of this paper is to take the producer through an analysis that reviews an electric motor, a gear reducer, mounted bearings and belt drives as each relates to overall system efficiency. There will be a thoughtful component by component analysis of an actual bulk material handling system. Alternative design concepts that are readily available will give the producers ideas that can increase their overall system efficiency and reduce operating costs through reduced power consumption.

2:45 PM

Data Driven Analysis for Design and Maintenance of Conveyors for Practical Improvements Towards Efficiency and De Carbonization Goals

P. Ormsbee; Overland Conveyor Company, Inc., Lakewood, CO

Modern mine development and planning requires cost effective material handling solutions. Additionally, certain areas of the world are providing significant incentives towards electrification projects, efficiency improvements, and general decarbonization initiatives. Belt conveyor solutions naturally fit within the conversation of decarbonization and electrification. However, not all conveyors are the same. This presentation will discuss how operating data from existing conveyors can drive us towards creating more efficient conveyor solutions. Real world new build design projects as well as existing conveyor projects will be discussed to show how easily available data can provide significant strides toward our efficient mining goals.

3:05 PM

Improving Haul Truck Operation with AI: Use-Cases for Optimization in the Mining Industry

A. Agarwal; Symboticware, Sudbury, ON, Canada

Mining haul trucks have an average utilization rate of 70%. A fleet of just 30 haul trucks may consume up to 28 million liters of diesel annually. Integrating AI engines into fleet management in the mining industry offers significant potential to improve the efficiency and productivity of haul trucks. Key benefits stem from real-time multi-variate regression and neural network-based analysis of key vehicle health, operational, and environmental parameters. These parameters include fuel consumption data, engine oil temperature, road surface conditions, strut pressure, vehicle speed and acceleration rates, the health of fuel and air filters, and others. The outcome of these analyses is presented as actionable recommendations leading to substantially reduced fuel wastage, precision maintenance, and higher productivity. The presentation will highlight the principal advantages of AI adoption, including a customer case study on optimizing fuel costs for haul trucks by up to 9%. The paper will also highlight the barriers to enterprise-level implementation of AI technology and opportunities to accelerate penetration by educating stakeholders across mine sites.

3:25 PM

Ultra-Efficient Haulage: First Rail-Running Belt Conveyor—To Carry 13,000Mtph in 2024

M. Lurie1, T. Turner1, C. Wheeler2, M. Carr1 and P. Robinson1; FLSmidth, Inc., Greenwood Village, CO and 1University of Newcastle, Newcastle, NSW, Australia

In 2024, the world’s first production conveyor system with the ultra-efficient Rail-Running Belt Conveyor™ technology (RRC) will haul up to 13,000Mtph of ROM copper ore over a 3,000m route. An RRC system of this scale can save more than $2,000,000 per year in power costs compared to conventional belt conveyors, with CO₂ reductions of 13,000mtpy. A second system of similar length will carry ore at 5,000Mtph in July 2025. RRC arrives as the most energy-efficient bulk haulage technology at any scale now available to the mining sector. OPEX reductions will be in the range of 30% to 60% vs. conventional conveyors, varying by the application. Additionally, meaningful CAPEX savings for civils, erection and equipment supply will flow to owners, depending on the terrain, lift and climate. The RRC technology platform also offers a step-change in conveyor maintenance and safety, thanks
to wheeled carriages that continuously circulate past an automated inspection and exchange point, eliminating fixed run-of-conveyor idlers. The RRC technology has come to fruition through a collaboration between FLSmidth, the University of Newcastle (Australia), and a visionary top 10 global copper miner.

**MONDAY, FEBRUARY 26  AFTERNOON**

**COAL & ENERGY: BEST OF GROUND CONTROL**

**North 227B**

2:00 PM • Monday, February 26

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

**2:00 PM**

**Introductions**

**2:05 PM**

**The Road to Zero: The Fifty-Year Effort to Eliminate Roof Fall Fatalities from US Underground Coal Mines**

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

Sixty years ago underground coal mining was the most hazardous job in the US. Roof falls were a big part of the problem. They killed about 100 miners every year, more than all other causes put together. Fast forward half a century to 2016, and the first year ever with zero roof fall fatalities. Just three miners were killed by roof falls during the following six years. How was this historic goal achieved? This paper starts with a modern analysis of the causes of the roof fall fatalities in 1968. Then it follows the reductions over time by category, using snapshots of the fatalities occurring in subsequent decades. Along the way it evaluates the influence of the regulatory environment, changing mining methods, and better ground control technology. The paper shows that in 1968 more than half of roof fall fatalities at large mines were attributable to an inadequate safety culture. The immediate effect of the 1969 Coal Mine Health andSafety Act was to reduce the riskiest activities, like needlessly going under unsupported roof. Roof Control Plans, which the US Bureau of Mines had been advocating since the 1920’s, played a significant role throughout the process.

**2:25 PM**

**Examination of Coal Burst Mechanics and Control Measures in Major United States Coal Fields**

H. Maleki; Maleki Technologies, Inc., Spokane, WA

This presentation will summarize results from a study completed for ACARP to assist Australian operations with better understanding of coal burst mechanics and control based on U.S. practical experience, and investigations in three major U.S. Coal Fields. The intent is to identify contributing risk factors and critical stress levels through re-examination of both nonviolent and burst prone case studies while addressing failure mechanism for major US coal fields in Utah, Colorado, and Kentucky, with diverse characteristics.

**2:45 PM**

**Coal Pillar Rib Stability: A Regression Model Based on Distinct Element Method**

K. Mohamed1, M. Sears1, T. Sherizadeh2, A. Kirmaci2, S. Nowak2 and D. Guner2; 1CDC NIOSH, Pittsburgh, PA and 2Mining and Explosives Engineering, Missouri S&T, Rolla, MO

Coal ribs present a safety hazard in underground mines, and there are no unified approaches for their design in the US. To tackle this issue, this study investigated the stability of underground coal pillar ribs under development load. Utilizing over a thousand 3DEC models, a framework for calculating Coal Pillar Rib Rating (CPRR) was developed. A detailed method was outlined for computing the CPRR based on a 3DEC analysis, which was validated with various 3DEC models, demonstrating a strong correlation between the two. Results demonstrated that the Rib Factor of Safety (RibFOS) under development load is directly proportional to Coal Pillar Rib Rating (CPRR), Coal Mine Roof Rating (CMRR), and floor strength, and inversely proportional to the overburden depth and rib height. Moreover, a regression equation was formulated to predict the RibFOS based on the aforementioned parameters. Empirical relationships were developed between the RibFOS and the applied Primary Rib Support Density (PRS D) in U.S. coal mines. To ease the calculations, a standalone application, Design of Rib Support (DORS), was developed. This application can be used to calculate CPRR, RibFOS, and PRSD easily.

**3:05 PM**

**Scale Effects in Coal Mine Ground Control and Implications for Practical Decision Making**

M. Gadde; Peabody Energy, St. Louis, MO

Practical applications of ground control in mining from experience over the past 20 years. Ground control decisions are often made very quickly in response to mine development and based on laboratory testing. The use of laboratory results and past scaling guidelines has significant implications on mine planning and ground control outcomes. There are still many opportunities to improve the correlations between lab and field scale and some will be explored during this presentation.

**3:25 PM**

**Numerical Modeling on Influence of Vehicle Dynamic Loads on Residual Subsidence Characteristics of Roads Above Longwall Gobs**

G. Zhao; Mining Engineering, West Virginia University, Morgantown, WV

Besides geological and mining conditions, surface residual subsidence above longwall gobs is also affected by the dynamic loads of vehicles. This paper will investigate the influence of road vehicle dynamic loads (RVDL) on residual subsidence characteristics through numerical simulations. FLAC3D modeling will be established based on geological mining conditions in a longwall mine (Jiaozuo, China), road structures (pavement, cushion, subgrade, etc.), and relative positions between longwall panels and roads. The input parameters of modeling will be calibrated by measured surface subsidence. Considering such factors as the road traffic volume, axle load conversion and distribution coefficient of vehicle types, the theoretical equation of RVDL will be derived with different time-period, traffic compositions and driving speeds. Then RVDL equation will be applied into the established numerical modeling. Finally, the influence of RVDL on residual subsidence characteristics will be analyzed, including surface subsidence, horizontal movements, slopes, curvature, etc. The research can provide theoretical support for designing, building and maintaining roads subjected to subsidence damages.

**MONDAY, FEBRUARY 26  AFTERNOON**

**COAL & ENERGY: COAL TO PRODUCTS**

**North 226A**

2:00 PM • Monday, February 26

*Chair: E. Shereda, CONSOL Energy Inc, Canonsburg, PA*

**2:00 PM**

**Introductions**

**2:05 PM**

**Innovative Repurposing of Appalachian Resources to Support U.S. Supply Chain Security**

J. Trembly and Y. Al-Majali; Ohio University, Athens, OH
Meeting the global demand for sustainable building materials, ensuring U.S. supply chain security, and minimizing environmental impact necessitates the use of alternative materials. Appalachian coal resources, encompassing reserves and waste, represent high-quality feedstock for the production of carbon materials suitable for a modern society. Ohio University (OHIO) and its industry partners have taken a leadership role in the development and application of technologies aimed at manufacturing carbon materials that cater to the building, construction, and energy storage market segments. This presentation offers an overview of the pivotal role coal plays in sustainably supporting a secure U.S. materials supply chain. Additionally, it will delve into ongoing R&D efforts focused on engineered composites, carbon foams, and nano-carbon products, along with their associated techno-economic and lifecycle considerations.

2:25 PM
Coal-Derived Graphene—An Economical and Environment-Friendly Process for a Spectrum of Applications
R. Mahajan; Mechanical Engineering, Materials Science Engineering, Virginia Tech, Fairfax, VA

In this talk, I will briefly describe an in-house developed, cost-effective, and environment-friendly innovative process that employs for the synthesis of graphene oxide from coal (Coal-GO), which is further reduced to produce a few-layered graphene nanosheets in lateral size of 300-700 nm. The superior properties of coal-derived graphene in comparison to its counterpart produced from graphite using the Hummers’ method will be demonstrated for a number of applications, including enhancing the mechanical performance of glass fiber reinforced polymer (GFRP) composites, and improving the sensitivity of chemiluminescence resonance energy transfer based biosensors.

2:45 PM
Coal to Carbon Products
G. Henthorn, D. Berry and S. Page; AmeriCarbon Products, LLC, Morgantown, WV

Industry relies on the steel industry, located principally in China and other Asian nations, to produce a coal tar by-product that is the precursor to a number of advanced carbon products including certain foams, composites, graphite, binders, and other important materials. AmeriCarbon has developed an alternative chemical pathway to manufacturing a highly tailorable coal tar pitch that meets and exceeds industry specifications. Our proprietary and patented chemical process does not use combustion and reduces greenhouse gas emissions dramatically compared to current supplies. Our Eco-Pitch™ can be optimized for specific applications including EV batteries, defense applications, and other growing markets.

3:05 PM
Value-Added Carbon Conversion Building Products and Battery Anode Materials
W. Easter, B. Mutter, W. Sherwood and K. Marcus; CEO, Oviedo, FL; Director, Bluefield, WV; Chief Scientist, Orlando, FL and Director of R&D, Oviedo, FL

X-MAT R&D activities with coal have been concentrated on the usage of coal as a carbon feedstock for building products and anode composites for lithium ion batteries. Carbon Core Composites do not burn in an open flame due to the ceramic transformation process and are lightweight, durable, and stronger than conventional building material alternatives. The DOE NETL has awarded X-MAT a contract to build a demonstration building using Carbon Core Ceramics by April 2024. 18650 Lithium Ion Batteries produced with coal-derived anodes have lasted over 1000 charge and discharge cycles. This talk will highlight the battery and building activities.

3:25 PM
Carbon and Graphite Products Synthesized from Coal
D. Morgan; Touchstone Research Lab, Triadelphia, WV

Coal is by far the nation’s most abundant energy source, constituting nearly 90% of all fossil fuel reserves. Coal has also been found to be a critical carbon source for synthesizing numerous chemical products. For example, by-products of coal, such as refined coal tar, are used in the manufacture of benzene, creosote oil, naphthalene, and phenol. Most recently there are significant research activities in the development of products from coal for aerospace, automotive, construction, energy, and industrial applications to name a few. A review of carbon and graphite products synthesized from coal at Touchstone Research Laboratory is presented.

3:45 PM
Coal-Based Products for Carbon Management and the Energy Transition
C. Hill; Ramaco Carbon, Ranchester, WY

At Ramaco Carbon we are promoting the slogan “Coal is Too Valuable to Burn!” and executing on the motto “No Molecule Left Behind.” Through our efforts we are beginning to focus on specific technologies in coal processing that result in products that are enabling the energy transition such as graphite for electric vehicle batteries, activated carbon fiber for exciting new carbon capture methods, and rare earth elements for high-powered magnets, motors, and electronics. The timeline of our development efforts as well as expectations for performance in emerging markets will be covered.

4:05 PM
Manufacture of Carbon Foam and Associated Microstructure, Properties, and Performance Characteristics
R. Olson; R&D, CONSOL Innovations LLC, Triadelphia, WV

Carbon foam products have been manufactured from coal for several years now. Advancements continue to be made in the manufacturing process, as well as the microstructure, properties and performance of the products. In order to reduce cost and increase capacity, a new process for making carbon foam is being developed that can be performed at atmospheric pressure (supported by a cooperative agreement with the DOE-NETL, award number DE-FE-0031992, Coal-Derived Carbon Foam Produced via a Continuous Process). This advance in turn would enable the development of a continuous manufacturing process, which is also being pursued. In addition, the microstructure and properties of carbon foams are being manipulated to create improved performance to enter new applications, such as heat exchange, batteries, and fire resistance. These new aspects and more will be discussed.

4:25 PM
Coal-Enhanced Composite Materials for Sustainable Additive Manufacturing: Material Development and Properties
Y. Al-Majali and J. Trembly; Ohio University, Athens, OH

This study investigated the utilization of coal as a filler in plastic composites for use in additive manufacturing (AM) applications. Coal (20-70 wt.%) was compounded with polyactic acid, polyethylene terephthalate glycol, polyamide 12, and high-density polyethylene to produce carbon-plastic composite filaments/pellets for use in commercially available 3D printers. Resulting composites, including carbonized ones, offer eco-friendly alternatives to existing materials used in building/construction and tooling applications. The impact of coal content and type on the thermal, physical, and mechanical properties of additively manufactured structures will be discussed. The presentation will also discuss preliminary techno-economic and market analyses of the technology.
2:00 PM
Introductions

2:05 PM
Comparison of Respirable Coal and Silica Dust Monitoring Systems for Underground Mining Applications

During coal mining operations, underground miners are exposed to respirable coal mine dust (RCMD) and respirable crystalline silica (RCS). Therefore, workers are constantly exposed to hazardous materials that may affect their health, causing lung disease and even death. This has led to the need to create better dust control techniques and dust monitoring systems to identify overexposure areas and implement controls. This research compares four silica analysis methods. The first method is the RingIR dust monitor. This measures real-time RCMD and RCS concentration levels. The second and third methods are NIOSH 7500, and NIOSH 7603, used for the Coal Mine Dust Personal Sampling Unit, consisting of an ELF Escort pump operating at 2.0 L/min, a 10-mm Dorr-Oliver cyclone, and a 37-mm 5 µm PVC filter. The fourth method is the NIOSH FAST, which uses a Coal Mine Dust Personal Sampling Unit or a 4-piece cassette. This will measure respirable dust concentration and determine the silica content. All testing is conducted by dispersing the aerosol generator SAG 410 U in a test chamber with the inlets of the sampling devices, connected with a humidity control station to monitor the conditions.

2:23 PM
Optical Microscopy as the Basis for a Coal Mine Dust Monitor for Simple Source Apportionment
N. Santa and E. Sarver; Mining and Minerals Engineering, Virginia Tech, Blacksburg, VA

Developing advanced real-time monitoring technologies that can identify the constituents and sources of respirable coal mine dust (RCMD) is critical for tracking dust sources, evaluating controls, and protecting miners from hazardous exposures. In many underground mines in the US, RCMD can be linked to three main sources: cutting into the target coal seam, cutting or drilling into the surrounding rock strata, and application of rock dust products used to prevent explosions. Our team is developing a new monitoring concept that can enable dust source apportionment. It uses portable field-microscopy with polarized light and advanced image processing to classify respirable particles into three categories: coal, silicate minerals, or carbonates. Laboratory results indicate that respirable particles can be classified with 84% accuracy. A new phase of research is investigating the feasibility of specifically classifying silica particles from other silicates.

2:41 PM
Synthesis of Graphene from Coal Waste for Advanced Applications
S. Reina1, W. Birch1, A. Douglas1 and C. Johnson2; 1: ‘Mining Engineer, Member, Rolla, MO; 2: ‘Blasting and Environmental, Research, Leeds, Beeston, UK

Coal has been a staple of electrical power for decades, though in varying quantities and in different forms, for many coals, though in varying quantities and in different forms, including tap and process water and simulated lung fluid. The pyrite surface was assessed using electro-kinetic measurements and infrared and X-ray photoelectron spectroscopy that indicate the presence of different impurities in the pyrite. Density functional theory simulations suggested the mechanisms of interactions on the pyrite surface. This research enhances our understanding of the potential health effects of pyrite dust and ways to reduce the OH on the surface of pyrite.

2:59 PM
Respirable Dust Generation from Coal Versus Rock Strata and the Effect of Continuous Miner Sprays
F. Animah, A. Greth, C. Keles and E. Sarver; Mining and Minerals Engineering, Virginia Tech, Blacksburg, VA

Respirable crystalline silica poses a significant health risk in underground coal mines. Particularly in room and pillar operations, silica and other silicate minerals found in the surrounding rock strata are often the main source of this hazard. Previous research has indicated that continuous miner (CM) cutting into the rock strata can generate substantially more respirable dust than cutting into the coal itself, which underscores the need for targeted dust controls. In the current study, we evaluated dust concentration, particle size and constituents associated with CM cutting into rock versus coal strata in a thin seam mine in central Appalachia. The CM was outfitted with typical chassis water sprays, as well as bit sprays (i.e., wethead). Samples were collected under standard spray pressure and volume per the mine’s MSHA-approved ventilation plan, and also when the spray pressure and volume were maximized to evaluate relative changes in dust suppression.

3:17 PM
An Evaluation of Pyrite as a Component of Respirable Coal Dust
A. Eskanlou and B. Arnold; Energy and Mineral Engineering, The Pennsylvania State University, University Park, PA

As coal worker’s pneumoconiosis has increased over the past two decades, researchers have evaluated the potential effects of coal, quartz, and other minerals as components in respirable coal dust. Pyrite is found in many coals, though in varying quantities and in different forms, for example, crystalline or framboidal. The oxidation of pyrite produces OH, a reactive oxygen species (ROS) thought to cause the toxicity of dust once in the lung. In this study, we used fluorescence values for OH and tested additives to inhibit OH production across different pH levels with different coal pyrite samples. Promising candidates were evaluated in various solutions, including tap and process water and simulated lung fluid. The pyrite surface was assessed using electro-kinetic measurements and infrared and X-ray photoelectron spectroscopy that indicate the presence of different impurities in the pyrite. Density functional theory simulations suggested the mechanisms of interactions on the pyrite surface. This research enhances our understanding of the potential health effects of coal pyrite and ways to reduce the OH on the surface of pyrite.

3:35 PM
Waste PET Bottles Derived Electrospun Ultrafine Nanofibers for Coal Mine Dust Filtration
M. Zaid, A. Kakoria and G. Xu; Mining Engineering, Missouri University of Science and Technology, Rolla, MO

Overexposure to coal dust is a significant concern, leading to various respiratory diseases in coal miners, including Coal Workers' Pneumoconiosis (CWP). Controlling this exposure relies on two key methods: dust control and personal protection, with the latter proving most effective. The N95 mask, while offering optimal filtration efficiency, poses limitations due to respiratory resistance and wear-time constraints (4 Hrs). If N95 mask is used continuously for a long time, it will cause lung injury. Our study introduces a novel nanoﬁber facemask crafted from waste plastic bottles (PET) using electrospinning (ES). Designed for coal mine dust, this mask offers high efﬁciency, low pressure drop, reusability, and extended lifespan, demonstrating its potential as a superior personal protective equipment option for coal miners.
Ultrasonic Water Spray System Technologies for Dust Control Applications
M. Beltran1, S. Han1, M. Lozano2, B. Arko1, M. Rezaee2 and P. Roghanchi2; 1Mineral, Student, Socorro, NM and 2Professor, Socorro, NM

Respirable coal mine dust (RCMD) poses an important occupational health hazard in daily mining operations. Spray technologies are commonly employed for dust control, however, the efficiency for reducing RCMD remains insufficient and has been reported to be below 50%. Several factors affect the ability of water droplets to interact and capture dust particles, with the droplet size being of utmost importance. This study aims to investigate the potential of ultrasonic nozzles which produce smaller water droplets, in comparison to traditional atomizing nozzles in capturing RCMD particles, with the objective of finding an efficient and operationally water-based technology for RCMD control.

Study on the Interaction Between Respirable Coal Mine Dust and Water Droplets by Analytical and Computational Approaches
S. Han1, M. Rezaee1 and P. Roghanchi1; 1Energy and Mineral Engineering, The Pennsylvania State University, University Park, PA and 2Mineral Engineering, New Mexico Institute of Mining and Technology, Socorro, NM

In practice, the capturing efficiency of Respirable Coal Mine Dust (RCMD) by water spray system is relatively low. To understand the capturing mechanism and develop improvement strategies, this research studied the interaction of water droplet with RCMD by an analytical approach. The model equation was parameterized on the properties of water droplet and RCMD, and clearly shows how those properties affect the capturing results. Based on the model, regime maps were created where strategies for enhancing the capturing efficiency were developed by modifying the water droplet characteristics. In addition, the interaction was also simulated by Computational Fluid Dynamics (CFD).

Towards Very Compact Photoacoustic Instruments for Real-Time Measurements of Respirable Crystalline Silica, Kaolinite, Coal, and Calcite
W. Arnott1, C. Kocsis2, X. Wang1, B. Osho1 and M. Sandink1; 1Physics and Atmospheric Science, University of Nevada Reno, Reno, NV; 2Mining Engineering Department, University of Utah, Salt Lake City, UT; 3Division of Atmospheric Science, Desert Research Institute, Reno, NV and 4Mineral and Metallurgical Engineering, University of Nevada Reno, Reno, NV

Real-time measurements of speciated coal mine dust mass concentration (DMC) are needed for health and ventilation on-demand applications. A common method captures dust on filters by means of a vacuum pump, sampling cyclone to get the respirable aerosol, and FTIR analysis to obtain end-of-work-shift measurements. We are developing a photoacoustic spectrometer equipped with a tunable quantum cascade laser (QCL) to measure speciated DMC in real-time. The QCL is tuned to four wavelengths to quantify DMC for respirable crystalline silica, kaolinite, coal, and calcite. We have demonstrated this approach with laboratory measurements and a well-characterized photoacoustic instrument. We report design and demonstration of a much smaller resonant cell photoacoustic instrument for realizing the goal of on-demand measurements of respirable aerosol components. The instrument is capable of detecting aerosols in real-time, providing respiratory health professionals with real-time data for making informed decisions.

Art and Engineering at South Dakota Mines
J. Kellar1, K. Donovan1, M. West1, M. Whitehed1, C. Birrenkott1, and D. Mitchell1; 1Materials Engineering and Science, SD School of Mines and Technology, Rapid City, SD; 2Humanities, Arts and Social Sciences, South Dakota School of Mines and Technology, Rapid City, SD and 3Mechanical Engineering, South Dakota School of Mines and Technology, Rapid City, SD

A multi-faceted pedagogical program focused upon inorganic materials, specifically clay-based ceramics and glasses, has been developed. The program has been branded as Art and Engineering (A+E) and involves undergraduate (Metallurgical Engineering) curriculum and co-curricular components. The A+E program components will be reviewed and a discussion of the role that A+E plays in the education process will be undertaken. A+E is responsible for adapting the education and training of future mining professionals to the constant changes and new training profiles required.
It is due to the need for constant updating in the educational training of mining engineers that private companies must be active promoters of the approach to new trends and market needs. Since 2018, the Universidad Politécnica de Madrid has implemented the Epiroc Industry-University Chair which involves the committed participation of Epiroc in an elective lecture in cooperation with the university which has increased the skills of the students and strengthens the relationship with the industry. After the pandemic, in 2021, the Universidad Nacional Mayor de San Marcos adopted the Spanish model and since then a Hub & Spokes model of collaboration between industry and academy has been developed. This paper aims to highlight the latest developments regarding the expansion of this model to other regions of the World.

3:05 PM

All About Mining: Partnering with K-12 Teachers on the Importance of Responsible Mining
R. Miles; The Electrum Group, Centennial, CO

AllAboutMining.org has transformed its courses to reach more teachers and students in more places about the importance of mining. We’ve modified our course from one long course into several shorter, flexible offerings. By offering multiple two-day teacher workshops, an online course, and two-to-four-day field trips we can immerse teachers into the world of modern mining and the importance of the industry today and in the future. A few quotes from our teachers reached this summer: “Go to this workshop! You will learn so much and experience the industry from all sides.” “The mine tours were amazing, I can’t wait to take my students!” “Mining is essential to our lives; we can’t do without it!” Since 1968, the All About Mining course has been offered annually on the Colorado School of Mines (CSM) campus in Golden, Colo. Initially the course was six-weeks long, but it was shortened to a four-week course in 1980s. In 2014, it was modified to a hybrid online and in-person course, with the current courses being developed in 2020. Since the first class in 1968, more than 1,800 teachers from 45 states and several foreign countries have attended an All About Mining course.

3:25 PM

Virtual Ore Microscope: An Interactive Cloud Application to Learn Optical Properties of Ore Minerals
H. Rezeau1, N. Pham1, J. Felker1 and L. Brown1; 1Mel & Enid Zuckerman College of Public Health, University of Arizona, Tucson, AZ and 2Department of Geosciences, University of Arizona, Tucson, AZ

The Virtual Ore Microscope (VOM) is an interactive virtual petrographic microscope that allows users to examine ore minerals and their microscopic optical features. The VOM app targets geoscientists and metallurgists as well as instructors who want to introduce ore microscopy in their courses. Available for iOS and Android, VOM helps users understand optical properties of various ore and alteration minerals formed in ore deposits without the need for expensive microscopes. VOM provides a database of polished thin sections featuring a variety of ore deposit types, such as porphyry copper systems, volcanogenic massive sulfide, and sedimentary-hosted deposits, among others. For each searchable sample, users can access 1) a geographical and geological context, a list of minerals, and a bibliography; 2) an interactive “Magic Lens” showing correlated views of scanned thin sections under different light types (transmitted PPL, XPL; reflected PPL, XPL); and 3) predefined locations of mineral assemblages where users may experience a hands-on, 360° rotation view under different light types. In this talk, we discuss the design and implementation of VOM, outlining use cases and results.

3:45 PM

Innovative Approaches to Building Technical Capability for a Modern Mining and Metals Organisation
B. Howard; Rio Tinto, Brisbane, QLD, Australia

Rio Tinto has a large globally distributed technical workforce and needs to ensure these employees have the requisite skills to not only manage technical risk and enable safe efficient production, but also ensure they are keeping pace with a fast changing technological landscape. Traditional approaches to learning struggle for scale and an inability to respond to the extreme diversity of capability development needs. In response, Rio Tinto has successfully introduced innovative approaches to learning and employee engagement via leveraging the power of globally distributed networks for peer to peer knowledge transfer and providing mechanisms to recognise, reward and retain the individual technical contributors. Some of the lessons learned have potential for a broader application at industry scale.

4:05 PM

Bridging the Gap in Engineering Development
S. Maldonado and M. Rubalcava; Plant Engineering, Freeport-McMoRan, Morenci, AZ

The mining industry has been challenged to attract, develop, and retain the ever-changing engineering workforce. By default, engineering groups only develop their teams by peer-to-peer, on-the-job learning, or site-specific professional trainings. This is an opportunity to formalize a standardized organization-wide program to develop our people through onboarding and continuous career development. The “Mining and Engineering Development (MinED) Program” identified the skills and knowledge the engineering workforce needs to be successful and effective at their job. This program identifies four core development pillars: (I) Engineering, (II) Technical, (III) Professional, and (IV) Operational Knowledge. Development in each of these pillars allows professionals to increase results, build a strong network, and foster development while increasing retention within our organization.

MONDAY, FEBRUARY 26 AFTERNOON

ENVIRONMENTAL: ABANDONED MINE LANDS: CONSIDERATIONS & OPPORTUNITIES

North 126B

2:00 PM • Monday, February 26

Chairs: L. French, WSP USA, Inc., Lander, WY
M. Chastain, WSP, Redmond, WA

2:00 PM

Introductions

2:05 PM

Fit-for-Purpose Mine Closures for Effective Safeguarding of Active and Abandoned Mine Sites
B. Drake and J. Nopola; RESPEC, Cheyenne, WY

The effective management and safety of mine openings, both at active and abandoned mine sites, are critical to prevent hazardous incidents and environmental degradation. RESPEC, with its clients, has created active mine openings with robust bulkhead designs that withstand ongoing mining operations, maintain ventilation pathways, create flow-control plugs, and maintain mine access. RESPEC has also worked with Abandoned Mine Land (AML) programs nationwide to create cost-effective mine closures for abandoned and legacy mine sites. A wide variety of conditions inform our closure techniques with abandoned sites, including water flow, bat/mammal ingress/egress, and mineral claimant/biologist access. RESPEC understands that effective bulkhead...
design and construction for mine openings demand a multidisciplinary approach, integrating geological, hydrological, engineering, and environmental factors. By implementing well-informed designs, mine operators and AML programs can ensure the long-term safety and sustainability of active and abandoned mine sites, mitigating potential risks and preserving the natural environment.

2:25 PM

Rehabilitation of Historic Mine Workings—A Phased Approach
S. Longo, J. Taylor and D. Kennard; WSP Canada Inc, Calgary, AB, Canada

In many abandoned or historic mine sites the problems are often well understood but the knowledge or experience or funds to actually fix them are out of reach. This results in many sites being ‘monitored’ and/or using treatment processes to ‘manage’ the situations. This technique is very common but it is also not really a solution to the underlying problems. In this paper we will discuss the assessment, design and implementation of rehabilitation options for near surface underground voids at historic mines. The paper will discuss the how and why of site investigations, stability assessments and remediation goals along with practical solutions and evaluation processes using case studies. Included will be a short history as to how the closed mine examples generated problematic contamination or why it continues to pose a risk and why its remediation is essential. The rehabilitation options and how they affect subsequent development will also be discussed. The intent is for this paper to present methods and solutions to go into the “toolkit” to practically and permanently fix the problems associated with near surface underground voids.

2:45 PM

Federal and State Efforts to Clean Up Abandoned Mines in Pinto Creek Watershed
K. Hermanson, Watershed improvement Unit, Arizona Dept of Environmental Quality, Phoenix, AZ

In 1998, Pinto Creek (Gila County, Arizona) was placed on the Clean Water Act Section 303(d) list as impaired for dissolved copper. The USFS remediated 5 abandoned mine sites excavating a total of 8,000 cubic yards of mine waste and closing 10 adits and 6 shafts. The largest copper source in Pinto Creek, the Gibson Mine, was remediated by ADEQ. The first remediation in 2007 removed 100,000 tons of mine waste from the site. Cu concentrations were reduced by 50% but surface water samples still did not meet water quality standards. The second remediation implemented stormwater controls: clean stormwater was diverted to a bypass culvert and discharged to an ephemeral tributary to Pinto Creek; disturbed lands channeled stormwater to impoundments to be retained on-site. Cu concentrations reduced by 75% but still did not meet standards. The final remediation (2022) consisted of “hot spot” excavations based on x-ray fluorescence (XRF) assessments that identified elevated concentrations of Cu. Today’s samples are meeting water quality standards. This improvement is attributed to the efforts of the USFS and ADEQ to identify, prioritize, and remediate abandoned mines in the watershed.

3:05 PM

Rehabilitating Abandoned Clay Tailings Storage Facilities for Use as Water Reservoirs and Alternate Water Supply Sources—A Case Study
N. Shah; WSP USA Inc, Tampa, FL

The Upper Peace River (UPR) basin in Central Florida has been extensively mined for more than 100 years, with all mining, beneficiation, and tailings disposal activities occurring adjacent to the Peace River. Repurposing abandoned mine cuts and clay tailings storage facilities as water reservoirs has a significant potential to serve as additional sources of water to enhance flows in the UPR during low flow periods, as well as provide flood storage during extreme flow events. Additionally, stored water may also be utilized as an alternative water supply to cater to increasing water demand. This presentation will review the data collection process, water balance analysis conducted for storage estimates and reservoir yield calculations, mine site rehabilitation process, construction feasibility and expected costs, and infrastructure design considerations for a proposed 2,500 acres reservoir location within the basin. The results of the feasibility analysis showed that routing excess flows from the river to the reservoir provided flood mitigation benefits and allowed for supplementing river flow during low flows, in addition to providing almost 2 MGD alternative water supply yield.

3:25 PM

Sage-Grouse Reclamation & Restoration
J. Oakleaf; Abandoned Mine Land Division, Wyoming Department of Environmental Quality, Lander, WY

The sagebrush steppe ecosystem is the largest interconnected habitat type in North America. It covers 165 million acres in 11 western states, one Canadian province and is home to hundreds of obligate wildlife species that rely upon the ecosystem’s health and vigor, including the greater sage-grouse (Centrocercus urophasianus). Sage-grouse habitat fragmentation and population declines across the sagebrush steppe have been so severe in the last half a century that the species has been designated as a candidate for listing under the Endangered Species Act. An endangered species listing could have the potential to severely impact Wyoming’s two most iconic industries, agriculture and energy development. In 2019, Governor Mark Gordon strengthened Wyoming’s Sage-Grouse Core Area Management Strategy by adding habitat restoration and enhancement as a conservation priority (Exec. Order No. 2019-3). AML identified this Executive Order as an opportunity to maximize reclamation outcomes by setting goals to establish functional sage-grouse breeding, brood rearing, and nesting habitats on large-scale geomorphic reclamation projects.

3:45 PM

Environmental Intelligence: GIS-Based Abandoned Mine Lands Assessment in Arizona
S. Salati, M. Barton, J. Neilson and C. Richardson; University of Arizona, Tucson, AZ

Arizona is developing an advanced GIS-based database for its abandoned mine lands (AMLs) that integrates diverse spatial data (e.g., mineralogy, water/soil chemistry, vegetation cover) to facilitate informed mining and environmental decision-making. Objectives encompass creating a comprehensive AML database, evaluating risks/opportunities, and engaging government, industry, and public partners. Existing AML datasets (often contradictory and incomplete) are being synthesized and expanded upon to address the varied needs of stakeholders. The goal of this project is to empower users with a decision-making tool to simultaneously help meet the increased demand for sustainable raw materials and identify areas in need of environmental/hazard mitigation.

4:05 PM

Building National Inventories of Mine Waste and Abandoned Mine Land Features for the United States
J. Mauk, N. Karl and C. San Juan; U.S. Geological Survey, Denver, CO

The U.S. Geological Survey’s USMIN project is working to build two new national inventories: (1) non-coal mine waste for the U.S. Geological Survey’s Earth Mapping Resources Initiative (Earth MRI) to help evaluate whether mine waste may be suitable for reprocessing to recover critical minerals and other commodities, and (2) abandoned mine features for the Department of the Interior to help assess, reclaim, and remediate these features. Both inventories are funded by the Infrastructure Investment and Jobs Act of 2021, and both rely on collaboration with State, Federal, and Tribal agencies to populate the databases. This presentation will describe both inventories.
4:25 PM
Application of Innovative Approach to Passive Water Treatment at Abandoned Mine Lands and Active Mine Sites
J. Collyard; SLR, Lakewood, CO
The Arizona Department of Environmental Quality (ADEQ) manages multiple Abandoned Mine Lands (AMLs) including many sites with impacts to surface water and groundwater. Of these sites is the Stormcloud Adit located near Prescott, Arizona. In 2020, ADEQ and SLR teamed up to perform a bench-scale test of a new treatment technology developed by SLR and Periodic Products for the treatment of mine impacted waters. This presentation will present the treatment approach developed by SLR and Periodic Products, the results of previous testing analysis conducted, and present the Stormcloud Adit project including the challenges at the site, the water quality, discharge criteria, bench-scale testing, and results of the project to date. This treatment technology and approach has proven to be successful for the treatment of mine impacted water at the benchscale and site level, including the Stormcloud Adit, and has been and is being tested at multiple other sites including active sites and may be a powerful tool for the closure and remediation of AMLs contributing to groundwater and stormwater impacts throughout the United States and beyond.

2:05 PM
Environmental Life Cycle Analysis of Direct Lithium Extraction From Brine Resources in Nevada
S. Nili1, S. Mousavinezhad1 and E. Vahidi2; 1Mining and Metallurgical Engineering, Ph.D. Student, Reno, NV and 2Mining and Metallurgical Engineering, Assistant Professor, Reno, NV
Most lithium (60%) is extracted from brines, while the rest comes from pegmatites. Evaporative methods for brine extraction face criticism due to water reliance, duration, and limited applicability. Direct Lithium Extraction (DLE) has emerged as an alternative that bypasses lengthy evaporation processes. This study evaluated the environmental impact of DLE in Clayton Valley, Nevada, and compared it to traditional brine and hard rock extraction methods. The study assessed DLE’s direct and indirect impacts, focusing on global warming, land use, and water consumption while providing valuable insights into lithium production from various sources.

