inc, Concord, CA

Abstract Accurate characterization of respirable dust is essential for protecting coal miners' health. Analyzing respirable particles directly collected on filters reduces the risk of particle loss or alteration during sample transfer, leading to more accurate results. In this study, Micro X-ray fluorescence (micro-XRF) was used for direct-on-filter characterization of coal mine respirable dust particles. Two types of filter samples were studied: artificial filter samples with different particle loadings and CPDM filter samples from one coal mine. The samples were analyzed using the Sigray AttoMap-310 Micro-XRF with Copper and Rhodium X-ray tube target anodes. The results indicated that when the Rhodium anode target was used, the L lines strongly excited fluorescent lines under 3 keV, such as S, P, Si, Al, and Mg, which are specific elements of interest for coal mine respirable dust. This study demonstrates the potential of using micro-XRF for direct-on-filter characterization of coal mine respirable dust.

9:45 AM

Comparative Performance of Battery- and Diesel-Powered Haulage Fleets in Underground Mines

A. Swift[1], A. Newman[1] and J. Porter[2]; [1]Colorado School of Mines, Golden, CO and [2]Brigham Young University, Provo, UT

Battery-electric vehicles have the potential to improve ambient conditions in underground mines by reducing the amount of heat and diesel exhaust emitted. Existing literature considers the differences in cost, heat load, and productivity between individual diesel and battery vehicles; this study uses simulation techniques to determine the effect of electrifying an entire haulage fleet on the overall heat load, emissions, and energy usage of an underground mine as activities take place deeper in the earth. This information is important as mine operators assess vehicle electrification as a means to achieve greenhouse gas emissions reduction targets.

10:05 AM

The Impact of Fleet Electrification on Productivity in Heat-Constrained Underground Mines

J. Ayaburi[1], A. Swift[1], J. Porter[2], A. Brickey[3] and A. Newman[1]; [1]Mechanical, Colorado School of Mines, Golden, CO; [2]Mechanical Engineering, Brigham Young University, Provo, UT and [3]Mining Engineering and Management, South Dakota School of Mines & Technology, Rapid City, SD

Underground mine planning uses production schedules to determine a (near-)optimal sequence of activity execution to maximize net present value while considering resource limitations and spatial precedence. The mining industry currently relies heavily on the use of diesel-powered equipment, which accounts for heat accumulation and exhaust emissions that can create unsafe conditions in the work environment. Sustainable mining practices call for the transition from diesel- to battery-powered equipment. We present a large-scale production scheduling model that (i) prescribes activity start times in a medium-term schedule at daily fidelity, taking into account ventilation and refrigeration; and, (ii) determines a fleet composition, relative to a diesel-only fleet, that improves productivity. We find that the need for refrigeration is delayed and exhaust emission is reduced as more battery-powered equipment is introduced, showcasing the utility of battery vehicles in maintaining productivity and improving the safety of underground work environments.

10:25 AM

Lighting As A Conduit For Technological Disruption

Y. Fletcher; Coolon USA, Inc., Racine, WI

Mine sites are increasingly investing in digital transformation to improve safety, reduce costs, and increase productivity. Some of today's mine sites are already automated, but the processing plant is hard to digitize conventionally. Cabling is expensive, signal propagation is reduced by steel structures, and IT support can be limited. But what if there was a way of doing this with little effort or cost? A typical wireless network can be simplified by using a densely packed mesh of nodes. Each node serves an area around itself and passes data to its neighbor for re-transmission. Lighting provides the best radio coverage—it is mounted in elevated positions, constantly powered, and everywhere. The new generation of lights has a smart connectivity module that meshes with nearby smart lights, forming a wireless network and unlocking the full potential of IoT technologies. Like an app store, you could pick a provider of asset tracking to locate equipment and people on-site, deploy machine condition monitoring, or monitor noise, pollution, air quality, and other conditions in real time in any area around the site. Helping the mine site of the future have endless and unlimited IoT solutions.

10:45 AM

Safety in Autonomous Haulage Systems: Lessons Learned and Best Practices

J. He, N. Risso and K. Luxbacher; Mining and Geological Engineering, the University of Arizona, Tucson, AZ

The mining industry increasingly uses robotics and autonomous systems to boost productivity and safety. Autonomous Haulage Systems (AHS), in use since the early 2000s, face global adoption challenges. This work examines AHS risks over the past decade, analyzing incidents and best practices to derive safety lessons. By reviewing global cases, we propose guidelines focusing on standard operating procedures and staff training to enhance safety and productivity in autonomous mining. This research emphasizes the importance of comprehensive staff training and adherence to best practices for safe operation.

11:05 AM

Comparison of Low-Cost Pollution Sensors Against Industrial Mining Dusts in a Calm-Air Aerosol Chamber

J. Patts, C. Wolfe and E. Cauda; CDC / NIOSH, Pittsburgh, PA

Exposure to respirable crystalline silica has serious, irreversible health effects and thus protecting miners in dusty environments is key to protecting their health. Low-cost dust sensors, originally intended for air pollution monitoring, increase the spatial and temporal quantification of dust levels and assist mines in assessing targeted control strategies. To evaluate their potential, calm-air aerosol chamber testing was conducted comparing the output of eight low-cost sensors to reference measurements while exposed to dusts commonly found in the M/NM sector. The results demonstrate that the units have high inter-unit correlation and high correlation to reference dust measures across the dusts tested.

11:25 AM

Increasing Safety by Understanding the Key Factors Impacting Overbreak and Underbreak

D. Osei and A. Brickey; Mining Engineering and Management, South Dakota School of Mines and Technology, Rapid City, SD

Overbreak and underbreak are phenomena that impact the safety of miners and equipment in underground mining environments, resulting in stope instability and other hazards. This research determines the key parameters impacting overbreak and underbreak using a machine learning model. Blasting, stope design, and production data acquired from a case study mine are analyzed to identify key parameters influencing the occurrence of overbreak and underbreak in underground stope development. Results from the analysis provide mining engineers and mine planners with methods of modifying design parameters, reducing overbreak and underbreak and improving stope safety.

TUESDAY, FEBRUARY 25 MORNING

HISTORY OF MINING I

Room 110

9:00 AM • Tuesday, February 25

*Chair: **G. Luxbacher**, NIOSH, Prosper, TX*

9:00 AM

Introduction

9:05 AM

The Struggles for Safety

E. McCarthy; Performance Minerals LLC, Morgan Hill, CA

The US mining industry experienced prolific growth in the years from the US Civil War to WW II, but at a steep cost in the safety and health of the miners. Fatality rates were three times that of countries like the UK and Germany and the longer term effects from respiratory problems were even worse. Still, the issue was largely ignored in the American mainstream, in part because most of the victims were immigrants or African Americans. There were many in the industry who worked hard to change this even as early as the 1860s. While most of their efforts are not well known, they did achieve steady progress in getting state mine inspections, better

healthcare, universal education, workmans compensation, dust control and protective equipment. But the process was always a struggle and sadly, the US was well behind other advanced economies during the era. This presentation will tell some of their pioneering stories, starting with the work of John Siney after the Avondale coal disaster in 1869, down to the Hawks Nest tunnel tragedy in the 1930s, which provided the catalyst for silicosis becoming a compensible disability.

9:25 AM

Daniel C Jackling and the Gilded Age

T. Braun; SRK Consulting (U.S.), Inc., Denver, CO

Daniel Cowan Jackling proved large scale mining of low-grade deposits could be economic. With the financial support of risk-tolerant investors, Jackling built the first commercial scale copper mining and milling operation at the Bingham Canyon mine near Salt Lake City, Utah in 1903. The success at Bingham Canyon led to the Utah Copper Company which, with the help of Guggenheim interests, ultimately joined the Kennecott Copper Company. In addition to the spectacular success of the Utah Copper Company, Jackling led the development of the Chino Mining Company in New Mexico, the Ray Mine in Arizona, and the Robinson Mine in Nevada. His ownership stake and dividend stream from these operations and others led to Jacking becoming a self-made millionaire before he was 40 years old. His technical contributions to the mining industry are well documented and recognized in many ways. This presentation is about his lifestyle after his sudden affluence in the early 1900's, near the tail end of the Gilded Age. Socialites, personal rail cars, yachts and hotel suites helped Jackling take a time out from his prodigious workload. Or integrate one or more these indulgences into his business routine.

9:45 AM

Chemical Equipment and Resources of the Bronze Age

S. Patterson; Mining Engineering, University of Arizona, Gilbert, AZ

Large-scale trade for minerals and industrial chemicals is considered a recent phenomenon, but archaeology throughout the Bronze Age shows well-traveled international trade networks moving commodities in huge quantities. Likewise, Bronze Age processing exploited the same physical and chemical properties of minerals that, since the Industrial Revolution, the modern era still uses to produce raw materials en masse. Bronze Age people throughout the Middle East and Mediterranean used a variety of fuels, furnaces, pottery, and crucibles in metalworking. The textile industry also used similar technology, organics, and inorganic resources to tan and dye leather and fibers. The use of these mineral resources fueled additional trade routes that are often overlooked in favor of the more prominent copper or tin routes. The examination of these networks, industry tools, and resources over time, shows how integrated chemical industry and trade are; and how ancient industry's chemical needs led to commerce and exploitation within textile and mining industries themselves.

10:05 AM

Early Milling & Smelting of Butte Copper Ores

T. McNulty; T. P. McNulty and Associates, Inc., Tucson, AZ

Following about six years of mining and processing shallow silver ores, miners in Butte, MT, developed extensive copper sulfide deposits. Arrival of the railroads enabled importing of heavy machinery and exporting of products. Direct smelting of high-grade ore and gravity concentration of lower-grade rock was followed by roasting and smelting. Smoke and fumes from roasting in open heaps reduced visibility to near-zero in the city, but methods quickly improved. Soon, there were 10,000 miners supplying feed to twelve mills and smelters along Butte's Silver Bow Creek.

10:25 AM

The Blind Horses

C. Anderson; Colorado School of MInes, Golden, CO

After the Civil War, a Gold Rush occurred throughout the Western United States. Many mining camps appeared almost overnight and then just as suddenly disappeared once the gold began to play out. One such mining camp in Montana almost sufferd the same fate. However, the fortuitous discovery and focused interest in local silver deposits reinvigorated the investment and development of the failing gold camp. This lead directly to the creation of The Richest Hill on Earth which subsequently expanded exponentially due to copper mining. This presentation will discuss the silver focused mining and investment activities in Butte Montana which created Montana's first millionaire and directly led to its development as arguably the greatest Copper Camp in the world.

10:45 AM

Mining Engineering Education in the US—The Torturous Path to the Present

G. Luxbacher; OMSHR, NIOSH, Prosper, TX

The first degrees in Mining Engineering in the United States were given by the Polytechnic College of the State of Pennsylvania, Philadelphia, PA, in 1862. While that institution faded from existence about 1890, mining engineering curriculum was added at other schools throughout the US, programs came and went, but peaked in number at about 36 in the early 1950s; the number of graduates peaked in 1982 at slightly over 700. Despite that impressive expansion, many of these programs suffered through the issues that plague the 13 accredited (or 14 depending on definition) mining engineering schools today—finding faculty and students. This presentation looks at the development of mining engineering programs after 1862 in the context of industry needs and opportunities.

MONDAY, FEBRUARY 24 AFTERNOON

INCLUSION & DIVERSITY: HOW TO BE AN UPSTANDER NOT A BYSTANDER: NAVIGATING SENSITIVE SITUATIONS AS AN ALLY: A PANEL DISCUSSION

Sponsored by: Newmont

Room 502

2:00 PM • Monday, February 24

Chairs: ***Z. Scopa****, Cargill Inc, Ithaca, NY*
J. Dowding*, Nevada Gold Mines, Winnemucca, NV*

2:00 PM

Introduction

2:05 PM

How to be an Upstander not a Bystander: Navigating Sensitive Situations as an Ally: A Panel Discussion

Z. Scopa; Engineering, Cargill Inc, Minneapolis, MN

An upstander is an individual that recognizes someone facing a challenge and speaks or acts to support them on their behalf. Advocating for oneself in the workplace can be difficult. In this session, we will explore identifying sensitive situations that require intervention and how to be an upstander when others may not be able to advocate for themselves. Our panelists will guide the audience through interactive case studies followed by a discussion regarding each scenario. Having upstanders in the workplace is important for developing an inclusive mining community and lessons learned from these case studies will help allies develop a toolkit for advocating for those around them.

TUESDAY, FEBRUARY 25 MORNING

INCLUSION & DIVERSITY: WE ALL HAVE UNCONSCIOUS BIAS: LET'S EXPLORE IT TOGETHER

Sponsored by: Newmont

Room 502

9:00 AM • Tuesday, February 25

Chairs: ***V. Gosteva****, ES Consulting, Denver, CO*
A. Williamson*, WSP, Albuquerque, NM*

9:00 AM

Introduction

9:05 AM

Leveraging Neurodiversity for a Competitive Edge in the Mining Industry

S. Houston; Strategist Solutions, Setubal, Portugal

The mining industry faces significant challenges, including an aging workforce, the need for technological innovation, and increasing scrutiny on sustainability and ethical practices. Embracing neurodiversity offers a promising competitive edge to address these issues. This presentation explores how integrating the strengths of neurodiverse individuals can drive innovation, enhance operational efficiency, and foster a resilient workforce in the mining sector. Sam will discuss the unique cognitive strengths of neurodiverse individuals, such as innovative problem-solving, exceptional attention to detail, resilience, and systematic thinking. These strengths can significantly improve the industry's ability to tackle complex challenges. The presentation also highlights the critical role of coaching in ensuring the successful inclusion of neurodiverse talent. Coaching leaders to develop empathy, effective communication, and inclusive practices is essential for creating an environment where neurodiverse employees can thrive. Similarly, coaching neurodiverse employees on navigating corporate cultures and leveraging their strengths ensures successful integration and career advancement.

9:25 AM

25-046

Inclusive Mining for Sustainable Development: Value Proposition That is Based on the Formation of Corporate Volunteering that Enhances Diversity and Inclusion Through the United Nations Sustainable Development Goals (SDGs)

M. Campos[1], J. Mujica[1] and M. Campos[2]; [1]Engineering, SME, Cajamarca, Cajamarca, Peru and [2]Economic, Accounting and Administrative Sciences, Student, Cajamarca, Peru

In a world where sustainability and inclusion are global imperatives, the mining industry plays a crucial role in economic and social development around the world. This paper proposes an innovative approach: Inclusive Mining for Sustainable Development, which not only seeks to maximize economic profitability, but also to promote social and environmental well-being with the integration of the United Nations Sustainable Development Goals (SDGs) aligned mainly with diversity and inclusion through the implementation of a key added value for the mining company that lies in the creation and operation of a Corporate volunteering that seeks to develop and execute inclusive practices to promote gender equality, inclusion of local communities and indigenous peoples, and accessibility for people with disabilities. This proposal will educate employees and collaborators about sustainability and promote concrete actions through corporate volunteering to strengthen the mining company's commitment to community development, improve social relations, and advance towards the fulfillment of the United Nations Sustainable Development Goals, establishing the company as an agent of global change.

9:45 AM

Attracting Diverse Talent to the Mining Industry

S. Loomis; Caterpillar Inc, Denver, CO

The mining industry struggles with attracting diversity in the workplace. This results in high competition with limited talent availability. As the war for talent increases, that makes every requisition that much more critical to find the best talent, every time. The industry has been vocal about priorities of gender equality, and miners are setting transparent targets for gender diversity. Studies have shown that a diverse workforce is higher performing and highly engaged which translates to better financial performance. As more and more operations go autonomous, with centralized control rooms, there is more of a chance to find and retain diverse talent.

10:25 AM

Blind Spot or Not: Mining Gets Better When We Are Better

S. Saffold-Harris[1], A. Anani[2], C. Abramson[2], J. Potter[2] and K. Luxbacher[2]; [1]Gender and Women's Studies, University of Arizona, Tucson, AZ and [2]Department Head of Mining and Geological Engineering, University of Arizona, Tucson, AZ

Are the statistics of mining employment as a gender-based-dominated field becoming a trend of the past? With jobs and collegiate student interest in mining trending downward for over a decade, how can mining experience a resurgence of talent with the assurance of continuous growth and systemic change along gender lines? Where are women situated in mining? How does adhering to gender norms impact employment and retention? From 2023 to 2024, we asked over 50 women working in mine operations, technical service, and administration within the United States about their experiences as women in mining. We will present the data publicly for the first time. The audience will be the first witnesses of employment testimonies from never-seen-before anonymous data sets, including focus groups, one-on-one interviews, and surveys. This presentation aims to provide participants with empirical data and compelling critical insight into employment trends and to inspire ways to attract women to work in mining and retain their talent.

10:45 AM

Transforming Mining Through Female Ownership: A Case Study of Inclusive Investment in Mineral Exploration

B. Borody; The Femina Collective, Kitchener, ON, Canada

In an industry where women constitute only 15% of the workforce, this study examines a novel approach to address gender disparities in mining investment and ownership. The cast study explores establishing a women-focused Limited Liability Partnership to increase female project ownership in exploration and mineral development. With Canada's critical minerals strategy allocating $1.5 billion to industry growth and US government-backed investment into Canadian projects, the timing is crucial to expand gender diversity in investment. This case study analyzes the challenges faced by women in mining, focusing on ownership underrepresentation, and explore how this initiative aligns with sustainability and responsible mining practices. The study examines transformation potential through increased female-focused project investment, focusing on responsible development criteria such as Indigenous participation and ESG considerations. Finally, the study contributes to the dialogue on diversity and inclusion in mining, offering insights into strategies for creating equitable environments while supporting industry growth.

11:05 AM

Methodology to Determine the Associative Potential of Small-Scale Mining Communities

O. Restrepo Baena, G. Viana, J. Tobon, J. González Guzmán, N. Jaramillo Zapata and N. Vásquez G; Materials and Minerals, Universidad Nacional de Colombia, Medellín, Antioquia, Colombia

Mining activity represents a significant contribution to the national economy and faces various technical, social and environmental challenges. In a context where mining activity in Colombia has experienced significant growth, it is imperative to address the challenges posed by its formalization and sustainable development. Over the years, the mining institutions have designed various instruments to characterize and categorize this activity, as well as to address the obstacles that hinder its orderly exploitation in harmony with the environment and other productive activities. Despite these efforts, informality in the sector continues to be significant. Given this situation, there is a need to promote and implement strategies to encourage mining formalization in order to guarantee high environmental, technical, economic, social and legal standards, as well as to minimize the environmental liabilities generated. Therefore, the creation of a methodology that promotes the association between miners becomes fundamental considering the labor tradition, the existing productive interconnections, the local economy and the dynamics of supply and demand in the sector.

11:25 AM

The Case for Social Performance, Inclusion and Equity: Generating Value and Resilience Through Social Inclusion and Equity

K. Neddenriep and L. Bundgartz; Social Performance, ERM, Portland, OR

Mining industry requirements for permitting, due diligence and investment necessitate evidence of meaningful stakeholder engagement, positive social impact, and respect for human rights. This includes efforts to minimize and mitigate injustice and inequalities from early exploration through to mine closure and post closure. ERM has partnered with mining clients to develop and embed robust social performance management systems to meet evolving social expectations while aligning with organizational goals. Our approach to meaningful stakeholder engagement, social knowledge base development, social risks and impact identification and management, and DE&I creates shared value, builds trust, increases transparency, and aligns with responsible mining standards (e.g GISTM, ICMM, IRMA, TSM).

TUESDAY, FEBRUARY 25 MORNING

INDUSTRIAL MINERALS & AGGREGATES: CRITICAL AND BATTERY MINERALS I

Room 106

9:00 AM • Tuesday, February 25

Chairs: ***T. Gupta****, MP Materials, Mountain Pass, CA*
O. Yavuzkan*, Clariant, Wilton, CT*

9:00 AM

Introduction

9:05 AM

Rare Earth Beneficiation: Insights from Recent Case Studies

J. Liu; SGS Canada, Lakefield, ON, Canada

Rare earth elements (REEs) play pivotal roles in modern technologies, from clean energy and defense applications. This paper compiles several case studies from recent rare earth beneficiation endeavors, including flowsheet development, laboratory trials, and pilot plant operations. The studies encompass various techniques including froth flotation, magnetic separation, and gravity separation. Different mineralogical compositions—ranging from bastnaesite and monazite to xenotime and allanite—are examined alongside their respective gangue minerals such as calcite, dolomite, ankerite, silicates, and iron oxide. The objective is to provide insights into REE responses under diverse technological approaches, highlighting the influence of mineralogical composition and texture on their extraction behaviors.

9:25 AM

Direct Lithium Extraction—DLE

V. Mwaba; SME, Shorewood, IL

As modern civilization races to de-carbonize transportation, in an effort to reduce the impact of CO2 emissions on climate change, lithium has emerged as the electrolyte of choice, because of it's energy density. However, conventional evaporation ponds methods and hard rock methods have their fair share of challenges with regards to water intensity and energy intensity, respectively. Direct Lithium Extraction (DLE) offers a greener alternative to scaling up lithium production at a pace that is impactful to the automobile and other energy storage industry.

9:45 AM

25-058

Minimum Concentrations of Critical Minerals for Exploration—How Good Is Good Enough?

R. Otoo[1], V. McLemore[2] and E. Owen[2]; [1]Mineral Engineering, New Mexico Tech, Socorro, NM and [2]New Mexico Bureau of Geology and Mineral Resources, Socorro, NM

Disruption in critical minerals supply chains has resulted in the evaluation of various types of mineral deposits for critical minerals potential. Much of the study on critical minerals focuses on occurrence and characterization, but little research has addressed what concentrations of critical minerals in a mineral deposit are required to make an exploration target into an operating mine. Understanding the cut-off grades of ore deposits being actively mined is one criterion to determine if concentrations in an exploration target are high enough. Cut-off grade is defined as the minimum amount of mineral contained in a ton of ore that is sent to the processing plant. Among many factors, cut-off grade depends upon the size and type of the deposit and mining operation, the processing technique, and market prices. This research does not aim to define cut-offs for determining if a mineral deposit is economic. Rather, it defines estimates of concentrations of critical minerals that could be considered good enough for further exploration. For example, ~2% total rare earth oxide (TREO) is the cut-off grade for Mt. Pass carbonatite, but 500 ppm TREO could be an exploration target for coals.

10:05 AM

Higher Yields and Lower Production Costs by Measuring Evaporation Rate on Lithium Evaporation Ponds

V. Mwaba; SME, Shorewood, IL

Radar level monitoring is of paramount importance in lithium evaporation ponds due to its ability to provide accurate and continuous measurements of water levels. This technology ensures precise tracking of water evaporation rates, enabling lithium producers to optimize resource management and enhance operational efficiency. With the added benefits of solar panels to power level transmitters, this approach not only ensures uninterrupted monitoring but also reduces operating costs and environmental impact. Furthermore, by incorporating temperature-native wireless transmitters, producers can accurately determine the optimal time for product transfer to the next evaporation stage, optimizing production time while minimizing energy consumption and maintenance requirements.

10:25 AM

Lithium Americas—Thacker Pass

J. Bilant[1] and R. Ravenelle[2]; [1]SME RM, Winnemucca, NV and [2]PHD, Reno, NV

Lithium Americas Corp. owns 100% of Thacker Pass, one of the most advanced lithium projects in the U.S., having commenced construction in early 2023. Thacker Pass, located in northern Nevada, is one of the world's largest known Measured and Indicated lithium resources with a forty-year mine life containing Proven and Probable Reserves of 3.7 million tonnes of lithium carbonate equivalent averaging 3,160 ppm lithium. The project is designed for a nominal production capacity of 80,000 tonnes

per annum of battery-quality lithium carbonate, built over two phases. Mining and processing the lithium-bearing clay will include a shallow open pit mine and a flowsheet consisting of beneficiation, sulfuric acid leaching, filtration, crystallization, and dry stack tailings. Thacker Pass is fully permitted for major construction and Phase 1 construction funding is substantially de-risked. General Motors has an exclusive offtake for 100% of Phase 1 production for up to 15 years. Presentation highlights will include a project and engineering overview, process design, metallurgical and recovery methods, and an economic overview.

10:45 AM

Investigating Novel Spodumene Collectors to Improve Flotation Efficiency

O. Yavuzkan[1], B. Kawenski Cook[2], W. Da Silva[1], S. Raju[1], M. Aghamirian[2] and P. Dopico[1]; [1]Clariant, Wilton, CT and [2]SGS Canada, Lakefield, ON, Canada

Traditional fatty acid collectors, despite their widespread use, often require high dosages and leave organic residues in the lithium concentrates, leading to a characteristic fatty acid odor in the downstream refineries and resulting in carbonaceous deposits during smelting, which can impair furnace efficiency, increase maintenance, and reduce product purity. These residues can also release VOCs, posing environmental and operational risks. This study evaluated the impact of novel flotation collectors on the selectivity in spodumene flotation. Flotation testing determined which collectors—at a range of collector dosages—were able to maintain or improve lithium recovery from baseline conditions while maintaining or improving the final concentrate grade. This investigation provides valuable insight into how different collector chemistries influence the selective rejection of silicate gangue like feldspars, quartz, and micas, as well as iron-bearing silicates prone to flotation under similar conditions as spodumene. Mineralogy and surface chemistry analysis of select flotation products supplement the flotation results and provide further insight into the flotation mechanisms.

11:05 AM

Stratigraphy, Geochemistry, and Petrography of the Phosphoria Formation: Insight Into Critical Mineral Enrichment

J. Alexander; Energy and Minerals, Utah Geological Survey, Salt Lake City, UT

The Permian-age Phosphoria Formation has produced phosphate for over 100 years in Utah, dominantly from the Meade Peak Member. Currently, ore-grade phosphate (20% P_2O_5 or higher) is mined north of Vernal, Utah, and east of Spanish Fork, Utah. The Utah Geological Survey is evaluating critical mineral content in Utah's phosphorite including the rare earth elements (REE) (e.g., praseodymium and neodymium), vanadium, chromium, and fluorine. Initial geochemistry data indicate a positive correlation between P_2O_5 content (up to 36 wt%), total REE enrichment (300-1200 ppm), and chromium content (200-1400 ppm).

TUESDAY, FEBRUARY 25 MORNING

INDUSTRIAL MINERALS & AGGREGATES: MINE DESIGN IN INDUSTRIAL MINERALS AND AGGREGATES I

Room 107

9:00 AM • Tuesday, February 25

Chairs: ***S. Stokowski****, Stone Products Consultants, Lawrenceville, GA*
J. Sackrider*, Westward Environmental, Inc., Boerne, TX*

9:00 AM

Introduction

9:05 AM

Back-Analysis of a Limestone Mine Pillar Collapse Using LaModel—A Case Study

A. Elibol[1], M. Suner[1], D. Tuncay[2] and Z. Agioutantis[3]; [1]Mining Engineering, Student, Morgantown, WV; [2]Mining Engineering, Assistant Professor, Morgantown, WV and [3]Mining Engineering, Professor, Lexington, KY

LaModel is a displacement-discontinuity variation of the boundary element method, which is utilized to analyze the displacements and stresses in flat-lying, tabular orebodies. Due to its inherent development, LaModel is commonly used in coal mining operations. However, recent developments that include the gradient strength equation derivation, local large discontinuity factor implementation, and the calibration layout for benching operations extend the usage of LaModel to underground stone mining operations. In this research, a massive pillar collapse that happened in a mine in Pennsylvania is back-analyzed using LaModel. First, in-seam material properties are adjusted based on the case mine for fully benched and initial development areas in the mine. Then, a population of large discontinuities going through the pillars is realized with various spacings. Finally, implementing the local large discontinuity factor and calibrating the layout for the benched areas allow us to estimate the pillar safety factors and overburden loads in the region where the massive pillar collapse occurred.

9:25 AM

Lessons Learned in Underground Stone Mine Planning

N. Hoffman; WSP, Ballwin, MO

The increase in underground stone mining has resulted in many traditional surface mine operators facing a new variety of unforeseen challenges that threaten the continuation of their operation. These include mine access, right-of-way crossings, stability issues, and changes in chemical composition. This paper will explore real life experiences of operators facing these issues, the solutions required, and mine planning recommendations for mitigation, with the end goal of providing insight and knowledge to the broader mining community.

9:45 AM

The Case to be Made for Going Deep

E. ARCHIBALD; Manufacturer, Stoneboro, PA

In modern sand and gravel mining the biggest hurdle in growth planning is how to mine material below the depths accessable by conventional excavation methods; especially if the greater depths require mining under water. This presentation will discuss the strategy and econimcs that go into making the investment to mine at greater depths underwater. That investment will often reuqire extensive exploratory drilling using advanced sonic core technology, which alone is a massive investment. Once a desposit has proven reserves at depth, equipment selection often leads to what will be the largest single capital investment that the operation will ever make. We will walk attendess through the step by step process used to evaluate the feasbility of this investment; everything from permitting hurdles, labor reuired, and plant modifiactions needed to handle high-volume wet material. Thank you for your consideration of our presentation.

10:05 AM

Roadmap for Autonomous, Intelligent, Precision Mining

E. Westman and J. Addy; Mining and Minerals Engineering, Virginia Polytechnic Institute and State University, Blacksburg, VA

The mining industry has seen improvements in efficiency but not at the scale that other industries have recorded over the past 25 years; additionally, our industry is challenged by the limited availability of workers. A movement toward intelligent, autonomous, precision mining can address both concerns. A roadmap is presented which defines the technologic requirements of moving toward this goal. The requirements include sensors (such as enhanced imaging with hyperspectral and XRF imaging), and autonomous, interconnected equipment which utilizes

machine learning on data acquired. Moving in this direction will provide significant efficiency improvements within the mining industry as well as addressing workforce limitations.

TUESDAY, FEBRUARY 25 MORNING

KAWATRA SYMPOSIUM: PHOSPHATE BENEFICIATION: TECHNOLOGY FOR FERTILIZER PRODUCTION AND BEYOND

Room 709

9:00 AM • Tuesday, February 25

Chairs: ***K. Swager***
S. Moffatt*, Syensqo*

9:00 AM

Introduction

9:05 AM

Analysis and Optimization of Phosphoric Acid Scrubber System

M. Verdi; Hatch, Belo Horizonte, Minas Gerais, Brazil

Facing the growing global demands for reducing pollutants in the atmosphere, one of the major challenges that the phosphoric acid industry has been facing is related to fluoride and particle emissions. During the production of phosphoric acid, fluorine forms gaseous forms of HF, SiF4 & and water soluble H2SiF6. In order to comply with the new fluorine emission standard, phosphoric acid industry have been forced to adapt their scrubbing systems. However, since the new environmental rules, the companies have been unable to meet design targets, despite significant efforts made to stabilize and improve the performance of the system. This paper aimed at providing a review of scrubbing systems operation and design to determine initiatives to improve its performance and reduce the fluorine and particulate matter (PM) emissions from the stacks to meet regulatory emission limits. It also aimed at providing a brief technical overview of how to measure efficiency of the scrubber system. In addition, this paper presents a case study where Hatch carried out an analysis of a client scrubber system in order to help them achieve the new emissions limits.

9:25 AM

Total Utilization of Byproduct Phosphogypsum for Production of REEs, Fertilizers, and Construction Materials I: Material Characterization and Purification

H. Liang, J. Zhang and A. Medley; FIPR Institute, Florida Polytechnic University, Bartow, FL

The US phosphate mining industry produces about 30 million tons of phosphogypsum (PG) byproduct annually, The current PG stacking practice is neither environmentally sound, nor economically viable. This research project of the Critical Materials Innovation Hub, funded by the U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, Advanced Materials and Manufacturing Technologies Office, has five major objectives: 1) reduce radionuclides in PG thus removing a hurdle to its use, 2) maximize REE leaching recovery from PG, 3) develop technologies for REE extraction from the leachate, 4) integrate PG use with significant CO2 sequestration, and 5) produce low-cost cement and concrete using PG as raw material with dramatic reduction in carbon footprint compared to the current commercial operations. This paper presents PG characterization results with a focus on distributions of radionuclides and major chemical components in different size fractions. Encouraging results were achieved in REE leaching from PG and PG purification. These early results are helpful for selecting research approaches and designing experiments to achieve the ultimate goal of this project.

9:45 AM

Run-to-Run Variation in Phosphate Flotation Outcomes: A Survey of Recent Experimental Data

S. Moffatt; Syensqo, Stamford, CT

An individual lab-scale phosphate flotation test yields somewhat noisy estimates of the true values of grade and recovery achieved with a given collector on a given ore under a given set of conditions. We prove this by showing how much scatter there is in the values for grade and recovery when two tests (and in one case, twelve tests) instead of just one are done, in testing of several combinations of collector, collector dose, and ore. The test results we examine are from ten separate studies of various collectors on various ores. We find that, on average, the standard deviation of the noise in measuring recovery (as P2O5) is about 3.5 percentage points, and the standard deviation of the noise in measuring grade is about 0.7 percentage points. To support these findings we show scatter plots of the deviations of individual tests done in duplicate (or more) from their respective mean values for each of the ten studies. We also show how these findings translate into "margins of error" for making claims about true values at either the 95% confidence level or at the (riskier) 80% confidence level. We also illustrate the implications for interpretation of grade-recovery curves.

10:05 AM

Mosaic South America Technical Mineral Characterization

L. Costa, F. Simões, D. Couto, J. Martins, J. Borges and A. Rosa; COE Process, Mosaic, Tapira, Minas Gerais, Brazil

Phosphate rock deposits can be found in igneous occurrences in different areas in Brazil. This kind of deposits generally presents complexes association of minerals, irregular distribution varying thickness layers, phosphorous and apatite content, weathering process exposure leading to a complex process need to concentrate phosphorous to be used as fertilizers. Technical mineral characterization is being used at Mosaic South America sites for over 20 years as a bridge between mine and the concentrate process in beneficiation plants. The technic identifies particles characteristics and behaviors of the extensive mineral matrix correlated to performance in processing stages. Taking the enormous variation in account, technical characterization is essential to subsidize mining planning, process engineers and operational team to evaluate previously data collected with the mineral characterization to rightly define ore metallurgical recovery, ore blends, process routes interference and adjustments, improving performance, cost and production strategy.

10:25 AM

Mosaic's Eastern Extension Subsurface Barrier Wall

B. Studiale[1] and W. Stevens[2]; [1]Mine Strategies, Mosaic Fertilizer, LLC, Lakeland, FL and [2]Engineering, Black and Veatch, Tampa, FL

At Mosaic's Eastern Extension project in West-Central Florida, local geology consists of sandy, highly transmissive overburden with deep phosphatic matrix requiring nontypical pre-mining dewatering techniques to improve dragline stability and maximize ore recovery. Feasibility assessments and conceptual design evaluations concluded that the best technical solution to mitigate against excessive seepage from offsite properties into the mine area and maintain off-site water levels was to construct an 11,400ft subsurface barrier wall along portions of the mine perimeter where the phosphate reserves are the deepest. Wall construction begins Summer 2024. This enables Mosaic's mine expansion further east and deeper than ever before.

10:45 AM

Scale Inhibition in Phosacid Process Elements—PHOSFLOW® Applications

J. Carr, A. Barry and S. Moffatt; Technology Solutions, Syensqo, Geneva, IL

Mineral scale accumulation in the filtration and concentrations sections of the phosacid production process directly affects a plant's efficiency leading to reduced production and additional maintenance costs. Typically,

phosacid plants address mineral scaling via scheduled maintenance that requires production interruption entailing cleaning via mechanical and/or chemical methods. One alternative approach that has been industrially tested and commercialized are Solvay's PHOSFLOW scale inhibitors. Solvay's scale inhibitors have allowed for higher production rates, extended cycle times in filtration and heat exchanger process elements, and reduced maintenance costs due to faster and more efficient scale removal. This paper discusses the most recent technical advances and the key benefits resulting from application of PHOSFLOW® technology on various process elements in the phosacid production process.

TUESDAY, FEBRUARY 25 MORNING

MINING & EXPLORATION: GEOSCIENCES: PRACTICAL GEOTECHNICAL STRATEGIES FOR UNDERGROUND OPERATIONS

Sponsored by: BARR

Room 601

9:00 AM • Tuesday, February 25

Chairs: ***D. Lye****, Freeport-McMoRan*
E. Rose*, Barr Engineering, Salt Lake City, UT*

9:00 AM

Introduction

9:05 AM

Creating a Geotechnical Rating System for Orepasses

K. Guerin-Davey and A. Brickey; Mining Engineering & Management, SDSMT, Rapid City, SD

Determining the optimal location for orepasses at an underground operation can prove challenging. This project presents the results of a survey focused on orepass design, construction, and planning processes for operations within Canada and the US. The responses provide insight into common issues seen in industry, and what current geotechnical parameters are considered in the orepass planning and design process. Using the survey data, a geotechnical rating system is presented. The rating system aims to decrease orepass instability issues, e.g., wall degradation, by analyzing orepass options.

9:25 AM

Novel Cemented Paste Backfill Strength Measurement Technique to Improve QA/QC Practices

J. Frimpong and R. Pandey; Virginia Tech, Blacksburg, VA

Accurate assessment of cemented paste backfill (CPB) strength is critical for safe and efficient underground mining. Current quality control practices, relying on UCS testing of cast samples at surface paste plants often provide inaccurate results, not reflecting in-situ curing conditions. We propose a novel hydraulic fracturing technique, which offers a reliable and cost-effective solution for assessing CPB strength in both ex-situ and in-situ applications. This technique involves controlled injection of hydraulic fluid into CPB, with the peak pressure required to initiate a fracture, termed the Fracture Initiation Pressure (FIP), serving as a measure of the material's strength. Laboratory experiments on CPB samples with binder contents of 4%, 8%, and 12% across 3, 7, 14, and 28 days of curing demonstrated the technique's ability to differentiate CPB strength. FIP values demonstrated strong linear correlations with UCS, tensile strength, and fracture toughness, while also offering enhanced resolution in strength measurements. These findings confirm the viability of FIP as a reliable and a practical measure of CPB strength.

9:45 AM

25-074

Preventing Stope Back Collapse—Practical Strategies

R. Cook, J. Hallowell and V. Zarate; CNI, Tucson, AZ

The long hole open stoping (LHOS) method is widely used in underground mining. While methods to predict stable stope geometries are well established, the ability to maintain a stable back often assumes effective ground support across the full stope span. The efficacy of the support strategy is dependent on rock jointing, quality, density, top cut width and height, and the type, amount, and orientations of bolts installed. However, it is becoming increasingly common for operators to assume narrow top cuts in service of wider stope spans with minimal bolting coverage. Failure to account for the required top cut drift size and support requirements can ultimately lead to raveling type instabilities along stope shoulders that result in back collapse. A new method has been developed to evaluate the minimum top cut dimension necessary to accommodate wider stope spans with various rock bolting configurations. Due to the economic impacts of top cut development and support, this is a critical consideration in the accurate costing and scheduling of a LHOS operation.

10:05 AM

25-045

Improving Shotcrete Application in Underground Mines through Training and Field Support for Nozzlemen

D. Wibisono; Civil and Environmental Engineering, Colorado School of Mines, Golden, CO

This paper focuses on the assessment and analysis of data collected from observations of nozzlemen during primary ground support activities in underground mines. The study highlights the importance of nozzlemen's skills in ensuring the quality of shotcrete application, which is critical for the structural integrity and safety of underground mining operations. A comprehensive training program and field support were implemented to enhance the nozzlemen's proficiency. The set of training covered both theoretical knowledge and practical techniques to improve shotcrete application on a daily basis. Proficiency improvement was evaluated using quantitative assessment metrics and rebound percentage calculations. The results of this initiative showed significant improvements in shotcrete quality, including increased efficiency, reduced waste, and fewer needs for reworks or rehabilitations. The findings aim to contribute to a broader understanding of best practices in shotcrete application and nozzlemen training, ultimately enhancing ground support measures in the mining industry.

10:25 AM

Assessment of Timber Support Systems Used In Artisanal and Small-Scale Mining: A Comparative Analysis of Stability Integrity

C. Mgiba and O. Kolawole; Civil Engineering, New Jersey Institute of Technology, University Heights, Newark, NJ

Artisanal and small-scale mining operations rely on timber for ground control in underground operations. The stability of hanging walls in tunnels and working faces remains a significant safety concern in mining. This study aims to analyze the mechanical integrity of timber support by establishing a constitutive model for timber material against estimated rock strength, excavation geometry, and stress distribution on the excavation model. The load capacity of timber utility in different mining settings was also evaluated. Numerical modeling and analysis of roof bolting support were analyzed to provide a comprehensive assessment, in addition to comparisons with other mining support systems. Keywords: ASM, timber stability integrity, numerical modeling, stability analysis

10:45 AM

25-071

Practical Model Approach for Relationship between Radioactive Waste Container Emplacement Position and the Spatial Thermal Radiation in Dry Salt Grit Backfill

I. Alsalamin, L. Schaarschmidt and H. Mischo; Underground Mining, Technische Universitat Bergakademie Freiberg, Freiberg, Sachsen, Germany

In order to store high-level radioactive waste underground, the German repository concept considers clay, crystalline and salt formations as suitable host rock materials. The current research projects of the Chair Underground Mining Methods at TUBAF (Technical University Bergakademie Freiberg) in nuclear waste repositories mainly focus on storage within salt formations. In this scenario, the high-level radioactive waste is supposed to be packed into specifically designed containers and then transported underground and emplaced in horizontal storage drifts. The residual temperature of the radioactive waste leads to the question if there are optimization possibilities for waste handling, the storage and the long-term emplacement of such high temperature level waste. A deeper understanding of the heat transmission from the container into the host rock might lead both towards possibly shorter surface interim storage times as well as size optimization possibilities of the repository itself. TUBAF has conducted research that succesfully proved that an optimized container positioning yields more favorable thermal patterns and can be achieved with conventional mining equipment.

11:05 AM

25-055

Managing Subsidence Impact on Active Production Cave to a New Production Footprint Through Draw Control Strategies

M. Hutahaean[1], S. Firmanulhaq[2] and R. Kayadoe[1]; [1]Underground Engineering, PT. Freeport Indonesia, Medan, Sumatera Utara, Indonesia and [2]Underground Geotechnical, PT. Freeport Indonesia, Tembagapura, Indonesia

Building a new production block next to an active cave requires continuous development and production activities monitoring. Deep Mill Level Zone (DMLZ) mine is developing a new footprint 225 meters above the south perimeter of the current active area. Production blocks 1 and 2 as of date produce around 80,000 tons per day from 464 draw points. Given the exhaustion sequences, remaining reserves, and maturity of the draw points, draw rates in the southern footprint have been increased up to 380 mm/day over time. Monitoring the progressive growth of the cave is vital to prevent impact on the new footprint that might lead to inaccessibility of planned-development drifts and sterilization of the reserves. The data shows various cave propagation rates from approximately 17.5 m vertically and 0.2 m horizontally per quarter. The present study experimentally investigated the effect of different draw rates on the lateral and vertical propagation of the cave. The result is not only to structure a triggered action response plan (TARP) proposal. But also, to guide production scheduling to orchestrate optimum rate in the affected extraction areas.

TUESDAY, FEBRUARY 25 MORNING

MINING & EXPLORATION: GEOSCIENCES: UNLOADING THE MODEL: MODELING METHODS FOR GEOTECHNICAL DESIGN

Room 507

9:00 AM • Tuesday, February 25

Chairs: ***E. Rose****, Barr Engineering, Salt Lake City, UT*
D. Lye*, Freeport-McMoRan*

9:00 AM

Introduction

9:05 AM

Techniques for Interpolating and Validating Geotechnical Block Models

J. Potter[1], J. Connolly[2], P. Calderon[2], S. Cylwik[2], J. sauceda[2], J. Beck[3] and J. McNabb[1]; [1]Geotechnical Center of Excellence, The University of Arizona, Tucson, AZ; [2]Call & Nicholas, Inc., Tucson, AZ and [3]Rio Tinto, Herriman, UT

Understanding the spatial distribution of the geomechanical properties of a rock mass is essential for proactive, de-risked mine design. Given the inherent heterogeneity of rock masses, exhaustive characterization of material properties in open pit and underground mines is impractical. Thus, modeling the spatial variability of geomechanical properties is necessary to account for areas of geotechnical concern. While geostatistical methods for ore grade variability are well-defined, the same is not true for geotechnical parameters. Additionally, geomechanical data are fundamentally different from resource estimation data and are often sparse in areas critical to slope stability. Therefore, construction of a geomechanical model must account for any site specific data limitations, as well as the geologic setting, mining method, use-cases, and potential limitations and value adds. This presentation will outline industry best practices for modeling geomechanical parameters in three dimensions, covering data collection, statistical analysis, geotechnical domain definition, variogram analysis, model interpolation and validation, and methods for communicating model reliability.

9:25 AM

A Parametric Study on QA/QC Cylinder Strength of Cemented Paste Backfill (CPB) Using Numerical Experiment Design

B. Kim, D. Sweet, T. Emery and J. Seymour; CDC/NIOSH, Spokane, WA

Cemented paste backfill (CPB) is commonly used to provide ground support for cut-and-fill mining methods in underground metal mines. The unconfined compressive strength (UCS) test is the most used to measure of the strength of the CPB and consequentially is the most common QA/QC test in mines. This study describes the results of a robust design to consider the impact of different testing factors impacting the UCS. Because the variability of testing factors is significant and the number of influential parameters in determining a parametric study is large, it is impractical to consider every simulation case by varying each parameter individually. To save time and honor the statistical distributions of the parameters, the National Institute for Occupational Safety and Health (NIOSH) developed orthogonal arrays using a combination of the a) width-to-height ratio of cylindrical specimens, b) CPB batch, c) loading rate for the UCS test, and d) end preparation, using 3DEC. After completion of the numerical experiments, statistical and multivariate analysis are performed using the calculated results from the orthogonal arrays to analyze the effect of these variables.

9:45 AM

Utilizing 3D Modeling and Numerical Analysis to Study The Impacts of Seismic Activities on Tailings Dam Stability

A. Bascetin and H. Çelt; Mining Engineering, Istanbul Technical University, Istanbul, Turkey

The study's objective is to evaluate the impact of seismic activities on the stability of a tailings dam in Türkiye, considering the effects of time, geological factors, and the dam's design. The parameters were modified to achieve various scenarios, and the results were analyzed. Each scenario was modeled using 3D finite element analysis. The following procedures were performed sequentially under a seismic load: Tailings layers, leakage zone simulation, and dam body design modification are the main dam construction processes. The findings indicated a positive correlation between the quantity of tailings and the stability of the dam. Due to seismic load, leakages increased pore water pressure and decreased stability. In areas with declining stability, the embankment design of the dam was changed. Therefore, the outcomes derived from various models serve as a valuable resource, particularly in situations encountered in Türkiye and the challenges that may arise in other dams with comparable designs.

10:05 AM

Evaluation of an Upstream Tailings Storage Facility's (UTSF) Susceptibility to Static Liquefaction Using the NorSand Constitutive Model—A Numerical Modeling Approach based on the Finite Element Analysis

P. Nso; Mining and Nuclear Engineering, Missouri University of Science and Technology, Rolla, MO

The response of the overall stability of tailings storage facilities (TSFs) and their resistance to static liquefaction require an understanding of the mechanical response of mine tailings. This is required to better predict tailings behavior, as well as using this knowledge for the validation of constitutive models in numerical simulations. These necessitate appropriate constitutive models that can describe the physics and mechanics of a TSF from its construction stage to its operational life. In this study static liquefaction and mine tailings susceptibility are evaluated using the NorSand constitutive model based on plane strain 2D finite element analysis. The design and evaluation analyses considered in this study accounts for the hydromechanical behavior of an upstream tailings storage facility (UTSF) considering different mine tailings mechanical properties. Findings of this study will significantly contribute to the safe design of these facilities and as impetus to complying with the Global Industry Standard on Tailings Management' benchmark of TSFs zero harm and tolerance to people and the environment from earliest phases of TSFs conception.

10:25 AM

A Proposal for Underground Stope Stability Chart Development Based on Probabilistic Models

L. Paixao and P. Rogers; Mining Engineering Department, University of Utah, Salt Lake City, UT

Since their first iteration presented in the 1980's by Mathews and Potvin, the use of stability graphs for stope stability assessment became popular in the mining industry due to their ease of use, generating many variants over the years, although their excessive simplification often made them target of criticism. In more recent years, the use of statistical and machine learning models has gained prevalence, although the specificity of the stability phenomenon can make it hard for a given single model to represent it adequately in every mine site. This study aims to propose a more generalized approach in graph development using a dataset from a zinc mine with 340 stopes characterized by 9 predictor variables and evaluating the performance of 5 different classification models on the AUC metric. The predictors were ranked based on the mean AUC decrease from the Permutation Feature Importance method, the two most relevant being used to plot stability zones in a bi-dimensional graph that separated unstable from stable stopes. When compared to the classical graph approach, the results proved more accurate, although very dependent on the data availability, quality and chosen metrics.

TUESDAY, FEBRUARY 25 MORNING

MINING & EXPLORATION: INNOVATION & TECHNOLOGY: REMOTE SENSING IN OPEN PIT MINING ENVIRONMENTS

Sponsored by: BRUGG Geobrugg

Room 503

9:00 AM • Tuesday, February 25

9:00 AM

Introduction

9:05 AM

An IOT-Based GNSS Platform for Mine Infrastructure Monitoring

E. Migneault; Worldsensing, Westerly, RI

In 2024 we witnessed large landslides happening at mining sites worldwide. Those events, like many others in the past years, remind us of the urgency and importance of accurate and continuous monitoring. In recent years, mining operators have adopted digital components (ICT) but still use manual processes to collect and process the data, thus making the protection of the mining critical assets a costly and highly complex problem, moreover, reducing the capabilities of the monitoring system to trigger automatic alarms. In this context, Tailings Storage Facilities (TSFs) are one of the most sensitive physical assets to be secured to guarantee mines infrastructure safety. IoT based monitoring systems can be implemented for automated data collection and quickly informed risk management. Long Range Radio transmission will allow for effective monitoring of complex structures located in remote places in mining sector. To achieve continuous operation during multi-year periods without maintenance and provide real-time and high-quality positional data, an IoT-based GNSS platform is described in this paper.

9:25 AM

25-096

Use of ASTER Satellite Images to Identify Ore-Bearing Hydrothermal Alteration Zones Within Asuncion and Cospan Districts

M. CASAS; CAJAMARCA, SME UNC, Cajamarca, CAJAMARCA, Peru

The research is located within Asuncion and Cospan districts, which according to their geological features in contrast with previous studies pointing out Au anomalies create an environment of prospective interest. The objective is to use ASTER Satellite Images to identify ore-bearing hydrothermal alteration zones. To do this, processing techniques such as the combination of bands, band ratio and Ninomiya indices were applied to identify the advanced argillic, phylic argillic and propylitic alteration. The results in the study area are confirmed by the Spectral Angle Mapper. Identifying kaolinite, alunite and pyrophyllite, assemblages of the advanced argillic alteration.

9:45 AM

Differentiating Fine-Grained Magmatic-Hydrothermal Sericite From Course-Grained Muscovite Using Airborne and Orbital Imaging Spectroscopy Data

J. Meyer[1], R. Kokaly[1] and E. Holley[2]; [1]U.S. Geological Survey, Denver, CO and [2]Mining Engineering, Colorado School of Mines, Golden, CO

Muscovite and sericite are often grouped together as 'white mica'. Course-grained muscovite is predominantly formed through igneous magmatic processes. Sericite is fine-grained and formed through magmatic-hydrothermal processes. Because ore deposits are often formed as the result of magmatic-hydrothermal activity, the ability to map occurrences of sericite can be a useful exploration tool. We present results from Battle Mountain, Nevada mining district in which we differentiate muscovite that is a component of siliciclastic host rocks from sericite that formed because of magmatic-hydrothermal activity based on the width of their diagnostic 2200 nm absorption feature in airborne and orbital imaging spectroscopy data.

10:05 AM

Accurately Pinpointing 2D Sensor Events in a 3D Environment Using Digital Twin Georeferencing

B. Meyer[1], J. McNabb[1], L. Brown[2], J. Potter[1], B. Ross[3] and C. Williams[1]; [1]Geotechnical Center of Excellence, University of Arizona, Tucson, AZ; [2]Mel & Enid Zuckerman College of Public Health, University of Arizona, Tucson, AZ and [3]Global Mining Education Foundation, Tucson, AZ

Accurate geolocation of sensor outputs is a critical component in site planning, monitoring, and hazard evaluation. Georeferencing tools are used to locate a 3D point on a site's topography from an image or other sensor output. In developing a new rockfall detection system using thermal imaging, the Geotechnical Center of Excellence (GCE) at the University of Arizona has created a workflow to accurately georeference movements detected in thermal video from a single camera by using topographic digital twins (e.g., DEM, point cloud, or 3D mesh) of a mine site. By integrating readily available software and well-established light modelling techniques, site locations and camera pixels may be correlated, yielding topographic coordinates for any tracked or observed event in the viewing area. Beyond its original purpose for georeferencing rockfall events, this technique provides a method for generating 3D locations from 2D sensor arrays for any camera-based monitoring technology, such as seep detection or bench design evaluation. In this talk, we outline our georeferencing framework and present test results. Potential use cases, future advancements, and limitations will be discussed.

10:25 AM

Development of a Collaborative Slope Monitoring Database for Large-Scale Geotechnical Data Analytics and Training

C. Ortmann[1], S. Sbai[2], J. Potter[1], J. McNabb[1], S. Warren[2], B. Meyer[1], C. Williams[3] and L. Brown[4]; [1]Geotechnical Center of Excellence, University of Arizona, Tucson, AZ; [2]Spokane Mining and Research Division, CDC/NIOSH, Spokane, WA; [3]Rio Tinto Kennecott, Salt Lake City, UT and [4]Mel & Enid Zuckerman College of Public Health, University of Arizona, Tucson, AZ

Understanding slope behavior is crucial to minimizing geotechnical risk and optimizing resource extraction in open pit mines. Major slope failures pose significant risks to mine personnel, equipment, and project longevity. To mitigate these risks, monitoring data is collected from actively moving slopes, enabling engineers to estimate the extent and timing of impending instabilities. Traditionally, this data is kept internal to the operator, resulting in small data sets and isolated analyses. Expanding the accessibility of this data beyond individual operations will allow geotechnical engineers to glean insights from historical slope incidents and the experiences of others. To address this issue, the Geotechnical Center of Excellence, NIOSH, and industry partners are developing a database of open pit stability incidents. The goal is to enable practitioners and researchers to take a proactive approach to slope management through access to a variety of data sets for training and analysis. Anticipated use cases of the database include data analytics, development of machine learning models, identification of industry-wide trends and risk factors, and training of geotechnical engineers.

10:45 AM

The Connected Future: Integrating Machine Tracking and Drone Data

A. Cronin and D. Siri; Propeller, Sydney, NSW, Australia

Explore the future of connected mining with machine tracking and drones creating a comprehensive management solution. Discover how the integration of drone data and machine tracking enhances visibility between surveys, leading to increased production efficiency. Through real-world customer stories, we illustrate the benefits of centralizing designs, drone surveys, and machine data. This convergence boosts operating velocity for mines, showcasing the power of integrated technology in revolutionizing mine management.

TUESDAY, FEBRUARY 25 MORNING

MINING & EXPLORATION: MANAGEMENT: PRODUCTIVITY MANAGEMENT TO IMPROVE FUTURE MINING OPERATIONS

Room 504

9:00 AM • Tuesday, February 25

*Chair: **M. Sorensen**, Rio Tinto, South Jordan, UT*

9:00 AM

Introduction

9:05 AM

25-054

Leveraging AI for Improved Contracting and Procurement in Mining

P. Culvenor[2] and B. Gyngell[1]; [1]Hevi, Bondi Beach, NSW, Australia and [2]Access Mining, Brisbane, QLD, Australia

Ensuring effective management of contractual processes is essential for maintaining profitability and operational efficiency in mining. However, due to limited capacity and resources, sites often struggle to manage these processes effectively, leading to oversights and financial losses. Recent advancements in Artificial Intelligence (AI) offer promising solutions to these challenges. Large Language Models (LLMs), like those powering ChatGPT, now enable machines to understand unstructured data like contracts. These can therefore be applied to address these challenges by taking some of the heavy lifting off of humans. In this paper, we propose a comprehensive framework that outlines how AI can be implemented throughout the end-to-end contracting lifecycle within underground mining to ensure contracts are set up and administered properly. This includes critical stages such as tendering, handover from commercial to operations, operational monitoring, subcontractor procurement, and dispute resolution. By leveraging LLMs, the framework aims to automate and optimise these processes, reducing the risk of non-compliance and improving overall contract management efficiency.

9:25 AM

Increase Mining Productivity Using Continuous Improvement

P. Daniels; SRK Consulting, Aurora, CO

Increasing productivity in mining through continuous improvement processes like Lean Six Sigma involves systematically identifying and eliminating waste, reducing variability, and enhancing operational efficiency. Lean principles focus on streamlining workflows and eliminating non-value-added activities, while Six Sigma emphasizes reducing defects and process variability through data-driven decision-making. By integrating these methodologies, mining operations can achieve significant improvements in productivity, safety, and cost-effectiveness. Continuous monitoring and iterative improvements ensure that processes remain optimized, leading to sustainable long-term gains. This approach fosters a culture of excellence and innovation, driving the mining industry towards higher standards of performance and competitiveness.

9:45 AM

Application of Machine Learning Algorithms for Geometallurgical Modeling

C. Yepez, A. Anani and S. Adewuyi; Mining and Geological Engineering, University of Arizona, Tucson, AZ

Geometallurgy integrates data from geology, mining, and processing into a cohesive model. Obtaining representative geometallurgical data is often challenging because only a limited number of samples can be taken to adequately represent an entire deposit. Traditional interpolation techniques

like geostatistics are commonly used for modeling this information. However, machine learning has become increasingly accepted for modeling geometallurgical domains due to its versatility and the range of available algorithms. This research focuses on evaluating the effectiveness of machine learning algorithms in modeling geometallurgical domains.

10:05 AM

Change Management for the Implementation of New Technologies in Mining

S. Nowosad[1], A. Tobar Escudero[3], O. Langefeld[1], J. Torpy[2] and J. Sánchez Blanes[4]; [1]Institut of Mining, Technische Universitat Clausthal, Clausthal-Zellerfeld, Lower Saxony, Germany; [2]Epiroc USA LLC, Broomfield, CO; [3]Epiroc Minería e Ingenieria Civil España S.L.U., Coslada, Spain and [4]Epiroc Drilling Solutions LCC, Garland, TX

The mining industry currently faces unprecedented challenges, compounded by the imperative to meet sustainability demands. Automation, digitalization and advanced technologies are set to play a crucial role in addressing these issues, driving the future of sustainable mining. These innovations promise increased efficiency, reduced environmental impact, and improved safety standards. However, implementing these technologies presents its own set of challenges, requiring a new strategy and management approach. Change management in mining companies and OEMs, as those like Epiroc, is essential for successfully implementing these advanced technologies. This study examines the unique management requirements necessary for integrating these innovations into mining operations. Through an in-depth analysis of Epiroc's experiences, the study highlights critical lessons learned, including the importance of strategic planning, personnel upskilling, and stakeholder engagement. The findings underscore that effective change management not only facilitates technological adoption but also ensures sustained operational efficiency and competitive advantage in the rapidly evolving mining industry.

10:25 AM

Mining Productivity Improving or Declining?

R. Riggle; Caterpillar Inc., Menomonee Falls, WI

Is the mining industry and more importantly your mining operation improving or declining as compared to historical productivity and efficiency? Small incremental changes today can add up to big improvements and bigger profits. This brief will discuss how Caterpillar solutions are enabling the mining industry to achieve higher levels of productivity, efficiency, uptime, safety, and sustainability.

TUESDAY, FEBRUARY 25 MORNING

MINING & EXPLORATION: OPERATIONS: DRILL & BLAST OPERATIONS—IMPROVEMENTS & CHALLENGES I

Room 505

9:00 AM • Tuesday, February 25

*Chair: **A. Ramos**, Hecla, Coeur d Alene, ID*

9:00 AM

Introduction

9:05 AM

Automating Drill and Blast QAQC at a Canadian Gold Mine: A Data-Driven Solution for Data Collection, Reporting, and Improving Drill and Blast Performance

Z. Levinson[1] and J. Prinsen[2]; [1]AIRL Technologies, Vancouver, BC, Canada and [2]Agnico Eagle Mines, Cochrane, ON, Canada

Assessing drill and blast performance is a multifaceted task that entails a comprehensive analysis of various operational parameters to enhance future blasting outcomes. Evaluations begin with a detailed review of the blast design and extends to the execution aspects such as drill deviation and loading compliance with the planned design. Critical to this assessment is the analysis of rock fragmentation and the effectiveness of the blast, considering factors like bench preparation, blasting parameters, and the subsequent movement of blasted material. Moreover, ensuring adherence to environmental and safety standards plays a pivotal role in the process. Through a critical examination of these elements, mining operations can gain valuable insights into optimizing blasting parameters, thereby improving productivity, reducing operational costs, and minimizing environmental impact. A scoring system and intelligent backtracking algorithm is used to address the impact of digging conditions and power usage at the crushing and grinding circuit using online sensors and relating these finding to drill and blast designs and compliance. The developed framework is tested at a Canadian gold mine.

9:25 AM

Effects of Blast Induced Damage on Ground Support at the Henderson Mine

J. Monsalve[1], S. Ferguson[1] and j. valencia[2]; [1]Henderson Mine, Freeport McMoRan, Blacksburg, VA and [2]ITASCA Consulting Group, Minneapolis, MN

The Henderson Mine uses C-Arches as a ground support measure to maintain stability of draw points in the extraction level. C-Arches are designed to withstand wear and tear and last through the life of the panels. However, C-Arches installed on the 7210A Panel experienced significant brow damage requiring repairs earlier than expected. Previous studies, and design iterations have determined that multiple factors contributed to the accelerated damage, most notably geology, production blasting, muck draw, and secondary blasting, amongst others. This work focuses on the observed effects of blasting on C-Arch performance by analyzing the results from the 7210A Panel and 7210N Panel at the Henderson Mine. This work uses far-field vibrations collected with a micro-seismic monitoring system coupled with near field vibration measurements from blast seismographs to understand how production blasting impacts this type of ground support. Results show how multi-layered monitoring efforts at the Henderson Mine are a valuable tool for blast monitoring, allowing for the continuous optimization of blasting practices, resulting in reduced ground support damage while ensuring desired results.

9:45 AM

Blast-Induced Impacts to Longhole Stope Stability Performance

A. Hashemi, L. Moreau-Verlaan and K. Kalenchuk; RockEng Inc., Kingston, ON, Canada

Longhole stoping is a commonly used underground mining method. Operational safety combined with low cost and high recovery have led this method to be widely adopted in underground metalliferous mining. A key measure of longhole open stoping performance is stability. Longhole open stope stability analyses can be divided into two categories: 1) geomechanic analysis of the stope boundaries focused on in-situ conditions, and 2) damage potential imparted onto stope boundaries by longhole blasting. Historically, stope stability analysis has focused primarily on rock engineering design approaches. However, even with robust stope design campaigns, stope overbreaks continue to be a frequent mine production challenge. To further reduce the potential for stope instability, the stope design process requires assessment of blast-induced rockmass damage potential. This presentation provides an overview of the blast design parameters and their impacts on stope stability. In conclusion, the content will motivate a broader perspective on stope stability design, incorporating design considerations particular to both the geomechanic elements and the blast design parameters.

10:05 AM

Better Predictors of Rock Fragmentation at the Sierrita Mine

D. Kelly; Geology, Freeport-McMoRan, Sahuartia, AZ

In 2020, excessively large rock fragmentation was becoming an issue at the Sierrita mine. Large rock fragmentation can have various negative effects including wasting ore grade material, higher comminution costs, premature wear on equipment, and production slowdowns. These effects require a better understanding and control of fragmentation. The best predictor of fragmentation came from calibrated production drill rates. Drill rates on each bench could then be stacked to create a 3D drill rate image that revealed geologic structures, hard and soft areas of the mine, and allowed for better planning for optimal fragmentation.

10:25 AM

Benefits of Presplitting Identified in the Field—Relieving Gas Penetration in Addition to Lowering Blast Vibrations to Highwalls

R. Yang; Orica USA Inc, Watkins, CO

Previous studies in the literature used geophones to measure blast vibrations at far distances and could not ascertain the significant benefit of presplit blasting in reducing the impact of blast vibrations on highwalls. Additionally, no studies in the literature address the role of presplitting in alleviating blasting-released gas pressure that could penetrate joints and open new fractures in highwalls. Yang & Proulx (2019) and Yang et al. (2022) conducted near-field blast vibration monitoring of signature hole blasts and revealed that peak particle velocity (PPV) of blast vibrations at a scaled distance of 1 m/kg^0.5 can be reduced by 50% or more for presplit-filtered vibrations. In addition to summarizing the reduction in blast vibrations due to presplitting, this paper demonstrates the relief through presplit blasted blastholes of subsequent blasting gases from trim blastholes, shown through video of gas ejections from previously fired presplit blastholes located 6 to 9 meters away from the final buffer row of a blast pattern. The results show that presplitting not only lowers blast vibration PPV's but also relief the high pressure gases from the trim blast into the highwalls.

10:45 AM

A Review of the Importance of Quality Drill and Blast Data Collection and Analysis to Help Ensure Operational Success

D. Schnell; Mining Engineering, University of Kentucky, LEXINGTON, KY

Blasting is the primary and most effective and time efficient method for breaking and moving material. Significant data can be collected from a single blast pattern. It is important to understand what the data means and how it can be used to better coordinate and execute and plan drill and blast designs to improve an operation's safety and efficiency. The importance of data collection and analysis is in improving and optimizing the overall performance of a blast to meet the goals of an operation. This includes reviewing blast design for explosive energy efficiency, vibration control, geotechnical considerations, and more.