4:45 PM
Anaconda Copper Mine Site, Remedial Actions, Historical Heap Leach Operations
C. Weber; Env. and Infrastructure, WSP, Denver, CO
The Anaconda Copper Mine Site (ACMS) is Nevada’s largest abandoned mine lands project undergoing remediation. The Nevada Division of Environmental Protection is the lead agency for oversight of this CERCLA protective cleanup action, and WSP is performing the work under contract with Atlantic Richfield Company (ARC). The ACMS covers approximately 3,000 acres, of which 50% is private and 50% public. Significant site features include an open pit, large wastestockpiles, historical heap leaches, abandoned processing areas, and tailings deposits. Current remedial actions involve managing and mitigating ongoing acidic draindown from heap leach piles that were constructed during prior mining activities that ceased in the late 1990s. The primary remedial actions are: -Upgrade the fluid management system including construction of five double-lined fluid retention basins; -Regrade, slope, and cap the heaps and some waste pile areas with alluvium material from onsite borrow sources; and -Construction of stormwater management features and relocation of a community wastewater facility. Some 5 million yards of material were moved as part of the current remedy phase completed in October 2022.

2:05 PM
Biological Recovery of Metals From Lithium-Ion Battery Wastes
D. Reed, Y. Fujita and V. Thompson; Idaho National Laboratory, Idaho Falls, ID
As the demand for electric vehicles increases, critical mineral (CM) requirements will vastly outstrip current reserves. To help circumvent this shortfall we have developed a bioprocess for recovery and separation of CM from spent lithium-ion batteries. We demonstrate bioleaching yields of Li and Mn at 100%, with Co and Ni at 86% and 84%, respectively. The Co and Ni were captured in a separation process at >70% recovery with 99% co-purity. This is significant because Co and Ni can contribute up to 90% of the recovered value.
3:25 PM
Advancing Sustainability: Comprehensive Life Cycle Assessment of Nickel Production to Meet Growing Industry Demands
A. Fahimi and E. Vahidi; University of Nevada, Reno, Reno, NV

With nickel driving over 85% of US consumption in stainless steel, alloy steel, and nickel-containing alloys, and amid the expanding electric vehicle sector, we’re pioneering a robust Life Cycle Assessment (LCA) framework for nickel production. Encompassing various extraction (open pit, underground mining) and processing methods (e.g. pyrometallurgy, hydrometallurgy, high-pressure acid leaching) from sources like laterite and sulfide ores, we’re creating a comprehensive database for producing 1 kg of Ni (class I, ferronickel, nickel sulfate). This LCA precisely evaluates nickel’s environmental impacts, offering vital sustainable insights. Our work drives eco-conscious practices, managing the nickel-critical landscape, and catering to stainless steel, alloy steel, and lithium-ion battery demands.

3:45 PM
Environmental Impacts of Gold Production From Refractory Ores
S. Kadivar and E. Vahidi; Mining and Metallurgical Engineering, University of Nevada Reno, Reno, NV

The properties of an ore deposit determine the mining techniques and requirements for the extraction process. The available supply of high-grade gold ore has significantly decreased, and there is growing concern about sustainable gold mining. Therefore, it is vital to assess the environmental sustainability of producing gold from refractory ores, which can be considered as the secondary source of gold ores. A holistic and comprehensive evaluation of the environmental impacts associated with gold mining can be the starting point to reduce the environmental burdens. In this research, life cycle assessment was used to quantitatively evaluate the environmental footprints of gold production from refractory ores through autoclave and flotation. The LCA results showed that the total greenhouse gas (GHG) emissions, including all the stages was 19100 kg CO2-eq, from which grinding was responsible for 39.4% of the overall GHG emissions. Higher electricity consumption in the grinding stage was the primary factor for generating CO2 emissions showing the importance of electricity transition to renewable and greener energy sources.

4:05 PM
Comparative Life Cycle Analysis of Lithium Separation Methods from Geothermal Brines
S. Nikfar and E. Vahidi; University of Nevada Reno, Reno, NV

The demand for lithium is rapidly increasing due to the growing adoption of electric vehicles, batteries, and electronic equipment. This has made lithium reserves, like brines, a crucial asset for countries, offering economic potential. Consequently, global attention has been directed toward extracting and separating lithium from brines. Recent advancements have led to innovative methods for extracting and separating lithium from brine more efficiently, meeting the rising production demands. However, the environmental impacts associated with lithium separation methods have not been thoroughly investigated. This project comprehensively analyzes various separation methods comprising adsorption, solvent extraction, electrodialysis, and precipitation for lithium extraction from geothermal brines to produce lithium carbonate, utilizing Life Cycle Assessment (LCA). The study aims to bridge knowledge gaps regarding environmental sustainability and comprehensively compare the environmental burdens of various separation techniques.

4:25 PM
National Goals, Environmental Policy, and Recent Supreme Court Decisions—New Developments and Some New Ways of Thinking
A. Martin; Mining, Foth Infrastructure & Environment, LLC, De Pere, WI

The US is pursuing vehicle electrification and decarbonization of our utilities, however, the supply of metals and critical minerals needed are currently not adequate to support the transition. Additionally, there is tension, inconsistency, and yes, incoherence in our policy, politics, and the recent court rulings on significant lawsuits with upcoming rulings winding their way through the courts. We will review a few significant Supreme Court decisions and the relevant policy associated with them. There are several developments that have benefits to mining projects, but those benefits won’t just be handed over. They need to be recognized and pursued. We will present some benefits, talk about pitfalls to avoid, and discuss strategies individual and professional groups can use to adapt to the latest developments.

MONDAY, FEBRUARY 26 AFTERNOON

HEALTH & SAFETY: PROCESS SAFETY AND RISK MANAGEMENT

North 128A
2:00 PM • Monday, February 26

Chairs: A. Gregor
S. Richard, Coeur Mining, Chicago, IL

2:00 PM
Introductions

2:05 PM
A System Safety Approach to Analysis of Lithium-Ion Battery Fires in Underground Mines
S. Eroglu and S. Duzgun; Mining Engineering, Colorado School of Mines, Golden, CO

We investigate Turquoise Ridge and Aracoma Alma Mine fires using system safety methods, namely Causal Analysis based on Systems Theory (CAST) to find system-level complexities that could cause fire accidents. We compared fire accidents of the electric vehicle-operated haulage system in the Turquoise Ridge Mine and the conventional haulage system in the Aracoma Alma using CAST. These findings inform the development of safety guidelines for electrical vehicle-operated systems in underground mines. We explored System Theoretic Process Analysis (STPA) to proactively identify potential loss scenarios and implement preventive measures for safer mining practices with system-level enhancements.

2:25 PM
Characterizing Mine Fire in Large Underground Ventilation Networks Using Machine Learning
D. Bahrami, Y. Xue, L. Zhou and L. Yuan; CDC NIOSH, Pittsburgh, PA

Underground mine accidents, such as mine fires, remain a health and safety risk to mine workers. Researchers at the National Institute for Occupational Safety and Health are developing a data-driven, predictive model that shows promise in characterizing unknown underground fires in terms of location and size. This paper describes the application of the methodology to a large, underground, metal mine ventilation network using simulated airflow test data. The results show the size and location of an unknown fire can be determined with over 80%, and 90% accuracy, respectively, and potentially reduce the risk of hazardous conditions for emergency response.
In this study, first, the effective mining and operational factors in underground mining method selection. Two large language models, including GPT-4 and Bi-Directional Encoders Representations from Transformers (BERT), are used to interpret incident reports in the MSHA accidents and injuries database and a collection of safety reports in participating operators’ safety management systems. We also discuss two publicly available, custom language models which have been developed by our team for mining safety and health tasks (MiningSH-GPT and MiningSH-BERT). Results are compared with robust general classifiers, including Support Vector Machines and Random Forest. We apply SHapley Additive exPlanations (SHAP) algorithms to explain model outputs and offer insights into the circumstances of incidents. Use cases of these techniques include discovering leading indicators for incidents, revising company standard operating procedures (SOPs), and predictive modeling of injury.

3:05 PM
Enhancing Mining Safety Through Quantitative Bowtie Risk Analysis of Haulage Truck Collisions
A. Monirimorad and J. Sattarvand; University of Nevada, Reno, Reno, NV
Ensuring the safety of mining operations plays a crucial role in maintaining secure working environments. Although the incorporation of advanced technologies has ushered in a new era of accident prevention in the mining industry, it remains vital to systematically identify, assess, and manage the potential hazards. This study revolves around the establishment of a quantitative Bowtie risk analysis to assess and manage the haulage truck collisions. This approach meticulously dissects potential hazards and quantifies the underlying contributing factors. Then, a probabilistic risk assessment (PRA) technique is employed to examine the risk associated with these hazardous scenarios. This procedure involves the development of a user-friendly risk analysis software platform, establishing a bridge between research findings and practical application in the real world. This platform aids professionals to assess and manage haulage operation risks.

3:25 PM
Using the Fdanp Method to Rank the Mining and Operational Factors in Underground Mining Method Selection
Z. Jahanbani1, M. Ataee-pour1 and A. Mortazavi2; 1Mining Engineering, Amirkabir University of Technology, Tehran, Iran (the Islamic Republic of) and 2School of Mining and Geosciences, Nazarbayev University, Astana, Kazakhstan
The process of selecting an underground mining method is an important decision-making issue with multiple criteria and depends on many factors. The purpose of this paper is to find and prioritize the mining and operational factors affecting underground mining method selection. In this study, first, the effective mining and operational factors in the selection of underground mining methods were identified. Then, a fuzzy hybrid quantitative approach consisting of Fuzzy Decision Making Trial and Laboratory (FDEMATEL) and fuzzy Analytic Network process (FANP) techniques known as FDOANP technique was utilized to prioritize and rank the mentioned factors. Information collection method was through library studies and the method for data collection was through questionnaires.

3:45 PM
Spoovable Large Diameter 8-inch Non-Metallic Flexible Composite Pipe for Transportation of High Erosion Minerals and Harsh Chemicals in a Mining Environment
M. Rosenow; Baker Hughes, Flexible Pipe System—Onshore, Houston, TX
In mining operations, minerals, harsh slurries and concentrate products need to be transported safely from the mining site over challenging terrains. Large diameter non-metallic composite flexible pipe can transport these materials safely and has a lower carbon footprint compared to steel pipe. The glass fiber reinforced high density polyethylene pipe can operate under high pressures and temperatures with a combination of physical and chemical resistance properties that reduce erosion and eliminate corrosion. Discussed will be the technical properties and operational benefits of the flexible composite pipe that make it especially relevant to mining operations.
overcome in enabling the usability, including underground coal mines, and provide examples of 3D imagery captured at recent incident events. Key advantages of utilizing 3D imaging is the ability to rapidly capture an incident scene to create a ‘digital twin’ as a permanent record, and further enabling future investigation, research and learnings to be conducted through an environment that can be virtually re-visited at any time.

2:45 PM

Validating SCSR Communication Capabilities Using Human-Centered Design Methods

E. Gyawu1, K. Awuah-Offei1 and D. Baker2; 1Mining Engineering, Missouri University of Science and Technology, Rolla, MO and 2Psychology, Missouri University of Science and Technology, Rolla, MO

Communication during a mine emergency is vital for successful self-escape by miners. However, the current self-contained self-rescuers (SCSRs) have no verbal communication capabilities. This flaw in the design of the current SCSR has caused major disasters in the coal mining industry such as the Wilberg Mine disaster in 1984 and the Sego mine disaster in 2006. There have been major research and development projects aimed at developing SCSR units that have verbal communication capabilities. However, there have not been any usability tests to evaluate how these designs overcome the issues of the ability to communicate verbally. This research uses a short in-person scenario-based experiment to assess miners’ ability to communicate during an emergency and to compare differences in effectiveness and attitudes between the current and proposed SCSR designs. The outcomes of these experiments are expected to provide concrete evidence to technology manufacturers and regulators on how changing the design of SCSRs could impact their effective use and acceptance by miners.

3:05 PM

3:05 PM

Using Event-Based Imaging and Deep Learning to Generate 3D Surface Maps for Autonomous Roof Bolting

R. Banerjee and A. Petruska; Mechanical Engineering, Colorado School of Mines, Golden, CO

This study explores implementing a machine learning based system to generate a 3D surface representation of the roof and support straps in the mine. Event cameras have been chosen for their performance in high-dynamic-range lighting conditions and for their low latency. To enable automated drilling and bolting, 3D vision using event-based cameras has been developed. A ground-truth set is created using two, time-synced event cameras and a LiDAR camera. These sensors are used to construct a ground-truth dataset of corresponding event-camera images and surface maps from the LiDAR. This dataset is used in conjunction with a recurrent convolutional neural network (R-CNN) to develop a learned stereo-vision output.

3:25 PM

Enhancing Workplace Safety in the Mining Industry: A Data-Driven Approach Through Unstructured Accident Narrative Analysis and Clustering

A. Danish and S. Chatterjee; Department of Geological and Mining Engineering and Sciences, Michigan Technological University, Houghton, MI

Despite considerable strides in worker safety, the mining sector continues to witness a significant number of accidents, necessitating the identification of areas of concern and adept risk management. This study proposes an advanced methodology employing natural language processing and unsupervised machine learning (ML) to analyze text-based accident narratives. Focusing on the mining industry, the study employs the Siamese Bidirectional Encoder Representations from Transformers (SBERT) for semantical extraction from accident narratives. High-dimensional embeddings are reduced using Uniform Manifold Approximation and Projection (UMAP) for kmeans clustering, facilitating safety risk analysis through cluster visualization. The study results highlight the importance of UMAP dimensionality reduction for computational efficiency and the robustness of the approach, showcasing the effectiveness of UMAP-based clustering in revealing safety insights and identifying risks tied to distinct mining operations, injury types, and equipment. This data-driven approach offers a framework for safety risk analysis with broad applicability across industries, bolstering worker health and safety.

3:45 PM

An Overview of NIOSH Safety and Health Research on Robotics and Automation in the Mining Industry

J. Carr, S. Sawyer, T. Ruff, R. Bissonette, W. Reed, M. Nasarwanji, P. Schmidt and M. McNinch; NIOSH, Pittsburgh, PA

This paper will provide an overview of research conducted by the National Institute for Occupational Safety and Health (NIOSH) in the area of robotics and automation in the mining industry. This includes intramural research at the NIOSH Pittsburgh Mining Research Division and Spokane Mining Research Division as well as research funded extramurally through contracts and grants. Relevant non-mining research from elsewhere in NIOSH will also be presented along with partnerships and cooperative relationships. Topics that will be discussed include robotics for mine escape and rescue, assured autonomy considerations for mining equipment, supporting technologies, and human-centered design for automation in mining.

4:05 PM

Using Reaction Time to Predict Fatigue of Haul Truck Operators

E. Talebi Esfandarani1 and P. Rogers2; 1Mining Engineer, University of Utah, Salt Lake City, UT and 2Assistant Professor, University of Utah, Salt Lake City, UT

The investigation of haul truck operator fatigue holds crucial significance due to its direct impact on operational safety and workforce health within the mining industry. It is crucial to detect fatigue early and ensure safe operations. Advances in wearable technology have made it possible to use smartwatches and applications to monitor the operator’s reaction time continuously during night and day shifts. Smartwatch applications can measure reaction time through simple tests such as the response time test or visual reaction time test. For this study, a developed application is used to measure users’ reaction time. The data from these tests can then be analyzed to determine the operator’s fatigue levels. This technology provides a non-intrusive, cost-effective, and continuous measurement of the operator’s reaction time, enabling the detection of early signs of fatigue. The collected data can be transmitted to a central monitoring system, allowing for real-time monitoring of the operator’s fatigue levels. This study explores the feasibility, limitations, and benefits of using smartwatch applications to measure reaction time as a threshold value of fatigue of haul truck operators.

MONDAY, FEBRUARY 26 AFTERNOON

HISTORY OF MINING

North 225B

2:00 PM • Monday, February 26

Chair: G. Luxbacher, NIOSH, Prosper, TX

2:00 PM

Introductions

2:05 PM

The Mining Legacy of John Ross Browne

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

John Ross Browne is not as well known in mining history as Rossiter Raymond or in literary circles as Mark Twain. He was a contemporary of both and each can attribute a part of their success to his pioneering work. Browne had a checkered career as a riverboat crewman, congressional reporter, whaleboat sailor, recorder of the California Constitutional
Conventional, travel writer, Indian Agent and ambassador to China. But he is best remembered for his illustrated descriptions of California and Nevada mining camps in 1856-1862 for Harper’s Weekly and his groundbreaking 1868 Report on Mining in the Western United States. The latter led to Rossiter’s government appointment as the US Commissioner of Mines to do an annual report on mining. This presentation will focus on his life and times of this self depreciating, misunderstood, but accurate reporter of the era who also displayed humanitarian insights that were unusual for the time and was true to his beliefs in his work to the extent that it harmed his personal and his family’s welfare.

2:25 PM

Three Mining Booms, Three Metals: The History of the Rand Mining District, California
S. Shoemaker; Metals, John T Boyd Company, Tooele, UT

Gold was first discovered in the Rand Mining district in 1893, resulting in a significant mining boom in eastern Kern and northwestern San Bernardino Counties, California. As the initial mining boom subsided in 1904, rich tungsten ores were discovered several miles to the southeast, in what would become known as Atolia. The resulting mining boom lasted until the end of World War One, when tungsten prices collapsed. The Rand Mining district was then rocked by the discovery of rich silver ores just east of Randsburg, near the community of present-day Red Mountain. The California Rand Silver Mining Company was formed to exploit this deposit, otherwise known as the Kelly mine. The Boom ended in 1929 with the low price of silver and the Great Depression. Minor production of gold and tungsten in the district continued until the early 1960s. In the late 1980s, the former Yellow Aster mine was developed as an open pit heap leach project which continued operations into 2001. This paper will describe the history of the Rand Mining District as well as its outlook for the future.

2:45 PM

American Mining and Strategic Minerals in the Early 20th Century
I. Barton, UA Lowell Institute for Mineral Resources, Tucson, AZ

Until 1915-16 the USA largely took strategic minerals supplies for granted. They first became a concern during World War I, as international hostilities reduced supplies while demand soared. Postwar, the first lists of strategic minerals were compiled in the 1920s, but got little attention due to a severe commodities glut lasting through the Great Depression. Minerals only regained US attention in the late 1930s with the growing threat of war. Official minerals stockpiling began in 1939. Though it was due to a severe commodities glut lasting through the Great Depression. Minerals only regained US attention in the late 1930s with the growing threat of war. Official minerals stockpiling began in 1939. Though it was incomplete in 1941, high industrial capacity ensured mostly adequate supplies throughout World War II. Afterward, demand drop, concerns about resource exhaustion, and policy preference for imported minerals decreased US capacity. As import reliance increased, strategic minerals became a major Cold War policy concern and helped cause several foreign entanglements. Imports were lower than projected as Europe’s ex-colonies declared independence, delaying stockpile fill dates. In 1950, for the third time in 33 years, the US entered a major international war with inadequate minerals supplies. Strategic minerals stockpiles have since been recognized as vital, but have seldom been filled.

3:05 PM

Island Creek Coal Company—A Coal Pioneer
G. Luxbacher; OMSHR, NIOSH, Prosper, TX

Island Creek was originally founded as the U.S. Coal & Oil Company in 1863, becoming Island Creek Coal Company with the acquisition of coal property on the Copperas Fork of Island Creek. Island Creek rapidly grew, operating underground coal mines in West Virginia and acquiring other coal properties. It survived as an independent company through 1969, when it was acquired by Occidental Petroleum, and was operated as the subsidiary Island Creek Corporation. The end to Island Creek came in July 1993 when Occidental exited the mining business, and it was sold to Consolidation Coal Company and ceased to exist as an operating entity. This presentation looks at the formation of Island Creek in its early years, including the acquisitions that enabled its growth. Island Creek's founder, Albert Holden, a contemporary of Daniel Jackling, is more closely associated with Utah copper however he created a coal company that lasted for almost a century.

3:25 PM

Antimony in WWII: Shifting Supply Chains and New Applications
M. Hendrickson; History, University of California San Diego, San Diego, CA

Globally, primary production of antimony is isolated to a few countries and dominated by China. My paper looks back to WWII which was a hinge point in the sourcing and industrial application of antimony. Between the WWI era and the mid-1930s, China dominated global supply chains for metallic antimony. Japan’s invasion of China disrupted this supply chain at a critical moment in US history. Complicating matters further, new wartime applications emerged for antimony oxide which served as a synergist in a new generation of flame retardants. My paper will explore these major wartime shifts in antimony supply and application.

3:45 PM

Oatman & Gold Road Mining District Mohave County, Arizona
T. McNulty; T. P. McNulty and Associates, Inc., Tucson, AZ

Gold-bearing outcrops were discovered in 1862 by Union troops camped in the northwest corner of the region that became the State of Arizona in 1912. Sporadic mining began several years later, but engineered shaft sinking and modern mill construction practices were not adopted at Oatman and the neighboring village of Gold Road until about 1900. Geological interpretations of the mineralized structures in 1915 enabled major production during the next decade, but rising costs and depletion of high-grade ore closed many operations during the 1920s through the Great Depression. In the late-1930s, the USSR&M Co. built a new mine and mill in Gold Road and the District flourished until closure by Order L-208 in October 1942. By that time, the Oatman & Gold Road District had produced a total of 2.1 million ounces of gold. The Tom Reed mine continues to be Oatman's source of water and Oatman hangs on as a “living ghost town” with a few hundred residents and several packs of feral burros that badger tourists for handouts. Gold Road has enjoyed at least two revivals. since 1990, including a new decline into the main orebody and a 500-ton per day cyanide mill, but success has been elusive.

4:05 PM

Copper Metallurgy Standards and Alloy Uses in Old Babylonia
S. Patterson; Mining Engineering, University of Arizona, Tucson, AZ

Ea-Nasir was a copper merchant who lived in the city state of Ur, or modern-day Iraq, during the Old Babylonia period of 1894-1595 BCE. He is primarily known from the discovery of a 1750 BCE cuneiform tablet dealing reimbursement for a delivery of poor quality copper. Metal extraction methods were widely discussed in Babylonia, with copper smelting furnaces dating back to 4000 BCE, while tin and arsenic alloys were utilized until approximately 1500 BCE. Ea-Nasir’s tablet highlights preferences and a regional standard in metals and alloy percentages at the time. ‘Poor quality’ could be due to impurities in the copper ore, poor melting techniques, or a transactional misunderstanding of what the buyer needed. This analysis explores the metallurgical methods at the time and the regional geology to cast light on what constitutes poor quality copper in ancient Babylonia.

4:25 PM

The Philosopher Kings of Copper
C. Anderson; Colorado School of Mines, Golden, CO

As a child growing up in Butte, America, I would play baseball on a field located on Lewisohn street. As children, we pronounced it “Lewishawn” and assumed it was named after yet another Irish Immigrant. Years later my ignorance was dispelled as I learned of the great Lewisohn family, their impact on my home town, their mining contributions and massive wealth and their lasting societal and philanthropic activities. This
The presentation will detail a successful story of immigrants who overcame prejudice, created great wealth and forwarded progress in many areas of societal need. In particular, the exploits of Adolph Lewisohn, who Time magazine called “one of the most intelligent and effective workers on human relationships in the U.S.,” will be elucidated.

MONDAY, FEBRUARY 26  AFTERNOON

INDUSTRIAL MINERALS & AGGREGATES: DIGITALIZATION AND AUTOMATION IN INDUSTRIAL MINERALS AND AGGREGATES

North 125B

2:00 PM • Monday, February 26

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

2:00 PM

Introductions

2:05 PM

24-041

Fleet Efficiency Evaluations for Optimal Cycle Times Through Various Blast Designs in the Sorted Geological Formation Under Constrained Operating Conditions

V. Kona; Aggregates, CRH, Portsmouth, NH

This paper examines the mining fleet performance at Sidney Quarry of Pike Industries by reducing cycle times and hauling less oversize material generated from the blast to the crusher to increase the overall plant throughput. We are constrained with blast patterns due to the poorly sorted and fractured seams in the quarry, which is angled at 35° NE and dipping at 80° and runs parallel to the I-95 highway on the east of the quarry boundary, making it challenging to alter the blast patterns for optimal yield. We evaluated multiple relationships between blast patterns in conjunction with loader diggability. Results analyzed include the digging hours, fleet cycle times, and the fragment size with the optimized blast design through 3GSM software to arrive at the optimal yield to maximize the crusher throughput. Our primary objective is to focus on safety with efficient cycle times and clean floors & clean face generation for better operational efficiencies. Secondly, to optimize the crusher yield which is an integral part of quarry operation. Further, this paper provides the utilization of VizaLogix, a fleet management software, and 3GSM blasting techniques in quarry applications.

2:25 PM

Utilizing SLAM LiDAR to Rapidly Map, Process, and Classify Mining Data

J. Kenney; Mapping & Measure, Wingfield Scale & Measure, Chattanooga, TN

Infrastructure failures have devastating effects and can lead to loss of life. A mine has the same issues with different challenges in a regulatory environment. Using SLAM LiDAR systems, manned and unmanned, enables the capture of high value data for analysis and potential mitigation of hazards. Streamlining data acquisition and rendering is key to reducing cost and producing results. We will examine in this presentation a comprehensive strategy for capturing, processing, and analyzing data to produce actionable decision-driven outcomes, fast. Using well-established hardware and software platforms, combined with innovative workflows, we will demonstrate how this can be accomplished cost-effectively, by clients and consultants alike, across a spectrum of industry sectors. Presentation data will focus on MSHA (Mine Safety & Health Administration) and NIOSH (National Institute of Safety & Health) pillar stability initiatives.

2:45 PM

Digitalizing Production Data: An Approach to Maximizing Operational Efficiency by Implementing Digital Data Collection Strategies to Improve Decision Making at a High-Volume Aggregate Operation

J. San Martin, I. Garcia, J. Trotta, L. Cruz and J. Woosley; CEMEX, Miami, FL

The FEC Quarry in Miami, FL is a high-volume limestone mine producing construction aggregate for concrete and asphalt plants throughout the state of Florida. Historically production, downtime and efficiency metrics within each department have been collected on paper reports and delivered to individual supervisors throughout the operation. This has resulted in key performance indicators (KPIs) not being compiled until days after the actual production run and only serving as lagging indicators that typically remain siloed within each department. To address this, the FEC quarry established an interdisciplinary team to create digital tools sets to track all aspects of production, update real time process flows through the plant, remove silos and rapidly communicate critical KPIs to stakeholders to empower rapid decision making. This paper will explore the challenges associated with this project, best practices learned and overall impacts to process efficiency.

3:05 PM

Intro to Smart Surveys: Navigating the Convergence of GIS and Survey Tech

R. Ward2 and C. Bentley1; 1Key Accounts, Propeller, Denver, CO and 2Marketing, Brand Lead, Propeller, Denver, CO

Previously, survey and GIS were separate applications. However, drones for site surveying and the cloud portals used to process their aerial data are encouraging mining & aggregate contractors to view them together. In this session, we will explain how 3D mapping technologies that exist between survey and GIS are accelerating the merging of these two fields, paving the way for a new category of technology called smart surveys—tightly integrated hardware and software products that transform surveys into interactive 3D maps. Smart surveys combine the accuracy of survey technology with the geospatial qualities of GIS to create a consolidated solution that field teams can readily use. New objective 1: Learn how both surveying and GIS are traditionally used New objective 2: Understand how surveying and GIS meet within smart surveys New objective 3: Implement smart surveys within your construction operations.

3:25 PM

Wireless Heap Leach Monitoring and Control

L. Bolton; Sales, Emerson Automation Solutions, Chandler, AZ

Heap Leach Solution Extraction is a cost efficient process for recovering metals in various ores including Copper, Gold and Uranium. While the concept is easy to understand until now the ability to execute flow control and monitoring over the entire operation has been prohibitive. Accurate solution distribution on the pad requires labor intensive operations to regulate valves, check for leaks and pipe breaks, look for plugging issues and assumes no “ponding” within the pad. All this is accomplished only during daylight hours. Instrumentation capable of withstanding the rigors on the pads exposed to weather, sun and corrosive solutions and able to communicate process variables reliably and accurately has been missing. Using Wireless HART instrumentation Emerson’s complete solution has been able to measure and control flow of extractive solutions to the pad, the distribution on the pad, pore pressure and temperature in the pad and flows off the pad. Activation of valves wirelessly, monitoring and controlling vertical wells and air blowers has all been accomplished with wireless instrumentation.
MONDAY, FEBRUARY 26 AFTERNOON
INDUSTRIAL MINERALS & AGGREGATES: MINE DESIGNINDUSTRIALMINERALSANDAGGREGATES
North 126A
2:00 PM • Monday, February 26
Chairs: P. Jacomet, Ohio Aggregates and Industrial Minerals, Gahanna, OH
R. Mitra, South Dakota School of Mines and Technology, Rapid City, SD
2:00 PM
Introductions
2:05 PM
24-034
Enhancing Ventilation and Development Planning in Underground Stone Mines: Insights from a CFD-Based Study
K. Mohamed1, M. Harris1, V. Sangrade1, K. Raj1 and S. Sarkar1; 1National Institute for Occupational Safety and Health, Pittsburgh, PA and 1KETIV, ANSI5 Division, BREA, CA
NIOSH conducted a ventilation survey on a new underground stone mine employing natural ventilation. The objective was to assess the impact of fan placement and ventilation stopping arrangements on ventilation efficiency, with a focus on enhancing worker safety. Computational Fluid Dynamics (CFD) modeling was employed to analyze the existing ventilation plan and examine the effects of larger fans for future mine expansion. This study presents the initial surveys, calibration of the CFD model, and optimization of fan and stopping arrangements for the forthcoming mine expansion. The results offer valuable insights for ventilation and development planning in stone mines at various operational phases.

2:25 PM
Measure While Drilling for Grade Control and Blast Optimization
E. Westman and J. Arnold; Mining and Minerals Engineering, Virginia Polytechnic Institute and State University, Blacksburg, VA
By knowing geologic variation within a blast pattern, operators can have the most accurate understanding of grade distribution and can optimize blast performance. This research utilizes machine learning with Measure While Drilling (MWD) data to display the distribution of the rock hardness within a mine bench, which allows better understanding of grade distribution and optimization of the blast design. In many sedimentary deposits, ore grade is correlated with lithologic unit, and these units can vary in hardness. Further, by mapping the distribution of hardness, the powder factor can be varied across the blast so that fragmentation is more uniform. The data set includes the following MWD parameters: engine RPM, rotation speed, feed pressure, flushing flow rate, flushing pressure, penetration rate, and rotation pressure. Following data cleaning steps, the parameters were compiled and organized for machine learning. We assume that using all the MWD parameters, rather than solely the penetration rate, will provide a more correct measure of the distribution of rock hardness. This work is conducted within the CASEM Mining Research Consortium, supported by industry members.

MONDAY, FEBRUARY 26 AFTERNOON
MINING & EXPLORATION: GEOSCIENCES: BEST PRACTICES IN GROUND SUPPORT IN UNDERGROUND MINES
North 222B
2:00 PM • Monday, February 26
Chairs: J. Bourgeois, National Institute for Occupational Safety and Health, Newport, VT
T. Thompson, Freeport-McMoRan

Towards to Safe Salt and Potash Mining: Risk Assessment from Exploration to Operation
T. Kiessling; ERCOSPLAN, Erfurt, Germany
Underground mines demand risk management in regard to the individual geological frame conditions, such as host rock failure followed by seismic events, sudden subsidence, water inflow or gas outbursts. Mining evaporite deposits requires once more prevention against flooding by water or unsaturated brines since the minerals in the deposits are soluble itself. Taylor-made exploration of the individual deposit and the surrounding protection barriers which conserving the evaporite deposits during the geological history up to date, and understanding the multiple interactions with the mining-induced changes of the stress field, are keys to success. Application of 3D geological modelling, geomechanical and geohydraulic modeling, based on close-to-reality rock mechanical and hydraulic properties, the suitable mining parameters, including extraction limits and spatial as well as temporary requirements for mine backfill are defined already during the mine planning procedures and creates a design base for realistic expenditure prediction. The paper presents a summary of the applied methodological inventory by recent projects.
2:00 PM
Introductions

2:05 PM
Convergence Regression Analysis at the A Panel of the Henderson Mine
J. Mansalve, S. Ferguson, A. hariyadi and N. Shea; Henderson Mine, Freeport-McMoRan, Blacksburg, VA

In block caving operations, as caving advances, abutment load is transferred to drawpoints ahead of the caveline. This increased stress from the abutment loading induces deformation on the extraction level until the abutment loading is released as the caveline progresses across the level. Additional deformation can also take place during the life of the production panel due to challenging geological conditions or uneven draw. The deformation is monitored to ensure they are within expected limits, ensuring the safety of the operators by maintaining extraction level stability. While the Henderson mine has monitored convergence on all extraction levels from first production to present day, convergence monitoring practices have evolved over time as each cave provides new learnings and understanding. This presentation discusses current convergence monitoring methods at Henderson mine and introduce a PowerBI convergence visualizer that allows to convert periodic field measurements into valuable information for effective decision making. In addition, a panel-wide regression analysis was performed to gain a better understanding about convergence mechanisms during caving.

2:25 PM
A Novel Hybrid Cementitious Material for Enhancing Pumpable Roof Support
L. Zhang and A. Nikvar-Hassani; University of Arizona, Tucson, AZ

To address the limitations of conventional roof supports, pumpable roof supports (PRSs) are increasingly used. However, the Portland cement/fly ash (PC/FA) based cementitious material currently used in practice to produce PRSs has limitations, including (1) the peak and residual bearing capacities are inconsistent and sometimes too small, and (2) when exposed to the air, the PC/FA cementitious material severely deteriorates. To enhance the performance of PRSs, we have recently developed a novel hybrid geopolymer/biopolymer (GP/BP) cementitious material to minimize or alleviate the limitations of the PC/FA cementitious material. This presentation will talk about the systematic experimental study including laboratory-scale investigation, batch-scale demonstration and full-scale production and test performed for developing the new hybrid GP/BP cementitious material. The results indicate that compared with the conventional PC/FA cementitious material currently used in practice, the hybrid GP/BP cementitious material can increase both the peak and residual bearing capacities of PRSs and effectively eliminate the deterioration of the cementitious material when exposed to the air.

2:45 PM
A Study on the Impact of In-Seam Rock Partings on Coal Pillar Strength Based on Field Instrumentation and Numerical Modeling at the Maple Eagle Mine
M. Sears1, M. Morris2 and J. Bright3; CDC/NIOSH, Pittsburgh, PA and 1Blackhawk Mining, LLC, Lexington, KY

Researchers with the National Institute for Occupational Safety and Health are involved in research aimed at understanding the impact of in-seam rock partings on the strength of coal pillars. The purpose of this study was to determine a virtual mining height that could be applied using current pillar stability analysis tools. In this study, data collected from BPCs at the instrumentation sites was used to calibrate the LaModel program which was subsequently validated by reducing the modeled mining height. By understanding the influence of rock partings on coal pillar strength, engineers can make more informed decisions related to safe pillar recovery.
behavior under various loading conditions. Despite these efforts, the issues of ground fall and pillar failure continue to cause issues in operating mines. There are few studies that have investigated pillar-support interactions at large scales and under controlled conditions. This study uses a series of large-scale laboratory compression tests along with the discrete bonded block modeling (BBM) approach on a porous limestone block to analyze the rock and support behavior at a scale close to that of in situ pillars (~0.5 m edge length). Multiple width-to-height ratio samples were tested, and laboratory tests were conducted for both unsupported and supported (grouted rock bolt and wire mesh). The latter included fiber-optic-sensor-instrumented rock bolts to study bolt deformation, load mobilization, and localized deformation of the rock mass. The data obtained from the laboratory tests served as target calibrations of the BBM models in UDEC.

4:25 PM
24–021
Corrosion Strategies at the Resolution Copper Project, Arizona
L. Sandbak and G. Paz; Technical Services, Resolution Copper, Oracle, AZ
Corrosion poses a risk to the long-term viability of infrastructures for Resolution Copper Project ground support. This is critical given the high sulfide environment coupled by the presence of hot water and associated high humidity (>60%) for the deepest Resolution Copper development of the 68 level at 6,780 feet below the surface. Fully encapsulated bolts and hardware are thought to provide the best corrosion protection. Strategies are to test corrosion resistant coatings on hollow anchor bolts, and cable bolts in trial situations. The selection of corrosion coatings will be based on ground support categories based on rock mass strength, and the categorization of short- and long-term excavation use.

MONDAY, FEBRUARY 26 AFTERNOON
MINING & EXPLORATION: GEOSCIENCES: SME/AIPG: PURE GEOLOGY: DISCOVERIES FROM GEOLOGIC EXPLORATION PROGRAMS
North 222C
2:00 PM • Monday, February 26
Chair: D. Wolfe, NACCO Natural Resources, Plano, TX
2:00 PM
Introductions
2:05 PM
ACME Lithium’s Fish Lake Valley Project: A Lesson in Using Geologic Models
W. Feyerabend; Geology, University of Southern California, Los Angeles, CA
Geologic models can be handy as a shorthand communication tool, they can help interpret data and they can also lead you astray. Acme Lithium’s Fish Lake Valley Project is an example of those. It also is an example of how really thinking through what a model tells you can lead to a happy ending and add value to a project.