TUESDAY, FEBRUARY 25 MORNING

MINING & EXPLORATION: OPERATIONS: OPERATIONAL TECHNOLOGY ADVANCEMENTS AND AUTOMATION IN MINING

Room 506

9:00 AM • Tuesday, February 25

Chair: ***S. Lee****, Capstone Copper*

9:00 AM

Introduction

9:05 AM

Tools for Tackling Wireless Coexistence: Ensuring the Safe and Effective Adoption of Wireless Technology

J. Coder[1] and R. Jacksha[2]; [1]National Institute of Standards and Technology, Boulder, CO and [2]Spokane Mining Research Division, NIOSH, Spokane, WA

From safety systems, to tele-remote vehicles, to fully autonomous systems utilizing wireless sensors, the use of wireless technology is rapidly proliferating across the mining industry. Adopting many wireless systems across a single mine often requires careful planning. Though each system works well on its own, bringing unrelated wireless systems nearby could create new challenges as the systems influence each other's performance; a challenge known as "wireless coexistence." We outline the challenge posed by deploying multiple wireless systems in the same mine, discuss practical solutions mines can implement, and showcase research that will provide new tools for tackling coexistence challenges.

9:25 AM

World's Largest Single Line Copper Smelter uses Operator Training Simulator (OTS) and Digital Twin to make the operation ready for start-up in 2024

B. POUR-AHMAD, A. Supomo, K. Pramono and W. Prasetio; Technical Services—Process Automation, Freeport Mc Mo Ran, Phoenix, AZ

Operator Training Simulators (OTS) play a crucial role in the training and development of process operators across diverse industries, particularly addressing challenges related to high turnover and inexperienced personnel in mineral processing plants. This paper examines the evolution, functionalities, and advantages of OTS in enhancing operator competency and ensuring operational safety. By immersing operators in realistic scenarios within a controlled environment, OTS enables them to familiarize themselves with complex processes, practice emergency responses, and refine decision-making skills in a risk-free environment. The paper also explores essential considerations for successful OTS implementation, including simulation platform selection criteria, system architecture, and workflow integration. Illustrated through case studies from projects at the PT Freeport Indonesia Smelter, this paper demonstrates how OTS significantly reduces training time, minimizes operational errors, and optimizes process control commissioning. Ultimately, OTS stands as an innovation in industrial training methodologies, effectively meeting the dynamic demands of modern operations.

9:45 AM

Automated Drilling—Performance Matters

C. Stacy; Hexagon Mining, Tucson, AZ

Automated blast hole drill control systems have been around for many years; so why is there so much variability in the performance of the drill rigs utilizing them? Shouldn't drill automation create parity among operators and even drill rigs when it comes to performance? What if drill automation could close the subject matter expert gap present in standard automation offerings by leveraging artificial intelligence? This paper will explore some of the pitfalls of standard drill automation offerings and the gaps filled by Hexagon Mining's AI enabled drill automation solution including field tested results and comparisons.

10:05 AM

New, Accelerometer-Based Slurry Density Meter

M. Touzin[1] and J. Peters[2]; [1]CET, Enschede, Netherlands and [2]Alia Instruments, Enschede, Netherlands

A non-nuclear, accelerometer-based density meter has been developed in partnership with a large Dutch high-technology company and the University of Twente to optimize productivity through density measurement in mining, drilling, and dredging operations. The measuring principle of Newton's second law has been implemented in a robust, industrial design. FEM (finite element method) and COMSOL Multiphysics were used during

simulation and hardware development. The in-line, fast-acting, full-bore instrument is designed to measure slurry bulk density over a very large density range. It is suitable for slurry flows with high abrasivity, corrosive characteristics, or high solids. Through the density measurement, the technology can also detect solids settling or sediment deposition, as often occurs with insufficient slurry flow velocity. Challenging slurry density measurement applications in the mining industry for which the instrument is well suited include thickener underflow, ore concentrates, tailings, and pastes. Examples of computer simulations, in-service measurement performance, limitations, and user experience in various industrial applications will be shown.

10:25 AM

Prep and Planning for Autonomous Haulage Execution of a Brown Field Operation

N. Amiotte, R. Yubeta, Z. Maughan and M. Elliott; SME Member—Freeport-McMoRan, Bagdad, AZ

In the United States, the adoption of advanced technology at brownfield sites is necessary due to the scarcity of new greenfield mining projects. Freeport-McMoRan Bagdad Operations is currently pioneering this effort with the implementation of the first fully autonomous haulage system in the U.S. utilizing CAT's Command Technology. This project focuses on the preparation, planning, and execution phases, addressing challenges in truck readiness, site preparedness, and workforce transition. Our current journey provides insight into practical implementation challenges, and essential factors for successful integration, shaping the future of mining in automated and robotic mines.

10:45 AM

Reinforced Multi Objectives Agent Based Truck Dispatching in Open Pit Mines

M. OWUSU TWENEBOAH[1], V. Temeng[2] and K. Awuah-Offei[1]; [1]Mining and Explosives Department, Missouri University of Science and Technology, Rolla, MO and [2]Mining Engineering, University of Mines and Technology, Tarkwa, Western, Ghana

In this work, a multi objectives agent-based truck dispatch algorithm that conceptualizes trucks as intelligent agents and make autonomous dispatching decisions to maximize their utility is proposed. The agents in the proposed model were further reinforced using the concept of Q-Reinforcement learning in order to incorporate adaptive behaviour. The advantages of this algorithm include agents with broad situational awareness, a multi objectives reinforced utility function with the ability to prioritise the system objectives due to the presence of a priority factor. They are also more suitable for autonomous trucks. The new algorithm was evaluated against a simple 1-truck-for-N-shovels dispatch strategies using discrete event simulation. The simulation results show that the new utility function has significant advantages over 1-truck-for-N-shovels inspired utility functions. Parameter analysis of the Q-reinforced learning component was conducted to determine the optimal learning and discount factors. Further analysis was conducted to demonstrate the possibility of prioritising the various management objectives.

11:05 AM

25-007

Advancements in Leach Pad Control with Emerson Technologies

T. Riters and L. Bolton; Sales, Emerson Automation Solutions, Chandler, AZ

Advancements in instrumentation technology have brought value and efficiencies to the mining industry. Most think of instrumentation as basic sensors and valves, but with our solutions, we equip operators with real time, accurate, and reliable data that they can use to operate more effectively. Working with Caltrol, an Emerson impact partner, we successfully engineered wireless skids for a leach pad to provide precise measurement and control of raffinate solution to Freeport-McMoRan as part of their "Leach to the Last Drop" initiative. Freeport is now able to disperse the solvent, monitor the system, and leach with more precision, quickly and accurately from their control room.

11:25 AM

General Purpose Robotics and the Last Frontier of Mining Automation

W. Pryor; Boston Dynamics, San Francisco, CA

The mining industry has historically been a pioneer in adopting technologies that enhance productivity, leading the way in automation over the past 15 years with advancements such as self-driving vehicles and autonomous drills. Despite these strides, fully automated "lights-out" operations remain elusive due to the complex and unstructured nature of mining environments. Traditional automation has struggled to address the long tail of tasks that persist after operators are removed from equipment. However, recent advancements in general purpose robotics offer new opportunities. Over the past four years, these robots have significantly matured, finding innovative applications in underground operations and ore processing facilities. This paper explores the current state of general purpose robotics in mining, examining how these technologies are set to transform the industry as it ventures into deeper, more remote areas, with a focus on eliminating human involvement in the most dangerous, dirty, and monotonous tasks.

TUESDAY, FEBRUARY 25 MORNING

MPD: CHEMICAL PROCESSING: COPPER EXTRACTION

Room 705

9:00 AM • Tuesday, February 25

Chairs: ***S. Gostu****, Glencore, Stamford, CT*
F. Liu*, Hatch Ltd, Mississauga, ON, Canada*

9:00 AM

Introduction

9:05 AM

Effects of Flotation Chemical Residues on the Electromagnetic Properties and Leaching Behavior of Chalcopyrite Concentrate

S. Patterson[2], J. Battaglia[1], A. Rieffer[1], I. Barton[2], Z. Mutlu[1] and A. Wessman[1]; [1]Material Science, University of Arizona, Tucson, AZ and [2]Mining Engineering, University of Arizona, Tucson, AZ

Froth flotation, the primary method of concentrating chalcopyrite and other copper sulfide ores, uses hydrocarbon-based surfactants like xanthates and dithiophosphates to make chalcopyrite and other sulfide minerals hydrophobic. Modifying chemicals such as pH modifiers and depressants may also be used. Traces of these chemicals and their reaction products with sulfides can remain on the surfaces of particles in concentrates. While these residues are not known to cause problems in industrial leaching and smelting operations, they may affect the results of laboratory leach testing using flotation concentrates to an unknown extent. This project tested the resistivity, mobility, and charge carrier density of chalcopyrite concentrate as received (with residues) and after being washed with alcohol to remove hydrocarbon-based surfactants. Results for air-exposed concentrates indicate significant changes in electromagnetic parameters and leaching behavior after washing. Results for concentrates held in inert atmospheres show smaller, but still measurable, changes.

9:25 AM

25-097

Use of a Chemical Additive to Enhance Metal Quality and Quantity in Copper Electrowinning

w. dickinson; R&D, Kemira, Atlanta, GA

Present research seeks to establish an effective chemical agent to maintain or improve copper smoothness and improve current efficiency during electrowinning. An electrochemical system was modified to enable high current electrodeposition and is used with commercial software to control plating performance. Comparative copper deposit smoothness is visually quantified at 10—200x by digital microscopy. Fifteen polymer-based products have been evaluated at target dosages from 2—4 ppm to identify the best performing additive. KemSmooth 4900 affords the best performance in current density with smoother, more regular deposits compared to an untreated control or to Guar treatment. Dose response behavior showed a progressive increase up to 1.7% in current efficiency over the indicated dosage range. In parallel with the electrowinning tests, acid-mist production—a corrosion and health hazard in electrowinning tankhouses—has been assessed using a colorimetric method. Kem Smooth 4900 appears to provide additional benefit in controlling acid-mist.

9:45 AM

A Study on the Effect of Surfactant on the Bubble Size, its Bursting Dynamics, and Acid Mist Suppression Using High-Speed Camera Imaging

A. Kakoria, G. Xu and M. Zaid; Mining and Explosive engineering, Postdoctoral Fellow, Phelps County, MO

In this work, we investigated the effect of different surfactants in a copper electrolyte solution on a single bubble formation and, later, bubble collapse. We investigated that these surfactant molecules have a remarkable effect on bubble size and its bursting dynamics. We have experimented with high-speed video imaging/videography (HSVI/HSVV). We have found that the bubble in the presence of FC-1100 has the smallest size, 174 μm, and moves very slowly because the bubble has shallow terminal velocity and high residence time amongst all surfactants in electrolyte liquids, and it experiences the stokes flow having Reynolds number less than 1. This bubble behavior alters the bubble-bursting dynamics at the liquid-air interface. The bubble's extra kinetic energy and pressure are transferred to the liquid visco-elastic film, and bursting dynamics change with the creation of a lesser jet and film drop. FC-1100 surfactant has the lowest surface tension among all. Finally, this work proves the effect of bubble size, bubble behavior, and bursting dynamics in different surfactant electrolytes and bursting dynamics in different surfactant electrolytes.

10:05 AM

25-102

Synergistic Effects of the Jetti Chalcopyrite Leach Catalyst and Biooxidation—A Bioreactor Example

J. Uhrie, M. Rebolledo and C. Simms; Jetti Resources, Boulder, CO

Jetti Resources has developed a catalyst which overcomes the passivation of primary sulfides, enhancing the heap leach recovery of copper from chalcopyrite. It is important to emphasize that heap leaching of copper sulfides, whether with or without the Jetti catalyst, is a biooxidative process. We have demonstrated this in bioreactors, where a chalcopyrite-dominant porphyry ore was leached using a factorially designed DOE test matrix. The addition of the Jetti catalyst using commercial raffinate under sub-optimal bioleaching conditions increased copper recovery over the baseline; however, under optimal bioleaching conditions and in the presence of Jetti catalyst, a higher increase was observed. Copper recovery was 1.7 times that of the baseline, achieving an additional 35% copper recovery.

10:25 AM

Subsurface Leaching of Copper Through Surfactant-Enhanced Acid Injection

R. Copp[1], J. heidlas[1], D. Rucker[2] and B. Cubbage[2]; [1]BASF Corporation, Tucson, AZ and [2]HydroGEOPHYSICS, Inc., Tucson, AZ

Subsurface leaching (SSL) through direct injection of acid to underperforming parts of a copper leach pad is well documented and proven effective at recovering metals. The potential of using leaching aids to enhance the rate and metal removal in SSL has not been extensively explored. For this work, a surfactant was added as a direct feed to injection wells used for SSL in a copper leach pad. The effectiveness of the leaching aid was determined using solution samples and electrical resistivity geophysics along the surface. The addition of the surfactant increased copper grades compared to long-term injection without the surfactant.

10:45 AM

Enhancing Sustainability in Mining: Pilot Study on Solvent Extraction Interface Monitoring

C. Mejías, E. Cáceres and E. Godoy; Hibring, Concepcion, Biobio, Chile

Efficient water use is crucial for addressing the challenges faced by the mining industry, significantly impacting its operational efficiency and sustainability. Additionally, the high costs associated with production inputs in mining make optimizing their use essential. By integrating laboratory data into industrial processes, we present an innovative solution for solvent extraction that autonomously identifies the separation interface of immiscible liquids using unique hardware available on the market. This study showcases pilot results on identifying and monitoring the interface between the organic and aqueous phases in the solvent separation process within the copper industry, detecting unexpected phase changes and preventing the organic phase from contaminating subsequent processes. The pilot demonstrates the feasibility of autonomously identifying the separation interface of immiscible liquids as an innovative technology in mining. The advances of this study point towards its implementation in an industrial setting to optimize the use of resources in the mining industry, thereby contributing to informed decision-making within the production process.

11:05 AM

The Study of the Leaching Behavior and Optimization of Chalcopyrite Concentrate in Ferric Sulfate Bio Acid

E. Owusu-Fordjour, X. Yang and M. Free; Materials Science and Engineering, The University of Utah College of Engineering, Salt Lake City, UT

The use of microorganisms in the leaching of copper from chalcopyrite is an emerging technology that has the potential to revolutionize the mining industry by encouraging the practice of sustainable mining (green engineering). Carbon dioxide is an essential carbon source for autotrophic microorganisms such as Acidithiobacillus ferrooxidans, where their metabolic activity can be boosted, leading to an improvement in leaching kinetics and efficiency. The role of carbon dioxide in bioleaching operations is important to extract energy-relevant minerals from sulfides. This study focuses on the use of CO_2 to optimize bio acid production and to investigate the leaching behavior of chalcopyrite concentrate in ferric sulfate bio acid under varying process parameters. Various leaching techniques and different reagents were employed to optimize chalcopyrite leaching in ferric sulfate bio acid. Characterization and leaching kinetics studies were also studied accordingly.

TUESDAY, FEBRUARY 25 MORNING

MPD: CHEMICAL PROCESSING: INNOVATIVE METHODS OF METAL PROCESSING

Room 711

9:00 AM • Tuesday, February 25

Chairs: ***M. Strauss****, Worcester Polytechnic Inst, Sparks, NV*
K. Chattopadhyay*, SLB*

9:00 AM

Introduction

9:05 AM

Mineral Valorization Through Classifcation: Case Studies

J. Fisher, M. Barish and J. Taute; Somerset International, Sewickley, PA

The issue of tailings from mining waste is a pressing environmental concern, especially in the wake of recent dam failures. Around the world, numerous tailings dams are at risk of failure, presenting significant environmental hazards. Many of these dams contain valuable mineral deposits that can be reclaimed using mechanical concentrating methods, producing streams as rich as current mining tailings. Somerset's approach is focused on concentrating these waste streams to generate economic benefits that can cover the cost of dry disposal of the tailings, thus eliminating the need for tailings dams. To this end, Somerset International has adopted a two-pronged strategy: 1. Maximizing the recovery of current and future tailings waste to ensure significant economic contribution towards dry disposal efforts. 2. Reprocessing material from previously deposited tailings ponds to fund its dry disposal. In this submission, Somerset International will present four case studies using various minerals highlighting how enhanced mineral recovery can offer substantial economic incentives to transition from wet tailings disposal to more stable dry disposal methods.

9:25 AM

Leaching Kinetics of Bromine Compounds in Antimony Leaching on Smelter By-Products

A. Hirata Miyasaki and C. Anderson; Mining Engineering, Colorado School of Mines, Golden, CO

Multi-stage acid leach has successfully recovered antimony from industrial by-products. In designing and scaling up the leaching process, it is important to understand the impact of the chemical reactions and how they are affected. This research was performed to understand the leaching kinetics of bromine compounds for antimony recovery. Variables such as the agitation speed, temperature, acid concentration, particle size, and addition of sodium bromide and stabilized bromine were examined. The preliminary results showed the controlling mechanism to be diffusion-controlled. Additionally, we demonstrated the technical feasibility of scale-up on the leaching process.

9:45 AM

Antimony Recovery from Industrial By-Products Through Multi-Stage Acid Leach

A. Hirata Miyasaki and C. Anderson; Mining Engineering, Colorado School of Mines, Golden, CO

Demand for antimony has increased over the last few years. Recycling supplied 15% of domestic consumption in the US while the remaining 85% was imported. Bromine compounds have been recently used to recover PGMs and REEs with success. Thus, antimony leaching with bromine compounds is theoretically feasible. This research was conducted to develop a viable technology for hydrobromic acid as a leaching reagent and add sustainability to current industrial processes while minimizing waste products in recycling processes through a multiple-acid leach. The preliminary results showed bromine, specifically hydrobromic acid, to be a viable leaching reagent. Consequently, we demonstrated that bromine compounds can recover more than 80% of antimony in smelter by-products.

10:05 AM

Microbial Marvels in Mining: Bioleaching and Beyond

T. Van Rossum, E. Marshall, C. Morgan-Lang, E. Abramovich, S. Hallam and A. Hahn; Koonkie, Vancouver, BC, Canada

By cell count, you are more microbial than human. Microbes not only vastly outnumber stars in the known universe, but they also sustain (and sometimes decimate) populations of higher organisms, acting as both the custodians and architects of Earth's ecosystems. To understand these tiny yet mighty entities, it is crucial to recognize their critical role in earth's ecosystems survival. This presentation focuses on the transformative role of microbes in environmental management through the lens of the mining industry. We'll explore case studies on optimizing bioleaching (where microorganisms are used to extract valuable metals from ores), environmental monitoring, bioremediation, tailings stabilization, and more. By using the DNA of microbes to understand how they function, we can put microbes to work to tackle pressing mining challenges, moving toward sustainable and efficient mining practices across the operational lifecycle.

10:25 AM

Development of a Novel Method for the Extraction of Lithium (Li), Cesium (Cs), and Rubidium (Rb) From Lepidolite

C. Subasinghe and M. Rezaee; Energy and Mineral Engineering, PennState University, State College, PA

Lithium (Li), rubidium (Rb), and cesium (Cs) are critical elements in modern technology, playing essential roles in energy storage, electronics, and specialty glasses. This paper investigates the extraction of lithium (Li), rubidium (Rb), and cesium (Cs) from lepidolite ore using a novel process by eliminating the need for existing high temperature processes. Thermodynamic modeling for both roasting and leaching was conducted using FactSage and HSC software. Thermal analysis and X-ray diffraction of the feed material and solid residues confirmed the theoretical calculations. The optimal conditions resulted in the extraction of 66 ± 5.08% Li, 97 ± 1.30% Cs, and 98 ± 2.61% Rb. The solution chemistry was studied using Pourbaix diagrams, and the products were characterized through Inductively Coupled Plasma (ICP) technology, X-ray diffractometry (XRD), Thermogravimetry (TGA), and Scanning Electron Microscopy (SEM) coupled with Energy Dispersive X-ray Spectroscopy (EDX).

10:45 AM

Unlocking Cobalt from Cobaltiferous Pyrites: A Thermal Decomposition Approach

L. Aguayo Torrez, C. Anderson and E. Spiller; Mining Engineering, Colorado School of Mines, Golden, CO

Despite ongoing efforts to find alternative materials, cobalt remains indispensable for the production of rechargeable batteries essential for the energy transition. Currently, most cobalt is sourced from unethical and politically unstable regions as a by-product of nickel and copper extraction. However, primary cobalt deposits, such as those in the Iron Creek area, could provide a reliable and responsible supply of this metal. In these deposits, cobalt is encapsulated within the pyrite (FeS_2) lattice, making traditional beneficiation methods ineffective. This study explored the thermal decomposition of pyrite to pyrrhotite ($Fe_{1-x}S$) and troilite (FeS) as a chemical pretreatment to (i) increase cobalt content in flotation concentrates by volatilizing sulfur and (ii) transform concentrates into a ferromagnetic product for magnetic separation to enhance cobalt recovery. Thermal decomposition tests under two cover gases increased cobalt grades by 15-17% and produced high-purity sulfur as a by-product. These promising results eventually led to a final magnetic concentrate containing 3.5% cobalt, representing a 94% increase over the grades obtained in previous base work.

11:05 AM

Smart Leaching Pads: Up to 3% Mineral Recovery Increase is Possible

V. Mwaba; SME, Shorewood, IL

Heap leach pads face challenges in metal recovery, often relying on manual monitoring, which poses potential safety risks and limitations in data collection, especially in hazardous conditions. Data collection is critical to being able to manage and control evry process. Portable skids with wireless instruments (P, F) offer visibility into irrigation processes, detecting failures and stabilizing bacteria, leading to a more stable leach process, reduced costs, and improved safety. More uniform leach solution application can boost copper recovery by up to 3%.

11:25 AM

Leaching of Lithium Contained in Clays

M. Jorges Villon; no, Lima, Peru

This research has the purpose of studying the concentration of these clays and the leaching of the metal with H2SO4. The magnetic (dry and wet) and gravimetric concentration (separation of fine particles in suspensión) were studied, being the latter the one that presents better results, going from 256 ppm of lithium in the original clay to 863 ppm of lithium in the concentrate. At the leaching stage, alkaline (NaOH and Mg (OH)2) and acid (H2SO4) leaching were tested, finding the best results with the last one; this is the reason why the effect of temperature, sulfuric acid concentration and solids percentage on the lithium leaching kinetics were studied. It was found that increasing the concentration of the solids in the leaching pulp decreases the rate of dissolution. Regarding the temperature effect, it was observed that this variable increases the lithium disolution rate and that starting from 50 °C its effect is less relevant. Likewise, it was found that after 4 hours the leaching rate decreases, so it is proposed that a leaching time of 6 hours is sufficient to reach 85% lithium recovery.

TUESDAY, FEBRUARY 25 MORNING

MPD: COMMINUTION: COMMINUTION I

Room 706

9:00 AM • Tuesday, February 25

Chairs: ***D. Rocha****, Freeport McMoRan, Sahuarita, AZ*
O. Arafat*, Metcom Technologies, Hamilton, ON, Canada*

9:00 AM

Introduction

9:05 AM

Chino Mill: SAG Throughput Optimization Through Basic Modeling, Sensor Evaluation, Equipment Parameter Changes and APC

K. Koeppl; Chino Mill, Freeport McMoRan Chino, Silver City, NM

This paper is a synopsis of Chino Mill's SAG operational experience in modeling, mill control and mine to mill communication since recommissioning in 2020. The Chino Mine is in Southwest New Mexico and belongs to Freeport-McMoRan. The porphyry copper mine is heterogeneous in hardness, mineralogy, and grade. The mill is challenged by Chino's complex mine sequencing combined with frequent changes in ore characteristics. The application of basic tools such as volume charge modeling, sound, and intensity measurements will be shown. The setting of SAG targets like ball charge, mill speed, in mill density will be discussed. This will tie into showing how to correlate mill efficiency to SAG targets in highly variable ore.

9:25 AM

The Fred C. Bond Award Winner: Paper Title Here

O. Arafat; Metcom Technologies, Hamilton, ON, Canada

Place holder for the Fred C. Bond Award. Replace this with actual abstract.

9:45 AM

Grinding Media Size Transition at the Sierrita Concentrator

D. Rocha and F. Patino; Metallurgy, Freeport McMoRan, Sahuarita, AZ

Sierrita is a copper and molybdenum mine located south of Tucson. The comminution circuit consists of primary, secondary, and tertiary crushers followed by a single stage ball mill in closed-circuit with hydrocyclones. The flotation circuit consists of roughers, cleaners, scavenger and column cells. Concentrate from cleaners and scavengers is sent to the regrind circuit for finer grinding. The reground product is sent to column flotation to produce final bulk concentrate. A detailed study to evaluate and optimize the screening efficiency in the fine crushing plant showed an opportunity to reduce the product size (P80). The aperture of the finishing deck screen panels was reduced by 1mm, resulting in a 15% product size reduction. The fine crushing plant capacity remained consistent, and a slight increase in circulating load was observed. Consequently, additional theoretical evaluations indicated that a change in grinding media size in the primary ball mills, 90mm to 80mm, would also have a positive impact in milling performance. This presentation discusses changes made at the crushing plant, effects of the grinding media size change, as well as past and current operating conditions.

10:05 AM

Crushing & Grinding Circuit Availability—Why is it Important in Design, and How Can We Increase it Cost-Effectively?

R. Chandramohan[2], G. Lane[2] and P. Dakin[1]; [1]MAusIMM, Vancouver, BC, Canada and [2]FAusImm, Brisbane, QLD, Australia

Crushing and grinding circuit availability is a critical design factor that defines the sizes of the installed equipment and the process buffers to maintain throughput during maintenance. The comminution circuit typically accounts for the largest capital expenditure and the highest energy use in a process plant. Thus, selecting appropriate equipment and optimizing the layout is crucial. This paper outlines fit-for-purpose design principles for optimizing process flow, eliminating standby equipment, reducing buffer residence time, and understanding limitations based on maintenance and operability. Keywords: comminution, cost and energy efficient design, circuit availability, utilisation, optimisation

10:25 AM

A Review of SAG Mill Discharge Classification Technologies for SABC Circuits

D. GONG, W. Tian, B. Foggiatto, R. Chandramohan and G. Lane; Ausenco, Vancouver, BC, Canada

The "Semi-Autogenous (SAG) mill—Ball mill—Pebble Crusher" circuit (SABC) has been widely used for the comminution of ores with varying competences at a wide range of throughput rates. As ore deposits become more competent, there has been an increase in demand for larger SAG mills associated with higher pebble recirculation rates, which brings challenges in ensuring efficient SAG mill discharge classification. Separating clean pebbles from the slurry phase is important for efficient pebble handling and crushing. Inappropriate design of SAG mill discharge classification can cause unwanted fines and excessive water to report to the pebble recycle conveyors and crushers, which can cause conveyor belt spillage and reduces the pebble crushing circuit availability. Relevant factors for the selection of SAG mill discharge classification technologies will be reviewed by investigating Ausenco benchmark data from 80+ SABC circuit designs. Additionally, two case studies will provide further insights into how SAG mill discharge classification design can impact plant layout, operational performance, and ultimately, economic feasibility.

10:45 AM

Mining Company Increase Gold Recovery and Optimizes Energy Usage in Their Milling Process by Implementing Real-Time Flow Measurements Thus Eliminating Manual Rounds

V. Mwaba; SME, Shorewood, IL

The milling process involves a series of challenges to any customer in the mining industry due to the high solids content (40%–60%), the safety risks, and the accurate monitoring of the mass flow in the feeding of hydrocyclons to determine and control the re-circulating load. Mass flow calculation are challenging when making a mass balance; when they are done manually. The use of cyanide solution, and the possibility of spills at this stage, represent a latent risk for the safety of personnel, process, and the environment. Manual control generate a limited gold recovery and additional energy costs are caused by reprocessing material. Thanks to the installation of robust flowmeters, mining companies can perform mass balance excercises through the in-line density and flow measurements, without any safety or operational inconvenience. Energy and gold recovery can also improve once automated measurements were installed.

11:05 AM

25-065

Optimizing Mill Performance: Real-Time Grinding Insights

E. Nunez; Technology, Molycop, Kamloops, BC, Canada

Real-time operational excellence is achieved through the seamless integration of various components. Key aspects include precise instrumentation, real-time data collection, data analytics, and an efficient optimization platform. Additionally, to ensure success, the real-time optimization platform must be incorporated into the site's internal process control system. This paper provides an overview of practical lessons and best practices for autogenous (AG), semi-autogenous (SAG), and ball mills (BM) grinding. It highlights the implementation of advanced instrumentation, specifically vibration sensors on the rotating mill shell. The paper also delves into the application of advanced analytics necessary for generating new measurements that accurately represent real-time grinding activity in the mill. These Advanced Analytics Measurements (AAM) are compared with well-known grinding curves to determine the optimal grinding point. The discussion focuses on key industry opportunities using real-time mill shell vibration results to derive new correlations and optimize the grinding process.

TUESDAY, FEBRUARY 25 MORNING

MPD: FLOTATION: ADVANCES IN CRITICAL MINERALS FLOTATION AND AUTOMATION

Room 708

9:00 AM • Tuesday, February 25

Chairs: ***P. Chu****, University of Nevada, Reno, Reno, NV*
T. Gupta*, MP Materials, Mountain Pass, CA*

9:00 AM

Introduction

9:05 AM

25-089

The Advanced Copper Rougher Scavenger at Doe Run Buick Mill—Its Design, Construction, Operation, Expert Control, and Its Wide Implications to All Doe Run Mills

W. Mang, A. Steimel, C. McNail and B. Mangogna; Southeast Missouri Operations, The Doe Run Company, Boss, MO

Together with innovatively applying modern flotation reagents and developing the breakthrough mill enterprise expert control and operating system, Doe Run Buick Mill constructed an advanced large copper rougher scavenger to process its complex Pb\Zn\Cu ore more efficiently and flexibly. The scavenger circuit, featuring its own motor control center, air blower, multiple reagent flowmeters and loops, VisioFroth camera and XRF froth channel, operates both mechanically and chemically to maximize copper recovery. Such scavenger features, already available for zinc rougher circuits for all Doe Run mills, can be applied to maximize copper recovery during copper special runs when the lead flotation circuit becomes the copper flotation circuit and the zinc rougher becomes a copper rougher scavenger.

9:25 AM

Optimizing Process Control for Energy Management

M. Tardif; BBA, Sandy, UT

Mineral processing is known to be energy intensive. With the rising cost of energy and the need to reduce carbon emissions, energy management has become crucial to the development of new projects and the sustainability of existing ones. To improve energy use in existing operations, a specific control strategy needs to be implemented. A common approach to process control optimization is to focus on throughput and product quality. This paper explains how to also manage energy usage as part of an optimization process without cutting back on throughput and quality. While complex control techniques such as MPC or fuzzy logic can be used, this paper will demonstrate how simpler advanced regulatory control can be easily implemented and yield good results and an unbeatable return on investment. Actual business cases will be used to demonstrate how these techniques can be implemented to reduce energy use for slurry pumping in concentrators and for off-gas extraction and processing in smelters.

9:45 AM

Online Analyzers: A History of Measuring Unrepresentative Sample Streams to a Future of Real-Time Metal Accounting

K. Keet and R. NOVAES; Sampling, Preparation, & Analysis, FLSmidth and Co A/S, Valby, Denmark

A history of disconnect exist between metal accounting and process control. Sampling for metal accounting is well researched and documented in the Theory of Sampling (TOS). Sampling for process control is regarded as its cousin, twice removed, only having to be 'good enough'. This developed into a clear distinction between samplers for metal accounting and extractors for process control. There were also fears that online analyzers would replace analytical laboratories. This is unfounded as online analyzers require ongoing calibration, confirming the need for quality sample collection, preparation and analysis. The analytical techniques used by the online analyzers are accurate and precise when calibrated properly. The downfall of online analyzers is the unrepresentative sample streams measured that limits the potential of the analyzer output to a trending tool for process control. A leap forward towards only using TOS accredited samplers to present analyzers with representative samples, are proposed. Combined with flowmeters and densitometers, the result will be a 'state of the art' measurement system that not only allows process control but also provide dynamic metal accounting.

10:05 AM

Advanced Instrumentation Combined With Digital Process Control Technologies for Flotation Optimization

D. Borim; Andritz, Vancouver, BC, Canada

In recent years, we have witnessed a strong desire in the mining community to improve flotation circuits efficiency by installing advanced instrumentation, using operational data, and adopting new digital technologies. The fundamental objective of these technologies in flotation circuits must be to provide automatic controllability of key process variables that allow the implementation of optimization strategies based on ore mineralogy and process conditions to maximize recovery and net metal production. This work highlights the step-by-step approach for the implementation of a copper flotation circuit optimization strategy based on the combination of advanced instrumentation, advanced process control, and real-time optimization strategies enabled by digital twins and artificial intelligence.

10:25 AM

Enhanced Sulfidization Flotation for Nickel Recovery From Mine Tailing

G. Kodali[1], X. Wang[1], J. Jin[1] and L. Pan[2]; [1]Materials Science and Engineering, University of Utah, Salt Lake City, UT and [2]Chemical Engineering, Michigan Technological University, Houghton, MI

Metal resources are increasingly vital in today's global energy transition efforts. As the demand for critical metals rises, the prices of critical metals have surged, sparking interest in processing tailings to recover critical minerals such as cobalt, lithium, rare earth elements, nickel, and platinum, among others. Research into tailing reprocessing presents an opportunity to increase the availability of critical minerals. However, significant challenges remain in developing a sustainable industry for extracting critical metals from tailings. This study investigates enhanced sulfidization flotation to recover nickel (Ni) from mine tailings. Bench-scale flotation experiments demonstrated a significant increase in Ni recovery using sulfidization flotation in the presence of NH_4^+ and Cu^{2+} ions. The effects of NH_4^+ and Cu^{2+} ions on sulfidization flotation for Ni recovery from tailings are discussed.

10:45 AM

25-032

Enrichment of Sphalerite and Hemimorphite From a High-Grade Zinc Tailing for the Potential Recovery of Gallium and Germanium

H. Aytac, F. Nakhaei and L. Alagha; Mining and Explosives Engineering, Missouri University of Science and Technology, Rolla, MO

Gallium (Ga) and Germanium (Ge) are considered critical elements and are typically found as substitutions or inclusions in zinc minerals. However, their distributions within zinc minerals are not well understood. To address this, trace element and mineralogy analyses of representative samples obtained from an old high-zinc-grade tailing were performed using various qualitative and quantitative techniques. These techniques included Inductively Coupled Plasma Mass Spectrometry (ICP-MS), Tescan Integrated Mineralogical Analysis (TIMA), X-ray Diffraction (XRD), and Scanning Electron Microscopy (SEM). Moreover, bench-scale froth flotation tests were conducted to enrich zinc minerals, the major hosts of Ga and Ge, using PAX as a collector, Na_2S as a sulfidizer, $Pb(NO_3)_2$ as an activator, and MIBC as a frother. Comprehensive characterization analyses of the flotation products showed significant enrichment of Zn, Ga and Ge in the flotation concentrates.

11:05 AM

Unlocking Tellurium's Enrichment Potential in Copper Concentrator Processing Streams

J. Corchado-Albelo and L. Alagha; Mining Engineering, Missouri University of Science and Technology, Rolla, MO

This research aimed to develop a novel flowsheet for enrichment of tellurium (Te) minerals from copper porphyry (CP) supply chains through the implementation of three research phases. Phase I examined the deportment of Te, copper (Cu), gold (Au), and silver (Ag) minerals in different processing streams during the froth flotation process of CP ores. Phase I revealed that over 90% of Te minerals were lost to flotation tailings, with >93% of Te minerals hosted in pyrite. Phase II involved bench-scale froth flotation studies to enrich Te minerals, utilizing various collector chemistries. Phase II tests resulted in ~ 92% recovery of Te minerals with xanthate collectors but a low enrichment ratio. Further enhancement was achieved using gravity separation prior to flotation, resulting in a ~78% Te recovery and an enrichment ratio of 13. Phase III focused on fundamental studies to optimize the collector's chemistry to promote selective adsorption on the Te minerals' host for enhanced recovery of tellurides in pyrite. This research showed practical approaches for recovering critical minerals from unconventional sources and provides a basis for the utilization of low-grade mineral resources.

TUESDAY, FEBRUARY 25 MORNING

MPD: FLOTATION: FLOTATION CHEMISTRY

Room 707

9:00 AM • Tuesday, February 25

Chairs: ***L. Alagha****, Rolla, MO*
Z. Zanetell*, Newmont, Castle Rock, CO*

9:00 AM

Introduction

9:05 AM

25-009

Alternatives Chemistries to Improve Copper Recovery from Secondary Sulphides with Low Floatability and Presence of Clays

P. Zarate; Mining Solutions, Clariant AG, Santiago, Region Metropolitana, Chile

Concentrators for base metals ores have key role to meet the global demand for these, such as copper, lead and zinc others. In flotation which is the primary process in a concentrator, chemical reagents as collectors, frothers and modifiers, play a key role in this process due to their influence on the flotation performance. There are many chemical families used as collectors in sulphide ores, use for these compounds is either as single collector or as co-collector to boost flotation recovery from the required mineral species. Still even with a combination of them in some ore-types flotation performance is low requiring additional reagents or changes in the process. This study discusses metallurgical results of one problematic ore the Americas where content of total copper is like the regular ore, but secondary copper sulphides are in higher proportion, impacting in more than 30% of total copper losses. Additionally, there is a high content of clays. Several chemistries were studied for collectors, and use of NaSH among the alternatives tested. Base conditions for rougher flotation tests were P_{80} of 150 microns, pH 10.5 and solids during flotation at 30% during rougher stage.

9:25 AM

Enhancing HydroFloat™ Performance with Novel Chemistry: Comprehensive Collector Screening and Adsorption Kinetics

Y. Ozsoy[1], R. Honaker[1], M. Mankosa[2], T. Bhambhani[4], A. Hobert[2] and S. Lycans[3]; [1]MiningEngineering, University of Kentucky, Lexington, KY; [2]Eriez Manufacturing, Erie, PA; [3]Chemical Engineering, University of Kentucky, Lexington, KY and [4]Mineral Processing, Syensqo, Stamford, CT

The development of HydroFloat™ technology marks a significant milestone in mineral processing, particularly for coarse particle flotation, challenging the "Elephant Curve" limits. This innovative technology has revolutionized mineral separation, enabling more efficient recovery of valuable minerals from coarser ore particles. However, its full potential is yet to be realized. A crucial aspect of its success lies in the chemical foundations of the flotation process, especially the collector types and their adsorption kinetics. Optimizing these chemical interactions may significantly enhance HydroFloat™ performance. This study focuses on the role of dithiocarbonate (DTC) and dithiophosphate (DTP) collectors, which are traditionally used to improve sulfide mineral flotation performance. Innovations in these flotation chemicals hold great promise for further advancements. By testing eight different commercial and novel DTC and DTP collectors, designed and manufactured by Syensqo, with various carbon chain lengths and structures, this research explores new frontiers in flotation chemistry for coarse particle recovery, aiming to unlock the full potential of the HydroFloat™ technology.

9:45 AM

Novel Mo Collectors and Impact on Mo Concentrate Oil Content

M. Lancaster; Mineral Processing, Syensqo, Stamford, CT

Diesel and other fuel oils/hydrocarbons have long been used as collectors for molybdenite. However, negative froth characteristics, compositional variability, and poor robustness can lead to highly variable performance, particularly on problematic ores. Additionally, HSE concerns surround the use of fuel oils. The first portion of this presentation will highlight Syensqo's development of new Mo collector formulations and single-component diesel replacements that can provide step-change performance benefits and improved sustainability/HSE profiles over traditional hydrocarbon collectors. The second portion will discuss the impact of these collectors and other reagents on the oil content of final Mo concentrates. Focus will be placed on the accurate measurement of the total oil content as well as identification of impurities within the Mo concentrates from multiple Cu-Mo operations in North and South America.

10:05 AM

Novel Frothers for Maximizing Cleaner Circuit Performance

T. Bhambhani, A. Santana, G. Alanis and E. Arinaitwe; Mineral Processing, Syensqo, Stamford, CT

Operations treating multiple ore bodies have to make large adjustments in the process as the ore types change. Making these changes is not easy, and often results in disruptions to the process, leading to problems in meeting production or quality targets. At a mine site in North America, a problematic ore was being fed to the plant, which resulted in final concentrate grade being lower than target. At this time, the plant initiated a trial of Syensqo's TransfoamerTM T-200 frother technology. The TransfoamerTM series of reagents act as strong frothers in the rougher, but with increase in pH, switch to a weak frother in the cleaner circuit. This translates to an ability to significantly reduce entrainment in the cleaners, thus improving the upgrading. During this trial, the cleaner circuit performed more efficiently resulting in improved grades without any effect on rougher or cleaner recovery, and the final concentrate grade target was met on a consistent basis. The identification of the problematic species, and its rejection from the concentrate stream with the TransfoamerTM was proven using QEMSCAN analysis.

10:25 AM

25-008

Alternative Methodology for Selecting and Formulating Collectors for Coarse Fractions Using Metallurgical and Statistical Analysis

P. Zarate and C. Saavedra; Mining Solutions, Clariant AG, Santiago, Region Metropolitana, Chile

This article introduces a methodology combining metallurgical and statistical analysis of results to classify and select collector reagents. This approach aims to develop customized collectors focusing on specific strengths, enhancing efficiency and effectiveness of flotation processes. Initially, 13 pure collectors were evaluated. The primary goal was to identify collectors that offered the best flotation performance. The metallurgical analysis was focused on determining copper recovery and copper distribution by size fractions. The performance metrics used in this study included copper recovery rates and the distribution of copper in the flotation tailings across size fractions. Regarding the statistical analysis, the collectors were considered as observations, treating the copper recovery and its distribution across the specified size fractions as variables. Statistical approaches: Principal Component Analysis (PCA) and Hierarchical Cluster Analysis (HCA), were applied to reduce data complexity and group collectors. The presented methodology provides valuable information for classifying and selecting collectors according to specific application needs.

10:45 AM

Enhancing Lead and Silver Recoveries in Lead-Zinc Operations: A Case Study on the Replacement of Xanthate with Aerophine 3413

m. ozcubukcuoglu; Mineral Processing, Syensqo, Niagara Falls, ON, Canada

This study explores the replacement of xanthate with Aerophine 3413 in a lead-zinc operation's lead circuit, aiming to improve lead and silver recoveries without sacrificing plant performance. Aerophine 3413, a phosphine-based collector, was tested against xanthate(SIPX) under identical conditions. Results indicated that Aerophine 3413 not only matched but enhanced the recovery rates of lead and silver, maintaining the concentrate grade and operational efficiency. The trial showcased Aerophine 3413's potential as a superior alternative to xanthate, offering environmental and economic benefits. This paper presents the methodology, performance comparison, and the significant implications of using Aerophine 3413 for the mineral processing industry, highlighting its role in advancing reagent optimization and sustainability in metal recovery processes.

11:05 AM

Case Study: An Environmentally Friendly BASF Frother for Enhancing Metallurgical Parameters in Cu-Mo Flotation Roughers

E. Blanco; BASF SE, Ludwigshafen, Rheinland-Pfalz, Germany

BASF utilizes industrially recognized chemistries and innovative formulations to enhance froth properties, thereby improving recovery of metal values in the Cu/Mo flotation circuit, without compromising safety and ecological concerns. Presently, a Mexican client contends with the challenge of increasing mill throughput without degrading the beneficiation of the resulting Cu/Mo-containing pulps. This occurs because the operator must contend with the degraded granulometric profiles (in terms of relative amounts of fines and coarse fractions) of these pulps. Following extensive testing, BASF offers Luprofroth 711 frother to effectively enhance the flotation of coarse sulfide particles; for mixed granulometries consisting of fine to medium-sized particles, Luprofroth 422 is considered most suitable for improving overall rougher recovery.

TUESDAY, FEBRUARY 25 MORNING

SME YOUNG LEADERS: LESSONS LEARNED: AN EXPLORATIONAL JOURNEY THROUGH THE MINING INDUSTRY PANEL

Sponsored by: RioTinto

Room 111

9:00 AM • Tuesday, February 25

Chair: ***R. Bakzadeh****, New Mexico institute of Mining and Technology, Socorro, NM*

9:00 AM

Introduction

9:05 AM

An Explorational Journey Through The Mining Industry

D. Ball[1], J. Boulard[2], A. Brickey[3], R. Dean-Pelikan[4] and M. Stearns[2]; [1]Technical Services, Northern Star Resources Limited, Perth, WA, Australia; [2]Hecla, Hayden, IL; [3]South Dakota School of Mines, Rapid City, SD and [4]North Star Resources, Anchorage, AK

This session will feature panelists sharing their journey through the mining industry and advice to those currently finding their way.

TUESDAY, FEBRUARY 25 MORNING

TAILINGS: ALTERNATIVE AND REMEDIAL TREATMENTS, AND REUSE OF TAILINGS AND MINE WASTE

Sponsored by: Newmont

Room 607

9:00 AM • Tuesday, February 25

Chairs: ***A. Hedayat****, Colorado School of Mines, Golden, CO*
M. Theron*, Stantec Inc.*

9:00 AM

Introduction

9:05 AM

Innovation in Tailings Thickening: Pilot Results for Integrating Laboratory Variables into Plant Operations

C. Mejias, E. Cáceres and E. Godoy; Hibring, Concepcion, Biobio, Chile

In the mining industry, optimizing water usage and reducing flocculant consumption are critical challenges that impact both operational efficiency and environmental sustainability. We present an innovative solution that integrates laboratory variables directly into the plant, allowing for more precise and efficient management of tailings thickening. This study presents the results of a pilot conducted at the Laraquete plant, where the technology was implemented to continuously measure sedimentation velocity and profile variables, capturing plant variability, anticipating flocculant usage, and predicting clay inflow. The pilot results at Laraquete demonstrate that this technology can increase the discharge solids concentration by 1%, which translates to annual savings of up to $3 million in water and flocculant costs for a 100 ktpd plant. Additionally, this optimization results in an annual reduction of up to 1.4 million cubic meters of water sent to the tailings dam, significantly contributing to the sustainable management of water resources.

9:25 AM

Reuse of Mine Tailings for Production of Lightweight Aggregates

F. SHABANI, A. Weiss, L. Tunstall and A. Hedayat; Civil and Environmental Engineering, Colorado School of Mines, Golden, CO

The reuse of mine tailings (MTs) provides promising opportunities to promote a circular economy by reducing the need to consume natural resources, decreasing tailings deposition, and providing cheaper and more sustainable materials for building and construction. One promising example of construction materials is lightweight aggregates (LWAs) made of MTs. LWAs have a low bulk density, and their use in concrete is increasing, as many of their properties, including unit weight, internal curing, insulating coefficient, and sound-dampening qualities, are superior to natural normal-weight aggregates. Our process of LWAs production involves alkali activation of MTs, using a pan pelletizer whereby an activator is sprayed on MTs to dissolve the aluminosilicates, forming a gel, and bind the tailings to form spherical granules of LWAs. This technique is more energy efficient than other commonly used granulation techniques. This study will explore the performance of MTs-based LWAs in concrete, including their strength and durability characteristics. It will be demonstrated that with the proper production process, applicable specifications for LWAs and the concrete made of them have been met.

9:45 AM

New Standard of Practice to Assess Subsurface Condition and to Mitigate Risks for Design, Construction, and Monitoring of Phosphogypsum Stacks in Karst Environment

P. Dominguez[1] and M. Al-hawaree[2]; [1]Mosaic Fertilizer, LLC, Lithia, FL and [2]Ardaman & Associates, Inc., Orlando, FL

Phosphogypsum management practice has evolved over the years, from disposal of phosphogypsum in lowlands, mangroves, and along coastline in the 1880s when phosphate mining in Florida began, to land stacking of phosphogypsum in the 1930s when the method was developed. Mosaic, in collaboration with Ardaman & Associates, Inc., and with support of the Florida Department of Environmental Protection, launched an initiative in 2018 to advance the state-of-the-art for design, construction, and monitoring of phosphogypsum stacks. With this endeavor, the standard of practice for subsurface exploration has advanced significantly through the adoption of the following new technologies that were not previously available or employed: (i) micro-seismic monitoring, (ii) distributed optical cable sensors, (iii) seismic reflection survey, (iv) microgravity survey, and (v) vibrating wire piezometers. This presentation will review the benefits of these new investigative tools to assess subsurface condition, and highlight recent advancements in design and monitoring of phosphogypsum stacks to mitigate risks.

10:05 AM

Toward Sustainable Mine Tailing Management: Utilization of Waste Material to Produce Eco-Friendly Construction Materials

A. Nikvar Hassani[1], L. Manjarrez[2] and L. Zhang[3]; [1]Stantec, Aurora, CO; [2]WSP, Tucson, AZ and [3]University of Arizona, Tucson, AZ

Both the construction and mining industries are resource-intensive, with over 30% of natural resources used for construction materials and more than 90 billion tonnes of waste rock and 8 billion tonnes of tailings generated from mineral production. Adopting a circular economy approach is crucial to minimize global impacts and conserve resources. Recent developments in technology have increased interest in using waste materials in construction, particularly industrial by-products for creating geopolymer-based materials. This paper reviews research by the SMART group at the University of Arizona, focusing on developing alkali or acidic geopolymer products from mine tailings. These products are concrete binders, road base materials, and bricks, promoting tailings reuse in construction.

10:25 AM

Dry Mining: Sustainability

C. SOTO[2] and M. Javier[1]; [1]EnviroMINE, Denver, CO and [2]Universidad Nacional Micaela Bastidas, Apurimac, Peru

Mining has evolved to intensive extraction rates due to declining oregrades which is inversely proportional to available storage space for the waste generated by mining. Managment of byproducts introduces uncertainties in physical, chemical&biological aspects disrupting the equilibrium achieved over millions of years. Water holds an "undervalue status" in human perception. Water&Minerlas are subject to depletion during mining process. What is the true cost of H_2O in mining? Why is the continued use of H_2O in mining permitted?Why is a model that treats TAILING as product still acceptable? Recently, a proposal has suggested that filtering tailing is a purported solution for H_2O usage. We propose the concept of DRY MINING. This research from qualitative perspective, stimulates discussion on new designs for dry mining that aim to break away from the unsustainable practices of traditional mining. It introduces the concept of new mining operating model that focus on characterizing materials, extraction, recovery, variability in Plant size&other factors while respecting ecosystem.ESGcriterion is integrated into core of mining rather than being a label. Mining is actively pursuing sustainability.

10:45 AM

Freeze-Thaw Durability of Mine Tailings-Based Geopolymer Bricks

C. Clements, A. Hedayat and L. Tunstall; Civil Engineering, Colorado School of Mines, Arvada, CO

The management of mine tailings waste is a major problem in the mining industry, and the current solution of indefinite storage in a tailings pond is insufficient. In fact, tailings contain aluminosilicates originating from the parent rock which can be used for the manufacture of value-added products such as construction materials. Studies have shown that

bricks produced through geopolymerization of mine tailings have high compressive strength, but the durability of the products has not been thoroughly characterized, especially the freeze-thaw performance. This study will explore the durability of mine tailings-based geopolymer bricks when exposed to freeze-thaw cycles, including characterizing the evolution of pore structure, phase composition, ultrasonic properties, and compressive strength as the number of freeze-thaw cycles increases. Mine tailings-based geopolymers have shown great potential as a low-carbon building material and a mine tailings management solution, but it is critical to understand their durability in aggressive environments before this solution can be implemented in the real world.

11:05 AM

Valorization of Copper Mine Tailings with Metallurgical Process and Value Added Product

J. Lee[1] and A. Jalbout[2]; [1]Mining Engineering, Colorado School of Mines, Golden, CO and [2]Auxilium Technology Group, Tucson, AZ

The mining activity of extracting copper contributes more than 40% of global mine tailings. Reprocessing, recovering values, and fabricating value-added materials are the best way to treat tailing. Three copper mine tailings from an active plant were received. A suite of chemical and mineralogical analyses have been carried out and flotation process was able to upgrade metal contents and sulfur as well. The high sulfur and metal containing concentrates were bioleached using a consortium of mesophilic microorganisms. Bioleaching extracts various metals associated with sulfides and produce sulfuric acid and ferric ions that can be recycled back to a heap leach operation. Geofoam is the value-added product and has very unique physical and chemical characteristics that can be used various constructional and structural materials. It can be sprayed and applied using 3D printing technology. Thermal conductivity of the product is very low as an insulating materials. During the fabrication process, calcite content was increased in the Geofoam confirming CO^2 sequestration is happening in the process. Detailed information about tailing materials, process, and Geofoam will be shared.

TUESDAY, FEBRUARY 25 MORNING

VALUATION I: CASE STUDIES

Room 112

9:00 AM • Tuesday, February 25

*Chair: **Z. Smith**, Withum, Jersey City, NJ*

9:00 AM

Introduction

9:05 AM

The Value and Risk of Different Development Approaches for a Copper-Gold Project

M. Samis and M. Paduada; SCM Decisions, Toronto, ON, Canada

Copper-gold projects have complex value and financial risk effects, given the two metals' differences in price behaviour that may impact a project's development strategy. In this presentation, we use a modified version of SolGold's Cascabel Project to look at how the relative proportions of copper and gold revenue streams impact the choice between staged development and frontloaded capital development. We show in some instances, staged project design increases value and reduces capital risk exposure, while in others, it may be better to frontload capital investment.

9:25 AM

A Simplified Rare Earth Element Mining Project Cost Estimator—A New Tool for Evaluating Future Mine Supply

T. O'Brien[2] and E. Alonso[1]; [1]U.S. Geological Survey, Reston, VA and [2]U.S Geological Survey, Knoxville, TN

Rare earth elements (REE) are essential for the future of EV's and renewable energy production, but there is limited production outside of China. Scenario analysis of global future supplies of REE relies on the valuation of advanced mining projects to assess if projects will initiate production. Classical valuation methods (e.g., NPV) require knowledge of initial CAPEX and OPEX to assess project economic feasibility. Typical expenditure projections are precise but require detailed knowledge of a site that is beyond the capabilities of a global model. To model future REE supplies, we developed a new globally representative cost model that can be used to approximate expenses of greenfield REE mining projects. Results from this model allow users to estimate expenses of open-pit and underground mines with mineral processing operations that range from solely beneficiation to individual REE separation. Using our new model, we evaluated 12 REE projects. Of the 12 projects, only 2 projects yielded positive NPV's using 2022 and projected 2028 prices, representing ~11% Dy, >9% Tb and Nd, and ~8% Pr of potential global supply.

9:45 AM

Gold Property Transaction Values and Gold Price (2012-2024)

G. Malensek, W. Roscoe, P. Chamois and P. Landry; SLR Consulting, Lakewood, CO

SLR has tracked transactions on gold properties worldwide from 2012 to 2024. For comparative purposes, transaction values can be expressed in US dollars per ounce gold ($/oz) and as $/oz as a percentage of the gold price at the date of the transaction (termed MTR). Previous studies have shown that $/oz and MTR values are significantly higher for producing properties than for non-producing properties, as expected. The present study shows the effect on these value metrics of the gold price, which has increased dramatically in recent years.

10:05 AM

Paying the Price for Byproduct Critical Minerals: A Tellurium Case Study

J. Trouba; Independent, Saint Paul, MN

The majority of critical minerals are produced as byproducts of another metal. Byproducts, especially the rarer ones, have small, opaque markets that are often influenced heavily by foreign entities of concern. Supply risks have raised interest in finding new sources and expanding production of byproducts to new sites lacking resolution on production technologies and costs. The combination of price instability and process uncertainty creates a challenging environment for investment in byproduct critical minerals. Common valuation methods can rely on faulty assumptions for process compatibility and recovery. These challenges are further complicated because critical and strategic minerals can have immense value to industry and defense applications not reflected in their price, resulting in government involvement. This work presents a framework for evaluating byproduct economic potential by employing tellurium as a case study and incorporating examples from other elements such as In, Ga, Sb. The work addresses common pitfalls and provides guidance for developing critical mineral supply chains relevant to miners, downstream users, government agencies, traders, and investors.

10:25 AM

25-026

Does Competition Affect Bidding Outcomes in Common Value Auctions?—Case of Coalmine Auctions in India

D. Dipu; Colorado Department of Regulatory Agency, Littleton, CO

In this paper, I look at the empirical evidence of coalmine auctions in India to understand how competition affects the bid amounts in common value auctions. The results suggest that competition is instrumental in determining the bids. The presence of higher numbers of bidders in the auction leads to higher bids—every additional bidder causes the bid amount to rise by INR 142.67 per tonne of coal for auctions studied for 127 coalmines from 2014 to 2023. The paper also examines the moderating and mediating effect of competition on bids and on excess of bids from the comparative market price of coal from alternative source of Coal India Limited. The results

indicate that competitive intensity does not have statistically significant impact on the relationship between common value of coalmines and bids, neither as a moderator nor as a mediator. The strategic behavior of the bidders has also been observed as bidders have been seen to bid in a higher than market price in order to outbid the competitors.

10:45 AM

Case Study—Enhancing Management Insight Into Mergers & Acquisitions Using Probabilistic Financial Analysis

L. Hughson; 4-D Resources Advisory LLC, Denver, CO

This case study analyzes public data from an energy industry merger. The traditional deterministic financial and valuation analyses undertaken are compared to a probabilistic approach based on Monte Carlo simulation. The probabilistic approach resulted in a significantly enhanced, quantitatively rigorous financial and valuation analysis that more accurately included real-world uncertainty in operational and financial inputs. This approach generated the full range of possible outcomes for key M&A transaction metrics including: (i) company valuations; (ii) the exchange ratio; and (iii) shareholder accretion analyses. The sensitivity analysis also provided management with greater commercial insights into shareholder risk, through the application of P90/P10 and coefficient of variance ratios—values not available in a deterministic analysis—to further enhance the key decision-making metrics. This case study provides a compelling example of how a probabilistic approach to M&A: (i) is straightforward to implement with Excel; (ii) efficiently facilitates a dynamic use of more data; and (iii) provides outcome probabilities and risk profiles unavailable with a deterministic approach.

TUESDAY, FEBRUARY 25 AFTERNOON

BULK MATERIAL HANDLING: STACKING OF FILTERED TAILINGS

Sponsored by: WOLONG Power your future

Room 610/612

2:00 PM • Tuesday, February 25

Chair: ***M. dos Santos****, SME, Marietta, GA*

2:00 PM

Introduction

2:05 PM

The Application of Conveyors for the Construction of Waste Dumps and Filtered-tailings Storage Facilities

G. Moniz; Minerals & Mining, BEUMER Group, Beckum, Germany

Waste rock management and tailings management are critical aspects of mine planning, especially for large-scale open pit mines. The design and construction of waste dumps and filtered-tailings storage facilities (FTSF) will largely affect the environmental and economic goals of a mining project. The construction of waste dumps and FTSFs can require substantial material haulage which is amongst the most significant costs for an open pit mining operation and is typically a major carbon footprint. Most large-scale and hard-rock open pit mines operate at stripping ratios greater than one which implies moving more waste than ore. Some of these mines have also to manage acid rock drainage (ARD), which is a major environmental hazard. Both facts reinforce the statement that the design and construction of waste dumps and FTSF will affect the environmental and economic goals of a mining project. BEUMER/FAM presents recent case studies where conveyors and crawler-mounted conveyor-equipment are considered for the construction of waste dumps and FTSFs. The presentation identifies major design and construction considerations, as well as involved operating costs.

2:25 PM

Handling Dewatered Tailings: The Three Root Causes of Poor Material Discharge and Bin Hang-ups

D. Vaile; Kamengo, Vancouver, BC, Canada

Dewatered tailings is among the most difficult flowing bulks solids found in the mining industry. Understanding the scientific principles is key to knowing how to design appropriate storage and feed systems capable of reliably handling difficult flowing cohesive materials, such as filtered tailings. In the 1980s, Kamengo led an extensive research program examining why bins plug, when handling difficult flowing materials. This presentation will review the three root causes of intermittent discharge and bin plugging, which are: 1) incorrect bin geometry; 2) compaction of the stored material by the discharge feeder; and, 3) uneven withdrawal of material by the discharge feeder. The presentation will use case studies to illustrate how the outcomes of Kamengo's research were applied in the design of a storage and feed system suffering from chronic plugging, including equipment handling filtered tailings. The presentation will look at the design of a truck-load out system handling nickel laterite dewatered tailings, and a paste mixer feed system. The presentation will also look at lessons learned from other parts of the mine handling cohesive materials, such as ore concentrate filter cake.

2:45 PM

Stacking of Filtered Tails 101

P. Emerson; None, Oceanside, CA

Stacking of filtered tails is being studied by more and more operators as a safer and more environmentally responsible tailings management method to wet tailings facilities. The reasons seem obvious: water recovery, dam failures, reduced waste footprint, etc., and yet implementation of these facilities seems relatively slow due to the complex operability and high power consumption of industry available filters and stacking technologies. Further dry tailings geotechnical designs do not necessarily consider the actual capabilities, limits or stacking methodologies of available stacking technologies until later in the pre-development process, potentially introducing higher CAPEX and OPEX with over complicated systems. This presentation compares proven stacking technologies, equipment capabilities, system avaiabilities, stacking methodologies and constraints in a simple side-by-side comparison for filtered tails stacking and poses why these equipment capabilities need to be considered earlier in project development to ensure process, geotechnical and stacking system alignment for the most cost effective, low risk for filtered tails stacking solutions and geotechnically stable landforms.

3:05 PM

25-088

Technological Aspects of Iron Ore Tailings Filtration and Dry Stacking Improvement using a Filter Aid

M. Vieira[2], G. Vilela Neto[2], W. Silva[2], P. Fernandes[1] and L. Faustino[1]; [1]Mining Solutions, Clariant, Belo Horizonte, Minas Gerais, Brazil and [2]Samarco, Belo Horizonte, Minas Gerais, Brazil

New global industry standards and regulatory changes regarding mining tailings management are driving installation of tailings filtration plants to decommission existing tailings dams and implement dry stacking. Target of this project was to reduce ultrafine slime tailings deposition. Previous investigation at Samarco concentrator has showed a 35% decrease in tailings filtration throughput when feeding a mix of 95% flotation tailings with 5% slime tailings (compared with 100% flotation tailings), also worsening geotechnical aspects such as material workability during dry staking. Industrial trials using a proper filter aid at tailings filtration plant feeding a mix of 94% flotation tailing and 6% slime tailing (equivalent to 30% of total slime generation) have provided filtration performance maintenance (throughput and cake moisture), and dry stacking the dewatered material. Results achieved will enable life expansion of existing slime disposal structures, as well as potential life of mine extension.

Furthermore, reagent chemistry influence is discussed by the light of geotechnical aspects, which has been showing improved KPIs, such as workability, compressibility and permeability.

3:25 PM

25-081

Slicklines, Droplines, Diverter Boots—A Monograph

R. Sacrison[1] and L. Roberts[2]; [1]Sacrison Engineering, Elko, NV and [2]Roberts Engineering and Development, Spokane, WA

Pipeline or borehole free-fall transfer of solid or slurry material has long been done in underground mining. This paper addresses some characteristics and design elements in selecting systems suitable to the transferred media and the mine requirements. Though overall system aspects are discussed, principal attention is directed to the slickline/dropline/transfer line and the discharge diverter/rockbox/energy dissipator/boot. These terms are common to these systems, often used interchangeably, and used here as appropriate to the material, equipment and construction. A principal distinction in the authors' experience being that slicklines refer to slurry transfer and droplines to dry transfer.

TUESDAY, FEBRUARY 25 AFTERNOON

COAL & ENERGY: COAL MINE ROCK MECHANICS

Sponsored by: BARR

Room 704

2:00 PM • Tuesday, February 25

Chairs: ***Z. Khademian****, National Institute for Occupational Safety and Health Pittsburgh Research Laboratory, Pittsburgh, PA*
S. Sawyer*, Pittsburgh, PA*

2:00 PM

Introductions

2:05 PM

25-082

Slope Failures Involving Draglines: Lessons Learned from Operational Experiences

R. Sheets, L. Workman, M. Haggerty and J. Greenwood; Engineering & Design, Barr Engineering Co, Minneapolis, MN

Mining operations utilizing draglines for overburden removal pose a different risk when assessing highwall stability given the critical function the dragline provides. Recently the authors have been involved in determining the cause for several highwall failures involving draglines. When a failure occurs, the best scenario is dragline recovery with no injuries and relatively minimal damage to the dragline; however, injury or significant damage to the machine are always possible. Geotechnical studies are often infrequent due to perceived consistency of geological and hydrological conditions. This presentation shares an overview of lessons learned, key findings, and recommendations based on the authors' experiences.

2:25 PM

Using the Updated Support Technology Optimization Program to Evaluate and Improve Secondary Supports in Longwall Tailgates

B. Diddle[1], T. Barczak[2] and Z. Agioutantis[1]; [1]Mining Engineering, University of Kentucky, Wilmore, KY and [2]Independent Researcher, Venetia, PA

The Support Technology Optimization Program (STOP) has been developed by the National Institute of Occupational Safety and Health (NIOSH) to provide a comprehensive tool for both performance evaluation and design of available secondary roof support systems based on support strength, convergence, cost, installation time and material handling. Support systems can be designed and compared for use in a new mining section or to evaluate potential replacements for an existing design. The support design requirements can be defined in four unique ways, allowing flexibility for operators with limited data. This paper presents two examples of STOP utilization, effectively displaying the practical benefits of the program for underground longwall mines. Current mine support data was evaluated using ground reaction curves for each location. Results were compared with potential improvements according to ground reaction, cost, and material handling parameters.