2:25 PM
Geologic Modeling of Metal Zonation and Trends—A Geology Based Approach to Account for Local Variations in Mineralization
J. Cardwell; AIPG, Denver, CO
In many mineral deposits metal zonation is present and can be related to grade trends. If the geology of the host rocks possesses certain geochemical and/or geophysical properties (porosity etc.) then the resulting mineral deposit could form zoned ore bodies (disseminated ore) with locally varying mineralization. Disseminated metal of varying degrees poses a significant challenge to grade estimation since it is possible that no clear boundary exists in which to differentiate distinct populations. Hence properly defining grade/geology domains may prove elusive. Current resource estimation workflows can sometimes address this problem reasonably well by utilizing pairwise relative variograms and localizing the kriging estimate. However, these geostatistical techniques may not fully account for all of the geology components or account for local variations in mineralization by assuming a single direction of continuity. By utilizing geologic knowledge and current software technology to model the metal zonation and associated trends, local variations in mineralization can be properly accounted for in grade estimation using non-linear block search paths.

2:45 PM
USGS Earth Mapping Resource Initiative Geophysical Surveys in the Southwest U.S. and their Importance to Mineral Resource Exploration
M. Bultman; Geology, Minerals, Energy, and Geophysics Science Center, USGS, Tucson, AZ
The USGS Earth Mapping Resource Initiative has sponsored three high precision aeromagnetic/aeroradiometric surveys in the U.S. Southern Basin and Range geologic province. These surveys include: 1) the Trans-Pecos survey, Texas and New Mexico, completed in 2021; 2) the New Mexico porphyry copper belt survey, scheduled to be completed in October of 2023; and 3) the Arizona porphyry copper belt survey which will begin in late 2023 and should finish in the early summer of 2024. This presentation will summarize the status of the surveys, survey interpretations to date, and the importance of these surveys to mineral resource exploration.

3:05 PM
Geological Interpretation Using Traditional Geophysical Surveys at the Santa Cruz Project, Arizona
C. Seligman, J. Ruffini and C. Shaw; Ivanhoe Electric, Herriman, UT
Magnetic, gravity, and resistivity surveys have been a starting point for mineral exploration programs for over five decades with coverage and quality improving substantially. Although the principal applications have not changed, improved data precision, computer algorithms, and numerical filters have allowed for traditional datasets to become broader and more precise in rapid timeframes, allowing geoscientists to draw better conclusions and interpretations in collaboration with other geologic information. Despite these developments, robust geologic interpretation of data is often dismissed following the natural progression and inflow of subsurface drill core datasets, which are often regarded as superior data, leading the inability to achieve full value from the surveys themselves. The discussion restates some fundamentals of the application of magnetic, gravity, and resistivity surveys, highlighting learnings drawn from such surveys using the Santa Cruz Project as a case, concluding that large scale and traditional geophysical surveys coupled with incisive interpretation have the ability to lead to exploration and interpretive achievements for discovery and resource development.

3:25 PM
Controls on Supergene Copper Mineralization at the Santa Cruz Project, Arizona
J. Ruffini; Technical Services, Ivanhoe Electric, Casa Grande, AZ
Supergene copper mineralization at the Santa Cruz deposit in Casa Grande, Arizona exhibits a moderately tilted copper porphyry enrichment profile including Leached Cap, Copper Oxide Zone, Supergene Enrichment Zone, and unique Exotic Copper Zone hosted in tertiary sediments. Basin and Range extension has played a significant role in segmenting the system, as well as producing progressive rotation causing supergene mineralization to occur at various orientations. The Copper Oxide and Supergene Enrichment Zones are primarily controlled by the paleo-water table and pre-existing fracture network, with increased local fluid conductivity along faults. The Exotic Copper Zone exhibits both bedding and lithologic control and also includes large, transported block or boulder deposits of Copper Oxide Zone likely transported during sediment deposition. Peripheral deposits exhibit varying supergene controls which are a combination of mineralized porphyry dikes, structures, and paleo-water table.
The development of the modern exploration environment has resulted in the application of sophisticated data-driven tools to probe mineralized systems, often through long-distance collaborative partnerships between multiple stakeholders and specialists. These tools require the critical geologic context provided by petrography. However, the collaborative interpretation of petrographic information is complicated by the non-digital nature of geologic thin sections. Here we describe the adoption and application of a new interactive digital microscopy system (PiAutoStage) to exploration environment workflows. We show that high-quality microscopy can now be accessed remotely, facilitating collaborative interactions and providing added value to existing data collection campaigns.

### MONDAY, FEBRUARY 26 AFTERNOON

**MINING & EXPLORATION: INNOVATION AND TECHNOLOGY: REMOTE SENSING FOR MINING: SATELLITES, DRONES, AND DATA MANIPULATION**

North 222A

**2:00 PM • Monday, February 26**

**Chairs:** B. Holtz, Coeur Alaska—Kensington Mine, Juneau, AK

D. Riley, Echo Labs, Whistler, BC, Canada

**2:00 PM**

**Introductions**

**2:05 PM**

**Why is Imaging Spectroscopy (Hyperspectral Imaging) Important for the Mining Industry?**

D. Riley1, J. Barton1, J. He1, B. Chung1, S. Salati2 and M. Barton; 'Mining & Geological Engineering, University of Arizona, Tucson, AZ and 2Geosciences, University of Arizona, Tucson, AZ

This talk covers imaging spectroscopy (IS) (aka hyperspectral imaging (HSI)) from satellites, aircraft, drones, tripods, laboratory systems, and coreloggers as these sensors are becoming commonplace. These sensors collect data across different parts of the electromagnetic spectrum (visible-near infrared, shortwave infrared, midwave infrared, and longwave infrared) for mapping minerals, gases, vegetation, man-made materials, and water. Leveraging the information and knowledge derived from these imaging spectrometers for effective decisions requires an understanding of their capabilities, limitations, and appropriate implementation. Understanding how these sensors and collection platforms can be effectively employed for open-pit operations, mine tailing storage facilities, ore-grade analysis, digital twins, acid mine drainage, abandoned mine lands, and others will be discussed.

**2:25 PM**

**Modeling Surface Hydrology for Hazard Mitigation in Open Pit Mines Using High-Resolution Drone Photogrammetry**

J. McNabb, J. Potter, G. Noonan, L. Brown and B. Meyer; School of Mining and Mineral Resources Geotechnical Center of Excellence, University of Arizona, Tucson, AZ

Surface water flow and accumulation in open pit mines can lead to serious safety and operational hazards. Catchment, flow direction, and ponding of surface runoff are often poorly understood due to the ever-changing topography of open pits and the limitation of observing surface flow only during large, infrequent precipitation events. Drone surveys are now commonplace in mining, and digital elevation models (DEMs) derived from drone photogrammetry can provide adequate resolution to run GIS-based surface hydrology models at scales relevant to open pit mining.

We utilize these GIS methods with high-resolution DEMs from routine drone surveys of open pits to better understand how surface water might impact slope stability and important infrastructure and provide suggestions for mitigating these impacts.

**2:45 PM**

**Digital Microscopy in Exploration Geology Through Implementation of the PiAutoStage System**

R. Stein; Big Rock Exploration, Duluth, MN

The development of the modern exploration environment has resulted in the application of sophisticated data-driven tools to probe mineralized systems, often through long-distance collaborative partnerships between multiple stakeholders and specialists. These tools require the critical geologic context provided by petrography. However, the collaborative interpretation of petrographic information is complicated by the non-digital nature of geologic thin sections. Here we describe the adoption and application of a new interactive digital microscopy system (PiAutoStage) to exploration environment workflows. We show that high-quality microscopy can now be accessed remotely, facilitating collaborative interactions and providing added value to existing data collection campaigns.
Unlocking Insights from the Past: Analyzing Tailing Storage Facilities through Archived Satellite Data
S. Rivet and V. Neel, Products and Solutions, PhotoSat, Calgary, AB, Canada

This paper studies the utilization of existing archived satellite data to produce valuable insight into existing Tailing Storage Facilities. Given the older nature of many TSFs and the frequency of ownership change, as-built and operational survey data is often unavailable. Following an extensive investigation into the content of commercial and government archives, a wealth of archive satellite imagery of both active and legacy mine sites exists. These satellite images, sourced from the Keyhole, Landsat, Sentinel, Pleiades and WorldView constellations, span a timeframe dating back to the 1960s. This data can compensate for a lack of on-going monitoring and as-built records by retroactively producing placement cut/fill maps, determine total and iterative placed volumes within and on the dyke structure, measure the capacity of the facility at different points in time, measure the height of the embankment walls and establish key performance indicators like beach freeboard on a historical and iterative basis. In the event of a dam breach, the information can be used to determine total tailings volume stored, total tailings volume released during a breach, and to measure movement.

Best Practices for Internal Controls over the Mineral Resource and Mineral Reserve Estimation Process
G. Gosson1 and S. Searston2; 1Wood PLC, Vancouver, BC, Canada and 2Mine Technical Services Ltd., Reno, NV

Item 1305 of Regulation S-K requires registrants to look at mineral resource and mineral reserve (MRMR) estimation from a process point of view. A process provides guidance, consistency, transparency, and measurement. It can be easily analyzed and improved. Governance is a system in place to maintain the integrity of the process including compliance with regulations, policies, and standards. Sign-offs attesting to the completion of key milestones in the MRMR estimation process are an important part of internal controls. This presentation will present objectives of the sign-off document, who should sign, and how this builds a pyramid of responsibility from site personnel to peaking with the CEO. Auditing of the MRMR estimation process are different from conventional audits. The auditors ask: Is there a process? Is the process adequate? Is it designed to comply with industry accepted standards? Is the process documented? Is there a sign-off procedure? Has the process been installed, is it operating as intended, and is it effective?

Reserves Reporting Observations under SK1300
F. Lieth; Geological Services, Vulcan Materials Company, Birmingham, AL

There are multiple observations about the transition to SK-1300 now that we have the benefit of hindsight. Among the variables that lead to calculating reserves, there are numerous subtleties that require further clarification for accuracy and consistency among the individuals making the calculations. Their definitions in practice have a significant impact on the reserves quantification. These variables must be known, understood and practiced consistently by the qualified person and the professionals providing supporting information. The creation of a customized internal reporting standards and guidelines for reserves calculations was an important (and sometimes contentious) conversation and then training tool that leads to consistency in supporting information.

Trends in SEC Comment Letters Related to Annual Cash Flow Presentation
K. Awuah-Offei2 and J. Offei1; 1University of Mines & Technology, Tarkwa, Ghana and 2Mining & Explosives Engineering Department, Missouri University of Science & Technology, Rolla, MO

Regulation S-K 1300 requires companies to file a technical report summary (TRS) to support disclosure of mineral resources and reserves on material properties. The TRS requirements include a requirement for the qualified person (QP) to disclose “...results of the economic analysis, including annual cash flow forecasts based on an annual production schedule for the life of project...” (Item 601(96)(ii)(B)(19)(ii)). The Securities & Exchange Commission (SEC) staff have been issuing comments on filings to elicit more complaint disclosures from QPs regarding how to present annual cash flows. This paper reviews SEC staff comments on this issue and provides commentary on the trends and best practices. Overall, the authors conclude that the SEC intends to elicit disclosure that is complaint with Item 601(96)(ii)(B)(19)(ii) as written. However, the SEC has allowed “aggregated” cash flow presentations (to facilitate succinct presentation to investors of material information) so long as those years have identical revenues/costs with adequate narrative clearly describing the “aggregation” process.
3:25 PM

The Challenges of Mineral Reserve and Mineral Resource Governance in a Global Company
L. Olsens¹ and C. Tabb,²; 'AusIMM(CP), Beford, WA, Australia and ²MAusIMM(CP), Perth, WA, Australia
Rio Tinto is a global mining company with 18 operations reporting Mineral Resources and Ore (Mineral) Reserves in more than 10 countries. Rio Tinto reports under the Australian Stock Exchange (ASX) and London Stock Exchange (LSE) as well as the Securities Exchange Commission in the United States (SEC). With around 50 Competent Persons / Qualified Persons reporting on in excess of 10 commodities across the globe, this is a highly complex reporting environment and requires extensive coordination and collaboration to ensure ongoing regulatory compliance and best practice. All Mineral Resources and Ore Reserves are estimated and reported at the business unit level (operation), with a small team within a central Centre of Excellence acting as coordinators, assurers and owners of the process. This paper discusses the processes put in place to build our community, share best practice, and overall ensure the accuracy of our reporting and compliance with disclosure regulations. Examples will be provided to illustrate how we maintain our cohesive community and culture of continuous improvement, which encourages the community to challenge normalised risks and strive for improvement.

3:45 PM

Impacts of Different Competent Persons Judgements in Mineral Resources Classification
S. Owusu; SME, Eureka, NV
The negative impacts of uncertainty associated with mineral resources estimation and classification can lead to unreliable production schedules and unpredictable cash flows. The various standard codes for public disclosure provide guidelines and recommendations for the classification of Mineral Resources and Reserves but lack the provision of details, for example, the amount of geological and geostatistical information needed to qualify for each category of the Mineral Resources and Reserves. This paper investigates the impacts associated with classification results due to different Competent Persons judgements, using same drill hole data. The results from this work underpin the need for a uniform classification framework.

4:05 PM

A Holistic Vision for a Systems Approach to Resource Governance
H. Arvidson², R. Sousa¹, B. Elloy⁴, N. Pollock¹ and C. Carrasco¹; ¹Industry Expertise, K2fly, Denver, CO; ²Industry Expertise, K2fly, Perth, WA, Australia; ³Chief Executive Officer, K2fly, Perth, WA, Australia and ⁴Chief Product Officer, K2fly, Perth, WA, Australia
Global public mineral reporting codes have driven strong governance of public disclosures of minerals information. Recently, we have seen an increase in disclosure of information related to Environmental, Social and Governance (ESG) issues, and governance of ESG information in mining companies has arguably reached a similar level of governance and diligence afforded mineral reporting. We define Resource Governance as the conjunction of environmental, social and minerals governance. A modern systems approach to Resource Governance, which combines mineral and ESG information, would provide not only reporting and governance capability, but also has the potential to sense/respond, predict, and manage ESG risks.

2:05 PM

Comparative Analysis of Autonomous vs. Conventional Drilling in Mining
K. Pacheco Hague¹, E. Loayza¹ and V. Tenorio²; 'Mining Engineering, Student member, Golden, CO and ²'Mining Engineering, Professor, Tucson, AZ
Autonomous drilling is a highly efficient technological innovation that is achieving significant improvements in productivity and safety. As part of the smart mining concept, it includes novel features such as simultaneous control of drills by a single operator, downtime reduction with continuous and automatic operation, better operation conditions with less dust and vibration, resulting in a lower cost per ton. A case study in a surface mine with autonomous drilling is presented where the implementation, selection and evaluation of equipment, operational control, and data management are analyzed to achieve a successful operating system, including a comparison with conventional technologies.

2:25 PM

Boxhole Backreaming: Technology and Case Study
M. Stöhr; Mining, Head of Sales, Schwanau-Allmannsweier, Germany
The Boxhole Backreaming technology was designed by Herrenknecht for fast and safe creation of shafts and ore passes. The BBR drills a pilot hole andreams it up to 3.6m for shaft lengths up to 70m. Based on the proven BBM technology, the BBR is characterized by high efficiency and safety standards. In combination with an optional lowering unit, shaft lining is carried out simultaneously while reaming. A BBR and lowering unit duo is used at El Teniente mine in Chile, where around 150m of shafts with a final diameter of 3m were drilled and lined in very challenging geologies.

2:45 PM

Horizontal Directional Drilling in Bedded Evaporite Deposits
A. Greenblatt and B. Lyddall; REI Drilling Inc., Salt Lake City, UT
Geophysical data gaps in bedded evaporite deposits put mines at risk of operational and safety hazards from unexpected ground conditions and the potential for water inflows. Using underground directional drilling combined with downhole geophysics, operators are supplied with vital data to update their geologic models and make safe decisions regarding their mining plans. Wellhead controls combined with engineered borehole designs targeting multiple features and mining horizons allow for the compilation of invaluable data from drilling, including focused gamma, hydrostatic pressures, temperatures, fluid flow rates, and drilling pressures which can be correlated to specific geologic properties. Geologic interpretation is further resolved with the application of post drilling geophysical tools such as gamma/density, borehole televiewer, and ground penetrating radar. When combined, LWD coupled with post drilling logging fills-in the data gaps. This paper presents the results of a number of LWD with post-drilling logging projects applied to evaporite mines for data gap analyses and verification of anomalies detected from surface geophysical techniques such as seismic surveys.
3:05 PM

**Reliability of Drill Bits Case Study**

*E. Thibaud; Pure Wave Consulting, Chattanooga, TN*

This paper presents a bit-conditioning method to extend the reliability of drill bits. Improving bit reliability minimizes downtime, reduces maintenance & operational costs, & improves safety in quarrying operations. The paper introduces a post-manufacturing treatment for drill bits that realigns the crystalline structure of the host body of the drill bit, which differs from standard surface-only coatings. The treatment allows vibration to be distributed evenly, thus reducing stress & heat buildup that leads to failure. Comparing the life of conventional bits to the treated bits from the same manufacturer is presented. In a full-scale granite operation in North Carolina, where drilling conditions are highly abrasive, hammer pressure, rotation, bit life, & drill hole accuracy were recorded & compared to identify failure modes. Treated bits were proven to achieve lifespans two times longer than conventional bits. In conclusion, the case study demonstrates tangible benefits to the treated bits, including efficiency, reduced frequency of tool replacements, & sustainable resource allocation. The study highlights the importance of adopting a proactive approach to reliability.

**MONDAY, FEBRUARY 26  AFTERNOON**

**MINING & EXPLORATION: OPERATIONS: LEO IN REVIEW: THE LIFECYCLE OF A GROUND FAILURE AT THE HISTORIC RIO TINTO/BINGHAM CANYON MINE**

**North 223**

2:00 PM • Monday, February 26

*Chairs: E. Hoffman, Rio Tinto, South Jordan, UT
K. Robertson, Rio Tinto, Draper, UT*

**2:00 PM**

**Introductions**

**2:05 PM**

**Pre-Failure of Leo; Observational Mining & Mitigations**

*M. Smith; Minerals, Rio Tinto, Eagle Mountain, UT*

In May 2021, the Leo Slice failed at the Bingham Canyon Mine, with a failed mass of over 20Mt. The instability was initially identified in 2020 and monitored closely throughout its progression. This presentation outlines and explains the build-up from initial identification of the Leo Instability in Q2 2020, the mitigating actions and observation mining controls implemented, which were necessary to safely continue mining under the instability and continue to deliver ore to downstream partners.

**2:25 PM**

**Leo Failure Geology**

*F. Da Prat; Geology, Rio Tinto, Herriman, UT*

The Leo failure is controlled by 6 geologic units. From West to East, it includes the Lark limestone, its associated quartzite unit, the Commercial limestone, and the Ohio quartzite which are intruded by the porphyritic quartz monzonite (PQM) and a thin monzonite (MZ) rind at the Ohio-Commercial contact. The right release was the 8-24” thick Lark fault, a continuous, clay-rich, bedding-parallel fault, lying near the base of the Lark limestone. The left release was controlled by a complex, stepped joint set at the contact between the Ohio quartzite and the intrusives.

**2:45 PM**

**Thermal Video Monitoring and Numerical Modeling of the “Leo Failure” Runout at the Bingham Canyon Mine, Utah, USA**

*K. Schafer and S. Ergun; Rio Tinto, Herriman, UT*

Alongside a state-of-the-art slope-monitoring array (including radar and optical/video), thermal video recordings documented a 21 million-ton collapse (the “Leo Failure”) of a pit-slope wall at the Bingham Canyon Mine in Utah, USA. Continuous thermal video recordings are available before, during, and after the slope collapse. The thermal video recordings document both the spatial distribution and frequency of pre-failure rockfall occurrences and the dynamics of the failure mass; including the toe runout. These data were used to calibrate a numerical particle-flow-code (PFC) model to simulate the runout of the failure mass and predict the spatial distribution of ore within the toe of the failed mass. In turn, the model results guide mine plans for excavation and recovery of ore in the failed mass. This study documents the value of thermal video coupled with PFC modeling to the mining of a failed mass.

**3:05 PM**

**Execution Supervisor POV of Dealing with the Leo**

*T. Lambert; Mine Planning, Rio Tinto Kennecott, Herriman, UT*

Leo failed mass mining presented unique operational challenges not seen elsewhere in the pit that required evacuation plans, adapted shovel mining methods, boulder management strategies, VCM construction controls, remote drilling and altered blasting practices. Area controls applied to safely operate in the Leo failed mass impacted equipment productivities. The number of teams & departments exposed to the area required consistent coordination and verification of understanding and control implementation. Frequent technical and in-field risk assessments, detailed crew lineouts, and other rigorous communication methods in coordination with engineered controls maintained operational safety of personnel and company resources.

**3:25 PM**

**Generating Value from a Geotechnical Failure—FM1 and FM2**

*M. Austin; Mine Technical, Rio Tinto, South Jordan, UT*

The Bingham Canyon Mine geotechnical failure known as the Leo Failure provided many technical challenges and opportunities. The Leo Failure contained high value ore targeted later in mine life within the pit phase “O-Cut”. The ore’s accelerated exposure introduced oxidation over time, with degradation and loss of value. Designs to safely recover the material were developed and reviewed by multiple teams. The individual designs, FM1 and FM2, provided unique situations and solutions. The geometrical and geotechnical circumstances generated technical risks and challenges to mining the failed material and provided valuable learnings and experience to the technical and operational teams involved.

**3:45 PM**

**Operational Geotechnical Controls Implemented at the Bingham Canyon Mine Above and Below a Large Failure Scarp**

*F. Schumacher; Rio Tinto, Sandy, UT*

In May 2021 a large pit slope failure, referred to as the Leo Slide, occurred in the southeast wall of the Bingham Canyon Mine. The instability displaced approximately 21Mt of material onto the pit floor and left a large, geotechnically complex scarp in the wall directly below the operating level. The scarp comprised a combination of damaged rock mass, intact overhanging blocks, and talus. The scarp was prone to failures, typically following blasting or heavy precipitation. The post-failure mining challenges were to a) safely mine above and through the failure scarp and b) safely mine out the high-grade ore within the failed mass at the slope toe. The geotechnical hazards included instability of the scarp directly below the working level, and rockfall at the toe from both failed material and mining above. This paper discusses these hazards in detail and the geotechnical controls implemented to manage them and maintain safe, efficient production. The controls included: real-time slope monitoring techniques, geo-spatial restrictions of mining equipment, thermal imaging, blasting controls, laser scanning and use of remote mining equipment.
2:05 PM
Unlocking Efficiency: Advances in Flotation Circuit Design and Optimization—Antoine M. Gaudin Lecture

P. Amelunxen; HudBay Minerals Inc, Etobicoke, ON, Canada

There is no widely accepted standard calculation for estimating residence time requirements and flowsheet configurations for flotation circuits. Part of the challenge relates to the fact that some of the key phenomena that occur in laboratory and industrial flotation machines are not quantifiable under the commercial constraints of most industrial engineering studies, and this has forced engineers, who must get on with the job at hand, to plug the knowledge gap with a guess (engineers call them “assumptions”). In this presentation I will review some of these “assumptions” and how they have introduced error, risk, and cost to the resulting flotation circuit design. Lastly, I will discuss some of the recent developments in addressing these shortcomings, and how they are being used to improve the efficiency of modern flotation circuits.

Award Committee chair and award presenter: Robert Dunne.

2:40 PM
Froth Flotation Then and Now—Robert H. Richards Award Lecture

R. Johnson; Johnson Mining Consulting Services, Bellaire, TX

In 1976, I began my career operating 7-rows of 48-ft³ (1.4-m³) Galigher Agitair float cells in the old plant and 3-rows of 300-ft³ (8.5-m³) Wemco cells in the new plant. Within a five-year span, we started replacing some of the small Agitair cells with 2,000-ft³ (56.6-m³) Maxwell pre-rougher cells, followed by 500-ft³ (14.2-m³) Outokumpu units. I was thinking what a very progressive operation I had joined. Flash forward 10 years, the OK-1,350-ft³ (38-m³) and Wemco 1,500-ft³ (42.5-m³) cells were the new rave. Jump another 10 years, and the Wemco 3,000-ft³ (85-m³) were making a splash, and we were talking about even larger tank cells in our future. Another 10 years later, the tank cells arrive at 100 m³ and are jumping to a new standard of 300-m³ cells. What I would like to discuss today is the ongoing shift back to smaller, more efficient cells and how we got there.

3:15 PM
What the MPD Can Learn from the Lead Battery—Milton E. Wadsworth Award Lecture

G. Van Weert; Oretome Ltd, Brampton, ON, Canada

The automotive starter battery industry provides just about the second-best example of what’s going to happen to most industrial metals: near complete recycling! With only residual domestic mining, U.S. steelmakers already operate with 50% steel scrap. Concrete waste and bricks are complete recycling! With only residual domestic mining, U.S. steelmakers already operate with 50% steel scrap. Concrete waste and bricks are attracting attention as cement replacement and wood is turned into char. The automotive starter battery industry provides just about the second-best example of what’s going to happen to most industrial metals: near complete recycling! With only residual domestic mining, U.S. steelmakers already operate with 50% steel scrap. Concrete waste and bricks are complete recycling! With only residual domestic mining, U.S. steelmakers already operate with 50% steel scrap. Concrete waste and bricks are attracting attention as cement replacement and wood is turned into char. The automotive starter battery industry provides just about the second-best example of what’s going to happen to most industrial metals: near complete recycling! With only residual domestic mining, U.S. steelmakers already operate with 50% steel scrap. Concrete waste and bricks are attracting attention as cement replacement and wood is turned into char. The automotive starter battery industry provides just about the second-best example of what’s going to happen to most industrial metals: near complete recycling! With only residual domestic mining, U.S. steelmakers already operate with 50% steel scrap. Concrete waste and bricks are attracting attention as cement replacement and wood is turned into char. The automotive starter battery industry provides just about the second-best example of what’s going to happen to most industrial metals: near complete recycling! With only residual domestic mining, U.S. steelmakers already operate with 50% steel scrap. Concrete waste and bricks are attracting attention as cement replacement and wood is turned into char.

MONDAY, FEBRUARY 26 AFTERNOON
OPERATIONALIZING NET ZERO (GMG)

2:00 PM • Monday, February 26
Chair: H. Ednie, Global Mining Guidelines Group

2:00 PM Introductions

2:00 PM Operationalizing Net Zero

H. Ednie; Global Mining Guidelines Group, Montreal, QC, Canada

Meeting the net zero goal successfully relies on operationalizing best practices. While many companies are setting net zero goals, it’s clear that the main concern across the industry has to do with implementation, and a common challenge around this involves energy management.
A holistic approach to energy management involves viewing energy as an asset rather than a commodity. This means, to understand energy management, it needs to be managed across the whole lifecycle of the mine from generation to regeneration. During this session, we will discuss approaches the industry can take to be more sustainable, map out energy management strategies, and looking at all the aspects around energy that are impacting mining. Proper energy management can help with not only meeting net zero goals, but also help to optimize the mine and make the implementation of new technologies more operationally efficient and cost-effective.

MONDAY, FEBRUARY 26  AFTERNOON
RISK MANAGEMENT & INSURANCE
North 227C
2:00 PM • Monday, February 26
Chair: C. Pecora, Hawcroft, Venetia, PA

2:00 PM
Introductions

2:05 PM
Bridging the Downturns—A Resilience Strategy For Mining Education
B. Ross; Global Mining Education Foundation, Tucson, AZ

Mining’s cyclical nature brings periods of growth and contraction. Beyond affecting industry operations, these cycles have profound implications for mining education. In times of economic downturns, mining education programs often grapple with lower student enrollments, smaller research funds, and challenges in retaining faculty. Such pressures can threaten the very existence of these programs. In response to these challenges, the Global Mining Education Foundation proposes a pioneering initiative: The Mining Education Resilience Fund. This fund aims to protect the mining sector against economic ebbs by supporting the reskilling of professionals affected by layoffs, aiding promising students, and facilitating the creation of innovative courses. The objective is to sustain mining education’s relevance and quality, preserving critical industry knowledge and fostering skill enhancement. Administered by an industry board, this fund is insurance on the industry’s workforce. It acts not just as a safety net, but as a strategic reservoir, offsetting the consequences of economic downturns. This presentation discusses the mechanics of the program and examines potential funding avenues.

2:25 PM
Water Stewardship Through a Mine Life Cycle
S. Bailey, WSP, Toronto, ON, Canada

There is increasing stakeholder and societal pressure on mining companies to recognize water as a shared resource. Water security is critical for both mine operational performance and the community at large. These risks will become more visible as competition for water resources increases due to population growth, urbanization, and climate change trends. In response, companies are moving towards proactive water stewardship program development involving the cataloging of risks and opportunities and establishing contextual water targets. Water stewardship considerations can change based upon the mining phase. While there are overarching water related risks that may persist throughout the life of the mine, some risks are more impactful at certain stages. This presentation will provide recommendations on how to address and account for water stewardship considerations at all stages of a mine life cycle. Corporate water stewardship programs must be adapted to the various stages of individual projects and take the overall catchment requirements into consideration. Therefore, having a dynamic program that can address individual sites needs is crucial to ensuring meaningful impact.

2:45 PM
Social Factor of the Mining Industry in the ESG Criteria
C. SOTO; UNAMBA, APURIMAC, Peru

The mining industry demands technological and multidisciplinary attention from the exploration stage to closure. It requires specialized attention in the social context. The study of the interrelationships of peoples is subjected to a harmonious dialogue based on ethics and transparency. It raises questions: Is there an appropriate social relationship? Is the qualitative data validated? How is social-industry relationship in the long term? How do we reconcile levels of education about effects of mining on communities? This paper analyzes and demonstrates the social aspect of the ESG criterion. The method is academic with a qualitative approach subjected to an extensive literature review, as well as results covered in field statistics that address the social problems of communities impacted by mining.

3:05 PM
Flexible Financing of Mine Water Treatment
L. Josselyn1 and S. Billin2; 1Linkan Engineering, Elko, NV and 2Linkan Engineering, Golden, CO

Financing water treatment projects at the front end of the mine life and with closure typically have high CAPEX cost and numerous risks. Changes in water quality, flow rate, commitment to a treatment technology, timing, built in redundancy, etc. have many risk and cost components. Flexible financing can resolve these issues in reducing upfront capital, adding adaptability, and placing responsibility on the provider instead of the owner. Most importantly there are benefits to both owner and provider using a design-build-operate model. Here we look at the pros and cons and the change to project finances in several project specific examples.

3:25 PM
Simultaneous Stochastic Optimization of Long-Term Production Planning and Forecasting of Mining Complexes—New Software Technologies and Implementations
M. Faris1 and G. dos Santos2; 1Mining Consulting, KPI Mining Solutions, Montreal, QC, Canada and 2Mining Consulting, KPI Mining Solutions, Vancouver, BC, Canada

Commercial software solutions for the long-term mine planning are commonly deterministic and follow a sequential optimization workflow. A single estimated model of the mineral deposits and various software tools are used to define pit limits, pushbacks, the sequence of extraction, cut-off grades, stockpiling and material handling and blending, and so on. A new optimization model is now available to the mining industry for the simultaneous stochastic optimization mining complexes consisting of multiple open-pits, stockpiles, waste dumps, and processing facilities. Geostatistical simulations of the mineral deposits are used to describe the geological uncertainty and variability. Its simultaneous optimization model allows capitalizing on the operational synergies across the mining complex. A case study at a gold mining complex demonstrates strategic production schedules are generated with substantially higher NPV while managing technical risks in meeting production targets. In addition, the solution simplifies the long-term planning workflow. Finally, joint supply and demand uncertainties can also be used for the risk management and assessment of the generated production forecasts.

MONDAY, FEBRUARY 26  AFTERNOON
SME YOUNG LEADERS: A DAY IN THE MINING LIFE
Sponsored by: Rio Tinto
North 125A
2:00 PM • Monday, February 26
Chair: S. Cicek, Nevada Gold Mines, Morgantown, WV
Women and minorities are making strides in the mining industry, and they are inspiring others to follow. The varied job roles and unique responsibilities of mining engineers allow them to develop a wide range of skills and expertise. In this talk, Alvar Marin, a Senior Mining Engineer at U.S. Silica Company, will discuss his experience in Nevada and share his insights on the future of the mining industry.

Alvar is a dedicated professional with a passion for mining. As a Senior Mining Engineer, he leads projects and develops strategies to optimize mining operations. He is known for his ability to work in diverse environments and his expertise in both technical and managerial aspects of the industry.

During the presentation, Alvar will discuss his journey from college to the mining industry, highlighting the challenges and opportunities he has faced along the way. He will also share his experiences working in Nevada and the importance of being part of a few different groups. Alvar's presentation will be an excellent opportunity for anyone interested in mining to learn from his insights and experiences.
The presenters will summarize the key uncertainties that remain following mineralogical, textural and geochemical assessment of the tailings matrix. The geotechnical test work was supplemented by a tube samples. The geotechnical test work was then undertaken on both reconstituted samples and the “high quality” was expanded to include in-situ vane shear tests (VSTs) and collection of bulk San Manuel copper mine in Arizona, USA. The work followed a staged to characterize the geotechnical behaviour of the tailings at BHP’s legacy expanding to include in-situ vane shear tests (VSTs) and collection of bulk was then undertaken on both reconstituted samples and the “high quality” was expanded to include in-situ vane shear tests (VSTs) and collection of bulk.
ONSITE PROGRAM

TUESDAY, FEBRUARY 27  MORNING

DOE ARPA-E REMEDY VAM Project Overview
J. Lewnard; ARPA-E, US DOE, Washington, DC
ARPA-E’s “Reducing Emissions of Methane Every Day of the Year” (REMEDY) program is a 3-year, $35MM program to reduce methane emissions from fossil energy sources. The program includes three projects to address coal mine ventilation air methane (VAM). Johnson Matthey is continuing work on the COMET process, which uses a noble metal catalyst. Massachusetts Institute of Technology is developing a low-cost copper-based catalyst.

COAL & ENERGY: DEPLOYMENT OF MINE EMISSIONS REDUCTION TECHNOLOGIES—MINE METHANE MANAGEMENT
North 226B
9:00 AM • Tuesday, February 27

Introductions

DOE ARPA-E REMEDY VAM Project Overview
J. Lewnard; ARPA-E, US DOE, Washington, DC
ARPA-E’s “Reducing Emissions of Methane Every Day of the Year” (REMEDY) program is a 3-year, $35MM program to reduce methane emissions from fossil energy sources. The program includes three projects to address coal mine ventilation air methane (VAM). Johnson Matthey is continuing work on the COMET process, which uses a noble metal catalyst. Massachusetts Institute of Technology is developing a low-cost copper-based catalyst.

COAL & ENERGY: DEPLOYMENT OF MINE EMISSIONS REDUCTION TECHNOLOGIES—MINE METHANE MANAGEMENT
North 226B
9:00 AM • Tuesday, February 27

Introductions

9:05 AM
Why Bins Plug: Compaction By The Feeder—How Your Feeder May Be Committing Power and Energy To Making Your Bulk Solid More Difficult Flowing
D. Vaile and J. Bundalli; Kamengo, Vancouver, BC, Canada
A properly designed storage bin handling a difficult flowing bulk solid will ensure that gravity is always sufficient to break the arch the material forms at the bin outlet. Material flow property testing provides engineers good guidance on the minimum hopper opening needed to ensure gravity will break the arch. But what happens if you build strength into the bulk solid at the outlet during discharge? This is what happens with some feeders that compact material at the discharge opening. The result is a bulk solid that has more strength than what you designed for, and a hopper opening that is not sufficient to promote gravity discharge. The result is a problem bin. Compaction of the bulk solid by the feeder is a case of power being applied where you don’t want it. Understanding how feeders compact material in a storage bin is necessary to understanding how it can be avoided. This presentation will review the basics of good bin and feeder design and look at the root causes of compaction by the feeder. Using case studies, the presentation will demonstrate solutions that will resolve compaction by the feeder. These solutions are not only more reliable but also more power efficient.

9:25 AM
24-016
Challenges of Design and Fabrication of Fiber Reinforced Polymer (FRP) Flanges
S. Shadlou; Engineering, RPS Composites, Maple, ON, Canada
FRP is an excellent material choice for a broad spectrum of corrosive fluids and, in many cases, offers the best value per dollar. FRP Flanges present the greatest design challenge of all standard piping components. The theory underlying the design of flanges is very complex. In addition, due to the nature of FRP material, proper fabrication of the flanges is as critical as the design. In this study, the challenges of making FRP flange along with the design techniques and best practices of fabrication that will lead to a high-quality flange will be discussed.

9:45 AM
Dozers in Action: Leveraging Production Dozing in Mining Applications
Y. Hurr; CAT, East Peoria, IL
Dozers are often used in mining applications for stockpiling or to clean up truck spills. However, as the mining industry continues to seek more efficient solutions and the lowest operating costs, in some applications, dozers can also be used as a primary production tool. This presentation will consider various mining applications in which dozers can help improve productivity. We will also compare different dozing techniques, including back-each-pass and front-to-back dozing, to determine the most efficient and productive methods for given applications. Finally, we will present examples of dozer technologies that can help mine sites increase efficiency and reduce fuel consumption; improve operator safety and comfort while minimizing environmental exposure; and optimize mining procedures to achieve the lowest cost per ton. Together, these topics will show how improvements to mining operations can deliver more efficiency and continuous innovation for mines—and miners—everywhere.