2:45 PM

25-034

Evaluation of Alternative Chain Pillar Designs in a Deep Longwall Mine

Z. Khademian; Ground Control, National Institute for Occupational Safety and Health Pittsburgh Research Laboratory, Pittsburgh, PA

This work investigates three alternative designs in a three-entry-system gateroad configuration with an inter-panel barrier in a longwall mine in Virginia. Starting with the current design, which has faced challenges such as excessive floor heave, a geomechanical model developed in 3DEC software is validated by monitoring pillar stress in the yield, abutment, and barrier pillars in the mine. Alternative chain pillar designs are evaluated in the model with a focus on roof sagging, floor heave, and pillar stress. Results show the relationships among alternative designs and instabilities in the mine, providing insights for optimizing longwall mining designs in deep-cover settings.

3:05 PM

25-098

Foamed Backfill and the Utilization of Liquid Sand

N. Sutmoller; Aerix Industries, Allentown, PA, PA

Liquid-Sand technology was developed as a cost-effective alternative to traditional backfilling methods, by replacing the water, cement and fly ash, with pre-generated foam to transport the sand or other backfill material into open voids. The foam dissipates in 24 to 48 hours, leaving only the backfill material, which self-compacts. The foam can be engineered for greater or lesser persistence, depending on the dissipation requirements. The presentation will go into some details Carlsbad Brine Well, in Carlsbad, New Mexico, operated between 1979 and July 2008, producing brine water for the oil and gas industries for nearly thirty years. In July 2008, those operations came to an abrupt halt due to concerns of a potential collapse causing significant damage to surrounding properties. A number of other projects will also be referenced such as the Glenrock Mies in Glenrock, WY; The Noonan Mine in Noonan, ND; Rapson Coal Mine in Colorado Springs, CO and others.

3:25 PM

Subsidence Prediction Over Highly Subcritical Panels in the Eastern US

M. Parra Valencia and Z. Agioutantis; Mining department, University of Kentucky, Lexington, KY

Prediction of subsidence caused by coal mining can be used to protect surface structures by anticipating ground movements that will occur during mining. The present work discusses a subsidence case related to the extraction of two adjacent longwall panels at a deep coal mine in the eastern US. Ground movement measurements were collected for transverse and longitudinal profile lines that were set up above both panels. An influence function model was developed using the SDPS package and analyses were conducted both for final and dynamic conditions. Prediction and measurement values are compared using the relative root mean square error. Subsidence progressing in highly subcritical panels is discussed.

3:45 PM

25-063

Optimization of Engineering Design Parameters of Injection Foams for Strengthening Purposes

A. Bascetin; Mining Eng Dept, Istanbul Technical University, Faculty of Mines, Istanbul, Turkey

The some parameters for foam technology such as discontinuities as well as the geological and geomechanical properties of the formations forming the ground play an important role in the success of the application. In addition, engineering parameters such as injection pressure, application point and range should also be taken into account. Another issue is, of course, material properties such as strength, fluidity and reaction heat of the injection or foam material. In this study, the engineering design parameters of a phenolic type foam injection developed for strength purposes for an underground coal mine were investigated and the most appropriate values were tried to be determined depending on the characteristics of the applied environment. In this study, a foam with a compressive strength of 1.5 MPa and an elastic modulus of 1 GPa was used for the field in question. It was determined that when the groundwater level is approximately 2 meters below the injection point and the hardest rock strength is 25 MPa, the injection pressure is 5 bar and the injection points are 2 meters apart, and the subsidence amount in this case will be 0.4 meters with the finite element solution.

4:05 PM

Investigation on Micro-properties Calibration of Shale Specimen Modeling with Bedding Planes Extracted by Image Processing

G. Zhao and D. Tuncay; Mining Department, West Virginia University, Morgantown, WV

Previous research not only simplifies shale's complex structure by modeling these planes as continuous, straight, and equidistant but also simplifies the model calibration process by often overlooking the anisotropic effects associated with different bedding plane orientations. This paper investigates the calibration of micro-properties in models simulating Opalinus shale specimens at the lab scale, focusing on capturing bedding planes through image processing and incorporating the resulting anisotropy from varied bedding plane orientations. Bedding plane contacts were obtained using image processing, which extracted spacing, and length of bedding planes with different orientations. Model calibration was conducted through a series of parametric studies on the micro-properties of trigon and bedding plane contacts to match laboratory stress-strain behaviors. The results show that: At 0° orientation, both trigon and bedding plane contact failures contribute to shale model failure. Conversely, at 90° orientation, the primary failure mode is bedding plane contact failure. At 45° orientation, bedding plane contact shear failures predominate.

4:25 PM

25-015

Assessment of Impact of Dirt Bands on Coal Pillar Strength at Different Depths of Cover—A Numerical Simulation Study

A. SINGH, S. Ram and P. Onam; Mining Engineering, National Institute of Technology Rourkela, Rourkela, Odisha, India

A numerical simulation study is carried out for assessment of stability of coal pillars having dirt bands by varying its size and depths. Physico-mechanical properties of dirt bands including thickness and its position in pillar system are varied in the simulation study. Results of the simulation study are correlated with the available empirical approaches of pillar strength are validated with field observations. It is observed that the presence of weak dirt bands significantly influences the strength of pillar. An attempt is made to develop correction factor for the available empirical approaches, which are developed without considering the weak dirt bands in pillar system. The findings of the study will be helpful for suitable design of different size of coal pillars at different depths and stages of depillaring operations.

TUESDAY, FEBRUARY 25 AFTERNOON

COAL & ENERGY: LAND RECLAMATION, PERMITTING AND ALTERNATIVE ENERGY

Room 703

2:00 PM • Tuesday, February 25

Chairs: ***B. Kudlaweic****, Tetra tech, Murrysville, PA*
E. Cavazza*, Tetra Tech, Inc., Pittsburgh, PA*

2:00 PM

Introductions

2:05 PM

Tetra Tech Abandoned Mine Land (AML) Reclamation Projects in the Appalachian and Mid-Continent Regions

E. Cavazza; Tetra Tech, Inc., Pittsburgh, PA

In 2021, the Bipartisan Infrastructure Law (BIL) or Infrastructure Investment and Jobs Act (IIJA) provided $11.3 billion in US Treasury funding over a 15-year period to address legacy coal AML and abandoned mine drainage (AMD) sites across the country. The funds are to be distributed in equal, annual amounts over a 15-year period to 23 states and one Indian Tribe based on the tonnage of coal produced in the state or tribe before August 3, 1977. For many of these states and the tribe, this results in significantly increased funding for AML work and exceeds their AML Program's resources. In order to obligate this funding to eligible AML projects, many states increased their use of and reliance upon consultants. Tetra Tech's OGA office in Pittsburgh, in response to various RFPs and RFQs, has entered into contracts with several State AML Programs and NGOs which have received AML grant funding to assist with project development, design, permitting and construction management. This presentation will highlight several of the AML projects and work that Tetra Tech is working on to support abandoned mine reclamation efforts in the Appalachian and Mid-Continent Regions of the country.

2:25 PM

Landslide Occurrences Associated with Legacy Coal Mining in Southwestern Pennsylvania

A. Iannacchione, D. Bain, E. Shelef, A. Ayo-Bali, E. Özpolat and C. Campbell; University of Pittsburgh, Pittsburgh, PA

The University of Pittsburgh, under contract with the IRISE consortium, created a database of landslide occurrences within the ten counties comprising southwestern Pennsylvania. The area has large numbers of landslides occurring under a variety of conditions. This study area has been subjected to intense historic or legacy bituminous coal mining activity. The analysis found that historical coal mining, especially mines developed prior to the implementation of Surface Mining Control and Reclamation Act (SMCRA) and its amendments, is far more likely to influence landslide occurrence as compared to Post-SMCRA mining operations. For example, the Pittsburgh Coalbed sites focus largely on early-20th century legacy underground mines in Allegheny and Washington Counties. The Allegheny Group Coalbed sites in Armstrong County focus on mid-20th century abandoned surface strip mining and the remnants of surface operations from underground mines. In both situations, preliminary analysis suggests that the occurrence of landslides is elevated in these areas. These examples are meant to increase awareness as to how coal mining may influence landslide occurrence in southwestern Pennsylvania.

2:45 PM

Demonstrating Compliance with $PM_{2.5}$ NAAQS for the Mining Industry

A. Jones, C. Keslar and A. Unruh; Trinity Consultants, Denver, CO

Demonstrating compliance with the $PM_{2.5}$ National Ambient Air Quality Standard (NAAQS) has become especially challenging with the recent revision to the annual standard from 12 to 9 $\mu g/m^3$. This presentation will explore the unique challenges the mining industry faces in demonstrating compliance with the $PM_{2.5}$ NAAQS standard and strategies for model refinements. Air dispersion modeling strategies discussed will include ambient air boundary considerations, background concentration refinements, and other AERMOD model refinements. Attendees will gain insight into strategies to consider for their next $PM_{2.5}$ NAAQS demonstration. This presentation will complement other $PM_{2.5}$ NAAQS presentations that will provide insight into permitting and emissions refinements.

3:05 PM

Navigating Air Dispersion Modeling Challenges for Mines

M. Ishak; Trinity Consultants, Phoenix, AZ

Minimizing dust impacts associated with mining activities and associated air dispersion modeling has been at the forefront of air impact evaluations for years. Additionally, the complexities associated with modeling nitrogen dioxide (NO_2) emissions from blasting is unique to mines. Attendees will gain insight into troubleshooting methods for various emission sources including fugitive dust and blasting and explore how to ultimately comply with the National Ambient Air Quality Standards (NAAQS) integral to air quality permitting in the United States. This presentation will cover how to prepare and overcome potential challenges associated with the air dispersion modeling of mines.

3:25 PM

Analytical Approach to Predicting Vibration Impacts for Safe and Environmentally-friendly Mining

S. Cohen; Trinity Consultants, San Diego, CA

Groundborne vibrations from mining activities such as underground and surface blasting, pile driving, beneficiation equipment, and road traffic can pose risks to existing structures, cultural resources, and cause disturbance to humans and wildlife. This presentation will present a comprehensive methodology for predicting the spatial extent and magnitude of these impacts using a combination of quantitative equations and spatial analysis. Using this methodology, vibration contours can be mapped to allow identification of critical areas where thresholds may be exceeded. Case studies demonstrate the utility of this method in identifying and mitigating potential impacts on historical structures, cultural resources, wildlife, and populated areas. Our findings enable more precise planning of blasting locations and parameters, ensuring minimized adverse effects and enhanced safety in mining operations.

TUESDAY, FEBRUARY 25 AFTERNOON

COAL & ENERGY: RESEARCH AND DEVELOPMENT

Room 702

2:00 PM • Tuesday, February 25

Chairs: ***M. Trevits****, Xtraction Science and Technology, Inc, Pittsburgh, PA*

S. Schafrik*, University of Kentucky, Lexington, KY*

2:00 PM

Introductions

2:05 PM

Impact of Tunnel Slope Angle on Exit Portal Pressure Profile in Scaled Blast Simulations

R. Bauer and C. Johnson; Mining and Explosives Engineering, Missouri University of Science and Technology, Rolla, MO

Full-scale coal dust and explosive testing in underground tunnels is vital for understanding the dynamics of blast wave propagation and associated risks in mining environments. This research evaluates the effects of explosive blasts in underground tunnels using scaled models. A 1/100 scale model of the Lake Lynn Experimental Mine was developed and simulated in Ansys Autodyn to analyze shockwave propagation through tunnels with various slopes. The study focuses on pressure differences based on tunnel incline, with simulations showing significant variations in air overpressure at the tunnel exit as greater slope angles produce a higher pressure outside the tunnel.

2:25 PM

Optimal Greedy Sequential Node Deployment Algorithm for Real-time Deployment in Unknown Post-disaster Underground Mines

P. Duane[2], S. Shao[3], V. Androulakis[4], H. Khaniani[5], M. Hassanalian[6] and P. Roghanchi[1]; [1]Mining Engineering, University of Kentucky, Lexington, KY; [2]Computer Science and Engineering, New Mexico Institute of Mining and Technology, Socorro, NM; [3]Electrical Engineering, New Mexico Institute of Mining and Technology, Socorro, NM; [4]Mineral Engineering, New Mexico Institute of Mining and Technology, Socorro, NM; [5]Mineral Engineering, New Mexico Institute of Mining and Technology, Socorro, NM and [6]Mechanical Engineering, New Mexico Institute of Mining and Technology, Socorro, NM

In the event of a mine emergency, existing communication infrastructure in underground coal mines may not be functional or useful. In developing an exploratory robot to aid mine rescuers, making mine rescues faster and safer, a reliable communication system must be deployed during exploration where there is limited ability to deploy infrastructure. This paper presents a real-time wireless mesh network deployment algorithm for an unknown post-incident area based on an experimentally verified raytracing model for estimating the wireless channel at the physical layer. The algorithm is a low-complexity greedy algorithm for sequential node deployment that achieves close to optimal results.

2:45 PM

Towards the Development of a Permissible Drone Platform: Technological and Regulatory Implications

P. Roghanchi[1], M. Hassanalian[2] and D. Wetz[3]; [1]Mining Engineering, University of Kentucky, Lexington, KY; [2]New Mexico Institute of Mining and Technology, Socorro, NM and [3]University of Texas at Arlington, Arlington, TX

This research discusses the challenges in developing drone technologies for underground coal mining applications. The project's overall goal is to demonstrate the feasibility of a permissible drone considering Mine Safety and Health Administration (MSHA) permissibility requirements. The application of drones in underground coal mines is limited due to the lack of a permissible platform. A permissible machine is usually much heavier than its non-intrinsically safe counterpart. Increasing the weight of a drone drastically decreases its efficiency. Therefore, the two main challenges in designing an intrinsically safe drone for indoor applications are (1) to demonstrate the permissibility and intrinsic safety of the vehicle and (2) to design a propulsion system that provides sufficient lifting power and reasonable flight time. Our team has achieved a design for a quadcopter drone that can potentially be safely used for underground coal mining applications. The team was able to demonstrate the assembly and a successful flight of the drone.

3:05 PM

25-099

Interpreting Lithology in Underground Coal Mines using Video Scopes

M. Van Dyke[1], Y. Xue[1] and J. Wickline[2]; [1]Ground Control, NIOSH, Pittsburgh, PA and [2]Geology, Arch Resources Inc., Philippi, WV

Video borescopes have become the standard for examining the roof lithology in underground mines. The information can be recorded quickly underground and then be closely examined on the surface. While this technology has been used previously by both operations and NIOSH research, the video scopes had poor resolution, short battery life, and relatively expensive. Advancements in technology has addressed some of these hurdles, and this paper will discuss the features of modern video scopes available, features that will aid in lithology description, and the deployment methods of the video scope for best practices pertaining to supplemental roof support recommendations.

3:25 PM

25-085

Study on the Influence of Borehole Condition on Panoramic Borehole Image Generation from Side-view Borescopes in Underground Coal Mines

Y. Xue, Z. Khademian, M. Van Dyke and K. Mohamed; National Institute for Occupational Safety and Health, Washington, DC

Borescoping has been widely used for geological mapping in U.S. underground coal mines. In a previous study, an image stitching technique was proposed to generate panoramic borehole images from side-view borescopes to visualize the geology along the whole borehole. However, the technique can be affected by borehole condition. In this study, borehole videos recorded at different times when the same borehole was drilled, freshly washed, and two weeks after washing, were processed with the proposed technique. The influence of borehole condition was compared from the success of image stitching and the visibility of geologic features. The study aids in further developing the proposed technique to help determine the optimal conditions for borescoping during geological mapping.

3:45 PM

25-051

Rib Monitoring Study in a Room-and-Pillar Mine

K. Mohamed[1], Y. Xue[1], A. Kirmaci[2], D. Guner[2] and T. Sherizadeh[2]; [1]National Institute for Occupational Safety and Health, Pittsburgh, PA and [2]Mining and Explosives Engineering, MST, Rolla, MO

Researchers from NIOSH and MST are developing a practical rib support tool for underground coal mines, addressing the lack of a unified rib support design approach in the U.S. A study in a room-and-pillar mine assessed coal pillar rib stability using instruments like borehole pressure cells, load cells, and a roof extensometer over six months. The data showed that rib bolts effectively controlled deformation, with roof caving within pillar lines limiting stress transfer. Visual inspections confirmed stable rib conditions with minimal sloughing except at mining sites. These findings highlight effective measures at this mine and may aid in developing the rib support tool.

TUESDAY, FEBRUARY 25 AFTERNOON

COAL & ENERGY: ROOM AND PILLAR OPERATIONS AND PROJECTS

Room 603

2:00 PM • Tuesday, February 25

Chairs: ***A. Patterson****, LCT Energy, LP, Latrobe, PA*
B. Williamson*, Consol Energy Inc, Hickory, PA*

2:00 PM

Introductions

2:05 PM

An Interseam Slope Project in a Room-and-Pillar Coal Mine in Central Appalachia

G. Hartsog; Alpha Engineering Services, Inc., Beckley, WV

As the thicker and more easily accessed coal reserves are exhausted the thinner and more technically challenging seams become "the best of what's left". This speaks also to reserves that have been by-passed or isolated and are not large enough to justify the capital for shafts, slopes, permitting and other investments required to recover them. While the use of inter-seam slopes in coal mining is not new it is becoming more common for various reasons. Each instance of constructing slopes, though, requires site specific engineering, design and specific considerations. In this instance, the interburden is relatively thin (about 30-ft) and the material testing indicates it can be mechanically excavated. This presentation will discuss some of the characteristics site which allow considerable safety related and cost saving measures to be used to expedite the project. At the same time, life of mine considerations for haulage, access and ventilation are addressed.

2:25 PM

Henderson County Mine Development

L. Griggs and B. Mackellar; River View Coal. LLC, Waverly, KY

The Henderson County Mine is a brownfield coal development project located in west Kentucky. River View Coal, LLC a wholly owned subsidiary of Alliance Coal, is the operating company of the Henderson County Mine. The reserve to which the mine will be accessing consists of approximately 260 million ROM tons of west Kentucky #9 seam. Development access is through a means of rehabilitating an abandoned slope, mining a "corridor" through the west Kentucky #11 seam, and mining three approximate 1000' slopes down to the #9 seam. This paper details the construction process of accessing this reserve base.

2:45 PM

Reopening and Rehabilitation of an Idled Central PA Metallurgical Coal Mine

S. Baker, B. Ashley and B. Welsh; Rosebud Mining, State College, PA

Today's metallurgical coal reserves often require innovative solutions to safely and efficiently recover the resource; overcoming challenges due to geological conditions, multiple seam mining and minepools, ventilation challenges and quality constraints. Rosebud Mining Company's Cherry Tree Mine reopening and rehabilation has involved engineering solutions to all of the above. This presentation will discuss the decision making process that led to reopening the Cherry Tree Mine, which had been inactive and flooded since 2016, and the engineering solutions that have been implemented to facilitate current and future mining in three overlapping thin coal seams.

3:05 PM

Itmann No.5 Mine Retreat Mining

J. Lu and M. Bohan; Consol Energy Inc, Canonsburg, PA

CONSOL Energy's Itmann No.5 mine operates as a three-unit super section room-and-pillar mine in the Pocahontas 3 seam. The mines B Panel Unit developed its first room and began retreat mining during the third quarter of 2024. In addition to primary roof support, the retreat mining plan utilizes four mobile roof support units and/or posts. Overlying strata in the immediate roof varies as dark gray shale (0 to 30 feet thickness), to massive sandstone (0—130 feet thickness). Overburden within pillaring areas ranges from 600 to 1,000 feet. Fire Creek seam with previous mining activities is located about 320' to 390' above the currently retreat panel. However no multiple seam mining interaction is considered in the retreat panel due to no retreat mining in the Fire Creek seam. Christmas Tress pillar retreat method is applied for the B Panel. This paper will explore the initial results from the first panel including strata monitoring data and analysis, module roof support performance, ACPS analysis (including

multiple seam mining interaction analysis), coal burst analysis, and other ground control observations related to the initial pillaring activities at the Itmann mine.

3:25 PM

Why Coal Miners Struggle to Forecast Accurately

M. Gadde; Peabody Energy, St. Louis, MO

Coal miners frequently face significant discrepancies between budgeted and actual outcomes, disrupting operations and financial stability. Life of Mine (LOM) plans, intended to guide long-term strategies, often fall short in accurately predicting critical performance metrics. This presentation examines the root causes of these forecasting challenges, focusing on the misalignment between conventional deterministic planning methods and the complex, variable nature of real-world mining conditions. Current deterministic planning models fail to capture the inherent uncertainties and risks present in mining operations, leading to substantial deviations from projected outcomes. Adopting a probabilistic approach that incorporates the complexities and uncertainties of the mining environment is the best way to address this gap. The discussion will explore how such probabilistic techniques can be practically applied to improve decision-making processes in coal mining operations, balancing technical rigor with real-world applicability.

3:45 PM

Floor Heave and Mine Convergence Disrupting Ventilation in a Central West Virginia Room and Pillar Mine, Randolph County West Virginia

T. Hamrick and J. Toombs; Engineering, United Coal Company, Daniels, WV

Soft floor material and differential horizontal stress resulted in catastrophic floor failure and mine convergence in room and pillar mains, reducing ventilation and threatening future mine viability in the Central West Virginia bituminous coal fields. Several corrective measures were considered, including conventional crib blocking, geo-engineered posts and supports, geogrid and truss systems, pumpable cribs, and driving alternate mains. The mine decided on pumpable cribs with reenforced floor cribbing and bearing plates to distribute load because of quick installation and cost. While corrective actions were ongoing, the mine began developing another set of parallel mains to ensure long-term operability. In addition to corrective measures, United Coal developed floor modeling methods using bearing capacity calculations, overburden depth, and floor strata thickness that could be extrapolated to our other company mines to both identify weak areas in existing mines and aid in future planning of new mines.

4:05 PM

Bluegrass Natural Resources—Development of the Black Mountain Reserves

K. Harris and F. Taglia; Bluegrass Natural Resources, LLC, Harlan, KY

Last year, Bluegrass Natural Resources obtained control of the Black Mountain coal reserves, located in Harlan County, within the southeastern Kentucky coalfields. With 4 current mining operations and growing development plans, Bluegrass's planned exploitation of these historically rich reserves focuses on efficient room and pillar mining of metallurgical and industrial grade coals. This area was initially developed by US Steel and International Harvester for metallurgical coals over 100 years ago, but recently enjoyed success as a thermal producer. With considerable market shifts for Appalachian coals, Bluegrass realized the significant economic potential available to breathe new life into the operation. With upwards of 16 mineable coal horizons throughout the current geologic column and the tallest peaks in Kentucky, numerous engineering and geologic challenges exist to successfully produce from this reserve. Overburden, which can exceed 2000 feet, is often associated with complex multiple seam interactions from prior operations. This paper details some of the engineering and business challenges associated with successfully producing coal from the significant reserve base.

TUESDAY, FEBRUARY 25 AFTERNOON

COLORADO MINING ASSOCIATION

Room 710/712

1:30 PM-3:00 PM

Competing for the Workforce of Today and Tomorrow – How to be Successful with Your Talent Attraction and Talent Retention Strategy in the Competitive Landscape we are Operating Within

Moderator: Adam Eckman, President & CEO, Colorado Mining Association

Panelists: Rhonda Zuraff, Co-founder and Principal, P&C Recruiting

Hugh Miller, Associate Professor Research Director—EMCIS Safety Program Mining Engineering Department, Colorado School of Mines

Weston Norris, General Manager, Mountain Coal Company/ Arch Resources

Noah Zedek, Associate Attorney, Womble Bond Dickinson

Kelly Ward, Producer, McGriff, President, Women in Mining Denver Chapter

This panel will discuss insights from leaders in the mining industry and related sectors on attracting new talent to the industry to address growing employment needs as well as talent retention strategies in a competitive employment landscape.

3:15 PM-4:00 PM

The Public's View on Nuclear: Here's What I Learned

Grace Stanke, Constellation Energy, Miss America 2023

Nuclear Energy is vital to our energy future and will play a central role in efforts to reduce carbon emissions. Grace Stanke, a nuclear engineer and Miss America 2023, will discuss her experiences as a nuclear engineer and what challenges need to be overcome to address public perceptions of nuclear energy.

EDUCATION INNOVATION FOR THE MINERALS INDUSTRY III

Room 501

2:00 PM • Tuesday, February 25

*Chairs: **A. McBrayer**, West Virginia University, Morgantown, WV*
***B. Carlson**, South Dakota School of Mines and Technology, Rapid City, SD*

2:00 PM

Introductions

2:05 PM

What Students, Parents, and Educators Really Think of Mining, and What that Means for Attracting the Next Generation of Mining Talent

J. Banta; School of Mining and Mineral Resources, University of Arizona, Tucson, AZ

Enrollment in mining education programs has been declining significantly in major mining markets like the US, Canada and Australia since 2015, resulting in program closures in each. Recent research by MiHR finds young people's intention to join the industry remains low. There's no shortage of opinions about why. Many blame media, others unsupportive parents or educators. Some suspect the lack of interest goes back to the near elimination of earth sciences from K-12 curriculum. To find answers, the University of Arizona conducted research on potential students, parents, and educators. We'll share what they're really saying about careers in mining, who and what is shaping their opinion, and what we're doing about it.

2:25 PM

Novel Recruitement Methods: Virtual Camps

A. McBrayer[2] and A. Brickey[1]; [1]Mining Engineering and Management, South Dakota School of Mines and Technology, Rapid City, SD and [2]Department of Mining Engineering, West Virginia University, Morgantown, WV

Recruiting students into the mining industry has been an ongoing challenge for US mining engineering schools. With declining university enrollments and an overall negative opinion of the mining industry (thanks Avatar), universities are looking to new recruitment methods. In this presentation, the authors present a recent collaboration between South Dakota Mines and West Virginia University of a free, virtual mining and explosives camp. The discussion will include the camp structure, topics, and engagement tools used to connect with students in middle and high school.

2:45 PM

An Analysis of Future Mining Engineers in the USA

F. Gil; WSP, St. Louis, MO

According to data compiled by the Society for Mining and Metallurgy, enrollment in mining engineering programs has fallen 45% since 2015. With only 14 mining schools, the USA is not in a good position to compete against the 44 mining schools that China has, considering the current global race and demand for rare earths. This paper will analyze the possible causes of the declining enrollment in mining programs, an opportunity in foreign students obtaining mining degrees (currently around 20% in the USA), possible educational measures to recruit more Gen-Z students, and preparations for future Gen Alpha students.

3:05 PM

Training Simulators: How to Make Operators Safer, More Productive and Less Destructive

P. Olckers; 5DT (Fifth Dimension Technologies), Pretoria, Gauteng, South Africa

Training simulators have proved highly effective in the aviation industry, where the main focus has been to improve safety. Training simulators entered the mining industry in the early nineties. In mining the focus was not only to improve safety, but to also improve productivity and to reduce unscheduled machine maintenance. Many mining operations and training institutions now have training simulators, but these simulators are not being used to their fullest potential and are often being referred to as 'white elephants'. A business improvement process (BIP) based on the use of training simulators will be presented. Several case studies, where mining operations achieved significant savings, will be presented. The potential return on investment (ROI) of simulators, when used optimally, will be calculated. Techniques to improve the utilization and efficiency of training simulators will be discussed. Typical pitfalls of integrating training simulators into a mining operation will also be addressed.

3:25 PM

Cu at the Mine: Mineral Resource and Mining Education Outreach for Secondary Science Teachers

D. Moreno and C. Earnest; School of Mining and Mineral Resources, University of Arizona, Tucson, AZ

Cu at the Mine! was a four-day professional development academy for middle and high school teachers hosted by the University of Arizona School of Mining and Mineral Resources during the summer of 2024. The impetus for this aggressive mining education outreach effort is the lack of awareness of mining and minerals concepts demonstrated by a high percentage of American science teachers. This lack of awareness hampers their ability to teach about mining or make recommendations about careers in the mining industry. Students choose majors and careers with which they are familiar, so increasing teachers' familiarity with mining and minerals concepts should lead to greater student awareness of opportunities in mining programs and careers. This paper reviews the rationale for aggressive mining education outreach, the structure and design of the professional development academy, highlights and lessons learned from the inaugural experience, a preliminary analysis of teacher self-report data, and projections for future efforts in teacher education outreach.

3:45 PM

25-018

Building Our Future: A Multi-Faceted Educational Program to Inspire and Engage Future Generations in Sustainable Mining

M. Portal Valdivia, F. Segobia Campos, F. YSLA QUIROZ, L. Goicochea Sánchez and J. Mujica; Mining engineering, Society for Mining, Metallurgy & Exploration, Cajamarca, Cajamarca, Peru

The "Building Our Future" project is a collaborative initiative between the UNC SME Student Chapter, and the Water and Earth Museum (MAT) of La Asociación Los Andes Cajamarca (ALAC) aimed at promoting responsible and sustainable mining among new generations while fostering a culture of equality and respect. This comprehensive educational program integrates sustainable development goals and includes workshops led professionals and external experts who share their personal stories to inspire students from rural and urban educational institutions to follow their dreams. Additionally, for this year 2024, the project development and implemented an interactive mobile application that educates users about the use of minerals in everyday life through four levels: Minerals in the Home, Minerals in Medicine, Minerals in Transportation, and Minerals in Agriculture. This multi-faceted approach seeks to raise awareness about the importance of mining in Peru's economic, environmental, and social development, ultimately fostering a new generation of informed and engaged citizens who understand the vital role of mining in a sustainable future.

4:05 PM

25-094

Training Programs Can Generate Measurable Value

K. Freitag, R. Seitz, D. Drinkwater, J. Cilliers and C. Castillo; Metcelerate, West Vancouver, BC, Canada

The talent gap in mining is not a new challenge. Mining companies continue to seek innovative ways to attract, develop and retain talent, and younger workers are looking for opportunities to develop their professional careers. Training provides a key value proposition for both employees and employers as it helps build a talent pipeline while offering opportunities for learning and growth and value creation. In 2020, Metcelerate launched its 20-month program for early career mineral processing engineers. The program helps develop critical technical skills in the workplace and is a tool to identify motivated engineers and change culture within teams. Learners cap their skills development by executing a technical investigation. This generates immediate value—a win-win outcome for learner and company.

TUESDAY, FEBRUARY 25 AFTERNOON

ENVIRONMENTAL: MINE WATER MANAGEMENT

Room 104

2:00 PM • Tuesday, February 25

Chairs: ***E. Rahimi****, The Pennsylvania State University, State College, PA*
Z. Kazemi Motlagh*, New Mexico Institute of Mining and Technology, Socorro, NM*

2:00 PM

Introductions

2:05 PM

An In-situ Approach to Tailing Water Management

J. Harrington and C. Pretorius; Ensero Solutions, Fort Collins, CO

Effective tailings water management is critical to managing environmental risks in mining operations and ensuring long-term sustainability. Excess water in the tailings storage facility (TSF) increases structural failure risk

and rapid dewatering mitigates this risk. Batch treatment implemented in situ should be considered because it is effective and rapid, able to treat millions of cubic meters of water in months at a fraction of the cost of a fixed plant. Ensero applied this approach at the Gibraltar Mine TSF, where nitrate was removed and metals were managed during in situ treatment thereby allowing water to be discharged from the TSF.

2:25 PM

Critical Pit Dewatering Components and Design Considerations

I. lines; Burns & McDonnell, Phoenix, AZ

The in-pit dewatering system is the last defense to prevent pit flooding and must be designed to function well within the ever-changing pit shape throughout the life of mine. This paper will review a recent in-pit dewatering design and focus on options to overcome the challenges facing an in-pit dewatering system with the following topics. Methods for determining a design pumping rate with respect to the estimated pit inflows. Options for a wide range of achievable flow rates to cover seasonal inflows. Methods for collecting water with a review of different initial pump types. Single lift vs multi-lift pumping systems and when its best to use each type. Skidded vs fixed pumping infrastructure (pumps, tanks, e-house, and transformer). Typical pipe materials pros and cons along with applications for each type. Design considerations for improved functionality and safety for the site operators.

2:45 PM

Pilot-Scale Turbidity-Based Membrane Scaling Mitigation on Gypsum-Impacted Groundwaters and Mining Wastewaters

J. Bush[1], R. Huehmer[2], T. Cath[1] and J. Vanneste[1]; [1]Civil and Environmental, Colorado School of Mines, Golden, CO and [2]Dupont Water Solutions, Edina, MN

High density sludge (HDS) systems followed by reverse osmosis (RO) are the state-of-the-art for acid mine drainage treatment. While HDS is very effective at removing metals, it increases the concentration of gypsum. When gypsum precipitates upon concentration, it can severely damage RO membranes. Until now no effective sensors have been identified that can detect this precipitation before it impacts the membrane. A groundwater with 1.5 g/L gypsum (75% saturation) and a mining wastewater with 1.75 g/L gypsum (87.5% saturation) were treated with a 20 GPM closed-circuit RO and a 2 GPM conventional RO, respectively. Both systems were equipped with advanced turbidity sensors on the concentrate which enabled detection of the onset of gypsum crystallization before it affects the membrane performance and this without the use of antiscalants. Even for rapidly changing water quality, scaling can be mitigated by adapting water recovery in real-time. This will reduce membrane cleaning, membrane replacement and labor costs. Moreover, avoiding antiscalants facilitates subsequent gypsum recovery as a fertilizer or building material and supernatant recycling will further increase water recovery.

3:05 PM

Using Sulfur and Oxygen Isotopes to Evaluate Natural and Anthropogenic Sources

J. McGunnigle; INTERA Incorporated, Eighty Four, PA

Ore milling sites are often located in areas with natural sources of contaminants. Stakeholders concerned with the long-term impacts of such sites may be interested in distinguishing these natural sources from anthropogenic sources. In this case study, sulfate sulfur and oxygen isotope measurements were evaluated for isotopic signatures that could be used to distinguish groundwater containing natural and mill-impacted sources. Sulfate sulfur isotopic and major ion concentration measurements were also used in a mixing and mass balance analysis to estimate the proportions of likely groundwater sources. Sulfate sulfur and oxygen isotope measurements show that distinct isotopic signatures exist for background and mill-impacted groundwater. Mixing and mass balance modelling shows that most wells can be understood in terms of simple mixing between background and a mill source, while some wells show evidence of both natural and mill sources. Mixing analyses also show that additional attenuating processes may account for observed isotopic values and ion concentrations. This work shows that conclusions drawn from isotopic measurements should be supported with other lines of evidence.

3:25 PM

Where Do I Put This Water? Temporary Solutions for Contaminated Water Handling

M. White and M. Groff; Engineering, WestLand Engineering and Environmental Services, Tucson, AZ, 85712, AZ

Mining operations and exploration programs often find themselves needing quick and effective temporary solutions for dealing with contaminated water. We will cover strategies and lessons learned for safely treating, moving, storing, and discharging this water. Discussion to include design and implementation of non-permanent infrastructure plus a special focus on temporary water treatment facilities including water quality sampling, equipment selection, operation and maintenance, risk mitigation, action response plans, environmental monitoring, troubleshooting, and demobilization.

3:45 PM

Advancing From Modeling to Real-World Decision-Making for Enhanced Water Management in Mining

R. Valdes Pineda; Piteau Associates, Tucson, AZ

Effective surface and groundwater management in mining environments requires innovative solutions derived from advanced modeling techniques. This presentation explores the fundamental principles and practical applications of surface and groundwater modeling to address these challenges. Focusing on real-world examples, it demonstrates how simulations from these models are utilized to solve complex water management issues. By transitioning from theoretical models to practical decision-making, this approach highlights the critical role of accurate and dynamic models in developing sustainable and efficient water management strategies. The session offers valuable insights into the impact of these techniques on improving mining operations.

TUESDAY, FEBRUARY 25 AFTERNOON

ENVIRONMENTAL: RECLAIMING THE PAST: STRATEGIES FOR MANAGING ABANDONED MINE LANDS

Room 103

2:00 PM • Tuesday, February 25

Chairs: ***A. Withers****, AECOM*
L. French*, WSP USA, Inc., Lander, WY*
L. Vecchiarelli*, Arcadis US Inc, Syracuse, NY*

2:00 PM

Introductions

2:05 PM

Cleaning Up Abandoned Mines Without Funding

B. Hilscher and V. Dybounov; ABH Engineering, Vancouver, BC, Canada

Historically, thousands of mines across America have shutdown with waste and low grade stockpiles left in the open. These piles often leach acid and metals into local creeks and water tables. By applying today's technology, we can remove the rocks containing sulphides and dispose of them safely. The fact that metals such as gold, copper, lead, and zinc usually concentrate into the sulphide waste concentrate, means the disposal of this concentrate can be highly profitable. These metal credits allow cleanup, water treatment, recontouring, and reforestation of hundreds of abandoned legacy sites at no cost to governments. This presentation will review technology, implementation as well as industry results.

2:25 PM

Pit Lakes: Global Liabilities or Sustainable Mining Legacies?

Z. Iranmanesh and B. Abbasi; Mining and Metallurgical Engineering, University of Nevada, Reno, Reno, NV

Pit lakes present both significant risks to ecological and human environments and socio-economic opportunities and benefits. However, the processes influencing these risks and opportunities are not well understood, and even when knowledge is available, its application is often inconsistent due to the lack of a uniform methodology. Life Cycle Assessment (LCA) has been recognized as a valuable tool for environmental assessment and land planning. Nevertheless, the complexity involved has prevented the standardized LCA framework from being used to assess the ecological impacts of pit lakes. This study addresses three major methodological challenges: (1) defining functional units, (2) selecting boundaries, and (3) refining the life cycle impact assessment phase to provide indicators for pit lake planning. The proposed framework aims to evaluate the sustainability of pit lakes as a mine closure option and to identify potential hot spots before new operations commence. This methodology was applied to case studies in Europe, Australia, and North America to investigate the sustainability of current approaches to remediate abandoned pit lakes.

2:45 PM

Effectiveness of Hardrock Abandoned Mine Land Remediation for Surface Waters

J. Elliott; Watershed Improvement, AZDEQ, Parks, AZ

According to USGS data, Arizona is #4 in the nation for AML features with various features impacting public safety, public health and the environment. More than 1300 of these features are within 2 miles of currently impaired surface waters as defined by the federal Clean Water Act. Heavy metals are one of the top impairments in the state. To mitigate the impact of heavy metals from AMLs in surface waters, the Arizona Department of Environmental Quality (ADEQ) is implementing remediation with a patchwork of available funding and through various Sections within the agency in collaboration with industry, private landowners, federal and state agencies. This work has led to a reduction of heavy metals in multiple streams in Arizona. Some of these streams are no longer impaired for heavy metals. ADEQ and their partners have completed this work through the application of various technology and methods associated with AML remediation. This presentation will cover the engineering controls implemented at multiple AML projects and review the data pre- and post-remediation that demonstrate the effectiveness of the ADEQ approach to hardrock AMLs.

3:05 PM

Carissa Gold Mine: Making an Abandoned Mine into a State Park

G. Robson[1] and B. Drake[2]; [1]AML, WYDEQ, Lander, WY and [2]Respec, Cheyenne, WY

Wyoming's largest gold boom occurred in the late 1800s in the South Pass Mining District. The boom peaked at the Carissa Gold Mine, the largest gold operation in the State at this time. Eventually, it became apparent that the mine was not profitable, and operations were shut down quickly. Left behind were the historic remnants of 20th-century mining operations. In the late 1990s, the WYDEQ-AML in coordination with Wyoming State Parks, hired RESPEC consultants to evaluate the site to prioritize the dangerous features and provide recommendations on mitigation techniques. Over nearly two decades, dozens of projects were undertaken to mitigate hazards including cleanup of dangerous mine-related chemicals, mine opening safeguarding, tailings encapsulation, structural stabilization, and overall site improvements to create a State Park that sees thousands of visitors. The entirety of the AML's 19 years of work is a testament to the program's commitment to public service and was achieved with multiple parties including WDEQ/AML, the State of Wyoming, Wyoming State Parks, Wyoming State Historic Preservation Office, and numerous Wyoming contractors and consultants who performed the work.

3:25 PM

25-027

Dual-Purpose Mine Land Rehabilitation: Integrating Environmental Restoration and Sustainable Use for Tourism and Agriculture in Cajamarca

M. Mendoza Tirado and F. YSLA QUIROZ; CAJAMARCA, Society for Mining, Metallurgy & Exploration, Cajamarca, Cajamarca, Peru

This proposal, based on the CIEMAN Cajamarca—Hualgayoc initiative, focuses on "Transforming Abandoned Mine Lands' ' We aim to study and assess the feasibility of an innovative rehabilitation method. Contaminated soils will be moved from the upper to the lower site, encapsulated with geosynthetic barriers, and covered with topsoil. The decontaminated upper area will be used for planting trees and large-stemmed plants for hiking and tourism, while the lower encapsulated area will support livestock and short-stemmed crops. This study will evaluate the economic viability and multi-use potential of this technique, promoting sustainable land recovery in Cajamarca, Peru.

3:45 PM

25-083

Spider Excavation Pilot Study for Removal Action Planning at Abandoned Uranium Mines Sites

J. Laggan; Freeport-McMoRan, Phoenix, AZ

Significant quantities of waste rock at abandoned uranium mine (AUM) sites in the western United States require removal from steep slopes exceeding 45 degrees in remote locations. This prevents the use of traditional excavation equipment and poses significant challenges for safe, effective material removal. A pilot study was conducted using a spider excavator to demonstrate the feasibility of removing waste rock and transporting it to areas where conventional equipment could be employed. The spider excavator was evaluated for its effectiveness in excavation, material movement and control, container usage, dust mitigation, and ensuring human health and environmental safety. The study established constructability and engineering parameters for implementing spider excavators in these challenging environments. Key outcomes include the preservation of existing vegetation, improved waste movement control, and enhanced safety measures for workers, nearby residents, and the environment.

TUESDAY, FEBRUARY 25 AFTERNOON

ENVIRONMENTAL: TAILINGS REPROCESSING FOR RESOURCE RECOVERY: FEASIBILITY, CHALLENGES, AND BENEFITS

Sponsored by: ARCADIS

Room 105

2:00 PM • Tuesday, February 25

Chairs: ***J. Provolt***
M. McCaughey

2:00 PM

Introductions

2:05 PM

A Survey of Critical Element Leaching From Copper Tailings

J. Gillow[1], S. Ulrich[2] and J. Schill[1]; [1]Arcadis, Highlands Ranch, CO and [2]Arcadis, Highlands Ranch, CO

Tailings from copper ore processing contain metals at concentrations that in the recent past may have been deemed uneconomical for recovery, but due to an increased need for copper and critical elements (e.g., cobalt, nickle, tellurium, rare earth elements) for advanced energy technologies, these tailings have become an attractive unconventional

resource. Recent technical literature on critical element recovery by leaching from copper tailings was reviewed and the key takeaways are: 1) full scale implementation of critical element recovery is limited, 2) principle technologies evaluated at the lab bench and pilot scale include atmospheric and pressure leaching using sulfuric acid, and 3) innovative technologies include bioleaching and leaching with alternative reagents (Fe/Cu chlorides, neutral and alkaline pH lixiviants) and inclusion of oxidizing agents, and 4) further size reduction, and/or flotation, is often used to preconcentrate target minerals. We expect interest in pursuing critical element leaching from copper tailings will increase in the future, with innovation combining preprocessing (e.g., flotation) with leaching technologies to drive more full-scale implementation.

2:25 PM

Recovery of Gold Mining Tailings Sands for Clinker Manufacture

O. Restrepo Baena and N. Jaramillo Zapata; Materials and Minerals, Universidad Nacional de Colombia, Medellín, Antioquia, Colombia

The objective of this work was to propose a methodology using waste sands from gold mining for clinker production, through the preliminary characterization of the material and its subsequent evaluation to identify the content of contaminants and harmful materials for clinker production. In the study area, four samples were collected and subjected to moisture percentage tests, granulometry, fire assay, XRD, XRF, SEM, and Hg and cyanide content. Subsequently, the obtained results were evaluated to identify the content of contaminants in the samples to proceed with their elimination through thermal treatment methods such as retort roasting and muffle roasting. Afterward, the specimen with the smallest grain size and the highest concentration of Fe, Si, and Al, elements necessary for clinker production, was selected from all these samples. The selected sample was again characterized by XRF and DTA to proceed with its sintering under different temperature ramps. The obtained results allowed for understanding the composition of the waste sands and their behavior in the sintering process, as well as evaluating their suitability for clinker production.

2:45 PM

Critical Metal Recovery from CO2-reactive Silicate Mineralsusing Mineral Carbonation

K. Ofori, L. Pan, K. Huang and W. Hanson; Michigan Technological University, Houghton, MI

Ultramafic ores, such as olivine, contain elevated concentration of critical metals including nickel. In this work, we developed an integrated critical metal recovery and CO2 sequestration process. Bothnickel and cobalt from olivine-rich feed materials were successfully leached into the aqueous phase with the addition of complexing agents during the direct ex-situ hydrothermal mineral carbonation reaction. Various physical and chemical activation techniques were employed, achieving over 80% metal recovery and carbonation efficiency within 8 hours. Roles of different operating parameters will be discussed, including pressure, temperature, and chemical additives.

3:05 PM

Assessing the Critical Mineral Potential of Arizona's Copper Mine Tailings

I. Barton[2], J. Mizer[3], D. Riley[2], M. Barton[1], C. Edwards[4], B. McKeeby[4], D. Chapline[4] and J. He[2]; [1]UA Lowell Institute for Mineral Resources, Tucson, AZ; [2]Mining & Geological Engineering, University of Arizona, Tucson, AZ; [3]Mining & Geological Engineering, University of Arizona, Tucson, AZ and [4]Astronomy and Planetary Science, Northern Arizona University, Flagstaff, AZ

Arizona's 100+ years of copper mining have resulted in roughly 17.5B tons of tailings held around the state, with 200M tons added each year. These deposits of pre-ground rocks contain elevated concentrations and large volumes of some metals and minerals on the US critical list. The amount of Ti, Mn, and many other metals moved in porphyry copper mining each year equals or exceeds annual global demand. However, the concentration, mineralogy, and extractability of most are unknown. Here, we present preliminary results from a new research project aimed at systematically assessing Arizona copper mine tailings as critical metal resources. The project is evaluating tailings using hyperspectral imaging, thermophysical and GPR scans, and chemical and mineralogical characterization. This is the basis for metallurgical testing to quantify recoverability, followed by techno-economic analysis to identify what critical metals are economically recoverable under what circumstances. This talk will summarize the typical mineralogy and chemical composition of Arizona copper mine tailings from different deposit types and the potential prospects for conventional and unconventional extraction.

3:25 PM

Design Concept for Recovering Resources From Pyrrhotite Tailings

J. Gusek; Jim Gusek MIW Consultant LLC, Lakewood, CO

Recovering resources from tailings offers many design challenges. However, reducing environmental risks and creating a new revenue stream from a current liability are attractive goals requiring innovative ideas. In this paper, a design concept for recovering copper, nickel, zinc, and REEs from a pyrrhotite TSF would be presented. The key processes in the proposed plant include: biological oxidation of the pyrrhotite in a deep vertical shaft bioreactor (DVSB), a process pioneered in the 1980's but never embraced by the mining industry; the passive oxidation of dissolved iron in an iron terrace; the recovery of copper, nickel, and zinc in a passive biochemical reactor (BCR); the recovery of elemental sulfur in a sloping sand bed filter; and the final passive polishing of the effluent where REEs would be adsorbed to manganese oxide. The DVSB process has not been used for sulfide oxidation but it entails a small footprint, minimal energy consumption, high static pressures that should accelerate reaction kinetics, and ease of expansion. Subsequent passive processes are also energy and cost efficient.

3:45 PM

The Plural of Anecdote is Not Data: The Case Study Approach to Tailing Reprocessing

J. Trouba; Independent, Saint Paul, MN

Tailings have been and will continue to be successfully reprocessed for the benefit of the environment as well as economic gain. In spite of, or perhaps because of these successes, sweeping generalizations are applied to the opportunity that tailings reprocessing presents for mineral supply and waste minimization. These generalizations when inappropriately applied contribute to undue criticism of mining companies on one hand, and poor investment decisions on the other. In this presentation, tailings reprocessing case studies are evaluated against historical data to contextualize successful projects as anecdotes. Successful reprocessing reflects advantageous conditions, as such advantages are inherently tied to the project selection. Case studies provide valuable information, but each site must still be uniquely considered. Data discussed includes historical recovery rates, metal prices, and technology, as well as the role of current status of the tailings facility. This presentation provides a framework for preliminary evaluations of tailing reprocessing that while obvious to some, is often absent from discussions on tailings reprocessing potential.

TUESDAY, FEBRUARY 25 AFTERNOON

HEALTH & SAFETY: NORA THE FUTURE OF HEALTH AND SAFETY IN AUTOMATED AND ROBOTIC MINES

Room 109

2:00 PM • Tuesday, February 25

Chairs: ***L. Saperstein****, Missouri University of Science and Technology, Nantucket, MA*
W. Reed*, CDC-NIOSH, Pittsburgh, PA*

2:00 PM

Introduction

2:05 PM

Eliminating Barriers for the Implementation of Automation in the Mining Industry: Preliminary Findings

K. Luxbacher[1], M. Savit[7], D. Kanagy[4], M. Levier[3], H. Miller[5], B. Miller[2], M. Moats[6] and R. Parratt[4]; [1]Mining and Geological Engineering, University of Arizona, Tucson, AZ; [2]Lewicki and Associates, Littleton, CO; [3]K. Marc Levier & Associates, Inc, Denver, CO; [4]SME, Denver, CO; [5]Mining Engineering, Colorado School of Mines, Golden, CO; [6]Materials Science and Engineering, Missouri S&T, Rolla, MO and [7]Predictive Compliance LLC, Denver, CO

Automation is revolutionizing the mining industry and has the potential to substantially improve worker health and safety while simultaneously improving efficiency and sustainability of mining operations. Companies are incentivized in several ways to incorporate automation, but these incentives may be eroded by regulatory or other barriers that impair implementation. To encourage the rapid integration of new technology into U.S. mining operations and to promote worker safety, better resource utilization, and greater economic utility, a comprehensive review and analysis of the regulatory framework and external factors influencing mine/plant development and operations is being undertaken in order to characterize the potential barriers that exist and the causation factors that govern why these barriers exist and how they evolve. Additionally, this work will provide an understanding of regulatory approaches, the political/social risks associated with innovation, and research that could enable high levels of automation in U.S. mines and processing plants to occur.

2:25 PM

The Journey to Safety Outcomes in an Autonomous Mine

M. Murphy; SME, Dunlap, IL

As autonomous mining has positively impacted mining productivity over the past ten plus years, it has also had a significant impact on mine safety. There are many elements to why autonomous mining impacts safety. This paper describes the key elements required to achieve the safety outcomes ranging from the design stage through simulation and validation in the lab to the critical step of real world testing at a proving ground. At site, the interaction of people and processes with the autonomous machines are another critical step in ensuring safe outcomes. This paper also describes the importance of people interaction and process on safety with the lessons learned over the past decade plus.

2:45 PM

Robotic System for Situational Awareness in Hazardous Mine Conditions

R. Mukherjee; Jet Propulsion Laboratory, Pasadena, CA

Situational awareness to support search and rescue operations in mines after any kind of real or suspected anomalous events are a significant challenge. There are potentials for presence of high concentrations of methane gas, fires, roof falls, water breaks among other hazards. To mitigate the safety concerns and other challenges for these operations, we are developing a robotic system to be certified to be operational in Zone 0 and Zone 1 areas, as defined in the IEC 60079 series of standards. Frequently referenced as "explosion proof", it refers to the techniques used to ensure that the robot will not be an ignition source in hazardous environments. Features include 10km total distance travelled with up to 10 hours of operations; traversing extremely challenging terrains including positive and negative obstacles, CMU blocks, roof-falls, high slopes, mud etc.; pitch dark operational conditions; onboard tether management system for communications among others. We also explored use of additive manufacturing in this context. In this paper, we present the progress made on this robotic system, including results from initial prototypes and independent third-party testing results.

3:05 PM

Longwall Command and Control: REST API—Remote Management

C. LeViere; Controls and Automation, Komatsu (Joy), Portersville, PA

Komatsu's Longwall Command and Control (LCC) software suite is a cross-platform / cross-browser NodeJS & ReactJS designed web-app delivering high-level automated feature control via live data, interactive graphs, and REST API. The LCC allows operators to reference several face-wide profiles such pan heights, pan pitch, and face survey to steer the longwall via REST API commands to the Faceboss Control System. The deployment of this software suite drives automation usage and thus increases consistency across shifts and decreases the need for live tele-remote control.

3:25 PM

Design and Manufacture of an Outby, Single Module, Electric, Automated, Roof Bolter

R. Burgess; R&D, JH Fletcher, Huntington, WV

The coal mining industry faces significant safety and efficiency challenges with manual roof bolting, which exposes workers to hazards such as dust, mechanical risks, and ergonomic strain. Despite over fifty years of advancements in drilling technology, automated roof bolters have not been widely adopted in coal mining, primarily due to concerns over their reliability and productivity. This project aims to address these issues by developing an automated roof bolter module for U.S. coal mines. Designed by JH Fletcher & Co., the bolter will operate remotely from an enclosed cabin, thereby reducing operator exposure and physical strain. It will handle both resin and mechanical bolts using a carousel and pneumatic system for resin injection. The project involves design, assembly, and field testing phases, focusing on metrics like drill cycle times, bolt installation rates, and machine availability. Collaboration with NIOSH will provide insights into dust and noise levels for the operator. Future plans include adapting the technology to meet MSHA standards for gassy environments. The aim is to enhance safety and productivity, paving the way for further innovations in mining technology.

3:45 PM

Development of a Remote Control Mine Rescue Support Machine and the Design, Construction, and Revision of the Prototype to Achieve MSHA Certification—A Manufacturer's Perspective

J. Rohrbaugh; Rohmac Inc, Mt Storm, WV

CDC-NIOSH, MSHA-MEO, and other representatives of the mine rescue community engaged in a collaborative effort to develop new technology and equipment that supports mine rescue and recovery operations. Based upon this research, a prototype radio-remote control compact track loader was designed and built, to improve efficiency and safety for mine rescue teams by reducing the physical labor involved. Next steps included design refinement and application for MSHA "permissible" approval. Aside from meeting stringent XP requirements, challenges occur where new technology does not fit existing regulations, requiring new approaches to ensure that safety is not compromised.

4:05 PM

In-Mine Autonomous Shuttle Car

H. Mearns; Engineering, Francis Enterprises Inc, Westover, WV

Shuttle cars are crucial for room and pillar coal mining, transporting raw coal from continuous miners at the face to conveyor belt feeders. Miners face many hazards while operating shuttle cars manually, including poor visibility and frequent collisions with mine infrastructure. Remote operations would solve many safety hazards operators face by removing them from the environment. Due to advancements in communications and remote-control technologies, the autonomous operation of shuttle cars is now feasible. A remote steering control system was integrated into a modified shuttle car using automotive-style PLCs, enabling remote

operation of steering, acceleration, braking, and conveyor functions as well as future autonomous decision-making. Key challenges include fusing the data from an adequate combination of sensor types to quantify the environment while meeting MSHA requirements and ensuring reliable real-time data flow. Operational challenges include aligning the shuttle car with feeders and miners, proper coal loading and unloading, addressing dynamic mining conditions like loading in motion, and interfacing with proximity detection of in-mine personnel.

TUESDAY, FEBRUARY 25 AFTERNOON

HEALTH & SAFETY: TOTAL WORKER HEALTH PANEL DISCUSSION: CONSIDERATIONS FOR ENHANCING SAFETY IN MINING

Room 108

2:00 PM • Tuesday, February 25

Chairs: ***M. Savit****, Husch Blackwell, Denver, CO*
L. Guasta*, Golden, CO*

2:00 PM

Introduction

2:05 PM

Health & Safety: Total Worker Health Panel Discussion: Considerations for Enhancing Safety in Mining

M. Savit[1] and L. Guasta[2]; [1]Predictive Compliance LLC, Denver, CO and [2]NCS, Parker, CO

This panel discussion focuses on the concept of Total Worker Health, integrating workplace safety and health with broader well-being initiatives. The session will feature a combination of expert presentations, interactive discussions, and Q&A, providing insights into current strategies and emerging trends in promoting comprehensive worker health. Additionally, attendees are encouraged to participate in the "Health & Safety: Impairment at Work: Fatigue, Substance Use and Mental Health" session on Tuesday morning, as we will explore and discuss key technical presentations from that session. This panel aims to foster an in-depth dialogue on the holistic approach to worker health, addressing both physical and mental aspects in the workplace.

TUESDAY, FEBRUARY 25 AFTERNOON

HISTORY OF MINING II

Room 110

2:00 PM • Tuesday, February 25

Chair: ***G. Luxbacher****, NIOSH, Prosper, TX*

2:00 PM

Introduction

2:05 PM

The History Copper Mining and Smelting in Shasta County California

S. Shoemaker; Metals, John T Boyd Company, Tooele, UT

Beginning as early as the 1860s, copper deposits of economic value had been identified in Shasta County California. Because of difficulty in treating this material, it was not until 1894 when large scale development and extraction of the County's copper resources commenced. Over the next quarter-century, the copper output of the Shasta County mines rivaled the output of many other well-known copper producing areas including Montana and Arizona. This period of heavy development and mining came at a significant environmental cost to Shasta County and resulted in some of the first air quality litigation in the United States. This paper will describe the development and history of the principal copper operations in Shasta County as well as the environmental legacy associated with it.

2:25 PM

History of the Burgin Mine and Its Shutdown in 1977

B. Ott; Tintic Consolidated Metals Division, Osisko Development, Eureka, UT

Osisko Development is a North American gold development company focused on past-producing mining camps located in mining friendly jurisdictions with district scale potential, some of which have storied pasts. Osisko's 100% owned Burgin Lead-Zinc-Silver Mine in Utah's historic Tintic mining district produced from 1971 to 1977 before abruptly shutting down. A combination of mine dewatering costs and depressed metals prices rendered the mine unprofitable, however, the complete story is more complex and serves as a lesson to today's mining stakeholders. The Cariboo Quartz Gold Mine is ostensibly only similar to Burgin in that Osisko is also the 100% owner of this storied mine, however, examining the shutdown in 1945 illustrates similar underlying causes. These cardinal challenges are still relevant in mining and metals today.

2:45 PM

Mountain Pass, California REE Mine; Perspective on its History and Economics

A. LEVY; Alan Levy and Associates, Sherman Oaks, CA

The Mountain Pass (MP) rare earth carbonatite mine in southeastern California has been owned by three different entities including Unocal-Molycorp (UOC-M) and is currently owned by Mountain Pass Materials. In addition to rare earth production at MP, UOC-M had an extensive worldwide portfolio of exploration properties, some of which are currently in production or potential production. A comparison of tonnage and grade of these properties informs the economics of all rare earth production. Alternating periods of cooperation and conflict between the owners of MP and non-U.S.entities have often defined the economics of world rare earth production.

3:05 PM

25-059

Mining History in the Black Hawk Mining District, Burro Mountains, Southwestern New Mexico

V. McLemore; NMBGMR/NM Tech, Socorro, NM

The Black Hawk district in NM hosts an unusual type of deposit: arsenide 5-element veins. These deposits are Ag-Co-Ni-Bi-As-bearing carbonate veins with local concentrations of U, Pb, Zn, Sb, etc. They are high-grade (1000's g/t Ag), but low tonnage (<1 Mt) and difficult to find. By 1881, claims were staked and a town developed. It is estimated that >$1,000,000 was produced in 1883-1893, when Ag prices dropped due to the 1893 Ag panic. Solid Silver Mining Co. produced $600,000 from the Black Hawk mine; one car load contained $28,000 worth of silver! The town of Black Hawk grew to 125 population by November 1883. By the end of 1893, the town was vacant; nothing remains. The district was idle until 1916, and the mines operated sporadically since because of lack of available capital, water issues, and difficulty in finding ore shoots. The area is a favorite for mineral collectors. Tungsten was found in the district in 1935 in pegmatites. Metal production from 1881-1960 is estimated as 3,000 lbs Cu, 1,000 oz Au, 1,286,000 oz Ag, and 4,000 lbs Pb. In addition, 10,542 short tons of 2.7-71 % WO ore and 615 short tons of fluorspar ore have been produced.

3:25 PM

Historic Critical Mineral Mines and Occurrences in Northern Appalachia: A Review

B. Arnold, T. Gangadari, S. Pisupati, J. Gill, I. Penrod, X. Cao and Z. Brown; The Pennsylvania State University, University Park, PA

The Consortium to Assess the Northern Appalachian Basin Resource Yield for CORE-CM (carbon ore, rare earth elements, and critical minerals) project sponsored by the US DOE CORE-CM initiative reviewed historic locations of critical mineral mines and occurrences in the basin while assessing many current opportunities for the recovery of these key elements. We provide a review of historic mines and occurrences of graphite, rare earth elements, and titanium and highlight published work on battery elements. The review suggests that the basin has a well proven history of providing critical minerals to US industry.

TUESDAY, FEBRUARY 25 AFTERNOON

INDUSTRIAL MINERALS & AGGREGATES: CRITICAL AND BATTERY MINERALS II

Room 106

2:00 PM • Tuesday, February 25

Chairs: ***R. Dube****, Metso Outotec USA Inc, Centennial, CO*
R. Jain*, Outotec USA Inc., Savage, MD*

2:00 PM

Introduction

2:05 PM

China, the Democratic Republic of the Congo, and Artisanal Cobalt Mining From 2000 Through 2020

A. Gulley; U.S. Geological Survey, Reston, VA

Despite extensive research on artisanal cobalt mining, fundamental questions about its production remain unanswered. Here artisanal cobalt production, processing, and trade are estimated. The results show that artisanal production grew from 1,000 to 2,000 t in 2000 to 9,000 to 11,000 t in 2020 (with a peak of 17,000 to 21,000 t in 2018). Artisanal production's share of world and DRC cobalt mine production peaked around 2008 at 18 to 23% and 40 to 53%, respectively, before trending down to 6 to 8% and 9 to 11% in 2020, respectively. Artisanal production was chiefly exported to China or processed within the DRC by Chinese firms. An average of 72 to 79% of artisanal production was processed at facilities within the DRC from 2016 through 2020. As such, these facilities may be potential monitoring points for artisanal production and its downstream consumers. This finding may help to support responsible sourcing initiatives and better address abuses related to artisanal cobalt mining by focusing local efforts at the artisanal processing facilities through which most artisanal cobalt production flows.

2:25 PM

Beneficiation of Lithium-Bearing Sedimentary Claystones Using A Lab-Scale Falcon Concentrator

S. Arthur, E. Mends, A. Tita, J. Thella and P. Chu; Mining and Metallurgical Engineering, University of Nevada, Reno, Reno, NV

Nevada's sedimentary claystones are a potential lithium source, but their processing is hindered by the high carbonate content, like calcite, which increases acid use and results in the generation of pure carbon dioxide during leaching, leading to economic and environmental issues. Removing carbonate gangue from the claystones prior to hydrometallurgical processing is critical; hence, this study explores a novel approach involving falcon gravity concentration, attrition scrubbing, and chemical dispersion to remove calcite from different claystone types- illitic, calcium-rich smectite, and magnesium-rich smectites. The results indicate the viability of this beneficiation technique for the clays, with about 84% lithium recovered and 73% calcium removed in the calcium-rich smectite, while the illite and magnesium-rich smectite recorded separation efficiencies of 45% and 35% for the illite and the magnesium-rich smectite respectively.

2:45 PM

Fluorspar's Future in Batteries: But Can it Achieve "Critical Mass"?

M. O'Driscoll; IMFORMED Industrial Mineral Forums & Research Ltd, Leatherhead, UK

Fluorspar is essential as the primary feedstock for hydrofluoric acid (HF) manufacture (the precursor to a wide range of fluorochemicals), and is vital in steel and aluminium production. However, its "criticality" has been raised markedly in recent years owing to its projected volume demand for use in Li-ion batteries. As a result, fluorspar has made the Critical Raw Material lists of the EU, USA, and Australia. But commercially developed world sources of fluorspar are limited, and the industry has lost production capacity in recent years, leading to a somewhat tight supply situation already. The USA has no established domestic source of fluorspar, and is 100% net import reliant for its fluorspar requirements. While the St Lawrence mine in Newfoundland is yet to restart operations, a new US fluorspar mine is progressing in development in Utah, and other new and alternative sources are being evaluated in Europe, South Africa, Mongolia, and Australia. This paper will review how and why fluorspar is in demand for Li-ion batteries, the global fluorspar supply situation, and emerging new sources which have the potential to meet this new demand market for fluorspar.

3:05 PM

Assessment of Potential Lithium Source From Abandoned Oil Wells in Nigeria

L. Ismail and V. Akinlosose; Mining Engineering, Federal University of Technology, Akure, Ota, Ondo, Nigeria, Nigeria

Lithium is one key element in renewable energy storage for solar and wind power towards clean energy utilisation, which helps to reduce air pollution from transportation. Lithium deposits have been found to occur majorly in pegmatite rock and brine with an abundance of 0.0018% in the earth's mineral resources. Lithium occurring in brine formation includes lakes, groundwater reservoirs, salars, oil fields, and geothermal brine, with more than 70% of the world's tonnage of lithium exists in brine sources. The Prometheus GAIA multi-criteria decision analysis framework is used in this study to assess the viability of lithium brine extraction in abandoned Nigerian oil wells. Significant judging criteria are used to assess and compare the economic viability of alternative lithium sources, resulting in a comprehensive evaluation of potential lithium extraction from abandoned oil wells. Result shows that with the numbers of operated wells drilled for oil and gas production, there are 698 abandoned wells while focusing on plugged and abandoned wells in Nigeria with leading numbers by Shell possessing 223 identified dry wells, which may show better prospects for the source of lithium brine.

3:25 PM

Petrography, Geochemistry, and Critical Minerals Potential of Proterozoic Ultramafic and Granitic Rocks in the Zuni Mountains, New Mexico

B. Hunt, V. McLemore, E. Owen and N. Hurtig; New Mexico Tech, Socorro, NM

The Zuni Mountains mining district is located in Cibola County near Grants, northwest New Mexico and includes an area of uplift exposing Proterozoic igneous and metamorphic rocks. The district contains sedimentary-hosted Cu deposits, fluorite veins, as well as other deposits and has been mined for a variety of commodities including copper, fluorite, and uranium. With the increased demand for critical minerals, the NMBGMR has been tasked by the USGS with evaluating the critical minerals potential of the Zuni Mountains district. The focus of this study is to characterize the granitic and ultramafic rocks using optical petrography, whole rock geochemistry, and electron microprobe analysis (EMPA). Results from whole rock geochemical analyses of Zuni Mountains granitic and ultramafic rocks show values of Ni, Co, and Cr up to 1000 ppm, 140 ppm, and 2180 ppm, respectively. The presence of these elements may indicate the potential for platinum group elements (PGE) in the district. Samples that are

elevated in Ni, Co, and Cr will be reanalyzed for PGE. Additional optical petrography and EMPA will aid in identifying the mineral phases that host critical minerals such as Ni, Co, and Cr.

3:45 PM

25-038

Geochemistry and Critical Mineral Potential of Stream Sediments from the Zuni Mountains, New Mexico

E. Owen and V. McLemore; Bureau of Geology and Mineral Resources, New Mexico Institute of Mining and Technology, Socorro, NM

The Zuni Mountains, located in Cibola County, New Mexico is an uplifted area that exposes Proterozoic igneous and metamorphic rocks overlain by Permian and younger sediments. Sedimentary-hosted Cu deposits and fluorite veins in the district have recorded production, but other deposits exist. Proterozoic ultramafic rocks may host Ni and PGE. A recent regional stream sediment survey collected 76 samples as part of an exploration geochemistry course at New Mexico Tech with the goal of assessing the critical minerals potential of the district. Whole rock and trace element chemistry of the sediment samples (<2 mm) show a variety of critical minerals possibly worthy of future targeted exploration including up to 700 ppm As, 2100 ppm Ba, 26 ppm Bi, 25 ppm Co, 640 ppm Cu, 145 ppm Ni, 110 ppb Sb, 170 ppm V, and 500 ppm Zr. Positive correlation between Bi, As, Cu, and Sb suggest that these critical minerals are found together within copper veins related to shear zones in the district. Samples collected from streams that drained outcrop of mafic and ultramafic rocks were found to generally contain more Ni, Co, and V. Samples elevated in Ni will be reanalyzed for PGE.

4:05 PM

Efficient Separation of Lithium-Titanate Oxide (LTO) Anode Using High Centrifugal Forces

U. Kar, S. Arthur, S. Hussaini and P. Chu; Mining and Metallurgical Engineering, University of Nevada, Reno, Reno, NV

The Falcon gravity concentrator (FC), which operates on subjection of materials to high centrifugal forces, is employed to separate the lithium-titanate oxide (LTO) anode and cathode active materials (CAMs). The investigations, which involved varying the particle size and FC bowl type, with/without binder removal and dispersant addition, yielded a maximum of 55% LTO recovery into the light fraction, while about 80% of the CAM was recovered into the heavy fraction. Findings from this study indicate the effectiveness of the FC for the separation; hence, recycling of battery materials and implementing a comprehensive gravity circuit can potentially optimize LTO recoveries.

4:25 PM

A Comprehensive Study on the Leaching Characteristics and Mechanisms of Nickel and Cobalt From Olivine

S. Ghaderi, B. Ji and W. Zhang; Mining and Mineral Engineering, Virginia Polytechnic Institute and State University, Blacksburg, VA

This study investigates the leaching behavior of Mg, Si, Fe, Ni, and Co from olivine using hydrochloric acid. Ni and Co, substituting for Mg or Fe in the olivine lattice, were efficiently leached 89.9% and 90.8%, respectively. The leaching kinetics, analyzed using the shrinking particle model, reveal two stages: film diffusion and chemical reaction control throughout the initial 10 min, followed by chemical reaction control. The findings are supported by activation energy values and morphological analysis of solid residues. Our study offers valuable insights into maximizing extraction efficiency and minimizing environmental impacts, enhancing nickel and cobalt recovery from ultramafic ores.

TUESDAY, FEBRUARY 25 AFTERNOON

MINING & EXPLORATION: GEOSCIENCES: INTERDISCIPLINARY ORE CONTROL: CASE STUDIES ON VALUE ADDED THROUGH TEAMWORK

Room 507

2:00 PM • Tuesday, February 25

Chairs: ***J. Baar****, Gastonia, NC*
A. Ebbers*, Maptek*

2:00 PM

Introduction

2:05 PM

Drawpoint Closure Criteria for Decision-Making Process in Deep Mill Level Zone (DMLZ) Mine, PT. Freeport Indonesia

R. Kayadoe[1], H. Fikri[1], R. Prasetyo[3] and D. Haflil[2]; [1]UG Cave Management, PT. Freeport Indonesia, Tembagapura, Papua, Indonesia; [2]UG Geology, PT. Freeport Indoensia, Tembagapura, Papua, Indonesia and [3]UG Engineering, PT. Freeport Indonesia, Tembagapura, Indonesia

PT. Freeport Indonesia is currently mining the fourth and deepest phase (1,500 m) of the East Ertsberg Skarn System (EESS) giant skarn and porphyry deposit, Deep Mill Level Zone (DMLZ) mine, through the panel caving method. The DMLZ mine is formed at the northern contact of large diorite intrusion and the southern synclinal flank of a deformed carbonate-rich sedimentary sequence. After the first undercutting initiation in 2015, the DMLZ mine ramped up to an 80,000 tons per day production rate in 2021 from 334 active drawpoints. As the copper equivalent value in some drawpoints is approaching cut-off grade (COG), a protocol must be set to evaluate and to determine when the drawpoints need to be closed. This paper describes the evaluation practices of determining the closure criteria based on economic aspects, such as grade performance and mining recovery, and to accommodate various technical considerations, ranging from the geological aspect (dilution and waste rock type) and cave management aspect (sequence of closure to avoid isolated draw). This paper also describes the decision-making process and the post-monitoring activity as the evaluation process for the drawpoint closure.

2:25 PM

Improving Local Resource Estimations Through Collaboration With Underground Mining Geologists Optimizing Mine Planning Practices

M. Rodriguez Escamilla, J. Espinosa and L. Snider; Geology, Nevada Gold Mines, Winnemucca, NV

The Mining Value Chain requires careful collaboration between all mining geology streams to maximize value creation through optimal mining plans. While daily ore control practices are focused on million-dollar ore versus waste routing decisions, it is locked in to optimizing mine plans to a fully characterized orebody geometry. To achieve this requires a deep sense of ownership across all streams and requires careful collaboration. This paper presents a case study from the Turquoise Ridge mine in Nevada showcasing the value of collaboration between detailed geological mapping and resource geologists with local refinements to geological interpretations and estimation domains, increasing the local accuracy of the block model that subsequently supports local mine design optimization within the one-to-two-year plans.

2:45 PM

Why Do We Let Reconciliation Affect Grade Control Value Recovered? Multi-Blast Grade Control Optimization

W. Hunt, B. Hall and L. Julian; Orica, Corinda, QLD, Australia

The edges of blasts are a challenging zone for grade control. It is nearly impossible to remove all previously blasted rock around the edges of a planned blast before the rock is blasted. Sometimes rock is intentionally left in front of a planned blast to prevent the free face from scattering across the pit. This blending requires reclassification, however this is presently difficult due to the constraints of existing grade control methods and reconciliation requirements. Presented in this paper is an innovative approach to grade control optimization and reconciliation using a predictive model and a digital twin. This approach is demonstrated on a series of recent blasts from a North American Gold mine. The quantity of rock that should have been reclassified when the blasts mixed and the financial implications of multi-blast grade control optimization in these blasts are presented and discussed. A suggested reconciliation methodology is then presented to meet the complex planning and tracking needs of production geology departments.

3:05 PM

Automating the 'Impossible'—A Case Study of Leveraging Interdepartmental Teamwork in a Complex Manual Workflow to Evolve a Push-button Scripted Improvement

R. Howell; Tech Services, Maptek, Kodiak, AK

Complex multi-departmental Production workflows can, paradoxically, be ideal for automation. In this case study, I describe software-agnostic methods and approaches I utilized to consolidate a convoluted & manual interdepartmental Grade Control block model update process into a standardized, meticulously validated, automated one. Upon implementation, the complete process, from receiving new assay data to having an estimated Grade Control block model in hand, takes either fewer than 3 hours with a full machine learning domain run, or under 30 minutes without a domain run—notably, requiring no further manual input after a few button presses, transformatively improving operational efficiency.

3:25 PM

We Got the Tonnes, Do We Know Where the Ounces Are?

I. Kadel-Harder; Nevada Gold Mines, Elko, NV

Stockpile generation is a part of mining. Stockpiles often exist as a solitary line on a spread sheet of tonnes, contained ounces, and constituents. When the time comes for them to be utilized, do we know where the ounces are located if we do not have the ability to run an entire stockpile? Mining companies collect copious amounts of data. Optimization is about linking your data systems together to be able to solve the needs of the business. Let's discuss the interlinking of those data streams to better manage our stockpiles and the people it takes to build a solution.

3:45 PM

Reconciliation in Open Pit Mines: Issues Explained and Solutions Recommended

A. Ebrahimi; Mining, SRK Consulting, Vancouver, BC, Canada

In open pit mines there is often a substantial difference between what is finally produced compared to what was originally planned. This difference is real and expected because our knowledge about the orebody is not complete until it is fully mined. The quality of reconciliation reports depends on the quality (and quantity) of measurements we take throughout the value chain. A good practice is to build numerous measurement points throughout the line of production so that the information can be tracked with confidence. Many numbers used in reconciliation reporting are estimates that come with an associated margin of error. It is important to minimize that margin of error through multiple measurements. Remember the only real number is the money in our bank account. While there are some general publications about reconciliation guidelines, there is no generic guideline for the mining industry. In the author's opinion, every mine must develop its own site-specific guideline that addresses the complexity of its orebody and the measurement capabilities installed on the site. And remember the reconciliation reporting in a mine is a process that needs time to mature.

4:05 PM

Interdisciplinary Ore Control Case Studies On Value Added Through Teamwork—Interactive Panel Discussion

J. Baar; Chief Production Geologist, Gastonia, NC

An interactive panel discussion exploring the case studies on value added through teamwork for ore control.

TUESDAY, FEBRUARY 25 AFTERNOON

INDUSTRIAL MINERALS & AGGREGATES: MINE DESIGN IN INDUSTRIAL MINERALS AND AGGREGATES II

Room 107

2:00 PM • Tuesday, February 25

Chairs: ***P. Jacomet****, Ohio Aggregates and Industrial Minerals, Gahanna, OH*
R. Mitra*, South Dakota Mines, Rapid City, SD*

2:00 PM

Introduction

2:05 PM

25-033

A Study of the Key Factors Affecting Roof Stability in Underground Stone Mine Subjected to High Horizontal Stress: A Case Study

G. Rashed and N. Evanek; NIOSH, Pittsburgh, PA

The high horizontal stress has been recognized as a key factor that affect the stability of roof in underground mines particularly when the immediate roof is weak or laminated rock. This paper explores the utilization of numerical models to gain more insight about the effect cap rock thickness, cutting sequence, and the driving direction with respect to the maximum horizontal stress on roof stability in underground stone mines. Numerical models were calibrated based LIDAR scans for roof falls at the study mine. The results of this study improve understanding of roof stability in underground stone mines subjected to high horizontal stress and help reduce the risk of roof falls.

2:25 PM

The Big Move: 2100 Tons on 432 Wheels

J. Renner, R. Knowles, D. Settles and S. Robertson; Titanium Technologies, The Chemours Company, Wilmington, DE

Chemours' Mission South Mine in southeast Georgia extracted titanium and zirconium mineral sands from 2014 through 2024 after which mining shifted 5 miles to the Mission North deposit. Pre-construction of the initial dig pit and wastewater treatment system began in early 2024, but mobile equipment and infrastructure couldn't be moved until mining finished in July. The most significant component of the move was transporting the wet mill which was accomplished in partnership with Mammoet, a heavy transport specialist. The 2100 ton floating mill was drydocked, lifted on self-driving dollies, and driven as a complete unit to the new location.

2:45 PM

Exploratory Data Analysis on Measure While Drilling Data in Mining Operations: A Precursor to Extracting Insights for Machine Learning Methods

J. Addy[1], I. Anafo[2] and E. Westman[1]; [1]Mining and Minerals Engineering, Virginia Tech, Blacksburg, VA and [2]Mining Engineering, University of Utah, Salt Lake City, UT

Exploratory Data Analysis (EDA) is vital in analyzing feature importance and trends in Measure While Drilling (MWD) data. This study uses EDA to examine distributions, outliers, and anomalies in MWD data to provide insights for optimizing Drill and Blast procedures. By studying drilling parameters, EDA helps identify patterns and trends, aids in feature selection and ensures data quality for subsequent advanced analytics. These insights enhance the development of predictive models, ultimately improving operational efficiency and safety. The ability to reveal hidden patterns and guide the modeling of machine learning algorithms makes EDA indispensable for data analysis.

3:05 PM

On Island Time—Challenging Mine Closure/Reclamation Planning Project in Paradise

M. Lee; Westward, Boerne, TX

On the small Island of Cayman Brac is a limestone quarry that provides quality aggregate for the isolated Cayman Islands. Located some 400 miles south of Miamai, FL and 150 miles northwest of Montego Bay, Jamaica, the islands have very few local resources, but aggregate is one of them. The limestone is mined and utilized on Cayman Brac and shipped to the Little Brac & Grand Cayman islands for use in infrastructure. A myriad of regulatory entities regulate mining activities and interim mine closure/reclamation plans are required every 5–7 years. The proposed Port Zeus Safe Harbor on Cayman Brac is currently in early planning stages and will directly affect the mine's closure/reclamation plans from this point forward. The mine office and maintenance complex and all current aggregate storage is in the proposed new development area and must be moved to the mine to accommodate the incoming harbor complex. Couple that with having a permanent plant, navigating a historic trail, limited blasting due to nearby residents and a highly regulated underground freshwater lens, and you have a challenge on your hands.

3:25 PM

Sectorization of Mined in Open-Pit Copper Mines

J. Mendoza; Mine Planning, Glencore, Arequipa, Peru

Currently, mining seeks to maximize the productivity of equipment, thus being able to extract a greater quantity of valuable metals to cover current demand, which is why the sectorization of mining areas based on the quality of the material, type of material, and destination of the material allows us to better distribute the movement of material. This article seeks to compare 2 cases: Initial Case represents continuous mining, without differentiating any type of characteristics of the deposit vs. Optimized Case, which seeks selective mining, in which the mining is sectorized according to the type of material and net characteristics of the deposit. When we divide the mining into sectors we can have greater control of the process, adapting the different geotechnical, geological, metallurgical and mining considerations to the operation, allowing us to have safer, more productive and efficient operations. This improvement allows savings in the transport of material, having a shorter fixed loading time, therefore a shorter cycle time, which will then be reflected in a greater shipment of material to the process, generating greater profits compared to the initial case.

TUESDAY, FEBRUARY 25 AFTERNOON

MINING & EXPLORATION: GEOSCIENCES: PRACTICAL GEOLOGIC MODELING CASE STUDIES OF COMPLEX OREBODIES

Sponsored by: BARR

Room 601

2:00 PM • Tuesday, February 25

Chairs: ***A. Gauer****, Maptek*
K. Alvarez*, I-80 Gold, Winnemucca, NV*

2:00 PM

Introduction

2:05 PM

Pregrob Modeling at the Nevada Gold Mines Crossroads Mine—Cortez Complex

D. Conn, M. Samson and T. Alvarez; Nevada Gold Mines LLC, Elko, NV

Current pregrob estimation techniques are not characterizing pregrobbing ore correctly, resulting in an overestimate of oxide material in the life of mine plan based on the current metallurgical data and production routing criteria. An analysis of limited geometallurgical and geochemical data shows that along the refractory-oxide (R-O) boundary is an approximately 50 foot wide 'Transitional Zone' where questionable 'lenses' of high pregrobbing material exist. It is difficult to relate these 'lenses' to any observable geological features for prediction of where the pregrobbing material will be. Current modeling methods for the R-O boundary have made significant overall improvements to the modelled surface by combining observations from logged core and RC chips with multivariate geochemical analyses. Samples determined to be pregrobbing based on AuCN:AuFA ratio, Sulfide Sulfur and Organic Carbon analyses show a strong correlation with Carbon logged as moderate or strong intensity. The resulting surface was compared against benches with dense blasthole samples and again shows a strong correlation, indicating this is an improved predictor for the R-O boundary.

2:25 PM

Breaking Down the Deposit: How Leeville's Large Scale Grade Control Models Reconcile Assays, Geochemistry and Ore Control Mapping for High Accuracy Modeling

A. Schreiner; Geology, Nevada Gold Mines, Elko, NV

Grade control models at Nevada Gold Mine's Leeville deposit seek to model more concise ore controls with higher accuracy modeling of mineralization than previous iterations. These models break down the deposit into large-scale models which are continually adjusted based on the latest drilling, and include geologic mapping of ore controlling structures unlike to deposit-wide models. This increase in available data requires increased scrutiny when reconciling assays, geochemistry and geologic mapping to create models with a high degree of accuracy for lithology, structure, and ore boundaries. Leeville's Grade Control models have created a template for how to manage this data.

2:45 PM

LSAM: A Holistic Approach to Re-Interpreting and Re-Modeling the Leeville Complex

C. Pollard; Mineral Resource Management, Barrick Gold Corporation, Elko, NV

In 2022 through 2024, an "LSAM" approach was used to re-interpret and re-model the entirety of the Leeville underground complex in the Carlin mining district, Nevada. Through updated modeling workflows utilizing redox sensitive geochemical ratios and whole rock geochemistry of igneous intrusions, lithological surfaces and structures were refined on a mine wide scale. The re-interpreted model directly impacted the development of geologically based domains for newly implemented implicit grade shell modeling and dynamic anisotropy. The product improved ore body understanding, targeting efficiency in near mine resource definition, and consistency in implicit grade modeling for resource estimation.

3:05 PM

25-078

Retrospective Analysis of the #5 Shaft at Solvay's Trona Mine

W. Pariseau; Mining Engineering, University of Utah, Salt Lake City, UT

This contribution describes an analysis of safety and stability of the #5 ventilation shaft at Solvay Chemical's trona mine in southwestern Wyoming. Analysis is by the popular finite element method. Geology is characterized by flat strata in the Green River formation where numerous trona beds of varying thickness occur. Five joint sets are identified by mapping and are used to compute equivalent elastic moduli and strengths for greater realism in the analysis. Pre-shaft stress is attributed to strata weight alone. The shaft was excavated as a raisebore pull using a custom-made cutter head that allowed for a 28 ft diameter shaft. Results indicate a safe, stable excavation that, in fact, was the case.

3:25 PM

Practical Geologic Modeling Case Studies of Complex Orebodies—Interactive Panel Discussion

M. Moore-Roth; Maptek, Golden, CO

An interactive panel discussion exploring the practical geologic modeling case studies of Complex Orebodies technical session.

TUESDAY, FEBRUARY 25 AFTERNOON

KAWATRA SYMPOSIUM: IRON ORE

Room 709

2:00 PM • Tuesday, February 25

Chairs: ***J. Ripke****, McCarl's Technical Services, Clover, SC*
C. Young*, Montana Technological University, Butte, MT*

2:00 PM

Introduction

2:05 PM

25-067

Overview of Iron and Steelmaking

V. Claremboux; Chemical Engineering, Michigan Technological University, Houghton, MI

The transformation of raw iron ore into high quality steel can take place via several processes. A general consistent theme involves the upgrading of the iron ores via methods such as flotation and magnetic separation, the preparation of an agglomerate such as via pelletization or sintering, the smelting of the agglomerate into a high grade iron product, and the further refining of iron into specific steel alloys. Each of these steps admit potential for optimizations and alternatives, and the process overall is critical to meeting the world's continuing iron demands.

2:25 PM

25-052

Iron Concentrator Design for the Santo Domingo Project

F. Solis, B. Akerstrom and P. Amelunxen; Capstone Copper Corp, Vancouver, BC, Canada

As it is well known in the industry, one of the main challenges for a greenfield project such as the Santo Domingo project is the obtention of samples for metallurgical testing and subsequent plant design. To face this challenge, the Santo project has completed drilling on 169,629 meters, covering both Santo Domingo and Iris Norte pits. The material collected has been then used for iron metallurgical testwork programs from laboratory to pilot scale, considering composite and variability samples, covering main geological units, through Life of mine. Davis Tube Test, small LIMS scale test and pilot 48" diameter magnetic separation drum was considered as well as hydroseparation operation unit. The testwork demonstrated suitability for the Santo Domingo ore to achieve iron concentrate grade of 65% Fe-suitable for blast furnace, and 67% Fe-suitable for Direct Reduction, and allowed for the iron concentrator plant design. Complementary pelletizing downstream testing also reported promising results for the project.

2:45 PM

25-062

Modern Process Design for Iron Ore

M. Rojas; Process Management, Andes Iron, La Serena, La Serena, Chile

In magnetic iron mining, the generation of particles called "middlings" iron -gangue, is closely linked to the philosophy of process design and is the main cause of low grades in the final magnetite concentrates. Through tests and studies focused on process design, a design was built that allows minimizing the generation of middling particles and achieving high metallurgical recovery, high grades in the final concentrate and mill dimensions adjusted to low circulating loads. The work describes the application of key mineral processing technologies, such as high pressure comminution equipment, size classification in high frequency screens, reverse flotation and an intelligent design architecture, which also allows savings in the consumption of balls, mill liners and savings in electrical energy consumption. The results on an average mineral sample from the Dominga project deposit in Chile showed an overall magnetic iron recovery of 94.9% and a final product quality of 67.3% total Fe and 4.51% SiO2, suitable for the international market.

3:05 PM

25-091

The Production of Zero Carbon Emission PIG Iron with the E-Iron Process

J. Simmons; Headquarters, Carbontec Energy Corporation, Naples, FL

Dr. Kawatra and Dr. Tim Eisele, in collaboration with and technically and financially supported by Carbontec Energy Corporation developed a unique patented process, that uses biomass, ie hard wood or soft wood as the reductant in the place of coal to convert steel mill waste or low cost mid-grade iron ore into zero carbon emission low sulfur, pig iron grade iron nuggets. Laboratory furnace tests conducted by Dr. Kawatra were followed by a pilot plant program conducted on a 24/7 basis in an electrically heated tunnel furnace that successfully used three types of biomass as the reductant to convert three types of iron ore concentrates into 96% iron, 3% carbon, pig iron grade, iron nuggets. Further tests used the process, trade named The E-Iron Process, to convert three types of steel mill waste into pig iron nuggets. Based on the successful test programs, Carbontec Energy formed E-Iron International, LLC who plans to build a 300,000 tonne/year E-Iron plant, that will be designed and furnished by Andritz Metals USA in Burns Harbor that will convert steel mill waste into zero carbon emission, low sulfur pig iron nuggets without the use of expensive hydrogen at a competitive cost.

3:25 PM

25-077

Anaerobic Reductive Bioleaching of Iron

P. Borkar, N. Sharma, K. Boafo, D. Amponsah-Berko and T. Eisele; Department of Chemical Engineering, Michigan Technological University, Houghton, MI

Reductive iron leaching from Fe^{3+} to Fe^{2+} was studied using metal-reducing organisms and biomass from Typha latifolia. A series of iron-leaching experiments were conducted to test the ability of metal-reducing anaerobic organisms to reduce iron from iron ore tailings. This bioleaching process involves the fermentation of biomass from T. latifolia to generate organic compounds, which, along with metal-reducing organisms, reduce and dissolve iron. The dissolution rate with time was studied for one year. Iron concentration above 1150 mg/L was achieved at a pH range of 3.95-5.36. Hematite, which has low dissolution rates, was dissolved by organisms in the same way as goethite. Results from flask experiments were used to

build a 19L continuous iron-leaching pilot plant experiment. The electrolytic oxidation method is being used to oxidize and precipitate iron. Preliminary results suggest that around 75% pure iron oxide is being produced. Our study indicates that iron leaching from iron ore tailings using metal-reducing organisms is feasible at a large scale.

3:45 PM

High Grade Iron Ore: A Natural Green Choice?

R. Chaigneau; Sales & Logistics, Baffinland, Amsterdam, Netherlands

The green DRI/EAF process requires a high-grade input, currently aiming at 67% high Fe, with associated low silica and alumina gangue. Most iron ores currently mined do not make it over 62% Fe, so most ores would require upgrading through processing (liberation & concentration = beneficiation). If possible, at all, this generally comes at excessive energy, material movement, waste generation and low yield. Based on a theoretical approach, it i made insightful why certain ores cannot be upgraded, why certain ores cannot be upgraded further and why currently only 45 Mt of the +1.5Bt seaborne trade ranks into the +67% level.

4:05 PM

The Clearite Carbon Capture Process

J. Simmons; Headquarters, Carbontec Energy Corporation, Naples, FL

Carbon capture technologies are deemed essential to reduce carbon emissions from power generation, cement and steel making plants. The patented Clearite Carbon Capture Process invented by Dr. Komar Kowatra, uses non-toxic sodium hydroxide as the capture agent and a bi-polar, dual membrane electrodialysis system for regeneration. A Clearite pilot plant installed at Michigan Techs' Energy Center reduced the plant's carbon emissions by 97% with a single scrubber. The Clearite process requires 60-70% less thermal energy for regeneration than the amine process. This is important in as much that regeneration accounts for approximately 70% of the total cost of carbon capture. Dr. Sriram Valluri estimated the total cost of carbon capture with the Clearite Process at $38/ton, considerably less than the DOE target of $100/ton. Carbontec Energy Corporation, who was granted exclusive world wide license rights by Michigan Tech, plans to move forward with a larger demonstration plant, the final step before commercialization. Carbontec plans to provide Clearite Process licenses to the power generation, cement, oil and gas and steel industries.

TUESDAY, FEBRUARY 25 AFTERNOON

MINING & EXPLORATION: INNOVATION & TECHNOLOGY: LEVERAGING MACHINE LEARNING, AI, AND DATA ANALYTICS IN MINING PROJECTS

Room506

2:00 PM • Tuesday, February 25

*Chair: **E. Talebi Esfandarani**, University of Utah, Salt Lake City, UT*

2:00 PM

Introduction

2:05 PM

25-070

Practical Applications of Large Language Models in Mining

B. Gyngell[1] and P. Culvenor[2]; [1]Hevi, Bondi Beach, NSW, Australia and [2]Access Mining, Brisbane, QLD, Australia

Large language models (LLMs) have generated a lot of hype since ChatGPT was released in early 2023. In essence, they allow people to interact with computer systems through natural language and have the ability to generate highly complex text, images and videos. It is clear that this technology has significant potential, however most mining companies have not yet found practical applications for it within their operations. In this paper, we present a range of such applications along with the tactical considerations associated with developing and implementing them. We have identified use cases across a variety of operational and functional areas within the mining industry and evaluated them based on their potential business value and ease of implementation. We share a discussion of the potential path forward for LLMs in Mining analysing the potential differences between early adopters and laggards in the artificial intelligence space. This research draws on interviews and surveys with Artificial Intelligence experts as well as Mining subject matter experts to connect cutting edge thought leadership with the specific problems faced by our industry.

2:25 PM

Practical Applications of Element-to-Mineral Conversion Algorithm in Mining Operations

M. Nicco[1], M. Herbelin[1], P. Boszczuk[2] and C. Bessin[2]; [1]Geometallurgy, ERAMET, Trappes, France and [2]Digital Mining and Metallurgy, Eramet, Trappes, France

Geometallurgy integrates geological, mineralogical, metallurgical, and engineering data to optimize ore behavior throughout the mining value chain. Understanding the composition and distribution of minerals within a deposit is crucial for optimizing mine planning strategies. Elemental analysis, using methods like XRF or ICP-MS, is routine. However, measuring mineral proportions is challenging, as technologies like XRD are qualitative or quantitative SEM-based automated mineralogy requires heavy preparation and high OPEX. Since chemical elements build minerals, it is possible to derive mineral proportions from elemental analysis using an element-to-mineral conversion algorithm based a robust database of chemistry and mineralogy of the deposit. This study, using the example of a heavy mineral sands deposit, presents the development of a reliable element-to-mineral conversion algorithm and compares gradient descent-based solvers with machine learning approaches. Practical applications in mine reserve estimation, planning, and mineral processing optimization are also discussed.

2:45 PM

Improving Surface Pit Mine Efficiency through Shovel-Based Payload Monitoring for Optimal Haul and Load Energy Management

A. Torabi; Core Products, Weir Motion Metrics, Vancouver, BC, Canada

This study introduces a shovel-based payload monitoring solution to optimize load and haul energy in surface pit mines. The system ensures shovel operators meet truck compliance for target payloads, preventing overloading and underloading, which affect maintenance, productivity, and safety. Integrating advanced monitoring technology, the solution provides real-time bucket payload assessments, facilitating optimal truck fills. This results in consistent load distributions, extending truck lifespan, reducing fuel consumption, and lowering operational costs. Implemented in a South American mine, the system showed reduced specific load and haul energy through improved efficiency and fewer truck passes, offering valuable insights for mining optimization.

3:05 PM

25-021

Concept of a Digital Twin for an Underground Laboratory at the Reiche Zeche Mine Utilizing Artificial Intelligence

E. Farys[1], J. Thomas[2], A. Ahmadi[3], A. Binder[4], E. Gerolymatou[3], D. Jeyaraj[5], M. Kolling[3], O. Langefeld[4], W. Ließmann[3], M. Martin[2], H. Mischo[1], N. Nöther[5], A. Rausch[6], T. Sen[4], T. Ulrich[3], S. von der Mark[5], S. Wittek[6] and J. Paffenholz[2]; [1]Institute of Mining and Special Civil Engineering, TU Bergakademie Freiberg, Dresden, Germany; [2]Institute of Geo-Engineering, TU Clausthal, Clausthal-Zellerfeld, Germany; [3]Institute of Disposal Research, TU Clausthal, Clausthal-Zellerfeld, Germany; [4]Institut of Mining, TU Clausthal, Clausthal-Zellerfeld, Germany; [5]fibrisTerre Systems GmbH, Berlin, Germany and [6]Institute of Software and Systems Engineering, TU Clausthal, Clausthal-Zellerfeld, Germany

This paper outlines the MOVIE project, which is dedicated to the development of a digital twin for an underground laboratory at the research and education mine "Forschungs- und Lehrbergwerk Reiche Zeche" in Freiberg (Germany). Data from induced rock deformations and temperature fluctuations is collected using fiber-optic sensors. The objective of the project is to establish a virtual laboratory for real-time analysis of the interactions between geology, geomechanics, geometry and ventilation. This will be achieved by integrating models from these disciplines with artificial intelligence, creating a sophisticated hybrid model. The insights gained will enhance safety and efficiency in mining through improved digital planning options, ultimately contributing to more effective resource management and operational decision-making in different mining environments.

3:25 PM

Advanced Techniques for Processing Georeferenced Map Data in Underground Gold Mining

E. Cáceres, C. Mejias and E. Godoy; Hibring, Concepcion, Biobio, Chile

Gold mining is a cornerstone of the global mining industry, with underground operations representing a significant portion of gold extraction activities. Geological mapping in these environments generate extensive volumes of data in diverse formats, requiring considerable standardization efforts. To address this, we developed GEOREC, an innovative geological-geotechnical software to optimize the transcription of large volumes of data using georeferenced information from digitized underground mine drawings, offering a robust alternative to AI techniques. Developed by a multidisciplinary team focusing on algorithmic efficiency, reliability, and robustness, GEOREC has been successfully tested in four Chilean underground mines, showing significant time savings and reduced human-induced errors. It allows process automation, extracting hundreds of data points in seconds and including comprehensive visualization and reporting tools. Its adaptability and user-friendly interface allow seamless online analysis and processing of data, digitizing historical drawings, making data available for integration with other software systems and enhancing efficiency in the underground gold mining sector

3:45 PM

Transforming Mining: Harnessing AI/ML for Operational Efficiency and Decision Making

P. Rogers[1], E. Koc[2], E. Anderson[2] and A. Moharana[3]; [1]Mining Engineering, University of Utah, Salt Lake City, UT; [2]airth.io, Tucson, AZ and [3]WSP, Tucson, AZ

The future of AI/ML models has been revolutionized by the application of large language models (LLMs) such as OpenAI's ChatGPT. In the mining industry, where data systems vary dramatically—from structured databases to unstructured and spatial data—scalable, contextual data analysis has been challenging. Airth's Co-Pilot leverages LLM and Large Action Model (LAM) functionalities to transform mining analytics. By ingesting diverse data systems and applying AI-driven dynamic ontology, it enables contextualized, prompt-driven querying and robust data pipelines. This ontology-based approach grounds LLMs, reduces hallucinations, and provides auditable results. Its use cases range from classroom education to practical mining operations, showcasing its versatility and impact.

4:05 PM

Robust Mineral Characterization Using a Physics-Informed Multi-Sensor Machine Learning Approach

J. Pigeon[1], F. Khomh[1], A. Ashraf[3] and P. Maghoul[2]; [1]Department of Computer Engineering, Polytechnique Montréal, Montréal, QC, Canada; [2]Department of Civil, Geological and Mining Engineering, Polytechnique Montréal, Montréal, QC, Canada and [3]Department of Electrical and Computer Engineering, University of Manitoba, Winnipeg, MB, Canada

Recent advances in machine learning algorithms and computing hardware create opportunities for processing big data in ways that were not previously possible. However, often described as a black-box problem, traditional deep learning methods can lack robustness and cause undesirable behaviors when working with imbalanced datasets. Here, we aim to create a framework for a more robust and accurate characterization of minerals by applying physics-based constraints on our model. Our approach focuses on the integration of multiple sensors, such as Laser Induced Breakdown Spectroscopy for elemental information and Raman spectroscopy for vibrational information, utilizing a machine learning fusion framework based on a geometric deep learning architecture for automated prospecting of critical minerals. By incorporating restrictions on the representation based on the fundamental physical principles of mineralogy, we increase both the accuracy and robustness of the characterization. This approach not only enhances the precision of mineral characterization but also streamlines the prospecting process, ultimately leading to more efficient mineral prospecting.

4:25 PM

Optimization of Loading and Hauling Operations in Open-Pit Mining through Data Analysis, Machine Learning and Artificial Intelligence

M. Portal Valdivia, F. Segobia Campos, L. Goicochea Sánchez and F. YSLA QUIROZ; Mining engineering, Society for Mining, Metallurgy & Exploration, Cajamarca, Cajamarca, Peru

This study proposes a data-driven approach to optimize loading and hauling operations in open-pit mining. Machine Learning algorithms will be applied to analyze telematics data from trucks and shovels, including cycle times, distances traveled, payloads, and environmental variables. Predictive models will be developed to identify bottlenecks, optimize equipment allocation, minimize waiting times, and maximize productivity. The implementation of this approach will reduce operating costs, improve efficiency, and increase production in open-pit mines.

TUESDAY, FEBRUARY 25 AFTERNOON

MINING & EXPLORATION: INNOVATION & TECHNOLOGY: REMOTE SENSING IN UNDERGROUND MINING ENVIRONMENTS

Room 503

2:00 PM • Tuesday, February 25

Chairs: ***I. Casasbuenas Cabezas****, 04231622, Medellin, Colombia*
J. Monsalve*, Freeport McMoRan, Blacksburg, VA*

2:00 PM

Introduction

2:05 PM

Underground Mine Mapping Using Stereo-Event Cameras And Deep Learning

A. Petruska; Mechanical Engineering, Colorado School of Mines, Golden, CO

This study investigates the implementation of a machine learning-based system for generating 3D maps of mine roofs using event-based cameras. Point cloud registration is performed on depth maps created using a stereo pair of event cameras. Simultaneous Localization and Mapping (SLAM) methods are commonly used to localize and build maps. A subset of these methods uses visual data like from cameras to solve for the rigid-body transform between temporally separated point clouds and then subsequently build the map. However, these classes of algorithms are sensitive to noise in image data. The pipeline proposed uses a deep learning approach with event-based images to generate real-time point clouds. Event cameras were selected due to their efficacy in high-dynamic-range lighting conditions and minimal latency, essential for dusty, single-source lighting conditions in mining environments. The integration of these technologies aims to provide dense maps of mines using methods that are resilient to severe optical conditions and computationally less expensive than handheld lidar scanners.

2:25 PM

Drones in Underground Mining

W. Peterson; Flyability, Paudex, Vaud, Switzerland

Emerging technologies have played a critical role in underground mining for decades. Remote sensing technologies include seismic monitoring systems, gas detection, extensometers, LiDAR scanners, amongst a handful of other useful tools that allow geotechnical and mining engineers to make the best decisions about managing their mines. Today, drones designed for underground locations give centimeter-accurate survey data to mining engineers in areas that were once deemed inaccessible. Mining is inherently risky, putting people into areas near uncontrolled ground is often unavoidable. Why needlessly expose miners to any unnecessary risk? Collision tolerant drones allow managers to eliminate inherent risk, while gathering imperative information through: visual inspection, condition monitoring, sectional mapping, volume calculation, blast performance, change detection, convergence, stabilization analysis, ultrasonic thickness measurement, and bolt inspection, amongst others.

2:45 PM

Advances in the Remote Mapping of Block Cave Excavations Using a Layered Systems Approach at the Henderson Mine

S. Ferguson; Cave Engineering, Freeport McMoRan, Empire, CO

Henderson mine has engaged in concerted efforts to better understand the impacts of drilling quality on cave development blasting. Additionally, this data aids in optimizing cave management during initiation and production. Henderson has implemented a multi systems approach to remotely map and monitor cave development. Utilizing a UAS with high-definition video and a LIDAR payload, coupled with production drill data, Henderson Mine has enacted a step-change improvement in remote excavation mapping, leading to improved accuracy of planned versus actual cave geometry and refinements to blast design. The UAS and its payload allow for remote structural mapping, revealing hidden features with potentially significant influence on cave development. These efforts, coupled with existing geomechanical monitoring technologies (micro-seismic, TDR, smart markers) provides unprecedented insight into cave morphology, behaviour, and rock mass modelling.

3:05 PM

Autonomous Robotic Inspection System for Underground Mines Using Unmanned Ground Vehicle (UGV)

K. Joao[2], A. Tejada Peralta[2], V. Androulakis[1], H. Khaniani[1], M. Hassanalian[1], S. Shao[1] and P. Roghanchi[2]; [1]Mineral Engineering, New Mexico Institute of Mining and Technology, Socorro, NM and [2]Mining Engineering, University of Kentucky, Lexington, KY

This study develops a robotic system for inspecting underground mines. Using the Rosbot Plus from Roboworks, the robot navigates autonomously via the Robot Operating System (ROS). It operates in confined, hard-to-reach areas, providing high-resolution visual and thermal imaging for detailed inspections. After designing the platform, pilot testing ensures safe and effective inspection capabilities. The system captures images and point clouds, digitally processing them to identify fractures, faults, and geological changes within the mine. This platform allows comprehensive monitoring of mine conditions, ensuring thorough coverage and reducing human presence in hazardous areas.

3:25 PM

25-100

Visualizing Rock Mass Displacement and Strain Data for Interpretation of TARP Levels as a Safety Measure: A Case Study at the San Xavier (SX)

N. Akbulut, A. Anani and S. Adewuyi; Mining and Geological Engineering, The University of Arizona, Tucson, AZ

The assessment and communication of geomechanical risks can be a daunting task due to the volume and velocity of data acquired. The multidimensional (space and frequency) nature of geotechnical data escalates such challenges. We propose a simple yet compelling visualization of displacement and strain data in 3D as a Trigger Action and Response Plan (TARP) to communicate geomechanical risks in near-real-time. We present a scientific visualization method by rendering geomechanical data over the surface of a 3D mesh to display TARP levels. The San Xavier Underground Mine Laboratory is used as a case study to validate the proposed approach.

TUESDAY, FEBRUARY 25 AFTERNOON

MINING & EXPLORATION: MANAGEMENT: MINE DATA MANAGEMENT: COLLECTING AND APPLYING IT

Room 504

2:00 PM • Tuesday, February 25

*Chair: **A. Rasti**, Geomechanical Engineering, Morenci, AZ*

2:00 PM

Introduction

2:05 PM

Data Collection and Testing programs for the Santa Cruz Pre-Feasibility Study

C. Shaw; Ivanhoe Electric, Herriman, UT

The Santa Cruz Project in Casa Grande, Arizona is an upcoming underground copper proposal which required extensive rapid data collection and test programs to inform the Pre-Feasibility Study. The rapid collection and coordination of efforts at Santa Cruz have allowed the project to advance at a fast pace with enough data to accurately inform the ongoing engineering studies include efforts to inform Resource Geology, Mine Planning, Metallurgy and Geometallurgy, Geotechnical parameters and Hydrogeology.

2:25 PM

25-101

What is the Secret to Preparing Your Data for AI Success?

C. Cathemer[2] and S. Hunter[1]; [1]Product Development, Eclipse Mining Technologies, LLC, Tucson, AZ and [2]Product Management, Eclipse Mining Technologies, LLC, Tucson, AZ

High-quality, well-prepared data is essential for successful AI implementation. The four pillars of data preparation ensure data is organized, understood, and actionable, enabling organizations to leverage it for strategic decision-making. While a data lake can store vast amounts of raw data, a structured data layer is necessary for organization and usability. Domain ontologies and knowledge graphs play a crucial role by defining concepts and relationships and providing structured background knowledge. Without knowledge graphs, important insights will be overlooked. An advanced knowledge system integrates these pillars to convert raw data into meaningful insights, making them accessible and applicable through custom applications that are meaningful to your organization.

2:45 PM

Gain Practical Knowledge of How to Design, Implement, and Sustain a Management Operating System (MOS, Operations / Maintenance)

D. Truchot; Hanzehogeschool Groningen, Groningen, Groningen, Netherlands

Management Operating Systems (or MOS) are not well understood, and this course aims to share our expertise and some of the key tools and supervisor training to start identifying gaps and missing links that slow your organization' successes and launch sustainable corrective action

plans. We will review with you best practices that are in use in the pits or in maintenance and share some of this insider knowledge so you can start optimizing your operations with frontline supervisors. Key elements we will review: Leader Standard Work, Short Interval Controls, Daily Weekly Operating Reports, Skills Matrices, Variance Reports, Action Logs, RCCA tools & processes, and 10 Active Management Behaviors. We will provide you with a critical approach and a proven suite of tools that are used underground, in daily production meetings, at dispatch, or in maintenance workshops, day in / day out. We will also share with you some of the pitfalls and strategies to ensure your changes are sustainable.

3:05 PM

Use of Machine Learning (ML) Technologies to Improve Risk Management in Mining

A. Neuwirt, A. Suvorov and W. Conrad; Mining, Canary Systems, New London, NH

Interest in machine learning technologies has accelerated dramatically in the last few years with the wide-spread adoption of generative AI technologies such as ChatGPT. While these technologies are focused on large language models (LLMs) and related applications such as research, copywriting and support chatbots, related machine learning technologies around numerical data processing are also becoming popular. These technologies promise to eliminate the tedium of analyzing large quantities of mostly static data that is associated with geotechnical/ geomechanical data collection and allow focus on the dynamic portions of data that are suggestive of developing or present risks to the operation and safety of mining operations. This paper will present an overview of these technologies along with several examples of how they can be used within a comprehensive data management platform, primarily through the integration of a Python runtime environment and task management system. This supports the simple integration with any of the several hundred thousand Python math modules available to the public, many of which support machine learning applications.

3:25 PM

Mine Control Maturity Assessment: Establishing the Guidelines for Underground Operations to Become Data-Driven

M. Antunano; Mining Operational Support Network, Newmont, Denver, CO

The common concept associated with Mine Control in Underground Operations concerns data collection and report generation without considering its capacity and potential to enhance the operation's sustainability and role as a stepping stone to becoming data-driven. The Mine Control Maturity Assessment is a comprehensive methodology based on a holistic approach that evaluates the interaction between four different but complementary elements: Technology, Data, People, and Business Objectives. It provides a thorough understanding of how far an operation is in becoming data-driven through quantifiable criteria that support correct resource allocation and continuous improvement. This methodology was developed by Newmont's Mining Operational Support Network team and deployed on all underground sites as part of the company's operational excellence vision.

TUESDAY, FEBRUARY 25 AFTERNOON

MINING & EXPLORATION: OPERATIONS: DECARBONIZATION: BATTERY ELECTRIC TECHNOLOGY AND CURRENT RENEWABLE ENERGY PROJECTS

Room 505

2:00 PM • Tuesday, February 25

Chairs: ***A. Ashok Parmar****, Freeport McMoran inc, Tucson, AZ*
M. Gobitz*, Stantec, Golden, CO*

2:00 PM

Introduction

2:05 PM

The Challenges, Best Practices, and Pitfalls of Delivering Renewable Projects as the Mining Industry Transitions to a Decarbonized World

D. Kenny and D. McLane; Burns & McDonnell, Westminster, CO

The Mining Industry is currently navigating a significant transformation driven by global decarbonization, critical mineral dependency, electrification, and net-zero targets. Additionally, a growing corporate focus on environmental, social and governance (ESG) is guiding the industry to a cleaner and brighter future. This presentation will review the challenges, best practices, and pitfalls for delivering mine site renewable projects to support the energy transition and ultimately meet corporate and global targets. Renewable power areas showcased will include solar generation, battery energy storage systems (BESS), and connecting microgrid technology. Along with content around renewable technology selection the presentation will also outline critical aspects of project execution for mining companies that understand decarbonization is coming but have limited familiarity with implementing non-core business renewable projects on a mine site.

2:25 PM

Mine Site of the Future: Linking the Electric Mine of the Future Simulation to Reality

T. Litkenhus; Caterpillar Inc., Tucson, AZ

As the mining industry continues to tackle the challenges associated with decarbonization, the pace of learning and problem solving is an increasingly important aspect of defining what the mine site of the future looks like. While it is clear the problem to solve is so much more than electrification of a haulage fleet, the integrated nature of the ecosystem to manage the flow of energy to the right place at the right time represents a tremendous change management problem. What starts with a simulation model with numerous input factors to characterize the system leads to a need for robust decision-making and feedback loops to keep the operation at the top of its game. As part of the learning process, the ability to effectively link the simulation with reality is a critical capability in the journey from functionality to optimization. This presentation will review some key considerations when planning for a future electrified mine site.

2:45 PM

Considerations of Mine Fleet Electrifications and MicroGrids

D. Richards; Mining, Burns & McDonnell, Phoenix, AZ

The presentation will discuss the considerations and constraints at play when considering a change to battery electric equipment for a mining site. Our team recently completed the detailed designs and is supporting construction efforts to enable a site to trail and demonstrate various battery electric equipment. This required the development of an advanded electrical model to simimulate various microgrid configuratons to connect various conventional and renewable power generation sources to handle the variable charging demands. Feasibility designs was completed to asses potential for a hydrogen generation and power center followed by detailed designs for the infrastructure upgrades. As the OEM develope new equipment and associated charging equipment a design must adjust and provide flexibility for the unknown.

3:05 PM

Adaptive Microgrid Control Strategies for Mining Operations

P. Curtiss, J. Onsager and D. Zabel; S&C Electric, Franklin, WI

The electrification of the mining industry's loading and haulage equipment presents new and complex challenges for supporting critical loads and integration of renewable sources. The load profiles at mine sites typically experience dramatic step changes and can be impacted by the addition or removal of key pieces of equipment. New developments in microgrid

controllers simplify the process of accommodating changes in connected equipment, including large loads, batteries, as well as renewable and conventional generation sources. Modern controls can also help achieve the goal of reducing carbon emissions by emphasizing the use of renewables. This presentation describes a method used by one controller that automatically implements control algorithms based on observed equipment, thereby easing the commissioning time, reducing maintenance costs and allowing for efficient operation of the 24/7 electric mine site.

3:25 PM

995 Volt Feeders: The Future for Underground Mines?

D. McLane; Mining, Burns & McDonnell, Phoenix, AZ

The operating voltage of electrical systems plays a crucial role in determining the effective operational range of equipment from a Mine Load Center (MLC). Traditionally, 480V has been the standard for mobile and auxiliary equipment in U.S. hardrock underground mines. However, 995V is emerging as a viable alternative. This presentation will explore the differences between 480V and 995V systems, provide a cost comparison, and examine the advantages and disadvantages experienced by underground operations using each voltage. Additionally, the presentation will discuss how the rise of battery electric equipment and mechanical miners might impact this decision.

3:45 PM

25-041

Hydrogen Peroxide Emulsion (HPE) Explosive for Nitrate and Ammonia Free Mine Blasting

D. Scovira[1] and T. Gustavsson[2]; [1]BME Global Manager of Blasting Science and Engineering, Harwich, MA and [2]CEO Hypex Bio, Farsta, None, Sweden

Exiting WW2, the potential of nitrates and hydrogen peroxide for application as a industrial explosives both became known. The technology stream advanced the development and uptake of nitrate based explosives to the point that they are the current global standard for blasting. Recently environmental issues are influencing the strategic agendas of extractive industries. The mid-2010s saw renewed interest in hydrogen peroxide explosives to eliminate NOx fume. Carbon reduction initiatives in the 2020s provided additional impetus to investigate hydrogen peroxide based explosives. Hypex Bio is at the forefront of developing and delivering bulk gas sensitized Hydrogen Peroxide Emulsion (HPE) for blasting. HPE consists of hydrogen peroxide along with smaller amounts of fuel and emulsifier. The consistency of HPE is similar to industry-standard nitrate-based emulsions. It is compatible with existing priming and initiation systems. HPE does not contain nitrates and thereby does not produce post blast nitrous oxide (NOx) fumes nor discharge of nitrates or ammonia to mine water. Importantly, HPE contributes to a reduction in total carbon emissions as compared to nitrate-based explosives.

4:05 PM

Technical-Economic Analysis of Replacing a Fleet of Diesel Trucks with Electric Trucks in a Cement Quarry in Peru

G. Vega and F. Arias; Arequipa, Universidad Tecnológica del Perú, Arequipa, Arequipa, Peru

In open-pit mining, transport in mining trucks is essential, as they travel long distances several times a day. The cost of this operation has a significant impact on operating costs due to high prices and the enormous fuel consumption of diesel trucks. On the other hand, the use of renewable energy in mining equipment is imperative. In this study, the replacement of diesel haulage equipment with electric equipment was diagnosed using the Choosing by Advanced (CBA) method. The application of CBA allows to analyze and make decisions between continuing with diesel trucks or replacing them with electric trucks, considering operating costs, productivity and criteria such as technical feasibility and economic viability. The technical-productive evaluation showed that electric trucks have better performance (148% more torque) and offer 10% more production compared to diesel trucks. Furthermore, from an economic point of view, electric trucks provide 80% savings in energy consumption and reduce operating costs by $292/hour, optimizing 34.78%. This research shows that electric trucks are viable and more profitable in the long term than diesel trucks.

TUESDAY, FEBRUARY 25 AFTERNOON

MINING & EXPLORATION: OPERATIONS: MINE PLANNING & OPTIMIZATION II (UNDERGROUND FOCUSED)

Room 502

2:00 PM • Tuesday, February 25

Chairs: ***S. Lolon****, Freeport-McMoRan Inc, Phoenix, AZ*
G. Anderson*, Freeport-McMoRan, Inc., Chandler, AZ*

2:00 PM

Introduction

2:05 PM

Case Study: Successfully De—Coupling a Mine—Constrained Underground Gold Operation in Central Alaska

D. Ball; Technical Services, Northern Star Resources Limited, Perth, WA, Australia

'Mine-constrained' operations can become beholden to short-term decision making that 'fills the mill' to the detriment of the mine schedule and medium-term production profile. Sustaining mill throughput doesn't necessarily equate to asset optimization and an operation's value may be compromised as decision making horizons are compressed. The Pogo mine is located in Alaska, 100 miles from the Arctic Circle with winter conditions and a number of operational constraints historically resulting in poor harmonization between mining and milling rates. A mining method change coupled with considerable uplift in the mill rate presented a mismatch between the mining and milling capacities that required correction to meet the company's strategic goals. Through a systematic approach to problem solving which focused on the fundamental constraints to production continuity, a strategy was developed to re-balance the operation and maximize asset value. Significant investments in technology, infrastructure, mobile equipment and human resources coupled with mine planning and operational process improvements have allowed Pogo to optimize the mine to mill throughput balance with record breaking results.

2:25 PM

Application of a New Underground Mining Method in Perú: UDF (Underhand Drift and Fill)—Tambomayo Mine Case

E. Apaza; Mining, Mining Engineering, Arequipa, Select, Peru

Peru is known for its focus on mining, particularly through underground mining methods such as sublevel stoping, bench and fill, and cut and fill. These techniques have been utilized for many years due to their success in recovering ore deposits. Today, the mining industry in Perú is harder to work in because the big, rich, and generous deposits are disappearing, making it more difficult to build or keep mines in production. The Buenaventura Mining Company, one of the most important Peruvian mining companies, sought new mining methodologies for areas with RMR <15 in its underground mines, particularly in the Tambomayo mine, which has collapse zones containing high-value ore worth close to 20M$ (78k ton @ NSR 254 $/ton). In this case, the company evaluated different mining methods to recover this ore, Buenaventura Mining Company has chosen to use the Underhand Drift and Fill, one of the most used in Nevada -USA. In the Tambomayo mine, we learned about spilling bar bolts, using a jammer, and backfill cement. It was a valuable experience that we would like to share with everyone.

2:45 PM

25-011

Application and Verification of an Automated Calculation Tool for Planning and Cost Estimation of Underground Mines

F. Günther and H. Mischo; Chair for Underground Mining Methods, TU Bergakademie Freiberg, Freiberg, Sachsen, Germany

A tool has been developed that enables automated calculation of underground mines and allows for the comparison of the effects of changing individual parameters. The calculation of costs for an underground mine, as well as the planning of the equipment and materials to be used, is a complex and time-consuming process. The estimation depends on a multitude of parameters, and all mining processes are interconnected. Previously, changing individual planning parameters often necessitated a complete recalculation of the mine. The newly developed calculation tool provides an innovative planning aid that allows for more efficient and accurate mine planning and cost estimation. The tool enables the user to implement continuously up-to-data costs and prices. This allows for more accurate planning data and results. The underlying concept of the calculation tool, its implementation at a planned quartz porphyry mine in Germany, and the verification of the tool at an existing underground mine will be presented.

3:05 PM

Less Common Aspects for Mine Electrical Distribution. What You Need to Know

J. Fisher; Mining, Stantec, Chandler, AZ

A mine electrical distribution system is expected to be design "Right, Redundant, and Resilient". This presents a unique set of design challenges. As mines move away from diesel to electrohydraulic and batteries, electrical loads increase at the extents of the mine. Environmental drivers are also becoming more important. Electrical harmonics, electrical efficiency, and air quality permits affect electrical supplies, and these topics are becoming more important to understand. This paper reviews some of these less common aspects and how they affect planning and operations.

3:25 PM

Dynamic Cutoff Grade Strategy for Large Underground Deposits

B. Syers; South32, Tucson, AZ

Optimizing project value and reserves in mine planning is crucial for large underground deposits. Traditional methods like fixed cutoff grades and the Hill of Value method do not account for the time value of money. Our presentation introduces a dynamic cutoff grade strategy, a simplified version of Kenneth Lane's algorithm, incorporating the time value of money to improve economic and operational outcomes. We will show how this approach accelerates payback periods by targeting higher value early and maximizes total reserve tonnes as cutoff grades approach break-even costs. By optimizing how we develop our resource, we enhance value for investors and the community.

3:45 PM

Longhole Stoping—A Practical Review of Sublevel Spacing

J. Sexauer and P. Schmidt; Stantec, Chandler, AZ

This abstract provides an overview of longhole stoping design, focusing on the critical decision of sublevel spacing and its associated risks and rewards. Longhole stoping is a widely used underground mining method involving the drilling and blasting of ore in vertical or sub-vertical stopes. Sublevel spacing is a crucial design parameter impacting efficiency and safety. Taller stopes, with greater sublevel spacing, can reduce development costs and improve ore recovery by minimizing waste rock production. However, these benefits come with increased risks, including ground control challenges and higher dilution rates due to larger voids and longer exposure times. Conversely, shorter stopes, with closer sublevel spacing, offer better ground stability and lower dilution but incur higher development costs and reduced ore recovery efficiency. Thus, choosing between taller and shorter stopes involves balancing economic efficiency and operational safety, considering site-specific geological conditions, engineering capabilities, and equipment limitations.

4:05 PM

Defining a Decision-Support System Tool for Continuous Economic Evaluation of Underground Critical Raw Materials Mining Projects

M. Islam and H. Mischo; Institute of Mining and Specialized Civil Engineering, Technische Universitat Bergakademie Freiberg, Freiberg, Sachsen, Germany

Potentially unfavourable economic circumstances have forced several critical raw materials (CRMs) mining projects to close or put on hold for development. Market price swings, erroneous interpretations of the ore body's characteristics, and unduly optimistic recoveries made during mine planning frequently cause unfavourable economic conditions. To continuously optimise the mining methods, ore grade and recovery rate, mine life, and production rate and provide economic scenarios for new and ongoing underground mining projects, the study has defined an artificial intelligence and machine learning-based decision-support system tool. The tool is expected to mitigate techno-economic ambiguities and facilitate decision-makers in attaining sustainable sourcing of CRMs.

4:25 PM

Adding an Orepass Placement Decision to Underground Scheduling Optimization

K. Guerin-Davey and A. Brickey; Mining Engineering & Management, SDSMT, Rapid City, SD

The use of optimization techniques has been shown to have positive impacts on an operation's economics and productivity. This research presents a modified optimization model that integrates the location, orientation, and timing of orepass design and construction. The model selects the orepass start- and end- levels and location, while simultaneously optimizing the production schedule. A case study is presented using data from an underground gold mine to demonstrate the impacts of incorporating orepass location and design into the underground production scheduling process.

TUESDAY, FEBRUARY 25 AFTERNOON

MPD: CHEMICAL PROCESSING: SELECTIVE SEPARATION AND PURIFICATION OF METALS

Room 705

2:00 PM • Tuesday, February 25

Chairs: ***Y. Shekarian****, The Pennsylvania State University, State College, PA*
C. Subasinghe*, PennState University, State College, PA*
J. Wu*, Ecobat, Irving, TX*

2:00 PM

Introduction

2:05 PM

Recovery of Rare Earth And Critical Elements From Low Concentration Secondary Resources

B. Vaziri; Earth and Environmental Engineering, Columbia University, New York, NY

Rong Yu Wan PhD Dissertation Scholarship Award 2022 Winner Presentation.

2:25 PM

Correlations between the Mineralogy and Recovery Behavior of Rare Earth Elements (REEs) in Coal Waste

B. Ji; Mining and Minerals Engineering, Virginia Polytechnic Institute and State University, Blacksburg, VA

Coal waste has been identified as a promising alternative source of rare earth elements(REEs). Studies showed that the calcination can significantly improve the REE recoveryfrom coal waste materials. In this study, scanning electron microscopy-and transmissionelectron microscopy-energy dispersive X-ray spectroscopy (SEM-EDS and TEM-EDS) were conducted to investigate the mineralogy of REEs in two coal waste samples. Theresults indicated that the REEs mainly present as apatite, zircon, monazite, xenotime, andcrandallite-group minerals in the coal waste samples. However, after REE recovery, thecrandallite-group minerals disappeared from the calcined coal waste samples. Therefore, itcan be confirmed that the calcination treatment resulted in the solubility improvement ofcrandallite-group mineralsin coal waste samples. In order to further investigate thecrandallite-group minerals, florencite was synthesized and subjected to a series ofcharacterization methods. The results suggested that the thermal phase transformation fromcrystalline florencite into amorphous state resulted in the solubility improvement.

2:45 PM

Development of Adsorption-Based Ion Exchange Process for Selective Separation of Scandium and Iron From Aqueous Solutions

T. Gangadari, M. Rezaee and S. Pisupati; The Pennsylvania State University, University Park, PA

Due to the scarcity of primary resources for Sc, it is often extracted from waste streams or byproducts from titanium, aluminum, and nickel production processes. These secondary resources have higher amounts of other impurities, such as iron (Fe). Most residues also have higher amounts of Fe, a major concern for Sc extraction due to their similar chemical behavior in aqueous solutions. This research focuses on developing a Solid-Liquid Extraction based ion exchange process using commercial anion exchange resins and uses the difference in speciation to achieve selective separation between Fe and Sc. The process was developed and optimized by studying the effects of resin dosage, chloride concentration, concentration ratio (Sc/Fe), adsorption isotherms, and kinetics. The results showed that at high concentrations of Cl- ligands, Fe forms $FeCl_4^-$ and $FeCl_3$ and are adsorbed on the resin, whereas Sc remains as $ScCl^{2+}$. The kinetic studies revealed that the adsorption of Fe is a chemical reaction-controlled process during the initial phase and then mixed-controlled during the later phase. The results also showed no significant decrease in adsorption capacity after multiple cycles.

3:05 PM

Selective Recovery of Critical Minerals from Acid Mine Drainage Utilizing Ion Exchange Resin

E. Cardenas[1] and Q. Huang[2]; [1]Mining Engineering, Student, Morgantown, WV and [2]Mining Engineering, Chair and Associate Professor, Morgantown, WV

This research investigates the development of an ion exchange process for recovering critical metals (Ni, Co, Zn, Mn) from acid mine drainage (AMD) and explores its potential for both remediation and economic profit. The proposed methodology reduces reagent consumption and pretreatment requirements compared to existing techniques such as solvent extraction. Initially, impurities are removed through caustic precipitation. The pH of the AMD solution is then adjusted with sulfuric acid to optimize conditions for ion exchange. Selective separation of Ni and Co is achieved using Ambersep M4195 resin, while Zn and Mn are addressed in subsequent stages. Metals are eluted from the resin using sulfuric acid, and the resulting solution is utilized for metal hydroxide precipitation. By optimizing ion exchange conditions through systematic single-variable testing, this project aims to develop a remediation technique that not only addresses the environmental impact of AMD but also enhances the feasibility of metal recovery, thus offering practical solutions to a persistent challenge in the coal mining industry.

3:25 PM

Selective Separation of Gallium and Germanium from Sulfate Solutions

W. Hartzell, L. Alagha and M. Moats; Material Science and Engineering, Missouri University of Science and Technology, Rolla, MO

The continued supply risk of gallium and germanium has led to an increased need to diversify resource streams. Gallium and germanium are found in small concentrations in zinc processing solutions and residues. Solvent extraction (SX) and ion exchange (IX) could be applied to extract these elements from new or existing streams. Equilibrium extraction data for gallium and germanium has been collected for commercial SX extractants and IX resins using model sulfate solutions. While no product evaluated displayed a combination of high distribution ratio and separation factor, some show promise with good selectivity over iron (III) and zinc. Development of specialized functional groups targeting high binding energies to create ligands that can produce both a high distribution ratio and separation factor for gallium and/or germanium is underway.

3:45 PM

Altering Mixing Conditions to Improve Precipitation-based Critical Mineral Extraction

S. Ramakrishnan[1], Q. Wang[2] and C. V. Subban[1]; [1]Energy and Environment Directorate, Pacific Northwest National Laboratory, Seattle, WA and [2]Physical and Computational Sciences Directorate, Pacific Northwest National Laboratory, Seattle, WA

Variability in natural feedstock introduces challenges to chemical separations for the mining industry. Most novel ligands, solvents, and membranes are often expensive and/or environmentally harmful. Precipitation-based mineral extraction is one of the most energy-efficient approaches to separation and is widely used in industry today. The rate, purity, and properties of the precipitates can be altered by simply changing the mixing conditions of the reactants. We demonstrate that by altering flow conditions from turbulent to laminar, the nucleation and precipitation reactions occurring at the mixing interface can be changed, leading to improved mineral separations without the need for specialty chemicals or ion-selective membranes/electrodes.

4:05 PM

Impurity Removal from Various Nickel-bearing Pregnant Leach Solution and Its Impact on the Quality of Nickel Product

P. Lin and L. Pan; Chemical Engineering, Michigan Technological University, Houghton, MI

Metal impurity can have a significant impact on the performance of precursor of cathode active materials (pCAM) used in Li-ion batteries. In this work, two types of feeds were studied, including 1) nickel-bearing sulfide minerals and 2) recycled nickel-rich Li-ion batteries. Common impurities in these two feed materials include aluminum (Al), copper (Cu), iron (Fe), fluoride (F), graphite, magnesium (Mg), as well as other trace amounts of metals. In this work, impurity removal from pregnant leach solutions (PLS) using various established flowsheets was investigated at a laboratory scale. Both nickel and cobalt products from various process flowsheets will be used as the feed for pCAM synthesis. The discussion will be made based on detailed material characterization and electrochemical testing.

4:25 PM

Enhanced Lithium Adsorption Using Innovative Nanosorbent Fibers

Y. Pan and W. Zhang; Virginia Tech, Blacksburg, KY

Electrospun nanosorbent fibers (Li-PNFs) were developed to extract lithium, featuring superior physicochemical properties. The fibers were fabricated using a polyacrylonitrile/dimethylformamide matrix, where optimal interactions were achieved at lower layered double hydroxide contents, as indicated by viscosity and dynamic mechanical analyses. This formulation led to the creation of lithium porous nanosorbent fibers with a

static lithium adsorption capacity of approximately 13.0 mg/g and notable selectivity against contaminant ions. Li-PNFs' continuous extraction performance reached up to 23.83% in a single fixed-bed experiment. These findings highlight Li-PNFs' potential for industrial applications and sustainable lithium recovery.