10:05 AM
Digital Bulk Material Handling: Increased Efficiency and Availability, Reduced Maintenance Efforts
L. Paul; SME, Denver, CO
Nowadays everything is becoming digital, even Bulk Material Handling is faced with this trend, and that for a good reason. As will be substantiated with a case study, the combination of the real machine and its theoretical design model, the combination of existing sensor data, some project specific additional sensors and the underlying calculation of the machine is a huge step forward in predicting the lifetime of the critical components. This allows maintenance to be planned, utilizing each component as much as possible while yet avoiding unplanned stops of the equipment. Looking at the data over time allows even to see possibilities to run the machine more efficiently or increase the design capacity in certain conditions. The key for each project then becomes to choose the right set up: Which data is to be collected? What are the critical components to be monitored and which additional sensors are required? Our case study will guide through these steps and point out the benefits that can be reached.

10:25 AM
Conveyor Pulley Material Selection for Constructability
J. Ellis; Precision Pulley and Idler, Altoona, IA
Over the years, there have been many innovations made in both the design of pulleys and materials used to construct them. As conveyor belts continue to advance and allow for smaller and smaller pulleys without a reduction in belt modulus, the need for high strength pulleys in a compact form has increased. To design pulleys to these criteria, both industry standard and exotic materials are used by pulley designers. We will discuss the advantages, and disadvantages, of materials commonly selected for pulley drum and shaft construction.

10:45 AM
The Romance of Conveyors
M. dos Santos; SME, Marietta, GA
Conveyors have long been used in and around mines, and are well recognized as an efficient means of moving materials from point A to point B. Ironically, their ability to get the job done in such a straightforward manner means that they're generally regarded as somewhat boring and they basically fade into the background. Haul trucks in the mine have the same romantic appeal as cars, boats and trains. There's something about these modes of transportation that evokes emotion in people, and leads to an elevated level of interest. Why though are conveyors not regarded in the same way? They offer smooth, elegant paths that carry material in a far more efficient manner than trucks. Less noise, less emissions, and less hassle. What's not to love? Maybe conveyors don't offer some of the excitement of haul trucks, but there's something to be said for consistency. This presentation will present the appealing aspects of conveyors that many seem to overlook, and make the point that conveyors are romantic too; some may even say "sexy."
Precise Combustion is developing a modular system that promotes methane reaction and manages thermal loads in a novel reactor design. Projects are completing Stage 1, focused on engineering studies and lab-based testing for system components. They will be assessed for Stage 2 funding, which includes building and operating field tests unit. This presentation will give an update to the 2023 Annual Meeting 2023 (https://arap-e.energy.gov/2023-remedy-meeting).

9:25 AM

Opportunities, Challenges and Solutions in the Development and Deployment of Catalytic Oxidation of Ventilation Air Methane (VAM)


Ventilation Air Methane (VAM) abatement provides a unique opportunity for underground mines to reduce greenhouse gas (GHG) emissions. As the global warming potential of methane is 25-28 times that of CO2 over a 100-year period, complete oxidation of methane can be an effective tool. Deployment of existing technologies carries immense challenges with respect to safety considerations, technical feasibility, and cost. Catalytic oxidation has many advantages over thermal oxidation, such as a smaller footprint and the ability of accommodating a wide range of methane concentration (from 0.1 to 1.6%). The low operating temperature also makes catalytic oxidation process inherently safer. Connecting the abatement unit to the fan brings in additional challenges not only on technologies but also on the safe operation of the entire system. This presentation will explore some of the consideration factors such as: safety aspects, MSHA approval, physical size/constraints, monitoring and verification and the ability to redeploy the methane abatement unit to new shafts. In addition, it will provide an overview of the commercial benefits and challenges of low methane concentration streams.

9:45 AM

Destruction of VAM Using a Modular Catalytic Element System

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

To eliminate the release of ventilation air methane associated with coal production, the core challenge is to oxidize methane given the low concentrations at moderate temperatures. To address this challenge, Precision Combustion, Inc. is developing a modular array combining 3 key elements: (i) short contact time, low thermal mass reactor design to achieve maximal total conversion in a small volume, (ii) catalyst formulation and loading to minimize the required operating temperature of the catalytic oxidation, and (iii) system design and architecture to maximize the degree to which released heat is retained and recirculated. In this work, the modular structure is modelled and optimized through computational fluid dynamics and thermal modelling to maximize heat transfer, both through the solid and from solid to gas. These optimized designs were manufactured to produce prototypes. Long term durability and contaminant tolerance for low methane concentrations were examined. In this talk, we will report performance data and the impact on methane mitigation from mining operations.

10:05 AM

Low-temperature, Low-Cost Ventilation Air Methane Destruction

D. Plata1, M. Pishahang1, A. Parker1, M. Mundthwa2, G. Han3 and A. Hart4, 1Civil & Environmental Engineering, Massachusetts Institute of Technology, Cambridge, MA and 2Mechanical Engineering, MIT, Cambridge, MA

Coal mining methane emissions reduction presents an opportunity to reduce the atmospheric accumulation of methane, which would bring important climatic benefits and help corporations meet greenhouse gas reduction goals. Historically, ventilation air methane destruction has been difficult and costly, due to the variable levels of methane, high heating requirements, and associated safety risks. We present a novel catalyst and reactor system for low-cost based on earth-abundant materials with heat recovery. The catalyst has been shown to be durable, tolerant to most poisons, and effective at over 99% methane destruction. The reactor is expected to offer 70-90% heat recovery without a costly pressure drop, allowing for cost-saving thermal demand reduction that further lowers the environmental footprint. Finally, the low steady-state operation temperature (~400°C) provides implicitly safer operation for use at active mines. This innovation will help mining industries continue to meet the energy and material demands of society, while fostering economic and environmental sustainability.

10:25 AM

Implementation of a Second-Generation VAMOX® Regenerative Thermal Oxidation (RTO) System to Abate Ventilation Air Methane (VAM) Emissions from a U.S.-Based Underground Coal Mine

D. Kay; Biothermica, Montreal, QC, Canada

Methane released by coal mining operations, known as Coal Mine Methane (CMM), is a greenhouse gas (GHG) 25 times more potent than CO2. More than 90% of these CMM emissions are believed to be from underground mines, of which about 70-80% is emitted through the mine ventilation air, known as Ventilation Air Methane (VAM). Global VAM emissions are estimated to contribute to more than 700 MtCO2e annually. Biothermica has developed a Vamox® Regenerative Thermal Oxidation (RTO) technology specifically optimized to abate VAM in self-sustained operation down to methane concentration as low as 0.25%. Its automated control strategy also adapts the process to highly variable methane concentration to maintain self-sustained and safe operation (preventing overheating), over a wide range of concentration up to 1.2%. Following the engineering, construction and commissioning in 2022 of a first full-scale Vamox® RTO system of 150,000 acfm capacity at a Virginia-based underground coal mine, a second-generation full-scale system with an increased flow capacity of 180,000 acfm has been designed and is being implemented at a U.S.-based underground coal mine.

10:45 AM

CSIRO Ventilation Air Methane Abatement Research

Y. Jin, H. Guo, X. Yu, L. Liu, J. Bae, M. Elmouttie and G. Zhao; CSIRO, Pullenvale, QLD, Australia

Approximately 50-85% of coal mining methane is emitted to the atmosphere through mine ventilation air, depending on mine site specifications. Ventilation air methane (VAM) is very challenging for coal industry to mitigate or use as an energy source because (1) the air volume is large and (2) the methane resource is dilute and variable in concentration. Since 2000, CSIRO has comprehensively studied VAM mitigation and utilisation through over 30 research projects ranging from fundamental studies to pilot-scale prototype unit development and site trials. To date, three patented VAM abatement technologies have been successfully trialled and demonstrated at a coal mine in Australia. The presentation will provide an overview on the CSIRO VAM abatement research and update our recent R&D progress in catalytic VAM mitigation including field trials and novel precious-metal-free VAM catalysts development.

11:05 AM

Detection, Quantification, and Mitigation of Fugitive Methane Emissions: Lessons Learned from the Oil & Gas Industry

A. Lashgari, Project Canary, Pittsburgh, PA

In the past few years, there has been a growing demand among operating companies, investors, the public, and governments to develop means to accurately monitor, measure, and mitigate methane emissions. United Nations Environmental Program (UNEP) recently announced its plans to establish MetCoal Methane Partnership to outline a performance and reporting framework to accurately estimate and reduce methane emissions from the metallurgical coal industry. It follows an existing UNEP
Oil & Gas Methane Partnership 2.0 and other voluntary initiatives for the oil & gas sector. These frameworks rely on empirical emission measurements to improve the accuracy of methane emission reporting. This presentation discusses these initiatives and their contribution to deploying advanced detection technologies and improving emissions reporting methods. It also offers insight into various types of methane emissions technologies, including next-generation emission measurement techniques, their capabilities, limitations, and applications. In addition, lessons learned from the application of methane emissions measurement and quantification in the oil & gas sector will be discussed.

TUESDAY, FEBRUARY 27 MORNING

COAL & ENERGY: OPERATIONS PROJECTS, DEVELOPMENTS, AND INNOVATIONS

North 226A

9:00 AM • Tuesday, February 27

Chairs: S. Baker, Rosebud Mining, State College, PA
J. Bobbera, Robindale Energy, Ligioner, PA

9:00 AM Introductions

9:05 AM Allegheny Metallurgical, LLC (“Allegheny Met”) Update
R. Toler; Allegheny Metallurgical, LLC, Volga, WV

Allegheny Met began underground development in the next generation steelmaking longwall coal mine, the Longview Mine, outside of Bridgeport, WV, in April 2022. The High Carbon Processing Plant started production in January 2023 shipping its first train in February 2023. Allegheny Met mines coal from the Lower Kittanning seam with ~93Mt of recoverable coal reserves and a planned 26-year mine life. Once fully operational, the Longview Mine will produce ~3.3Mtpa of high quality, high fluidity, high-vol steelmaking coal for the export and domestic markets annually. The longwall startup is the next project milestone and production will begin in the 4th Quarter 2023. The Longwall System was designed using the latest proven technology by utilizing several longwall equipment manufacturers to construct a safe and efficient system. A mini build of the longwall is being completed on the surface for compatibility testing and job training for Allegheny Met employees. Allegheny Met is a wholly owned subsidiary of North Central Resource, LLC (“NCR”), a privately owned holding company, backed by experienced and well capitalized coal and steel investors—AMCI, Itochu, POSCO, and JAZ Ventures.

9:25 AM Minimizing Risks and Creating Solutions for Ground Control in Confined Spaces
R. Boothby; GMS Mine Repair and Maintenance, Morgantown, WV

Miners have traditionally used light weight portable spot bolters to install ground control products. Sometimes they are used in areas where heavy equipment cannot be used to help move the equipment, and the operators are exposed to stress/strain injuries. The operators are also exposed to falling rock, stored energy, tripping hazards, and pinch points. GMS has utilized automation and innovation to help protect our miners. This presentation will review the dangers associated with installing ground control and the equipment GMS has created to help mitigate those risks and protect our miners. Examples of this equipment are Monorail Bolter, Mini Bolter, and Robotic Shotcrete Arm. Film footage of the equipment installing bolts underground in various locations will be showcased, and an explanation of how we have both minimized risks and increased production.

9:45 AM

Controlling the Roof in the Pittsburgh No. 8 Seam: A 20 Year Retrospective
R. Poland and B. Mirabile, Jenzmar, Morgantown, WV

The Pittsburgh No. 8 coal seam has often been touted at the most valuable mineral deposit on the planet. The seam has been extensively mined for well over one hundred years, and many coal mining best practices started at Pittsburgh seam mines. This paper outlines the development of the six foot fully-grouted mechanical shell tensioned primary bolt for use as primary roof support. This bolting system is the embodiment of multiple roof bolting concepts aimed at controlling tabular, bedded strata subjected to both vertical and horizontal stresses. Development of this system began in the early 2000s with industry partners. In 2023, nearly every mine operating in the Pittsburgh No. 8 seam utilizes this system for primary roof support. The paper will discuss the development of this bolting system and outline the improvements the system has made in controlling ground movement and reducing roof fall frequency.

10:05 AM

Inert Gas Pressure Fracturing Applications in Underground Mining
D. Brunner and B. Lyddall, REI Drilling, Salt Lake City, UT

Inert Gas Pressure Fracturing is a technique that has been used in mines for decades, although it has been widely unused in US Mines since the mid-1900s. Recently, this technique has been adapted as a fracturing tool, used in in-seam boreholes in Chinese coal mines to enhance wellbore connectivity to natural fractures to improve gas drainage. Recently this technology was applied in the US in conjunction with directional drilling for softening of overlying strata as a pretreatment to improve longwall caving and manage underground stresses. Designed specifically for use in mining, this system offers a broad range of potential applications including softening of intrusions significantly in advance of mining, preconditioning in advance of cave mining, and providing connectivity between horizontal boreholes and adjacent wells or boreholes to develop drainage manifolds. This presentation provides an overview of Inert Gas Pressure Fracturing as a system to enhance gas drainage, presents the results of the application of the system in the Eastern Utah coal fields for stress management, and provides application concepts for pit slope stability in hard rock open pit mines.

10:25 AM

Geosensing for Exploration—New Technology for Underground Directional Drilling
S. Thompson1 and D. Brunner2; 1Coalbed Innovations, Sydney, NSW, Australia and 2REI Drilling, Inc., Salt Lake City, UT

Geosensing is used in oilfield drilling in conjunction with geophysical tools to support characterization of rock properties, geology, and reservoir conditions. This technology is now available to the mining industry and has been successfully applied to underground in-seam directional drilling in Australian coal mines for geologic exploration and methane drainage. The system utilizes a range of drill rig and wellhead mounted sensors which, combined with analytical software, produce real-time data from which 3D spatial features can be accurately modelled significantly in advance of mining. This innovation greatly expands on the information obtained from current in-seam directional drilling practices and provides for improved characterization of coal seams, including soft and weak zones, locations of geologic discontinuities, and analysis of formation flow. This presentation provides a description of the geosensing system and the interpretation of actual data from long in-seam directionally drilled methane drainage boreholes at mines in Australia, and discusses how this system will increase the value of directional drilling as an exploration tool for the mining industry.
TUESDAY, FEBRUARY 27  MORNING
COAL & ENERGY: VENTILATION INNOVATIONS I

North 227B
9:00 AM • Tuesday, February 27

Chairs: M. Gray, MSHA, Washington, PA
A. Kumar, The Pennsylvania State University—University Park Campus, State College, PA

9:00 AM
Introductions

9:05 AM
EWS for Real-Time Mine Safety Intervention
G. Danko, Mining and Metallurgical Engineering, Univ. of Nevada, Reno, Reno, NV
An Early-Warning System (EWS) software is developed to analyze real mine data. The EWS is based on real-time data from the Atmospheric Monitoring System (AMS) of the mine for continuous, automatic safety and health evaluation. A Dynamic Mine Ventilation Model (DMVM) is used for matching AMS data and predicting future simulated outcomes. The AMS layout of the mine is mapped in the mine ventilation model for connecting the sensor’s locations to the DMVM. For prevention-focused engineering design, an EWS-specific convolutional time series model is applied for the identification of the contaminant transport system of the mine from AMS data. The calibrated DMVM model extends the EWS applicability to the entire mine airway system by creating simulation data for unmonitored areas. EWS supports preventive intervention real-time (1) by the recognition of an accident- or health hazard-prone atmospheric event; and (2) by design, accounting for any potential, anticipated, accident- or health hazard-prone atmospheric condition, determined by a trained model, to be triggered real-time by a disturbing signal, either coming from the mine’s AMS or other source.

9:25 AM
Enhancing Air Quality in Underground Stone Mines: Evaluating the Efficacy of an Auxiliary Fan Air-Filtration to Reduce DPM
This research study aims to address the persistent hazard of diesel particulate matter (DPM) exposure in underground stone mines by investigating the potential of air filtration systems. With the objective of reducing DPM concentrations in the mine environment, a mobile diesel-powered booster fan was equipped with standard media filters. The fan was tested in an underground stone mine, and DPM measurements were taken before and after the air filtration in working areas. The results demonstrated that the implementation of filtration systems effectively reduced DPM levels, emphasizing the importance of such interventions in safeguarding the health and well-being of mine workers. This study contributes to the ongoing efforts of the National Institute for Occupational Safety and Health (NIOSH) in developing strategies to protect miners from hazardous airborne contaminants.

9:45 AM
Breath of Innovation: Wireless Gas Monitors Reinvent Mine Safety and Ventilation
M. Fisher, Programs, Innovative Wireless Technologies, Lynchburg, VA
Wireless Communications and Tracking systems are essential for miner safety. However, digital C&T networks have additional capabilities to improve mining safety and efficiency. One proven extended capability is adding Wireless Gas Monitors (WGMs). WGMs provide atmospheric monitoring, and push alarms for elevated gas levels directly to miner handsets in the affected areas. WGMs can also be used for ventilation monitoring, allowing mining operations to efficiently ventilate working sections. Additionally, the data from WGMs can be used for ventilation planning, allowing mining operations to cost effectively design and deploy ventilation systems in new mining areas.

10:05 AM
Adaptive Ventilation Control for Enhanced Efficiency in Indian Underground Coal Mines
H. Shekhraj and D. Mishra, Mining Engineering, Indian Institute of Technology (Indian School of Mines), Dhanbad, Dhanbad, Jharkhand, India and Associate Professor & Head, Dept. of Mining Engineering, Indian Institute of Technology (Indian School of Mines), Dhanbad, Dhanbad, Jharkhand, India
The current ventilation practice in Indian underground coal mines employs a fixed-speed fan system irrespective of varying factors like mine temperature, coal production, employee presence, and harmful gas concentrations. This approach leads to energy waste and operational inefficiencies. To address these issues, we propose an automated fan control system. This system utilizes real-time data from sensors to monitor hazardous gases, temperature, and other parameters. An intelligent algorithm processes this data dynamically adjust the fan speed. During low-demand periods such as maintenance or blasting, the fan speed reduces, conserving energy. Conversely, high gas concentrations or elevated temperatures trigger increased fan speeds to meet demands effectively. By employing this automated system, a more responsive and efficient ventilation solution can be achieved for underground coal mines. This not only enhances worker safety by ensuring adequate air quality and
temperature regulation but also contributes to energy savings and reduced operational costs. This paper presents the design, implementation, and potential benefits of this innovative ventilation control approach.

10:25 AM
Optimizing Fire Emergency Evacuation Routes in Underground Coal Mines: A Lightweight Network Flow Approach
S. LOTERO LOPEZ, V. Androulakis, H. Khaniani, M. Hassanalian, S. Shao and P. Roghanchi; 1Mineral Engineering Department, New Mexico Institute of mining and technology; Socorro, NM; 2Electrical Engineering Department, New Mexico Institute of Mining of Technology, Socorro, NM; 3Mechanical Engineering Department, New Mexico Institute of Mining and Technology, Socorro, NM; 4‘Mining Engineering Department, University of Kentucky, Lexington, KY

In underground mine fires, the presence of smoke, toxic gasses, and high heat can significantly hinder the evacuees from identifying the optimal path to safety. This study presents a framework that couples a mine fire simulator software with a Ford-Fulkerson algorithm to model fire evacuations as a minimum-cost flow problem. The fire-induced risks are quantified based on the MSHA safety standards and a user-friendly FFA computes the evacuation routes. By accumulating the quantified effect of the risk exposure and updating the network depending on the mine conditions, different safe evacuation routes are identified. The algorithm is demonstrated through fire simulation data acquired from a model of the VentSim™ DESIGN software. Airflow quantity, heat, carbon monoxide concentration, and visibility obstruction are acquired from the simulations and processed through the proposed algorithm. The computed evacuation routes minimize the exposure to fire-induced hazards while at the same time prioritizing the shortest routes. The presented framework can be used for evaluating ventilation designs and emergency plans as well as in real-time self-evacuation in mine emergencies.

10:45 AM
24-036
Estimating Air Blast Velocity Using Optical Flow Algorithm
V. Gangrade; National Institute for Occupational Safety and Health (NIOSH), Pittsburgh, PA

Large-opening underground stone mines pose significant ground control challenges, including the risk of massive pillar collapses. These collapses can result in dangerous air blasts characterized by tremendous force and high velocity. Estimating the velocity of these air blasts proves challenging due to the absence of accurate air velocity instruments near the mine portals. To address this issue, this paper proposes a novel approach that leverages closed circuit television camera footage from the mine. Specifically, it employs the optical flow algorithm implemented in Python to estimate the velocity of the air blasts, providing a valuable tool for assessing and mitigating risks in such mining environments.

TUESDAY, FEBRUARY 27 MORNING
ENVIRONMENTAL: ADTI-CRITICAL MINERALS IN MINE WASTES

North 126B

9:00 AM • Tuesday, February 27

Chairs: V. McLemore, NMBGMR/NM Tech, Socorro, NM
D. Levitan, U.S. Geological Survey, Reston, VA

9:00 AM
Introductions

9:05 AM
Low-Cost Technologies for Extraction of Rare Earth Elements from Coal Mine Wastes
S. Jayaraman Sridharan, P. Tukkaraja, G. Buckingham, V. Gadhamshetty, D. Weaver and M. Zahan; 1South Dakota School of Mines and Technology, Rapid City, SD; 2DISA, Casper, WY and 3University of British Columbia, Vancouver, BC, Canada

Recent research has revealed that the total rare earth elements (REEs) content in the coal discard and run-of-mine coal are well above the cut-off grade of 130 ppm for extracting rare earths in coal. This paper discusses a low-cost biobased system to extract REEs from coal mine wastes. The novel bio-extraction process employs a non-conventional bioleaching bacterium called methanotrophs, which use methane as a carbon source, that are capable of accumulating REEs. A bio-electrochemical system is used to accelerate the bioleaching and bioaccumulation capacities of methanotrophs for REEs. The process requires REE enriched material to make it economically viable process. In this study, pilot scale testing and Computational Fluid Dynamics (CFD) modeling techniques are used to evaluate the effectiveness of High-Pressure Slurry Ablation (HPSA) technology in producing the REE concentrate. HPSA has shown to be a high recovery and low energy process for mineral liberation applications.

9:25 AM
Investigation of Turkish Coal and Coal Waste for Rare Earth Elements by Image Processing Methods
M. Bilen1and D. Talan1; 1MiningEngineering, WestVirginiaUniversity, Morgantown, WV and 2‘Mining Engineering, Bulent Ecevit University, Zonguldak, Turkey

The urgent need to develop new and alternative sources to produce rare earth elements (REEs) led to identifying coal and coal wastes as potential sources. However, the studies utilizing image processing to identify REE occurrence are limited even though it aids in improving separation processes. Image processing analysis is widely employed for characterization purposes in ore preparation and is addressed as a way to digitize images. Representing each image with numerical RGB & HSV values provides meaningful data in terms of the samples’ characteristics and content. This study investigated 23 coal and coal refuse samples and four ash (2 fly ash, 2 bottom ash) samples collected from Zonguldak Hard Coal Basin and coal-fired power plants located in Zonguldak, Turkey. Samples were prepared for image processing analyses, and each sample’s color space orientation (RGB, HSV) was determined, which was later used to interrelate the REE content and color space orientation. Overall, image processing is a user-friendly and statistically significant method to have an initial understanding of REE content in coal and coal-based samples.

9:45 AM
24-043
Geochemistry of Critical Minerals in Mine Wastes in New Mexico
V. McLemore and E. Owen, NMBGMR/NM Tech, Socorro, NM

There are tens of thousands of inactive mine features in 274 mining districts in New Mexico (including coal, uranium, metals, and industrial minerals districts). However, many of these mines have not been inventoried or prioritized for reclamation. 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. The purpose of this project is to characterize and estimate the critical mineral endowment of mine wastes and “beta-test” USGS sampling procedures. This project is important to the state of NM because critical mineral resources must be identified before land exchanges, withdrawals or other land use decisions are made by government officials. Future mining of mine wastes that potentially contain critical minerals will directly benefit the economy of NM. Possible re-mining of mine wastes could clean up these sites and pay for reclamation. Furthermore, this project will include training of younger, professional geologists and students in economic and reclamation geology by the PIs.
ONSITE PROGRAM

10:05 AM
24-042
**Geochemistry of Critical Minerals in Mine Wastes at Hillsboro and Steep Rock Districts, New Mexico**
A. Acheampong-Mensah1, and V. McLemore2; 1Mineral Engineering Department, New Mexico Institute of Mining and Technology, Socorro, NM; and 2New Mexico Bureau of Geology and Mineral Resources, Socorro, NM

Critical mineral endowment of mine wastes in two mining districts in New Mexico (Copper Flat at Hillsboro and Carlisle-Center mines in Steep Rock district) was characterized and estimated. "Beta-testing" of USGS procedures was performed. Potential critical minerals at these deposits include As, Bi, Te, Zn, Co, Ni, Mg, Mn, and fluorite. pH and particle size of samples were analyzed to determine weathering and migration potential of heavy metals. Soil pH was also measured to determine the potential for Acid Rock Drainage. The pH of the waste rock piles ranged from 3.66 to 5.67 which indicates fine-grained pyrite or sulfide oxidation. pH of soil from the tailings ranged from 6.30 to 8.62 possibly due to the presence of carbonates. The difference in particle size fractions and distribution along the slope of the waste rock pile is generally influenced by natural occurrences (e.g., gravity and pre-mining hydrothermal alteration) and operational activities such as material piling or dumping. Future work includes analyses of mineralogy and particle size correlation and estimation of critical mineral endowment of these mine wastes at New Mexico.

10:25 AM
24-022
**Acid Mine Drainage and Critical Minerals in Black Hawk Mine Waste, Grant County, New Mexico**
Z. Kazemi Motlagh1, V. McLemore2, J. Newcomer2 and S. Griego1; 1Mineral Engineering, New Mexico Institute of Mining and Technology, Socorro, NM; 2New Mexico Tech, Socorro, NM; 3New Mexico Bureau of Geology and Mineral Resources, Socorro, NM and 4University of New Mexico, Albuquerque, NM

There are more than 15,000 abandoned mine features in New Mexico. These mine wastes represent a potential contamination source, but should also be examined as a resource of critical minerals. Many legacy mine waste deposits have undiscovered commodities and critical minerals, due to low recovery processes during past production. In this project, Black Hawk mine wastes in Grant County, New Mexico are examined by thorough mineralogical and geochemical characterization. This project seeks to characterize and estimate the critical minerals in mine wastes of the Black Hawk mine and determine the acid-generating potential of mine waste.

10:45 AM
**Molecular Assessment of Metal-Cycling Microbial Communities Associated with Critical Mineral Resources in Historic Mine Waste**
M. Best1, D. Jones1 and V. McLemore2; 1Earth and Environmental Science, New Mexico Institute of Mining and Technology, Socorro, NM; and 2New Mexico Bureau of Geology and Mineral Resources, New Mexico Institute of Mining and Technology, Socorro, NM

Many of New Mexico’s historic mines were operating when metallurgical processing technologies were in their infancy, and contain substantial metal resources in tailings and waste rock that could be used to support domestic critical mineral demand. However, many of these waste piles have been untouched for decades, which may have resulted in metal mobilization by microorganisms. We will present data on the composition and abundance of microbial communities from three historic waste sites in South-Central New Mexico, analyzed using modern molecular microbiological techniques. We will also describe our protocols for DNA-, RNA-, and fluorescence microscopy-based assessment of different waste materials.
Introductions

9:00 AM

Chevron Mining Company vs. United States: Holding the United States Accountable in Superfund Site Remediation

R. Dewey1 and G. Todd2; 1SME, Rancho Palos Verdes, CA and 2Chair, Regulatory Litigation, Sidley Austin LLP, Washington D.C., DC

In 2022, a federal court ordered the United States to bear 30% of the costs to remediate the Molycorp molybdenum mine in Questa, NM. In listing the mine as a superfund site, EPA had burdened Chevron with more than $1 billion in cleanup costs. The Court, however, found that the US had abetted the mine by contributing land, money, and technological knowhow. This consequential judgement has far-reaching implications for government liability for other mines established on federal land or with federal support. This presentation will review the history of the Molycorp mine and this precedent-setting litigation.

9:25 AM

Additional Damage to Buildings and Infrastructure Induced by Long-Term Surface Movements Above Abandoned Coal Mines (Longwall Mining)

A. Vervoort; KU Leuven, Leuven, Belgium

After the systematic closure of Europe’s coalfields in the late twentieth century, the emphasis is now clearly on industry’s environmental legacy. One aspect of the latter is the long-term surface movement above abandoned coal mines (longwall mining). The analysis of satellite data shows that the subsidence lasts longer than generally assumed. However, a few years after the flooding of the abandoned underground coal mines, a new phenomenon was observed, i.e., the direction of the surface movement was reversed. The phase of upsidence has already lasted for several decades, and only future measurements will tell how long it continues. A key conclusion is that the regions with maximum subsidence do not necessarily correspond to the greatest upsidence. In other words, buildings and infrastructure are subjected to a different loading from this upsidence than during the subsidence phase. The long-term surface movements have an impact on vulnerable structures in the densely populated regions of the former deep coal mining areas in Europe. These movements create additional damage. This new knowledge is also relevant for mines that are still in operation or future mines that are planned.

9:45 AM

Characterization of Mine Tailings From Legacy Mine Sites in Montana, California, and Oregon

X. De Gracia Medina, M. Alghzawi, R. Wilson, R. Root and J. Chorover; Environmental Sciences, University of Arizona, Tucson, AZ

Many legacy mines have tailings that have been exposed for hundreds of years to the climate conditions of each site. They contain different minerals and metal(loid)s that can enhance or limit the transport of hazardous elements into the subsurface. It is essential to characterize these residues’ physical and chemical properties. Mine tailings from polymetallic sulfide ore from three States in the Western US were characterized: Montana, California, and Oregon. The specific surface area (SSA) of the tailings was analyzed through the BET N2 adsorption technique to obtain information on tailings surfaces available for reaction and metal(loid)s adsorption. Particle size distribution (PSD) was studied using laser diffraction. Knowing the distribution of particle sizes helps to understand the material’s potential porosity and reactivity. X-ray diffraction was used to analyze the mineralogical composition of the tailings. Batch and flow-through experiments were conducted to monitor the developed pH changes and release metal(loid)s in tailings exposed to water and oxygen. The tailings from varying climates show weathering depth profiles and metal(loid) release that differs by site.

10:05 AM

Evolution of Financial Modelling Related to Mine Closure

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

Financial models inform decision making related to mine development, changes in mine planning and selecting the final mine closure design. The treatment of concurrent, closure and post closure costs in these financial models vary. Net Present Value calculations form the basis for internal decision-making and for audit closure provisions in financial statements. This presentation examines recent lessons learned in NPV-based closure planning and execution and introduces new concepts in development or early application.

10:25 AM

The Benefits of an Integrated and Transparent Closure Cost Model

T. Mandziak, J. Collyard and B. Subrahmanyan; SLR International Corp., Lakewood, CO

A closure strategy and cost estimate are often developed to meet a specific purpose, such as regulatory submittal and bonding obligations or to support an Asset Retirement Obligation (ARO). This approach may result in a closure plan and cost estimate that does not convey a complete understanding of the closure risks (i.e., uncertainties or unknowns), or facilitate the process of identifying a successful closure approach and accurate cost estimate. By developing a comprehensive closure cost estimate model, major closure project risks can be clearly communicated, and work plans developed to mitigate these risks. This comprehensive closure cost estimate model can be achieved through using a suitable work breakdown structure, and developing unit rates with codes that allow for the simple and transparent means to present and interpret the data. The closure cost model results can then be presented in a manner that is relatable to facilities, activities, quantities, and risk, allowing various disciplines to identify impacts to the closure plan and costs and identify activities to reduce risk and costs, as the closure project progresses from concept to execution.

10:45 AM

Application of Uplift-Floating Failure Analysis for the Design of Cap & Cover Systems

S. Bogart and S. Steele; Consultant, Syracuse, NY

The design of cap & cover systems for environmental reclamation projects with steep slopes (e.g., consolidation piles, landfills) typically requires a more complex analysis to understand and mitigate the risks of sliding failures. However, the use of typical mechanistic analysis alone may underestimate the stability of cap & cover systems on moderate slopes, pending drainage conditions. When a cover media placed above a low-permeability layer (such as a geomembrane) becomes saturated, the buildup of hydraulic pressure (or uplift-floating force) within the cover media may lead to veneer destabilization. This paper explores the Uplift-Floating failure mode through a practical design example, discusses techniques for mitigation, and explores the risk associated with failing to mitigate Uplift-Floating failure root causes.
ONSITE PROGRAM

TECHNICAL SESSIONS

11:25 AM
Changing Subgrade Conditions During Liner Deployment and Cover Placement
L. Vecchiarelli; Arcadis US Inc, Highlands Ranch, CO
In the case study presented, Flexible Membrane Liner (FML) was deployed over consolidated tailings during the course of 7 months in Manitoba, Canada. FML installation began in March, during winter conditions, overtop a frozen subgrade. A soil cover was then placed above the deployed FML. As FML deployment continued throughout the summer and fall, the covered tailings materials continued to thaw and settle. Challenging subgrade conditions were encountered during the project (frozen subgrade, soft subgrade, mud waving, and differential settling). This case study presents these challenges, resolutions, and lessons learned.

11:45 AM
Why Long-Term Care and Maintenance is a Forever Undertaking
P. Werner; US Department of Agriculture, Washington, DC
Approximately $3B has been spent by federal agencies on abandoned mine work between 2008 and 2017, with annual expenditures running close to $300M. Future costs for managing abandoned mine sites will run billions more. The public, including investors, are demanding responsible land stewardship from mining companies, and the ESG movement has provoked an awareness of the burden and impacts, both short-term and long-term, from mining operations. To remain competitive, mining companies must address how to resolve the long-term impacts from their operations. Enlightened mine closure in the 21st century must include long-term care and maintenance provisions to avoid further system failures. Responsible closure planning requires a shift away from an approach based on engineering time and towards one that acknowledges many closed mine facilities carry latent risks and may need to remain functional far into the future. Evaluating this residual risk requires a reasoned and transparent approach. What follows is one approach for identifying, evaluating, and quantifying the risks associated with closed mining operations and why long-term care and maintenance may be necessary.

TUESDAY, FEBRUARY 27 MORNING

HEALTH & SAFETY: TOTAL WORKER HEALTH

North 127C

9:00 AM • Tuesday, February 27
Chairs: G. Poplin, CDC/NIOSH, Spokane, WA
M. Parker, Piedmont Lithium, Charlotte, NC

9:00 AM
Introductions

9:05 AM
Combatting Worker Fatigue: Evaluating Training Approaches to Raise Awareness and Mitigate Health Risks
J. Gordon and M. Acevedo; Mineral Engineering, New Mexico Institute of Mining and Technology, Socorro, NM
Worker fatigue is a global issue affecting employees worldwide, leading to increased risks of illness and injuries. To address these concerns, this study aimed to create effective training materials to raise awareness among workers. Two categories of materials were developed: instructor-led presentations with handouts and blended learning techniques including posters, narratives, and discussions. Over 320 workers in New Mexico underwent training to evaluate the effectiveness of these materials. Our findings indicate that self-learning and blended techniques were more engaging than instructor-led training. The presentation also presents qualitative data on how fatigue impacts workers’ personal and professional lives.

9:25 AM
What Do the Indicators of Workers’ Mental Health Status in Mining and Other Industries and Occupations Tell Us?
A. Russell and G. Poplin; Spokane Mining Research Division, CDC/NIOSH, Spokane, WA
Mining has a variety of stressors that affect worker well-being. Psychosocial hazards are aspects of work that can harm workers’ mental health. Increasing drug overdose and suicide rates among U.S. workers are indicators of poor mental health. NIOSH used data from the CDC’s Behavioral Risk Factor Surveillance System survey to examine the five-year prevalence of workers’ self-reported mental health indicators (depression, frequent mental distress, extreme mental distress) across industry and occupations groups, including mining. The data for suicide rates (previous NIOSH study) and self-reported mental health indicators by industry and occupation will help to target future research and prevention efforts for mental health.

9:45 AM
Lessons Learned: Gamification of Total Worker and Occupational Health Training
R. Reed, L. Brown, G. Smith and J. Burgess; Mel & Enid Zuckerman College of Public Health, The University of Arizona, Tucson, AZ
While training has traditionally focused on prevention of injuries and fatalities, less time is directed to worker health and well-being. Our team has developed a cooperative card game called Mining Strong which addresses topics in Total Worker Health, such as fatigue, obesity, and diabetes. Initial feedback from trainers was generally positive. However, qualitative data gathered during playtesting suggested that the rules were too difficult to learn in a short time, challenging to implement online, and lacked core learning components. Subsequent revisions to Mining Strong’s game design improved trainer feedback and achieved the desired learning outcomes. This presentation will discuss key lessons learned, including 1) Less is More: providing players with less information can increase engagement and learning; 2) Solo Mode: the development of a “solo” or solitary variant allows trainers to operate online controls and allows remote players to focus on making game-related decisions; and 3) Endemic vs Re-Themed Mechanics: endemic rules allow game designers to tailor mechanics to the learning outcomes, but rules must be very simple compared to popular games that have been re-themed.

10:05 AM
In Today’s Technological World, Underground Gold Mine Workers Are Still Exposed To Diesel Particulate Matter And Crystalline Silica Hazards
M. Mensah1, E. Armah1 and M. Antwi-Adjei2; 1Surface Mining, Technical University of Mining Freiberg, Germany; Freiberg, Saxony, Germany; 2Public Health, The International Center for Sustainable Environment Promotion, Sefwi Wiawso, Ghana and 3Applied Chemistry, School of Chemical and Biochemical Sciences, C. K. Tedam University of Technology and Applied Sciences, Navrongo, Ghana
This study assessed underground gold mining workers’ exposure to occupational respirable mine dust (RMD) and diesel particulate matter (DPM) hazards. A total of 95 participants from 10 different working groups (SEGs) were understudied. Sampled particulate matter was analyzed based on standard methods by NIOSH and MSHA. Field surveys helped assess workers’ awareness and adaptation to workplace air hazards. The results showed that, despite the functioning mine ventilation systems in place, 41 % and 49 % of SEGs were exposed to contents of CS and DPM above the threshold limit values recommended by NIOSH and MSHA, respectively. Blast men, rock drillers and shotcrete operators were identified as the high-at-risk SEGs. Whereas 62 % of interviewees were aware of the existing workplace hazards, they
Explosion-Proof Enclosure Failure to Contain a Lithium-Ion Battery Thermal Runaway
T. Dubaniewicz; NIOSH Pittsburgh Mining Research Division, Pittsburgh, PA
In gassy underground mines, explosion-proof (XP) enclosures are commonly used to enclose electrical ignition sources to prevent propagation of an internal methane-air explosion to a surrounding explosive atmosphere. NIOSH researchers conducted a lithium-ion battery thermal runaway test within an MSHA approved XP enclosure to assess thermal runaway containment. Thermal runaway produced jet flames emanating from the cover joint at several locations and distorted the cover joint and bottom plate of the enclosure beyond allowable limits. The test demonstrates that XP enclosures may not provide adequate explosion protection against lithium-ion battery thermal runaway. Approaches to mitigate the hazard are suggested.

Characterization and Pathloss Prediction for 1800MHz n3 5G New Radio Frequency Band in Underground Mine Environment
H. Anabi; Mining, Missouri S&T, Rolla, MO
5G wireless communication is widely available in surface mine environments where it is the preferred wireless communication band of choice. The network is the driver towards the deployment of several uses, such as Internet-of-Things (IoT), real-time performance monitoring via sensors, high-capacity internet connectivity to legacy machines, and ultra-low latency networks for robotic operations. Several measurements campaign and characterization have been previously conducted for the other bands, such as 900MHz, 2.4GHz, and 5.8GHz bands, respectively. However, no measurement campaign for the 1800MHz n3 5G New Radio (NR) frequency band has been implemented and characterized. The goal of this paper is to conduct extensive characterization of 1800MHz radio bands and fit a pathloss model to the band. Based on empirical data, it was shown that the Hata model is closely fit to the measured data with a pathloss value of 2 which is close to that of free space pathloss. This study is expected to contribute to the body of knowledge on the desirability or otherwise of 5G NR implementation for mine emergencies.

Enhancing Safety, and Productivity in Mining Operator Training through Clustered Unsupervised Learning
R. Arrieta Zapata and B. Chavez Olano; Yes, Lima, Lima, Peru
A major problem with the current new operator training model is the approach of serving only those operators who have the lowest or highest scores for each aspect measured, which represents only 1% of the total number of operators. This leaves a large pool of people to train at the same time. Using machine learning from the unsupervised learning branch, they can be clustered and training plans can be generated according to their characteristics. This study allows optimizing productivity and reducing safety events, which can be replicated in any mining operation.
 strategic roadmap, this approach encompasses career pathway creation, ensuring growth from initial awareness to impactful implementation.

10:05 AM
The Development of Spokane Mining Research Division's Diversity and Inclusion Committee
C. Stazick and J. Bourgeois; Spokane Mining Research Division, National Institute for Occupational Safety and Health, Washington, DC
To meet the ever-changing and multi-dimensional nature of current occupational safety and health challenges, the National Institute for Occupational Safety and Health (NIOSH) must attract, develop, and retain a talented and diverse workforce. To help facilitate this goal, a strategic plan titled, “Blueprint in Action” was developed with the purpose of 1) providing institute-wide leadership, information, and consultation on promising practices and strategies to build and sustain a diverse, equitable, and inclusive community at NIOSH and 2) to enhance the relevance and responsiveness of NIOSH research and services to the growing diversity of workers in the U.S. and abroad. In response to this effort, members of the Spokane Mining Research Division (SMRD) developed a diversity and inclusion (D&I) committee to help accomplish the strategic goals outlined in the “Blueprint in Action” and enhance the research conducted by the Division to eliminate fatalities, injuries, and illnesses across all mining sectors. This presentation outlines the development of SMRD’s D&I committee and how it can positively impact the mining industry.

10:25 AM
Making Everyday Respect a Reality
G. Lyons; Rio Tinto, Draper, UT
Today, company culture is a key consideration for job seekers. A study by MIT Sloan Management Review reported that of ten elements of culture that matter most to employees, respect is 18% more powerful as a predictor of a company’s culture rating than the average topic, (In the study over 150 culture topics were referenced). In February 2022, Rio Tinto published the findings of an independent review of their workplace culture resulting in 26 key recommendations for implementation. It is known as the Everyday Respect report. This has served as a turning point for the company and industry, and has led to other organizations taking a closer look at their own culture. Following a period of what has been deep reflection this paper takes a closer look, through the use of a few practical case studies, at how Rio Tinto Copper has sought to bring real change in simple and practical ways. It’s a cultural transformation and a journey that will take time and requires the partnership, collaboration, engagement, and commitment of all. At the end of the day, we at Copper are passionate and deeply committed to creating an environment where everyone feels safe, valued and cared for.

10:45 AM
Mining for Talent, Updated: Present Landscape of D&I in the Mining Industry
C. Kincaid; JDS Mining & Energy, Vancouver, BC, Canada
It has been nearly a decade since mining companies have started publicly reporting on their diversity and inclusion efforts in their annual sustainability reports. Despite a vastly changed social and political landscape, demand for D&I in the mining industry remains high, because many companies see encouraging D&I as a mechanism to meet their growing workforce demands and pursue social license to operate. But what has changed? In this presentation, we update the current picture of diversity in the mining industry, and briefly go over new focus areas and strategies which have emerged in the last five years.

11:05 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.

TUESDAY, FEBRUARY 27 MORNING
INDUSTRIAL MINERALS & AGGREGATES:
INNOVATIONS IN INDUSTRIAL MINERALS AND AGGREGATES

North 125B
9:00 AM • Tuesday, February 27
Chairs: G. Tomaino, Minerals Technologies Inc, Easton, PA
B. Li, Michigan Technological University, Houghton, MI
9:00 AM
Introductions
9:05 AM
24-032
Enhancement of Ultrafine Phosphate Flotation Using Eriez’ Cavtube Column Flotation Technology
M. Fan1, S. Kumar2, R. Singh1 and E. Dohm1; 1Eriez Flotation, Eriez Manufacturing Co, Eriez, PA and 2Industries Chimiques du Senegal (ICS), Dakar, Senegal
The rapid increase of P2O5 use for food, biofuels, and LiFePO4 batteries etc. accelerates the depletion rate of phosphate reserves. In the phosphate industry, a significant amount of ultrafine phosphate has been discarded as slime tailing due to processing difficulties. This paper investigates the enhanced ultrafine phosphate flotation by Eriez’ CavTube generated fine/ultrafine bubbles and the improved flotation selectivity by wash water etc. Ultrafine phosphates with various gangue minerals were studied. Microscopic observations show that the entrained ultrafine gangue minerals can be minimized by using wash water in column flotation. A three-factor three-level central composite experimental design was conducted for ultrafine phosphate flotation. Both benchtop mechanical cell and laboratory column flotation tests were performed at their optimal respective flotation conditions. Using Eriez CavTube column flotation technology for Industries Chimiques du Senegal (ICS) ultrafine slime tailings, a concentrate grade of 36.0% P2O5, was achieved at 89.4% P2O5 recovery. The benefits of Eriez’ column flotation technology realized from this study include the high P2O5 grade and recovery.

9:25 AM
Mining Innovation in North America
A. Sargeaunt; 2S Water Inc., Edmonton, AB, Canada
North America is a global leader in the mining industry, with a long history of mining excellence and a strong commitment to innovation. The country’s mining sector has been at the forefront of adopting new technologies and practices to improve efficiency, reduce environmental impacts, and enhance safety. North American mining companies are focused on developing sustainable solutions that can help address the challenges facing the industry, such as declining ore grades, water scarcity, and social and environmental concerns. Some of the key areas of innovation in the North American mining sector include the use of advanced analytics, automation and robotics, renewable energy, and the application of artificial intelligence and machine learning. This talk will cover new and interesting innovation projects currently underway in North America.
9:45 AM
Combination of Pre-Concentration and Concentration Techniques to Address Potential “Fiber” Type or an Asbestos Component for Various Industrial Mineral and Aggregate Matrices Followed by Evaluation and Identification of the Concentrates
G. Tomasin, Minerals Technologies Inc, Easton, PA

Whether for established products or a future sustainable re-use/recycle product, the evaluations and the identification for potential “fiber” type or an asbestos component has and will continue to be a need by industrial mineral and aggregate sector. Domestic and international definitions whether mineralogical or not for a “fiber” type can vary between a given regulatory regime(s) and a given delineation of acicular, fibrous or asbestiform habits. Hence, a removal of potential interferences or the bulk matrix to concentrate a potential “fiber” type component(s) would provide pertinent information and clarification on a given data set. Additional constraints as to an inherent “degree of liberation” and comminution attributes will be reviewed and discussed that allow for a set of pre-concentration and concentration techniques under differing combinations (high precision sieving and heavy liquid separation) followed by mineral identification will be reviewed.

10:05 AM
Applications of Bentonite Clay in Underground Water Retaining and Desert Control
B. Li1 and F. Li2; 1Materials Science and Engineering, Michigan Technological University, Houghton, MI and 2Chaoyang 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 retaining of underground water and desert control. The practical performance and mechanisms will be discussed.

10:25 AM
Recent Advances of Bentonite in China: Resources, Market, and Applications
B. Li1 and J. Tang2; 1Materials Science and Engineering, Michigan Technological University, Houghton, MI and 2China Nonmetallic Minerals Industry Association, Beijing, China

Over the last decade, driven by market demand, China has received considerable development in mineral exploration, production, and applications of bentonite clay. This paper provides a summary profile of bentonite clay in technology and market development in the country.

10:45 AM
Product Certifications and Pursuing Sustainability
C. Walby, Management, Barretts Minerals Inc, Dillon, MT

Certifications represent standards products meet in order to qualify as environmentally sound, sustainable, or renewable products. Such certifications as they apply to mining can represent utilization of materials in such a way that creates less waste and provides more benefit based on resources expended to produce the ore. Barrett Minerals has gone through the process of evaluating materials we produce to determine if products can be produced from previously discarded material.

TUESDAY, FEBRUARY 27 MORNING
MINING & EXPLORATION: GEOSCIENCES:
INTEGRATING EXPLORATION AND PRODUCTION
GEOLOGY: PANEL DISCUSSION
North 223
9:00 AM • Tuesday, February 27
Chair: E. Baar, Rangefront Mining Services, Gastonia, NC
9:00 AM
Introductions
9:05 AM
Exploration and Production Geology: How Are They Different? How Are They the Same? How Can They Connect?
E. Baar, Rangefront Mining Services, Gastonia, NC

The mining industry traditionally employs two distinct types of geologists: Exploration and Production. Both come out of school with the same basic education, but upon entering the workforce are often faced with choosing between two very different career paths, each with it’s own distinct set of prorities and passions. Both are integral to the success of the discovery and then mining of a deposit. But how, and when, to their worlds overlap? How does the Exploration geologist convey their orebody knowledge to the Production geologist and how is that knowledge used? How orebody knowledge captured in a production environment conveyed back to exploration? This panel discussion hopes shed light on how each type of geologist functions, how they communicate with the other, how orebody knowlege and data is transferred, and what each can do to understand the other better.

TUESDAY, FEBRUARY 27 MORNING
MINING & EXPLORATION: GEOSCIENCES:
PRODUCTION GEOLOGY: FROM MINE TO MILL
Sponsored by:
North 225A
9:00 AM • Tuesday, February 27
Chair: B. Griffiths, Rio Tinto Minerals—Borates, South Jordan, UT
J. Gurtler, California
9:00 AM
Introductions
9:05 AM
Journey to 3D Mapping and Model Integration
M. Giebel, J. Onsel, K. MacWilliam, R. Inglis, C. Luneburg, F. Valli, M. Aliaga Oblitas and M. Adams; 1Newmont Mining, Indian Hills, CO and 2SRK, Vancouver, BC, Canada

Geological mapping in underground, openpit and exploration environments has been part of the mine geologists’ daily workflows for generations. The typical workflow involves mapping with pencil and paper, followed by 2D digitization. This creates inherent spatial errors and results in mapping that is not integrated into 3D geological models. Throughout Newmont’s journey to improve our models, we identified opportunities to enhance the mapping process and resultant data quality through training and the use of photogrammetry, LiDAR and other new technologies to create seamless workflows from field to model. EasyMineXR, a 3D mapping software developed by SRK, is a vital tool in this transition. It allows greater flexibility in when, where and how mapping is completed. With quality imagery, geologists can now create 3D attributed and georeferenced mapping...
using points and polylines stored in a peer-reviewed database. This gives the ability to export to multiple software platforms and integrate seamlessly into our implicit, geological models and maps or be used by any downstream stakeholder.

9:25 AM
24-053
Improved Drilling Controls Through Forecasting
K. Ingmarsson; Boart Longyear Company, Salt Lake City, UT
Larger mines spend millions of dollars annually on rock drilling tools, but often purchase based on historic consumption. The results vary from excess inventory to acute tools shortages. These lead to emergency sourcing, sometimes mixing products that don't perform optimally. Boart Longyear analyzed the usage pattern of 96 thousand drill bits at thirteen different underground mining contracts, showing very high variability. The monthly standard deviation on a product level was 42%, with the highest for development and low volume bits. A new rule of thumb is suggested to carry only one month of safety stock for high volume bits, but increase to three months for low volume bits. This balance will reduce the risk of outages with less inventory. The accuracy can be improved by considering the specific conditions at each mine and reclassifying individual bits for a different safety stock level. Root cause analysis and collaborative forecasting between mines and suppliers can lead to further optimization of inventory and availability levels.

9:45 AM
Discrimination of Geological and Rock Alteration Units Using Hyperspectral Imaging System: Case Studies From Two Open Pit Mines in Nevada
M. Abdolmaleki and K. Esmaili; Civil and Mineral Eng., University of Toronto, Toronto, ON, Canada
Identification and characterization of geological features affecting ore grades and mineral distributions are crucial for optimizing exploitation processes and production planning. In conventional pit wall mapping procedures, manual observations are made by the technical staff, and these observations are subjective, time-consuming, labor-intensive, and expose them to hazardous conditions. This study aims to develop an automated imaging system for collecting and analyzing geological data from two open-pit gold mines in Nevada. This research is focused on analyzing data at the laboratory scale, specifically characterizing representative rock samples. The analysis of thirty rock samples included clay, oxides, and carbonaceous minerals, was performed using hyperspectral scanning with VNIR-SWIR-LWIR sensors. The results demonstrate successful discrimination between samples using Spectral Modeling techniques. This study showcases the potential of the developed methodology in streamlining and enhancing geological mapping processes for improved operational efficiency.

10:05 AM
Conditional Bias in Mineral Resource Estimation: Impacts on the Productivity Measurements
A. Sama; GeoGlobal LLC, Riverton, UT
Estimates of grades in a block model depend on various interpolation parameters. Such parameters include the number of samples used, spatial spacing of the samples, dimensions, and orientation of the search ellipsoid, variogram model, etc. The estimated value of any block can change by changing any one parameter. These estimation parameters induce conditional bias in the block model estimates. Conditional bias is the statistical difference between the input data and the resultant block model estimates. In this presentation, identifying and measuring the extent of conditional bias will be discussed with anonymous examples. The presentation will highlight the impacts of extreme cases of conditional bias in measuring productivity in mining operations.

10:25 AM
Characterizing Rock Properties Using Autonomous Blasthole Drilling
S. Lee1, J. Park1, N. Risso1, S. Cho1 and S. Cho2; 1Mining and Geological Engineering, University of Arizona, Tucson, AZ; 2Mineral Resources Research Division, Korea Institute of Geoscience and Mineral Resources, Daejeon, Korea (the Republic of); 3Mineral Resources and Energy Engineering, Jeonbuk National University, Jeonju, Korea (the Republic of) and 4Mineral Exploration and Mining Research Center, Korea Institute of Geoscience and Mineral Resources, Daejeon, Korea (the Republic of)
Efficient mining operations depend on controlling rock fragmentation. The size distribution of rock fragments resulting from blasting significantly impacts production processes, including loading, hauling, and comminution. To achieve optimal rock fragmentation, understanding the rock’s mechanical properties is crucial to adjust blasting energy and design. However, performing rock tests on-site is challenging due to short blasting cycles and additional manpower requirements. In this study, we use MWD (Measurement While Drilling) to characterize rock properties in real-time, reducing the need for extra personnel and minimizing human errors. We analyze drilling data from autonomous blasthole drills in Northern Chile. Our research highlights the potential of MWD data to enhance mining precision through data-driven blast design decisions, streamlining the mine-to-mill process.

10:45 AM
Reducing Ore Loss through 3D Blast Movement Application at Merian Mine, Newmont Suriname
R. Hupsel; Technical Services, Mine Geologist, Paramaribo, Suriname
3D Blast movement technology revolutionizes Mining operations and is the solution for accurately tracking post-blast material displacement, ensuring grade control certainty, optimal ore recovery, waste reduction, and economic viability. Increased accuracy of ore-waste delineation aids in efficient resource allocation and reducing operational costs. This paper explains the transition from lateral blast movement tracking to 3D blast movement material tracking, the utilization of “in-house” developed calculation tool and the resulting revenue benefits for Newmont’s Merian Mine. 3D blast movement has shown significant improvement in revenues and reduced risk in material misplacement.

11:05 AM
Increasing Stockpile Grade Accuracy Through the Introduction of Stockpile Modeling at Newmont Suriname’s Merian Mine
V. Hoř; Technical Services, Mine Geologist, Ephearm, Suriname
Stockpile modeling offers pivotal advantages to the mining industry. By creating precise 3D representations of material accumulations, it optimizes inventory management, enabling accurate volume estimation and production scheduling. The models aid in identifying material characteristics, facilitating proper blending and processing where needed. This paper explains the implementation process of stockpile modeling at the Merian Mine—Newmont Suriname, utilizing detailed aerial surveys and fleet management system data. The stockpile modeling’s purpose is to get accurate estimated grades of the several stockpiles, resulting in proper re-handling and reporting. Ultimately, stockpile modeling drives operational efficiency, informed decision-making, and sustainable mining practices.

11:25 AM
Underground FaceMapping in the 21st Century
J. Mancia; Technical Services, Maptek, Lakewood, CO
Over the years, there have been technological mining innovations to improve the mining cycle. One of those innovations has been digital underground mapping. We will explore why paper mapping is in the past and discover the benefits of digital mapping such as being able to model the ore and geotechnical structure data more accurately, have the flexibility to store site specific metadata and measurements to external databases
to streamline data sharing, and more accurately make critical geological informative decisions, especially for geology driven mines. We will also explore what pain points have been encountered when adapting digital mapping such as data management and underground environmental obstacles. Case studies from a variety of deposit types will be showcased.

TUESDAY, FEBRUARY 27 MORNING

MINING & EXPLORATION: INNOVATION AND TECHNOLOGY: APPLICATIONS AND DESIGN CONSIDERATIONS FOR BATTERY EQUIPMENT IN MINING

North 222A

9:00 AM • Tuesday, February 27

Chairs: T. MacLean, MacLean, Collingwood, ON, Canada
A. Howse, MacLean Engineering, Rossland, BC, Canada

9:00 AM

Introductions

9:05 AM

Mine Site of the Future: Considerations for Building an Electric Mine

C. Kuchta and T. Lauer; Electrification, Caterpillar, Tucson, AZ

As with the rest of the world, the mining industry is faced with the challenge of reducing their carbon footprint. To meet their emissions reduction goals, hauling and loading equipment will likely transition to electrified equipment. This simple statement could create a huge cascade of complexities for mine sites. Over the past several years, our teams have gathered insight into solving these challenges, we would like to review a few key considerations to take when planning for an electrified mine sites, such as: Does my machine have enough energy? Where and how do I integrate the charging infrastructure? How do I plan and manage the fleet & infrastructure?

9:25 AM

Discrete Event Simulation (DES) in Swapping/Charging of Battery Electric Trucks (BETs)

A. Ampsonem, S. Frimpong and K. Awwah-Offei; Mining Engineering, Missouri University of Science and Technology, Rolla, MO

Climate change, significantly influenced by Greenhouse Gases (GHGs), poses a severe global threat. International policies, including the Kyoto Protocol, the Paris Agreement, and the U.S. Presidential Policy, are actively aiming to reduce GHG emissions substantially by 2050. The mining industry is beginning to implement lithium-ion batteries (LIBs) to power mine utility vehicles (MUVs) and rubber-tired mantrips (RTMs). However, the ability of LIBs to withstand the harsh conditions for these applications has not been rigorously evaluated. Concerns with the use of LIBs in the mining environment will be discussed including the effects of mechanical shock and vibration, temperature extremes, and moisture exposure. This paper will discuss adverse effects of the mining environment on LIBs and provide an overview of scientific gaps associated with environmental susceptibility of LIBs used on MUVs and RTMs.

9:45 AM

Case Study on the Benefits of Implementing Lithium-Ion Battery Powered Haulage in Underground Mining

J. Davis; Komatsu, Warrendale, PA

An underground mine has used diesel powered DBT Ram cars to haul rock from Joy continuous miners for more than 20 years. These cars have become old and obsolete plus have poor emissions. The reliability has become a real challenge for the mine. A decision was made to replace the diesel cars with Joy battery haulers powered by lithium-ion batteries. This presentation will discuss how the battery powered haulers have benefitted the mine using real world data.

10:05 AM

Simulation Analysis of Dispatch Requirements for Battery Electric Haul Trucks

C. Eustace; Simulation, Deswik, Brisbane, QLD, Australia

With an expected reduction in range for Battery Electric Haul Trucks (BEHT’s) compared with their diesel counterparts, additional dispatch considerations will be required to maximize use of the available BEHT range. A typical range of diesel haul trucks (approximately 15-20 haul cycles, depending on the operation) allows refueling to be managed using straightforward practices, such as refueling at the next opportunity once the gauge reaches 20%. Using this approach doesn’t require estimation of remaining range, nor does it influence routing decisions. This paper describes a simulation analysis of a large surface haulage operation with fixed charging locations. Calculation of energy costs for routing options is used to manage dispatch decisions and ensure that BEHT’s can return to charging locations. The analysis is used to determine the useable proportion of total battery range for BEHT’s, the impacts of range constraints on dispatch decisions and resulting performance of the haulage system.

10:25 AM

Concerns with the Environmental Susceptibility of Mine Utility Vehicle and Rubber-Tired Mantrip Li-Ion Batteries

D. Yantek; CDC NIOSH, Pittsburgh, PA

The mining industry is beginning to implement lithium-ion batteries (LIBs) to power mine utility vehicles (MUVs) and rubber-tired mantrips (RTMs). However, the ability of LIBs to withstand the harsh conditions for these applications has not been rigorously evaluated. Concerns with the use of LIBs in the mining environment will be discussed including the effects of mechanical shock and vibration, temperature extremes, and moisture exposure. This paper will discuss adverse effects of the mining environment on LIBs and provide an overview of scientific gaps associated with environmental susceptibility of LIBs used on MUVs and RTMs.

10:45 AM

Comparison Between Productivity of Battery and Diesel Versions of a Load Haul Dump (LHD) Unit in a Block Cave Mine Using Discrete Event Simulation (DES)

J. Hooli, A. Halim, F. Sundqvist and S. Mariager; ‘Mining and Rock Engineering, Luleå University of Technology, Luleå, Sweden and ‘BHP Group Limited, Adelaide, SA, Australia

The use of Battery Electric Vehicles (BEVs) in underground hard rock mines offers a significant benefit than the traditional use of diesel machines, which is creating healthier working conditions due to the zero emissions of toxic gases & Diesel Particulate Matter (DPM), and lower heat and noise levels. However, it remains to be seen whether the productivity of BEVs can match that of their diesel version. Aspects such as number of batteries & charging stations, their locations, and the duration & the frequency of battery swapping can affect the productivity of BEVs. Therefore, productivity simulations using Discrete Event Simulation (DES) were conducted using Arena software for a planned new block cave mine.
The aim of the simulations is to compare the productivity of two versions of 18 tonne Load Haul Dump (LHD) units—one BEV and one diesel. This paper presents preliminary results of these simulations. The work was conducted as a part of the ongoing European Union’s funded project Next Generation Carbon Neutral Pilots for Smart Intelligent Mining Systems (NEXGEN SIMS, www.nexgensims.eu).

11:05 AM
Development of a Transformation Concept (TC) for the Electrification of Mine Sites
D. Wagner and E. Clausen, Institute for Advanced Mining Technologies (AMT), RWTH Aachen, Aachen, Germany
The electrification of transport machines represents one crucial step towards achieving climate goals in mining operations. But electrification goes beyond the mere replacement of combustion engines by electric alternatives. It should be emphasized that, in addition to machine setup changes, other operational areas must be considered. Therefore, a TC for the electrification of mine sites is developed within the German funded Research Project “Integration and Demonstration of the Use of Electric Transport Machines in mining operations” (ELMAR). The goal of the TC is to provide a systematic and modular methodology for the conversion from conventional to electrified transport. The fields of consideration of the TC are derived from the effects of machine electrification. These include site geometry, machinery parameters and changes in infrastructure. Key factors and criteria of the transformation are elaborated within the transformation process. The findings will be used to formulate general recommendations for mine operations. This presentation will give an overview of the motivation, structure, and methods as well as the use cases from the ELMAR project used to validate the TC.

TUESDAY, FEBRUARY 27 MORNING
MINING & EXPLORATION: MANAGEMENT: FAILURES IN MINING: LESSONS LEARNED FROM THE PROJECTS THAT DID NOT SUCCEED
North 222B
9:00 AM - Tuesday, February 27
Chair: M. Sorensen, Rio Tinto, South Jordan, UT
9:00 AM
Introductions
9:05 AM
Coordinating Chaos: Learning from the Past to Plan for an Achievable Future
M. Tomaszewski; Integrated Operations, Kennecott Utah Copper LLC, Magna, UT
Everybody has a past. So do companies. Explore with a planning engineer their experience in learning about the past of people, processes, and flows in production planning to emerge as a people-centric, process-mapping, ever-improving planner. Centered on their experiences developing value stream production plans for a historic and complex copper mine, from ore extraction to refined copper cathode with a multitude of by-products, they will share lessons learned the hard way and proven tactics that can help coordinate the chaos that is production planning.

9:25 AM
Learnings from Applying New Technologies for Solving Orebody Knowledge Problems
P. Rodriguez, AusIMM The Minerals Institute, Carlton South, VIC, Australia
With the rapid developments in data collection and data analysis, Bingham Canyon has tried to take advantage of this and use it to improve models used for orebody knowledge. Since 2020, we have identified high value projects that use of machine learning to improve ore and waste characterization. Unfortunately, there has been roadblocks that have prevented us to get the full potential of these projects. This presentation goes through the projects, which roadblocks prevented us to complete the projects and lessons learned that will be applied in future projects.

9:45 AM
The Illusion of Knowledge: What Happens When “Industry-Standard” Processes Fail to Consider the Cumulative Negative Impact of Multiple Strategic and Economic Factors.
M. Blattman; Hecla Mining, Post Falls, ID
Mining ventures often hinge upon exhaustive economic analyses aimed at quantifying technical, financial, and strategic risks prior to committing substantial capital investments. These analyses are built upon an amalgamation of factors, measured, estimated, or predicted, which serve as the bedrock for pivotal investment determinations and the establishment of a company’s standing. These evaluations are conducted in accordance with internationally acknowledged standards, scrutinizing economic and technical facets. These assessments systematically manipulate key variables to stress-test the project’s resilience, often accompanied by unequivocal assertions of the authors’ confidence in the project’s viability and robustness. Nonetheless, these methodologies might fall short in foreseeing every adverse economic eventuality. This presentation presents a case study in which the various models overlooked a “perfect storm” scenario, culminating in the collapse of a mining project and, ultimately, the corporation that owned it. This study highlights the importance of understanding the limitations of these models and their implied usefulness.

10:05 AM
Should a Study be Considered a Failure if it Doesn’t Progress to the Next Stage?
D. Martin; Professional, West Jordan, UT
In a culture that is more energy conscious than ever before, how does an organization balance decarbonization goals while managing the additional operational risks, project effectiveness, and cost of a project? Rio Tinto Kennecott recently completed an OoM and PFS for a non-traditional waste conveyance system that did not result in execution of the project, but there are many key lessons learned that can be applied in project evaluation. This talk reflects on the challenge of decarbonizing traditional truck haulage and RTK’s proposed solution, the key considerations for project progression, and the lessons learned to be adapted for future projects.

10:25 AM
A Case Study of Capital Project Excution Methods: EPC Versus Design, Bid, Build
D. Richards; Mining, Burns & McDonnell, Phoenix, AZ
Capital projects can be executed in a variety of methods. A case study project be reviewed from a mine in the western US that was bid out utilizing two different methods. Orginally it was bid out as Engineer, Procure, Construct (EPC) but then bid again utilizing a Design, Bid, Build approach and then excuted as Design Bid Build. The cost and schedules for the two methods will be compared and project challenges along with lessons learned will be summarized.

10:45 AM
Valuable Lessons Learned at the Rio Tinto Kennecott Concentrator in the Past 10 Years
J. Mortensen; Integrated Planning & Systems, Rio Tinto Kennecott, South Jordan, UT
Rio Tinto Kennecott’s Concentrator can group many learning lessons into the following 4 categories: 1) Re-arranging the Deck Chairs on the Titanic: Missing the Root Problem -Running too many Molybdenum Flotation column cells in series—Shutting off cyclones by hand instead of using the instrumentation—Piling work orders onto an endless backlog instead of...
9:05 AM  
Economic Impact of the Conga Project Cancellation: Opportunities on Hold
M. Portal Valdivia and F. Segobia Campos; Mining engineering, Society for Mining, Metallurgy & Exploration, Cajamarca, Cajamarca, Peru

Mining is one of the most important economic activities in the Cajamarca region of Peru. Formal mining generates around 100,000 direct and indirect jobs in the region and generates tax revenue for the regional and national governments. The Conga Project is a copper and gold mining project located in the Cajamarca region of Peru. The project was paralyzed in 2011 due to local protests led by pseudo-environmentalist leaders who are currently serving sentences for corruption. The project would have generated around 10,000 direct and indirect jobs and would have generated tax revenue of around $1 billion per year. The cancellation of the project meant a significant loss for the economy of Cajamarca. In this study, we evaluate the economic impact generated by the cancellation of the Conga Project and provide a perspective on mining for the coming years in the Cajamarca region. Formal mining is development and work for our regions and the country.

TUESDAY, FEBRUARY 27 MORNING
MINING & EXPLORATION: OPERATIONS:
OPTIMIZING THE SAFETY AND EFFECTIVENESS OF BLASTING PROGRAMS
North 222C

9:00 AM • Tuesday, February 27
Chair: E. Thibaud, Pneu Wave Consulting

9:00 AM  
Introductions

9:05 AM  
HMX Based Electronic Initiation System for Blasting in High Temperature Ground and/or Extremely Reactive Ground
K. Dufresne1 and D. Scovira2; 1Global Manager of Blasting Science and Engineering, Harwich, MA and 2Market Development Manager, Mining International, Troisdorf, Germany

To improve blast performance, a mining company engaged DynaEnergetics to develop an in-hole electronic initiation system for application in geothermally high temperature ground and/or extremely reactive ground conditions. The IGNEO system is rated for in-hole use up to 150°C (302°F) for 48 hours. The system consists of an HMX base charge detonator with thermally resistant downline, booster charge assembly housing an HMX shape charge, and control equipment to time and fire the blast. Compared to surface initiation, in-hole initiation improves floor quality and reduces top size fragmentation. Longer safe loading windows enable increased blast block size and decreased blasting frequency.

9:25 AM  
Blast Program Progression and the Effect on Operational Efficiency
R. Sibley, K. Perry and K. Awuah-Offei; Mining & Explosive Engineering, Missouri University of Science and Technology, Rolla, MO

This paper analyzes the effect of progression variation of a blasting program to minimize costs and ensure a continuous operation. Multi-bench construction and mining operations with a small operational area are often poorly planned with regards to blasting progression. Emphasis on proper planning prevents cyclic processes so that there are no scheduling conflicts between drill & blast and excavation crews thus leading to higher equipment utilization. Generalized costs and performance ratings for drilling, blasting, excavation, and haulage were utilized for the investigated projects. The outcomes based on the varied program progression highlight the importance of a properly planned blast program's effect on overall efficiency and utilization.

9:45 AM  
Shifting Blast Vibration Frequencies Higher to Obtain Lower Highwall PPV's from Near-Field Blasts
R. Yang; Orica USA Inc, Watkins, CO

A successful project for shifting blast vibration frequencies near highwalls was conducted at an open pit mine in Mexico. The blast monitoring collected useful data for the site rock—vibration attenuation versus scaled distance; site resonant frequency, ground p-wave velocity, and rock fragmentation were all measured from typical blasts. Using the multiple seed waveforms that are encoded within the site frequency response, the Multiple Seed Waveform (MSW) blast vibration model accurately predicted the dominant frequency at highwalls from a near-field blast. Blast design scenarios were then modeled for blast vibration PPV's and dominant frequency. With the site measurement, the Multiple Blasthole Fragmentation (MBF) and MSW models are established for the site. The models explore benefits from various design scenarios. The delay timing in terms of lower PPV and higher dominant frequencies for the pits were recommended—an increase in frequency of 10 Hz at a hard rock pit and an increase in frequency of 5 Hz at another relatively soft rock pit. The MBF modeling indicated the timing change from the base case to the improved cases would not cause any significant fragmentation change.

10:05 AM  
Case Study: Blast Design Considerations for Blasting Near Quarry Infrastructure
D. Schnell; RESPEC, Lexington, KY

Blasting is the primary and most effective and time-efficient method for breaking and moving material at most mine sites. There is often the added challenge of requiring the blast to be redesigned in a manner to control the environmental effects related to blasting. This is especially the case for quarry sites expanding their operations to access additional resources and reserves. The purpose of this presentation is to review a case study where special considerations were reviewed and implemented for blasting operations at the pit boundary above a site's cement processing facilities and active quarry. The author will review the steps taken to limit resultant blast vibrations appropriately and effectively at the facilities in addition to implementing cautious and controlled blasting techniques and methods to mitigate the potential for unintended rock movement towards the facilities. The final findings and recommendations from the case study will be summarized and reviewed. At the end of the presentation, the audience will have increased knowledge of potential blast design considerations for blasting near quarry infrastructure.
10:25 AM  
**Minimizing Muckpile Movement for Daylight Edge Blasting**  
R. Sibley and K. Perry, Mining Engineering, Missouri University of Science and Technology, Black, MO  
This paper analyzes the effectiveness of various detonator timing and sequencing in low stiffness ratio mining of grade driven deposits during pioneering of terrace benches. A group of blasts along daylight edges of benches were analyzed for muckpile movement and fragmentation. Blasting variables, such as stemming ratio, pattern size, orientation, and explosive type were constant, regardless of hole depth. A variety of sequencing was tested: trenching, daylight edge initiation, and daylight edge termination. Timing was also varied for the different sequencing methods. This paper highlights the different timing & sequencing changes and the effect on muckpile movement and fragmentation.

10:45 AM  
**Freeport-McMoRan Inc. Implementation of Trigger Action Response Plan for Management of Instabilities and Ground Control Risks in Open Pit Mines**  
A. Soni, H. Hazwezwe and L. Tejada; Freeport-McMoRan Inc., Tucson, AZ  
Systematic execution of Trigger Action Response Plan (TARP) for maintaining globally safe working conditions in open-pit mines is a critical part of ground control management plan. It is framed to serve as a guideline for monitoring, assessment and effectively identifying the hazards to mining in proximity to moving slopes. TARP is developed by characterizing appropriate geotechnical triggers, thresholds, and communicating responses based on monitoring capabilities and impacts to operations. Its continuous evolution based on slope behavior and failure analysis is also crucial. This study discusses the implementation of TARP for safeguarding personnel, equipment and infrastructure against slope instabilities.