4:45 PM

Process Development for Selective Separation of Cobalt and Manganese from Acid Mine Drainage

Y. Shekarian, M. Rezaee and S. Pisupati; Department of Energy and Mineral Engineering, The Pennsylvania State University, University Park, PA

Cobalt (Co) and manganese (Mn) have been in the spotlight due to their significant role in clean energy transitions. Acid Mine Drainage (AMD) presents a potential secondary resource for these elements. Recovery of these elements from AMD through precipitation requires elevated pH (~9) or costly oxidizing reagents. In our previously patent-pending published work, ozone oxidative precipitation was used as a chemical-free process to recover these elements from AMD. This study advances the work by developing a process to selectively dissolve and separate Co and Mn from model solutions and AMD. The process involves three main steps: (i) ozone precipitation, (ii) ammoniacal selective dissolution, and (iii) potential-control selective precipitation of Co and Mn. Oxidation Reduction Potential (ORP) significantly impacted the selective precipitation of Co and Mn in potential control oxidation processes. Co and Mn selective dissolution was based on selective Co recovery by reducing ammonia–ammonium carbonate leaching of the produced mixed oxyhydroxide precipitate. The study also highlighted the role of temperature in leaching recovery to understand the mechanism governing the reactions.

TUESDAY, FEBRUARY 25 AFTERNOON

MPD: CHEMICAL PROCESSING: SPECIAL TOPICS IN CHEMICAL PROCESSING

Room 708

2:00 PM • Tuesday, February 25

Chairs: ***B. Vaziri****, Columbia University, New York, NY*
D. Lelinski*, FLSmidth, Midvale, UT*

2:00 PM

Introduction

2:05 PM

25-066

Optimizing the Impacts of Organic and Surfactants on the Suppression of Sulfuric Acid Mist in Electrowinning System

E. Afful, A. Kakoria and G. Xu; Department of Mining and Explosives, Missouri University of Science and Technology, Rolla, MO

Electrowinning and solvent extraction are crucial steps in the production of high purity copper. However, safety concerns have been raised regarding the acid mist generated from the electrowinning process. The mist generated results in health risks to workers and damage to machinery and infrastructure. Currently, chemicals and pellets are used to control acid mist. However, the effectiveness of these controls may possibly vary depending on the type of organic used in the extraction phase, which can influence the generation of acid mist. This study aims to evaluate the impacts of organic solvents and surfactants on the suppression of acid mist. In this study, an electrolyte is contacted with organic solvents to simulate the solvent extraction process. The electrolyte is dosed with suppressant at each contact. Acid mist testing is performed on the electrolyte that is separated from the organic phase at the end of the solvent extraction step. The mist collected, is analyzed to determine the level of acid mist generated. The result from this study indicates that organic solvents and suppressants have a key role to play in copper production and may also play a role in mist suppression.

2:25 PM

25-079

Selective Leaching of Rare Earth Elements From Complex Rare Earth Ore Using Deep Eutectic Solvents

F. Agyemang, Z. Nasrullah, R. LaDouceur and M. Saddat; Materials and Metallurgical Engineering, Montana Technological University, Butte, MT

Rare earth elements (REEs) are valuable resources that are necessary for a wide range of modern technological applications, including metallurgy, machine building, radio electronics, instrument engineering, nuclear engineering, and manufacturing. Extraction and separation of REEs from their complex ore are very difficult due to their unique physical and chemical properties process, thereby making them scarce in the market. Currently, the recovery of REEs involves the traditional pyro- or hydrometallurgical process. The overall process in the recovery and separation of individual elements from complex REE systems suffers from high energy demands and the use of many hazardous chemicals that negatively impact the environment. With the growing trend toward a circular economy aiming to balance sustainability, efficiency, and environmental impacts, this research is focused on using deep eutectic solvents (DESs); a combination of a quaternary salt: Choline Chloride and five organic acids: Oxalic Acid, Urea, and Ethylene Glycol, Lactic acid and Glycerol for the selective leaching of REEs from their complex ore which are proven to be green, slective, non-toxic, biodegradable, and cheap.

2:45 PM

Enhancing Critical Mineral Recovery with Industrial Biotechnology

L. Dennett, R. Hodges and C. Green; Endolith, Westminster, CO

Endolith harnesses microbes and synthetic biology to enhance metal recovery from low-grade ores. We combine biohydrometallurgy and biotechnology using specialized microbes to improve copper recovery from chalcopyrite and high-impurity ores, and lithium recovery from brines and clays. Our biodiagnostic tools assess the health of your heap, and our solutions involve applying low-dose bioaugmentation to promote consistent and efficient bioleaching using strains that have been optimized for over a decade and primed for use on low-grade challenging mineralogy. We have developed a comprehensive genomic extraction pipeline and an extensive proprietary database of over 1000 samples, providing a foundation for these targeted solutions. Mining companies leverage our platform to gain valuable insights into the microbiome of active and inactive leach pads connecting our data to real-time operational and historical databases. Our products are developed using real ore, PLS and raffinate samples from copper mining companies worldwide. Partners include BHP's Unearthed Think and Act Differently Biometals cohort and the AK Critical Minerals Cooperative.

3:05 PM

A Review of Extraction of Technologically Critical Elements–Gallium, Germanium, and Indium–From Solutions Using Ionic Liquids

M. Silwamba[1], E. Oteng[2] and L. Alagha[1]; [1]Mining and Explosives Engineering, Missouri University of Science and Technology, Rolla, MO and [2]Department of Materials Science and Engineering, Missouri University of Science and Technology, Rolla, MO

Gallium (Ga), germanium (Ge), and indium (In) are crucial elements for the production of high-tech products such as semiconductors, integrated circuits, solar panels, electronics, drones, robots, and optical fiber as well as data storage. Many governments and private entities classify these as critical minerals or elements due to the potential risks associated with supply disruptions stemming from geopolitics and stockpiling. When these minerals are leached from their different source materials, leach solutions usually contain low concentrations of these critical elements and many folds of impurities. This review focuses on the extraction processes of these critical elements from leach solutions using ionic liquids (ILs). Emphasis is placed on elucidating the extraction mechanism

and assessing selectivity criteria. In general, several reviewed ILs exhibit low selectivity towards Ga, Ge, and In over Fe(III), Al, and Zn, which often occur at high concentrations in leach solutions. The scaling-up process, IL recycling, and comprehensive economic feasibility analysis of ILs require thorough investigation to facilitate potential commercialization to extract these crucial metals.

3:25 PM

Green Synthesis of Single Crystal Ni-Rich Cathode Materials for Lithium-Ion Batteries

I. Habib[1], L. Alagha[2] and M. Moats[3]; [1]Mining and Explosives Engineering, Postdoctoral Fellow, Rolla, MO; [2]Mining and Exposives Engineering, Associate Professor, Rolla, MO and [3]Materials Science and Engineering, Professor and Chair, Rolla, MO

Nickel and cobalt play vital roles in modern technology and sustainable energy solutions, making them critical elements. As the demand for clean energy and advanced technologies continues to grow globally, the significance of nickel and cobalt has also increased. They have become indispensable in the transition towards a low-carbon economy. In this study, in-house synthesized nano-sized zero-valent iron with various core/shell compositions, along with improved solvent extraction technology will be employed to selectively separate nickel and cobalt from industrial leachate solutions that contain other metal impurities. The recovered nickel and cobalt will be utilized to create an effective single-crystal nickel-rich cathode material (NCM 811: Ni80%, Co10%, Mn10%). The aim is to achieve a high capacity for lithium-ion batteries and promote sustainability.

3:45 PM

25-073

Onshore Processing of Seabed Polymetallic Nodules: Revisiting Pressure Acid Leaching

N. Verbaan; Natural Resources, SGS Canada, Lakefield, ON, Canada

Seabed polymetallic nodules, which contain significant quantities of metals key to electrification (nickel, cobalt, copper and manganese) can be processed using a variety of different metallurgical processing routes, including direct smelting and subsequent hydrometallurgy, ammoniacal leaching (gas reduction or Cuprion), or acid leaching (often reductive). Many of these approaches suffer from reduced cobalt extraction, difficult physical performance or just general overall circuit complexity. SGS has considered pressure acid leaching of nodules for further investigation, as publicly shared data on this processing route stems from the 1970's and 1980's and is not always easily accessible. This paper will provide a brief review of processing technologies considered by current projects and will also discuss results of an internal R&D testwork program indicating high extraction of nickel, cobalt and recovery recovery with limiting co-extraction of manganese and iron. The paper will also comment on the potential treatment options of leach liquor and leach residues.

4:05 PM

25-050

Introduction of a New Environmentally Friendly Acid Mist Suppressant in Copper Electrowinning—ACORGA® EW98

T. Doubleday, W. Szolga Jr., L. Moya and T. Mccallum; Syensqo, Tempe, AZ

Sulfuric acid mist is an undesired by-product of the copper electrowinning process. Oxygen formation at the anode can entrain droplets of the acidic electrolyte solution and leads to acid mist when these droplets become aerosolized at the surface of the cell. The addition of chemical anti-misting agents to the copper electrolyte is a common mitigation technique. This paper details Syensqo's laboratory development of a new environmentally friendly acid mist suppressant, ACORGA® EW98. The product exhibits excellent acid mist suppression and full compatibility with the adjacent solvent extraction process. The product has been recommended for a commercial trial at a major copper producer.

4:25 PM

Accelerating Access to Copper Sulfides Through Leaching

J. Mather; Ceibo, Draper, United States, UT

Ceibo's leaching process extracts copper in all sulfides using existing leaching plants, achieiving recoveries comparable to traditional concentrators (75-85% recoveries). This process more quickly and effectively catalyzes the oxidation in the ore through electrochemical reactions, resulting in higher recovery rates in shorter operational cycles. The technology's efficiency in recovering copper from low-grade ores makes it a cost-effective and sustainable alternative to concentrating. Additionally, it significantly reduces environmental impact by lowering emissions and energy consumption. This advancement in leaching technology offers a promising solution for the copper industry, combining high recovery rates with environmental benefits. Ceibo's technologies can be used in many ways including increasing the output of existing operations, extending the life of a mine, and enabling new brownfield and greenfield projects.

4:45 PM

Refining Methodology for Cu SXEW Mist Suppressant Validation

T. McDonald, J. heidlas and B. Chanez; Mining Solutions, BASF, Tucson, AZ

Acid mist generation continues to be an issue faced by the mining industry, stemming from O_2 generated by hydrolysis during copper electrowinning. It has previously been controlled by use of reagents that are being phased out, opening the door to new chemistries. BASF has developed a comprehensive approach to validating mist suppressing reagents at laboratory scale. This test regime addresses: mist reduction, plating, SX compatibility, and stability. Standard methods have been developed that allow rapid vetting of potential candidates, with confidence and reproducibility. Additionally, attention has been given to detection and quantification of potential mist reagents in CuSX plant streams.

TUESDAY, FEBRUARY 25 AFTERNOON

MPD: COMMINUTION: COMMINUTION II

Room 706

2:00 PM • Tuesday, February 25

Chairs: ***A. Boylston****, Metso Minerals, York, CO*
N. Blumberg

2:00 PM

Introduction

2:05 PM

Machine Vision as a Tool for Enhanced SAG Mill Inspections

C. Reynoso Gonzalez; Molycop, Tucson, AZ

In grinding operations, ensuring efficiency and optimization requires continuous monitoring and analysis of various operational variables. While some variables like mill power, weight, particle size, and vibration patterns can be measured in real-time, others such as charge and ball filling, grate wear and ball size distribution require periodic manual inspections. These inspections are often limited by tight maintenance schedules and safety concerns. This study leverages machine vision (MV) techniques, specifically convolutional neural networks, to enhance the efficiency and accuracy of SAG mill inspections. Utilizing models for semantic segmentation and object detection, this research aims to automate the measurements of key components within the mill. Detailed data collection and manual annotation procedures support the training and evaluation of these models. Post-processing techniques, including perspective correction and morphological operations, further refine the analysis. The results demonstrate the potential of MV technologies to provide accurate assessments of SAG mill conditions, reducing the reliance on manual inspections and enhancing operational efficiency.

2:25 PM

Benefits and Risks of Using Bigger SAG Media

T. Fawcett, B. Cornish and J. Zela; ME Elecmetal, Chandler, AZ

SAG (Semi-Autogenous Grinding) operations must continually adapt to the inevitable changes in ore characteristics. One easily modifiable alternative for continuous improvement is using a larger ball diameter in SAG grinding operations. This adjustment helps mitigate the mineralogical changes projected as the mine's lifespan progresses. Here are the key points regarding the use of larger ball diameters: 1. Operational Range Enhancement: Larger ball diameters accommodate mineral variability, including increased hardness. This broader operational range contributes to better performance. 2. OPEX Savings: Larger balls experience lower wear rates due to reduced surface area. Additionally, they spend more time within the mill, leading to cost savings. 3. Adverse Effects Mitigation: To prevent adverse effects on mill grates or liners, it's essential to understand ball trajectories. 4. Maintaining Jb Level Control: Re-estimating the recharge velocity for larger-diameter balls ensures consistent Jb (ball charge level) control. This paper provides a deep dive into each of these areas as well as other valuable insights regarding optimizing SAG milling performance through using larger diameter media.

2:45 PM

Importance of Quality Audits for Grinding Media Users

A. Wilson; SME, Evergreen, CO

Steel grinding media is a critical consumable for many mines. All grinding media looks the same but can have wildly varied properties. Those properties can result in highly wear and fracture resistant balls. But balls can also be soft with little wear resistance or too hard and subject to breakage. Tracking a mines grinding media supply properties allows for historical trends to be tracked and compared with consumption. This expensive consumable should be a part of every mines quality audit program.

3:05 PM

25-014

Mitigating SAG Mill Underperformance: The Role of Robust Sampling, Testwork and Design Practices

M. de Paiva Bueno[2], R. Chandramohan[3], M. Pyle[3], L. Lara[2], M. Powell[1] and G. Lane[3]; [1]Sustainable Mining Institute, The University of Queensland, Saint Lucia, QLD, Australia; [2]Geopyörä, Oulu, Finland and [3]Ausenco, Brisbane, QLD, Australia

Recent industry trends reveal a significant number of SAG mill projects failing to achieve their nameplate capacity, raising concerns about the reliability of current design and testing methodologies. This paper investigates the underlying causes of these underperformances, emphasizing the importance of robust sampling, comprehensive testwork, and sound design practices. Through an in-depth analysis of public domain data and specific case studies, we highlight the critical gap between the extensive number of assays conducted for grade estimation and the relatively few comminution tests performed. Our findings suggest that increasing the number of comminution tests can greatly enhance the understanding of ore hardness variability, leading to more precise throughput predictions and optimized mill designs. Furthermore, we explore the economic trade-offs of different risk management strategies, advocating for a balanced approach that combines thorough testwork with strategic design considerations. By adopting these practices, industry professionals can improve SAG mill performance, thereby restoring market confidence in this mature but essential technology.

3:25 PM

3D Characterization of Micro-Cracks in Silicate-Rich Crushed REE Ore Particles for Fluid Transportation and Carbonation

R. Jaramillo[1], J. Jin[1], X. Wang[1], P. Chu[2] and R. Zahn[3]; [1]Materials Science and Engineering, The University of Utah, Salt Lake City, UT; [2]University of Nevada Reno, Reno, NV and [3]FLSmidth, Midvale, UT

Comminution of REE ores requires a relatively small grinding size (20 um) to achieve sufficient liberation between REE minerals from gangue. To reduce the energy consumption in fine grinding, carbonation of silicates in the crushed REE ore has been studied to alter the mineralogy and the corresponding ore hardness. The micro-cracks in silicate-rich phases is important for the transportation of CO2 saturated fluid, to facilitate the carbonation reactions. Silicate-rich crushed REE ore particles were selected by X-ray radiography, which were then classified to three groups based on TIMA determined mineral textures. X-ray CT scans with a voxel size about 3 um were conducted to characterize the micro-cracks/pores in these crushed REE ore particles. 3D structures of the micro-cracks were analyzed for pore size distribution and surface areas. LBM simulation was used to determine fluid transportation in selected volumes.

3:45 PM

Minimizing Power Loss in Microwave Pretreatment for Ore Comminution

S. Adewuyi[1], A. Anani[1], L. Akinyemi[2] and K. Luxbacher[1]; [1]Mining and Geological Engineering, University of Arizona, Tucson, AZ and [2]Department of Mathematics, Prairie View A&M University, Prairie View, TX

Energy consumption for ore comminution is one of the current challenges in the mining industry. Microwave pretreatment is being explored to improve ore grinding and reduce energy consumption. However, accurately assessing and minimizing microwave power loss is critical to effectiveness and economic feasibility of microwave pretreatment. This study uses advanced multiphysics simulation software to investigate microwave power loss during ore pretreatment. The research aims to improve understanding of microwave power dynamics, provide optimized design guidelines for industrial microwave systems, and offer recommendations for best practices in microwave-assisted mineral processing. The model to be developed will be validated with experimental data.

4:05 PM

Reduction of Comminution Energy Consumption by CO_2-Assisted Grinding

Y. Wang, X. Wang and W. Zhang; Mining and Mineral Engineering, Virginia Polytechnic Institute and State University, Blacksburg, VA

Different minerals within the same react differently with CO_2, potentially causing flaws and cracks in the ore particles. In response, Virginia Tech initiated a comprehensive experimental program to assess the impact of CO_2 treatment on the grindability of two ores of distinct types: bastnaesite and chalcopyrite. The treatments were conducted both in-situ and ex-situ to identify the optimal conditions for the experiment. By refining the experimental route under these conditions, a multi-stepwise combination of in-situ and ex-situ treatments was employed. The results demonstrated that CO_2 treatment and grinding significantly reduced the grindability of the ores, with the Bond Work Index decreasing by more than 20%. This study offers valuable insights for enhancing ore processing efficiency and reducing energy consumption in mineral grinding, contributing to more sustainable mining practices.

TUESDAY, FEBRUARY 25 AFTERNOON

MPD: FLOTATION: INNOVATION IN FLOTATION

Room 707

2:00 PM • Tuesday, February 25

Chairs: ***M. Carlisle****, Newmont, Englewood, CO*
G. Bermúdez*, Metso Canada Inc, Burlington, ON, Canada*

2:00 PM

Introduction

2:05 PM

25-023

The Development Journey of Metso's FloatForce®+ Flotation Mixing Mechanism

C. Cardoso[1], G. Bermúdez[1], I. Sherrel[3] and H. Vepsalainen[2]; [1]Metso Canada Inc, Sudbury, ON, Canada; [2]Metso Finland, Espoo, Finland and [3]Metso USA, York, PA

Performance of mixing mechanisms in flotation cells is paramount, as inefficiencies can lead to financial losses through valuable minerals lost to tailings. Technological advancements have been implemented in flotation cells to optimize performance, but regardless of the efficacy of these developments, room for improvement may persist. Since its launch in 2005, FloatForce® has set a high industry standard for flotation mixing mechanisms. However, current mining trends call for sustainability-driven developments while improving metallurgical performance. Metso has recently introduced the latest iteration of FloatForce, developed through extensive laboratory, pilot, and industrial testing, aligning with mining sustainability trends. It has been designed to maximize recovery, reduce power draw and optimize manufacturing materials. This development stems from a redesigned rotor profile paired with a harmonizing stator configuration. This paper presents the development journey of Metso's latest flotation mixing mechanism, an advancement to improve metallurgical performance at a high sustainable standard in flotation cells. The theory, CFD modeling and test work are discussed in detail.

2:25 PM

REFLUX™ Flotation Cell Full-Scale Trial in a Copper Concentrator Cleaning Application

S. Saurabh[1], B. Dabrowski[3], L. Christodoulou[1], M. Czekajlo[2], P. Kwiatkowski[2], E. Kasinska-Pilut[2] and R. Pepkowski[2]; [1]Global Product Line Management, FLSmidth Inc., Midvale, UT; [2]KGHM, Polkowice, Poland and [3]Mineral Testing $ Research Center, R&D, FLSmidth Inc., Midvale, UT

REFLUX™ Flotation Cell (RFC™) is being tested extensively at laboratory, pilot, and industrial scales across various commodities in rougher, scavenger, cleaner, and tailings reprocessing applications. The test results show that RFC™ transforms the hydrodynamics of flotation. RFC™ commercial scale unit was tested at one of the KGHM's copper concentrators in cleaning application. RFC™ was earlier tested in a scavenger application, and the results were published and presented at several national and international conferences. The plant had incumbent conventional flotation cells with three stages of cleaning. Slipstream from the first cleaner feed was provided to the RFC100 pilot unit and the RFC850 commercial unit. The feed was tested in both the units and results were compared against conventional bench-scale test results. The results show that this technology provides faster flotation kinetics and can shift the grade-recovery curve. The results from this testing campaign will be discussed in this presentation.

2:45 PM

The NovaCell™, How Much Liberation is Needed for Flotation Recovery

S. Morgan; Jord International Pty Ltd, St Leonards, NSW, Australia

The NovaCell™, is a novel flotation device, that has separate recovery zones for coarse and fine particles. Invented by Laureate Professor Graeme Jameson, Jord International has the global exclusive rights to commercialise the technology. The paper, Pinto Valley Mine—Copper recovery study with the NovaCell, demonstrated the potential benefits of this innovative technology in coarse particle flotation (CPF) circuits. The NovaCell™, as a substitute for existing mechanically agitated float cells, suggested a 20% increase in plant production and a 15% reduction in carbon emissions. It is hypothesized that the improved recovery efficiencies with NovaCell™ at coarse grind sizes, is due to its ability to recover valuable minerals with low levels of liberation by surface area. To investigate this further, the NovaCell™ recovery performance was compared to existing technologies, for fresh run-of-mine ores. The NovaCell™ products were submitted for mineral liberation analysis, and the results suggested the liberation needed for flotation recovery. This provided insights into current practices and whether communition energy can be reduced through adoption of the NovaCell™ technology.

3:05 PM

25-036

FloatForce®+ Flotation Mixing Mechanism trial at Kennecott Copperton Concentrator

J. Cole[2], J. Dettamanti[2], R. Abbasi[2], J. Sovechles[1], C. Cardoso[1], G. Bermúdez[1] and M. Hirsi[3]; [1]Metso Canada Inc, Sudbury, ON, Canada; [2]Rio Tinto, Salt Lake City, UT and [3]Metso Finland, Espoo, Finland

The implementation of technological advancements in flotation is key to optimize performance in mining operations. Consequently, flotation cell's performance is highly dependent on the effectiveness of the mixing mechanism. A more efficient flotation mixing mechanism is likely to improve metallurgical performance and optimize energy consumption, which is the motivation for Metso's journey to develop the latest iteration of FloatForce®. Looking to test the new design at plant scale, Metso approached the Kennecott Copperton concentrator, which is continuously looking for different venues to improve metallurgical performance. In this context, a test campaign was conducted to implement this new flotation mixing mechanism in their rougher circuit during 2024. The industrial trial consisted in several sampling campaigns assessing different operational parameters for comparison purposes around a 300m^3 flotation cell. The effect of the new flotation mixing mechanism on the cell's power draw was also studied. The results of this trial at Kennecott are presented on this paper.

3:25 PM

Industrial Demonstration of Coarse Particle Flotation at Rio Tinto Kennecott

A. Hobert[2], R. Van Wagoner[1], E. Dohm[2] and T. Byrd[1]; [1]Rio Tinto Kennecott Utah Copper, South Jordan, UT and [2]Eriez USA, Erie, PA

As global copper demand increases to support transition from carbon to renewable-based systems of energy production, mine operators seek innovative ways to increase mill throughput, improve efficiencies, and improve environmental sustainability. Flotation is an essential process for concentrating porphyry copper ores, but conventional flotation technologies are unable to efficiently recover coarse particles. Conversely, the Eriez HydroFloat technology increases the maximum floatable particle size using a combination of flotation and hindered-bed separation, which facilitates optimization of metal recoveries, flotation grind size, mill throughput, and tailings water recovery. Upon completion of extensive laboratory and pilot testing, Rio Tinto Kennecott constructed a HydroFloat coarse particle flotation demonstration plant to investigate recovery of copper and molybdenum from Copperton concentrator tailings at industrial scale. This paper summarizes the multi-year collaboration between Rio Tinto Kennecott and Eriez to successfully demonstrate the HydroFloat technology at Kennecott, as well as the direct scalability of flotation results from laboratory and pilot to industrial scales.

3:45 PM

Investigating the Flotation Performance of coarseAIR™: Sulfide Mineral Applications

H. Patel, J. Bowden and L. Christodoulou; FLSmidth, Midvale, UT

With decreasing mineral grades, conventional sulfide mineral flowsheets require increased mill throughput to produce similar metals. Due to increased throughput, grinding circuits produce coarser particles, which are lost in conventional flotation. Innovation in mineral processing is needed to recover particles with low mineral liberation, i.e., at a coarser particle size than conventional flotation. FLS's coarseAIR™ is an innovative hybrid-gravity-flotation system based on the REFLUX™ Classifier. The coarseAIR consists of an aerated fluidized bed utilizing a system of inclined channels

to maximize mineral recovery while rejecting fine gangue minerals. This paper focused on the performance of the coarseAIR while testing copper ore. The project aimed to maximize copper recovery, and multiple tests were conducted to assess this objective. Various parameters were tested, like fluidization water, flotation air, and throughput. The results demonstrated a significantly higher recovery than conventional flotation cell testing. A value proposition using simulated plant data was presented. The scope for additional testing and plans for future testing were discussed.

4:05 PM

Mitigating the Negative Effects of Clay Minerals in Flotation: An Innovative Approach

O. Onel and M. Hoang; Mining RD&E, Ecolab/ Nalco Water, Blacksburg, VA

Clay minerals present significant challenges in mineral flotation due to their fine particle size and impact on pulp rheology, both of which impair flotation efficiency. Changes in pulp rheology can disrupt bubble–particle interactions and the movement of bubble–particle aggregates, which are crucial for froth generation. The presence of clay minerals in flotation slurries negatively affects both the concentrate grade and recovery. The mechanical entrainment of clay particles compromises concentrate grade, while recovery is hindered by the formation of cross-linked clay network structures, like house-of-cards or honeycomb patterns, which elevate pulp viscosity. Different clay types cause distinct issues in flotation due to their unique properties. This study explores innovative strategies to alleviate clay-related challenges, especially with swelling clays, by using novel reagents, enhanced froth stabilization methods, and optimized process parameters. These approaches aim to improve the separation efficiency of valuable minerals from high-clay ores, offering promising solutions for more efficient and sustainable mineral processing operations.

TUESDAY, FEBRUARY 25 AFTERNOON

MPD: PLANT DESIGN: DETAILED DESIGN AND CONSTRUCTION (PANEL)

Room 711

2:00 PM • Tuesday, February 25

Chairs: ***A. House****, Paterson & Cooke, Helena, MT*
M. Spicher*, Montana Tech of the University of Montana, Meridian, ID*

2:00 PM

Introduction

2:05 PM

MPD Plant Design Panel Discussion, 2025, Detailed Engineering and Construction

J. Wickens; Wood Group US, Sparks, NV

This Panel Discussion is the second in a three-part series covering the different phases of project development. Last year's session, the first in the series, was on Project Development, including technical studies, permitting and financing. This year's session focuses on the detailed engineering and construction phases. The third and final session in this series, in Salt Lake City (2026), will focus on commissioning/start-up/ramp-up. The panelists for these sessions are leaders in our industry, and this year's panelists include Matt Sletten, Terry Owen, Jeff Nodine and Jim Sorensen. The panel discussions are moderated, with a series of "hot-topic" questions posed to the panelists to share their insight and wisdom. Each panelist will have an opportunity to share their thoughts on each question, as well as field questions from the audience. This year's session will be moderated by Adam House.

TUESDAY, FEBRUARY 25 AFTERNOON

SME YOUNG LEADERS: PROFESSIONAL DEVELOPMENT

Sponsored by: RioTinto

Room 111

2:00 PM • Tuesday, February 25

Chairs: ***A. Soni****, Freeport-McMoRan, Tucson, AZ*
V. Srivastava*, Freeport McMoRan, Tucson, AZ*

2:00 PM

Introduction

2:05 PM

Loading Your Personal Toolbox: The Skills that Lay the Groundwork for Mining Application Engineering and Entry-Level Roles

K. Slaughter; Application Engineering, Komatsu, Tuscson, AZ

The mining industry boasts a myriad of entry-level job opportunities across many different disciplines. For mining engineers, the jobs that come to mind most likely take place on a mine site in mine planning, blasting, or reclamation. However, there are other lesser-known roles available that individuals may be well-suited for. One of these roles is that of a mining application engineer (MAE) with Komatsu—a role that both requires and enhances certain soft skills that are not quite as emphasized in other fields. MAEs serve as subject matter experts for different mining applications and customer needs for Komatsu's current and future mining equipment product lines. Using this knowledge, they act as liaisons between both internal and external customers to support machine selection, design, sales, and performance benchmarking analyses around the globe. MAEs rely on strong leadership, verbal communication, and interpersonal communication skills to successfully complete customer studies and day-to-day job functions. This talk will explore these skills through the lens of an MAE, discuss their importance in any field, and explain how they can be developed to improve one's career.

2:25 PM

Mining Engineer Graduates Career Path

Y. Hurr; Caterpillar Inc, Peoria, IL

Are you a Mining Engineering student and wonder where you could work after graduation? If so, this session is for you! Mining Engineering opens a wide range of job opportunities—and this session will dive into several different career paths. Will you ultimately decide to work in a mine or for a mining equipment manufacturer? Will you go into a consulting role or decide to continue in your education and research? Does one career path leverage your personal strengths and interests better than another? We will discuss all these options as a Mining Engineering graduate to help you define your own career path.

2:45 PM

Today's Outlook on the Future of Mine Management for a Successful Industry

P. Dolph; LInkan, Golder, CO

There is a new generation of mine managers that recognize the need to adapt to the faster pace introduction of technology, human resources, regulatory challenges and community relations. This presentation will highlight dissusions with some of the industry's leading managers who represent the use of current and innovative solutions to both mine operational improvement and industry acceptance by the public. Topics covered will include the cost impacts of energy efficiency, AI application in mine development, innovative engineering concepts, and incentives to develop the workforce of the future. Source interviews will include CEO's, General Managers, and mine analysts who best represent a newer vision for our industry.

3:05 PM

Graduation vs Retirement: Can We Meet the Growing Demand?

A. Faust; SynTerra, Lexington, KY

Declining graduation rates and retirement on the rise within the mining industry is creating significant vacancies in high-level positions. Ever increasing demand for products that use mined materials requires new mines to be opened. These new mines, in addition to existing mines, need educated and skilled personnel to design and manage them. However, low university recruitment coupled with an aging workforce has resulted in a shortage of qualified professionals. There are several solutions currently being attempted, however, it is yet unclear if they are making any impact. It is clear, however, that universities, mining companies, and the media are the keys to recruiting more people to work in this field.

3:25 PM

From Student to Professional: The Quantifiable Impact of SME Student Chapters on Professional and Personal Development

M. Portal Valdivia, F. Segobia Campos, L. Goicochea Sánchez, F. YSLA QUIROZ and V. Jauja; Mining engineering, Society for Mining, Metallurgy & Exploration, Cajamarca, Cajamarca, Peru

This study examines the impact of Society for Mining, Metallurgy & Exploration (SME) student chapters on the professional and personal development of mining students and young engineers. Through surveys and interviews with student chapter members and leaders, the research will analyze how participation in these organizations has influenced career trajectories, technical skills, leadership abilities, networking, and personal growth. Statistical data quantifying the impact of student chapters on professional success will be presented. Additionally, the study will explore intangible benefits such as the development of soft skills, self-confidence, and a sense of belonging within the mining community. This research will provide concrete evidence of the value of SME student chapters as catalysts for developing future leaders in the mining industry.

3:45 PM

Gold and Knowledge: An Educational Solution to Connect Vulnerable Youth to the Mining Industry

C. Navia Vasquez; Mente Soñadoras Foundation, Green valley, AZ

Artisanal and small-scale gold mining in Tutunendo, Colombia is one of the main economic activities in the region. Young people in these areas face significant challenges such as illegal labor, lack of access to quality education, and high school dropout rates. The Mentes Soñadoras Foundation aims to transform the skills and talents of these young people in vulnerable situations by providing them the tools to achieve their dreams through knowledge, ultimately improving their quality of life. Through the M.I.P.E. (Mental, Intellectual, Physical, Emotional) program, we empower young people to education and provide opportunities in the areas of earth sciences. This approach not only addresses immediate educational gaps, but also builds a sustainable future where young people can positively impact their community and the mining industry.

4:05 PM

Mining Engineering...The Warrior Way

A. del Angel; Mining Engineering, Student, Greeley, CO

Warrior Met Coal is a company focused on the extraction and handling of metallurgical coal, extracted from the Blue Creek Seam in Alabama. As a Summer Intern with Warrior Met Coal, my objectives were to be exposed to the different facets of coal mining which included the operations, engineering services, and safety compliance that is directly involved with coal mining. The objective of this presentation is to not only educate the general public of the importance of coal mining, but of the lessons I learned through the duration of my internship at Warrior Met Coal.

TUESDAY, FEBRUARY 25 AFTERNOON

TAILINGS: EDUCATING STAKEHOLDERS/ MANAGEMENT ON TAILINGS TECHNOLOGY AND IMPACTS ON PRODUCTION AND FINANCES

Sponsored by: Newmont

Room 607

2:00 PM • Tuesday, February 25

Chairs: ***D. Korri****, Society for Mining Metallurgy and Exploration, Silver Bay, MN*
C. Pecora*, Hawcroft, Venetia, PA*

2:00 PM

Introduction

2:05 PM

Tailings & ESG 101: A Mining Leader's Masterclass

K. Morrison; Morrison Solutions, Lakewood, CO

In the wake of tragic tailings facility failures and intensifying scrutiny over mining's environmental and social impacts, the industry can no longer afford to have knowledge gaps around tailings management and ESG risks at the highest leadership levels. This presentation draws upon over 25 years of front-line experience in sustainable tailings stewardship to equip mining executives, board members, and governance leaders with vital competencies. Key takeaways include understanding the criticality of tailings management from a technical, environmental, social and financial risk perspective; implementing robust tailings governance models aligned with global best practices; fostering ethical leadership that embeds ESG into corporate strategy and decision-making; and fulfilling comprehensive ESG disclosure obligations to meet mounting stakeholder demands for transparency and accountability. Through real-world lessons learned, cautionary tales where leadership failed, and proven governance practices, this insiders' deep dive equips mining leaders to responsibly navigate an increasingly complex ESG landscape.

2:25 PM

Balancing Investment in Geotechnical Studies and Performance Monitoring at TSF to Improve Stability as they Gain Height, or Investigation Investment versus FOS at TSF

W. Walton; GeoStructural, GEI Consultants, Inc., Harwich Port, MA 02646, MA

Recommended investment decision making process for owners is to understand the geometry, water level, foundation and fill rates for active sluiced TSF sites. This includes TSF perimeter fill and foundation strengths, density, and permeability values. As active TSF sites gain height; there will be an increase in lateral loading, due to hydrostatic and earth pressures on perimeter dams. Understanding of TSF behavoir is key on how PMFs involving undrained loading on TSF due to increased shear stresses, submergence or hydro-consolidation of loose tailings as TSF stacks grow. Triggered liquefaction of loose wet tailings threaten the integrity of TSF, mine, downstream parties and environment. Determining if liquefaction occurs when the tailings are wet, loose, and loaded rapidly is key; without 3 of these conditions occurring at once, liquefaction is unlikely. We suggest choosing undrained strengths using multiple methods; this can lead to using defensible higher undrained design strengths compared to strengths based on empirical and limited case history data. To reduce TSF risks and save money, managers should invest in early and thorough geotechnical site characterization of their TSFs.

2:45 PM

25-049

International Standards for Tailings Management

C. Dumaresq; Mining Association of Canada, Ottawa, ON, Canada

Having standards for tailings management is essential. A history of failures of tailings facilities has eroded trust and has had significant impacts on people, the environment, and companies. Standards help raise performance expectations and provide a means to measure and report on performance. They help demonstrate that tailings are being responsibly managed, build trust, and most importantly—help ensure that risks are properly managed. Two standards are being applied internationally, the Global Industry Standard on Tailings Management introduced in 2020 and the tailings component of the Toward's Sustainable Mining program, introduced in 2004. These standards have similar objectives and cover similar topics. Each has strengths, weaknesses and gaps and each can help improve tailings management and reduce risk. However, we cannot rest on our laurels because we have achieved conformance. Conformance can breed complacency. To achieve the goal of these standards, we need to continually improve. That takes a commitment to excellence, leadership, and a systematic, holistic approach. Responsible tailings management is more than just an exercise in good engineering.

3:05 PM

The Golden Keys to Successful Tailing Facility Management—Committed Tailing Engineer Engagement, Careful Attrition Mitigation, and Proactive Succession Planning

C. Hatton; WSP, Parker, CO

The successful governance of a tailing storage facility depends on key individuals and their ability to not only provide technical expertise but to administer the governance in a way that deals with many of the intangibles necessary for success. This includes understanding what commitment and engagement look like, characterizing multiple levels of commitment, and establishing expectations against these levels. Attrition, although undesirable is a fact of life. What comes into question is whether the attrition is natural professional progression or is forced attrition for other means and what are the impacts of forced attrition. The most important concept currently overlooked is the idea of proactively managing the tailings facility leadership by strategic succession planning and prioritizing maintaining quality and plentiful resources.

3:25 PM

The Importance of Technical Governance Renewing a Tailings Master Plan Adding Concepts of ESG and GISTM—A Real Case of a Phosphate Mining Complex in Brazil

T. Oliveira and E. RODRIGUES; Mining CoE, Mosaic, Araxá, Minas Gerais, Brazil

From the past five years mining operations are being demanded to be more aligned with principles of sustainability, transparency with communities and social agendas. These new operating visions are supported by practices such as the ESG (environmental, social and governance). Furthermore, due to the latest tailings dams failures, the International Council of Mining and Metals (ICMM) created a worldwide guide aiming to standardize the management of tailings storage facilities (TSF) named GISTM (Global International Standard of Tailings Management). This paper aims to show a real example of a phosphate mining complex located in Brazil that was impacted by all the several changes occurred in the past years. From the base case, this complex had two existing tailings dam that including two new future tailings dam would support the life of mine. During the double checking everything were re-evaluated starting with the tailings characteristics, the process route, existing permits and structures. The results ensure that the complex will need only the existing tailings dams with coarse tailings piles buttressing the existing dams. This solution has been called the Hybrid Solution.

3:45 PM

Conformance vs. Compliance: Contrasting the Voluntary GISTM to 9 years of Federal CCR Regulations

L. Carr; Ramboll Americas Engineering Solutions, St. Louis, MO

The tailings failures of the 2010s were preceded by failures at U.S. coal combustion residual (CCR) impoundments (e.g., Kingston, 2008; Dan River, 2014). The failures involved static liquefaction and/or flow-failure of waste impoundments. Both led to offsite impacts, public scrutiny, litigation, and efforts to develop systems to prevent future failures. The failure prevention systems differ between CCR and tailings. For CCR, the system is mandatory compliance via Federal regulation via 40 CFR Part 257 (USEPA CCR Rule). No additional failures have occurred since this system was implemented in 2015. However, the CCR Rule utilizes prescriptive criteria, is the subject of ongoing litigation, and was expanded in scope in 2024. This approach is different than the 2020 Global Industry Standard for Tailings Management (GISTM), which relies on voluntary conformance with a stakeholder-developed program with the allowance for variations and multiple layers of governance and overlapping review. This presentation will contrast each method—compliance vs. conformance—such as the advantages of the GISTM over the CCR rule and provide lessons learned from over 9 years of CCR compliance.

4:05 PM

Factor of Safety and Risk Associate with Prescribe Factor of Safety

B. Ulrich[2] and A. Sharifabadi[1]; [1]ADEQ, PE, Phoenix, AZ and [2]Bryan Ulrich LLC—Tailings Solutions, PE, Denver, AZ

The FoS varies across different engineering disciplines depending on the nature of the structures, systems, and components, as well as the risks and consequences associated with failure. Generally, the FoS ranges from 1.2 to 3.0 in geotechnical engineering. Selecting an appropriate FoS involves balancing safety, cost, material properties, and performance requirements. Guidelines from organizations such as CDA and ANCOLD recommend minimum FoS values for designing embankments. These values, referred as magic numbers have been used for decades and have provided acceptable probabilities of failure. The FoS 1.5 assumes that material properties follow a normal distribution, and engineer's judgment has been used for selection of these properties to ensure stability. During the early design and operation of tailings facilities, using the recommended FoS is generally acceptable. However, as the project matures and more data becomes available, it is advisable to shift from a deterministic to a probabilistic approach to better understand the facility's probability of failure and selected FoS is acceptable.

TUESDAY, FEBRUARY 25 AFTERNOON

VALUATION II: LESSONS LEARNED

Room 112

2:00 PM • Tuesday, February 25

*Chair: **Z. Smith**, Withum, Jersey City, NJ*

2:00 PM

Introduction

2:05 PM

Economic Damages in Extractive Industries

L. Bartlomain and Z. Smith; Forensic & Valuation Services, Withum, Jersey City, NJ

We review the concept of compensable damages associated with various scenarios across the life cycle of predominantly energy projects from extraction through transportation, processing, and storage. Examples from damages cases, such as the Dimmock case, will be discussed. What are some potential impacts to the surrounding properties (and wildlife) when

an underground pipeline ruptures and spills oil into the Pacific Ocean? Or when a pipe ruptures at an oil refinery causing an instant fire? Natural gas storage can also cause havoc when a leak persists at a storage facility. Join us as we discuss these issues, and more, and their potential impacts on surrounding properties as the damages, or diminution in value, can vary.

2:25 PM

The Influence of Climate Policy and Carbon Price on Mine Valuation and Investment Dynamics

J. Davdson; Consulting, Worley, Mosman Park, WA, Australia

To achieve the goals of the Paris Agreement more countries are adopting carbon pricing mechanisms. Currently over 45 countries have implemented some form of mechanism, with many more planning to introduce similar measures. To accommodate this policy movement, an increasing number of mining companies are integrating an internal carbon price into their capital decision-making process. However, the forecast carbon price remains uncertain with a range of potential prices adopted spanning US$50/tCO2e to US$175/tCO2e by 2030. This research study investigates the role of carbon pricing and the impact on valuation of mining assets. Specifically, the study explores a case study of the potential development of two Iron Ore deposits in Australia and the impact on development pathways. A Monte Carlo based sensitivity analysis was conducted across a range of potential carbon price scenarios while also assessing several carbon reduction and mitigation measures that could limit any negative financial impact. The results of the research show that carbon price has the potential to significantly impact asset valuation and highlights the need for ongoing and proactive decarbonisation action.

2:45 PM

Highest & Best Use Analysis in Energy & Mining

Z. Smith; Forensic & Valuation Services, Withum, Jersey City, NJ

This talk will explore the standard components of highest and best use: legally permissible, phyically possible financial feasibile, and maximally productive, plus two additional factors that could be considered part of the financial feasibility test, the imminent and probable tests. Applications to mixed asset estates will be explored as well as considerations for unique intended uses such as noncash charitable contributions and conservation easements. Time permitting, we will further discuss examples of highest and best use errors commonly found in mineral appraisals.

3:05 PM

How Developers Should Use Technical Economic Analysis Results to Drive Project Strategy

C. Hizmeri; Process Engineering, Kiewit, Denver, CO, United States Minor Outlying Islands

Technical Economic Analyses (TEA) are crucial for decision-making in the early stages of a mining project's lifecycle. Often, TEA results indicate that a project is either marginal or not feasible, leading to disappointment and misplaced blame on engineers. Instead, developers should collaborate with engineers to evaluate the project's strengths and weaknesses. By analyzing key project strategy inputs, the team can identify and revise critical drivers. This presentation shares recent insights on effectively combining evaluations with strategic adjustments to achieve a positive technical economic outcome. The goal is to mitigate potential financial losses and personal costs while fostering promising investments with controlled risk.

3:25 PM

An Analysis of the Valuations Methods Used in Valuing Small Rural Aggregate Producers in Rural Arizona and Colorado

J. Moores; Arctic Carbal/Elk Creek, Pine, CO

This paper presents an overview of valuation methods used to assess small rural aggregate production facilities in Arizona and Colorado. The study highlights the unique challenges of valuing these commercial operations, which are often influenced by their remote locations, smaller scales, and the distinct market dynamics. Chief amongst these is the factor that many of these locations are either municipal owned and controlled or leased to municipalities by private parties with little or no other direct interest in developing the property. These mining locations may be operated on a seasonal or intermittent basis, sometimes interrupted by long periods of inactivity or limited production, or they may be subject to multiple uses, including mining, materials and commodities storage. By focusing on the application of traditional appraisal methods—such as income capitalization, market comparison, and cost approaches—this paper explores how these techniques are tailored to establish comparative values for rural aggregate producers. The analysis addresses gaps prevalent in the more traditional appraisal approaches and underscores the importance of common-sense in approaching the valuation.

3:45 PM

Using the MSHA MDRS Database to Understand the Aggregate Market Supply Dynamics

N. Sanchez Calderon and E. Moritz; WSP, St. Louis, MO

When doing market studies, production data from aggregate mines can be challenging to obtain. Some state departments of natural resources require mines to provide yearly production data, but most do not. MSHA requires all coal mines to report production data, but not to other types of mines. However, MSHA does require all mines to report employee hours per year. This presentation will show how MSHA data can be used to obtain mine locations and infer mine sizes, and how this can tell a story of the aggregate market supply dynamics in places like Texas or Florida, supplemented with state, juridictional, and other public data resources.

WEDNESDAY, FEBRUARY 26 MORNING

BULK MATERIAL HANDLING: DIGITIZATION IN MATERIAL HANDLING

Sponsored by: WOLONG Power your future

Room 610/612

9:00 AM • Wednesday, February 26

Chair: ***S. Knutson***

9:00 AM

Introduction

9:05 AM

Improving the Validation of Online Sensor Precision Through Variographic Analysis

L. Sheehy; Real Time Instruments, Mackay, QLD, Australia

Rapid analysis of material properties is crucial for controlling mineral extraction processes. Although viable sensor technologies are available, their industrial use is limited due to the challenge of validating their precision. Current validation typically involves comparing sensor data to lab measurements of process samples. But the precision of many sampling systems often underperforms that of the sensors being verified. Current methods, like Grubbs Estimation, are impractical because they require a third sampler that is precise, temporary, and safe. Many sampling systems still have precision issues that affect accurate precision estimation using these methods. A promising approach is to separate validation into two tasks: assessing bias and precision independently. Sampling systems can normally effectively reduce their bias, allowing large datasets to be used in validating sensor bias. Sensor precision can be assessed using variographic analysis of time series data from the sensor to evaluate the nugget effect. This method has been tested in the field for accurate sensor performance estimation compared to sampling-based data.

9:25 AM

Applying Digital Technology to Consumables as an Addition to a Robust Wireless Condition Monitoring Program

K. Walker; Product Manager, Simpsonville, SC

Condition monitoring answers the question, "which" of my many assets may be approaching failure. Analytics, including vibration analytics answers the question "why" a specific asset may be approaching failure, or if an assets' changing condition originates inside the asset or is a reflection of an overall change in the powertrain. The deployment of remote, wireless, cost effective bluetooth sensors has widely expanded the scope of condition monitoring and asset analytics. The next step is applying the same digital communication technology to consumables like grease, oil, and dessicants to automate routine maintenace activities, and add an automated layer of protection for assets in an environment characterized by a shortage of trained experienced labor. In this presentation we will look at lessons learned, both above ground and below ground, of remote wireless sensors and digital consumables applied in the mining environment.

9:45 AM

Lessons Learned from a Year of Continued Data Analysis on a High Performance Belt Conveyor Using Conveyor Digital Twinning

P. Ormsbee; FLSmidth, Denver, CO

FLSmidth and Overland Conveyor Company have recently completed a full year of active monitoring, evaluation, and data analysis on the operation of a long-distance, high capacity, overland belt conveyor. The goal of this analysis was to better understand the operation of the conveyor, eliminate unreliable symptoms, and systematically improve its performance. FLS' proprietary live digital twin service was used to process live operating data into meaningful and actionable feedback to mine maintenance and operations personnel. This presentation will discuss the methods used to evaluate the conveyor, as well as lessons learned from data analysis, live observation, and the effect of revamp changes towards the conveyor's performance.

10:05 AM

Development of Modern Block Models using a Data Driven Approach

T. Meuzelaar[1] and K. Salzsauler[2]; [1]Life Cycle Geo, LLC, Glenwood Springs, CO and [2]Geosyntec, Vancouver, BC, Canada

Modern block models estimate resource volumes as well as geometallurgical and environmental characteristics. Inclusion of the latter facilitates estimation of project assets and liabilities associated with management of various material types over the project life cycle and enables assessment of ore beneficiation and waste/water management alternatives. Given that metallurgical and environmental characterization tests are expensive and time consuming, they are typically not conducted at a density sufficient for block modeling. Machine learning methods can be leveraged to classify material types and develop proxies that extend material domains to the full exploration assay dataset. As an example of this workflow, five geoenvironmental block models were developed for the proposed KSM project (Golden Triangle district, northwestern British Columbia, Canada) employing supervised and unsupervised machine learning methods. This innovative data-driven approach provides considerable flexibility to operators in the mine planning and development stages and reduces misclassification and material dilution during operations, providing significant long-term capital and operating cost reduction.

10:25 AM

A Flexible Material Handling Network Model to Refine Major Capital Design

A. Greer and S. Parakh; MOSIMTEC, Brentwood, TN

The client is expanding operations to become India's largest single-location steel manufacturing facility. The facility has aggressive growth goals. The raw material handling system supplies different materials to multiple operating plants without interruption. The system included trains, trucks, conveyors, junction houses and stacker-reclaimers. Goldratt Research Labs worked with MOSIMTEC to develop an AnyLogic simulation model, allowing the client to understand if planned material handling changes will be able to keep up with demand. This allowed for understanding conveyor network requirements, along with replenishment policies. Missing critical connections were identified allowing them to be addressed during the design phase, saving costs.

10:45 AM

Effective IoT Monitoring of Backstops in Coal Mine Applications

W. Sullivan and C. Moriondo; Engineering, RegalRexnord, Warren, MI

Implementing IoT monitoring for backstops in coal mines has been a challenging yet rewarding endeavor. The tough, corrosive environment and tight production schedules make installations particularly demanding. Our strategy prioritizes well-coordinated, thorough installation methods and durable telemetry equipment to ensure dependable data collection. To tackle communication issues within the metal-framed drive house, we've devised an innovative solution that involves bouncing signals off each other to reach the gateway effectively. The health data we gather on backstops is vital, necessitating accurate analytics and diligent verification. This approach not only bolsters the reliability of our equipment and enhances customer confidence. Key Challenges: -Navigating harsh, corrosive conditions -Working within limited downtime windows -Overcoming communication barriers in metal-framed structures Key Enhancements: -Employing coordinated and comprehensive installation techniques -Utilizing robust telemetry equipment -Implementing creative signal-bouncing communication strategies -Ensuring precise data acquisition and analysis -Boosting customer confidence through reliable equipment performance

WEDNESDAY, FEBRUARY 26 MORNING

COAL & ENERGY: COAL MINING HISTORY

Room 105

9:00 AM • Wednesday, February 26

Chairs: ***G. Luxbacher****, NIOSH, Prosper, TX*
J. Gardner*, SynTerra Corp., Lexington, KY*

9:00 AM

Introductions

9:05 AM

The Coal & Energy Division—Our History in Brief

G. Luxbacher; NIOSH, Prosper, TX

The American Institute of Mining Engineers was founded in 1871 in Wilkes-Barre, Pennsylvania by 22 mem who primarily represented the anthracite coal industry. As the Institute membership began to group into specialties, Technical Committees were formed beginning in 1912, including Coal and Coke. In 1930, the Coal Division was established as the 4th professional division within SME; it was then and remains today the only division focused primarily on a specific commodity. As the Division grew along with AIME and, later, SME, it has led in programming and scholarships. This presentation, inaugurating mining history programming within the C&E Division, looks at that rich 113 year legacy.

9:25 AM

From Mines to Headlines: A Historical Look at Coal and Climate in the Media

L. Gattis; University of Oregon, Eugene, OR

This paper provides a detailed historical analysis of how media coverage has portrayed the environmental impact of coal mining, with a specific focus on climate change. A comprehensive review of archival sources, news articles, and journalistic reports spanning several decades traces

the evolution of media narratives regarding coal mining practices and their environmental consequences from 1970-2000. The study examines the influence of media representations on public perception, policy discussions, and industry practices over time. By identifying key themes and shifts in media coverage, this research highlights the pivotal role of media in shaping environmental awareness and regulatory responses within the coal mining industry.

9:45 AM

A Brief History of Roof Control in US Underground Coal Mines

C. Mark; MSHA, Pittsburgh, PA

During the 20th century roof falls killed more coal miners than all other causes together, more than 50,000 in all. Reducing this terrible toll was a continual focus for mine safety professionals. In the hand-loading era, when miners were typically paid by the ton, installing roof support was often considered "deadwork." The Bureau of Mines initially exhorted miners to install more support posts, but soon concluded that mine operators should employ "Roof Control Plans" to set minimum support standards on a mine-by-mine basis. During the ensuing decades there were new safety laws, a shift to mechanized mining methods, and a changeover from timbers to roof bolts, but none significantly reduced the roof fall fatality rate. Finally the Farmington Mine Disaster and the resulting 1969 Health and Safety Act set the industry on the path towards zero roof fall fatalities. This paper discusses the many social, technological, and political aspects of this fascinating history.

10:05 AM

JOY—100 Years of Innovations

J. Haughey; Komatsu, Warrendale, PA

For over 100 years, JOY has been developing and providing innovations to underground coal mining. From the invention of the underground coal loader in 1919 to the latest developments in equipment automation, these innovations have provided operators with the opportunity to increase productivity of their operations. JOY continues to develop and introduce new products and technologies today, and has plans to continue developments as we take operations forward. This paper will look at the last 100 years and provide a glimpse of the future.

10:25 AM

Island Creek Part 2—The Growth and Demise of a Major Coal Company

G. Luxbacher; OMSHR, NIOSH, Prosper, TX

A prior presentation focused on the founding of Island Creek Coal Company and its early growth. This presentation will look at Island Creek's expansion into a major player in the eastern coal fields, its failed expansion in the west and the impact of its acquisition by a major oil company, Occidental Petroleum, with its larger-than-life Chairman, Armand Hammer. As the nature of the coal industry changed, Occidental divested Island Creek to Consol and sadly, Island Creek now exists only in memory.

10:45 AM

Kentucky's Coal Heritage Trail

J. Gardner; Tetra Tech, Lexington, KY

Coal mining began in Kentucky in the 1800's and development of railroads led to tremendous expansion in the early 1900's. Tens of thousands of people came to the Appalachian Mountains to work the mines including many immigrants fleeing Europe plus thousands of African Americans seeking a better life. Coal camps sprung up throughout the coal fields with ones in the mountains by necessity having to be self-sufficient communities that depended on one thing, COAL. With the decline of coal in recent decades Kentucky coal fields communities turn their eyes to tourism to help fill the void left by closed mines. There are numerous attractions throughout the region that already exist. The Kentucky Coal Heritage Trail is designed to become the virtual link between these attractions and sites giving those that are looking for their roots and heritage numerous places to go while visiting Kentucky. Linkages will be made to similar trails in West Virginia and Virginia. This presentation will showcase several recent projects that are designed to help bolster the economy of the region and honor those who helped build the economy of this state and nation.

11:05 AM

Factors Influencing Bituminous Coal Production in Pennsylvania—1983 to 2022

A. Iannacchione; University of Pittsburgh, Pittsburgh, PA

The study area consists of twelve counties in southwestern Pennsylvania where a long history of coal extraction has occurred. Underground coal mining along the slopes of Mount Washington was reported in the late 18th century. By 1983, Pennsylvania bituminous coal production increased to over 65 million short tons (Energy Information Administration assessment of the Mine Safety and Health Administration's database). This was accomplished through almost equal amounts of surface (30.6 million tons) and underground (34.5 million tons) mining methods. In 2022 surface mining accounts for only 2.2 million tons while underground mining accounts for 35.1 million tons. For the 39 years of data available, surface mining production has dropped to 7% of the 1983 totals. Conversely, underground mining has increased by almost 2%. Underground mining production increased dramatically in the 1990s largely due to the rapid expansion of longwall mining methods. However, since 1998, underground mining production has declined at an almost steady rate to its current value.

WEDNESDAY, FEBRUARY 26 MORNING

COAL & ENERGY: COAL PREP OPERATIONS AND PROJECTS

Sponsored by: SOMERSET INTERNATIONAL

Room 702

9:00 AM • Wednesday, February 26

Chairs: ***J. Bobbera****, Robindale Energy, Ligioner, PA*
M. Barish*, Somerset International, Sewickley, PA*

9:00 AM

Introductions

9:05 AM

Black Otter Preparation Plant Drier Effluent Circuit

K. Schaff; Engineering, Signal Peak Energy, Roundup, MT

Signal Peak Energy (SPE) operates the Black Otter Preparation Plant which utilizes 15 mechanical driers to remove water from the clean coal product. Drier Effluent material historically returned to the heavy media dilute circuit. The dilute circuit utilizes magnetic separators to recover magnetite before returning the non-magnetic material to the plant feed distributor bowl. The drier effluent material returning to the dilute circuit represents a recirculating load of already washed product that reduces throughput capacity and overloads the magnetic separators. SPE installed new dedicated effluent pumps and now processes this material on a Connweld clean coal sieve-bend to remove excess water, clay, and magnetite. All coarse coal from the sieve-bends is processed via a dedicated effluent CMI drier with smaller basket openings, thus eliminating the recirculating load. A dedicated magnetic separator recovers magnetite and returns excess non-magnetic material and water back to the dilute circuit. A reduction in magnetite usage of approximately 10-15% and additional throughput capacity of 100 raw tons per hour has been observed due to the dedicated effluent circuit.

9:25 AM

25-013

Arch Resources' Industry First Application of Eriez StackCell® Technology for Recovery of Low-Ash Metallurgical Coal from an Ultra-Fine Refuse Stream

J. Nielson[2], E. Dohm[1] and A. Hobert[1]; [1]Eriez USA, Erie, PA and [2]Arch Resources, Philippi, WV

Metallurgical coal is an essential component for the blast furnace-basic oxygen furnace (BF-BOF) steelmaking process, which accounts for roughly 70% of total global steel production. To meet the growing demand for metallurgical coal, Arch Resources identified the potential to recover low-ash coal from ultra-fines discarded prior to the deslime flotation circuit across their portfolio of operations. Historically, many flotation circuits were designed to discard this ultra-fine coal due to high clay content and technological barriers to cost-effectively upgrade and dewater the coal to a saleable product. Recent advancements in high-intensity flotation technology, including the Eriez StackCell®, have enabled coal producers to recover ultra-fine coal while minimizing capital and operating costs. In July 2023, Arch Resources commissioned the first full-scale ultra-fines recovery circuit utilizing StackCell® high-intensity flotation technology at the Leer Mining Complex. This paper reviews the approach utilized to develop the flotation process design, learnings from the commissioning and ramp-up period, and performance data through the first year of operation.

9:45 AM

Don't Backup. Keep Effluent Moving Forward

T. Toney; Somerset International, Sewickley, PA

Recycling centrifuge effluent is a common practice in coal preparation. But should it backup? This recycling takes the effluent back to the feed source that has already rejected it as being too fine. Instead of the backup, the material should benefit from moving forward to a unit more suited to the finer sized material. With screen bowl centrifuges it is well documented that eliminating recycle through direct recovery improves total fines recovery. Further, it reduces the load in the fines circuit and eliminates losses due to further degradation. Does the same concept apply to the coarse coal centrifuges? As opposed to recycling the coarse centrifuge effluent, the effluent keeps moving forward. It goes to the next finer circuit where it can be recovered with a higher G-force machine. This prevents a recirculating load and provides lower moisture on the fines recovered. Somerset is working to model and test this concept to improve the total plant moisture and recovery.

10:05 AM

Re-creating ESG and Economic Value from Coal Discard and Slurry Ponds

T. Kale; Metallurgical, SACPS, Benoni, Gauteng, South Africa

From washing Run-of-mine Coal to reprocessing waste dumps, or employing dry processing methods, each Coal facility confronts an inevitable issue—Coal Fines (-5+0mm). What are the some of the sustainable ways to deal with coal fines? This is a discovery paper that explores the success story of the Optima Separator in processing of different coal size classes up to 6mm and producing product from 4800 to 6000 K.Cal. It also takes a brief look at data generated over a two-year period where the facility was buying-in Coal of different qualities and seams. Lastly, the paper shows how the Optima can be combined with next generation screening to ensure ultimate desliming and reduce product contamination.

10:25 AM

Innovative Magnetic Flotation Hybrid Process for Enhanced Coal Cleaning

A. Sobhy; Mining and Explosives Engineering, Missouri S&T, Rolla, MO

The hybrid separation process, combining magnetic flotation and column flotation, was developed to enhance the beneficiation of a coal sample from the El-Maghara coal mine, which has a high ash content of 27.21%. This system integrates a high-gradient magnetic field into a flotation column to prevent magnetic particles from floating, improving coal demineralization and producing high-quality coal. The Box-Behnken design and response surface methodology were used to optimize the effects of various operating parameters on process performance. Key parameters such as magnetic field strength, slurry circulation flow rate, air flow rate, collector dosage, and frother concentration were examined. The process responses included ash percentage, combustible recovery, and separation efficiency. Under optimal conditions—1.2 T magnetic field strength, 1500 ml/min circulation flow rate, 11.64 ml/min air flow rate, 0.87 kg/ton diesel collector, and 42 ppm methyl isobutyl carbinol frother—the predicted and confirmed results showed ash percentages of 7.78%, 7.89%, and 7.71%, with maximum recoveries of 75.86%, 76.37%, and 75.94%, and maximum separation efficiencies of 77.17%, 78.51%, and 78.71%.

10:45 AM

Froth Booster Technology Applications in Coal Flotation

P. Bozzato; WV Process Solutions, Dellslow, WV

Froth height is universally considered of primary importance in all types of flotation machines. Generally, the deeper the froth the higher the grade of the froth and the lower the product yield. Froth depth can be increased adjusting reagents dosages but there are limitations and, generally, with negative side effects. The ability to obtain an increased froth depth simply by changing flotation cells internal design has positive consequences if achieved at no or negligible negative effects on product yield. A froth booster has been developed to achieve deeper froth at minimal cost and it was tested in coal flotation facilities and laboratory. Importance of deep froth is briefly explained together with potential applications in the coal industry. Simulations will also prove that coal preparation plants would highly benefit from cleaner froth due to its effects on overall product moisture. Finally, froth booster separation results will be included and discussed together with applications of the technology in coal flotation to highly increase product quality in existing or new plants.

WEDNESDAY, FEBRUARY 26 MORNING

COAL & ENERGY: GAS WELL AND UNDERGROUND MINING INTERACTION (LW, STONE, POTASH)

Room 703

9:00 AM • Wednesday, February 26

*Chair: **R. Kimutis**, CDC/NIOSH, Pittsburgh, PA*

9:00 AM

Introductions

9:05 AM

25-084

Study of Breached Gas Mitigation in an Underground Coal Mine using Network Modeling and Physical Model

R. Kimutis; PMRD/MSSB, CDC/NIOSH, Pittsburgh, PA

Due to the surge in shale gas production, a substantial number of unconventional shale gas wells have been drilled across US coal reserves. Gas breaches resulting from damaged wells pose considerable safety risk to miners. This paper investigates how a ventilation system can effectively manage breached gas through a network-based numerical model and laboratory-scaled physical model. Several hypothetical gas breach scenarios in a longwall area are simulated, exploring factors influencing gas mitigation. The study establishes correlations between breached gas inflow and gas concentration at critical locations. Findings provide valuable insights for managing mine ventilation systems and enhancing coal miner safety.

9:25 AM

25-001

A Comparison of Ground Permeability Changes Before, During and After Longwall Panel Mine-bys Under Deep and Shallow Cover

M. Harris, S. Schatzel, J. Addis, Z. Khademian, Y. Zheng and C. Matthews; PMRD, National Institute for Occupational Safety and Health, Washington, DC

Shale gas wells can sometimes drill through coal reserves. The caving of the gob from longwall coal mines may deform the shale gas well casing and potentially result in a breach. NIOSH researchers studied the permeability of the surrounding ground strata that may affect the potential for an inflow of gas into an underground mine environment. An overview and comparison of measured permeability values under differing cover depths and mining cycle phase will be presented and discussed. The findings highlight considerations that affect the interaction between gas wells extraction and mining operations that may lead to potentially hazardous environments.

9:45 AM

Data-driven System to Support Co-development of Oil, Gas, and Potash Resources from the Designated Potash Area in the Permian Basin of New Mexico

J. Melendez, R. Pillers, D. Ensign, L. Dair and J. Mauk; Geology, Geophysics, and Geochemistry Science Center, U.S. Geological Survey, Denver, CO

The 2012 Department of the Interior Secretarial Order No. 3324 tasked the Bureau of Land Management with orderly co-development of oil, gas, and potash resources within the Designated Potash Area in the Permian Basin region of southeastern New Mexico. This area is the preeminent source of potash production in the United States. The U.S. Geological Survey's USMIN project is building a database which integrates more than 2,800 drill cores across the area to develop a data-driven system to help the Bureau of Land Management manage concurrent oil and gas drilling and underground potash mining.

10:05 AM

Prediction of Rockmass Permeability Changes by Longwall Mining

Z. Khademian and M. Harris; National Institute for Occupational Safety and Health Pittsburgh Research Laboratory, Pittsburgh, PA

Predicting rockmass permeability is critical in evaluating various engineering designs, including estimating gas inflow to a longwall mine in the case of a hypothetical breach in the gas well. This study uses a geomechanical modelling methodology and predicts rockmass permeability changes above an abutment pillar in a longwall mine in Pennsylvania. A series of slug permeability tests are planned to be conducted to measure permeability values during first and second panel mining. The measured permeabilities by the slug tests will be later used to evaluate the accuracy of permeability prediction and possible calibration requirements.

WEDNESDAY, FEBRUARY 26 MORNING

COAL & ENERGY: GENERAL VENTILATION

Sponsored by: BARR

Room 704

9:00 AM • Wednesday, February 26

Chairs: ***M. Burich****, Komatsu, Warrendale, PA*
J. Bowling*, SRK Consulting, Clovis, CA*

9:00 AM

Introductions

9:05 AM

25-093

Three-Dimensional Ventilation Modeling of Large Opening Stone Mine Using COMSOL Multiphysics

K. Raj and V. Gangrade; CDC NIOSH, Spokane, WA

Airflow in large opening stone mines is largely dependent on the natural ventilation due to the large cross-section area of the opening. The openings of such stone mines are typically twice or thrice the size of typical underground coal or metal/nonmetal mines. Due to the influence of natural ventilation air velocities as well as the static pressure drop in the mines are low. Mines rely on auxiliary fans to ventilate active faces to reduce contaminant exposure to mine workers. National Institute for Occupational Safety and Health (NIOSH) is conducting research on ventilation of large opening stone mine to reduce worker exposure to dust and other contaminants such as diesel particulate matter (DPM). In order to reduce worker exposure to dust and DPM, an understanding of the airflow pattern due to auxiliary fans in the mine is needed. Under this research, NIOSH researchers are exploring the CFD modeling to understand the airflow behavior in large opening mine. In this paper, we are presenting the results from three-dimensional CFD modeling of airflow in a large opening stone mine. We investigated the effects of fans in the model in combination with movement of trucks in the model.

9:25 AM

25-064

Optimization of Fire Suppression Nozzle Location on Mobile Mine Equipment

D. Bahrami, R. Thomas and L. Yuan; Pittsburgh Mining Research Division, National Institute for Occupational Safety and Health, Washington, DC

The positioning of fire suppression nozzles is critical for their effectiveness in extinguishing mobile mine equipment fires. To effectively suppress such fires, optimization needs to be considered for the suppression nozzle locations. Detailed experiments were conducted to study the effectiveness of fire suppression with different nozzle locations. A variety of fire suppression systems including dry chemical, wet chemical, dual agent (dry and wet chemical), carbon dioxide, and water mist were used. 6 types of nozzle locations were studied, and their fire suppression effectiveness were compared. Results from this work can help mining companies and manufacturers develop effective fire suppression designs.

9:45 AM

Easy Up—Easy Down: An Innovative Ventilation Stopping for Large-opening Metal/Nonmetal Mines

V. Gangrade and J. Addis; National Institute for Occupational Safety and Health (NIOSH), Pittsburgh, PA

Large-opening underground mines have a huge ventilation challenge due to their size. Directing the airflow to the working faces is often difficult due to slow air velocities and lack of continuous stoppings in the mine. Providing a consistent supply of fresh ventilation air is imperative for mitigating the presence of airborne contaminants such as diesel particulate matter, diesel and blasting fumes, and silica dust to safeguard the well-being of underground mine workers. The traditional mine stoppings have three common problems, they get damaged by blasts, they are difficult to raise and lower, and they are expensive. This paper showcases a novel design ventilation stopping solution that prioritizes safety, ease of operation, operation without continuous power supply, and cost-effectiveness, with the goal of enabling widespread adoption for efficiently directing ventilation airflows in large-opening metal/nonmetal mines. The paper details the design attributes, individual components, and the operator-friendly 'easy up, easy down' mechanism of the stopping, emphasizing its role in optimizing ventilation management.

10:05 AM

Real-Time Evacuation Optimization in Underground Mines Using Simulation Rig and "Egg" Sensor

S. Bunning[2], S. Goodyear[2], R. Owusu-Ansah[3], S. Kingman[4], H. Khaniani[3], V. Androulakis[3], S. Shao[5], M. Hassanalian[2] and P. Roghanchi[1]; [1]Mining Engineering, University of Kentucky, Lexington, KY; [2]Mechanical Engineering, New Mexico Institute of Mining and Technology, Socorro, NM; [3]Mineral Engineering, New Mexico Institute of Mining and Technology, Socorro, NM; [4]Computer Science and Engineering, New Mexico Institute of Mining and Technology, Socorro, NM and [5]Electrical Engineering, New Mexico Institute of Mining and Technology, Socorro, NM

Underground mine fires pose significant dynamic hazards on mine workers, threatening their safety and complicating self-evacuation and rescue operations. To mitigate these risks, a physical simulation rig of an underground mine, as well as a real-size deployable sensor unit, referred to as "egg" sensor, are developed. The "egg" sensors measure CO concentration, temperature, humidity, and particle size, while transmitting in real-time the data to a command center via wireless communication. These concepts aim to identify optimal escape routes using graph-based search algorithms by minimizing health impacts on humans and reducing the distance traveled to safety during a fire emergency.

WEDNESDAY, FEBRUARY 26 MORNING

COLORADO MINING ASSOCIATION

Room 710/712

9:00 AM–10:15 AM

CMA Regulatory and Policy Updates

10:15 AM-11:00 AM

National Mining Association Litigation Update

Tawny Bridgeford, General Counsel, National Mining Association

The National Mining Association is engaged in several litigation activities impacting the issues most important to the mining industry across the country. These cases have the potential to significantly shape the legal and regulatory environment for a broad range of mineral commodities moving forward.

ENVIRONMENTAL: MINING HYDROGEOLOGY

Room 103

9:00 AM • Wednesday, February 26

Chairs: ***C. Peters****, Montgomery & Associates, Tucson, AZ*
B. Moravec

9:00 AM

Inroductions

9:05 AM

Direct Lithium Extraction Wellfield Design Strategies and Optimization: Insights From the Kachi Lithium Brine Project

M. Gabora[1], A. Fulton[2], W. Minchin[3] and J. Wang[4]; [1]Lake Resources, Tomball, TX; [2]Groundwater Exploration Services, Melbourne, NSW, Australia; [3]Watershed Hydrogeo, Nowra, NSW, Australia and [4]S.S. Papadopulos & Associates, Inc., Rockville, MD

The Phase I Kachi Lithium Brine Project is a planned 25-yr and 25,000-tonne pa Lithium Carbonate Equivalent (LCE) operation located in the Carachi Pampa Basin, in Catamarca, Argentina. The project will recover lithium via direct lithium extraction (DLE), with spent brine being reinjected into the subsurface. A calibrated variable-density groundwater flow and transport model was used to assess wellfield designs. Maintaining hydrogeologic conditions east of the extraction wellfield was critical, as spring flow is crucial for important natural lake habitat. It was also essential to site the injection wells to minimize dilution of the brine resource while remaining close enough to sustain hydraulic heads in the extraction wellfield, thereby minimizing drawdown and reducing subsidence risk. The plan utilizes permeable alluvial fans fringing the salar for high injection rates and rapid pressure propagation in the semi-confined / confined aquifer with lower injection rates near sensitive areas designed to preserve the aquifer's natural state. Extensive real-time monitoring and frequent model updates will be used to understand deviations from predictions and adjust operations accordingly.

9:25 AM

Just a Drop Will Drill Ya—Harmonizing Bedrock Drilling Programs and Hydrogeologic Investigations

J. Wartman and J. Brown; Foth Infrastructure & Environment, LLC, Duluth, MN

Subsurface site characterization for mining projects is a data driven process, with significant efforts and expenses incurred on the collection of data through different drilling investigations. Programs are often run in parallel during early phases of project development. However, groundwater is not always considered during these investigations. To best leverage the costs associated with exploration and geotechnical drilling, there are time-critical and opportunistic activities that projects should consider to inform and prepare their groundwater program. This talk will review activities that projects should consider adopting, cost savings that can be realized, and risks that can be mitigated by incorporating groundwater considerations into existing drilling programs.

9:45 AM

Technical Evaluation of Lithium Brine Deposits

M. Rosko; Montgomery & Associates, Tucson, AZ

Lithium brine mineral resources are fluid deposits of variable density and mobility, and need to be evaluated differently than traditional hard rock resources. These mineral-enriched brines are hosted in porous- and fractured-rock aquifers, typically within closed hydrologic basins where lithium has been concentrated via evaporation over long periods of time. The conceptualization and exploration of brine mineral resources requires not only an understanding of the spatial and temporal variability of brine densities and concentrations, but also the hydraulic parameters of the aquifer. Key parameters such as brine volume and grade, aquifer geometry, hydrogeologic unit definition, effective porosity, specific yield, flow rate, recoverability, etc. are used in order to meet the definition of reasonable prospects of economic extraction and define the mineral resource. Practical methods have been developed to characterize and evaluate lithium brine resources and reserves.

10:05 AM

Management of Data Uncertainty in Water Resource Characterization for Mining Projects

V. Tandon, J. Brown and J. Wartman; Mining, Foth Infrastructure & Environment, Saint Paul, MN

Hydrogeologic characterization data serve as critical foundations for understanding groundwater flow at mine sites. These data support conceptual and numerical models used in project feasibility and environmental impact assessments. Practical and cost limitations introduce uncertainty into predictions. For example, only so many boreholes that can be drilled, depth intervals hydraulically tested, and wells installed. In this talk, we explore how uncertainty is effectively managed through the sequential deployment of various techniques, including borehole geophysics, hydrophysical logging, packer testing, and well construction/testing. Progressive reduction of data at each testing phase leading to identification of critical test intervals will be reviewed.

10:25 AM

Efficient Shallow Dewatering in Open-Pit Mining Using Blastholes

R. Valdes Pineda; Piteau Associates, Tucson, AZ

Mining operations often face challenges in managing groundwater levels during the concluding phases of open-pit extraction and pit floor deepening, where efficient shallow dewatering is critical for continued operations. This technical presentation explores a successful engineering application of blastholes for shallow dewatering, presenting a novel approach that optimizes water removal and enhances operational mining and safety. Through the drilling and construction of blasthole wells, this method has demonstrated significant benefits, ensuring operational continuity, achieving targeted dewatering objectives, and providing safer working conditions. The conclusions highlight the effectiveness of blasthole wells in accomplishing operational, safety, and efficiency benefits in end-of-phase open-pit mining.

10:45 AM

Leveraging Hydromechanical Simulation for Superior ESG Results

S. Dehkhoda, T. Chung, A. Flatten and V. Ievkovitch; Beck Engineering, Bowen Hills, QLD, Australia

Hydrogeology plays a crucial role in responsible mining operations. The intricate relationship between mining operations and hydrogeological systems requires strategies that not only consider the physical processes involved in mining activities but also how they interact with water resources. This paper presents an advanced hydromechanical modeling framework that accurately represents subsurface water dynamics, accounting for geological inconsistencies like faults and incorporating realistic boundary conditions such as drainage, terrain, rivers, and rainfall. The simulation offers insights into water-rock interaction and groundwater behavior around active and abandoned mines. Its fully transient nature enables time-dependent observations, providing an evolving view of the hydrogeological landscape. Notably, the framework's ability to simulate pit reflooding is vital for ensuring mine safety, predicting environmental impacts, and planning for potential closures. These insights are essential for informed decision-making, mitigating environmental impacts, and ensuring sustainable resource extraction, ultimately supporting Environmental, Social, and Governance (ESG) goals.

Wednesday, February 26 Morning

ENVIRONMENTAL: PASSIVE MINE WATER TREATMENT: SUCCESSES, REALITIES, AND LESSONS FOR THE FUTURE

Sponsored by: ARCADIS

Room 104

9:00 AM • Wednesday, February 26

Chairs: ***J. Gillow****, Arcadis, Greenwood Village, CO*
M. Hay*, Arcadis U.S., Inc., Broomfield, CO*

9:00 AM

Introductions

9:05 AM

Ten Top Game-Changing Technical Papers on Mining Influenced Water Remediation

J. Gusek; Jim Gusek MIW LLC, Lakewood, CO

Forty years of mine remediation conferences and their proceedings can offer many learning opportunities. Some pre-internet papers are true technical "game changers", advancing the state of the art of mine remediation. This presentation revisits ten papers (not by this author) that focus on the use bactericides to suppress acid rock drainage, and the development of passive treatment systems for both coal and hard rock mines. As a new generation of mine remediation engineers takes the helm, familiarity with past successes will benefit them, the mining industry, and the planet.

9:25 AM

A Design Framework for Passive Bioreactors

L. Figueroa; Civil Environmental/Mining Engineering, Colorado School of Mines, Golden, CO

Solid substrate bioreactors are a promising solution for treating mining-influenced water with low operational and maintenance requirements. However, there is a lack of validated design guidance, particularly in selecting and specifying organic substrates to ensure long-term effectiveness in reducing sulfate, nitrate, and metal concentrations. Current design criteria often assume a constant rate of carbon release, which does not accurately reflect the variable release rates of natural solid-phase materials like hay and wood. To address this, a simple method based on agricultural sequential extraction protocols was developed to characterize organic substrates. This method was used to select organic solid substrates for a series of bioreactors. The rate of substrate consumption, along with the performance in removing sulfate and metals, was then analyzed and is presented within a more comprehensive design framework.

9:45 AM

Passive-Aggressive: The Integration of Constructed Wetlands into Active Mine Water Treatment Trains for Sustainability Goals

J. Sharp, W. Wang, Z. Yang, R. Germain, D. Tepedelen, G. Vanzin, J. Ranville and J. Vanneste; Civil and Environmental Engineering, Colorado School of Mines, Golden, CO

Recent findings in our laboratory have revealed that a unique diatom-dominated, photosynthetic open-water wetland holds promise for the attenuation of a wide variety of metal(loid)s. We propose that further gains can be achieved through integration with active engineered technologies. We have investigated the bench-scale application of this wetland as a chemical-free alternative that provides both alkalinization and oxidation. This results in more cost-effective arsenic and boron treatment when combined with membrane processes. Expanding from that work, we have explored the feasibility of biological oxidation followed by ferric flocculation for the removal of arsenic and other metals. There are also advantages in reversing the operational order—less aggressive alkalinization (e.g., from pH=3 to pH=5) of acid mine drainage via chemical dosing can be used as a pretreatment strategy. This can be followed by wetland transit to further increase the pH and passively remove challenging metal constituents. These findings support the application of a hybrid approach toward mine water treatment that combines passive, nature-based and active technologies to achieve sustainability goals.

10:05 AM

A Multi-Model Evaluation for Passive Infiltration of Metals From Mine Water Discharge

P. Nolan, C. Mayer, K. Richards and G. Konzen; WSP, Redmond, WA

The management of mine discharge water presents a challenge due to the impact of high metal loads on surface and groundwater. Active treatment can be costly and difficult to implement in remote locations. Here, we present a multi-model approach using MIN3P, PHREEQC, and PHAST to determine if infiltration ponds can safely manage discharge water from an abandoned mine. Discharge water seasonally contains elevated concentrations of arsenic, iron, and manganese. Groundwater and surface water data together with detailed site information helped in developing robust models. MIN3P and PHREEQC modeling indicated iron hydroxide precipitation with decreasing porosity in the vadose zone. Results of MIN3P and PHREEQC were used to provide a source term for PHAST. PHAST modeling demonstrated that arsenic attenuates well in the vadose zone due to iron hydroxide formation and sorption. However, results show that manganese concentrations may exceed compliance

limits in 20 years as vadose zone sorption capacity is exceeded. This multi-model approach demonstrates the complexity required to evaluate the feasibility of passive mine water infiltration to prevent groundwater and surface water impairment.

10:25 AM

Case Study: Passive Treatment at Elizabeth Mine in Strafford, Vermont

B. Butler[1] and L. Dunnington[2]; [1]Office of Research and Development, U.S. EPA, Cincinnati, OH and [2]Office of Land and Emergency Management, U.S. EPA, DC, DC

The passive system at Elizabeth Mine has been in operation since 2019 and treats iron from a tailings facility. The system comprises an anoxic limestone drain, settling pond, vertical flow pond, and two wetlands. The effluent from each component has been sampled to track the sequential removal of iron through the treatment train. A program through the Office of Land and Emergency Management has enabled consistent monthly sampling since May 2022. Sampling includes on-site measurement of aqueous ferrous and total iron, flows, water quality parameters, and laboratory metals analyses. Seasonal data trends and lessons learned to date will be presented.

10:45 AM

Uranium Migration From Former Tailings Areas to a Receiving River: Are Intervening Ponds a Uranium Sink, Source, or Temporary Storage?

R. Johnson[1], V. Ocampo[2], E. Au[1] and E. Evans[1]; [1]RSI EnTech, LLC, Grand Junction, CO and [2]Applied Research Center, Florida International University, Miami, FL

Natural and engineered wetlands can function as passive mine water treatment systems to remediate metals contamination. At four U.S. Department of Energy Office of Legacy Management sites, uranium tailings have been removed but residual solid phase uranium creates persistent groundwater plumes flowing near and toward adjacent rivers. Between these residual source zones and nearby rivers, surficial ponds occur as expressions of the groundwater. Three sites contain ponds created by gravel mining operations, while one site contains a natural former oxbow of the river channel. All four sites experience intermittent seasonal wetting and drying. Pond sediments create a sink for uranium, but uranium concentrations in pond waters remain above remedial goals at all four sites. Sediment and water data, groundwater flow patterns, and column studies are being used to evaluate if uranium (1) continues to be mobile as throughflow, (2) is being precipitated and immobilized, or (3) is being sorbed to pond sediments in a temporary storage scenario. The results are determining if these ponds are already functioning as a passive treatment system or could be engineered to enhance uranium capture.

WEDNESDAY, FEBRUARY 26 MORNING

HEALTH & SAFETY: ADVANCES IN EDUCATION AND TRAINING

Room 109

9:00 AM • Wednesday, February 26

Chairs: ***R. Reed****, University of Arizona, Taylor, AZ*
W. Derber

9:00 AM

Introduction

9:05 AM

From Good to Great: Building a Global Safety Education Center

B. Ross; Global Mining Education Foundation, Tucson, AZ

The mining industry's significant investment in safety education has led to remarkable improvements in safety performance over time. However, we can achieve even greater success by enhancing the effectiveness, efficiency, and affordability of safety training. Currently, each company, mine, and often individual departments are responsible for their own safety programs, which can lead to inconsistencies and gaps due to varying levels of resources and expertise. The mining industry can bridge this gap by establishing a global center dedicated to safety education. This center, envisioned as part of a larger mining education institute, would harness the expertise of top industry professionals to create and deliver world-class safety courses accessible to miners everywhere, at any time. By achieving economies of scale, these courses will be more effective, efficient, affordable, and credible. Join us to explore the blueprint for creating this Safety Education Center, the benefits of a global approach, and successful examples of industry-driven professional development programs. Be part of the movement to set a new standard in mining safety.

9:25 AM

The Human Factor in Mining: A Proposal for Behavioral Transformation and Enhanced Safety

C. Navia Vasquez; StartMomentum Consulting, Green Valley, AZ

The mining industry is a key sector for global economic development, which requires a comprehensive rethink to prevent occupational fatalities and accidents, which continue to rise. Human behavioral factors are the origin of unsafe acts, which are human actions that generate risk situations resulting in occupational accidents. These unsafe acts are a consequence of personal aptitudes, attitudes and conditions. Personality factors influence the likelihood of such accidents. In this research, Behavioral Transformation (BT) is presented as an alternative to identify and address these factors, improving the well-being of workers, reducing costs, increasing productivity and maximizing the quality of work in mines.

9:45 AM

A Novel Approach to Workforce Improvement Using the MetaVerse Turning AI into IA (Intelligence Amplification)

M. Poulton, M. Peltier and M. Baker; Desert Saber LLC, Oro Valley, AZ

Using virtual environments for training provides a photorealistic opportunity to expose workers to potentially hazardous situations that allow them the flexibility to respond without exposing them to physical harm. A high-fidelity model of a portion of a mining operation has been created for training and testing a workforce's competencies and capabilities for working at heights. Large amounts of data exist for mine operations but the data available for workforce competencies and capabilities are very limited in most companies. Stealth assessment is used to capture data while the worker is making decisions. AI is a powerful tool for analyzing large data sets and making predictions. It is also a powerful tool for analyzing documents and creating summaries or new content. But AI is only as good as the data used to build the underlying models. The large amount of detailed data collected on every worker can be combined, using AI, to better understand (amplify our intelligence) the ability of each worker and collectively the larger workforce to perform a task or job as well as their ability to problem-solve under more authentic, dynamic circumstances, including atypical job tasks.

10:05 AM

25-072

Pre-Implementation Evaluation of VR as a Mine Safety Training Tool

C. Hoebbel and J. Bellanca; CDC NIOSH, Pittsburgh, PA

High-fidelity, immersive training is known for its logistical and learning benefits. While other industries have used it for decades, the same uptake has not been seen in mining. NIOSH recently developed an adaptable, scalable VR training platform, VR Mine Rescue Training (VR-MRT), which has attracted significant industry interest. NIOSH is using VR-MRT to understand the barriers to adoption and implementation of VR. Researchers conducted usability and acceptability testing as well as

pre-implementation interviews. In this paper, authors identify potential barriers and ongoing efforts to overcome them, to position VR-MRT as a supplemental training resource for mine workers and safety professionals.

10:25 AM

Owning Safety with Smart Leadership: A Case Study of the Mining Institute for Supervisory Leadership Program

R. Reed[1], L. Brown[1] and E. Lutz[2]; [1]Mel & Enid Zuckerman College of Public Health, The University of Arizona, Tucson, AZ and [2]School of Mining & Mineral Resources, The University of Arizona, Tucson, AZ

The University of Arizona's Training Resource Center (TRC) developed the Mining Institute for Supervisory Leadership (MISL) training program with topics including accountability, communication, conflict resolution, mentoring, and more. Two underground coal mine companies, representing three mines, requested the TRC MISL training. Key personnel at the supervisory (123), management (50), and executive (12) levels of the companies attended. Feedback for the MISL course was overwhelmingly positive. Eighty-four percent (155) of trainees agreed or strongly agreed that the course improved their confidence as a leader, while 96% (178) agreed or strongly agreed that overall, this was an excellent course. Ninety-six percent (178) agreed or strongly agreed that the trainers were confident and prepared. When describing the biggest issues they faced at work, the most frequently cited issues were related to tools and equipment (lack of or improper, 13), staffing shortages and similar (15), and attitudes and team-related issues (9). Leadership training can equip mining professionals to achieve more with less and leverage existing staff and resources to exceed safety and health objectives.

10:45 AM

Escape! Gamifying Self-Escape Training for Underground Mines Using Mobile Devices

N. Pham[1], J. Felker[1], R. Reed[1], L. Brown[1] and E. Lutz[2]; [1]Mel & Enid Zuckerman College of Public Health, The University of Arizona, Tucson, AZ and [2]School of Mining & Mineral Resources, The University of Arizona, Tucson, AZ

"Serious games" can provide scenario-based active learning that enhances worker competency, leading to better outcomes for health and safety training programs. Escape! is a multiplayer, turn-based strategy game for mobile devices (e.g. iPhones and Android) that is designed to enhance emergency response and self-escape training for underground miners. The app includes training modules for both underground coal and metal mine operations. It features role-playing scenarios with realistic hazard events such as fires, inundation, irrespirable air, and ground failures. Players must engage in high-stress decision-making and use resources efficiently to secure the scene and evacuate the mine. In this talk, we outline key game mechanics to elicit critical thinking and evoke discussion around mine emergency topics. A short demonstration and feedback from beta testing are provided. Through realistic scenarios and interactive gameplay, Escape! will bolster miner competency in real-life emergencies, augmenting miners' decision-making skills and improving self-escape outcomes.

11:05 AM

Strategic Health and Safety Communication in Mining: Media Approaches and Public Perception

L. Gattis; University of Oregon, Eugene, OR

This study investigates how mining companies strategically communicate health and safety practices through media channels. It systematically reviews industry approaches and media content to assess the effectiveness of different communication strategies in enhancing public perception and engaging stakeholders. By examining the dynamics between corporate communication strategies and journalistic practices, the research provides insights into the framing, dissemination, and reception of these messages across diverse audiences. The findings contribute to a deeper understanding of how media influences health and safety narratives within the mining sector, offering practical implications for industry stakeholders and communication professionals.

11:25 AM

What's a Resilient Safety Culture (And How Do You Get It)?

Z. Knoop; Caterpillar Inc., Groveland, IL

Safety culture exists whether an organization proactively manages it or not. Over the past 50 years, Caterpillar Safety Services has worked with hundreds of organizations striving to build the strongest safety culture possible to keep their people safe. What we've learned is that the key to success and sustainability is resilience. In this presentation you will learn about the four interdependent components that are necessary to achieve a resilient safety culture.

WEDNESDAY, FEBRUARY 26 MORNING

HEALTH & SAFETY: BEST PRACTICES—PROCESS SAFETY AND RISK CASE STUDY

Room 108

9:00 AM • Wednesday, February 26

Chairs: ***S. Richard****, Coeur Mining, Chicago, IL*
M. Main*, Freeport-McMoRan Inc, Leadville, CO*

9:00 AM

Introduction

9:05 AM

An Agent-Based Parametric Analysis of Miners' Evacuation Time From an Underground Fire for Improved Emergency Planning

O. Salami; Tunnels, HATCH, Los Angeles, CA

This study investigates the critical importance of efficient crew evacuation during hazardous situations in underground mining environments. Focusing on a drilling rig (29.4 MW) fire scenario, the research examines the evacuation duration for a 25-member crew through model–based evaluations of designated escape routes. The findings emphasize the significant impact of fire-induced smoke on evacuation times, challenging assumptions about the shortest path being the safest or fastest. The study underscores the necessity of optimizing evacuation efficiency by selecting appropriate routes during an emergency in the underground. While specifically addressing fire-related risks, it acknowledges the potential applicability of the evacuation modeling approach to other hazards in underground mines, however without accounting for their direct influence on evacuation procedures. The findings from this study serve as a crucial resource for enhancing safety protocols within mining operations, highlighting the need for further exploration into comprehensive evacuation strategies considering various hazards present underground.

9:25 AM

Ergonomic Safety Guarding and its Return on Investment

C. Allen; Belt Conveyor Guarding, Barrie, ON, Canada

According to the US Bureau of Labor Statistics (BLS), back injuries make up 20% of all workplace injuries. Only the common cold accounts for more missed days of work. In this presentation, we will take a look at the importance of safety guarding ergonomics as well as the Return on Investment that comes with it. Key topics we will cover include: - OSHA/MSHA Machine Guarding Standards and how to apply them to your equipment - Principles of fixed guarding - Explanation of how companies can make their guarding ergonomic and maintenance-friendly - Demonstration of cost effects of injuries due to non-ergonomic guarding - Providing a useful tool to estimate direct and indirect costs caused by poor ergonomics Belt Conveyor Guarding is an industry leader in providing sustainable guarding solutions for rotating equipment and conveyor applications. We provide safe, affordable solutions that ensure your equipment is compliant with health and safety regulations and protect the worker from exposure to danger zones

9:45 AM

Applying Generative AI to Job Hazard Analysis and Safety Observation Reports

Y. Dong[2] and L. Brown[1]; [1]Mel & Enid Zuckerman College of Public Health, The University of Arizona, Tucson, AZ and [2]College of Information Science, The University of Arizona, Tucson, AZ

Risk management processes such as job hazard analysis are critical in preventing incidents and avoiding occupational injuries on the worksite. We explore state-of-the-art generative AI technologies, such as GPT-4 and Claude-3 Opus, to predict potential injuries, explain the causes of injuries, and generate safety recommendations from textual descriptions of proposed job activities and work areas. In this talk, we discuss strategies to integrate expert suggestions and mining safety-specific knowledge to improve AI performance, using techniques such as few-show learning and Retrieval-Augmented Generation (RAG). For example, in an injury labelling task conducted with work area safety observations farmed from a partner's management system, the models achieved F1 scores which met or surpassed the inter-expert comparisons -- 0.41-0.7 for GPT-4 versus 0.48-0.57 for experts, where the expert annotations were used as gold labels. Furthermore, expert reviews of the AI's explanations for each potential injury found most to be practical and useful. AI models show great potential to assist in job planning and risk management tasks, serving as a foundation for smarter safety management systems.

10:05 AM

A Case Study in Core Processing Facilities Modernization: Creating a Significantly Safer Work Environment at Vale Stobie

C. Meandro[2] and E. Maag[1]; [1]CoreLift, Sudbury, ON, Canada and [2]In-Mine Geology, Vale Canada Ltd, Sudbury, ON, Canada

The Vale Stobie core shack was a traditional high volume mining operations using racking and wooden benches to layout core with over 100,000 metres of diamond drill core logged per annum. By significantly retrofitting the work environment and adding adjustable equipment, Vale reduced the physical handling of core boxes by 83% and thereby having a significant reduction in Health & Safety hazards for repetitive strain injuries like MSDs. The new fully adjustable equipment allows for a greater physical diversity of geologists and technicians as well as increase the productivity of the core logging operations.

10:25 AM

Developing Leading Indicators for Safety Risks in Mining Operations Through Holistic Error Data Analysis

P. Guild and P. Rogers; Mining Engineering, University of Utah, Magna, UT

Safety outcomes are highly dependent on the efficiency of leadership, the prevailing culture, and the systems utilized to enable a sustainable mining operation. While error data is collected across multiple functions of a mining operation to project business risks and fine-tune processes that impact returns, safety insights often rely heavily on lagging indicators, resulting in reactive solutions that typically fail to consider evolving risks. This research holistically analyzes error data, including operational error data, production variance, maintenance error data, and safety event data, to determine if patterns exist that can help form leading indicators for projecting safety risks.

10:45 AM

Development of Hazard & Risk Identification System Utilizing Virtual Reality (VR) and Augment Reality (AR) Technologies

V. Alves, T. Dias de Almeida, C. Kocsis and D. Wood; Mining, University of Utah, South Jordan, UT

This paper will focus on the development of an underground mine emergency evacuation system coupled with a health and safety training program to identify hazards and risks using metaverse-based virtual reality technology. This simulator can help model and understand human behavior in case of emergency, eliminate panic, and increase the confidence of mine workers in case of underground fires and other emergency situations. Two interconnected modules will be developed under the main metaverse platform enabling the system to be used as: (1) training & testing mine personnel, and (2) guided evacuation of underground mine personnel to a safe area.

11:05 AM

Leveraging Psychological Safety to Enable Improved Safety Performance

T. Dillon and W. Leavitt; ERM, Elko, NV

ERM has supported mining clients facing safety performance challenges by emphasizing the importance of a collaborative approach. By engaging employees at all levels within the organization, these clients have been able to identify root causes and implement effective changes. For employees to thrive and speak freely, it is important to create a psychologically safe workplace. A heightened level of awareness is required to uncover blind spots and embed sustainable interventions. We explored the human experience, including physiological responses to cues of safety and danger. We brought systems thinking forward to help foster an environment where purposeful relationships and healthy interactions lead to a human-centered, psychologically safe workplace.

11:25 AM

Leveraging CMMS for Enhanced Health & Safety: A Case Study on Haul Truck Hydraulic Hose Failure Fires

M. Smyth; Cogep, Moncton, NB, Canada

In the mining industry, the reliability and safety of equipment are paramount to ensuring operational efficiency and worker safety. This case study explores the critical role of CMMS in improving maintenance practices and preventing equipment failures, focusing on the safety challenges posed by hydraulic hose failures. At a mine site, recurring incidents of haul truck fires were traced back to bursting hydraulic hoses, posing significant safety risks. Our investigation revealed that preventive maintenance tasks were not consistently performed, leading to catastrophic hydraulic hose failures. By optimizing the CMMS, we were able to track and manage both preventive and corrective maintenance activities. The software facilitated detailed logging of maintenance work, enabling the identification of trends and root causes behind equipment failures. Analysis of maintenance data highlighted the critical need for a mid-life replacement strategy for hydraulic hoses. This presentation will delve into the methodology of using CMMS data to drive maintenance decisions, the implementation of the mid-life replacement strategy, and the resulting improvements in safety and operational efficiency.

WEDNESDAY, FEBRUARY 26 MORNING

INDUSTRIAL MINERALS & AGGREGATES: HEALTH & SAFETY IN INDUSTRIAL MINERALS (JOINT SESSION WITH HEALTH & SAFETY DIVISION)

Room 107

9:00 AM • Wednesday, February 26

Chairs: ***R. Mitra****, South Dakota Mines, Rapid City, SD*
A. Moradi*, University of Kentucky*

9:00 AM

Introduction

9:05 AM

In-Mine Underground Collision Avoidance Information System

M. Long[1], S. Schafrik[1], J. Sottile[1], Z. Agioutantis[1], A. Rajvanshi[2] and H. Chiu[2]; [1]Mining Engineering, University of Kentucky, Winchester, KY and [2]SRI International, Menlo Park, CA

Despite significant advancements in mine health and safety, mining remains a hazardous environment with fatalities increasing in recent years, with 2023 being the highest in 10 years for fatalities at 39, and with 23% of the fatalities in 2023 being attributed to powered haulage. This is exacerbated by the use of large equipment in confined spaces, poor visibility, and operator fatigue. Collision avoidance systems (CAS) have been successfully utilized in surface operations to mitigate these hazards. However, they have not been implemented in underground applications as of yet due to the complex conditions of underground mines. This paper proposes a novel low cost CAS, utilizing machine learning and depth-sensing cameras for underground applications. Training image data captured of underground mobile equipment in underground stone mines and a zinc mine was used to improve a vision-based recognition engine developed by SRI International. Utilizing the data from the CAS, a front-end interface will alert equipment operators to potential collisions, thereby enhancing safety and reducing incidents in underground mining environments.

9:25 AM

Characterization and Toxicity Analysis of Lab-Created Respirable Crystalline Silica Dust From Metal and Non-Metal Mines

S. Siahidouzazar[1], M. Rezaee[2] and P. Roghanchi[1]; [1]Mining Engineering, University of Kentukcy, Lexington, KY and [2]Mining Engineering, Penn State University, State College, PA

This study investigates the physicochemical characteristics and toxicity of lab-prepared, respirable-size silica dust from different metal and non-metal mines. Respirable crystalline silica dust (RCS) samples are analyzed for dissolution characteristics in simulated lung fluid (SLF) through batch reactor studies under conditions that mimic the lung environment. These experiments explore the relationship between different samples' toxicity and physicochemical characteristics. The ongoing research in this field also highlights the need for more intensive risk assessment and better management options to protect the health and safety of miners.

9:45 AM

Diesel Particulate Matter Emissions from Underground Mining Equipment

F. Ayaburi[1], K. Bamwisho[2], B. Yendemeh[2], A. Swift[1], J. Ayaburi[1], A. Brickey[3] and A. Newman[1]; [1]Mechanical, Colorado School of Mines, Golden, CO; [2]Colorado School of Mines, Golden, CO and [3]South Dakota School of Mines & Technology, Rapid City, SD

This study investigates Diesel Particulate Matter (DPM) emissions from large underground mining vehicles. We conduct empirical experiments in an at-scale, experimental mine using an aethalometer in a controlled setting. Our findings enhance the understanding of DPM sources and sinks; and, they support strategies for mitigating health risks in underground mining environments.

10:05 AM

25-029

Effect of System Type and Information on Miners' Decisions and Trust in AI-based Monitoring Systems

M. OWUSU TWENEBOAH[1], K. Awuah-Offei[1], D. Burns[2] and S. Ghazal[2]; [1]Mining and Explosives Department, Missouri University of Science and Technology, Rolla, MO and [2]Psychological Science Department, Missouri University of Science and Technology, Rolla, MO

Trust in AI systems and the nature and amount of information about the system can influence decision-making. It is, therefore, crucial to understand how automated monitoring systems influence miners' trust and decision-making. This work focused on measuring the differences between how participants respond to a simulated underground mine emergency evacuation situation when warnings are represented as coming from a human or AI-based monitoring system. We also manipulated the amount of information participants received about the system, yielding a 2×2 between-participants survey design. The participants received an alert message about rising gas levels in a mine and provided a response on how they would react and reported their perceived safety. We also asked questions to assess their trust in, preference for AI over human-based gas monitoring systems, and whether they are willing to delegate the duties of underground gas monitoring to AI systems. The experiment results show the effect of the nature and amount of information on miners' trust and decision-making. This work provides valuable insights as the industry deploys AI systems to aid mine safety.

10:25 AM

Predicting Miner Location during Underground Mine Emergencies Using Artificial Intelligence with Data From a Delay-Tolerant Network Database

P. Nonguin, S. Frimpong and M. Raza; Mining and Explosives Engineering, Missouri University of Science and Technology, Rolla, MO

Underground mining environments are characterized by hazards like cave-ins, gas explosions, and fires, causing emergencies that can trap miners. Rapid and accurate location information is critical for effective miner self-escape. The MINER Act of 2006 mandates the implementation of underground communication and tracking systems to enhance safety and improve emergency response. Previous research has developed the Delay-Tolerant Network (DTN) technology to enhance accurate detection, tracking, and localization of miners for safe self-escape from underground mine emergencies. This research leverages artificial intelligence (AI) techniques to develop a hybrid model combining Long Short-Term Memory (LSTM) and Deep Neural Network (DNN) to improve detection, tracking, and localization of miners in emergencies using data from DTN nodes. Extensive experiments are carried out to generate results based on simulated emergencies within Missouri S&T's Experimental Mine. The main novelty is the improved AI algorithm that improves tracking, detection, and localization for safe miner self-escape from mine emergencies.

10:45 AM

Mining Knowledge From Failure: Lessons Learned from the Fatalities of 2023

N. Kelley[1], M. Savit[2], E. Lutz[3] and P. Roghanchi[1]; [1]Mining Engineering, University of Kentucky, Lexington, KY; [2]CEO, MSHAWise LLC, Denver, CO and [3]University of Arizona, Tucson, AZ

The 2023 fatality reports by MSHA reveal a devastating year for the mining industry, with 40 mine workers losing their lives. This study aims to analyze the lethality of mining in 2023, provide insights into mining safety trends, and propose potential interventions to reduce fatalities moving forward. The data over the last 20 years is categorized into specific areas of interest to be examined with the 2023 data for the causes and contributing factors for these fatalities. Areas with increased and decreased fatalities will be investigated to find the root causes of these accidents. These findings will be compiled to form the best practices moving forward.

11:05 AM

Implementing a Fatality Prevention Program—A Contractor's Perspective

S. Wrixon; Cementation Americas, North Bay, ON, Canada

Good companies in the mining industry want to prevent all injuries. Many feel that one injury, regardless of severity is too many. While there are healthy debates about the practicality of this, there is no debate that everyone wants to prevent workplace fatalities and life altering injuries. While the mining industry has done a commendable job in reducing Total Recordable Injury Frequencies, the frequency of workplace fatalities in our industry has largely flat lined. Mining contractors are often tasked with complex work which can have energy sources that have the potential to cause fatalities. In many cases, while working for a mining client, a contractor will work under aspects of the owner's safety program. A contractor who works across the world has the benefit of being exposed to safety programs from multiple companies and jurisdictions, providing the opportunity to learn from them and apply them to their own internal programs. This paper will discuss Cementation Americas' journey in rolling

out a fatality prevention program. It will cover why this was important, how selection and development of a program took place, rollout strategies, and lessons learned.

WEDNESDAY, FEBRUARY 26 MORNING

MINING & EXPLORATION: GEOSCIENCES: LESSONS LEARNED IN RESOURCE ESTIMATION

Sponsored by: BARR

Room 601

9:00 AM • Wednesday, February 26

Chairs: ***A. Jewbali****, Newmont, Denver, CO*
S. Leclerc*, SRK Consulting, Elko, NV*

9:00 AM

Introduction

9:05 AM

Geological Characterization for Lithium Pegmatite Projects: A Summary of Commonly Observed Fatal Flaws, Challenges, and Good Practices

E. Ronald; SRK Consulting, Denver, CO

Lithium-bearing pegmatite dykes represent a significant source of lithium for global markets. Over the past decade, SRK Consulting has conducted numerous studies, disclosure of mineral resources, and due diligence reviews on Li-pegmatite deposits around the globe. SRK has noted that the geological assessment of these hard rock Li sources shares common features, gaps, and challenges. Successful resource risk assessment requires the evaluation of dyke mineralogy, textures, and chemistry along with overall dyke geometry, continuity, internal dilution, and cross-cutting features which directly impact project viability and resource classification. In additional, most pegmatite projects require detailed structural geology assessment, geometallurgical domain characterization, tight-spaced diamond drilling, and 3D modeling at deposit-scale to provide sufficient detail for successful mine planning, metallurgical assessment, and economic assessment for project viability.

9:25 AM

Improved Grade Continuity and Reconciliation Through the Novel Unfolding of a Structurally Complex Gold Deposit

M. Bzdok[1], E. Daniels[1], F. Paiva Leite Pereira[1], A. Chojno[2] and R. Barnett[1]; [1]GeologicAI, Woodland Park, CO and [2]Newmont Corporation, Denver, CO

Resource estimation in a structurally complex setting is inherently difficult due to the challenge of replicating realistic grade continuity along intricate geologic features, as exemplified by a Newmont Corporation deposit in Canada. Historical gold estimates of the deposit resulted in grade smearing and reconciliation challenges, frequently associated with complex limb folds and hinge thickening. These estimates used available commercial implementations of ordinary kriging and unfolding. The recent application of an innovative unfolding approach led to increased grade continuity that was reflective of the geologic setting. This has proven to yield improved reconciliation, while encouraging additional collaboration between production geology, exploration geology and resource modeling teams for greater overall deposit knowledge and resource estimate outcomes. Prior model challenges are illustrated for the deposit, before demonstrating the unfolding technique and its associated improvements.

9:45 AM

Defining High-Grade Values in Composited Data for Grade Estimation in a Resource Model

A. Samal; GeoGlobal LLC, Riverton, UT

Various interpolation techniques are be used to estimate grades in a block model. Irrespective of the interpolation techniques, the high-grade value for the variable (Cu, Au, Ag etc.) in composited data is an important decision. Because changing the cutoff grade for defining high grade, the grade estimates in the block model can have a substantial effect. These high-grade values receive special treatment. Sometimes the composited data are capped i.e. all values above that grade are treated as one value. For example, if a decision is made to treat all copper values ≥1% as high-grade (in composited data) and 'capped', then all values ≥1% will be treated as 1% in the grade estimation. Another way of treating these high-grade values is using a smaller search ellipsoid during interpolation so that smearing effects due to these high grade vales are minimized. We also know that if another decision is made to use 0.5% in place of 1%, then the impact will be different. Therefore, decision of high-grade value in a composited data set is very important. In this presentation, the process of defining high-grade values in a composited data will be discussed with an anonymous example.

10:05 AM

Uncertainty Study Cerro Negro Project Cerro Negro, Argentina—Newmont Mining Corporation

M. Loayza Montenegro; Resource Modeling, Newmont Mining Company, Weston, FL

This work summarizes the Uncertainty Study for the Cerro Negro projects in Argentina, operated by Newmont Mining Corporation. The study employed Gaussian and Categorical simulation techniques using RMS software to evaluate grade and geological uncertainties. Gaussian simulation (turning bands) was applied to vein thickness, surface position, and gold grade, while hierarchical truncated pluri-Gaussian (HTPG) simulation was used for vein boundaries. Simulations were conducted by orientation groups and integrated into the final model. Fifty realizations were simulated, validated, and compared to existing models using grade-tonnage curves. The Deswik Stope optimizer was used to assess uncertainties in tonnes, grade, and ounces, ensuring a 90% probability within ±15% limits annually.

10:25 AM

Lessons Learned in Resource Estimation—Interactive Panel Discussion

M. Moore-Roth; Maptek, Golden, CO

An interactive panel discussion exploring the lessons learned in resource estimation technical session.

WEDNESDAY, FEBRUARY 26 MORNING

INDUSTRIAL MINERALS & AGGREGATES: INNOVATIONS IN INDUSTRIAL MINERALS AND AGGREGATES I

Room 106

9:00 AM • Wednesday, February 26

Chairs: ***G. Tomaino****, Minerals Technologies Inc, Easton, PA*
B. Li*, Michigan Technological University, Houghton, MI*

9:00 AM

Introduction

9:05 AM

Developing Real-Time Priority Indices for Critical Minerals: Emphasis on Defense, Technology, and Energy Sectors Supply Chain Disruptions

E. QUANSAH and A. Anani; Mining and Geological Engineering, University of Arizona, Tucson, AZ

Studies have documented the top minerals needed to fuel sectors of the economy. However, minerals priority change due to technology, demand, and substitution. This research aims to develop real-time priority indices for minerals, emphasizing their importance to the defense, technology, and energy sectors. Using economic and production data, the study will create real-time indices to forecast and prioritize minerals essential for these sectors. The methodology includes data acquisition, cleaning and processing, modeling, and visualization through Python libraries and API integration. Results will aid strategic resource allocation, boost supply chain resilience, meet industry demands, and support timely informed decisions.

9:25 AM

Non-Destructive Rock Characterization Using Laser-Induced Breakdown Spectroscopy

R. Madavi[1], R. Mitra[1] and P. Diwakar[2]; [1]Mining Engineering and Management, South Dakota School of Mines & Technology, Rapid City, SD and [2]Mechanical Engineering, South Dakota School of Mines & Technology, Rapid City, SD

Laser-Induced Breakdown Spectroscopy (LIBS) offers a revolutionary approach to rock characterization with rapid, non-destructive analysis. This study applies LIBS to accurately characterize rocks by determining their strength, leveraging its capability to deliver in-situ elemental composition data. The research investigates the correlation between LIBS-generated spectral data and rock mechanical properties by examining various artificial and natural rock types. Key parameters such as laser energy, pulse duration, and focus are optimized to enhance precision and reproducibility. Initial findings demonstrate that LIBS can differentiate rock strength based on spectral signatures, enabling the characterization of geotechnical materials. The study reveals that strength measurements obtained using different types of lasers (continuous, pulsed, or combined) correlate with laboratory strength measurement methods and exhibit no size effects, ensuring the accuracy and reliability of evaluations regardless of specimen size. This research underscores the potential of LIBS as a vital tool in geotechnical engineering, mining, and planetary exploration.

9:45 AM

North American Iron Mine Enhances Productivity Through Predictive Analytics

M. Stammenga, C. Hill and J. Hansen; Kemira Water Solutions Inc., Atlanta, GA

A mining operation sought to improve its thickening clarification process. Kemira assessed if KemConnect™ technology could eliminate equipment fouling caused by excessive solids in the recycled clarifier effluent. KemConnect measures changes in settleability, assesses data, and changes chemical dosage to optimize settling velocity. A review of chemical treatment efficiency identified an enhanced flocculant combination that produced a robust floc with increased shear capacity and settling speeds. The new chemistry and KemConnect lowered and stabilized turbidity in the clarifier outfall, allowing for increased mineral slurry processing. The mine now has the process visibility to manage suspended solid fluctuations that affect performance.

10:05 AM

Natural Pozzolans in Utah

A. Rupke and T. Boden; Utah Geological Survey, Salt Lake City, UT

The Utah Geological Survey has recently completed a reconnaissance-level investigation of natural pozzolan potential in Utah on behalf of the Utah Trust Lands Administration. Seven known natural pozzolan deposits were identified in the state that included primarily volcanic materials, but also some clay and diatomaceous earth deposits. Additional potential natural pozzolan resources were identified through field investigation, whole-rock geochemical analysis, x-ray diffraction (XRD) analysis, and thin section examination. Several potential deposits within the state were identified that include substantial amounts of reactive materials from a pozzolanic perspective (e.g., volcanic glass, zeolite minerals) and deserve additional investigation.

10:25 AM

Non-Intrusive Flow Measurement of Compressed Air in a Deep-Level Underground Platinum Mine

V. Mwaba; SME, Shorewood, IL

Compressed air systems are one of the most significant energy users on a mine, with a contribution of about 20% to the total electrical energy consumption. The air is used to power tools, mainly the pneumatic rock drills. Surface compression facilities supply air to an underground network of pipes laid in the vertical and horizontal shafts. The air is typically provided from a DN 24" supply into 6" to 12" feeder pipes at around 90 psi. As various sections of the ore body are extracted, air supply is required in different shafts. The electricity costs associated with supply utilities are significant—in an underground platinum mine near Rustenburg in South Africa circa R350K (25K USD) per day. Flow measurement is needed for the following objectives: Identify if there is flow in inactive areas, isolate the ring, and stop wastage. Identify high consumers in active areas. This may indicate equipment wear and therefore able to prioritize these for intervention. Identify leaks; it is estimated a punch hole caused by a nail can result in loss of R500K (36K USD) p.a. while open ends can be as much as R10 million per annum (715K USD)

10:45 AM

Applications of Bentonite Clay for Solidification of Drifting Sands

B. Li[1], X. Xu[2], F. Li[3], G. Fu[2] and C. Chai[2]; [1]Materials Science and Engineering, Michigan Technological University, Houghton, MI; [2]Gansu Desert Control Research Institute, Lanzhou, China and [3]Chaoyang Qingjian Mining Co, Jianping, Liaoning, China

Bentonite clay has unique and excellent properties such as hydrophilicity, swelling, lamination, small grain size, and easy processing, as well as broad distribution as a mineral resource. These properties have been already developed for applications, but many potential utilizations still remained to be exposed. This paper discusses the applications of bentonite clay in drifting sands and dunes, as well as the solidified surface of sands. The practical performance and mechanisms will be discussed.

11:05 AM

25-012

Approach to Selecting Research and Development Investment Projects in Mining

A. Nieto and J. Castillo Gomez; MineralsTech.org, Salt Lake City, UT

Research and Development (R&D) departments in the mining sector are essential for creating new solutions on productivity, safety, and sustainability. Nevertheless, the selection of R&D projects is complex, often influenced by subjective judgments and uncertainties. This paper explores the application of the Multicriteria Decision Analysis (MCDA) as a structured approach to evaluate and prioritize innovation projects based on various criteria such as safety, cost, environmental impact, and social acceptability. By assigning weights and quantifying criteria, MCDA enhances decision-making transparency and objectivity. This study aims to show a method that facilitates strategic thinking, resource optimization, and stakeholder engagement, ensuring that selected innovations align with the company's long-term objectives and commitment to responsible mining practices.

WEDNESDAY, FEBRUARY 26 MORNING

KAWATRA SYMPOSIUM: COMMINUTION

Room 709

9:00 AM • Wednesday, February 26

Chairs: ***M. Larson****, Molycop, Ewen, MI*
K. Bartholomew*, Metcom Technologies, Grand Rapids, MN*

9:00 AM

Introduction

9:05 AM

The HPGR—A View of Today and into the Future

R. Seitz; Metcelerate, Simpsonville, SC

The paper reviews the current capabilities of HPGR technology, highlighting its efficiency in reducing energy consumption and improving throughput in mineral processing. It discusses the applicability of HPGR in various flowsheets, emphasizing its role in enhancing the overall performance of mineral processing circuits. The paper identifies the limitations of HPGR, such as wear and tear on the rolls and the need for robust maintenance practices. A framework is presented that outlines the key variables impacting HPGR application and performance, including ore characteristics, operational parameters, and maintenance strategies. The paper provides insights into the future potential of HPGR technology, suggesting areas for further research and development to overcome current limitations and enhance its application in the industry.

9:25 AM

Development of the Larson/Morrison IsaMill Model

M. Larson[1], R. Morrison[2] and W. Xie[3]; [1]Molycop, Ewen, MI; [2]Univeristy of Queensland, Indooroopilly, QLD, Australia and [3]University of Minnesota Duluth, Duluth, MN

The IsaMill is a high intensity horizontal stirred mill developed by Glencore Technology that utilizes small ceramic grinding media for attrition grinding. Grinding duties range from feeds coarser than 300 microns being ground to sub 50 microns and UFG grinds as fine as 5 microns. Being completely dissimilar to normal ball mill breakage using steel media and cyclones for classification, it was desired to produce a model for this process. The result of this study was the discovery that IsaMill breakage and the resulting particle size distribution curve can be reliably predicted on a basis of energy versus the squared value of the percent passing of a range of given sizes. This relationship can be used to analyze circuit efficiency for varying feed sizes. By using this new relationship, the product size distributions for new feed sizes and energies can be reliably predicted with simple math, something not previously possible with only a signature plot. This method also provides a valid tool for comparisons of different stirred mills under varying conditions. This paper will provide details on the model development, validation, and implementation.

9:45 AM

Discovery and Application of the Functional Performance Equation

K. Bartholomew; Metcom Technologies, Grand Rapids, MN

The Functional Performance Equation was discovered and formalized by R.E. McIvor in the 1980's as a result of a serendipitous period of his employment which prompted investigation of the relationship between classification and ball mill grinding. In the subsequent five decades of application the Functional Performance Analysis method has resulted in numerous plant optimization projects and forms the basis of the Metcom Training program which empowers metallurgists worldwide to understand, improve, and control their comminution circuits. This paper describes the discovery of Functional Performance and a series of case studies in its application.

10:05 AM

HPGR Application Versatility in Flowsheets of Gold Leaching Projects

E. Licares and N. Logan; Minerals & Metallurgical Processing, Weir, West Valley City, UT

Gold can be extracted through various metallurgical processes, including leaching. The choice of leaching method depends on the ore's gold grade: low-grade ores typically undergo heap leaching, while high-grade ores are processed through tank leaching. The effectiveness of these cyanidation processes is influenced by the presence of fine particles. Fine particles are advantageous for tank leaching but can hinder heap leaching. In both scenarios, High Pressure Grinding Rolls (HPGR) play a crucial role. The product size distribution can be managed by adjusting the pressure and RPM of the HPGR. Additionally, the type of HPGR feed (full or truncated) significantly impacts the results of the particle size distributions. This presentation will explore the optimal placement of HPGR in gold leaching project flowsheets highlighting the equipment's unique versatility in controlling the generation of fine particles.

10:25 AM

The Effect of Oversizing Equipment in Crushing/Milling Circuits

N. Logan; Comminution, Weir Minerals, West Valley City, UT

Mining projects have the potential to suffer the negative effects of improper equipment sizing. It is critical to capture realistic data inputs that utilize numbers that were collected using industry standard methods which eliminate sources of error and use this data to size equipment correctly to the application. Whether its from a project that is designed for higher throughput than will ever be achieved due to other limitations on site, or from multiple safety factors being applied at various stages of design, improperly sized or oversized equipment can lead to wasted energy, premature failure, and wasted capex funds that could be utilized elsewhere. Mining equipment typically has a performance curve and is tested to establish the best operating/efficiency point. This efficiency curve and the operating duty point must not be ignored when evaluating sizing for an application. Wear parts in improperly sized equipment also have the potential to experience uneven wear and reduce product life while causing unnecessary and costly downtime.

10:45 AM

Optimization of Fine Grinding for Banded Iron Low Grade Deposit in a Vertical Stirred Mill

A. Kumar[2], R. Sahu[2] and S. TRIPATHY[1]; [1]Mineral Processing and Metallurgy, National Resources Research Institute, University of Minnesota Duluth, Grand Rapids, MN and [2]Department of Metallurgical and Materials Engineering, National Institute of Technology, Jamshedpur, JH, India

With the growing emphasis on decarbonization, minimizing energy in comminution circuits has become a critical focus area in mineral processing flowsheets. The present investigation emphasized a banded iron formation (BIF) deposit from eastern India to grind to finer sizes in an energy-efficient vertical stirred mill (VSM), along with supported characterization data. From the characterization, it was found that the BIF deposit is a low-grade ore assaying 36.5% iron with a gangue of 47.8% silica. Automated mineralogy studies confirmed the presence of hematite as an iron mineral and quartz/jasper as a major gangue mineral. Based on characterization data, it was concluded that the ore needs finer size grinding below 100 μm to liberate the particles. The grinding studies focused on achieving the finer particle size by varying the main process parameters such as grinding time, agitation speed, and feed pulp density. It is concluded that particle size can be lowered up to 49.9 μm at an energy of 16.7 kWh/t from a feed size of 870 μm. Further, the optimization strategy of the VSM opted to grind the low-grade ore efficiently to liberate the hematite.

11:05 AM

25-061

Models of Breakage Effectiveness in HPGR Depending on Operational Press Parameters

D. Saramak; Environmental Engineering, AGH University of Cracow, Cracow, Malopolska, Poland

The paper concerns investigations on operational parameters of HPGR and determination the model of breakage effectiveness in the press as a function of pressing force and the feed moisture. A series of laboratory crushing tests will be conducted for a limestone for three levels of operational pressure and two or three levels of moisture. Each HPGR product will undergo the kinetics analysis as well as determination the Bond working index Wi. Breakage effectiveness will be analysed from the scope of fines production and achieved comminution degrees Sx. On the obtained results specific functional models will be calculated. The practical aspect of this study will be to show how to achieve specific fineness of the product through control and setting the values of operational parameters of the press device. It is planned to verify the obtained results also for the other type of raw material—copper ore.

WEDNESDAY, FEBRUARY 26 MORNING

MINING & EXPLORATION: INNOVATION & TECHNOLOGY: EVOLUTION OF EQUIPMENT USE IN MINING

Room 506

9:00 AM • Wednesday, February 26

Chair: ***P. Lazaro Trujillo****, Caterpillar, Tucson, AZ*

9:00 AM

Introduction

9:05 AM

So You Want to Electrify Your Mine: A Primer on Underground Mine Design to get the Most Out of Battery Electric Vehicles

C. Kincaid; Mining, JDS Energy and Mining, Vancouver, BC, Canada

BEVs (Battery Electric Vehicles) can unlock huge ventilation savings, energy savings, and increased productivity for underground mines, but only if the mines are designed with their strengths and weaknesses in mind. Attempting to use them on standard long mucking routes, on uphill loaded hauls, and in similar situations can easily wipe out any savings you would otherwise have seen. In this talk, I will introduce foundational principles of underground mine design that allow any underground mine to save as much money as possible with BEVs, centered around a principle of maximizing energy efficiency in material flow. We will apply these lessons immediately in the session, as I walk you through modifying the design of an example greenfield underground project into one optimized for BEV use. We will then review the pros, cons, and difficulties of making these changes, assuming a fully BEV fleet.

9:25 AM

Analysis of Battery Electric Vehicle-Operated Underground Haulage Systems Using Discrete-Event Simulation

M. Kahraman and S. Duzgun; Colorado School of Mines, Golden, CO

Battery Electric Vehicles (BEVs) are increasingly being used in various underground mines worldwide to improve safety and reduce emissions. This study explores the potential use of discrete-event simulation to test different production scenarios at the Konsuln underground iron mine in Sweden as diesel vehicles are replaced with BEVs. The Konsuln mine currently operates with four Epiroc ST18 LHDs and eight Epiroc MT42 trucks. The simulation model was created to calculate cycle times for the mine's haulage system, incorporating various probability distributions. According to the simulation results, the cycle times for the trucks range from 34 to 45 minutes, depending on their location within the mine, with a queue time of 25 seconds at the LHDs. These findings can be utilized to optimize processes at the Konsuln mine, such as updating the ventilation system and potentially implementing ventilation on demand (VOD).

9:45 AM

Engaging Your Teams to Enable Successful Technology Adoption

B. Haskins; Caterpillar Inc, Peoria, IL

Change is inevitable, and while many companies recognize this, most struggle to adapt. Realizing the promises that technology can bring requires understanding the interconnectedness of people and human response first. Engaging appropriate stakeholders early on and throughout each project promotes a seamless implementation of new technology. By supporting the people along the journey with knowledge, skills, and confidence to embrace the new normal and avoid the dip that can occur at each transition point. Join this session to understand proven methods on how to effectively engage your teams in disruptive technology deployments.

10:05 AM

Drill and Blast Optimisation for Hole Position, Explosives and Drill Bit Clusters

O. Perincek[1], R. Loxton[2], S. Kulkarni[2] and D. Arthur[1]; [1]Rio Tinto, Perth, WA, Australia and [2]Curtin University, Perth, WA, Australia

The locations and sizes of drill holes are two critical decisions in drill and blast design. These decisions are a trade-off between meeting blast objectives such as fragmentation, cost, and ease of operational execution. Additionally, selecting the correct diameter for holes allows placing the optimal explosive amount without exceeding constraints such as ground vibration. Simulations show that varying distances between holes (burden and spacing) can better optimise fragmentation. However, a complex pattern hinders the capability of the trucks to deliver explosives to holes by traversing both diagonally and horizontally across the blast. Keeping navigation options open is important because obstacles in mines, such as pit walls, limit explosive truck movement. This work presents a heuristic approach for automating pattern designs to optimise fragmentation while considering desirable truck navigation. The new approach uses ground hardness estimations from a network of drills to provide fragmentation control with a 3% to 4% better adherence to target particle size. This is achieved with fewer drill holes when the blast is near a vibration-sensitive area.

10:25 AM

Classifying the Root Causes Contributing to Overbreak and Underbreak During Stope Development Using Machine Learning

D. Osei and A. Brickey; Mining Engineering and Management, South Dakota School of Mines and Technology, Rapid City, SD

Overbreak and underbreak in underground hardrock mining impacts productivity, safety, and costs. This research utilizes a machine learning technique, specifically logistic regression, to identify and classify key parameters causing overbreak and underbreak. Stope development data acquired from a case study mine is analyzed to define parameters into significant and less significant causes of overbreak and underbreak. The findings from the study provide insight to design engineers to improve ore recovery, rock stability, and ultimately a safer and more cost-effective underground mining operation. Furthermore, the results provide valuable guidance for optimizing drilling and blasting operations in underground hardrock mining environments.

10:45 AM

Predictive Modeling of Fuel Consumption in CAT 793 Mining Truck Fleets using Artificial Intelligence and Machine Learning

M. Portal Valdivia, F. Segobia Campos, L. Goicochea Sánchez and F. YSLA QUIROZ; Mining engineering, Society for Mining, Metallurgy & Exploration, Cajamarca, Cajamarca, Peru

This study presents a predictive mathematical model to optimize fuel consumption in CAT 793 mining truck fleets operating in open-pit mines. Artificial intelligence and machine learning algorithms will be employed to analyze truck telematics data, including variables such as speed, payload, slope, environmental conditions, and maintenance records. The developed model will identify consumption patterns, quantify the impact of each variable, and generate accurate fuel consumption predictions under various operational scenarios. This will enable the optimization of route planning, preventive maintenance, and operational strategies, reducing costs and improving the energy efficiency of mining operations.

WEDNESDAY, FEBRUARY 26 MORNING

MINING & EXPLORATION: OPERATIONS: DRILL & BLAST OPERATIONS—IMPROVEMENTS & CHALLENGES II

Room 507

9:00 AM • Wednesday, February 26

Chair: ***Z. Forest-Dupont****, Stantec, Salt Lake City, UT*

9:00 AM

Introduction

9:05 AM

25-042

Improved Drill and Blast Designs Free $3.6M of Ore for Surface Copper Mine

T. Ferreira[1] and L. Diaz[2]; [1]DynoConsult, Dyno Nobel, Queen Creek, AZ and [2]Mine Engineering, Capstone Copper, Phoenix, AZ

Capstone Copper's Pinto Valley Mine faced challenges in recovering rock and ore on final walls because of geotechnical constraints that require restrictions on methods for loading blastholes adjacent to the pit boundaries to preserve wall conditions. The operation had been using the same drill and blast designs for years. With changing geology, such as harder rock, as mining progressed, material was being left unmined in final walls because of poor breakage. The amount of unrecovered, unprocessed ore was estimated at approximately 380,000 tons a year generated from an average of 60 final wall blasts performed annually. The engineering team from Capstone and Dyno Nobel engaged to minimize the amount of material left on the final pit walls. In this paper we present how we collected data, reviewed design standards, and found opportunities to improve ore recovery from pit final walls without increasing drilling and blasting costs. The results collected from implementing the new design on two benches showed the potential for extra revenue of approximately $3.6 million generated annually from reducing final wall unrecoverable underbreak by nearly 71% on the mine's highwalls.

9:25 AM

Use of Wireless Detonator Technology to Eliminate Live Holes in Open Pit Mining

N. Nunes de Oliveira; Drill and Blast, Freeport McMoran, Green Valley, AZ

Wireless detonator technology represents a major advance in personnel safety and operating efficiency in blasting. Decreasing detonator failures in open pit mines involves enhancing the reliability of initiation systems through the introduction of a wireless initiation system. By adopting the use of cutting-edge wireless detonator technology, there is a potential to reduce detonator failures due to cut down lines to zero. Every detonator can be activated, programmed, and adjusted using a user-friendly remote programming unit. The benefits of wireless technology include improvements in safety as well as production. This innovative system increases productivity and simplifies processes by eliminating live holes.

9:45 AM

Reliability of Drill Bits Case Study (Part 2)

E. Thibaud; Pneu Wave Consulting, Chattanooga, TN

In a follow-up to the 2024 Presentation introducing the Enrich Bits & Tools treatment to the Drilling and Blasting Industry. This paper will provide further details into field studies that show how this innovative treatment can drastically reduce drill fleet downtime and consumables by improving bit life. Part 1 introduced the methods, history, and preliminary results. Part 2 dives into a larger data set and benefits seen in both lime stone and a granite quarry application.