11:05 AM  
**Rock Mass Characterisation and its Influence on Blast Performance Derived From Blast Modelling**  
R. Yang; Orica USA Inc, Watkins, CO  
Blast performance is derived from a specific blast design applied to a particular rock mass. The explosive detonation parameters can be defined through the measurement and non-ideal detonation modelling. The rock mass characteristics have a significant array of parameters that influence the rock to blasting. A proper site characterisation is of critical importance—implicitly or explicitly obtaining the effect of the site geology on blasting results. Previous methods to characterise a rock mass in terms of blastability has succinctly selected a small number of dominant parameters to derive a single blastability value for a given rock mass. Unfortunately, the rating system requires the prior knowledge of a specific parameter on the blast performance to properly ‘rate’ the parameter. Current advanced blast modelling can effectively take the guess work out of rating a rock mass parameter by utilising it as an input to the model or calibrating the rating system based on the model output. The models can be utilised for fragmentation, vibration, damage, and heave metrics. The calibrated models can be used as powerful tools to predict blast results for various design scenarios.
Direct acid leaching was conducted to recover rare earth elements (REEs) from an allanite-bearing silicate mineral assaying 9,861 ppm of REEs. The effects of operational variables such as acid type (i.e., HCl, HNO₃, and H₂SO₄), H₂SO₄ concentration, temperature, and particle size on the total REE (TREE) recovery were systematically examined. The REE mineralogy and the involved leaching mechanisms were investigated by microscopic characterization, kinetic study, and re-leaching tests. It was found that approximately 80% of REEs was extracted using 1 M H₂SO₄ at 75°C for 2 h. Increasing temperature significantly improved the REE extraction, while acid type, H₂SO₄ concentration, and particle size did not. The low Si recovery (<4.0%) suggests that the extraction did not significantly alter the crystal structure of the dominant mineral. The leaching kinetics of REEs were fast within the first 10 min, followed by a much slower stage (i.e., 10-120 min). The kinetic modeling results show that each stage may be a mix control. The activation energies (Eₐ) for REE leaching using 1 M H₂SO₄ in the 0-10 min and 10-120 min were determined to be 20.3 and 10.8 kJ/mol, respectively.

10:25 AM
Rare Earth Element Recovery and Hydrochar Production from a Hyperaccumulator by Acid Leaching and Microwave-Assisted Hydrothermal Carbonization
S. Li, B. Ji and W. Zhang; Mining and Minerals Engineering, Virginia Tech, Blacksburg, VA
Grass seeds were watered with a solution containing Y, La, Ce, and Dy, resulting in grass leaves (GL) containing 510.5 mg/kg of total rare earth elements (REEs) on a dry basis. EPMA analysis showed that REEs in the GL existed in the form of complexation with phosphorous. Around 95% of REEs were extracted from the GL using 0.5 mol/L H₂SO₄ at 5 wt.% solids concentration. Microwave-assisted hydrothermal carbonization (MHTC) was used to convert the solid residue into hydrochar to achieve a comprehensive utilization of the GL. The effect of temperature on the structural properties and chemical composition of the resulting hydrochar was evaluated. Scanning electron microscopy analysis revealed that the original structure of GL was destroyed at a temperature of 180°C during MHTC, producing numerous microspheres and pores. As the reaction temperature increased, there was a concurrent increase in carbon content, higher heating value, and energy densification, coupled with a decrease in hydrogen and oxygen contents. The results showed that the remaining biomass of the GL after metal extraction can be effectively converted into energy-rich solid fuels and low-cost adsorbents via MHTC.

10:45 AM
Development of an Ammonium Chloride Leaching Process for the Selective Removal of Contaminant Metals from Unconventional Rare Earth Element Resources
M. Noonan¹, O. Wong-Branscombe¹, T. Larochelle², P. Ziemkiewicz² and A. Noble;¹ Minerals and Mining Engineering, Virginia Tech, Blacksburg, VA;²West Virginia University, Morgantown, WV and³L3 Process Development, Bent Mountain, VA
Many rare earth element (REE) resources contain significant amounts of calcium, zinc, and magnesium, which are deleterious contaminants that contribute to low product purity and high processing costs. For example, calcium and magnesium are often found in the host mineralogy of REE carbonatite ores and contribute to higher acid consumption and unacceptable leaching costs. For unconventional resources, such as acid mine drainage solids, coal byproducts, and mine tailings, calcium and zinc are often leached with the REEs and co-recovered through solvent extraction, thus necessitating numerous scrubbing and purification stages. In this study, a low-cost leaching process was developed, whereby ammonium chloride is used as the lixviant to selectively remove contaminants while leaving the rare earths in the residual solids. The process was successfully demonstrated at the laboratory-scale using an REE preconcentrate recovered from acid mine drainage. Data show that over 90% of the calcium and zinc can be removed in a single leaching stage, while recovering 95% of the REEs to the purified solids. Results from the study and implications for future process development will be discussed.

11:05 AM
Process Intensification for Rare Earth Elements Adsorption by Resonant Vibratory Mixing
Q. Adebayo and Z. Nasrullah; Metallurgical & Materials Engineering, Montana Technological University, Butte, MT
The adsorption capacity and recovery efficiency of biochar for four rare earth elements (Lanthanum, Neodymium, Dysprosium, and Holmium) from aqueous solution was determined. Resonant vibratory mixing was utilized for the process intensification and optimization of the adsorption kinetics in the process. Hemp as the source of biomass was pyrolyzed to produce biochar at a temperature of 450°C for 60 minutes. Five different concentrations of each rare earth element were prepared by dissolving a known amount of the rare earth chlorides (LaCl₃, NdCl₃, DyCl₃, and HoCl₃) in di-ionized water. An experimental design was set up for the adsorption experiments with three variables which are time of mixing, intensity of vibration, and recovery. The vials containing the five concentrations of rare earth solutions and known weights of biochar were placed into a reactor and loaded into the resonant vibratory mixer. ICP-OES was conducted to confirm that the results generated after the experiments were accurate. Response surface methods were used to optimize the adsorption process and analyze the variables’ relationship.

11:25 AM
24-082
Sulfide Tailings as Potential Secondary Sources of Critical Minerals
F. Nakhaei, L. Alaghja, J. Corchado-Albelo and N. Munoz Garcia; Department of Mining and Explosives Engineering, Missouri University of Science & Technology, 1400 N. Bishop Ave., Rolla, MO, USA, 65409, Rolla, MO
Sulfide tailings from past and present mining activities are important hosts of critical elements and precious metals. This review paper presented a literature survey on the recovery practices of some critical minerals containing Au, Ag, and Te from sulfide tailings with a special focus on the physical beneficiation and hydrometallurgical separation methods. Finally, a conceptual framework and possible processing flowsheets were proposed. The findings of this review will be useful for the researchers in the field of geochemistry, mineral processing, and metallurgy to evaluate the separation processes for reprocessing of mine tailings for the recovery of critical minerals.

TUESDAY, FEBRUARY 27  MORNING
MPD: CHEMICAL PROCESSING: RECYCLING
North 228A
9:00 AM • Tuesday, February 27
Chairs: J. Wu, Ecobat, Irving, TX
Z. Cicek, West Virginia University, Morgantown, WV
J. Trouba, Colorado School of Mines, Lakewood, CO
9:00 AM
Introductions
9:05 AM
Zn Leaching Recovery and Mechanisms from End-of-Life Tire Rubber
S. Li, B. Ji and W. Zhang; Mining and Minerals Engineering, Virginia Tech, Blacksburg, VA
Experiments were conducted to investigate the leaching recovery of Zn from waste tire rubber. XRD and XPS analyses showed that the Zn-containing phase in the material was mainly ZnO. SEM-EDS analysis confirmed the presence of both exposed and encapsulated ZnO particles. Acid leaching tests indicated that the carbon black comprised in the material can be
oxidized and dissolved by HNO₃, resulting in the dissolution of completely encapsulated ZnO particles that had relatively thin covering layers. Then, leaching tests using HNO₃ as the lixiviant were performed at varying acid concentrations and leaching temperatures. The results showed that over 98% of Zn was recovered using 2.0 mol/L HNO₃ at 90°C after 400 min of reaction. Leaching kinetic results were best fit with the Avrami model, indicating the leaching process was controlled by diffusion. The activation energy determined by Arrhenius formula was 12.92 kJ/mol, which further supports the proposed diffusion controlled leaching process.

**9:25 AM**

**Minimizing Leaching of Al, Co, Cu, Fe, Li, and Ni During Discharge of Lithium-Ion Batteries**

L. Sanchez-Calderon and L. Alagha; Department of Mining and Explosives Engineering, Missouri University of Science & Technology, Rolla, MO

The current recycling practices of lithium-ion batteries pose challenges that start with safe preparation of the batteries to prevent explosions. Submerging batteries in sodium chloride (NaCl) solutions has become an acceptable industrial practice. However, the use of NaCl to leach lithium-ion batteries rusts the batteries’ cases and release metals such as Fe which impact the downstream processes that involve selective recovery of Li. This study aimed to determine the optimal concentrations and pH range of NaCl for the discharge of lithium-ion batteries for the purpose of minimizing the leach of Al, Co, Cu, Fe, Li, and Ni.

**9:45 AM**

**A Feasibility Study of Methanesulfonic Acid (MSA) as an Alternative Lixiviant to Recycle Spent Lithium Ion Battery**

J. Ahn and H. Jung; Mineral Resources and Energy Engineering, Jeonbuk National University, Jeonju, Korea (the Republic of)

Nickel, cobalt and lithium are raw materials for lithium ion battery (LIB). Recently, hydrometallurgical recycling of the metals from spent LIB are promising due to limitation and production of the metals deposit at certain countries. During hydrometallurgical recycling, sulfuric acid (H₂SO₄) are generally used. Methanesulfonic acid (MSA) can replace the conventional lixiviant. It has characteristic of higher metals solubility with biodegradability, low toxicity and corrosiveness. In this study, leaching behavior of MSA was investigated. MSA and H₂SO₄ were investigated with different conditions to leach metals from spent lithium ion battery. MSA achieved higher than H₂SO₄ with 1.0 M hydrogen peroxide (H₂O₂) as a reducing agent at 80°C. Also, metals leachability enhanced by increasing MSA concentration from 0.3 M to 1.0 M with 0.3 M H₂O₂. Meanwhile, it was similar for all conditions of H₂SO₄ from 0.3 to 1.0 M at 0.5 M MSA. Based on the results. The concentration of MSA possibly governs leaching kinetic than H₂SO₄ in MSA–H₂O₂ leaching system. *This work was supported by the National Research Foundation of Korea(NRF) grant funded by the Korea government(MSIT) (No. RS-2023-00212245).

**10:05 AM**

**Recycling Sm-Co Permanent Magnets via Selective Oxidation Roasting**

M. Harvey, M. Caccia and C. Young; Metallurgical & Materials Engineering, Montana Technological University, Butte, MT

Sm-Co permanent magnets contain up to 77 wt% cobalt. With 3,431 tons of cobalt used in 2022 to make Sm-Co magnets, having an effective way to recycle them is important for ensuring a continuous supply of this critical material. Thermodynamic calculations and literature review identified a range of operating conditions for a selective roasting operation whereby samarium is oxidized to Sm₂O₃ while leaving the cobalt in elemental form. Results obtained thus far are promising and are therefore compared to other technologies being examined and used.

**10:25 AM**

**Graphite Recycling From Lithium-Ion Battery Anode Scrap**

Z. Zhou and W. Zhang; Mining and Mineral Processing, Virginia Tech, Blacksburg, VA

A significant portion of anode and cathode materials are discarded as scraps during the fabrication of lithium-ion batteries (LiBs). Compared with the materials from spent LiBs, the scraps are easy to recycle, and the recycled materials are more advantageous due to their high purity and low lattice defects. In this study, the recycling of graphite from an anode scrap was achieved through a process consisting of washing, leaching, de-watering, and drying. The effect of different parameters on the washing efficiency was assessed, and the detaching mechanisms of graphite from the copper foil were investigated from thermodynamic and kinetic perspectives.

**10:45 AM**

**Recovery of Valuable Metals From Municipal Solid Waste Incineration (MSWI) Bottom Ash by an Integrated Hydrometallurgical Process**

B. Ji and W. Zhang; Mining and Minerals Engineering, Virginia Polytechnic Institute and State University, Blacksburg, VA

An integrated hydrometallurgical process was developed for producing high-purity Cu, Zn, Mn, Co, and Ni products from municipal solid waste incineration (MSWI) bottom ash. 100% of valuable metals can be released from the bottom ash by pH static leaching at pH 0.0. The leach liquor was then subjected to sequential precipitation to remove the contaminants and preconcentrate the valuable elements. The results show that after removing most of the Al and Fe by elevating the pH to around 4.0 (Stage I), ~80% Cu and ~30% Zn can be recovered at pH 5.5 (Stage II), while ~90% Mn, Co, Ni, and ~65% Zn were precipitated in the pH range of 5.5 to 10.0 (Stage III). The precipitates of Stage II and Stage III were redissolved to further purify the valuable elements. Then, the solvent extraction tests were conducted to separate and purify the valuable elements in dissolved solutions. Nearly 95% of Cu and Zn can be extracted from the dissolved precipitate of Stage II by Acrorga M5640 and Aliquat 336, respectively. After recovering the Zn from the dissolved precipitate of Stage III, most of the Mn was extracted by D2EHPA, while Co and Ni remained in the aqueous phase were separated by Cyanex 272.

**11:05 AM**

**Partitioning of Metal Ions During Acid Neutralization of Nickel-bearing Pregnant Leached Solution**

P. Lin and L. Pan; Chemical Engineering, Michigan Technological University, Houghton, MI

Loss of transitional metals during the neutralization of nickel-bearing pregnant leached solution (PLS) was commonly observed. However, the effect of various neutralizing chemicals on the removal rate of both iron and aluminum as well as the loss of nickel and cobalt has not been studied. This work employed various neutralizing reagents, such as CaCO₃, CaO, NaOH, and Na₂CO₃, and evaluated the effects of pH and temperature on the partition of various metal ions. Results showed that both iron/aluminum removal rate and loss of nickel and cobalt has been achieved through a process consisting of washing, leaching, de-watering, and drying. The effect of different parameters on the washing efficiency was assessed, and the detaching mechanisms of graphite from the copper foil were investigated from thermodynamic and kinetic perspectives.
Impact of Organic Impurities on Acid Leaching of Valuable Metals from Used Li-Ion Batteries

M. Bae, H. Lee and S. Kim; Korea Institute of Geoscience and Mineral Resources, Sejong-si, Korea (the Republic of)

As the utilization of lithium-ion batteries (Li-ion) grows, efficient recycling methods for recovering valuable metals, such as lithium, nickel, and cobalt, become essential. Acid leaching is a commonly employed technique for metal recovery from used Li-ion batteries. However, the presence of organic impurities within the battery materials can significantly influence the leaching process. This study investigates the effect of these organic impurities on the efficiency of acid leaching processes. Spent Li-ion batteries were subjected to thermal treatment to eliminate organic components, including binders and separators, followed by sulfuric acid leaching to extract valuable metals. The thermal treatment process was carried out at various temperatures, and the resulting black powder was analyzed for changes in metal concentration after leaching. The influence of organic impurities on the leaching process was examined by comparing the leaching efficiency of samples with and without thermal treatment.

The Bond Legacy: Part I

R. McIvor, Metcom Technologies, Hamilton, ON, Canada

Fred C. Bond is recognized throughout the mineral processing world as the father of comminution equipment applied science and engineering. The Bond Work Index became a universal standard, and is the most widely used measurement tool for comminution energy consumption. This biography is the story of his lifetime of study, work experiences, experimentation, analyses, and findings. In Part I, Bond’s published writings up to the time of his discovery and publication of the Third Theory of Comminution.

The Bond Legacy: Part II

R. McIvor, Metcom Technologies, Hamilton, ON, Canada

This is a continuation of the review of Fred C. Bond's work provided in Part I, completing the review of his entire body of published work, commencing from the time of his discovery and publication of the Third Theory of Comminution.

Secrets of the Bond Ball Mill Grindability Test

A. Doll1 and V. Nikolić2; Alex G Doll Consulting Ltd, Cork, Ireland and 2Technical faculty in Bor, Department for Mineral and Recycling Technologies, University of Belgrade, Bor, Serbia

The Bond ball mill grindability test is one of the most common metrics used in the mining industry for ore hardness measurements. The test is an important part of the Bond work index methodology for designing and measuring the efficiency of mineral grinding circuits. The work index equations are an empirically measured regression of a large data set collected by the Allis-Chalmers corporation in the period between 1930 and 1952. As a regression, it is valid within a specific ‘calibration space’, and great care is required when deviating the test procedures or observing results that are outside of that calibration space. This paper is a collected summary of other works by the Authors that describe feed sizes, product sizes, quality control checks, and other information about interpreting the test and using its results. Examples of adjustments that are sometimes required when using the test are: changing the test product (P80), and coping with a feed that is too fine to apply the “proper” feed preparation steps. Related metrics, like the Morrell Mib value and Levin B value will be discussed, along with recommendations for their use on design projects.

Navigating Operational Hurdles in SAG Mills: Identifying and Addressing Common Challenges

K. Erwin, C. Menke and R. Chandramohan; Ausenco, Rossland, BC, Canada

This paper explores prevalent operational challenges encountered globally in SAG mills, including suboptimal throughput, liner wear, excessive energy consumption, and SAG mill load stability. The paper delves into the root causes behind these issues, such as ore variability, poor operating strategy, or inadequate process control. Drawing on industry experience and case studies, the paper highlights the significance of addressing these challenges to enhance overall mill performance and efficiency. It underscores the necessity of tailored strategies, encompassing improved monitoring, optimized liner designs, and refined control techniques to mitigate these challenges and promote sustainable SAG mill operation.

Optimising Ball Mill Grinding Circuits—It’s Not Just the Mill

B. Cornish; Grinding Media, ME Elecmetal, Port Douglas, QLD, Australia

Ball mill grinding circuit operation is complex due to the interactions between the circuit components; as such, there is little to be gained from attempting to optimise the milling or classification stages independently. Circuit optimisation is best undertaken with a holistic approach, and a well-proven system is the Functional Performance Evaluation as developed by Metcom Technologies (McIvor et al, 2017). This analysis involves assessing mill power draw along with grinding and classification efficiencies, including a full review of all mineral characteristics testwork and circuit operating data. Mill grinding efficiency is established based on precise testwork with an actual sample of ball mill feed using a laboratory torque mill that reproduces the conditions in the laboratory. The Bond index has been calculated for different steel balls giving an approximation of the ball wear/kWh of energy used in the comminution process for a given ore. When the Bond index was compared with the actual wear rate in an operative ball mill, the results show that this index can be used to predict the wear rate of steel balls better than the Bond Abrasion index.
Improving Flotation Using Novel Hydrophobizing Agents

M. Gupta, K. Huang, O. Onel, and R. Yoon; Chemical Engineering, Virginia Polytechnic Institute and State University, Blacksburg, VA; Chemical Engineering, Michigan Technological University, Houghton, MI; 3Mining and Minerals Engineering, Virginia Tech, Blacksburg, VA

In flotation, air bubbles selectively collect hydrophobic particles, leaving hydrophilic particles behind. Various hydrophobizing agents (collectors) are used to increase the water contact angles ($\theta$) of target minerals, typically to 60-90°. In the present work, we developed novel collectors that can increase $\theta$ to 150°. Based on laboratory flotation test results and liberation data, the impacts of using the new reagents, tentatively called Super Collectors, have been determined using a flotation model that can predict both grade and recovery. The results show that the new reagents can greatly increase throughput without losing copper recoveries. The reagents are also useful for coarse particle flotation.

Enrichment of Rare Earth in Allanite Through Comprehensive Screening of Flotation Agents

Z. Xiao, W. Liu, and W. Zhang; 1Mining and Minerals Engineering, Virginia Tech, Blacksburg, VA; 2Department of Material Science and Engineering, University of Utah, Salt Lake City, UT

Allanite contains critical rare earth elements. Around 0.9% of total rare earth elements, 8.7% of aluminum, 7.8% of iron, and 26.1% of silicon were found in the allanite sample used in this study by fusion tests. This study aims at the flotation process to concentrate rare earth elements in allanite. Systematic experiments will be carried out to determine the influential collectors for rare earth separation through comprehensive screening of agents. Other flotation factors, such as dispersants and the pH of the pulp, will also be investigated for optimization. The experimental results will be combined with the mineral characteristics of allanite to explain the flotation phenomena. The rare earth enriched by flotation will be used in the downstream hydrometallurgy process for further purification and production.

Impact of Low pH Pit Water Containing Various Ion Species on Copper Sulfide Flotation at Chino Mine

C. Beaven, F. Dehghanian, and T. Vethosodsakda; Freeport-McMoRan Chino Mine, Metallurgist, Silver City, NM

Surface chemistry of sulfide ores plays a substantial role on flotation performance. Chino mine, New Mexico, is going to mine ore underneath pit water level containing dissolved compounds and ions of almost all types with low pH around 1.8. The water will change the surface chemistry of the ore. Consequently, the processing of this ore would be challenging. In this study, the impact of pit water was investigated on copper sulfide flotation by conducting bench-scale flotation. In the first step some control tests were done on clean ore to check its flotation performance. Then, a series of flotation tests were designed and conducted based on various contacting time between ore and pit water, surface treatment, different types, and dosage of chemicals, pH, and solids. Finally, the tests results were analyzed to identify, and mitigate any negative impact of pit water on kinetics, grade, and recovery of the flotation.
ONLINE PROGRAM

11:05 AM

The Combined Use of CuSO₄ and NaSH in Sulfide Mineral Flotation: Going Against the Conventional Wisdom
S. Guo, D. Nagaraj, B. Vaziri and R. Farinato; Earth and Environmental Engineering, Columbia University, New York, NY

CuSO₄ and NaSH are among the extensively used inorganic modifiers in sulfide mineral flotation. CuSO₄ is used as an activator for sulfide minerals, especially sphalerite, pentlandite, pyrite, and pyrrhotite. NaSH is used in three important applications, viz. activating tarnished sulfides, sulfidization of oxide Cu/Pb/Zn minerals, and depression of Cu sulfides and pyrite in Cu-Mo separation. The conventional wisdom is that CuSO₄ and NaSH are never used together since the insoluble Cu sulfide (Ksp ~10⁻²⁷) precipitates instantaneously, thus rendering both Cu²⁺ and S²⁻ unavailable for function as modifiers. We have now sought to challenge this conventional wisdom and revisited the combined use in a systematic manner. In this paper, we will present results from flotation tests, using sulfide ores and model systems, to investigate the dosing strategy, addition point, and sequence of addition of CuSO₄ and NaSH. These will be supported by surface spectroscopy and wettability measurements to shed light on linking interfacial processes to flotation outcomes.

11:25 AM

Alkoxy carbonyl Alkyl Dithiocarbamates and Their Interactions with Sulfide Minerals and Precious Metals
N. Bellucci, D. Nagaraj, R. Farinato, B. Vaziri, T. Bhamhani and E. Annanwe; Earth and Environmental Engineering Department, Columbia University, Stamford, CT and Solvay Technology Solutions, Stamford, CT

Alkoxy carbonyl alkyl dithiocarbamates (ACADTCs) represent a class of ligands with unique coordination chemistry and interfacial properties. Under appropriate process conditions, they can be used for either selective separations of mineral/metal values from gangue iron sulfides or bulk sulfide flotation when all the sulfides possess value. Empirical ore flotation studies have demonstrated that they have a unique affinity for soft Lewis acids, especially Au, Ag, and platinum group metals. There is currently no published literature on their coordination chemistry and interfacial behavior, while linking these to their flotation performance in sulfide and precious metal ores. In this paper, we introduce scientific insights into the behavior of the ACADTCs, focusing on their interfacial and coordination chemistry. Electrochemical, spectroscopic, and wettability studies were used to probe the molecular level processes of these ligands, while comparing them with the dialkyl dithiocarbamates and their alkoxy carbonyl alkyl thio-analogues. Several examples of flotation practice with the ACADTCs in sulfide and precious metal ore systems are also provided to highlight their unique attributes.

11:45 AM

Mercaptan Collector Performance in Copper Sulfide Ores
C. Brown; Specialty Chemicals, Chevron Phillips Chemical Company, Bartlesville, OK

Mercaptans and alkyl sulfides have been known for decades to provide excellent performance as a collector in sulfide ores. For example, dodecyl mercaptan has shown to be highly effective in copper-molybdenum ores, precious metal ores (gold), and platinum group metals, as alternatives to a variety of common sulfide collectors including xanthate-type promoters. Historically adoption of these reagents has typically been hampered by their odor or perceived odor, but significant manufacturing improvements have been made to reduce odor while increasing performance. However, there has not been a systematic study of how these structures influence flotation of various mineral types for a given metal, such as copper as chalcopyrite, chalcocite, covellite or bornite. This paper will provide data from laboratory tests evaluating the performance of select mercaptans and alkyl sulfides as collectors in copper sulfide flotation of primary and secondary copper minerals.

TUESDAY, FEBRUARY 27 MORNING

MPD: PLANT DESIGN: PLANT DESIGN I

North 225B

9:00 AM • Tuesday, February 27

Chairs: C. Foxworth, Weir Mineral, North Pole, AK
N. Newton

9:00 AM

Introductions

9:05 AM

Overview of CuMo Copper-Molybdenum-Silver Project Owned by Idaho Copper Corp. in Boise County, Idaho
A. Brodecky, Idaho Copper Corp., Boise, ID

Idaho Copper Corp. (IDCU) is a mining exploration and development company, focused on exploring and developing a massive copper-molybdenum-silver deposit in Idaho (the CuMo project). CuMo is among the largest undeveloped copper projects in the Americas and we believe the largest undeveloped primary molybdenum project in the world, with Measured and Indicated Resources (at a RCV cutoff at US$2.50/lb) of almost 4 billion pounds of copper, 1.5 billion pounds of moly, adn almost 180 million ounces of silver. Over 50 million dollars have been invested in the project by IDCU and its predecessprs since the 1970's. The most recent PEA/Technical Report authored by SRK in 2020 used a 150K tpd concentrator at an initial Capex of over US$3 billion. Our goal and studies during 2023 are to incorporate ore sorting results from XRF bucket level testing to dramatically eliminate waste and greatly improve head grade, allowing IDCU to downsize the mill to around 30K tpd, and reduce Capex to under $1 billion. IDCU is also progressing final work with the US Forest Service to publish an updated Plan of Operations leading to a new Record of Decision for our EA to permit drilling at the project in 2024.

9:25 AM

Teck QB2 Project Design
E. Huls, Project Development Group, Teck Resources, Vancouver, BC, Canada

An overview of the Teck QB2 project focusing on the flowsheet, layouts, project equipment, and plant design considerations taken to ensure a successful project. QB2 is a 140,000tpd copper concentrator located in northern Chile, the project includes a 100,000 m³/day desalination plant, port facilities for concentrate storage and shipping, and 16km long water and concentrate pipelines up to the concentrator at 4300m elevation.

9:45 AM

The Development of the North Bullfrog Processing Flowsheet
J. Olson, AngloGold Ashanti, Reno, NV

The majority of the ore to be processed from the North Bullfrog Project is low grade with finely disseminated gold that is amenable to run-of-mine heap leaching. The remaining ore is mined from a relatively narrow, high grade, vein and stockworks zone containing coarse gold. The remaining ore is mined from a relatively narrow, high grade, vein and stockworks zone containing coarse gold. Although representing less than 5% of the total ore, the vein and stockworks material contributes about a third of the total LOG gold production. The process flowsheets and designs were developed to reduce the capital and operating costs as much as possible without significantly reducing the operability and functionality of the equipment. This goal led to some unconventional designs in the flowsheet including direct leaching of a coarsely ground slurry (80%-300µm) and comingling of filtered tails with run-of-mine heap leach material.
The Doe Run Company (Doe Run), a global supplier of lead, copper and zinc concentrates, and lead metal alloys, installed an enterprise expert control system termed as Digital One—on the company’s lead, copper and zinc circuits at its Buck Mill in December 2022. Digital One was developed with Metso and deploys Metso’s product, VisioFroth. This automated system is now running and optimizing the flotation processes for all three circuits (lead, zinc and copper circuit), all plant air and Methyl Isobutyl Carbinol (MIBC). In addition, Digital One also controls a second newly built, modern flotation reagent system. Digital One also paves the way for automation and expert control of the entire mill, integrating grinding, thickening and filtration. Digital One is digitally immersed in universal Distributed Control System (DCS), therefore today’s mineral processing plants may be upgraded to it or designed around it. This presentation will explore the plant design and operation of this technology at the Doe Run Buck Mill.

10:25 AM
Leveraging Project Definition Rating Index (PDRI) in the Mineral Processing Industries
G. Westan and B. Kearns; Mining & Mineral Process, Kiewit Industrial Group, Lone Tree, CO

The Construction Industry Institute (CII) initially developed the Project Definition Rating Index (PDRI) in 1994 to provide a framework of easy-to-use scope definition and alignment tools. After nearly three decades of evolution, PDRI has become a widely utilized toolset to help assess project design maturity in various stages of the project development lifecycle. PDRI is briefly referenced in the SME published “Project Management for Mining Handbook for Delivering Project Success”, this presentation seeks to expand on the use of the PDRI toolset on projects in the mineral processing industries. A general overview of applying PDRI to mineral processing projects is followed by several case studies highlighting specific benefits and considerations at various phases of project development.

10:45 AM
Idaho Cobalt Operations—America’s Cobalt Mine
M. Sletten; Professional Engineer, M3 Engineering, Chandler, AZ

Idaho Cobalt Operations is located in east central Idaho in the heart of the Idaho Cobalt Belt. The project site is located in the Salmon National Forest west of the town of Salmon, Idaho. Idaho Cobalt Operations will process 1200 short tons per day of sulfide ore to produce two products: a copper concentrate and a cobalt concentrate. The primary metal bearing minerals in the ore are chalcopyrite and cobaltite. Size reduction of the ore will be via a primary jaw crushe, along with a SAG Mill and a Ball Mill to produce a slurry at an 80% passing size of 75 microns. The primary ground slurry will report to sequential flotation circuits where the copper will be floated first to produce a copper concentrate, followed by flotation of the cobalt to produce a cobalt concentrate. The concentrates will be independently dewatered via thickeners and pressure filters, with the concentrate cake being bagged for shipment for further processing off-site. The tailing from the flotation circuit will be dewatered via a thicken and two vacuum filters. The tailing will be dry stacked or used to produce a paste backfill for the underground mine.

11:05 AM
Low Cost/High Reward Plant Optimization
B. Moreno Baquero Sansao, K. ADAMS and A. House; Paterson & Cooke USA, Golden, CO

Paterson & Cooke (P&C) was recently asked to review the recommended modifications to a gold mill in South America. The existing plant had two ball mills in the grinding circuit. A previous consulting assessment indicated that a third ball mill was necessary for the desired 30% increase in throughput. P&C assessed crushing, grinding and leaching operations, optimizing the circuits with stress tests to find bottlenecks. By improving crushing utilization, a finer product was delivered to the mills. Raising mill power utilization from <90% to >95% allowed for a higher throughput with same product quality. Leaching recovery tests also showed overall gold recovery was unimpacted if the grind product coarsened from 160 to 190 μm. The assessment demonstrated that plant could increase throughput by approximately 40%, while maintaining leaching suitability. P&C’s analysis and expertise boosted mill capacity, surpassing targets, and enhancing ore treatment productivity. This strategy averted a mill purchase, elevating competitiveness. This case demonstrates the benefits of plant optimization, with low investment in mining.

11:25 AM
How to Allow Flow Test Data to Guide Design Minimizing Project Risk
T. Holmes; Jenike & Johanson, Mississauga, ON, Canada

Since Dr. Jenike’s breakthrough research regarding the flow of solids at the University of Utah in the 1950’s, bulk solids handling flow testing has been key in understanding how a bulk solid behaves or is going to behave. So how can testing be used to guide equipment/plant design and operations? Questions such as these commonly come up for discussion by the operations and engineering/planning groups: Ore continues to plug our transfer chutes and surge bins and we have limited ability to change the equipment—can we change the material flow properties (e.g., different PSD, adding additives/anti-freezing agents) enough to return to reliable flow? Our sticky ore with high clay content is causing flow issues, but we know our equipment works well with our typical ore, how much free-flowing ore do we need to blend with the sticky ore to reliably handle the sticky ore through our process? Flow testing can provide answers before incurring the cost and time to implement changes such as additive or blending operations or modifying equipment. Different case studies will be presented to discuss how material flow testing can be used to guide plant design and operating parameters.
Humans mining on the moon will face numerous health and safety hazards (HSH) not seen on Earth. HSH could be encountered in transport to and from the moon, at the mine site as well as in the lunar habitat. It is important to understand these HSH to develop mining strategies, equipment, and staffing. Some of these issues are well known in the space community such as space motion sickness, cardiovascular deconditioning, solar flares, > 450-degree temperature gradients, decompression sickness, blunt and penetrating trauma, illness, delay in communication, teamwork controversy, food and sanitary limitations as well as pressure injury from EVA suits. One of the most vexing HSH problems is inhalation of lunar dust (charged silica particles) that was described as “lunar hay fever” by the Apollo astronauts. Inhalation of lunar dust may lead to a host of pulmonary sequela including cancer and should be studied further. This study will include a broad review of a number of key HSH that will impact humans as they begin to commute, work, and live on the lunar surface as well as mitigation (known and speculative) strategies.

9:25 AM
24-026
Development of a Comprehensive Mine Plan Approach for the Extraction of Icy Regolith on the South Pole of the Moon Using Surface Mine Modelling Software
V. Tenorio1, K. Brown Requist1, M. Hunt1, G. Gill2 and R. Downer2;
1Mining and Geological Engineering, University of Arizona, Tucson, AZ and 2OpenContour, Salt Lake City, UT
One of the first activities after returning to the Moon will be finding sources of water and materials for the construction of human settlements and other infrastructure. There is evidence of the existence of deposits in the bottom of craters at the South Polar region and in flat areas around. Based on geological data from the Moon, a block model representing a deposit of icy regolith has been defined in the vicinities of Shackleton Crater; with unique characteristics of shape, thickness, and water contents. A mine plan utilizing surface mine modeling software for ore extraction from an open pit-type of excavation to a delivery point near a water processing facility is proposed, with monthly, quarterly, and yearly schedules. Production results, dashboard charts and progress of the topographic changes are also presented.

9:45 AM
Building a Solar System Civilization—How Offworld’s Terrestrial Swarm Robotic Mining and Construction Robots Will Operate on Earth and the Moon
L. Rivera; Marketing, OffWorld, Altadena, CA
OffWorld is building millions of smart robots working on the human supervision on earth and in space, turning the solar system into a habitable place for life and civilization. What we absolutely require in space is a robotic workforce for tough jobs. We need to emulate the entire infrastructure value chain. We cannot just export Earth-based practices and technology. We must reinvent how we undertake these processes here on earth, and transfer them directly to the expansion of civilization into the solar system. OffWorld has undertaken extensive R&D in the field of extreme environment industrial robotics initially applied to the mining and processing sector. The objective is the establishment of an end-to-end collaborative robotic system comprising of hundreds or thousands of multi-species robots working together within internal and collective autonomy to achieve strategic objectives. With the ongoing input of mining industry expertise on a daily basis, OffWorld has developed its robotic systems to work tough jobs. OffWorld is currently developing regolith to gaseous oxygen and gaseous hydrogen subsystems using six distinct processes.

10:05 AM
Insects-inspired Robots for Lunar Exploration
C. Dunaway, N. Devlin, B. Herkenhoff and M. Hassanalian; Mechanical Engineering, New Mexico Tech, Socorro, NM
In the necessity for robust autonomous and highly mobile robotic platforms for the challenging environment of the lunar surface, inspiration from unique natural mechanisms produces many novel concepts. Three individual robotic systems have been developed to explore the various forms of insect-based movement. For instance, the fine lunar regolith poses a significant challenge to all forms of transportation on the moon, as there is no atmosphere or liquid water to erode the surface materials. As a solution, a conceptual jumping robot, inspired by a grasshopper, was designed to minimize contact with the regolith. Another challenge the lunar environment poses is unhindered solar radiation and extreme temperature fluctuations. The pillbug inspired a system that hosted versatile locomotive abilities as a multi-legged platform and an effective method for protecting sensitive instruments by rolling up to seal the electronics bay. Finally, a concept for a rolling robot will give greater accessibility to many areas of high interest, such as craters and subterranean lava tubes, which are challenging to reach with standard heavy-bodied rovers.

10:25 AM
New Mexico Tech’s NASA Lunabotics Robots: Design and Autonomy
N. Devlin, M. Escarcega, C. Dunaway and M. Hassanalian; Mechanical Engineering, New Mexico Tech, Socorro, NM
The Artemis mission is an exciting opportunity for humanity to return to the Moon. NASA aims to lay the groundwork for the construction of a sustainable lunar base. The base must be sustainable so as to minimize the amount of raw materials shipped between the Moon and Earth. As such, NASA aims to collect in situ (on-site) resources from the lunar surface. The resources that will be mined from the Moon include but are not limited to methane, hydrogen, oxygen, and water. To reduce the man hours of the in situ resources collection, NASA plans to deploy a fleet of autonomous robots to dig for and collect lunar ice from underneath the lunar regolith. NASA challenges collegiate teams to design, build, and test an autonomous mining robot that can navigate through an obstacle course, mine simulated lunar ice, and deposit the collected material at the starting position. This competition gives NASA the data points required to plan and execute a large-scale operation. The challenge has the added bonus of intermingling the fields of autonomy and mining, as well as training professionals who are equipped to work in the intersection of the two fields.