10:05 AM

Analysis of Geological Structures and Geotechnical Properties of Rock Mass using Cutting Edge Technology for accurate Blast Loading Planning and Prediction Results

A. AGRAWAL[1], R. Sahu[2] and E. Williams[3]; [1]Mining Engineering, IIT (ISM) Dhanbad, Kurud, Chhattisgarh, India; [2]Computer Science, Strayos, Buffalo, CO and [3]Civil Engg, Strayos, Buffalo, CO

Recent advancements in drone technology have created opportunities for geotechnical and geological analyses. Rock mass characterization is the first step in defining rock mass strength. Rock mass structural geology can be analyzed using the Rock Mass AI tool in the software with the simultaneous planning of drill hole locations. In this research, several techniques have been used in the determination of rock mass discontinuities and facets of a blast bench. Moreover, Measure While Drilling (MWD) data were collected for the determination of the penetration rate and rotation pressure of rock mass to convert it into specific energy and compressive strength. In this study, the geological and geotechnical properties of limestone rock were analyzed before planning for explosive loading and hole collar position, and compared the mapping method between the Unmanned Aerial Vehicle (UAV) and the conventional method. Based on the manual mapping and drone image analysis, limestone benches are classified as fractured rock. However, the advantage of using UAV photogrammetry can obtain high-precision images of the discontinuity on the bench face that are difficult to obtain by manual mapping.

10:25 AM

Correlating Atmospheric Pressure Changes with Airblast Dynamics and Seismograph Placement in Topographically Diverse Open-Air Blasting Environments

F. Frimpong and C. Johnson; Mining and Explosives Engineering, Missouri University of Science and Technology, Rolla, MO

Topography and weather conditions, including elevation, terrain variations, humidity, and atmospheric pressure, influence air overpressure in blasts. This paper investigates these air overpressure variations by strategically placing seismographs in an open-air blasting environment with varying topography and weather conditions. The study triangulates seismograph data from three locations to identify correlations between explosive charge sizes, distance, humidity, atmospheric pressure, topography, and air overpressure. The insights gained from this analysis will contribute to optimized blast designs and improved safety measures while ensuring environmental compliance. Notably, air pressure variations from blasting show strong correlations at high elevations and weaker ones at lower elevations.

10:45 AM

A Legal Case for Blasting

R. Sibley and K. Perry; Explosives Engineering, Missouri University of Science and Technology, Rolla, MO

The mining and explosives industries are consistently plagued by the general public's ignorance with respect to the economic and societal impact of their products. This regularly creates legal issues for mining and blasting companies when trying to begin new and continue existing operations. In recent years this has included class-action lawsuits against insurance companies that are not protected in the same manner as mining and blasting companies are by the law. These lawsuits are often based

around the idea that blasting that adheres to regulations does not properly protect structures. Insurance companies and their legal teams are not as well suited as a mining or blasting company for defending these cases, due to their lack of knowledge and experience in the field. Improving the understanding of the blasting process is of major importance when building a defense. This paper will explore the criticality of these industries coupled with the science of the environmental effects of blasting and the respective regulations. This exploration will be through analogous explanations that would prove beneficial when discussing mining and explosives with the general public.

11:05 AM

Investigating Geometrical Deviations and Drilling Efficiency in Underground Mining: Geological and Operational Perspectives

A. Ajatasatru, H. Subagyo, A. Widodo and A. Hall; GBC Development, PT Freeport Indonesia, Jakarta Timur, DKI Jakarta, Indonesia

Achieving efficient long-hole drilling is critical in underground mining, supporting infrastructure needs like groundwater management and cable installations. Precise geometrical alignment during drilling is essential for optimizing performance, minimizing deviations, and ensuring safety in challenging geological conditions. This study investigates factors affecting geometrical deviations and drilling efficiency to determine optimum drilling times for varying hole lengths. Advanced surveying techniques at regular intervals are used to measure deviations between actual and designed trajectories. Geological and operational parameters are analyzed to evaluate their combined impact on drilling performance. Mathematical modeling establishes correlations between these variables and drilling time, providing insights into ideal operational settings for different scenarios. Customized recommendations optimize efficiency and precision, adapting to varying geological complexities. The findings offer a framework for improving long-hole drilling practices, enhancing safety, productivity, and operational performance while advancing best practices in underground mining.

WEDNESDAY, FEBRUARY 26 MORNING

MPD: CHEMICAL PROCESSING: RECYCLING

Room705

9:00 AM • Wednesday, February 26

Chairs: ***D. Rodriguez***
B. Ji*, Virginia Polytechnic Institute and State University, Blacksburg, VA*

9:00 AM

Introduction

9:05 AM

Critical Material Recovery from End-of-Life Solar Modules

J. Groppo and Z. Hart; Mining Engineering, University of Kentucky, Lexington, KY

A sustainable alternative to landfilling end-of-life solar modules has been developed to separate and recover contained values. The benefits of physical and chemical processing are combined to recover not only commodity-grade products but refined critical materials suitable for higher value applications such as LIB anodes and photocatalysts. Circularity is achieved by producing higher value products to offset costs and reduce the need for subsidy.

9:25 AM

The Recycling of Perovskite Solar Cells Using Iodide Salt Solutions

B. Carlson and J. Kellar; Materials and Metallurgical Engineering, South Dakota School of Mines and Technology, Rapid City, SD

Perovskite solar cells are poised to play an important role in next generation of solar energy technology. However, there exist challenges to their adoption tied to environmental concerns regarding their use of lead perovskite compounds, such as methylammonium lead iodide. In this research, a new method for the selective removal of these lead containing compounds is explored that utilizes iodide salts. It was found that these salt solutions were able to effectively dissolve the lead containing layer, leading to the solar cell layers exfoliation and recover of the solar cell cover glass intact.

9:45 AM

Kinetics Study of the Removal of PVDF from Spent Lithium-Ion Batteries Black Mass

M. ISLAM; Chemical and Materials Engineering, Graduate Research Assistant, University of Nevada, Reno, Reno, NV

Removing polyvinylidene fluoride (PVDF) binder from spent lithium-ion batteries (LIBs) black mass is crucial for efficient recycling. This study investigates the kinetics of PVDF removal using aqueous NaOH solution with varying NaOH concentrations, reaction time, and temperature. Initial results showed that the reaction follows first-order kinetics with respect to the molar concentration of NaOH. The calculated rate constant and activation energy for the reaction from the experimental results suggest that PVDF degradation in an alkaline environment is relatively slow, but the manageable activation energy indicates that temperature adjustments can enhance process efficiency. At 70°C, PVDF removal was observed to be 90%, highlighting the effectiveness of temperature control. This study provides valuable insights into the chemical kinetics of PVDF removal, contributing to the development of more efficient recycling processes for spent LIBs by improving the understanding of PVDF degradation in alkaline conditions.

10:05 AM

Physical Separation of Black Mass for Lithium Ion Battery Recycling

N. Smith and J. Lee; Mining Engineering, Colorado School of Mines, Golden, CO

With the rise of electric vehicles, Lithium Ion Battery (LIB) recycling needs to increase to meet the economic demands of LIBs and the environmental concerns of "Black Mass" (BM). Research focused on using magnetic separation processing to separate the Lithium Metal Oxide (LMO) cathode materials from the BM to determine viability and benefits for downstream hydrometallurgical processes. Magnetic separation was successful in the enrichment of LMOs, with a lithium concentrate forming in the process water that can be recovered separately. Leaching tests showed that the enriched feed was more efficient than the standard direct leach processes using standard processes. Detailed magnetic separation process and chemical/electrochemical processing for efficient lithium ion battery recycling will be discussed.

10:25 AM

Battery Recycling Using Green Reductant Under Microwave

S. Li and W. Zhang; Virginia Tech, Blacksburg, KY

Reducing agent consumption is a significant operating cost in battery recycling. This study explores the use of biomass waste as an eco-friendly reductant for battery recycling. It was found that under microwave irradiation, the reducing capacity of biomass waste was activated, resulting in better leaching performance than hydrogen peroxide under the same conditions. Various characterizations, including SEM, XRD, UV-Vis, FTIR, XPS, and LC-MS, were conducted to uncover the underlying reaction mechanisms.

10:45 AM

Methanesulfonic Acid (MSA), an Alternative Lixiviant to Recovery Critical Minerals (Li, Co, Ni and PGM) From Secondary Metals Resources

H. Jung, J. Lee, H. Kim and J. Ahn; Mineral Resources and Energy Engineering, Jeonbuk National University, Jeonju, Korea (the Republic of)

Nickel (Ni), cobalt (Co), lithium (Li) and PGM (Platinum Group Metals) are ingredients for next generation batteries such as lithium ion batteries (LIB) and fuel cells. The metals need to be recycled from secondary metals resources due to their scarcity and maldistribution. The secondary metals resources can be recycled by hydrometallurgical processes which starts from leaching process. However, conventional lixiviants such as nitric, hydrochloric and sulfuric acid are extremely toxic, corrosive and less environmental lixiviants. In this study, MSA (methanesulfonic acid), an alternative lixiviant, was investigated to recover Li, Co, Ni from spent LIB black mass and iridium (Ir) from PGM scrap. MSA—hydrogen peroxide (H_2O_2) system were investigated with various conditions, and solvent extraction with MSA leachate was followed. In addition, Ir leaching with MSA was also studied. MSA—H_2O_2 achieved >99% Li, Co, Ni leaching using 1.0 M MSA and 1.5 M H_2O_2. Also, Ni and Co extraction of 99% were observed with conventional extractants, Versatic acid 10 and Cyanex 272, respectively. MSA is proven to be compatible to solvent extraction circuit.

11:05 AM

Comparison of Metallic Elements as Reductants in Leaching of Cathode Materials of Spent Lithium-Ion Batteries Using Organic Extractants

K. Kurniawan[1], S. Kim[2] and M. Bae[2]; [1]Resources Recycling, KIGAM campus, University of Science and Technology (UST), Yuseong-gu, Korea (the Republic of) and [2]Korea Institute of Geoscience and Mineral Resources (KIGAM), Resources Utilization Research Division, Daejeon, Korea (the Republic of)

This study proposes an innovative approach for treating the cathode material of spent lithium-ion batteries (LIBs), specifically $LiCoO_2$ (LCO) and nickel-cobalt-manganese oxide (NCM) chemistries. The method involves employing acidic organic extractants (dissolved in kerosene) as lixiviants. The utilization of acidic organic extractants enables process intensification by combining leaching and solvent extraction in a single stage. This study evaluated and compared the possibility of metallic elements (Al, Cu, Fe, Mn, Ni and Zn) as reductants to replace classical H_2O_2. The leaching process was conducted by examining the effects of various parameters, such as the mass ratio of cathode materials to metallic elements, the addition of water, and the type of organic extractants. A suggested leaching mechanism was substantiated through thorough examination, including UV-Vis and FTIR. The obtained results were compared with the classical method of leaching using sulfuric acid, revealing notable differences when the leaching process was carried out using acidic organic extractants.

11:25 AM

25-075

Process Intensification by Resonant Vibratory Mixing for the Recyclable Samarium—Cobalt Magnets After Chemical Leaching with Deep Eutectic Solvents

Z. Nasrullah, F. Agyemang, M. Saddat and R. LaDouceur; Metallurgical and Materials Engineering, Montana Technological University, Butte, MT

To advance the circular economy and renewable technologies, recycling rare earth elements (REEs) from secondary resources is vital. This has led to significant research into effective REE extraction and separation. Historically, Sm-Co recycling involved pyrometallurgy, physical separation, and hydrometallurgy, each with drawbacks in energy, cost, and environment. Although chemical leaching has effectively recovered Sm-Co, it faces issues with slow mass transfer and the use of toxic, non-selective reagents. This study tested a novel method using Deep Eutectic Solvents (DESs) for Sm-Co leaching, which are green, non-toxic, biodegradable, and 82% selective for cobalt over samarium. To improve leaching rates, resonant vibratory mixing (RVM) was employed, enhancing mixing efficiency through resonance. Four DES combinations were tested, including Choline Chloride and Tetra Butyl Ammonium Chloride with Oxalic Acid, Urea, and Ethylene Glycol. Leaching efficiency was measured with and without RVM, using Inductively Coupled Plasma-Optical Emission Spectroscopy (ICP-OES). Future work will compare RVM with conventional mixers and further explore DES properties.

WEDNESDAY, FEBRUARY 26 MORNING

MPD: FLOTATION: SURFACE CHEMISTRY AND CHEMICALS

Room706

9:00 AM • Wednesday, February 26

Chairs: ***V. Srivastava****, Freeport McMoRan, Tucson, AZ*
K. Huang*, Michigan Tech*

9:00 AM

Introduction

9:05 AM

Role of Electrical Double Layer (EDL) Forces on Flotation Kinetics

M. Gupta and R. Yoon; Mining and Minerals Engineering, Virginia Tech, Blacksburg, VA

When an air bubble approaches a mineral surface in water, a thin liquid film (TLF) known as wetting film is formed in between. Its stability is controlled by the pressure in the film, known as disjoining pressure (Π). If P < 0, the film will rupture at a critical film thickness (h_c) to form a solid/vapor interface with a finite contact angle (θ). In the present work, we studied the role of different surface forces, particularly that of the electrical double-layer (EDL) force, using a flotation model derived from first principles (Huang et al., 2022). It has been found that flotation rates can be greatly improved by judicious control of the z-potentials of particles and bubbles.

9:25 AM

25-010

An AFM Imaging Study of the Adsorption of Hydroxamic Collectors on Malachite

J. Zhang and W. Zhang; Mining & Geological Engineering, The University of Arizona, Tucson, AZ

An atomic force microscopy (AFM) image analysis has been applied to study in situ the adsorption of hydroxamic collectors, i.e., octanohydroxamic acid (OHA) and salicylhydroxamic acid (SHA) on malachite in aqueous solutions. AFM images show that hydroxamic collectors adsorb strongly on malachite mainly in the form of insoluble copper hydroxamate complex. Increasing the collectors' concentration and the adsorption time both increase the adsorption of hydroxamic collectors on malachite. Results from the attenuated total reflectance–Fourier transform infrared spectrometry (ATR-FTIR) also show that both these collectors adsorb strongly onto malachite, with strong absorbance spectra being detected, and the ATR-FTIR results confirm those as obtained by AFM. This specific adsorption mechanism explains that a high selectivity with a moderate collectivity will be achieved with a hydroxamic acid collector for the flotation of malachite. The findings of present study also show that AFM image analysis is a powerful tool for the study of the hydroxamic collectors' adsorption on malachite surface and it can help with the development of novel collectors for malachite flotation.

9:45 AM

High MgO in Sulfide Concentrates: Slime Coating or Other Mechanisms?

K. Huang, O. Agbelusi and L. Pan; Chemical Engineering, Michigan Tech, Houghton, MI

One challenge in processing nickel sulfide ores is high MgO content in sulfide concentrate due to the recovery of silicate minerals such as olivine and serpentine. The conventional wisdom was that this problem was attributed to slime coating, i.e., heterocoagulation between ultrafine silicates and sulfides. In this work, we revisited high MgO issue in sulfide concentrate by examining surface properties of silicate minerals using our advanced thin liquid film (TLF) analyzer and flotation studies. Results revealed that TLFs between air bubble and olivine were unstable below pH 9, suggesting that olivine recovery may be due to its own natural floatability.

10:05 AM

25-006

Advancements in Frother Optimization for Enhanced PGM and Sulphide Ore Recovery

N. Shackleton; Metallurgy, AECI Mining Chemicals, Sasolburg, Free state, South Africa

Frothers play a crucial role in sulphide and PGM ore flotation recovery, and studies on PGM ores have shown significant kinetic increases with the optimal frother-collector combinations. Using Sasfroth 200 as the industry baseline, remarkable kinetic increases were observed in the first concentrate. Even in the worst-case scenarios, 4E PGM recovery increased by 5% at a slightly higher concentrate grade. It is important not to limit frother dosage to a fixed value. Instead, enough frother should be added to maintain a stable bench float, measuring the dosages by frother volume before and after tests. Frothers can be specialized blends and should not be underestimated. The results produced by formulating and innovating frothers to address specific industry challenges have been encouraging. Testing a frother on plant scale does not have to be as daunting as with collectors, enabling the identification of the best frother-collector combinations at an industrial scale. AECI Mining Chemicals bench scale test work has motivated plant-scale trials that have successfully transitioned to commercialization and it is believed that this is a better way to screen frothers for the industry.

10:25 AM

Flotation of Pyrrhotite from Mine Tailings

K. Huang, R. Oboh, K. Seagers and L. Pan; Chemical Engineering, Michigan Tech, Houghton, MI

Pyrrhotite, iron sulfide minerals, is commonly rejected to flotation tailings due to its low-nickel and high-iron contents. These sulfide-rich mine tailings have to be stored under water to prevent acid mine drainage. In this work, we investigated flotation method to desulfurize pyrrhotite-rich mine tailings from Eagle Mine. Tailing samples were subjected to mineralogical characterizations as well as laboratory flotation tests. Minerology study showed that pyrrhotite particles were fully liberated, while the challenges for pyrrhotite flotation were slow flotation kinetics and poor selectivity. New flotation chemistries have been developed to address these challenges. After flotation, <0.8 %sulfur non-sulfide gangue was obtained.

10:45 AM

25-040

Optimising Grinding Chemistry for Improved Base Metal Sulphide Flotation

C. Greet; Magotteaux Australia, WINGFIELD, SA, Australia

Grinding with an electrochemically inert grinding media shifts the pulp potentials to more oxidising conditions, increases the dissolved oxygen content and reduces the EDTA extractable iron concentration when compared with milling with electrochemically active grinding media. These changes in pulp chemistry produce cleaner particle surfaces, reduce reagent consumption and increase concentrate grades and recoveries. This paper presents a robust laboratory test programs that is able to not only demonstrates these effects but also provide an indication of the magnitude of the improvements that are possible. While laboratory studies are interesting, the proof is in the pudding! So, the paper provides an overview of plant trials conducted at a number of other operations around the world, including: Evolution's Northparkes operations and Perilya's Broken Hill Mine. These successful plant trials clearly demonstrate that selection of the right grinding media alloy will yield savings in grinding media consumption, reagent consumption as well as increases in revenue through improved recoveries.

11:05 AM

Moly Flotation: A Case Study—NaHS or Na_2S?

S. Merrill and N. Kadappan; FLSmidth Inc, Riverton, UT

NaHS is a common reagent used in the separation process to float Molybdenite away from Copper minerals. Nevertheless, the use of Na_2S and steam is also still practiced in some float plants as an alternative to NaHS. This presentation will discuss the differences in each process and review results from testing that was performed to evaluate the use of each method. Test results include both rougher and cleaner flotation from bench scale tests done on fresh bulk Cu/Mo concentrate.

11:25 AM

25-053

Iron Ore Flotation with Biosurfactant: an ESG-Friendly Option to Boost Performance

R. Rodrigues Silva, C. Monyake, R. Mendonca and G. Knesel; Locus Mining Solution, The Woodlands, TX

Locus Mining is working side-by-side with a prestigious iron ore company to evaluate the addition of Locus ESG-friendly green flotation reagents with the primary goal of improving recovery and grade. In this paper, we will focus on the cationic reverse flotation application. The most "established industry" reagents for cationic reverse flotation are amine as the collector, starch as the depressant, and some cases frothers. Here, we evaluate the synergies of different classes of eco-friendly biosurfactants and industry-standard reagents during the cationic reverse flotation method. Exploratory research was done first with an analog sample under different pHs, 8 different biosurfactants with starch and no-starch, and a customized DOE was used to perform 145 microflotation tests. The results show Separation Efficiency from 20% (baseline) to 50% (biosurfactant), and Selectivity from 3.27 (baseline) to 5.67 (biosurfactant). Optimized result conditions were then applied to the iron ore samples received from our client to perform flotation tests on a Denver Lab cell. Similar results were obtained improving Separation Efficiency and Selectivity, which corroborate with the previous work.

11:45 AM

Chemisorption of Thio Ligands on Cu, Ag and Au via Lewis Acid-Base Interactions

N. Bellusci[1], D. Nagaraj[1], R. Farinato[1], B. Vaziri[1] and M. Lancaster[2]; [1]Earth and Environmental Engineering Department, Columbia University, Stamford, CT and [2]Syensqo Technology Solutions, Stamford, CT

For nearly all ligands used as collectors in sulfide ore flotation, the soft S donors are key in selective and efficient binding to a given mineral/metal surface. Much of the academic literature is focused on xanthate-sulfide systems, wherein the most widely proposed adsorption mechanism involves coupled oxidation of the collector and reduction of oxygen at the interface. However, the validity of these notions become questionable for several reasons. These include the significant surface heterogeneity of real ore particles, the small collector concentration used in practical systems, the narrow potential window of natural ore pulps, and the use of many other S-ligands that are non-oxidizable under flotation-relevant conditions. In this paper, we provide insights on the interactions of several classical and industrially relevant S-ligands with Cu, Ag, and Au. We demonstrate that these molecules simply passivate the surface without electron transfer (out of the surface complex) in potential ranges relevant to flotation. Instead, it is a redistribution of electron density upon overlap of the frontier donor-acceptor orbitals, which exemplifies Lewis acid-base concepts.

WEDNESDAY, FEBRUARY 26 **MORNING**

MPD: PHYSICAL SEPARATION: PHYSICAL SEPARATIONS I

Room 708

9:00 AM • Wednesday, February 26

Chairs: ***R. Gujardo***
J. McDonald*, Weir, Menasha, WI*

9:00 AM

Introduction

9:05 AM

Introduction to Ore Sorting Technology

B. Hilscher; ABH Engineering, Vancouver, BC, Canada

As the technology of sorting advances with artificial intelligence and multi sensor sorting options, it is sometimes worth going back to basics and explaining the first principals of the current ore sorting technologies. What they do, how they do it, and the array of benefits derived from being able to separate ore from waste while rocks are large. This presentation covers everything you need to know to understand the basics of ore sorting.

9:25 AM

25-043

The Development of Magnets Provides Process Improvements in Magnetite Processing

G. Mandarakas; SME, Cologne, Germany

Published information indicates that the mining industry consumes approximately 12 EJ per year—or 3.5% of total global final energy consumption globally [2] or 3.33 trillion kilowatt hrs. This energy consumption is significant, considering the critical role mining plays in extracting and processing essential minerals for economic development and human progress. The perception of the mining industry is that not only does it consume significant power, but it also consumes a lot of the freshwater in the world. In fact, it consumes approximately 5% [3] of the total freshwater demand. According to the Intergovernmental Panel on Climate Change (IPCC), by 2050, 60% of the world's population will be living in countries that are classed as water-stressed [3]. As part of this review, recent advancements in magnets have enabled magnetite processing facilities to achieve between 30 to 40% dry gangue material rejection before the wet beneficiation process (grinding and sorting). This reduction in energy consumption allows the reduction of energy consumption. Secondly, there is less material ground in the mills, which requires less water for mineral downstream processing.

9:45 AM

High-Pressure Slurry Ablation—Advances in Selective Mineral Liberation to Enhance Mineral Processing Efficiency

B. Berg, A. Halverson and J. Dick; Disa Technologies. Inc, Casper, WY

High-Pressure Slurry Ablation (HPSA) focuses on the selective liberation of target metals/minerals leveraging particle-particle collisions. Disa has performed multiple lab campaigns that show promise for moving into larger pilot testing programs. Disa has successfully installed continuous operation units from 3—10tph in graphite and phosphate. Results have demonstrated increases to overall recoveries and other simplifications to the processing circuits that justify increasing to higher throughput units. A 50 tph unit will be installed and operated continuously in 2024. With the 50 tph unit in operation, design will be completed for units that can process up to 250 tph.

10:05 AM

Improvement in the Recovery of Fe Value From Slimes Using an Improved Design of Cavex® 2 Hydrocyclone—A Case Study

C. Banerjee[1], P. Dixit[2], V. Shankar[2], N. CHM[1], T. R[1], S. Hunter[1], A. Mukherjee[2] and D. Switzer[1]; [1]Weir Minerals, Cody, WY and [2]Tata Steel, Jamshedpur, Jharkhand, India

The demand for iron ore has surged due to the growth of the iron and steel industry. Presently, declining grades of iron ore pose a challenge. To maximize the recovery of Fe value from the ore, innovative solutions are needed to extract additional iron content from slimes disposed to the tailings. Iron ore slimes are fine-grained waste by-products generated during the iron ore beneficiation process, and typically consist of iron, alumina, and silica with variations in size and density. In this study, we highlight the advantages of the Cavex® 2 (CVD) hydrocyclone for recovery of the Fe value from slimes and reduction of Al2O3 % in the concentrate. A trial in the desliming circuit at an iron ore beneficiation plant in the Khondbond region of India, showed an improved plant yield of 8% with CVD 400 hydrocyclones compared to 5.5% yield with conventional Cavex® (CVX) hydrocyclone. Furthermore, Cavex® 2 achieved a finer cut, improving mass recovery of iron ore slimes while keeping Al2O3 % within acceptable limits in the concentrate. Key words: Cavex® 2 hydrocyclone, classification, iron ore, slimes

10:25 AM

Pneumatic Pressure as Primary Dewater Force in Pressure Filtration

C. Lutheran; Mining - Filtration, FLSmidth, Midvale, UT

Almost all pressure filtration applications use an air blow step to achieve the desired filter cake final moisture. However, most industrial scale equipment relies on means other than pneumatic force for cake formation/consolidation (pumping into a fixed chamber, membranes, etc). This technical session will present using pneumatic force as the main dewatering driver for pressure filtration. The process is very similar to the laboratory scale units that can be found in almost any mining laboratory, but industrial scale implementation is not prolific. Technical session will discuss the fundamentals of operation, advantages and potential pitfalls of this technology, and existing and future applications.

10:45 AM

Game-Changing Technology for Large Scale Filtered Tailings

O. Whatnall and S. Caldwell; Jord International, Denver, CO

Introducing vibration energy to tailings often induces liquefaction (release of water) and/or a thixotropic response (shear thinning). Performing filtration simultaneously delivers game-changing filtration performance. This is the basis of Viper, the vibration enhanced vacuum belt filtration technology which continuously produces filtered tailings with desirable moisture content at high production rates. This paper introduces the technology and shares case study data from various projects around the world, including pilot plant and industrial equipment—answering the question "how much difference can vibration make?" The conclusion contemplates the resultant filtration plant, explaining how Viper unlocks a step change reduction in cost and complexity as well as delivering operational and maintenance advantages relative to competing technologies. It is for these reasons that Viper is enjoying interest, investigation and implementation from a number of the world's leading mining and minerals organizations.

11:05 AM

The Use of Preconcentration in Industrial Mineral Beneficiation

E. Wingate[1], H. Cline[2] and J. Bergmann[3]; [1]Critical Minerals & Operational Excellence CoE, Bechtel Mining & Metals, Fortitude Valley, QLD, Australia; [2]Area Sales Manager Mining, Tomra, Lakewood, CO and [3]Segment Manager Industrial Minerals, TOMRA Sorting GmbH, Wedel, Germany

The processing of sedimentary phosphate and spodumene ores over the last decade has seen innovation in the area of ore preconcentration. This presentation will consider ore preconcentrating with respect to the advancements that ore sorting has led to in the design of processing facilities. The use of preconcentration to preferentially remove waste and low grade ore from the run of mine ore has led to a reduction in downstream dry and wet processing plant capacities and footprints. The technology is based around the use of Near Infra Red, laser, XRF, electromagnetic, colour and x-ray tomography technology. Ore sorting is used to differentiate between the target ores and the gangue materials usually associated with ores such as silica, magnesium and iron oxides. The downstream processing water requirements can be reduced due to reductions in the amount of material being processed along with a reduction in process tailings volumes that have to be contained in engineered impoundments. From a sustaining capital perspective, reducing downstream crushing and grinding costs by the early removal of silica/chert has been seen to lead to a reduction in the impact of silica based abrasion.

11:25 AM

Utilizing Cyclowash™ Technology to Reduce Fines Reporting to Hydrocyclone Underflow

M. Wright; FLSmidth, Brisbane, QLD, Australia

Cyclowash™ is an elution device exclusive to FLS KREBS® Hydrocyclones. It utilizes the injection of an elutriation liquor to induce a second stage of classification slightly above the theoretical plane intersecting the cyclone axis below which all solid and liquid particles will report to the hydrocyclone underflow despite any possible interference. The gain from this second stage separation is the displacement of entrained -#400 mesh particles from the liquid reporting to the underflow causing the classifying phenomenon of short circuiting. Previous test work using gMAX6 hydrocyclone with Cyclowash™ resulted in an average reduction from ~14.6% -#400 mesh recovery to the underflow to ~9.1% without major sacrifice of the underflow density. This major recovery of -#400 mesh cannot only make substantial differences to the sustainability of a mine's tailings dam but could potentially positively affect a grinding circuit through the reduction of recirculating fines. Pending ongoing research, the recirculating fines reduction induced by Cyclowash™ on hydrocyclones classifying mill discharge may possibly increase the overall circuit capacity, consequently increasing throughput as well.

11:45 AM

Magnetic Separation of Gold from Roaster Tailings

D. Steiner; Metallurgy, Nevada Gold Mines, Elko, NV

Nevada Gold Mines operates a double refractory gold ore roaster at their Gold Quarry mine. Recently, a legacy Magnetic Separation circuit was restored to operation after several years offline. This presentation discusses how maghemite (a gold bearing iron oxide) is formed when arsenian pyrite is roasted, the mineralogical test work supporting the recommission of the circuit, as well as plant design, the underlying science of magnetic separation, and recommission successes and challenges such as filtering the magnetic concentrate without the use of a thickener.

WEDNESDAY, FEBRUARY 26 MORNING

MPD: PLANT DESIGN: PLANT DESIGN I

Room 707

9:00 AM • Wednesday, February 26

Chairs: ***J. Trouba****, Colorado School of Mines, Lakewood, CO*
E. Wingate*, Bechtel Mining & Metals, Fortitude Valley, QLD, Australia*

9:00 AM

Introduction

9:05 AM

Using your Sulphuric Acid Plant as an Onsite Power Producer

J. Kelly; Atkins Realis, Etobicoke, ON, Canada

Global sulphuric acid production is about 260M tpa, a very large commodity market. Sulphuric acid plants (SAPs) are a common part of non-ferrous smelting operations, and also of mineral processing operations when sulphuric acid is required as a reagent. Production of sulphuric acid is a highly exothermic process. Superheated steam can run a Steam Turbo-Generator to supply site power, or to export power for use elsewhere. Low pressure steam can be extracted for site use. All this is well-known; what is perhaps less well-known is how much power can be generated. An example is presented of a recent project which can generate >95% (up to 44 MW) of the whole process plant site electric power, from the onsite SAP / STG. The SAP and STG use only a small part of this power, the bulk of it powers the rest of the site. Some details of the SAP and STG design are presented including how the power production is maximized.

9:25 AM

Cariboo Gold Project—Processing Optimization

B. Ott; Tintic Consolidated Metals Division, Osisko Development, Eureka, UT

Osisko Development is a North American gold development company focused on past-producing ming camps located in mining friendly jurisdictions with district scale potential. Osisko is committed to responsible mining practices with a vision of building modern, safe, socially and environmentally sustainable mining operations that support generations to come in the surrounding communities. Osisko's 100%-owned Cariboo Gold Project located in the historic Cariboo Mining District of central British Columbia is the primary focus for near-term development with engineering and pre-construction work in progress. Ongoing optimizations to the feasibility study especially focused on the mine plan and improved processing plant concepts, are expected to yield positive results while adhering to existing environmental, social, and permitting constraints.

9:45 AM

Improving Concentrator Throughput by Primary Crusher Debottlenecking

C. Churchman; Freeport-McMoRan Inc, Apache Junction, AZ

Freeport McMoran Cerro Verde CV2 Concentrator is primary crusher limited. This presentation will discuss the reliability centered approach to increase concentrator throughput by increasing machine reliability and throughput. Crusher concave / mantle design, operating parameters including OSS and stroke as well as lubrication will be discussed.

10:05 AM

Seamless Integration of Direct Flotation Reactor (DFR) Technology: From Pilot to Full-scale Operations at Barrick's Jabal Sayid Copper Concentrator

T. Banerjee and E. Kulbak; Sales, Woodgrove Technologies Inc., Toronto, ON, Canada

The adoption of innovative technologies in mineral processing often raises concerns about complexity and integration. However, Woodgrove's Direct Flotation Reactor (DFR) technology at Barrick's Jabal Sayid copper concentrator provides a different perspective. This paper outlines the smooth integration of DFR technology from piloting to full-scale commissioning, showcasing how easily the cells were brought online. Installed in a cleaner scalper role, DFR cells at Jabal Sayid upgrade re-ground rougher concentrate to final concentrate in one stage. Despite processing challenging ore, the DFR cells delivered concentrate grades that consistently exceeded expectations. The commissioning process was straightforward with minimal hurdles, highlighting the technology's user-friendly nature. This paper advocates for a shift in perceptions about new technologies in mineral processing. The success of DFR technology at Jabal Sayid demonstrates that "different" doesn't mean "difficult." By

focusing on ease of commissioning and operational integration, innovative solutions can enhance processes, improving efficiency and productivity in the mining industry.

10:25 AM

Reduce the Risk of Freezing Paste Lines

T. Brueggeman; Hecla Mining, Coeur d'Alene, ID

Most paste plants utilizing mine tails run around the clock to keep paste fluid and flowing in the pipe. So, what do you for a disconnected plant that starts and stops with shift change? You can deal with 5k-10k gallons of water and non-affective paste times at the beginning and end of every shift. Or, you can find a new process to mitigate the risk, improve efficiencies, and even find benefits that you didn't know were on the table. This case study at the Hecla Greens Creek mine in SE Alaska demonstrates the benefit of a low cost product with high cost savings.

10:45 AM

Modernization of Molybdenum Flotation: A Case Study with Rio Tinto Kennecott Copper

T. Banerjee and E. Kulbak; Sales, Woodgrove Technologies Inc., Toronto, ON, Canada

Optimizing mineral processing circuits is crucial for enhancing efficiency and profitability. This paper presents a case study on the collaboration between Rio Tinto Kennecott Copper (RTKC) and Woodgrove Technologies to improve the Molybdenum plant at the Kennecott facility in Salt Lake City, Utah. Success was achieved through a comprehensive approach, including extensive pilot plant testing and advanced modeling. Woodgrove conducted about 100 pilot tests to understand the Molybdenum flotation circuit's performance. These tests provided critical insights for the project. Advanced modeling demonstrated the benefits of replacing legacy flotation equipment with Woodgrove's Direct Flotation Reactors (DFRs), which improve efficiency, product quality, and reduce costs. This modeling helped RTKC justify retrofitting existing flotation cells with DFRs. The case study underscores the importance of data-driven decision-making in modernizing mineral processing. By utilizing pilot testing and modeling, Woodgrove and RTKC optimized the Molybdenum flotation circuit, achieving greater efficiency and operational excellence.

WEDNESDAY, FEBRUARY 26 MORNING

TAILINGS: RECLAMATION, CLOSURE AND POST-CLOSURE PRACTICES OF TAILINGS AND MINE WASTE

Sponsored by: Newmont

Room 607

9:00 AM • Wednesday, February 26

Chairs: ***T. Walkenbach****, WSP USA Inc.*
L. Gonzales*, Arcadis, Mesa, AZ*

9:00 AM

Introduction

9:05 AM

Geopolymerization of Mine Tailings: Transforming Waste into Sustainable Resources

K. Mudzanani[1], V. Masindi[2], D. Maiga[1] and T. Phadi[1]; [1]Measurements and Control, Mintek, Randburg, Gauteng, South Africa and [2]Research and Development, Magalies Water, Rustenburg, Gauteng, South Africa

Mine tailings, the residual solids, rocks, and wastewater left after extracting valuable minerals, present significant environmental, health and economic challenges. Aligning with the GISTM, which aims for zero harm, innovative solutions are essential. Geopolymers, synthesized by reacting silica and alumina-rich tailings with an alkaline activator, offer a promising eco-friendly approach. This study repurposes mine tailings into geopolymers, assessing economic feasibility and market potential. Tailings were characterized using XRD, FTIR and SEM. Blended with an alkaline activator and additives, the mixture was molded, cast, and cured under controlled conditions, 40-90°C. Results showed -COOH and -OH functional groups that are effective for adsorbing heavy metals and pollutants. XRD and SEM analyses confirmed favourable crystalline phases and surface morphology. Geopolymers achieved a 92% reduction in Fe^{2+} concentration from 2500 to 200 ppm, indicating substantial potential for wastewater treatment. Conclusively, mine tailings can be converted into sustainable geopolymers, reducing environmental impact, enhancing durability, and being cost-effective compared to traditional concrete.

9:25 AM

Climate Change Effects at Mazapil Catchment and Impacts Over the Newmont Peñasquito TSF During Closure and Post-closure

E. Garcia and M. Sosa; Newmont, Mazapil, Zacatecas, Mexico

Peñasquito mine is located in the Mazapil valley, a 168 km2 catchment in northern Zacatecas, México. This open pit operation generates 250,000 ton of tailings that are disposed at the Tailings Storage Facility (TSF) which operates since 2015. Closure plans for this TSF are under design and analysis since 2018, actions include generation of large scale data about available closure materials for cover, climate data, hydraulic assessments, groundwater quality, water flows rates and monitoring and consolidation. Climate change variables are being considered according to Global Industry Standard on Tailings Management (GISTM), Newmont corporate guidance and recommendations of external revisors. The projection of long term climate effects are compared with quaternary patterns onsite, characteristics of surface runoff, vegetation and landscape. All the latter supports the forecast of effects that necessarily will be magnified according to climate change trend. This paper presents the focus and strategies that are being followed at Peñasquito, in order to generate credible mid and long term scenarios for climate change effects which will support closure and post closure projects.

9:45 AM

Hyperspectral Sensing for Oil Sands and Hard Rock Tailings Characterization

J. Bindner, I. Entezari and D. McGowan; ConeTec Investigations Ltd., Vancouver, BC, Canada

Hyperspectral sensing has shown strong promise for the characterization of tailings properties and providing recent advancements in optical sensing technologies, including reduced sensor size and cost, hyperspectral sensors can now feasibly be adapted for use in direct push methods, including the CPT. Given the industry-advancing potential of this technology, a hyperspectral module was designed to be included as part of a CPT probe and is currently under development. This preliminary study explores the use of hyperspectral data collected ex situ on oil sands and hard rock tailings for the characterization of tailings properties including moisture content, solids content, and fines content using hyperspectral data with a spectral range similar to the hyperspectral module under development. Machine learning models were developed to predict tailings properties using hyperspectral data and the models were evaluated using separate testing data. Results highlight the potential of hyperspectral sensing for improving tailings characterization.

10:05 AM

Enhancing Mine Closure Projects Through Proactive Risk Management

D. Kijewski; Mine Economics and Risk, Stantec, Surprise, AZ

Mine closure project success can improve from early risk-informed closure planning. This investment can transform an end-of-life project obligation into a residual value-adding asset. Several key points and industry sentiments about risk management on closure projects will be discussed, including: - How risk workshops are often viewed as burdensome, and their

completion "checks a box." - An overview of risk application methodologies, their characteristics, and when to apply each depending on resources and company goals. - Ways that risk-informed closure strategies can increase mining support locally and globally. - Case study of closure assessments on tailings and heap leach facilities.

10:25 AM

Liquefaction Prediction Using Ensemble Machine Learning Methods

P. Ayawah[1], W. Nyaaba[2] and A. Kaba[3]; [1]Mining, Metal & Minerals, Stantec, Broomfield, CO; [2]University of Illinois, Chicago, IL and [3]Los Alamos National Lab, Los Alamos, NM

The impact of liquefaction on tailings storage facilities (TSFs) and the need for its precise prediction cannot be overemphasized. While traditional physics-based liquefaction prediction models offer valuable insights into soil behavior, they often face challenges in capturing the full complexity under dynamic loading conditions. Conversely, data-driven machine learning (ML) techniques excel in pattern recognition though they may lack physical interpretability. This paper proposes an ensemble ML model to improve liquefaction prediction accuracy by integrating diverse data sources and leveraging the strengths of multiple ML methods. The proposed ensemble model will harness the predictive capabilities of four different ML methods—Support Vector Machine, Gradient Boosting Machine, Random Forest, and Artificial Neural Network. A dataset including earthquake data, cone penetration test data from New Zealand will be used to develop the proposed ensemble ML model. The developed model can be applied for liquefaction assessment of TSFs with higher prediction accuracy than the existing empirical methods. This can lead to the implementation effective liquefaction mitigation practices.

10:45 AM

25-016

Assessment of Long-Term Physical Stability of Remediated Mining Structures in Hualgayoc, Cajamarca, Peru: A Success Story of the Center for Mining Environmental Research and Studies (CIEMAN)

M. Portal Valdivia, H. LOZANO, F. Segobia Campos, L. Goicochea Sánchez and F. YSLA QUIROZ; Mining engineering, Society for Mining, Metallurgy & Exploration, Cajamarca, Cajamarca, Peru

This case study evaluates the long-term physical stability of various historical mining structures remediated by the Center for Mining Environmental Research and Studies (CIEMAN) in Hualgayoc, Cajamarca, Peru. The region has a long history of mining activity, with remnants dating back to pre-Inca times. CIEMAN has assumed responsibility for remediating 286 environmental liabilities in the area, including adits, shafts, pits, tailings dams, and waste rock dumps. The study analyzes the methods employed to stabilize these structures, including geotechnical engineering techniques and revegetation. Long-term monitoring results are presented, assessing the effectiveness of remediation measures and predicting the future stability of the structures. This study highlights the importance of responsible remediation of mining environmental liabilities to ensure the safety and sustainability of communities and ecosystems affected by historical mining.

11:05 AM

25-037

Geochemical Characterization to Support Groundwater Remedy Selection at a Former Uranium Mill Site

K. Belli[1], C. Bokman[1], J. Nyman[1], E. Moran[2] and K. Pill[3]; [1]Remediation, Geosyntec Consultants, Oakland, CA; [2]Office of Environmental Management, Department of Energy, Moab, UT and [3]North Wind Portage, Moab, UT

Removal of the tailings impoundment at the United States Department of Energy Moab site is expected to be completed around 2029, at which time it is anticipated that a final remedy to address uranium and ammonium in site groundwater will be determined. The site is considered complex due to multiple source areas, vertically stratified groundwater due to brine formation at depth, discharge to the Colorado River, endangered species habitats in river backchannels, and ongoing implementation of multiple interim measures to achieve protection of human health and environment. Geosyntec will discuss recent column and batch testing results that will be used to support remedy selection.

WEDNESDAY, FEBRUARY 26 MORNING

THE HIGH PERFORMANCE MINE OF THE FUTURE

Room 110

9:00 AM • Wednesday, February 26

*Chair: **H. Ednie**, Global Mining Guidelines Group*

9:00 AM

Introduction

9:05 AM

The High Performance Mine of the Future

L. Walker[1], A. Scott[2], Z. Lukacs[5], M. O'Brien[3] and H. Ednie[4]; [1]Freeport-McMoRan, Morenci, AZ; [2]BHP, Dayboro, QLD, Australia; [3]CITIC Pacific Mining, Parker, CO; [4]GMG, Montreal, QC, Canada and [5]Advisor, Calgary, AB, Canada

Explore the multifaceted landscape of modern mining in this comprehensive session designed to construct the high-performance mine of the future. With a focus on pushing boundaries and revolutionizing mining practices, this session delves into emerging best practices, innovative strategies, and key considerations to enhance mine efficiency, safety, and sustainability while rethinking what's possible for the industry. Session Highlights Include: Foundation for Success: Collaboration and Open Innovation: Enhancing Safety and Managing Risk Autonomous Mining Electrification and Future Roadmaps Sustainability in Action AI and Data Applications This session aligns closely with the Global Mining Guidelines Group's (GMG) mission to foster innovation, collaboration, and sustainability within the mining industry. By attending, you'll not only gain insights into how these strategic areas connect to GMG's broader goals but also explore the bold steps required to revolutionize mining for the future. Together, we will weave these critical elements into a holistic vision, offering a roadmap to create high-performance mines that rise to the challenges of tomorrow and seize its opportunities. Let's reimagine the future of mining—one innovation at a time. Presenters include: Lia Walker, Manager of Innovation and Senior Quality Leader, Freeport-McMoRan Driving Step Change in Mining: Establishing the Foundations for Innovation Andrew Scott, Lead Principal, Think and Act Differently, BHP Roadmap to Zero Entry: Enabling the Future of Mining Zoli Lukacs, Advisor, Asset Management and Operational Readiness You can't improve what you can't measure: operational management, OEE and benchmarking Mike Mayhew, Founder, Mayhew Performance (MPL) Are you ready? Planning and implementation of an electrified fleet Mark O'Brien, General Manager, Digital Technology and Innovation, CITIC Pacific Mining and Chair, GMG Building the Mine of the Future: Strategies for Global Collaboration and Innovation Panel Discussion: Mining Reinvented: from urgency to action

WEDNESDAY, FEBRUARY 26 AFTERNOON

COAL & ENERGY: INNOVATIONS IN DUST CONTROL AND RESEARCH II

Room 702

2:00 PM • Wednesday, February 26

*Chairs: **F. Animah**, Virginia Polytechnic Institute and State University, Blacksburg, VA*
***A. Greth**, Virginia Polytechnic Institute and State University, Blacksburg, VA*

2:00 PM

Introductions

2:05 PM

25-020

CFD study of the Impact of Powered Air Purifying Respirators (PAPR) in Underground Mining Operations

L. Sanchez Gonzalez, A. Kumar and B. Arnold; Energy and Mineral Engineering, The Pennsylvania State University, State College, PA

Mining operations adopt a variety of remedial measures to combat dust underground. Powered Air-Purifying Respirators (PAPRs), used commonly in medical and other sectors, are not prevalent in the mining industry. PAPRs use P100 filters that have 99.97% dust capture efficiency. We present our results from computational fluid dynamics (CFD) simulations performed to understand the impact of a PAPR on airflow and dust particle concentration in the vicinity of a miner. These results show that donning a PAPR can lower the exposure of the miners to respirable coal dust.

2:25 PM

Exploration of Flooded Bed Scrubber Respirable Dust Removal Efficiency as a Function of Particle Type and Size

F. Animah[1], H. Jiang[2], Y. Zheng[2], S. Klima[2], A. Bugarski[2], T. Beck[2], S. Schafrik[3] and E. Sarver[1]; [1]Mining and Minerals Engineering, Virginia Polytechnic Institute and State University, Blacksburg, VA; [2]PMRD/HHPB, NIOSH, Pittsburg, PA and [3]Mining Engineering, University of Kentucky, Lexington, KY

Flooded-bed scrubbers (FBSs) have been used over the past few decades in underground coal mines to mitigate exposure to respirable coal mine dust (RCMD). Previous studies have evaluated the performance of FBSs to reduce RCMD mass concentrations but there has been little investigation regarding the effects on specific RCMD constituents and particle sizes which may have important health implications. To begin filling this knowledge gap, a series of tests were recently conducted at NIOSH's dust gallery facility in Pittsburgh, PA, using a newly built experimental apparatus. The apparatus enables sampling up and downstream of a full-sized FBS under controlled conditions. For these tests, key variables included FBS filter type (i.e., conventional 30-layer screen versus novel impingement filter) and dust material (i.e., coal versus rock-strata), and scrubber efficiencies were determined on the basis of particle counts across size bins between 0.1-10 μm.

2:45 PM

Can Optical Microscopy be Used to Classify Respirable Coal Mine Dust?

N. Santa and E. Sarver; Mining and Minerals Engineering, Virginia Tech, Blacksburg, VA

High prevalence of lung diseases among US coal miners has spurred new research on innovative respirable dust monitoring methods. Previous laboratory experiments have indicated that Optical Light Microscopy (OLM) combined with advanced image processing could enable classification of respirable coal mine dust particles–perhaps in real-time. The current study extends that work into the field, using dust samples collected from active production and roof bolting areas in an underground coal mine. The samples were imaged by OLM and then a classification algorithm was applied to identify and count dust particles in three classes: silicates, carbonates, and coal. To evaluate the accuracy of the results, the samples were also analyzed by scanning electron microscopy with energy dispersive X-ray.

3:05 PM

Study on the Interaction between Respirable Coal Mine Dust and Water Droplets by Computational Fluid Dynamics (CFD)

S. Han[1], M. Rezaee[1] and P. Roghanchi[2]; [1]Energy and Mineral Engineering, The Pennsylvania State University, University Park, PA and [2]Mining Engineering, University of Kentucky, Lexington, KY

In practice, the capture efficiency of Respirable Coal Mine Dust (RCMD) by water spray system is relatively low. To understand the capturing mechanism and develop enhancement strategies, this research studies the interaction of water droplets with RCMD by computational fluid dynamics (CFD). The effects of physicochemical properties of water droplets and RCMD, including contact angle, surface tension and viscosity, on critical velocity were investigated. Regime maps of critical velocity vs. physicochemical properties were created and the corresponding attachment efficiencies were calculated. Accordingly, strategies for enhancing the capture efficiency were developed by modifying the physicochemical properties of water droplets.

3:25 PM

Evaluation of PVC and PTFE Filters for Direct-on-filter Crystalline Silica Quantification by FTIR

B. Osho[1], M. Elahifard[2], X. Wang[2], B. Abbasi[1], J. Chow[2], J. Watson[2], W. Arnott[3], W. Reed[5] and D. Parks[4]; [1]Mining and Metallurgical Engineering, University of Nevada, Reno, Reno, NV; [2]Desert Research Institute, Reno Nevada USA, Reno, NV; [3]Atmospheric Sciences, University of Nevada, Reno, Reno, NV; [4]Spokane Mining Research Division, National Institute for Occupational Safety and Health, Spokane, Washington, Spokane, WA and [5]Office of the Director, National Institute for Occupational Safety and Health, Pittsburgh, Pennsylvania, Pittsburgh, PA

Fourier Transform Infrared (FTIR) spectroscopy via a Direct-on-Filter (DoF) analysis is a useful tool for determining the exposure risks of respirable crystalline silica (RCS), providing faster measurements than standard methods. However, its limit of detection (LOD) needs to be evaluated against the regulatory RCS limits. This study evaluated the uncertainty in RCS quantification arising from background effects when using polyvinyl chloride (PVC) and polytetrafluoroethylene (PTFE) filters. When unexposed filters were used as the spectral reference, the RCS LODs were 5.9 and 1.2 $\mu g/m^3$ for PVC and PTFE filters, respectively, representing day-to-day variability of blank filter FTIR reference spectra. When a designated laboratory blank was used as the reference, both filter types showed higher RCS LODs of 7.4 and 12 $\mu g/m^3$ for PVC and PTFE filters, respectively, attributed to filter-to-filter variability. For PVC filters, filter mass variation was the source of filter-to-filter variability, where the absorption increased linearly with filter mass, providing a means to correct the absorption differences between the unexposed and reference filters, thereby reducing LODs.

WEDNESDAY, FEBRUARY 26 AFTERNOON

COAL & ENERGY: LOW CARBON ENERGY RESOURCES

Room 107

2:00 PM • Wednesday, February 26

*Chair: **R. Pandey**, Virginia Tech, Blacksburg, VA*

2:00 PM

Introductions

2:05 PM

From Geothermal Brine to Lithium: Emerging Technologies and Solutions

M. Chowdhury[1] and D. Talan[2]; [1]Department of Geosciences, Graduate Student, Starkville, MS and [2]Department of Mining Engineering, Assistant Professor, Morgantown, WV

By 2030, the global demand for lithium-ion batteries is projected to reach approximately two million metric tons, highlighting the increasing need for lithium. Geothermal brine, a naturally occurring metal-rich hot water from underground geothermal reservoirs, has emerged as a promising and environmentally friendly source of lithium to meet this growing demand. This study reviews the global landscape of lithium in various

geothermal brine compositions and evaluates the latest advancements in extraction methods. Direct Lithium Extraction (DLE) technology, which is significantly faster than the conventional brine evaporation process, offers a potential solution by eliminating the need for brine evaporation ponds and presenting lower environmental risks and considerable ecological benefits. This study summarizes and evaluates the advantages and challenges of implementing DLE technology, focusing on its scalability and economic feasibility from a green mining perspective. It compares DLE technology with conventional brine evaporation processes to assess its potential as a sustainable and game-changing technology. Keywords: Lithium, geothermal brine, DLE extraction technologies.

2:25 PM

Evolution of In-situ Caprock Permeability During Underground Hydrogen Storage

R. Pandey; Virginia Tech, Blacksburg, VA

Efficient underground hydrogen storage (UHS) in depleted reservoirs depends on the overlying caprock integrity. Recent studies on crushed Marcellus shale, a potential caprock, have indicated that cyclic injection and depletion of pressurized hydrogen leads to the formation of micro-fractures in the shale matrix. This results in increased matrix porosity and permeability of the shales, leading to increased diffusive loss through the caprock. Building on the initial results, here the core-scale permeability changes in Marcellus shale under cyclic hydrogen exposure was investigated, which is more representative of in-situ conditions. Permeability was measured using a pulse decay permeameter under varying confining and pore pressures. Results showed only a minor change in absolute permeability values, but the Klinkenberg slip factor, governing slip flow in shale, increased with cyclic hydrogen exposure, suggesting enhanced hydrogen loss via slip flow through the caprock over the life of the UHS reservoir.

2:45 PM

An Overview and History of the Uranium Roll Front Model

C. McDowell and B. Schiffer; WWC Engineering, Sheridan, WY

Why is this here and where can I find more? Is a question that has puzzled geologists and proto geologists since mining began in the Lion Cavern at Ngwenya Mine in Eswatini approximately 43,000 to 41,000 BCE. To answer this question, geologists evaluate an initial ore deposit to determine characteristics about the depositional environment, host material, mineralogy, etc. which can then be used to search for new areas to explore. Roll front uranium deposits were first identified at the underground Shirley Basin Mine in central Wyoming in the early 1960s. The classic "C" shaped roll front deposits occur along the contact between oxidized and reduced sandstones, also known as the redox boundary. An understanding of the roll front model assists geologists exploring for uranium as the redox boundary can be used to guide drilling. Since they were first described, roll fronts have been identified in sedimentary hosted uranium deposits worldwide.

3:05 PM

25-086

Subsurface Spatial Planning for Energy and Storage Applications in Germany

M. Gurgel; Faculty of Georesources and Materials Engineering, RWTH Aachen University, Aachen, Germany

Subsurface spatial planning is becoming increasingly important in view of competing underground applications. This development is influenced by global agreements to reduce greenhouse gas emissions. Therefore, precise knowledge of the underground space is a basic prerequisite for future applications. The three-dimensional registration and reliable georeferencing of underground infrastructures can establish a holistic geodata basis for such tasks. Those tasks are discussed both for the development of energy projects such as deep geothermal energy as well as for storage applications. Research on geothermal energy has been carried out at RWTH Aachen University as part of the SuperC project in a license field in the Aachen area since 2001. Recently, this research has been extended to include monitoring aspects in the overlapping GEObservatorium Aachen field. The documentation and visualization of underground activities using photogrammetric methods like Structure from Motion is discussed based on recent research in sites for the final disposal of radioactive waste. Finally, both applications provide an outlook on supporting underground projects by using high-resolution geodata.

WEDNESDAY, FEBRUARY 26 AFTERNOON

COAL & ENERGY: MINE EMERGENCY PREPAREDNESS

Room 105

2:00 PM • Wednesday, February 26

Chairs: ***S. Bealko****, GMS Mine Repair, Oakland, MD*
E. Zeglen*, Zeglen Consulting, Clarksville, PA*

2:00 PM

Introductions

2:05 PM

Air Quality Data Driven Self-Escape for Underground Coal Mines Fire Emergencies

S. Kingman[2], R. Owusu-Ansah[1], H. Khaniani[6], V. Androulakis[1], S. Shao[3], M. Hassanalian[4] and P. Roghanchi[5]; [1]Mineral Engineering, New Mexico Institute of Mining and Technology, Lexington, KY; [2]Computer Science and Engineering, New Mexico Institute of Mining and Technology, Socorro, NM; [3]Electrical Engineering, New Mexico Institute of Mining and Technology, Socorro, NM; [4]Mechanical Engineering, New Mexico Institute of Mining and Technology, Socorro, NM; [5]Mining Engineering, University of Kentucky, Lexington, KY and [6]Petroleum Recovery Research Center, New Mexico Institute of Mining and Technology, Socorro, NM

Aiming to assist mine workers self-evacuation during fire emergencies in underground mines, ventilation data driven algorithms could provide mine-wide situational awareness to the evacuees. Efficient real-time path planning algorithms utilizing a mine-wide IoT, which collects air quality, can provide beneficial assistance to mine workers. This study presents proof of concept for a real-time smart evacuation route-planning approach based on a coupling VentSim™ DESIGN fire simulations with three path-planning algorithms. The quantification of fire-induced hazards based on data collected by the IoT and the MSHA health regulations provides optimized escape routes that can assist mine workers to reach a safe location.

2:25 PM

Analog RF Backscatter with Organic Photovoltaics for Underground Mine Self-Assisted Rescue

M. Salas[2], S. Shao[2], H. Khaniani[3], V. Androulakis[4], M. Hassanalian[5] and P. Roghanchi[1]; [1]Mining Engineering, University of Kentucky, Lexington, KY; [2]Electrical Engineering, New Mexico Institute of Mining and Technology, Socorro, NM; [3]Mineral Engineering, New Mexico Institute of Mining and Technology, Socorro, NM; [4]Mineral Engineering, New Mexico Institute of Mining and Technology, Socorro, NM and [5]Mechanical Engineering, New Mexico Institute of Mining and Technology, Socorro, NM

Light-powered analog RF backscatter communication offers a battery-less solution for ultra-low power scenarios like self-assisted mine rescue. This study introduces an RF device enabling communication with a Search and Rescue Robot's RF Transceiver, improving trapped miners' self-assisted capability. The device utilizes an organic polymer photovoltaic cell optimized for low illumination and employs frequency shift keying for non-continuous data transmission, allowing ultra-low power analog control circuitry. We explore a self-canceling network in the RF Transceiver to enhance communication range. A prototype is presented with experimental performance characterization, demonstrating the potential for critical rescue operations in challenging environments.

2:45 PM

Enhancing Search and Rescue Operations in Underground Coal Mines with Unmanned Robotic Agents

D. Vosbein[1], N. Bagheri[1], J. Racette[1], V. Androulakis[2], H. Khaniani[2], M. Hassanalian[1], S. Shao[3] and P. Roghanchi[4]; [1]Mechanical Engineering, New Mexico Institute of Mining and Technology, Socorro, NM; [2]Mineral Engineering, New Mexico Institute of Mining and Technology, Socorro, NM; [3]Electrical Engineering, New Mexico Institute of Mining and Technology, Socorro, NM and [4]Mining Engineering, University of Kentucky, Lexington, KY

Search and rescue operations remain extremely hazardous for mine rescue teams. In the era of ever-increasing applied robotics, mine rescuers could benefit from deploying scouting robotic agents. The proposed solution deploys a custom-made collaborative UGV-UAV system with the objectives of environment mapping, and air quality data collection, while maintaining communications for data transferring with the rescue mission center. Designing such a system involves a plethora of hardware and software selection, fabrication, and deployment challenges for the robotic agents. A successfully developed UGV-UAV system can significantly expedite S&R operations, while minimizing risks for the rescuers, and saving lives.

3:05 PM

25-003

A Simulation-Based Training Framework for Mine Rescue and Self-Escape Readiness

M. Raza and S. Frimpong; Mining and Explosives Engineering, Missouri University of Science and Technology, Rolla, MO

Underground mining environments are inherently hazardous and can lead to emergencies where effective rescue and self-escape become critical. Missouri University of Science and Technology is pioneering new technologies for effective self-escape. The rescuers and miners need to be trained in these new technologically driven environments. Previous research in fields like aviation, medical surgery, and oil and gas drilling has demonstrated the effectiveness of virtual simulation training, but the mining sector has yet to fully adopt advanced tools such as eye-tracking and immersive training modules. This research proposes a comprehensive training infrastructure incorporating these technologies to enhance situational awareness and decision-making during emergencies. The novelty lies in the application of advanced miner escape and communication technologies, specifically designed to monitor and enhance cognitive responses in high-stress situations. By leveraging these technologies, the proposed training infrastructure aims to prepare the next generation of underground miners and operators, by equipping them with the necessary skills to manage emergencies effectively.

3:25 PM

Advances in Mine Emergency Preparedness and Response

K. Armstrong; Draeger, Houston, TX

This presentation examines the enhancement of mine emergency preparedness and response through the integration of advanced technologies and comprehensive planning strategies. By leveraging robust physical and digital infrastructure, mines can enhance safety and ensure that response teams are adequately trained and equipped. Innovative technological solutions improve communication and situational awareness, facilitating quicker and more informed decision-making during emergencies. The application of state-of-the-art technology within a new portfolio of solutions optimizes preparedness and response capabilities, thereby safeguarding both personnel and operations and enabling more effective and rapid responses to emergency situations.

3:45 PM

Optimizing Underground Search and Rescue Robotic Systems to Meet End-user Expectations

R. Bakzadeh[1], H. Khaniani[2], V. Androulakis[2], M. Hassanalian[2], S. Shao[2] and P. Roghanchi[1]; [1]Mining Engineering, University of Kentucky, Lexington, KY and [2]New Mexico Institute of Mining and Technology, Socorro, NM

The mining industry increasingly adopts robotic technologies for various applications, including search and rescue operations. Human-machine interaction is critical in these missions due to their stressful and time-sensitive nature. However, challenges arise from the lack of data on end users' expectations, the necessary capabilities for these robots, and the best practices for robot-rescuer interactions. To address these issues, subject matter experts (SMEs) were consulted through questionnaires and interviews to gather their insights on the capabilities, components, and human-machine interface of search and rescue robots. Qualitative questions were asked about robot navigation capabilities, data display and accessibility, data priority, and perceived challenges to the robot's functionality. The outcomes of this study help develop an optimal human-machine interface for mine rescue missions.

4:05 PM

Enhancing Underground Mine Rescue Mission: Addressing Cybersickness and Human Decision-Making in VR Training Simulations

T. Hunter[2], M. Hassanalian[2], H. Khaniani[3], V. Androulakis[3], S. Shao[4] and P. Roghanchi[1]; [1]Mining Engineering, University of Kentucky, Lexington, KY; [2]Mechanical Engineering, New Mexico Institute of Mining and Technology, Socorro, NM; [3]Mineral Engineering, New Mexico Institute of Mining and Technology, Socorro, NM and [4]Electrical Engineering, New Mexico Institute of Mining and Technology, Socorro, NM

Aiming for better use of VR simulations in training underground mine personnel, we investigate the effects of cybersickness, a physiological condition induced by head-mounted Virtual Reality devices. Additionally, human decision-making factors in VR simulations are examined by incorporating sensor data from a physical mine model under fire emergency. The goal is to use VR simulations alongside search and rescue robotic agents to enhance emergency preparedness in underground mine emergencies. Future directions include incorporating robotics into the simulations to prepare and train miners and personnel to work alongside these technologies in real-world applications.

4:25 PM

A System Dynamics Analysis of the Battery Fire in an Underground Mine

S. Eroglu and S. Duzgun; Mining Engineering, Colorado School of Mines, Golden, CO

This study employs a system safety approach to analyze lithium-ion battery fires in underground mines, with a focus on communication failures within the system. Using the causal analysis based on systems theory (CAST), the research identified critical communication gaps that led to a battery fire at Turquoise Ridge Underground. A causal loop diagram created in Vensim software and converted to a network in Python reveals critical system components, local clustering coefficients, network communities, and missing intra- and inter-community connections. These insights aim to enhance system connectivity, providing essential safety guidelines for integrating battery electric vehicles (BEVs) into underground mines.

WEDNESDAY, FEBRUARY 26 AFTERNOON

ENVIRONMENTAL: ADTI-CRITICAL MINERALS IN MINE WASTES

Room 104

2:00 PM • Wednesday, February 26

Chairs: ***D. Levitan****, U.S. Geological Survey, Reston, VA*
V. McLemore*, NMBGMR/NM Tech, Socorro, NM*

2:00 PM

Introductions

2:05 PM

Mine Waste as a Resource

V. McLemore; NMBGMR/NM Tech, Socorro, NM

There are tens of thousands of inactive mine features with significant mine wastes throughout the United States (including coal, uranium, metals, and industrial minerals). Many of these mines have existing mine wastes, generated during mineral production, which could have potential for critical minerals, especially since the actual mineral production was generally for precious and base metals and not critical minerals. Characterizing and estimating the critical minerals endowment of these mine wastes is important to understand if these mine wastes could be reprocessed. Characterization includes determining the mineralogy, geochemistry, types of microprobes, and size of the material. The mine history of the area needs to be summarized. Future mining of mine wastes that potentially contain critical minerals will directly benefit the economy of the local areas. Possible re-mining of mine wastes could clean up these sites and pay for reclamation. Furthermore, these characterization projects will include training of younger, professional geologists and students in economic and reclamation geology by the PIs.

2:25 PM

25-039

Geochemistry of Critical Minerals in Mine Wastes in Grant, Sierra, and Socorro Counties, New Mexico

Z. Kazemi Motlagh[1], V. McLemore[2] and E. Owen[2]; [1]Mineral Engineering, New Mexico Institute of Mining and Technology, Socorro, NM and [2]Bureau of Geology and Mineral Resources, New Mexico Institute of Mining and Technology, Socorro, NM

Mine wastes are potential sources of critical minerals, non-fuel commodities essential to the U.S. economy and national security whose supply chain may be disrupted. Critical minerals are being characterized in three mining districts in New Mexico: Black Hawk (Grant County), Hillsboro (Sierra County), and Magdalena (Socorro County). The Black Hawk district contains arsenide 5-element veins with Ag, Ni, Co, As, U, Bi, with local Pb, Cu, Zn. The Copper Flat mine in Hillsboro is a copper porphyry deposit. The Kelly mine in Magdalena is a carbonate-hosted deposit. Mine waste piles and tailings were sampled using USGS sampling procedures. Black Hawk wastes samples are elevated in Co (292 ppm), Ni (2128 ppm), and Zn (8463 ppm). Finer size fractions show increasing concentrations of Co, Cu, and Ni. Copper Flat tailings are elevated in Bi (111 ppm), Cu (7453 ppm), and Zn (2360 ppm). Magdalena samples are elevated in Cu (5700 ppm) and Zn (13%). Determination of acid-generating potential in the areas suggests that Black Hawk district mine wastes are non-acid-forming while some Copper Flat and Magdalena samples can potentially cause acid mine drainage.