10:45 AM
RedWater: A Rodwell System to Extract Water from Martian Ice Deposits
J. Schultz; Space Resources, Colorado School of Mines, Sierra Madre, CA
In recent years, orbital measurements have revealed that there is a potential for ice deposits near the Martian surface in mid latitudes. Understanding the stratigraphy of the Martian surface is paramount to human sustainability and future missions. Honeybee Robotics has a demonstrated history with leveraging existing terrestrial technology for space applications. Redwater is a Rodriguez Well (Rodwell) System developed to extract water from Martian ice deposits. This system utilizes a coiled tube drilling system to penetrate depths up to 25 meters below the Martian Surface to reach the ice that is buried deep in the subsurface. The primary advantage of this system is that there are many sensors and instruments in the auger tip. This brings the instruments to the sample so data measurements can be collected real-time as a function of depth. Additionally, the cuttings created by drilling can be pneumatically cleared out of the borehole and can be collected and analyzed by surface-level instrumentation. The sampling instruments integrated into the head allow for detection of hydrogen as well as measuring the volatile content and mineralogy of the regolith.
ONSITE PROGRAM

TUESDAY, FEBRUARY 27 MORNING

SMYEOUNGLEADERS: PROFESSIONAL DEVELOPMENT FOR EMERGING INDUSTRY PROFESSIONALS

Sponsored by: Rio Tinto

North 125A

9:00 AM • Tuesday, February 27

Chairs: V. Srivastava, Freeport-McMoRan, Lexington, KY
A. Anani, University of Arizona, Tucson, AZ

9:00 AM

Introductions

9:05 AM

Unleashing Potential: Embracing Continuous Improvement for Enhanced Computer Skills

T. Faulkner; Mining, Carlson Software, Inc., Maysville, KY

When honing a skill, the amount of time dedicated to practice often directly correlates with proficiency—the more one practices, the greater the improvement. Nevertheless, as habits solidify, progress can plateau, impeding further growth. The key to overcoming this stagnation lies in consistently asking ourselves, “How can I improve?” and then proactively implementing change. This presentation centers on the significance of continuous improvement, with a specific focus on computer skills. As technology becomes increasingly integral to our daily lives, a considerable portion of our time is spent navigating the digital realm. Despite investing substantial hours in these tasks, many individuals remain content with familiar approaches, unintentionally limiting their productivity potential. By elucidating the principles of continuous enhancement, attendees will gain an understanding of how incremental changes can lead to significant productivity boosts. Exploring real-world examples, the audience will witness the transformative impact of small adjustments in workflow and digital practices, as well as learn about additional tools for completing common tasks.

9:25 AM

24-076

Project Building Our Future: Inspiring Young People to Follow Their Dreams and Aspirations

M. Portal Valdivia, F. Segobia Campos, L. Goicochea Sánchez and F. YSLA QUIROZ; Mining engineering, Society for Mining, Metallurgy & Exploration, Cajamarca, Cajamarca, Peru

It is our responsibility to share responsible and sustainable mining with the new generations, always promoting a culture of equality and respect. To fulfill this responsibility, we are working with the team of SME UNC Student Chapter, Newmont Yanacocha, BRG Women and Allies and the Water and Earth Museum (MAT) to carry out the “Building Our Future” project. This project is focused on instilling in the new generations the importance of mining, promoting a culture of equality and respect. We have the participation of professionals from Newmont Yanacocha and externals, who share their life story and inspire young people from Rural and Urban schools to follow their dreams and aspirations. We believe that this project is important because it will help the new generations understand the importance of mining and the role it plays in the country’s development. It will also help to promote a culture of equality and respect in mining, which is essential for the sustainable development of industry. This project has been underway since 2022 and we have reached over 500 young people.

9:45 AM

The Mining Engineer of the Future: Skills to Move Forward in a Changing World

S. Nowosad1, L. Mendieta Britto2, J. Villon2 and O. Langefeld1; 1Institut of Mining, Technische Universität Clausthal, Clausthal-Zellerfeld, Lower Saxony, Germany; 2Holcim, Birmingham, AL and 3Pontificia Universidad Católica del Perú, Lima, Lima, Peru

The mining industry is currently facing challenges. Not only the demand for raw materials is increasing globally, net zero for improving long-term operation performance, but also the demand for leaders in the mining sector and the demand for suitable mining engineering professionals able to move the industry forward, too. Likewise, the mining industry and its practices are often under scrutiny and therefore a need towards more sustainable practices in mining has gained relevance. Furthermore, the technologies and methodologies have also changed in the last 20 years and the mining industry is in need of a restructuration. Different initiatives around the globe are currently being developed from the side of academia and the industry itself which define, among other factors, the characteristics of the mining engineers of the future. This presentation provides an overview on the technical and human skills for mining engineers will have to develop and will be necessary to succeed and lead in the mining industry, especially towards enhancing sustainability practices in mining. This paper aims to encourage all young engineers to be the leaders the industry needs for a brighter future.

10:05 AM

Engaging the Academic Talent Pipeline to Establish its Role in Technological Innovation in Mining Industries

E. Glenn; Department of Geological & Mining Engineering, University of Arizona, Tucson, AZ

How might we approach our educational/academic talent pipelines to support, encourage and aid in development of technological solutions as they are needed and developed within and across the industry space? The intention of this conversation is to engage what it is that the industry is in need of from the perspective of the stakeholders in the room and welcome a meaningful dialogue about how we challenge ourselves in industry versus academia to grow with technological advancements and perhaps even ahead of them to ensure the talent pool meets the demands and needs of an industry with massive growth and innovation potential.

10:25 AM

Unleashing Zimbabwe’s Mining Potential: A Young Engineer’s Perspective

T. Chimbwanda, N. Risso and A. Anani; Mining and Geological Engineering, The University of Arizona, Tucson, AZ

Zimbabwe has a highly diversified mining sector, with a wide range of resources including gold, coal, platinum group metals, chrome, and diamonds. Despite previous political instability, the country is on a path to recovery, offering great growth opportunities for the mining industry. With abundant lithium reserves and being the world’s second-largest platinum producer, Zimbabwe has the necessary resources, skilled workforce, and favorable mining conditions to attract foreign investment. By prioritizing ESG factors and embracing emerging technologies Zimbabwe’s mining sector can be transformed into a sustainable and globally competitive industry. This presentation provides an overview of the mining landscape of Zimbabwe and its potential, as well as perspectives of younger generations about how to contribute in this transformation.

10:45 AM

The Power of Mentoring: A Catalyst for Professional Development

F. Rivas; Resource Industries, Caterpillar, Tucson, AZ

As a minority in the mining industry, mentorships provided me the opportunity to learn and grow early in my career through the guidance of other professionals in the field. These relationships helped shape my
career by increasing my knowledge, skills and confidence both personally and professionally. I am passionate about the benefits of mentorship and believe that tangible examples of successful and fulfilling career paths can inspire both young and established professionals. Mentorships provide helpful insights into careers and industries and offer access to trusted advisors who can help individuals navigate complex personal and professional situations. As little as one conversation can make a lasting impact. In support of Caterpillar’s efforts to support career growth in mining while increasing the diversity of the industry’s workforce, I am confident that my contributions can effectively shape the mentorship program. I am eager to contribute to the success of the program and make a lasting impact on other professionals in the industry.

TUESDAY, FEBRUARY 27 MORNING

TAILINGS: CASE STUDIES–RECLAMATION, CLOSURE AND POST-CLOSURE PRACTICES AND RISK ASSESSMENT OF TAILINGS MANAGEMENT FACILITIES

Sponsored by:

North 131B/C

9:00 AM • Tuesday, February 27

Chairs: R. Dorow, Stantec, Aurora, CO
J. Nielson, Rio Tinto

9:00 AM

Introductions

9:05 AM

Detailed Dam Breach Population at Risk (PAR) Assessment, an Arizona Case Study

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

As Tailings Storage Facility’s (TSFs) Dam Breach Assessments (DBAs) become more sophisticated and begin to simulate something closer to a realistic breach outcome, subsequent Population At Risk (PAR) and Potential Loss of Life (PLL) assessments must also be done to a greater level of detail. Limited detailed guidance is offered on this subject, and it is left largely to the Engineer of Record’s (EOR) and client’s discretion and appetite for risk when it comes to the finer points of these assessments. This presentation/paper presents a detailed PAR quantification method and assessment for an Arizona TSF’s inundation zone, that effects a heavily populated residential and commercial area, utilizing census data, property records, aerial imagery and Department Of Transport (DOT) road use records. Note to the reviewer: The site and client/miner will be named during the presentation, just finalizing this permission currently. Many thanks Ezra Coyle

9:25 AM

Investing in Sustainable Tailings Management: Reduce Risk by Considering Environmental and Utility Costs During Pre-feasibility

J. Kruszwijek1 and E. Vlot1; 1 Weir Minerals, Venlo, Netherlands and Sustainable Mining Technology, Weir Minerals, Venlo, Netherlands

Increasing pressure to reduce emissions and improve environmental and social stewardship makes mining companies consider alternative technologies for tailings management. Converting an existing tailings management system to a more sustainable deposition method during the operation of a mine incurs operational and financial risk. Consequently, most mines continue using their conventional methods. Improving only pumping efficiency lowers emissions and reduces power costs. When at the same time tailings dewatering is improved additional reductions in power and water costs can be achieved, amplifying the sustainability effects of efficient pumping technology. The results indicate improved tailings dewatering shorter the time required to break even on investment. It was considered that introducing carbon tax will drive technology shift. Unexpectedly carbon tax has a very limited effect on project feasibility. There is more return on investment when less water is lost to the environment. In this paper, the payback period on the conversion to a high-density tailings handling system is analyzed on a holistic level taking into account the uncertainty in environmental and utility costs.

9:45 AM

Decision and Design Approach to Risk Reduction Activities for a Legacy Tailings Storage Facility

C. Sonntag; Legacy Assets, BHP, Oro Valley, AZ

Solitude, owned by BHP Copper, Inc., is a legacy tailings facility located on private land approximately 1 mile southwest of Globe, Arizona. The facility was closed in 1959 and reclamation at the time included placement of a thin dust cover and revegetation over the impoundment. A site-wide closure project was commenced in early 2015 to identify data gaps in the historical records and to define closure objectives, regulatory requirements, evaluate investment alternatives, and initiate a final closure design for the site. Technical and risk assessments completed have identified that the current configuration of the Solitude TSF does not meet the BHP’s key risk indicators and that remedial measures to reduce tailings related risks are required. This paper summarizes the approach taken to identify, characterize, develop and select preferred remedial measures to bring the facility within BHP risk guidance. The approach include technical analysis, a rigorous alternative assessment and selection process which included engagement with local stakeholders, consideration of long-term closure objectives and timeline to complete.

10:05 AM

Fly Ash Pond Closure Expertise Applied to Mine Tailings

P. Schmall; Keller North America, Rockaway, NJ

Given the parallels between sluiced in place fly ash and mine tailings, there is significant potential to apply recently developed ground improvement methods to stabilize mine tailings. With recent EPA regulations, many fly ash ponds have been closed and much experience has been gained in working in and stabilizing difficult, sluiced in place residual materials. Expertise includes modified dewatering techniques to physically drain the material, soil mixing to create improved accessways as well as improved ground structures within ponds to act as barriers or gravity dams, and geotechnical instrumentation to serve as an early warning of the potential for liquefaction. The presentation will provide a geotechnical comparison between fly ash and mine tailings, highlight numerous project examples which illustrate the parallels between fly ash tailings and mine tailings and the potential application of the new methods developed.

10:25 AM

Maximizing Value at Legacy Sites

D. Mumm1, J. Schmidt2 and C. Harris1; 1Closure, Rio Tinto, Centerville, UT and 2Jacobs Engineering, Tempe, AZ

A Life of Asset Study was completed to assess revenue generation and long-term management options for former mill and tailings site. A regional market and stakeholder analysis of potential revenue generation and long-term management options was completed for tailings reprocessing, wind power, solar power, geothermal power, and land and water valuations. Using the regional analyses, five scenarios were developed. The scenarios identified were a baseline scenario, status quo plus, tailings reprocessing, renewables leased, and expedited divestiture. This presentation covers the multi-criteria options analysis performed to rank scenarios for non-financial benefits, non-financial risks, and financial performance.
TUESDAY, FEBRUARY 27  MORNING

VALUATION I: CASE STUDIES

North 128B

9:00 AM • Tuesday, February 27

Chairs: B. Suppes, IIMA, Johnstown, PA
J. Kern, IIMA

9:00 AM
Introductions

9:05 AM

Visualizing a Capital Project Portfolio Based on Technical and Financial Risk Levels
M. Samis; SCM Decisions, Toronto, ON, Canada

Mining companies often group projects in their corporate portfolio into exploration pipeline, innovation, operating assets, brownfields, and sub-economic resource categories. However, it is not often recognized that these groupings have characteristic cash flow risk levels allowing for a useful risk-based representation of a corporate project portfolio. This presentation proposes separating project risk into technical and financial risk components and argues that these components can then usefully differentiate the various project categories for decision-making purposes. The resulting framework allows a company’s project portfolio to be represented in full rather than in silos.

9:25 AM

Case Study: Front Loading Damage Claims Versus Just Compensation in Condemnation
C. Wood; Stagg Resource Consultants, Inc., Cross Lanes, WV

When mineral-bearing property is taken through condemnation, the perception of market value for the Take often differs between the parties, with appraisals typically conducted to support the finder of fact’s determination of Just Compensation. This Case Study discusses the taking of a surface right-of-way over a portion of a large, permitted limestone property, the initial opposing perceptions of value for that take, and how the lost limestone may or may not impact the determination of Just Compensation—defined as the diminution of value of the whole property on a before-take and after-take basis.

9:45 AM

Reviewing Mineral Appraisals: Common Errors and Red Flags
Z. Smith; Forensic & Valuation Services, Withum, Jersey City, NJ

This talk will explore common errors found in mineral appraisals, especially in the context of litigation using examples from oil, natural gas, sand & gravel, limestone, and dolomite properties principally in the eastern United States. The talk takes the perspective of a third-party reviewer with emphasis upon items that could be flagged by non-appraisal and/or non-technical reviewers.

10:05 AM

Valuation of Minerals for Charitable Gift
G. Scheig; STOUT, Dallas, TX

The presenter was contracted to develop an appraisal for a large volume of volcanic ash being gifted to an international charitable organization. This presentation covers the development of the concluded FMV for the client. Time permitting, I also will share some of the problems noted in the previous appraiser’s report.
2:00 PM  Introductions

2:05 PM  Environmental Impact of Improving Crushing and Conveying Process in Existing Mines Through Digital Twin Solutions
P. Munoz; Solutions Minerals, Innomotics, Erlangen, Bayern, Germany
Mining plays a key role in society’s progress, with its consequent major impact on biodiversity, communities and water use, among others. The construction of greenfield projects has slowed down due to increasing pressure from society for stricter environmental standards to offset their negative impacts. To address this situation, it is increasingly important to optimise the performance of existing operations. Innomotics’ Digital Twin solution for the crushing and conveying process provides an advanced analytical tool that enables a potential increase, as reported by customers, in the crushing rate of more than 1%, reducing energy consumption in trucks and better utilisation of the conveying system of 4%, transporting more tonnage with the same amount of energy.

2:25 PM  Improving the Environmental Impact of Mining Operations
M. Rever; BEUMER Group, Beckum, Germany
Striving for enhanced efficiency, environmental responsibility, and enhanced reliability, this case study explores the successful implementation of an overland conveying system (OLC) as a sustainable alternative to traditional truck transportation for raw materials at Jiangsu Jinfeng Group. The successful replacement of 4000 truckloads per day with an overland conveying system marked a significant milestone in enhancing sustainability, operational efficiency, and environmental responsibility. By addressing the challenges of connecting three quarries situated about 3 km apart to a central raw material storage facility, this innovative solution not only optimised energy consumption but also significantly reduced the carbon footprint by millions of tons annually. This reduction along with the elimination of inefficiencies inherent in truck transportation, underscores the importance of adopting forward-thinking strategies in industrial operations. A key of the successful implementation was selecting the right components for the OLC system to achieve optimal performance, cost-effectiveness, and sustainability.

2:45 PM  Nanofibrillated Cellulose for Improved Bulk Material Handling
K. Gourlay; R&D, Performance BioFilaments, Garibaldi Highlands, BC, Canada
NanoFibrillated Cellulose (NFC) is an emerging new biomaterial produced from wood pulp. This material is comprised of very thin, long fibrils, which have exceptional strengthening/consolidation capabilities. This effect has been demonstrated at lab scale in a variety of different tailings and soil samples, as well as in several field trials. In this presentation we will provide a brief background on NFC, followed by a detailed description of the consolidating effects of this exciting new biomaterial. Data demonstrating that very low loadings of NFC (<0.05 wt%) can be used to dramatically strengthen a wide range of unconsolidated sediments will be presented. This strengthening effect results in increased viscosity in slurries, reduced tendency to liquefy during transport, improved conveyability/truckability, reduced water bleedout, and other benefits. Results on coal fine tailings, oil sands tailings, and earthwork consolidation will be presented.

3:05 PM  State of the Art 21st Century Two-Mass Screening Technology
D. Kerker; General Kinematics corp., Crystal Lake, IL
I will describe in depth the technology behind two-mass and the benefits it will give you. Increase in flow rates, capacities, efficiency, life of machine, all while reducing horsepower required, unscheduled downtime, and maintenance to name a few. Sub-resonant natural frequency design is what will drive a very large machine with a very small input force.

L. Sheehy; Real Time Instruments, Mackay, QLD, Australia
With the depletion of high-grade mineral reserves worldwide, the mining industry faces a critical need to enhance productivity and optimise resource utilisation. An avenue being utilised is bulk ore sorting which promises to be a pivotal component in future mineral processing. However, effective bulk sorting is dependent upon the compatibility of the chosen sensor with the varying characteristics of the material being progressed. Advanced technologies like Prompt Gamma Neutron Activation Analysis (PGNAA) provide comprehensive insights into the elemental composition of the entire material stream, rendering it an ideal fit for many bulk sorting applications. This presentation demonstrates the effective use of PGNAA for bulk sorting, underscoring the significance of analysis that correctly aligns with material variability. We discuss the practical implementation of an optimisation approach for PGNAA analysis, striking a balance between precision and analysis duration. By aligning with the timely distribution of grades in the material flow, this approach can improve the overall performance of the sorting process.

3:45 PM  Stockpiles From Ore Sorting vs. Traditional Methods
B. Hilsher, H. Kanaan and D. Kim; ABH Engineering Inc., Surrey, BC, Canada
The importance of low-grade stockpiles can be profound. By deferring marginal ores to later years uneconomic deposits can be made economic. Already economic projects can be further optimized. The deferral of marginal material allows the NPV to increase without impacting life of mine or total metal produced. Deferral also allows metal prices to increase, turning marginal material into respectable ore. The inclusion of ore sorting in the stockpiling process has several potential benefits. By scanning all ore before stockpiling there is an opportunity to switch high grade rocks from the low-grade ore with low grade rocks from high grade zones. This creates a higher-grade mill feed today and a lower grade stockpile for the future. This paper will go over production examples as well as a more nuanced approach to stockpiling which can further optimize NPV.

TUESDAY, FEBRUARY 27  AFTERNOON

COAL & ENERGY: ALTERNATIVE LAND AND ENERGY SOLUTIONS
North 226A

2:00 PM  Introductions
Chair: G. Hasenfus, Barr Engineering Co, Sewickley, PA

2:05 PM  Development of a Mine Water Management Model for Flooded Mines
M. Bothe-Fiekert; Underground Mining, Clausthal University of Technology, Clausthal, Lower Saxony, Germany
Over the last two decades, the importance of sustainable water management has increased both nationally and internationally. Water management faces major challenges due to climate change, increasing water demand and regulatory requirements: Mine water in flooded underground mines offers significant potential for water storage, energy generation and even resource recovery. However, not every potential use is suitable for every site. Therefore, a comprehensive global literature review is conducted to define selection criteria for potential uses. Based on these criteria, a mine water management model will be developed to identify suitable uses for mining-influenced water from a flooded mine. The model will take into

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M. Bothe-Fiekert; Underground Mining, Clausthal University of Technology, Clausthal, Lower Saxony, Germany
Over the last two decades, the importance of sustainable water management has increased both nationally and internationally. Water management faces major challenges due to climate change, increasing water demand and regulatory requirements: Mine water in flooded underground mines offers significant potential for water storage, energy generation and even resource recovery. However, not every potential use is suitable for every site. Therefore, a comprehensive global literature review is conducted to define selection criteria for potential uses. Based on these criteria, a mine water management model will be developed to identify suitable uses for mining-influenced water from a flooded mine. The model will take into
account not only the temporal development of water quality and quantity, but also information on the infrastructure (depth, stability). At the same time, planning recommendations can be made to facilitate the subsequent use of mine water after mine closure. This contributes to the concept of Blue Mining, which is a holistic approach to defining responsible mining that aims to exploit the potential of mines during and after production, based on an early planning philosophy.

2:25 PM
Integrating Renewable Energy Use Into an Area Mine Production Scheduling Model
A. McBrayer; Department of Mining Engineering, West Virginia University, Morgantown, WV

While historically employed in regions where power availability or reliability is of concern, in recent years, there has been a dramatic increase in use or planned use of renewable energy sources on active and reclaimed mine lands. At the same time, mining companies have begun to focus on developing sustainable mining practices while increasing or maintaining their efficiencies. Herein, we examine the potential for integrating electricity usage and demand during the production scheduling process to exploit periods in which alternative power generation is at its peak. Furthermore, we discuss the potential to reduce costs with favorable pricing strategies. Utilizing real data from an active coal mine, we show the impacts of integrating seasonal power price fluctuations in a medium-term production schedule and hourly power price fluctuations in a short-term extraction schedule.

2:45 PM
Evaluating Renewable Energy Installation Potential on Previously Mined Lands in Select Western States
S. Arrieta Ruiz and A. Brickey; Mining Engineering and Management, SDSMT, Rapid City, SD

Recently, there has been a push to identify locations for renewable energy facilities. One area that is of particular interest is the construction of renewable energy installations on previously mined lands. Mines often require significant electrical infrastructure to support mining and processing activities leaving the potential for its use to support renewable energy transmission. This project is focused on evaluating previously mined and reclaimed lands in Montana, Wyoming, and North and South Dakota for their potential for various renewable energy applications, e.g., solar, wind. The result will assist in evaluating post-mining land uses for renewable energy generation.

3:05 PM
J. Grantham, Energy, Burns & McDonnell, Phoenix, AZ

With the escalating demand for electrification and other factors contributing to the rising costs of line power, mines are confronted with challenging choices to ensure their continued operations. Emphasizing the potential benefits, there is a compelling argument for incorporating on-site gas generation to mitigate overall power expenses and enhance operational reliability. This presentation will primarily concentrate on the observable increase in the US’s average cost of line power and how the integration of gas generation can lead to substantial cost reductions. Real-world data from power projects and existing utility tariffs will be shared to support these findings.

3:25 PM
Federally Funded Coal Abandoned Mine Land (AML) Program Overview
E. Cavazza; Tetra Tech, Inc., Pittsburgh, PA

The federally funded Abandoned Mine Land (AML) Program was established under Title IV of the Surface Mining Control and Reclamation Act of 1977 (SMCRA) and was originally authorized for 15 years. Funding for the AML Program was originally derived exclusively from fees on the active coal mining industry. There have been several extensions of the program and changes in the fees over the 46 years since SMCRA's passage. The industry derived fees were supplemented with US Treasury funding beginning in 2007. In 2016, the Abandoned Mine Land Economic Revitalization (AMLER) Program was first funded. And in 2021, the Bipartisan Infrastructure Law (BIL) extended the SMCRA Title IV AML Program through 2034 and also provided an additional $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. This presentation will cover some of the history of the AML Program, the shift from industry funding to US Treasury funding, the various current AML Programs and their requirements, and highlight some of the work that Tetra Tech is doing to support abandoned mine reclamation efforts nationwide.

3:45 PM
Nevada Division of Minerals Open Data Site and the C.L.A.I.M.S. Hub: Utilities and Data for Land Research, Public Outreach/Education, and Land Withdrawal Analysis for Nevada and Beyond
L. Patterson; Minerals, Nevada Division of Minerals, Carson City, NV

New web-hosted data solutions, like ArcGIS Online, ESRI hub sites (open data sites), and various application builders, have revolutionized the way public agencies are able to view, analyze, and share data internally and with the public. A wide array of tools and viewing methods provide users with the means to display datasets in very specific, targeted ways to address the needs of, and assist people in, specific industries. The development of our open data site has greatly enhanced our ability to interface with partner organizations and enabled the public to access data that was previously inaccessible due to technology limitations. These web applications do not require any specialized software or prior knowledge. Data is updated frequently, is freely downloadable, and can be imported into the end user’s third-party software, if desired. Real-time tutorials and “how-to” documentation can be woven into each application to assist users in learning “on the fly.” These tools enable everyone, from federal, state, local government agencies, mineral explorationists, landmen, realtors, and the public to employ the utilities offered within the open data site for their own unique purposes.

TUESDAY, FEBRUARY 27 AFTERNOON
COAL & ENERGY: INNOVATIONS IN MINING MACHINES AND AUTOMATION
North 226B

2:00 PM • Tuesday, February 27

Chairs: J. Haughey, Komatsu, Warrendale, PA
V. Androulakis, New Mexico Institute of Mining and Technology, Socorro, NM

2:00 PM
Introductions

2:05 PM
A Data Driven Argument for Surface Mine Automation
A. Sebom Seidu and S. Frimpong; Mining and Nuclear Engineering, Missouri University of Science and Technology, 226 McNutt Hall, 1400 N Bishop Ave., Rolla, Mo 65409, Rolla, MO

Mine safety remains one of the core values of many mining companies. Despite significant progress made to improve worker safety in the mining industry, there is still the prevalence of accidents, many of which have received massive media attention. As a result of this, many mining companies are shifting their focus towards autonomous mining systems to improve mine safety. This paper proposes the adoption of full automation
in the surface mining industry, using results from over a century’s worth of mine safety data. It also reviews historical surface mine accidents to identify their leading causes. The study found a positive correlation between worker numbers and accidents. A decrease of 89% in the number of workers working in the mine led to a 95% reduction in the rate of fatalities. Hence, the implementation of full automation in the mining process can significantly improve safety in the industry due to the elimination of human involvement in unsafe processes.

2:25 PM
RF Backscatter Communications System with Organic Photovoltaic Power Harvesting for Underground Coal Mine Search and Rescue
A. Salustri1, S. Shao2, V. Androulakis1, H. Khaniani3, M. Hassanaliali4 and P. Rohganchi5; 1Mineral Engineering, New Mexico Institute of Mining and Technology, Socorro, NM; 2Electrical Engineering, New Mexico Institute of Mining and Technology, Socorro, NM; 3Petroleum Recovery Research Center, New Mexico Institute of Mining and Technology, Socorro, NM; 4Mechanical Engineering, New Mexico Institute of Mining and Technology, Socorro, NM; and 5Mining Engineering, University of Kentucky, Lexington, KY

Battery-free Radio Frequency (RF) backscatter communication systems present a compelling solution for emergency transponders during coal mining search and rescue (S&R) operations. This study introduces a wearable RF backscatter device, capable of transmitting sensor data or messages to an RF transceiver stationed on an S&R robot. A lightweight, wearable communications system that allows trapped miners to efficiently transmit their status to the rescuers could be lifesaving. Uniquely, the proposed device operates without a battery, leveraging flexible organic polymer photovoltaic cells optimized for the low-illumination environments found in underground mines as its energy source. We present a prototype of this device and experimentally characterize its performance. Additionally, a simulation of antenna performance in an underground mine-like environment is presented to establish the fundamental understanding of the antenna shape design.

2:45 PM
Automation and Electrification: Improving Operator Safety with a Single Operator System
T. Cressman; Komatsu, Franklin, PA

With advances in automation and a history of electrification, Komatsu continues to focus on moving operators further from harm’s way with an all-electric mining system. Running the Joy Flexible Conveyor Train (FCT) in follow me mode while partnered with the 12HM46 has now successfully been trialed at a salt mine. The increased level of automation has allowed the mine to operate the system with a single operator. Through electrification and automation advances, we continue to help mining operations mine in increasingly challenging conditions, lessen the repetitive tasks that lead to fatigue, move operators further from the face, and reduce operator exposure to diesel particulate matter (DPM).

3:05 PM
Benchmarking Performance of the 12HM46 Titan Continuous Miner and Flexible Conveyor Train (FCT) in a Canadian Industrial Minerals Application
M. Jennings and M. Burch; North American Region & Global Mining Solutions, Kabushiki Kaisha Komatsu Seisakusho, Minato-ku, Tokyo, Japan

Underground industrial mineral mining applications present challenges for mechanized mining machines used for cutting highly resistant minerals. Komatsu continues to drive innovation with the 12HM46 Titan, specifically designed for the industrial minerals market with an increased gearcase power of 850kw (+1100hp), increased machine weight, increased drum diameter, and the ability to perform autonomously. Paired with a Flexible Conveyor Train (FCT) continuous haulage system this creates a seamless solution with only one operator. During 2022-2024, in-depth cutting cycle analyses were performed to benchmark the 12HM46 Titan's baseline key performance indicators: sumpdepth, sumprate, shearrate, and cutterhead raise rate during both manual and autonomous operation. Machine data was utilized to determine active parameters and settings for correlation to the observed cycles. The baseline performance was utilized to target a range of parameters and settings that could be changed to increase the machines overall efficiency based on the application's seam geology and mining cycle. Following the parameter changes, further cycle analyses determined the new benchmark of machine performance.

3:25 PM
Hybrid UGV-UAV Robotic System for Search and Rescue Operations in Underground Mine Emergencies
J. Racette1, M. Escarcega1, N. Devlin1, S. Goodyear1, A. Aguilar1, V. Androulakis1, H. Khaniani1, S. Shao1, M. Hassanaliali1 and P. Rohganchi5; 1Mechanical Engineering, New Mexico Institute of Mining and Technology, Socorro, NM; 2Mineral Engineering, New Mexico Institute of Mining and Technology, Socorro, NM; 3Petroleum Recovery Research Center, New Mexico Institute of Mining and Technology, Socorro, NM; 4Electrical Engineering, New Mexico Institute of Mining and Technology, Socorro, NM; and 5Mining Engineering, University of Kentucky, Lexington, KY

In mine catastrophes, mine rescue teams must effectively locate and extract trapped miners, while operating with their safety in mind despite their time-sensitive mission. Thus, mine rescuers must often wait for...
ONSITE PROGRAM

Day 3: Tuesday, February 27, 2024

ENVIRONMENTAL: ENVIRONMENTAL SOLUTIONS TO PROTECT THE ENVIRONMENT

North 126B
2:00 PM • Tuesday, February 27

Introductions

2:05 PM

The Impact of Long-Term Stockpile Storage and its Depth on Soil Quality and Implications for Revegetation Strategies in Mining-Disturbed Areas

Covering mine tailings with non-contaminated soil material is a widely used strategy for land reclamation in disturbed regions. Topsoil stockpiles provide an alternative source of a capping layer to provide favorable conditions for plant growth. Nonetheless, successful revegetation is often challenged by the alteration of soil properties caused by long-term storage of soil as stockpiles. Thus, the aim of this research was to identify specific soil health parameters associated with a stockpile’s depth profile that can be used as valid markers for forecasting revegetation success. We examined ten capping materials derived from two soil cores drilled from a 14-year-old copper mine stockpile to the depth of 20 and 30 meters, respectively. Each core was divided into five distinct depths to establish a greenhouse experiment. Using a non-invasive root phenotyping technique in rhizoboxes, we evaluated the effect of capping material on plant performance. The findings suggest the critical role of soil chemical composition, particularly of nitrate and iron, and that depth-related shifts in microbial communities affect plant survival.

2:25 PM

Landform Design in Mine Reclamation: Is This the Future?
P. Werner, US Department of Agriculture, Washington, DC

The practice of landform design in mine reclamation is gaining momentum as an alternative to traditional reclamation techniques which can result in highly stylized and engineered analogues for natural systems. Rigid geometric shapes, uniform slopes, and the use of non-native materials are common design features which certainly are not representative of the natural world. Conversely, landform reclamation borrows from the surrounding landscape to create a reclaimed surface that is similar to nearby undisturbed areas. The features of a particular landscape reflect how it has evolved over time and will continue to evolve based on the prevailing climatological and environmental processes unique to the area. The reclaimed mining landscape must incorporate features that reflect this evolutionary history if reclamation is to be stable and self-sustaining. Using the surrounding landscape as a guide, landform reclamation embodies the architect Louis Sullivan’s famous axiom, “form follows function.” We have the tools to begin to make predictions about how these sites will evolve, thereby providing opportunity to enhance our stewardship of these reclaimed lands.

2:45 PM

Towards Enhancing Carbon Capture in Mining-Impacted Dryland Vegetation From the Southwest
S. Irwin1, C. Norton1, W. van Leeuwen1, L. Rahner1, A. Babst-Kostecka2, J. Neilson3 and F. Babst3; 1School of Natural Resources and the Environment, The University of Arizona, Tucson, AZ and 2Environmental Science, The University of Arizona, Tucson, AZ

Revegetation is a keystone component in reclaiming mining-impacted lands that has the capacity to support climate mitigation via carbon drawdown. Dryland sites remain critically understudied in this respect and the scientific guidance for climate-conscious management is insufficient. We explore new opportunities based on ground and airborne LiDAR to efficiently assess the structure of dryland vegetation across mine legacy sites, quantify its biomass and carbon content, and identify key species with higher carbon-capturing potential. Importantly, such scalable vegetation data help evaluate the success of past revegetation efforts and constitute the foundation of a predictive capacity to guide future site reclamation.

3:05 PM

Bioinspired Green Glycolipids as Fugitive Dust Mitigation Agents
D. Grinnell1, H. Pershing1, R. Maier1, D. Hogan1 and M. Kim2; 1Environmental Science, University of Arizona, Tucson, AZ and 2Materials Science & Engineering, University of Arizona, Tucson, AZ

Particulate matter is one of the most common air pollutants and a leading contributor to global disease burden. The mining industry accounts for over 12% of global particulate matter health impacts. For operators, fugitive dust emissions are especially problematic as they can disrupt operations, incur regulatory penalties, degrade social license to operate, and increase operational costs. Thus, development of innovative and environmentally-compatible technologies capable of mitigating fugitive dust emissions are extremely important for protecting human and environmental health while also ensuring regulatory compliance and improving operational conditions. Bio-inspired glycolipids are environmentally-friendly, effective dust suppression agents. In this presentation, glycolipids’ efficacy as dust suppressants and their resiliency against environmental factors will be discussed.

3:25 PM

Advancing Mining Sustainability in the US Southwest: Legacy Mine Surveys Enable Discovery of Metal Accumulation and Tolerance in Plants
T. Wlodarczyk1, K. Murawska-Wlodarczyk1, O. Stokes2, Y. Legrand3, C. Grison1, R. Maier1 and A. Babst-Kostecka1; 1Environmental Science, The University of Arizona, Tucson, AZ and 2Laboratoire de Chimie Bio-Inspirée et d’Innovations Ecologiques, CNRS-Université de Montpellier, Grabels, France

In Arizona legacy mine sites, poor nutrient status and metal contamination coupled with arid conditions makes it challenging to establish a post-mining plant cover. Finding plant candidates that can thrive in such conditions will enable more predictable success for the revegetation of these sites. To address this gap, we screened soil and vegetation at a legacy copper-molybdenum mine tailings site using portable X-Ray fluorescence (XRF) spectroscopy to identify drought-resistant, native, metal-tolerant plant species. This analysis revealed associations between plant ecotypes and environmental factors that control both metal accumulation and tolerance offering insight into strategies that plants use to adapt to mining-affected soils.
3:45 PM  
**Impacts of Climate Change on Hyperaccumulators in the Zambian Copperbelt**  
M. Garza, Colorado School of Mines, Golden, CO

Copper and lead-contaminated mining wastes present a variety of negative effects for human and environmental health, particularly in developing countries like Zambia. Hyperaccumulating plants offer a sustainable alternative to traditional remediation strategies, but recent literature suggests that climate change may impact treatment efficacy. Therefore, meteorological and climate trends—such as precipitation and temperature—for field sites in Zambia were used to determine how regional-specific changes affect native hyperaccumulators and the associated metal uptake. Preliminary results suggest that climate change trends, including increased mean temperatures and more variable precipitation patterns, across Zambia may negatively impact plant-metal interactions at mine waste sites.

4:05 PM  
**The Role of Early Successional Plant Species in Facilitating Mine Revegetation**  
S. Lauman, J. Neilson and E. Gornish; University of Arizona, Tucson, AZ

Post mining revegetation efforts in arid regions are faced with challenges associated with poor soil conditions, severely altered microbial communities, sparse vegetation, and scant rainfall. A potential resource for accelerating land reclamation are early successional plant species due to their high dispersal capabilities and rapid growth rates; however, they may impede the establishment of more desirable species. This research evaluates the capacity of fifty desert broom (Baccharis sarothroides) plants, a common early successional species, to either facilitate or hinder growth and regeneration of native plant communities on a copper mine in Southern Arizona. Desert broom was found to facilitate native plant growth through alleviation of abiotic stresses and promotion of soil fertility.

4:25 PM  
**Geopolymerization of Mining Tailings as an Alternative for Its Use in the Construction Industry**  
C. Toledo, M. Guzman, J. Rau, P. Pereyra and A. Ruiz; ‘Mining Engineering, Pontificial Catholic University of Peru, Lima, Peru;’ ‘Physics, Pontificial Catholic University of Peru, Lima, Select One,..., Peru;’ ‘Industrial Engineering, Pontificial Catholic University of Peru, Lima, Peru and Peruvian Institute of Prospectors and Developers, IIPPD, Toronto, ON, Canada

The use of mining tailings-based geopolymer binder as a substitute for cement can be an interesting alternative to the problem of final disposing of large volumes of them. Indeed, mining tailings have a high silica content, which makes them suitable for geopolymerization. The tailings samples contain Cu, Pb, Zn, As, Sb, Cd and B, mainly. X-ray diffraction results show that the tailings are composed of quartz, SiO₂ (81%). Geopolymerized tailing samples (GTPS) were obtained by varying the ratio of Si/Al and Si/Na. The compressive strength of the GTPS varied between 2 MPa and 8 MPa. The electrical conductivity in the leaching tests varies between 13.91-16.11 mS/cm² indicating that ions are present in the solution. However, the pH = 10.5 indicates that acidity is not being generated. The element that mostly leaches is iron (318 ppm). The highest percentage of leaching is observed for cadmium (69%) and chromium (93%). The concentrations of elements are under the maximum permissible limits for water according to the Peruvian legislation. However, mass transfer leach tests and immersion leach tests must be realized.