2:45 PM

Assessment of Microbial Populations in Kinetic Tests of Sulfide-bearing Rock Subjected to Different Moisture, Temperature, and Chemical Conditions

D. Jones[1], M. Best[1], Z. Wenz[2], S. Koski[2] and A. Gehn[2]; [1]Earth and Environmental Science, New Mexico Tech, Socorro, NM and [2]Division of Lands and Minerals, Minnesota Department of Natural Resources, St. Paul, MN

Microorganisms are important catalysts for the oxidation of sulfide minerals in natural and engineered settings. In earlier research, we found that long-term kinetic tests contained abundant and active microbial populations that likely contributed to rock weathering processes. However, it remains unclear how microbial communities evolve during the weathering process or how they react to different treatment conditions. Here we report on new RNA and DNA analyses of microbial communities in humidity cells and field-scale rock piles of Ely Greenstone with different sulfide mineral contents operated under different test conditions, in order to evaluate microbiological influences on sulfide oxidation and considerations for kinetic test work.

3:05 PM

High-throughput DNA and RNA Sequencing Reveals Total and Active Microbial Populations Associated with Critical Minerals in Historic Mine Waste, South-central New Mexico

M. Best[1], D. Jones[1] and V. McLemore[2]; [1]Earth and Environmental Science, New Mexico Institute of Mining and Technology, Socorro, NM and [2]New Mexico Bureau of Geology and Mineral Resources, Socorro, NM

New Mexico has a long history of mining, with hundreds of mining districts across the state that often contain inactive operations with historic tailings and waste rock. Many of these deposits are associated with critical minerals, and contain substantial resources in their waste that could be used to support domestic critical mineral demand. We analyzed the composition of microbial communities from five inactive mine sites in south-central New Mexico using rRNA gene and transcript sequencing to assess total and active microbial communities and explore microbial contributions to metal mobilization and the in situ bioleaching potential of these non-traditional metal resources.

3:25 PM

25-002

A Framework for Assessing Land Use Impact Assessment of Mining Sites

D. Otarod[1], J. Maurer[2], K. Awuah-Offei[3] and P. Duah[4]; [1]Geology and Geophysics, Student, Springfield, VA; [2]Geology and Geophysics, Assistant Professor, Rolla, MO;[3]Mining and explosive engineering, Professor, Rolla, MO and [4]Mining and explosive engineering, Student, Rolla, MO

Land use impact assessment for mining is time-consuming and expensive. Because of mining's impact on biodiversity, land use assessment methods that evaluate biodiversity are important for mining land use impact assessments. Remote sensing, in particular satellite multispectral sensing platforms such as Sentinel-2 and the LandSat mission series, have been used to assess and quantify biodiversity through proxy variables such as NDVI (Pena-Lara et al., 2022). The objective of this paper is to present results of a comparative study of land use and biodiversity based on multispectral satellite observations and production data from copper and cobalt mining in the Democratic Republic of Congo. We quantify the relationship between different spectral bands and vegetative indices and the production data provided by the mining companies and measure correlations. The results suggest that remote sensing could be a cost-effective means of assessing biodiversity impacts of mining.

3:45 PM

Metal Recovery from Pit Lakes; Prospecting, ROI and ESG

D. Castendyk, B. Kimball and J. Lindauer; WSP, Lakewood, CO

Recovery of metals from pit lakes has the potential to change perceptions of pit lakes from post-closure liabilities to future resource assets. We present two proposed metal recovery operations for two legacy pit lakes containing acid mine drainage from former copper mining operations located in the Western US. Both pit lakes store water with high concentrations of dissolved metals and are actively managed as hydrogeologic sinks. Solvent extraction/electrowinning for zinc recovery, and sulfide precipitation for copper recovery, respectively, show positive returns on investments. Benefits include revenue to offset annual maintenance costs and advancement of corporate ESG objectives.

4:05 PM

Combining Community-based Monitoring and Backward Trajectory Modeling for Pollutant Evaluation and Culpability Analyses

S. Adamson and J. Szust; Trinity Consultants, Salt Lake City, UT

Community-based monitoring has received increasing interest over the last few years. The Environmental Protection Agency (EPA) has taken a range of actions to promote community-based monitoring projects, ranging from providing grants for grassroots air quality monitoring projects to

mandating industrial facilities to implement community-based monitoring projects. Data collected by community-based monitoring programs are used by stakeholders to better understand the relative risks and impacts of local air pollution concentrations. However, ambient air quality monitoring equipment is not capable of differentiating among air pollutant sources and only present the concentration available in the atmosphere at the time of measurement. In other words, the sensors are unable to distinguish the contribution of multipple sources of the pollutant. In order to develop an understand the challenges of air quality in the community, further analysis of the data is required. This presentation will provide an overview and case study for combining community-based monitor readings, human reports, and back trajectory modeling using HYSPLIT to evaluate culpability of pollution events within a community.

4:25 PM

25-030

Empowering Community Engagements: Knowledge and Sustainable Management of Critical Raw Materials

M. Islam[1], G. Meissner[1], J. Joutsenvaara[2], S. Pettersson[3], K. Käär[4], M. Szumny[5], C. Vrabie[6], S. Ojalammi[7], O. Kotavaara[8], L. Suopajärvi[9] and H. Mischo[1]; [1]Institute of Mining and Specialized Civil Engineering, Technische Universitat Bergakademie Freiberg, Freiberg, Sachsen, Germany; [2]Kerttu Saalasti Institute, University of Oulu, Nivala, Finland; [3]University of Lapland, Rovaniemi, Finland; [4]Department of Geology, Tallinn University of Technology, Tallinn, Estonia; [5]KGHM CUPRUM sp. z o.o., Wroclaw, Poland; [6]Geonardo Environmental Solutions, Budapest, Hungary; [7]University of Oulu, Linnanmaa, Finland; [8]University of Oulu, Nivala, Finland and [9]University of Lapland, Rovaniemi, Finland

This study outlines implemented tactics and results for community empowerment through participation in questionnaire surveys, educational programs, and discussion on sustainable sourcing from new critical raw materials (CRMs) projects. Utilising questionnaire surveys, including the Public Participation Geographic Information System (PPGIS), the research gathered public opinions from Estonia, Germany, Poland, and Zambia, receiving 1,068 responses. These responses addressed various social, economic, and environmental issues related to CRM projects. Feedback from educational courses with participants from over 25 nations and public events provided additional insights. The collected data and feedback offer crucial input for advancing sustainable and responsible CRM sourcing strategies in these regions.

WEDNESDAY, FEBRUARY 26 AFTERNOON

ENVIRONMENTAL: GEOSYNTHETICS APPLICATIONS

Room 103

2:00 PM • Wednesday, February 26

Chairs: ***N. Shah****, WSP USA Inc, Tampa, FL*
M. Isola*, WSP, Tampa, FL*

2:00 PM

Introductions

2:05 PM

Erosion Control in Extreme Mining Conditions—A Framework for Holistic Evaluation of Geosynthetic Revetments

N. Shah and M. Isola; WSP, Houston, TX

A key component of surface water management system design is selection of appropriate revetment for erosion control. Ponds and channels with inadequate revetment design are susceptible to failure and/or extremely high cost of material (if overdesigned). Additionally, lack of erosion control can result in excessive sediment transport which may eventually obstruct downstream conveyance features and further result in cascading failures. Currently, a wide variety of geosynthetic products are available catering to varying needs for erosion control. However, selection of appropriate product is an extremely important task where factors such as site locations, expected quality and quantity runoff, aesthetics requirements, and availability of skilled labor should be considered. This presentation will provide an overview of selected commercial revetments products and discuss design guidelines and application case studies. The objective of this presentation is to provide a framework for holistic evaluation of a revetment product for a given site conditions and desired use, such that, the selected product will meet the desired design criteria while optimizing other constraints including cost.

2:25 PM

Flexible Facia MSE Wall System for a 100ft High Crusher Wall

L. Mottadelli, C. Andrade and P. Frankenberger; Maccaferri, Hagerstown, MD

The development of a Gold Mine in Ontario's northern territories required meticulous planning to optimize operational space, particularly in constructing a wall to expand the loading area for the primary crusher. Ensuring the expansion pad could support heavy mining equipment without significant deformation or settling was crucial. The chosen solution was a Mechanically Stabilized Earth (MSE) retention system with flexible facia elements. It utilized Double Twisted steel wire mesh with High Abrasion Resistance (HAR) Polymeric Coating for the facia and high-tensile strength geogrids with heavy coating for soil reinforcement. Given the remote location and harsh climate, the system had to withstand long-distance transport and extreme cold, with a free-draining facia to mitigate water-related issues. This approach ensured durability and operational reliability under challenging conditions. This paper explores the rationale for choosing this solution, technical hurdles encountered during implementation, and the successful completion of the project.

2:45 PM

Ensuring Quality Geosynthetics Installations

G. Toepfer; CQA Solutions, Ltd, Toledo, OH

Geosynthetics are an important part of many containment systems used in the mining industry. Failure of these geosynthetics can result in severe liabilities to the owner including jeopardizing operations at the mining site. Therefore, it is imperative that these geosynthetics be installed correctly. Proper installation quality is not solely the responsbility of the geosynthetics installer—there are numerous other factors that influence the quality of the installation from project conception through installation and the operational lifecycle of the containment system. This paper will share lessons learned on ensuring geosynthetics quality through over thirty-four years of involvement on geosynthetics projects. Specifically, this paper examine the different roles (owner, design engineer, construction vendors, quality control/quality assurance personnel, the certifying engineer, and the regulators) and how they can either ensure or negatively impact quality. Key photographs will serve as a visual aid for those looking to identify issues during field installation.

3:05 PM

Erosion Protection at Mining Sites Using a Concrete-Enhanced Synthetic Turf System

T. Sanville; Watershed Geo, Alpharetta, GA

Mine sites face many water erosion challenges due to changing weather patterns and more frequent extreme weather conditions. A concrete-reinforced engineered turf system has been developed for erosion protection and used in mining applications recently. This system consists of an impermeable geomembrane that does not allow the stormwater runoff to be in contact with the subgrade and hence, eliminating potential erosion of subgrade. This presentation provides an overview of conventional erosion protection methods and the concrete-reinforced engineered turf system, followed by an evaluation of the hydraulic performance of the concrete-reinforced engineered turf system, including the steady state overtopping flume testing, heavy debris load testing, and intentional damage testing. Case studies are provided to demonstrate installation and field performance of the erosion protection system for stormwater channels, downchutes, spillways, and slopes at mining sites.

WEDNESDAY, FEBRUARY 26 AFTERNOON

HEALTH & SAFETY: MINE VENTILATION HEALTH

Room 108

2:00 PM • Wednesday, February 26

Chairs: ***P. Tukkaraja****, South Dakota School of Mines and Technology, Rapid City, SD*
C. Strong*, University of Kentucky, Alpharetta, GA*

2:00 PM

Introduction

2:05 PM

Respirable Coal Mine Dust Respiratory Deposition Using a Mobile Aerosol Lung Deposition Apparatus (MALDA)

A. Vanegas Valderrama[2], W. Su[3] and P. Roghanchi[1]; [1]Mining Engineering, University of Kentucky, Lexington, KY; [2]Freeport McMoRan, Morenci, AZ and [3]Public Health, Baylor University, Waco, TX

This research explores the deposition fraction of particles in the human respiratory tract, focusing on occupational hazards in coal mining. Using the Mobile Aerosol Lung Deposition Apparatus (MALDA), a 3D lung model, and a wind tunnel, the first phase involved ten experimental analyses with one APS 3321 unit, followed by 18 tests with two units. These tests simulated lung function and assessed the deposition patterns of particles larger than 0.1 micrometers in the upper airways and alveolar regions. The study aims to determine lung deposition fractions of coal mine dust, contributing to Coal Mine Dust Lung Diseases (CMDLDs), including Coal Workers' Pneumoconiosis (CWP). With increasing incidence rates reported by the National Institute for Occupational Safety and Health (NIOSH), this research highlights the need for better monitoring and control measures against hazardous dust exposure in mining. By examining how particle characteristics such as size, shape, charge, and aerodynamic diameter affect lung deposition, this study offers valuable insights into CMDLD pathogenesis and stresses the importance of protecting miners' health.

2:25 PM

SLAM Lidar for Particulate Matter Monitoring: Case Study in the San Xavier Mine

K. Brown Requist and M. Momayez; Mining and Geological Engineering, University of Arizona, Tucson, AZ

The monitoring of particulate matter (PM) presents a major cost to mining operations. With a lack of widely accepted non-regulatory means of monitoring, there is a need to develop new methods for cost-effective area monitoring of PM. With the use of simultaneous localization and mapping (SLAM) lidar scans, we present an attempt to monitor PM as an additional method for monitoring. Testing of this method was conducted at the San Xavier Mining Laboratory under various mining conditions. SLAM lidar estimates are compared with a commercially available real-time area monitor to assess SLAM lidar's ability to quantify PM concentrations.

2:45 PM

A Computatinal Fluid Dynamics Approach to Investigating Geothermal Effects on Methane Flow Near the Cutting Interface In Underground Coal Mining

T. Chimbwanda, N. Risso and M. Momayez; Department of Mining and Geological Engineering, University of Arizona, Harare, Harare, Zimbabwe

World over, as near-surface deposits deplete and mineral demand increases, deep mining is becoming more prevalent. However, the deeper we go, the geothermal gradient steepens implying increased temperatures that influence environmental conditions and operational safety. This study explores geothermal gradient effects on methane gas behavior near the cutting face in underground coal mines. Elevated temperatures due to deeper geothermal activity can reduce the coal matrix's capacity to adsorb methane, potentially increasing the rate of methane desorption. This study provides insights for more effective ventilation strategies, enhancing safety by predicting methane release rates more accurately in response to geothermal variations.

3:05 PM

Estimating Respirable Silica Concentration From CPDM Samples Using FTIR Analysis: Results From Lab and Field Samples

A. Greth and E. Sarver; Mining & Minerals Engineering, Virginia Polytechnic Institute and State University, Blacksburg, VA

There is an increasing need for respirable crystalline silica (RCS) monitoring on mine sites to understand and limit exposure risks. To enable RCS monitoring in coal mines at the end of a shift, a method for direct-on-filter RCS analysis by Fourier Transform Infrared spectroscopy (FTIR) has been developed by NIOSH. It is for use with PVC filter samples collected using the standard Coal Mine Dust Personal Sampling Unit (CMDPSU). However, a method that can be applied to samples collected with the Continuous Personal Dust Monitor (CPDM) could be very valuable, since mines are now using the CPDM more frequently than the CMDPSU. While the CPDM sample cannot be analyzed directly, a 3-step method has been piloted to: (1) recover the dust from the CPDM's filter, (2) deposit it onto a PVC filter, and (3) analyze it by FTIR to estimate RCS. In this presentation, we discuss the method in detail and show results for CPDM samples collected in both the lab and field. Moving forward, this method could enable mines to leverage the CPDM samples they are already collecting to collect additional RCS data.

3:25 PM

Characterization of Gas and Particle Emissions from Lithium-Ion Battery Fires

X. Wang, M. Claassen, B. Bingham, J. Chow and J. Watson; Atmospheric Sciences, Desert Research Institute, Reno, NV

Lithium-ion batteries (LIB) fires pose a catastrophic risk if they occur in underground mining environments, where ventilation and evacuation are challenging. Inhalation of LIB fire smoke is a health threat to miners and firefighters. It is therefore necessary to properly characterize gas and particle emissions of LIB combustion to understand their health risks and determine the best methods for fire detection, suppression, and post-fire clean up. This study conducted a comprehensive characterization of gas and particle emissions from thermal runaway of two LIB types (cylindrical lithium-iron-phosphate [LFP] cells and pouch-type lithium cobalt oxide [LCO] cells), each at five charge levels between 0% and 100%. A large amount of hydrogen fluoride (HF) was released during fire, sometimes exceeding the immediate danger to life and health (IDLH) concentration limit. Depending on charge level and combustion behavior, the $PM_{2.5}$ composition was dominated by organic matter, elemental carbon, and/or phosphate. LFP cells had higher emission factors for HF and $PM_{2.5}$ than LCO cells.

3:45 PM

25-069

Powered Air Purifying Respirator: An Efficient Personal Protective Device for Protection From Dust Underground

L. Sanchez Gonzalez, A. Kumar and B. Arnold; Energy and Mineral Engineering, The Pennsylvania State University, State College, PA

The health and safety of miners is critical in the industry. Prolonged exposure to dust-laden air results in irreversible ailments like pneumoconiosis that have a severe impact on the miners' lives. Operations use various personal protective devices (PPEs) to alleviate their exposure to respirable dust. Powered Air Purifying Respirator (PAPR) is one such device that uses high-efficiency filters and a positive pressure mask to shield miners from airborne contaminants. Used in the medical and other industries, these respirators protected healthcare workers during the COVID-19 pandemic efficiently.

Recently, the mining industry has shown a growing interest in adopting this PPE to ensure safe working conditions for the miners. We present an introduction to the PAPRs and discuss their dust capture efficacy.

4:05 PM

Prediction of Wet Bulb Temperature from Field Data using Machine Learning Algorithms

I. Anafo[1], C. Arthur[2] and E. Marshall[1]; [1]Mining Engineering, University of Utah, Salt Lake City, UT and [2]Mining engineering, University of Mines and Technology, Tarkwa, Ghana

This project uses Machine Learning to predict Wet Bulb Temperature (WBT) from microclimatic conditions, addressing inaccuracies in traditional psychrometry. By examining the relationship between the WBT and the Dry Bulb Temperature (DBT), Relative Humidity (RH), and Air Velocity (AV), four different models were developed namely: Multi-Layer Perceptron, Random Forest AdaBoost Regression as well as Multi-Variable Linear Regression. Results indicate that these models can better predict WBT values than the empirical equation by Roland Stull. Establishing a direct relationship between AV and WBT will enable ventilation engineers to regulate WBT by varying the AV in mines.

4:25 PM

Occupational Exposures and Acute Health Effects Associated with Renewable and Regular Diesel in an Underground Mining Laboratory

R. Reed and J. Burgess; University of Arizona, Taylor, AZ

Objective: To evaluate health effects and exposures associated with the use of regular (D) and renewable diesel (RD) from operation of a Skid Steer at an underground mining laboratory. Methods: Biological monitoring was conducted immediately before and after subjects' exposure sessions, which included: exhaled nitric oxide (NO), exhaled carbon monoxide (CO), urine specific gravity (USG), and blood draw. Subjects operated a (2018) Caterpillar (289D) Skid Steer with 73 HP, C3.3B DIT engine while diesel particulate matter (DPM) and nitrogen dioxide (NO_2) exposures were measured. Results: A significant reduction in DPM was observed from D to RD (220 to 165 mg/m^3, p=0.028). While other results were not statistically significant, there was a decrease in NO_2, CO. Compared with D, pre-post levels of serum P-Selectin tended to increase with no change to serum Endothelin-1 levels. Nine protein biomarkers showed increased differential expression with D, as compared to just one protein with RD. Discussion: The use of RD showed variability amongst several health outcomes. This work underscores the importance of investigating vehicle-fuel pairings evaluation exposures and health effects.

WEDNESDAY, FEBRUARY 26 AFTERNOON

INDUSTRIAL MINERALS & AGGREGATES: INNOVATIONS IN INDUSTRIAL MINERALS AND AGGREGATES II

Room 106

2:00 PM • Wednesday, February 26

Chairs: ***S. Stokowski****, Stone Products Consultants, Lawrenceville, GA*
T. Newman*, Holcim (US) Inc., Fort Collins, CO*
J. Sackrider*, Westward Environmental, Inc., Boerne, TX*

2:00 PM

Introduction

2:05 PM

Calibrating Phosphatic Ore Resource Models to Mill Feedstock Head Grade Accurately Using Machine Learning

F. Yusufali[1], O. Alassaf[2], N. Almuhaisen[2], S. Algharbi[2], A. Fayrq[2] and O. Morton[2]; [1]StratumAI, Richmond Hill, ON, Canada and [2]Ma'aden, Riyadh, Saudi Arabia

Machine learning creates value in the mining industry by allowing multiple data types to calibrate resource model predictions to measured mill feed. The authors demonstrate using attention-learning neural network modelling, selecting features, and considering intemediary steps like cleaning and sorting. This calibration technique was applied in the Al Khabra area, an Arqah Phosporite member in northern Saudi Arabia. Features like segregation rate history, sand concentration, lithologies for ore and waste, seam number, etc. are considered inputs. Limited feature selection is crucial to ensure no overfitting. The predictions were for phosphate (P2O5), silicon oxide (SiO2), and calcium oxide (CaO). The ground truth was 10 months of monthly head grade readings. The benchmark was the Kriging model's predictions for the minerals above. The results are the following: 1) for P2O5, there was 39% less monthly deviation, 2) for SiO2, there was 64% less monthly deviation, and 3) for CaO, there was 36% less monthly reduction. The results demonstrate that machine learning-based calibration techniques, as they are non-linear, are more accurate in predicting mill feed over the existing methods.

2:25 PM

Benefits of Ripperveyor Cutter Head Technology in Underground Industrial Minerals Mining Applications

M. Jennings; Komatsu Mining Technologies, Warrendale, PA

Industrial mineral mining applications require mining machines with the capability to cut minerals that exhibit lower propagation to fracturing via mechanical cutting practices. Higher resistance to cutting represents a challenge for traditional solid head continuous mining machines operating in the industrial mineral sector. Komatsu's Ripperveyor cutter head design was engineered to increase cutting cycle efficiency through the elimination of cores, improved material conveying and allowance for tighter bit spacing. During 2024, in-depth cutting cycle analyses were performed in a US based gypsum application to document and evaluate several key performance indicators—depth of sump, sump rate, shear rate, and cutting cycle time. Data recorded during the evaluation will be utilized to compare the mining cycle efficiency of both solid and Ripperveyor cutter head mining cycles in industrial minerals applications.

2:45 PM

25-056

Meerschaum Mining Activities in Eskisehir, Turkiye

M. Yavuz; Mining Engineering Department, Eskisehir Osmangazi University, Eskisehir, Turkey

Sepiolite is widely used in various industries due to its adsorptive, rheological, and catalytic properties. Two genetic types of sepiolite are found around Eskisehir. The most common type is the so-called "Meerschaum," which occurs as nodules and concretions within the Miocene-Pliocene conglomerate that surrounds the magnesite deposits in the region. Meerschaum mining has been carried out for centuries by local farmers in two distinct regions of Eskisehir. Traditional tunneling methods are employed in production activities by these local farmers. The raw meerschaum they produce is processed by many artists in Eskisehir. The best nodules are carved into objects such as pipe bowls, bracelets, and necklaces. In recent years, various challenges have emerged in both the processing and mining of sepiolite. Notably, meerschaum production has significantly decreased, making it difficult for artists to obtain high-quality meerschaum. This paper describes the studies conducted to address these issues. Solutions for both the production and processing stages of the meerschaum sector have been developed and are presented in this work.

3:05 PM

Wetland Mitigation Banking as a Post Mining Adaptive Reuse

J. Sackrider; Westward Environmental, Inc., Boerne, TX

Though the supreme court reduced federal protections for wetlands in the 2023 Sackett v. EPA decision, their presence remains an obstacle to development. Impacts to wetlands must be offset by either creation of new wetlands, or purchase of wetland mitigation credits. Aggregate mines are uniquely positioned to generate new wetlands once reserves have been depleted. With the existing bank and credit system, this post mining adaptive reuse can provide both environmental and economic benefits long after the last truck leaves the scale.

3:25 PM

Utilization of Local Raw Materials and Mine Waste to Manufacture Cement in Northwest Territories, Canada

G. Huang[1], J. Zhao[1], G. Dzemua[2], S. Cairns[2], P. Normandeau[2] and W. Liu[1]; [1]School of Mining and Petroleum Engineering, University of Alberta, Edmonton, AB, Canada and[2]Northwest Territories Geological Survey, Yellowknife, NorthWest Territories, Canada

Currently, all the cement consumed in Northwest Territories (NWT), Canada, is imported from other provinces (e.g., Alberta) by long-distance (~1,800 km) truck freight. Transporting cement over long distances not only raises its cost, but also results in a higher carbon footprint. Locally producing cement is a potential low-carbon and economical solution for the local industry. However, it is unknown if the local raw materials are suitable for cement manufacturing; and there is a lack of a critical raw material—Iron ore—for cement manufacturing. Instead of iron ore, there are iron-rich tailings from a local rare earth element (REE) mine. Towards low-carbon and circular economy, this study explored the use of local raw materials (i.e., limestone, clay, and gypsum) and mine waste (REE tailings) to manufacture cement in the NWT and successfully produced the first bag of cement in the history of the NWT. The results showed that concrete samples made with NWT cement achieved comparable strength to commercial OPC-based concrete. There is a potential to reduce 3.0%–61.7% of CO_2 emissions when compared with importing cement from other provinces.

3:45 PM

25-068

Past, Present, and Future of Cement Manufacturing and Decarbonization in the United States

P. Duah and K. Awuah-Offei; Mining & Explosives Engineering Department and Thomas J. O'Keefe Center for Sustainable Supply of Strategic Minerals, Rolla, MO

Regulatory pressure to mitigate the cement industry's environmental impact has intensified recently, spurring innovation in low-carbon cement technologies. In the United States, cement production, consumption, and carbon emissions are accelerating. Despite this trend, the adoption of environmentally friendly dry clinker production technology with combined preheater-precalciner systems has surged from 53.3% in 2002 to 88.5% currently. Concurrently, reliance on wet technologies, known for their higher environmental impact, has dropped from 16.5% in 2002 to 0.6% today. This paper presents the results of our comprehensive study, utilizing over 100 years of industry data, to analyze these technological shifts and their environmental implications.

WEDNESDAY, FEBRUARY 26 AFTERNOON

MINING & EXPLORATION: GEOSCIENCES: PRACTICAL GEOTECHNICAL STRATEGIES FOR SURFACE OPERATIONS

Sponsored by: BARR

Room 601

2:00 PM • Wednesday, February 26

Chairs: ***E. Rose****, Barr Engineering, Salt Lake City, UT*
D. Lye*, Freeport-McMoRan*

2:00 PM

Introduction

2:05 PM

Evolution and Management of Large-Scale Instability using Pit Depressurization at Freeport-McMoRan Bagdad Mine

A. Soni, A. Wamweya, H. Hazwezwe and L. Tejada; Freeport-McMoRan, Marana, AZ

Freeport-McMoRan's Bagdad mine in western Arizona is an open-pit copper and molybdenum mining complex. The southwest wall of the mine faces large-scale instability issues, posing challenges to both current operations and future expansion plans. These issues stem from major geological structures and poor rock mass quality, exacerbated by precipitation, groundwater, and 'artificial recharge' in the form of Pregnant Leach Solution (PLS) from leaching operations. Effective pit depressurization, especially by targeting drainage channels, is crucial for managing slope instabilities and ensuring geotechnically safe benches. This involves deploying a combination of shallow interceptor wells, horizontal drains, and directional drains to capture groundwater or PLS and prevent slope destabilization. Monitoring tools such as piezometers, ground-based radars, and satellite-based InSAR are utilized to assess water levels and slope stability, aiding in the optimization of dewatering strategies amid ongoing mining activities. Addressing these geotechnical complexities is crucial for planning future depressurization controls and sustaining stable slopes.

2:25 PM

Assessing Variations in Rock Strength for Evaluating Stability of Mine Designs

A. Patterson and J. sauceda; Call & Nicholas Inc., Tucson, AZ

Rock strength testing and characterization is crucial in geotechnical engineering because it helps assess variations in rock strength and is essential for evaluating the stability of mine designs. When data is limited, it is common practice to attribute rock strength parameters across the mine property for individual rock types. Due to faulting, weathering, alteration, and variations in characterization, rock strength parameters for the same lithology can vary considerably from one location to another. This paper aims to demonstrate the importance of conducting a comprehensive sampling, rock strength testing, and spatial lithologic review for each new mine design outside the extents of the rock strength database coverage. By understanding the rock strength properties of each unique location, engineers can better optimize mine designs to keep miners safe and improve economics where applicable.

2:45 PM

Rockfall Hazard Mapping from High-Resolution Point Cloud Terrain Analysis

J. McNabb[1], S. Warren[2], J. Restrepo[1], J. Potter[1] and J. Bourgeois[3]; [1]School of Mining and Mineral Resources Geotechnical Center of Excellence, University of Arizona, Tucson, AZ; [2]Spokane Mining Research Division, National Institute for Occupational Safety and Health, Spokane, WA and [3]Geotechnical and Foundation Services, HNTB Corporation, Bedford, NH

Rockfall hazards pose a critical threat to miners and infrastructure in open pit mining environments. The unpredictable timing, distribution, and trajectories of rockfall precludes detailed predictive hazard assessments, such as those conducted for large-scale slope movements. Observations of video-recorded rockfalls show that low angle bench face protrusions struck during rockfall tend to "launch" rocks into more horizontal trajectories, greatly increasing the risk to personnel and infrastructure downslope. These protrusions are readily observed along bench faces using high-resolution photogrammetry or LiDAR point clouds, which are now commonplace

survey tools in open pit mining. We present a method for generating preliminary rockfall hazard maps from 3D point clouds based solely on mapping of these bench face protrusions and the delineation of potential downslope rockfall hazard zones they create. This study represents the first step in creating comprehensive rockfall hazard maps that incorporate multiple factors influencing rockfall such as rockfall source regions, adverse bench and slope geometries, and meteorological events.

3:05 PM

The Importance of Surface Water Control in Relation to Open Pit Slope Stability

T. Feehan; Piteau Associates, Tucson, AZ

Proper surface water control is critical to open pit mine operations to limit infiltration to damage zones created from normal blasting and mining operations. Many bench scale, multi-bench scale and larger slope failures can be attributed to poor surface water control in open pit mines. Implementation of practical surface water controls can increase high wall stability, reduce risk to personnel and infrastructure, and have long-term benefits to overall mining operations.

3:25 PM

Coal Optimisation of Extended Pit Using 3D Slope Analysis and Slope Simulation

N. Adhyananda; University College London, London, UK

The initial design of the extended pit in Sangatta Mine Project was uniform despite variations in slope heights. This approach resulted in varying factors of safety (FS) across different pit sections, potentially limiting coal reserve. This paper aims to standardise FS across all slopes to achieve an optimised final design to maximum coal extraction. The methodology involved conducting detailed slope stability analysis and conducting slope optimisation. Initial analysis identified critical areas primarily in the eastern part of the pit, which hindered optimisation efforts in that region, prompting a shift in focus to the western part. Subsequent 2D slope stability analysis on the western part of the pit with detailed probabilistic assessments highlighted FS ranging from 1.236 to 1.513. The optimisation process successfully increased coal reserves by 10,000 tonnes with a reduced stripping ratio of 0.6%, maintaining FS values of 1.236 to 1.420 in safe zones. While the increase in coal reserves at this pit was moderate, the techniques and methodologies developed here hold significant promise for broader applications in similar mining contexts, particularly those with thick coal seams.

3:45 PM

Closure of Three Open Pits Considering Long-Term and Short-Term Slope Stability

j. cremeens and R. Abousleiman; Geomechanical, Knight Piesold and Co., Fort Collins, CO

The transition from an operating pit to pit closure changes the focus of pit slope stability. Typically, open pit closure involves water management and access control. Open Pit closure often requires construction of water management structures such as perimeter diversion channels and lined retention structures that require work in and around the pit. Short-term of stability must be assessed prior to commencement of closure work. Once construction has been completed, long-term slope stability should be assessed to identify potential impacts to closure structures. Knight Piésold conducted short-term and long-term stability evaluations for three pits at the Alamos Gold, Mulatos mine in Sonora, Mexico. The short-term evaluations involved global stability and rockfall analyses and were focused on the current state of stability. The long-term stability evaluation was focused on providing estimates of risk to closure structures in terms of ultimate pit slope configurations.

WEDNESDAY, FEBRUARY 26 AFTERNOON

KAWATRA SYMPOSIUM: PLANT OPERATIONS

Room709

2:00 PM • Wednesday, February 26

Chairs: ***J. Ripke****, McCarl's Technical Services, Clover, SC*
J. Uhrie*, Jetti Resources, Boulder, CO*

2:00 PM

Introduction

2:05 PM

How to Re-Open an Old Mine With New Technology

B. Hilscher and E. Chilongo; ABH Engineering, Vancouver, BC, Canada

Mines shut down for a variety of reasons the most common being decreasing mill feed grade and increasing dilution. This paper discusses how old mines can be reopened using new technology to reduce dilution and increase mill feed grade. Contract mining, direct ship ore and other relevant topics will also be covered.

2:25 PM

Application of Soft Sensors for Real-Time Process Prediction and Control of Mineral Processing Plants

M. Yahyaei; Julius Kruttschnitt Mineral Research Cnetre, The University of Queensland, Brisbane, QLD, Australia

Automation and advanced process control are technological advances that are pivotal for enhancing the performance of mineral processing plants. Despite substantial technological progress and investments in digitalisation, achieving fully autonomous operations remains a distant goal for the minerals industry. One of the primary challenges hindering the adoption of automation is the reliability of measurements and sensor data. Soft sensors, which are mathematical models that emulate the role of physical sensors, offer a promising solution to enhance measurement reliability and data quality. Soft sensors contribute significantly to developing efficient autonomous systems by leveraging existing data sources and process understanding. This abstract delves into the critical role of soft sensors in mineral processing and highlights their practical applications by reviewing two soft sensors developed at the Julius Kruttschnitt Mineral Research Centre (JKMRC), JKMill FIT and JK CycloPS. Soft sensors could validate hard sensor measurements in real-time, ensure the reliability of decisions made by autonomous systems, and pave the way toward fully automated mineral processing plants.

2:45 PM

Leveraging Operational Experience to Rapidly Adapt to New Markets at Energy Fuels' White Mesa Mill

P. Keller; Technical Services, Energy Fuels Resources (USA) Inc., Lakewood, CO

The White Mesa Mill was constructed in 1978 and commissioned in 1980 to serve as a centralized uranium ore processing facility for the uranium mines of the Colorado Plateau region. With a nameplate capacity of 2,000 tons per day of ore and a licensed production capacity of 8 million pounds of U_3O_8 per year, the Mill operated for decades processing conventional ores. Energy Fuels also has an extensive history of uranium recycling programs ("Alternate Feeds") and circuits were installed at the Mill specifically to enable the processing of a wide variety of feed materials. By utilizing decades of operational experience adapting to the processing of alternate feed materials at the Mill, Energy Fuels was able to rapidly adapt to a new type of feed material, uranium and rare earth bearing monazite sands. By taking advantage of existing infrastructure and adding new circuits for solvent extraction, Energy Fuels has become a leader in the domestic rare earth element industry and is one of two U.S. companies currently producing separated rare earth products from domestic sources.

3:05 PM

Computational Evaluation of Feedwell Design & Performance in Gravity Thickener

Y. Lu[1], T. Sok[1], F. schoenbrunn[2], J. Scott[2] and C. Gilbert[2]; [1]Ming R&D, FLSmidth, Midvake, UT and [2]Thickener Products, Flsdmith, Midvake, UT

The feedwell functions as the heart of a gravity thickener. However, the feed system in industry thickeners remain poorly optimized due to the interplay of complicated factors and lack of consistent evaluation criteria. From a thickening perspective, an ideal feed system should effectively dilute the feed slurry, dissipate the kinetic energy of feed stream, provide expected dispersion of flocculant, and discharge the flocculated feed flow evenly. This paper proposes criteria to quantify these requirements: (1) Dilution ratio: a simple indicator of dilution, which is a ratio of dilution water to total feed stream; (2) Residence Time (RTD): an effective way for feedwell evaluation, from which both flow and mixing condition can be deduced; (3) Shear-rate: a driving force for flocculant dispersion, also a breaking force of the flocculated aggregate; (4) Torque: any tangential component in the discharged flow would result in an unbalanced torque and cause an unexpected rotating flow; By implementing these criteria into computational analysis, an effective method has been demonstrated for design verification of new feedwell or performance evaluation of feed system in industry thickeners.

3:25 PM

25-019

Cobalt Recovery from Mill Tailings at Mantoverde

P. Amelunxen and B. Akerstrom; Capstone Copper Corp, Vancouver, BC, Canada

In 2024, Capstone Copper commissioned a new sulfide flotation plant at Mantoverde in the Atacama region of Chile to process copper ore at a design rate of 32,000tpd. The pyrite associated with the copper ore body contains cobalt in solid solution (Co replacing Fe in the pyrite matrix). As per the existing sulfide flotation flowsheet most of the pyrite is depressed and sent to tailings via the cleaner scavenger tail stream. A new project considers the recovery of the pyrite from the cleaner-scavenger tails via froth flotation to produce a cobaltiferous pyrite concentrate, which is then leached via the existing dynamic copper leach pad to oxidize the pyrite and dissolve the cobalt. The cobalt is recovered from the solution by treating a bleed stream of copper SX raffinate through a continuous, counter-current ion exchange (CCIX) facility. This approach to by-production of cobalt confers numerous benefits, including reduced costs compared with alternative cobalt recovery processes, reduced acid consumption in the heap leach, increased copper production, and reduced acid mine drainage potential due to the removal of pyrite from the mill tailings.

WEDNESDAY, FEBRUARY 26 AFTERNOON

MINING & EXPLORATION: GEOSCIENCES: DEVELOPING THE GEOSCIENCE TALENT PIPELINE PANEL DISCUSSION

Room 507

2:00 PM • Wednesday, February 26

Chairs: ***J. Spring****, Nevada Gold Mines, Spring Creek, NV*
M. Giebel*, Newmont Mining, Indian Hills, CO*

2:00 PM

Introduction

2:05 PM

Developing the Geoscience Talent Pipeline Panel Discussion

M. Moore-Roth; Maptek, Golden, CO

Interactive panel discussion to explore tangible ways to develop the geoscience talent pipeline while partnering with academic and industry experts.

WEDNESDAY, FEBRUARY 26 AFTERNOON

MPD: CHEMICAL PROCESSING: PRECIOUS AND SCATTERED METALS EXTRACTIVE METALLURGY

Room 708

2:00 PM • Wednesday, February 26

Chairs: ***J. Baron****, Newmont, Weston, FL*
W. McCombe*, Hatch*

2:00 PM

Introduction

2:05 PM

Recovery of Critical Elements (i.e., Gallium and Germanium) From Copper Flash Smelting Slag by Sulfuric Acid Pressure Leaching

E. Oteng[1], M. Silwamba[2] and L. Alagha[2]; [1]Materials Science and Engineering, Missouri University of Science and Technology, Rolla, MO and [2]Mining and Explosives Engineering, Missouri University of Science and Technology, Rolla, MO

Gallium (Ga) and germanium (Ge) are critical elements necessary for hig-tech applications. Although these elements are essential, they do not form their own primary sources, but are usually recovered as byproduct of processing other metals such as copper, zinc, and aluminum. Consequently, the lack of primary deposits for these elements, combined with high demand, disrupts their supply. This study investigated the recovery of Ga and Ge from copper flash smelting slag, a waste product of the copper sulfide process. During the smelting of copper sulfide minerals, significant amount of Ga and Ge are partitioned to the slag. To recover these elements high pressure sulfuric acid (H_2SO_4) leaching was used, and the effects of the following parameters were investigated: (1) oxygen partial pressure, (2) H_2SO_4 concentration, (3) solid-to-liquid ratio, (4) leaching time, and (5) leaching temperature. These leaching parameters were optimized using surface response methodology (RSM). The results showed that high pressure sulfuric acid (H_2SO_4) leaching can be used to recover Ga and Ge from copper slags, contributing to the sustainable supply of these critical elements from secondary resources.

2:25 PM

Pyrometallurgical Approach to Gallium/Germanium Extraction

E. Kolb; Microbream Technologies Inc., Grand Forks, ND

Microbeam Technologies Inc. (MTI) developed a novel method to recover gallium and germanium from coal byproducts. The technology has been demonstrated at the laboratory scale and is being further developed at bench/pilot scale in a project funded by the Department of Energy and Industry. The technology has produced purities of Ge and Ga concentrates of greater than 65% and is expected to produce oxides and metals of these elements at greater than 90%. The concentrate compositions are compatible with common downstream refinement methods.

2:45 PM

25-092

The Role of Oxidizing Agents in the Recovery of Precious Metals and PGMs During the Alkaline Leaching of Selenium-Rich Metallurgical Wastes

L. Sanchez-Calderon, W. Kirk, M. Silwamba and L. Alagha; Missouri University of Science and Technology, Rolla, MO

Selenium-rich metallurgical waste product is usually generated during refinement of copper anode slimes collected from electrochemical processes. This by-product, known commercially as "crude selenium", contains 90% selenium, precious metals, PGMs, and other critical elements. This study selectively leaches selenium under alkaline conditions using oxidizing agents to enrich PGMs and precious metals in the residue. The

effectiveness of each agent during leaching was assessed and compared. The process was optimized using pH-EH diagrams to identify optimal conditions. Key variables, including leaching time, temperature, and oxidant concentration, were evaluated for their impact on efficiency and selectivity.

3:05 PM

Evaluations for Implementing the SART Process at a Gold Mine Using the Merrill Crowe Process

B. Baker, D. Kratochvil and H. Liang; BQE Water, Denver, Colorado, CO

The SART (Sulfidization, Acidification, Recycle and Thickening) process has been integrated into the metallurgical process at many gold mines throughout the world to facilitate recovery of free cyanide from metal cyanide complexes and to recover copper and/or silver from barren leach solutions. This paper will present METSIM modeling, laboratory testing, and engineering evaluations for implementing a SART facility at a gold mine using the Merrill Crowe process to recover gold from the pregnant solution. Assessments of how the SART process can fit into various metallurgical flowsheets and the main aspects driving the process and flowsheet selection will also be presented.

3:25 PM

Improving of Gold Recovery From High Copper Content Refractory Ores

O. Restrepo Baena, E. Soto Bedoya and D. Chaverra; Materials and Minerals, Universidad Nacional de Colombia, Medellín, Antioquia, Colombia

The cyanidation process for gold recovery is not efficient when there is interference from certain minerals that react with the cyanide ion. The difficulty in treating a gold-bearing mineral with conventional methods where low recoveries are obtained is known as refractoriness. Copper, for example, present in sulfides and oxides, is a highly refractory element because it forms Cu-CN compounds, which leads to the use of excessive amounts of cyanide in the process and low gold recoveries. This research proposes a pretreatment in the presence of sulfuric acid and hydrogen peroxide to reduce the interference of copper in a subsequent cyanidation process. By applying an exploratory pretreatment with concentrations of 1 M and for 1 hour, gold recovery increased to 80,6%. The experimental design defined gold recovery as the target variable, cyanidations were performed at 4 hours, and an increase in recovery in the same time frame was verified compared to preliminary tests, obtaining significant increases.

3:45 PM

Gold Recovery From Roasted Refractory Gold Concentrate Through Cyclic Extraction Using MnO2-Assisted Thiocyanate Leaching

J. Wu, W. Li, F. Jiao and W. Qin; Central South University, Changsha, China

Cyanidation has long served as the industrial standard in the gold industry, necessitating heightened attention to cyanide management owing to its inherent toxicity. This study developed a novel MnO2-assisted thiocyanate leaching system as an alternative to cyanide. The sample was generated from a refractory gold concentrate processed by roasting, containing 54.4 g/t gold with iron oxide and quartz as the major mineral phases. Within the framework of the novel system, gold recovery was investigated in terms of gold association, recovery behavior, thermodynamics, and optimization using cyclic extraction protocols. Gold extraction comparable to cyanidation was obtained under the optimal leaching conditions, and cyclic leaching scheme was also adopted to reduce the reagent consumption. This acidic leaching system yields satisfactory gold recovery with minimized reagent consumption, particularly suited for refractory gold ore that has undergone acidic pretreatment.

WEDNESDAY, FEBRUARY 26 AFTERNOON

MPD: CHEMICAL PROCESSING: RARE EARTH EXTRACTIVE METALLURGY

Room 705

2:00 PM • Wednesday, February 26

Chairs: ***X. Yang****, University of Utah, Salt Lake City, UT*
P. Keller*, Energy Fuels Resources (USA) Inc., Lakewood, CO*

2:00 PM

Introduction

2:05 PM

Extraction of Heavy Rare Earth Elements from Coal Byproducts

M. Gupta[1], E. Mensah[2], R. Rousan[2], W. Liu[1], O. Onel[1], K. Huang[1], A. Noble[1], a. esker[2] and R. Yoon[1]; [1]Mining and Minerals Engineering, Virginia Tech, Blacksburg, VA and [2]Department of Chemistry, Virginia Tech, Blacksburg, VA

Grades of the ion-adsorption clays (IACs) are low (0.05-0.3%) as compared to those (4-8%) of the conventional rare earth ores. Yet, >85% of the heavy rare earth elements (HREE) are produced from the former, as clay surfaces provide excellent adsorption sites for the heavy Ln^{3+} ions. An analysis of the USGS coal database suggested that the REEs in coal are partitioned into kaolin clays. Therefore, many investigators explored the possibility of extracting REEs using the ion-exchange leaching process employed in South China without much success. In the present work, we studied the reasons for the difficulty and developed new approaches that can potentially lead to an economically viable extraction process.

2:25 PM

Optimizing Rare Earth Element Extraction Using Mesoporous Metal-Organic Frameworks for Enhanced Efficiency and Reduced Energy Consumption

P. Sarswat; Materials Science and Engineering, University of Utah, Salt Lake City, UT

Rare Earth Elements (REEs) are central to the future green energy transition and are classified as a subcategory of critical minerals. However, their production presents significant challenges due to low concentrations, associated impurities, and the economic constraints of mining primary resources. Additionally, extracting REEs from primary deposits is energy-intensive and often requires organic solvents or extractants. This research addresses these issues by focusing on reducing energy consumption in secondary resource processing and utilizing REE-selective mesoporous adsorbers. To tackle the challenges in secondary resource extraction, such as separating REEs from impurities and achieving individual REE fractionation, we employed mesoporous Metal-Organic Frameworks (MOFs). MOFs are crystalline structures formed from organic linkers and inorganic metal substrates, resulting in highly porous networks. Their ability to modify pore sizes enhances their selectivity and efficiency as adsorbents. By utilizing MOFs, we aim to reduce energy requirements, improve selective separation, and minimize toxic waste generation in the extraction process.

2:45 PM

Pretreatment of Allanite (REE) with Oxalic Acid for Enhanced Rare Earth Element Extraction

S. Nili and E. Vahidi; Mining and Metallurgical Engineering, University of Nevada, Reno, Reno, NV

Allanite, a common rare earth element (REE) mineral, is a complex silicate with significant potential for REE extraction due to its high content of cerium, lanthanum, and other rare earth elements. Effective pretreatment of allanite is crucial for optimizing the extraction process due to its silicate structure. Oxalic acid, a mild organic acid, is employed to treat allanite ore in a series of experiments aimed at improving the subsequent extraction of REEs. The study examines the impact of various parameters including oxalic acid concentration, treatment duration, and temperature on pretreatment efficiency.

3:05 PM

Process Development for the Recovery of REE/CM from Acid Mine Drainage via Acid Leaching of Preconcentrates

M. Noonan[1], T. Larochelle[3], K. Strickland[1], D. Hoffman[2], P. Ziemkiewicz[2], O. Wong-Branscome[1] and A. Noble[1]; [1]Minerals and Mining Engineering, Virginia Tech, Blacksburg, VA; [2]West Virginia University, Morgantown, WV and [3]L3 Process Development, Trois-Rivieres, QC, Canada

Over the last decade, researchers at Virginia Tech and West Virginia University have shown that acid mine drainage (AMD) is a viable unconventional source of rare earth elements and critical minerals (REE/CM), particularly the heavy REEs. The development of the processes to extract and recover these valuable materials from AMD has been effectively tested at the laboratory and pilot scales and is currently being deployed at the demonstration scale. Using a patented two-staged precipitation process, the REE/CM are first preconcentrated from the AMD by precipitation into a solid phase before being redissolved and recovered through acid leaching. This presentation describes the development of the leaching process, including determining the activation energy for various preconcentrate materials.

3:25 PM

A Novel Process for Enhancing Scandium Recovery From Red Mud Using a Two-Stage Acid Baking and Water Leaching Process

H. Jammulamadaka[1], M. Rezaee[1], D. Park[2] and S. Pisupati[1]; [1]Energy and Mineral Engineering, Penn State, State College, PA and [2]LLNL, Livermore, CA

Red mud (RM), a byproduct of bauxite processing via the Bayer process, has emerged as a potential secondary source of Scandium (Sc), a critical Rare Earth Element. However, utilizing RM for Sc recovery has been hindered by its high neutralization potential and co-extraction of Iron (Fe). Previous research using direct acid leaching (DL) or acid baking and water leaching (ABWL) processes achieved limited Sc recoveries of up to 60%. Improved recovery has been achieved using high-temperature pretreatments or extended leaching time. This study aims to develop a more efficient H_2SO_4 ABWL process to achieve higher Sc recovery without using high temperatures or excess acid. SEM-EDS analysis on the baked sample showed that Sc recovery was limited by the mass diffusion of acid through the sulfated layer formed during baking. This paper introduces an efficient two-step ABWL process, achieving Sc recovery exceeding 75%. Baking at 200°C for two hours and water leaching at 75°C for two hours offers a 20% improvement in Sc recovery vs the one-step process. The improved recovery is attributed to the enhanced porosity and improved Sc accessibility through the repeated process.

3:45 PM

Development of an Ion-Exchange Technique for Rare Earth Elements Recovery From Acid Mine Drainage (AMD)

P. Gallego and Q. Huang; WVU, Morgantown, WV

Treating acid mine drainage (AMD) to meet federal regulations is a major social, environmental, and economic challenge for the mining industry but also presents an opportunity to recover critical minerals (CM) as a viable treatment. This research aims to develop a cost-effective sorption technique for recovering Rare Earth Elements from AMD. Laboratory-scale experiments using real AMD have been conducted to first preconcentrate the elements of interest for then applying ion-exchange recovery. Key parameters investigated include solution pH, resin concentration, sorption time, and elution conditions. The results could advance methods for mineral recovery and enhance regulatory compliance.

4:05 PM

Development of Technologies for Efficient Recovery of Rare Earths From Placers

E. Asencios Toledo; Lima, Universidad Nacional Mayor de San Marcos (UNMSM), Lima, Lima, Peru

The recovery of rare earth elements (REE) from placer alluvial deposits provides a sustainable alternative to conventional mining. This study focuses on developing innovative technologies for the separation and efficient recovery of REE from alluvial deposits located in the provinces of La Libertad, Puno, and in the areas of Rio Chancay, Casma and southern Peru. These deposits contain rare earth rich minerals such as monazite, zircon and apatite, which present cerium, neodymium, yttrium and lanthanum. The objective is to improve extraction efficiency and reduce environmental impact and to establish a technical-economic framework. Monazite was processed by acid leaching, achieving recoveries of 70-85% of rare earth elements, such as cerium, neodymium and lanthanum. Gravity separation was used in preliminary stages, achieving concentrations of 60-75% of the ore. Zircon was subjected to gravity separation with jigs and concentration tables, achieving recovery rates of 80-90%. In cases where zircon showed magnetic properties, electromagnetic separation was applied, improving purity with recoveries of 75-85%. Apatite was treated with froth flotation, 85-90% recovery.

4:25 PM

Inverted Leaching—A New Mechanical Process for Leaching Metals

F. VAZ; CEO, SmartDry Liquefaction, Recife, PE, Brazil

We invented, developed (TRL 3) and patented anew MECHANICAL process for leaching metals, we call it INVERTED LEACHING. It can be applied to any leachable metal and any material containing it that has the chemical protocol established or will be developed. In INVERTED LEACHING the lixiviant is injected at the base of the vessel containing the material with the leachable metals. Vibrations are applied causing the liquefaction effect. This forces the lixiviant to rise passing through the material. The grains are vibrating, rubbing against each other improving extraction via friction. After the lixiviant rose and formed a liquid layer on the top of the solid, it can be recirculated as many times as necessary to reach full extraction. Once extraction is done, decontamination, washing and neutralization steps can be taken to improve performance and reduce ESG impacts. Simultaneously, all insoluble metals present in the material are being concentrated at the bottom of the vessel. This concentrated can be sold, increasing revenues while reducing ESG impacts (AMD). Once the full process is done, the material leaves the equipment dry stackable, so no dewatering step is necessary.

WEDNESDAY, FEBRUARY 26 AFTERNOON

MPD: FLOTATION: FLOTATION EQUIPMENT

Room 706

2:00 PM • Wednesday, February 26

Chairs: ***R. Dube****, Metso Outotec USA Inc, Centennial, CO*
S. Merrill*, FLSmidth USA Inc, FLSmidth, Salt Lake City, UT, Midvale, UT*

2:00 PM

Introduction

2:05 PM

A Review of Metallurgical and Hydrodynamic Performance of Large TankCell® Flotation Cells

T. Mattsson, N. Vatanski and A. Rinne; Metso, Espoo, Finland

After introductions of TankCell® e500 and e630 in 2012 and 2014, respectively, the mining industry has witnessed a shift to more sustainable processing of large capacities with savings in energy, construction, and manufacturing. Now 10 years after the installation of the first 500m3 flotation cell we have seen a wide acceptance of these sizes, whilst most of the major large scale green and brownfield projects, in which these sizes are applicable, have selected these instead of smaller sizes. Along the shift the performance of these large flotation cells has been validated in multiple locations and in this paper a review of the conducted studies will be provided.

2:25 PM

Performance Comparison of the Standard WEMCO and WEMCO II at 80m3 and 250m3 Industrial Scales

I. Coltrin[1], B. Forbes[2], T. Sok[2] and D. Lelinski[1]; [1]Product Line Managment, FLSmidth and Co A/S, Valby, Denmark and [2]R&D, FLSmidth, Midvale, UT

The WEMCO flotation cell has been a technology standard for many decades. FLS has improved the original design with a new configuration which improves hydrodynamic, kinetic, and metallurgical performance. Guiding principles were investigated and generated with FLS's forced air flotation offering, the nextSTEP flotation cell, and carried over into the improvement of the new design, the WEMCO II. Principles developed at bench and pilot scale were applied to prototype industrial scale units which were compared with existing traditional WEMCO installations in mills in Northern and Southern America. The North American installation involves a quantity of two WEMCO 1+1 #225 (80m3) cells installed at the end of a rougher row. The South American installation involves a quantity of two WEMCO 250RT (250m3) cells installed second from the first rougher and second from the last scavenger in a row. Improvement is measured from comparative data including intake air velocity, superficial gas velocity, retention time and Peclet number comparison from RTD testing, solids suspension, froth velocity, froth stability, and metallurgical performance. Qualitative results are also reported.

2:45 PM

Brownfield Expansion Opportunities in Base Metal Concentrators using StackCell® High-Intensity Flotation

E. Dohm[1], M. Tuchscherer[2] and H. Thanasekaran[3]; [1]Eriez USA, Erie, PA; [2]Eriez Canada, Delta, BC, Canada and [3]Eriez Australia, Epping, VIC, Australia

As the demand for critical minerals increases to support transition to renewable-based systems of energy production, mine operators seek profitable methods to increase production from existing base metal assets. High-intensity flotation technology presents a substantial opportunity for debottlenecking and plant expansion projects due to reduced capital and operating costs compared to conventional flotation technology. In the past decade, application of high-intensity flotation to base metal production has expanded from cleaner duties to include rougher and scavenger applications made possible through new technological developments. This paper highlights brownfield expansion opportunities in base metal concentrators using StackCell high-intensity flotation technology, including the approach to develop flotation process design through laboratory and pilot testing. A techno-economic comparison is offered to summarize the benefits of StackCell technology in contrast to conventional technology in base metal flotation applications. The highlighted approach provides a framework for mine operators to evaluate and assess high-intensity flotation for future brownfield expansion projects.

3:05 PM

Concorde Cell: Onsite Testwork to Industrial Installation

R. Dube[1], A. Yanez[1], N. Kupka[2] and J. Sovechles[2]; [1]Metso USA Inc, Centennial, CO and [2]Metso, Espoo, Finland

The Metso Concorde Cell™ is an advanced pneumatic flotation cell that uses supersonic shockwaves and high shearing to enhance the recovery of fine to ultrafine particles. Originally developed and patented by Prof. Jameson in the late 2000s, it was officially launched by Metso on November 4th, 2021. This technology generates fine air bubbles with a high carrying capacity, enabling increased capacity per unit, smaller plant footprints, and improved recovery of valuable fine particles that are often lost in other flotation cells. Additionally, it reduces the need for multiple flotation stages or extensive recirculation, leading to lower operational costs for power, water, and reagents. Metso's Concorde Cell journey started back in 2018 when developing first prototypes, then introducing demonstrative and production units into minerals processing flowsheet since Q1-20. To date, plant level experience has been secured in copper, gold and platinum amongst other applications. In this article, a case study will be presented, covering the metallurgical performance of the Concorde Cell from on-site lab-scale.

3:25 PM

A Case of Bad Gas: The Effect of O_2 in Cu/Mo Separation

C. Smith[2], C. Strauss[2], S. Merrill[1] and P. Thompson[1]; [1]FLSmidth Inc, Riverton, UT and [2]Rio Tinto, South Jordan, UT

The negative effect of oxygen presence on NaHS consumption is a well known problem in the separation of Molybdenite from Copper. This presentation will review a case study where different concentrations of O_2 were used in Molybdenite flotation (from 100% Nitrogen to 78% Nitrogen) to evaluate the effects it had on NaHS consumption and overall metallurgical performance. It will also discuss the different processing options that can be used to approach this problem.

3:45 PM

Jig Flotation of Coarse Composite Particles

M. Gupta, J. Leland, A. Srinivasan and R. Yoon; Mining and Minerals Engineering, Virginia Tech, Blacksburg, VA

Coarse particle flotation is difficult due to the low contact angles (θ) associated with poor liberation and the high probability of detachment due to turbulence. In the present work, we have addressed these problems by increasing the contact angles using Super Collectors that can increase θ to >150° and by improving the hydrodynamics of bubble-particle attachment. Jigs are designed to separate particles according to the specific gravities (SGs) of particles alone and to lift coarse particles by acceleration rather than inertia, both of which help improve the separation efficiencies and throughput. Promising results have been obtained on porphyry copper ore samples.

4:05 PM

Rethinking Froth Pump Sizing: Field Trials with Recessed Impeller Centrifugal Slurry Pumps

L. Haines; FLS, Tucson, AZ

Froth flotation in mineral processing often faces challenges with centrifugal pumps due to air-locking, leading to flow loss. Traditional methods oversize pumps using a froth factor to handle the expanded volume, effective for all but a few percent of applications. This paper explores adjustments to this methodology for recessed impeller centrifugal slurry pumps. Field trials with the vertical vMAX pump at a zinc & lead mine revealed the potential of recessed impellers. Despite a 3.5 froth factor suggesting air-lock risk, the vMAX operated without issues, likely due to the recessed cup impeller redirecting slurry back to the eye of the pump, breaking up air bubbles. Similarly, the horizontal hMAX, installed in a molybdenum froth transfer, replaced a failing open-auger impeller froth pump and has operated for eight months without air-locking. These trials suggest recessed impeller pumps might not need traditional froth oversizing and could be a solution for the small percentage of froth applications that traditional oversizing cannot handle. This paper will explore this idea and propose new methodologies for sizing recessed impeller pumps in froth applications.

WEDNESDAY, FEBRUARY 26 AFTERNOON

MPD: PLANT DESIGN: PLANT DESIGN II

Room 707

2:00 PM • Wednesday, February 26

Chairs: ***C. Foxworth****, Weir Mineral, North Pole, AK*
E. Buck

2:00 PM

Introduction

2:05 PM

25-028

A Review of the Operating Cost Economics of Alkaline POX

L. Coleman and C. Song; Hatch, Toronto, ON, Canada

Alkaline pressure oxidation (POX) is an oxidative pre-treatment option that is commercially used for high carbonate sulfidic gold ores. The high carbonate grades within the feed ore shifts the ideal operating pH to a basic regime. Compared with acidic POX, alkaline POX typically requires additional steam input due to a lower sulfur load and a high rate of carbon dioxide gas flows within the vent. The cost of this steam addition is the largest differentiator between acid POX operation and alkaline POX from a cost comparison. However, alkaline POX can offset these costs through reduced acid usage for pre-acidulation and decreased alkali reagent consumption for subsequent neutralization. This paper reviews this and the other impacts of alkaline POX compared to acidic POX and reviews the overall economics of alkaline POX and the regimes in which it is economically favourable. The findings aim to guide industry professionals in making informed decisions for alkaline POX adoption by providing a summary view of its operational benefits and costs, contributing to the development of cost-effective and sustainable gold ore processing techniques.

2:25 PM

Bridging the Gap Between Thickener Test Work, Equipment Designs, & Operations

M. Cook and M. Cook; Management, MINEXXT, Inc, Golden, CO

Thickeners are often a source of frustration for operations, whether for tailings or concentrates. While they can be a significant bottleneck, they often do not get the attention they need, resulting in short circuiting, insufficient feed dilution, poor flocculant addition, froth buildup, or low underflow densities and contaminated oveflow. Improperly designed feed systems can lead to air entrainment and high discharge velocities affecting settling and disturbing the settled bed. Flocculant addition in the wrong location also leads to preferential settling of coarse particles. Underperforming dilution systems that operate outside the optimal feed density impact functionality and use excessive flocculant. These factors combined with typical feedwell design flaws, result in poor thickener performance and more frustration. MINEXXT is dedicated to addressing these challenges. Case studies presented demonstrate how MINEXXT incorporates test work and latest technologies ensuring the design of specific components such as feed systems, can accommodate varying operating conditions, improve performance, reduce operating and maintenance costs, extend equipment life, and improve reliability.

2:45 PM

Rapid In-pit Crushing and Conveying (IPCC) Decision Matrix

M. Dammers[1] and T. Elkington[2]; [1]MINCS Process Engineer, Metso USA Inc, Brookfield, WI and [2]Executive Management, Snowden Optior, Perth, WA, Australia

The adoption of energy-efficient In-pit Crushing and Conveying (IPCC) technology has been unexpectedly uneven across the global mining industry, despite the critical need to reduce diesel dependence and enhance "green" electrification. Hesitancy persists even as the industry faces increasing pressure to adopt sustainable practices. There exists a range of factors to consider when evaluating IPCC viability, especially in scenarios where multiple solutions are possible. However, the complexity of these evaluations often leaves mining operations uncertain about committing to an IPCC solution. To address this, developed is a practical matrix decision tool designed to rapidly model the potential business case for various IPCC scenarios, leveraging engineering fundamentals. This paper will showcase informative plots that enable stakeholders to estimate key economic and environmental outcomes of IPCC implementation, tailored to their specific site conditions. By offering this tool, the paper contributes to the ongoing conversation on sustainable mining by equipping industry professionals with a means to make informed decisions about IPCC adoption within electrified mining operations.

3:05 PM

Flow Property Testing—How to Use Test Results to Properly Design Bulk Material Handling Systems

J. Nowoselski; Jenike & Johanson, Mississauga, ON, Canada

Material characterization is a critical first step in the process of bulk material handling system design. Understanding how a material will behave under various conditions will allow prediction of bulk material handling challenges that may be present and mitigation of the associated risks before they even arise. But how do you design your test program to properly capture the full range of conditions that may be experienced in operation? And what do you do if the results of your flow property testing show challenges that are seemingly impossible to overcome while respecting the other constraints in your system? This presentation will discuss the importance of understanding the full range of flow properties that your material could exhibit in operation and ways to mitigate risk when handling more challenging materials. Different case studies will be presented to show how your material's flow properties can be used to support decisions during the design phase to optimise the investment in the process and handling equipment to reliably meet the project objectives.

3:25 PM

Machine Learning Tools for Mineral Processing Engineers

E. Marshall; Engineering, Hecla Greens Creek Mining Company, Juneau, AK

The application of machine learning and advanced statistical modeling to sensor data typically requires coding skills, which can be a barrier for plant engineers. To bridge this gap, a public domain tool has been developed that facilitates the handling of sensor data for a broad range of machine learning applications, including time series analysis and other methods. This tool allows for the creation of time-continuous data subsets and offers user-friendly interfaces for applying various machine learning techniques to better understand plant data and its operations. The application of the tool to the grinding circuit of a large mine demonstrated impressive results and is reported in the presentation.

3:45 PM

25-005

Accelerating Plant Commissioning: Unlocking Early Profit Through Strategic Planning

A. Berton, D. Bouffard, D. Roy and S. Gariepy; Soutex, Québec, QC, Canada

Commissioning a mineral processing plant has always been a challenging task. The process includes pre-operational verification, dry and wet commissioning, and a gradual ramp-up to full production, all of which must be executed within the shortest possible timeframe, requiring numerous highly interdependent tasks to be conducted concurrently. This phase is under scrutiny by shareholders, corporate management, and other stakeholders who are keen to see a return on investment as the operation starts yielding results. Despite extensive documentation in the literature highlighting its significance, the impact of the commissioning phase remains underestimated in contemporary mining projects. This paper provides an overview of the commissioning process and its associated challenges before focusing on a critical success factor: building a dedicated commissioning team with the required competencies and personality profiles. Insights from Soutex's involvement in multiple start-ups are shared, offering lessons learned that emphasize best practices and challenges encountered in expediting the ramp-up process while maintaining high Health, Safety, and Environment (HSE) standards.