4:45 PM  
**Status of Waters of the U.S. in the Arid West (Reprise)**  
B. Lindenlaub; WestLand Resources, Inc., Tucson, AZ

The definition of waters of the U.S. (WOTUS) remains an enduring source of confusion and debate for mine projects, particularly in the arid west. The presence of WOTUS can significantly impact permitting timelines and compliance obligations for mining projects. Four administrations in a row have attempted to clarify the definition of WOTUS, with the most recent rule published in January 2023. Despite the attempts at clarity, the result has been persistent uncertainty for the mining community. In light of the ever-shifting political landscape, and the recent U.S. Supreme Court decision in Sackett v. Environmental Protection Agency (EPA), we provide a brief review of WOTUS history and a discussion of the current and potential future status of WOTUS in the arid west.

**TUESDAY, FEBRUARY 27 AFTERNOON**

**ENVIRONMENTAL: GEOPHYSICS FOR MINING APPLICATIONS**

**North 126A**

2:00 PM • Tuesday, February 27

**Introductions**

2:05 PM  
**Arizona Department of Water Resources Land Subsidence Monitoring Program—20 Years of Using Interferometric Synthetic Aperture Radar (InSAR) Data**  
B. Conway, Hydrology Division, Arizona Department of Water Resources, Queen Creek, AZ

Since 2003, ADWR has been collecting and processing monthly SAR data from various satellites, producing Level-2 and 3 InSAR-derived products for the State of Arizona. Since 2003 the program has developed important partnerships with numerous State, County, and Local Agencies, Water Districts and Water Companies who provide annual contributions to help support the data collection costs. ADWR has identified more than twenty-eight active land subsidence features that cover an area of 4,300 square miles, determining the spatial extent, deformation rates, and time-series history of each land subsidence feature. The process of collecting, processing, and interpreting InSAR data has resulted in ADWR producing land subsidence maps for each land subsidence feature covering different time periods. There currently is a total of 750 land subsidence maps that are available for download on ADWR’s website. With the recent launching of higher-resolution SAR satellites, such as the Sentinel-1, and the expected launch of NISAR in early 2024 ADWR has seen and will continue to see an increase with data availability (spatially and temporally).

2:25 PM  
**Mapping the Depths: Geophysical Advancements In Modern Mining**  
S. Calendine; Geoscience, hydroGEOPHYSICS, Tucson, AZ

Non-invasive subsurface geophysical techniques are reshaping how active mine sites operate, enhancing safety, aiding production, and tackling environmental issues. While many conventional subsurface investigations are dependent on invasive drilling—often inferring broader contexts from point source data—geophysical methods present a robust alternative. They enrich drilling programs with improved targeting and span various mine stages: from exploration and preconstruction characterization to heap analysis in leaching operations, injection monitoring, and environmental assessments for seepage and plume mapping. Unique to these geophysical surveys is their ability to deliver high-resolution, spatially continuous insights. When conducted repeatedly in the same area, they reveal subsurface hydrological evolutions over time. This presentation delves into three critical geophysical advancements in mining: heap permeability characterization, injection tracking, and subsurface environmental profiling, and all are supported with real-world examples.
2:45 PM
Reanalysis of Lake Seismic Surveys to Verify Underground Mineral Reserves and Overburden Continuity
C. Thompson; 4C Exploration Ltd, Mammoth Lakes, CA

Two-dimensional seismic reflection surveys are effective tools for delineation of subsurface geologic structures with potential to interfere with underlying mine workings. Seismic surveys are even more valuable for mines and reserves under bodies of water. This paper presents Prestack Depth Migration (PSDM) analysis results of seismic surveys shot over a glaciogenic lake, which placed critical stratigraphic horizons below the lake and above the underlying room-pillar mine at their respective depths to verify the overburden continuity. Using appropriate preprocessing tools, PSDM provided significant corrections to high lateral velocity contrasts between lake sediments and underlying rock layers constituting the lake basin. This study provided considerable improvements over previous Prestack Time Migration (PSTM) analyses of the seismic survey lines, as PSTM was found inadequate in reconciling the high velocity contrasts between sediments and rock strata. Ultimately, several lake bottom features previously identified as potential geologic anomalies by PSTM were concluded to be superficial glacial scours in the carbonate beam below the lake, unlikely to adversely impact mining.

3:05 PM
How NMR and Microresistivity Logging are Bridging the Geophysical Data Gaps in Brine-Rich Environments
A. McIntyre and G. Bauer; Hydrophysics, COLOG, Lakewood, CO

Borehole geophysics has emerged as a valuable tool in the exploration and production of economic resources typically found in highly saline brines such as lithium and potash. Nuclear Magnetic Resonance (NMR) and Microresistivity logging are powerful techniques and are being used in highly saline environments to estimate porosity, lithology, fluid saturation, and permeability in various geological settings. In brine-rich environments, the high electrical conductivity of the fluids poses a significant challenge to traditional logging methods, making NMR and Microresistivity logging essential tools for evaluating the vertical distribution of permeability and lithology in these challenging environments. In summary, NMR and Microresistivity logging are robust geophysical logging methods that prove invaluable in demanding brine-rich environments, particularly in lithium exploration where the pursuit of accurate measurements of effective porosity, permeability, and lithology is akin to the quest for the Holy Grail, often sought after but rarely achieved. These techniques bridge critical data gaps where conventional geophysical and flow-logging methods may fall short.

3:25 PM
Geophysical Investigation into Chino Stockpile Permeability Characterization, Raffin injection Tracking, and Subsurface Environmental Profiling
S. DONKOR ABRADUH; CHINO HYDROMET, FREEPORT-MCMORAN, Silver City, NM

As part of the Freeport-McMoRan’s Leach to The Last Drop Initiatives, Chino Hydromet has embarked on initiatives that include slope leaching and raffinate injection to increase its copper production. These initiatives, however, face major challenges that include seepage and slope stability. Actions taken to solve these problems include geophysical investigations such as seismic, airborne electromagnetic (AEM) characterization, electrical resistivity test, and a seep and well sampling program. The results from these surveys have shown the complex nature of percolation of raffinate through distinct layering of wet and dry materials, and internal dams holding back large volumes of pregnant leach solution leading to seeps. Therefore, the objective of this presentation is to highlight the role of geophysical methods to characterize the Chino leaching activities in an attempt to find solutions to the seepage issues as well as identifying the right locations for raffinate injection, drainage wells, and slope leaching.

3:45 PM
Permeability of Underground Sandstone Structures Studied by High Resolution 3D Imaging of Cuttings and Flow Simulation for CO2 Storage
J. Jin1, N. Moodie1, E. Edelman1 and B. McPherson2; 1Materials Science and Engineering, The University of Utah, Salt Lake City, UT and 2Civil and Environmental Engineering, University of Utah, Salt Lake City, UT

There have been feasibility studies on producing Direct Reduced Iron (DRI) at the iron mountain deposit near Cedar city, UT. The Navajo sandstone structures around this area are considered to store the CO2 generated from DRI production. Due to the depth of over 6,000 ft and the fragile mechanical property of sandstone, it was difficult to collect a centimeter size sandstone core from drilling for conventional permeability measurement. In this study, high resolution X-ray Computed Tomography (XCT) was used to image the 3D structures of pore network inside 2 mm sandstone cutting at a voxel size of 1.85 µm. The permeability of underground sandstone structures was estimated from flow simulation by Lattice Boltzmann Method (LBG). The simulated permeabilities were consistent with predictions from the geological formations and gave insights for future CO2 storage tests.
2:25 PM
Lessons Learned from Commissioning Full-Scale, Non-Biological Selenium Removal Plants
B. Baker, V. Sundar, R. Mutsaers, H. Liang and D. Kratochvill; BQE Water, Denver, CO
Prior to the development and implementation of a non-biological water treatment process utilizing electro-reduction to remove and stabilize selenium, all full-scale selenium treatment plants in mining relied on biological selenium reduction. Since the inception of this relatively new selenium treatment process, four industrial scale non-biological systems using either ion exchange or membrane filtration combined with electro-reduction of selenium have been commissioned between 2020 and 2023 to help meet stringent selenium treatment requirements in mining and other industrial sectors. The paper presents lessons learned from commissioning these full-scale, non-biological selenium removal plants and compares and contrasts the challenges of commissioning non-biological versus biological mine water treatment facilities.

2:45 PM
Prevention of Acid Mine Drainage from Its Source: Inhibition of Pyrite Oxidation Using Humic-Rich Food Waste Compost
W. Liu1, S. Hornback2, L. Jiang3 and X. Yang3; 1Department of Material Science and Engineering, The University of Utah, Salt Lake City, UT; 2Vanderbilt University, Nashville, TN and 3Department of Physics, Virginia Tech, Blacksburg, VA
The possibility of preventing the formation of acid mine drainage (AMD) in pyrite-rich coal wastes using humic acid (HA)-rich food waste compost has been explored in this study. The concentration and composition of the HA generated from the compost were determined by UV-vis and FTIR, respectively. The acid generation capacity of the HA was evaluated with and without the presence of food waste compost containing HA was evaluated by conducting a series of column leaching tests at various aerated rates, intermittent water flowrates, and temperature. The generation of HA in the compost was confirmed by FTIR and the maximum concentration was measured to be around 7.5%. The continuous column leaching results showed that the addition of food waste compost containing HA can reduce the oxidation rate of pyrite due to the chemical deposition of R-COOFe complexes on pyrite surface, which resists the electrochemical reaction of pyrite corrosion. Findings from this work suggest an eco-friendly pathway for AMD control.

3:05 PM
Fenton's Reagent Facilitated Gypsum Precipitation in Reverse Osmosis Brines
J. Wu, T. Horseman and S. Barton; Linkan Engineering, Golden, CO
Reverse osmosis (RO) has become a mainstay of modern mining operations with water balance challenges. While effective, RO is limited by mineral scaling. Effective dewatering necessitates targeted mineral scaling removal, but highly effective antiscalants hinder their precipitation. Fenton’s reagent is a strong oxidant capable of decoupling the strong antiscalant-scalant interaction, allowing for effective post-RO precipitation, and ultimately improved overall treatment efficiency. This report outlines recent bench and pilot studies using Fenton’s reagent for post-RO mine water brine precipitation. Results confirm that Fenton’s reagent is effective at destabilizing the antiscalant-scalant interaction, allowing for further RO recovery enhancement.

3:25 PM
Ion Flotation Treatment of Uranium-Impacted Waters: Characterizing Controlling Factors to Achieve Compliance
S. Perez, R. Root, R. Maier and D. Hogan; Environmental Science, University of Arizona, Tucson, AZ
Uranium is present in many mining-influenced waters throughout the arid southwest, and remediation of these waters may be necessary to meet future water demands. We have previously shown ion flotation as an effective technology for the removal of uranium from groundwater using environmentally-friendly glycolipids (sugar-based surfactants) under narrow solution conditions. In this study, the physicochemical characteristics of uranium-contaminated solutions and process conditions are further investigated to identify operational parameters—such as glycolipid molecular structure and solution constituents/chemistry—that control the efficacy of uranium remediation from mining-influence waters using glycolipid-based ion flotation.

3:45 PM
Improving Overflow Water Quality From Thickeners Using Integrated Clarifiers
C. Ille1, C. Reyes2, C. Arratia2 and P. Valencia1; 1Innovation, Shimin Engineering, Santiago, Chile; 2Department of Mining Engineering, University of Chile, Santiago, Chile and 3Nordic Institute for Theoretical Physics, Stockholm, Sweden
In light of the concurrent advance of climate change and mineral resource exhaustion, an increasingly challenging aspect of modern mineral processing, including brownfield projects and flotation plants, is the need to keep water recovery and its chemical and physical characteristics within specified limits. The potential to include additional water assets for water recovery, such as thickeners and clarifiers, which are required to increase water recovery and decrease water turbidity, is significantly constrained by available space. Process intensification is an excellent approach to make the most of the functional unit processes by enhancing or increasing the number of functions they cope with. In this paper, we present the opportunities and challenges associated with including inclined plate clarifier technology within already operational thickeners to minimize overflow turbidity, thus making it possible to increase water recirculation without installing new clarifier units downstream thickeners. This enhanced clarification process benefits fine overflow water quality of very fine or clay-laden ores.

4:05 PM
Findings and Value Addition From a Three-year Field Study for Acid Rock Drainage (ARD) Characterization at the Bagdad Mine in Arizona
M. Raghav1, J. Szaro1, T. Graham2 and B. Callen2; 1Freeport-McMoRan Inc, Sahuarita, AZ; 2Freeport Minerals Corporation, Phoenix, AZ and 3Freeport-McMoran Bagdad Inc, Bagdad, AZ
Mine operational materials and water management, as well as closure planning and management are critical strategies for the reduction of long-term environmental liabilities at mine sites. Characterization of acid rock drainage (ARD) and metal leaching (ML) potential through predictive tests is essential for these strategies to be effective. We will present the main findings from a three-year field test pad study at the Bagdad Mine in Arizona, including reclassification of ARD potential, seepage water quality evolution under field conditions, effect of geochemical reactions on rock geotechnical strength, etc. We will also share lessons from construction, operation, and deconstruction of the test pads.

4:25 PM
Green Bio-Inspired Glycolipids for the Recovery of Rare Earth Elements From Mining-Influenced Waters
K. Graves, R. Maier and D. Hogan; Environmental Science, University of Arizona, Tucson, AZ
As demand for rare earth elements (REEs) continues to grow, mining wastes are being reevaluated as potential resources to bolster the supply of critical materials and reduce the environmental footprint of mining operations. Bio-inspired glycolipid surfactants are environmentally-friendly materials that exhibit selectivity for REEs and have great potential for use in remediation technologies for aqueous systems. Thus, the use of glycolipids in both ion flotation and direct precipitation technologies was investigated to demonstrate the efficacy of these approaches for the valorization of REEs and other valuable metals from real-world, mining-influenced waters.
TUESDAY, FEBRUARY 27  AFTERNOON

HEALTH & SAFETY: HEALTH & SAFETY IN INDUSTRIAL MINERALS (JOINT SESSION WITH INDUSTRIAL MINERALS & AGGREGATES DIVISION)

North 128A

2:00 PM  •  Tuesday, February 27

Chairs: P. Roghanchi, New Mexico Institute of Mining and Technology, Socorro, NM

S. Amini, West Virginia University, Morgantown, WV

2:00 PM

Introductions

2:05 PM

Lab Scale Investigation of the Effectiveness of Different Fire Extinguishing Agents on Lithium-ion Batteries Fires

A. Iqbal and G. Xu; Mining and Nuclear Engineering, Missouri University of Science and Technology, Rolla, MO

Despite their advantageous features such as high energy density and reliability, the widespread adoption of LIBs has been impeded due to concerns regarding fire safety. The unique fire threat posed by LIBs remains unclassified, rendering the availability of appropriate extinguishing agents inadequate. Therefore, this study aims to investigate and enhance the effectiveness of existing fire extinguishers against LIB fires. The research encompasses testing four different extinguishers on five distinct LIB chemistries using dedicated laboratory equipment. The study’s outcomes will illustrate the performance of prominent extinguishers when combating fires originating from various LIB chemistries. Subsequently, based on these findings, modifications will be proposed to the extinguishers by employing different additives. This research contributes to the advancement of LIB fire safety and environmental well-being, presenting a significant stride in the field. Keywords: LIB fire Safety, Electric Vehicles, Environmental Safety, Fire Extinguishers.

2:25 PM

Size-by-Size Particle Deposition Through Vibration-Enhanced Flooded Bed Dust Scrubbers

M. Uluer, A. Noble, S. Amini and M. Shigo; Mining and Mineral Engineering, Virginia Polytechnic Institute and State University, Blacksburg, VA

Over the last 20 years, the flooded bed dust scrubber (FBS) has been an integral component of dust control strategies for underground continuous mining operations. These units have been shown to be effective and robust in mining environments; however, several technical challenges and knowledge gaps limit their performance and efficiency. In our prior studies, a laboratory-scale vibration-enhanced FBS was tested and confirmed that induced mesh vibration enhances collection performance and reduces mesh clogging. In this study, the system was further analyzed to investigate the size-by-size recovery of dust particles to various endpoints in the scrubber, under both vibrating and static conditions. Results show that while a majority of the particles are recovered into the demister sump, nearly a quarter of the dust mass is recovered upstream of the screen. This suggests that vibration prompts notable improvements to collection efficiency, particularly for the finest size class (~2.5 micron). Results from the testing and implications for FBS mesh design will be discussed.

2:45 PM

Canopy Air Curtain to Reduce Diesel Particulate Matter Exposure for Underground Blasters

S. Mischler, T. Lee and S. Vanderslice; PMRD, NIOSH, Pittsburgh, PA

Diesel exhaust is considered a carcinogen to humans by the International Agency for Research on Cancer (IARC). Miners are one of the highest exposed occupations, and those who work outside of cabs, such as underground blasters, can be the highest exposed working groups. One potential control technology to reduce these exposures is a canopy air curtain (CAC) which has been demonstrated to successfully reduce respirable coal mine dust exposure for roof bolters and shuttle car operators. This manuscript presents the results of a study evaluating the use of a CAC to reduce diesel particulate matter (DPM) exposure of underground blasters.

3:05 PM

Enhancing Safety Using Energy-Efficient Machine Learning Algorithms Through Prediction of Rock Type and Cutter Wear


This study presents a comprehensive investigation into identifying wear conditions of conical pick cutters and rock types using cutting force signal data. Derived from full-scale cutting tests conducted on a linear cutting machine (LCM) at the Earth Mechanics Laboratory (EML), we employ various machine learning (ML) techniques for classification, such as Support Vector Machines (SVM), k-Nearest Neighbors (KNN), and Deep Neural Networks (DNN). Upon classification, we explore the optimization trade-offs concerning time, energy, and accuracy across various platforms, including single and many core CPUs, GPUs, and deep learning accelerators (DLA) on Raspberry Pi 4 and NVIDIA Orin Nano. Our experimental results highlight the effectiveness of our design, showcasing a remarkable 36x speed improvement in time-critical scenarios and 12x improvement in energy efficiency where energy is limited. The findings provide practical implications to assist operators in assessing material and wear conditions from a safer distance by timely identifying wear conditions for proactive maintenance and improving cutter longevity.

3:25 PM

Risk Assessment, Monitoring and Prevention of Hazardous Exposure to Solid Inhalable Airborne Carcinogenic Substances in Underground Mines

T. Kiessling; ERCOSPLAN, Erfurt, Germany

Solid inhalable airborne carcinogenic substances such as cadmium, chromium–VI, arsenic, nickel oxide, lead and many others can cause cancer to humans being permanently exposed. More than 25 solid inhalable airborne carcinogenic elements and compounds have been identified in the air of underground mines, especially but not limited to the application of fly ash from incineration when applied as backfill. Recently the European regulation has tightened the thresholds for carcinogenic substances, challenging the mines to apply extensive monitoring and prevention measures. This paper presents the state of the art for risk assessment, monitoring and prevention of hazardous exposure to solid inhalable airborne carcinogenic substances in underground mines in the EU.

3:45 PM

Changes in Principle Horizontal Stress Direction Contributing to Massive Roof Collapse at the Subtropolis Mine

N. Evanek1, G. Rashed1 and T. Miller2; 1Pittsburgh Mining Research Division, National Institute for Occupational Safety and Health, Pittsburgh, PA and 2East Fairfield Stone Co., Petersburgh, OH

In 2015, the Subtropolis mine experienced a massive roof collapse that continues to expand over time. Both pillar and roof driven massive ground collapses endanger the safety of underground stone miners. The goal of this study is to better understand the factors that lead to this massive roof collapse and how findings from this study can be used to further reduce the likelihood of massive ground collapses from occurring. This collapse, as well as other roof falls at this operation, can be attributed
to the existence of horizontal stress, weak overburden and minimal cap rock available in the roof. Generally, the direction of the maximum principal horizontal stress remains the same across a mine. However, at Subtropolis mine, the variation in the roof fall pattern suggests that the principal horizontal stress direction can be variable. The growth over time of this collapse and other roof falls at this mine have been captured and analyzed using geologic mapping, 3D LiDAR scanning and numerical modeling. Utilizing these tools to better understand site specific conditions can be critical to reducing the potential of massive ground collapses in the underground stone industry.

4:05 PM

Prediction of Slope Failure in Open Pit Mines via an Artificial Intelligence Approach

M. Madahana; School Of Mining, University of the Witwatersrand, Johannesgut, Gauteng, South Africa

The mining industry is currently considering ways of conducting mine operations such that maximum ore can be extracted in an economically safer way while prioritizing health and safety of the mine workers. The main objectives of this research work are to conduct a comparative study on the effectiveness of five machine learning algorithms in predicting slope failure. The machine learning techniques are used in prediction of the safety factor. Artificial Neural Networks, Support Vector Regression (SVR), Simple Linear Regression (SLR), Multiple Linear Regression (MLR) and Random Forest (RF) are applied in predicting slope stability. To test, train and validate the models, real data sets of earth slope stabilities from open pit mines in South Africa are used as a case study. Future work includes in cooperating the effective machine learning algorithm in Unmanned Aerial Vehicles for monitoring of stability of rock slopes in open pit mines and quarry operations.

4:25 PM

Hierarchical Training Pipeline for Event-Based Robotic Perception Models for Autonomous Roof Bolting

R. Banerjee, A. Marsset and A. Petruska; Mechanical Engineering, Colorado School of Mines, Golden, CO

Event cameras are used for their performance in high-dynamic-range lighting conditions which are canonical to active mining environments. Direct labeling of event-based-image data to train a model to perform semantic segmentation using traditional methods is slow and error-prone. This study proposes a framework to use roughly hand-labeled RGB images from a mine as input to an intermediary probabilistic algorithm to generate a ground-truth dataset. These high-fidelity labels can be used to train a semantic segmentation model to segment the support strap from the roof. This model can then be leveraged to segment an event-based scene to enable autonomous roof bolting. This approach has resulted in higher fidelity output with a validation accuracy of 90%, as well as low latency performance in the field.

4:45 PM

Integrating Boston Dynamics Robots into Surface Mining Operations: Advancing Efficiency and Safety in Resource Extraction

T. Adebajoj, A. Ananii, S. Adewuyi1, M. BOATEMAA2 and E. Amakye3; 1Mining and Geological Engineering, University of Arizona, Tucson, AZ, 2Geotechnical Engineering, Newmont Gold Operation, Cripple Creek, CO and 3Mining Engineering, Newmont Gold Operation, Cripple Creek, CO

This work presents the use of Boston Dynamics robots in mining operations as part of the industry’s move toward automation and digitalization. These robots, equipped with advanced sensors and AI, can perform tasks like bench inspections, geospatial data collection, equipment monitoring, and ensuring mining progress aligns with plans. Their mobility and navigation capabilities make them suitable for hazardous areas, void zones, leading to more accurate resource assessments and mine planning. They can conduct risk assessments, monitor unstable slopes, and inspect equipment remotely, reducing exposure to dangerous environments. This work also highlights the use of robust communication systems for the robot’s coordination and examines the economic implications, including potential cost savings through resource optimization and increased equipment lifespan.

TUESDAY, FEBRUARY 27 AFTERNOON

HEALTH & SAFETY: LEADERSHIP PRACTICES AND BEHAVIORAL SCIENCE

North 127C

2:00 PM • Tuesday, February 27

Chairs: M. Mains, Freeport-McMoRan Inc

T. Bauerle, National Institute for Occupational Safety and Health, Spokane, WA

2:00 PM

Introductions

2:05 PM

Using Human and Organizational Performance (HOP) to Enhance Workplace Safety & Culture

L. Guasta; National Safety Council, Parker, CO

Human and Organizational Performance (HOP) is an operating philosophy combining human factors engineering with organizational psychology. The goal of HOP is to create more efficient, more resilient, and safer workplaces where employees and leaders are both engaged and valued by each other and the organization. This reflects a positive workplace culture where all individuals feel a sense of psychological safety, which enables them to work safely and productively. This session will provide an overview of the six key HOP principles to enhance workplace safety and culture:

-Everyone makes mistakes -Employees are masters at adaptive problem solving -Organizational context drives employees’ actions, behaviors, and decisions -Leadership response to failure matters -Blame fixes nothing -Improvement happens through learning

2:25 PM

Safety Pays in Mining v2.0—Demonstrating the Financial Impact of Injuries in Mining

J. Heberger1 and B. Ngo2; CDC NIOSH, Pittsburgh, PA and 1University of Washington, Seattle, WA

The NIOSH Mining Program has updated that data used for the Safety Pays in Mining v2.0 web application, which helps mines determine the potential costs associated with mining injuries and the distribution of these costs. This web application groups injuries by severity (medical only or lost-time injury cases) and then by injury cause, part of body injured, potential costs associated with mining injuries and the distribution of medical and indemnity costs of workers’ compensation claims for that type of injury. Based on other user inputs, the web app will estimate the total costs of the selected injuries, including an estimate of additional indirect costs, and the impact of total injury costs on mining company profits. This conference proceeding reviews the Safety Pays in Mining v2.0 web application by discussing the updates, how it is used to show the true costs of mining injuries, and how mines can benefit from using this application.
**ONSITE PROGRAM**

**2:45 PM**

**ONsite Program**

Pre-to-post training changes in lagging indicators will be reviewed.

**ONSITE PROGRAM**

lack of communication up and down the chain of command (12.7%).

staffing shortages (18.7%), motivating team members (13.3%), and poor more effective leaders. The most frequently cited needs were related to agreed that they learned skills and concepts that would help them be it was an excellent course. Eighty-eight percent agreed or strongly confidence as a leader, while 87% agreed or strongly agreed that Trainees filled out a reaction survey and needs assessment at the end of interactive training were delivered in person over several months.

The Mining Safety Center of Excellence is creating a new leadership Competent leadership is a key driver of sustainable safety culture.

**3:05 PM**

**Industry Perspectives on Mineworker Fatigue: Findings from a Needs Assessment**

Z. Dugdale and T. Bauerle; Spokane Mining Research Division, National Institute for Occupational Safety and Health, Washington, DC Mineworkers are especially susceptible to fatigue due to several fatiguing work-related hazards, including dim lighting, heat/cold, noise, vibration, toxic fumes, long commute times, remote work locations, monotonous/disengaging tasks, and manual labor. Using a needs assessment framework, virtual interviews were conducted with health and safety leaders in the U.S. mining industry to gauge the burden of fatigue across varying sites, to learn about the current activities companies are engaged in to monitor and manage worker fatigue, and to obtain feedback on what additional resources are needed to address this critical health and safety issue. A qualitative content analysis of the interviews was conducted independently by two researchers. The following are the preliminary themes identified: the associations between fatigue and changing workforce demographics, challenges with staffing and turnover, long shift schedules and commute times, workers' hesitancy/opposition toward fatigue detection technologies, other co-occurring environmental hazards such as heat/cold, and the overarching need for more readily available fatigue-related training materials for workers and supervisors.

**3:25 PM**

**Safety and Productivity Share the Same Sire: Competent Leadership**

R. Reed, E. Lutz and L. Brown; Mining Safety Center of Excellence, University of Arizona, Tucson, AZ Competent leadership is a key driver of sustainable safety culture. The Mining Safety Center of Excellence is creating a new leadership development program for frontline supervisors, superintendents, and managers. As a pilot test for this program, we conducted a leadership workshop with 152 supervisors, 26 managers, and 7 executives at two underground coal companies (a total of 185 trainees). Two days of interactive training were delivered in person over several months. Trainees filled out a reaction survey and needs assessment at the end of each training session. Feedback was overwhelmingly positive. Eighty percent of trainees agreed or strongly agreed that the course improved their confidence as a leader, while 87% agreed or strongly agreed that it was an excellent course. Eighty-eight percent agreed or strongly agreed that they learned skills and concepts that would help them be more effective leaders. The most frequently cited needs were related to staffing shortages (17%), changing work locations (13.3%), and poor lack of communication up and down the chain of command (12.7%). Pre-to-post training changes in lagging indicators will be reviewed.

**3:45 PM**

**Enhancing Mine Safety Through Stress Management**

S. Annavarapu, Master Geotech Services Pvt Ltd, Nagpur, Maharashtra, India

The impact of safe operations on productivity is well documented and tools and procedures are constantly being developed for the assessment of hazards and the prevention of accidents. While the reduction of exposure to hazards and the design of protection systems help in improving safety in the mines, the root causes of human error which result in mine accidents/incidents are often not addressed. Physical and mental stress are recognised as the main contributors to human error. Stress management and the improvement of situational awareness can help reduce these issues and improve safety in the mines. This paper explores the application of soft tools for stress management and the potential impact on enhancing safety in mine operations.

**TUESDAY, FEBRUARY 27 AFTERNOON**

**INCLUSION & DIVERSITY AFTERNOON**

**Multigenerational Workforce—Challenges & Opportunities—A Panel Discussion**

V. Gosteva1, A. Williamson2 and J. Baron1; 1 Asset Management, Newmont Corporation, Greenwood Village, CO and 2 WSP, Albuquerque, NM The current workforce spans five generations, from the Silent Generation to Generation Z. Baby Boomers, Gen X, and Millennials dominate, with Gen Z a growing force. This diversity brings both challenges and opportunities for employers and employees alike. In this panel discussion we will explore challenges that arise in multigenerational work environments, such as communication gaps, cultural clashes, and generational stereotypes. We will also ask Panelists will be asked to share some best practices and strategies for creating cultures of inclusion, collaboration, and mutual learning among different generations that can help unlock the benefits of a multigenerational workforce, such as increased innovation, productivity, and engagement. Panel: Nathan Bennett, Mine Manager, Nevada Gold Mines Michael Chanen, Environmental Affairs Director, Newmont Sena Cicek, Mine Planning Engineer, Nevada Gold Mines Tina Darakjian, Geological Engineer, WSP Steve Holmes, COO First Majestic Silver Harriet Naakai Tetteh, MSc Mining Engineering student at the NM Institute of Mining and Technology Pablo Altamirano Soto, President of SME Student Chapter UPC, Peru

**TUESDAY, FEBRUARY 27 AFTERNOON**

**INDUSTRIAL MINERALS & AGGREGATES: CRITICAL AND BATTERY MINERALS I**

**2:00 PM • Tuesday, February 27**

Chairs: V. Gosteva, Newmont Corporation, Denver, CO J. Baron, Newmont, Weston, FL A. Williamson, WSP, Albuquerque, NM

Introductions

**2:05 PM**

**Multigenerational Workforce—Challenges & Opportunities—A Panel Discussion**

V. Gosteva, A. Williamson and J. Baron; 1 Asset Management, Newmont Corporation, Greenwood Village, CO and 2 WSP, Albuquerque, NM

The current workforce spans five generations, from the Silent Generation to Generation Z. Baby Boomers, Gen X, and Millennials dominate, with Gen Z a growing force. This diversity brings both challenges and opportunities for employers and employees alike. In this panel discussion we will explore challenges that arise in multigenerational work environments, such as communication gaps, cultural clashes, and generational stereotypes. We will also ask Panelists will be asked to share some best practices and strategies for creating cultures of inclusion, collaboration, and mutual learning among different generations that can help unlock the benefits of a multigenerational workforce, such as increased innovation, productivity, and engagement. Panel: Nathan Bennett, Mine Manager, Nevada Gold Mines Michael Chanen, Environmental Affairs Director, Newmont Sena Cicek, Mine Planning Engineer, Nevada Gold Mines Tina Darakjian, Geological Engineer, WSP Steve Holmes, COO First Majestic Silver Harriet Naakai Tetteh, MSc Mining Engineering student at the NM Institute of Mining and Technology Pablo Altamirano Soto, President of SME Student Chapter UPC, Peru

**TUESDAY, FEBRUARY 27 AFTERNOON**

**INDUSTRIAL MINERALS & AGGREGATES: CRITICAL AND BATTERY MINERALS I**

**2:00 PM • Tuesday, February 27**

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

Introductions
The unusual five-element deposits of the Black Hawk district in Grant County, New Mexico is one of the few examples of nickel-cobalt-arsenic-silver-bismuth mineralization in the United States. A detailed investigation of the arsenide and sulfide mineralization will be performed by using a handheld LIBS device.

The drive to combat climate change and reduce carbon emissions has increased the demand for cobalt—a key component in lithium-ion batteries that power electric vehicles. However, environmental, social, and governance (ESG) concerns, coupled with the monopoly of cobalt supply chains by key actors like China and the DRC, have hindered its production, prompting questions about its sustainability. This study aimed to comprehensively review the ESG aspects of the cobalt supply chain by identifying gaps in cobalt-related sustainability frameworks, while evaluating the impact of artisanal and small-scale mining sectors. Thus, the study sought to identify enduring remedies in line with the sustainable development goals. Additionally, it delved into the cobalt industry's role in the energy transition process, considering market constraints, processing techniques, and production capacities to gauge if the projected demand for cobalt in greener technologies can be fulfilled.

Mineral and Geochemistry of Heavy Mineral Beach-Placer Sandstones in New Mexico

Heavy mineral beach-placer sandstones are accumulations of high-sensitivity gravity, resistant minerals that form from mechanical concentration by waves, currents, and winds in marginal-marine environments. These sediments are enriched in critical minerals such as titanium, zirconium, and REE. Cretaceous beach-placer sandstones are found in the Colorado Plateau of northwestern New Mexico. Originally discovered by airborne radiometric surveys for uranium in the 1950s, these beach-placer sandstones have been sampled, mapped with ground radiometric surveys, and analyzed with whole-rock and trace element geochemical methods. Mineralogy is being determined with optical methods, XRD, and EMPA. Zircon, rutile, ilmenite, and monazite are the primary heavy minerals of interest found in the studied deposits. Initial results show that the sandstones contain up to 1.4% rare earth elements (REE), and an estimated 3% ZrO₂. Chondrite-normalized REE diagrams show distinct light REE and minor heavy REE enrichment, as well as pronounced negative Eu anomalies for each deposit.

A Pilot Scale Investigation of Lepidolite Flotation

Lepidolite, a critical lithium bearing mineral, is a promising contender for the lithium supply chain. This article presents the development of a lepidolite flotation flowsheet through laboratory and pilot scale investigations. A pilot plant campaign processing 300 tons at 650 kg/h was performed with the objective to produce a concentrate grading over 4.2% Li₂O with maximum lithium recovery from a 0.87% Li₂O lepidolite feed. The flowsheet included grinding and classification, gravity separation (tantalum and tin), and lepidolite flotation. Laboratory and pilot investigations evaluated the impact of grinding requirements, flotation reagents, twin conditions (pH and % solids), and froth properties. The pilot plant results confirmed commercial-quality concentrate grading 4.2% Li₂O with lithium recovery 75% can be produced, with over 40% and 65% of the Ta and Sn recovered by gravity separation, yielding valuable byproducts at over 10% Ta₂O₅ and 65% SnO₂. The findings of this work serve to improve the industry understanding of lepidolite flotation and reiterate the need for continuous development of environmentally conscious processes in lithium resource extraction.
ONSITE PROGRAM

TUESDAY, FEBRUARY 27  AFTERNOON

MINING & EXPLORATION: GEOSCIENCES:
CASE STUDIES ON ORE CONTROL BEST PRACTICES

North 223

2:00 PM • Tuesday, February 27

**Introctions**

**2:05 PM**

Geology Focused Grade Control Modeling and the Effects on the Production Processes of Underground Ore Control

A. Prevalllet; Geology, Nevada Gold Mines, Elko, NV

Routing accuracy in relation to Carlin type gold deposits has been prone to a high degree of variability—particularly when entering, exiting, and driving along the fringes of the ore body. This is accredited primarily to the complex geologic history of the deposits on the trend. The minor faults and offsetting, intrusives and lithologic changes seen in Carlin type gold deposits are considerably difficult to define on a scale smaller than measured drill spacing and have a large impact in grade variability and resultant routing accuracy. GC modeling has allowed for a higher definition understand of these complex geological controls through the correlation of underground mapping, drilling and production sampling. This defines geologic variability that is not always captured by core and RC infill drilling and manipulates resulting geologic and gold models.

**2:25 PM**

ShovelSense Bulk Ore Sorting Use Cases and Value at Freeport-McMoRan Chino Mine, New Mexico, USA

F. Gomez; 1, J. Van Nes; 1, C. Allen; 1, E. Gonzalez; 1 and F. Faraj; 1; 1Freeport-McMoRan, Silver City, NM and 1MineSense, Tucson, AZ

Chino is a highly heterogeneous Cu porphyry skarn mine where ore control is especially challenging due to the natural variability of the deposit, sparse blasthole sampling, and blast movement, causing inevitable ore loss and dilution. Chino retrofitted their main production P&H4100 electric rope shovel with ShovelSense, which is a robust X-ray fluorescence-based sensor which can predict grades at the mine face. This information is used to improve the efficiency of metal extraction and to reduce costs. The general objective is to evaluate the polymetallic veins (Au and Ag), for which the classification of resources (measured, indicated and inferred) has been carried out, taking into account the parameters of minimum distance from the composite, corresponding volume and tonnage calculation. In addition, an inventory of estimated geological resources was carried out with the block grades obtained to generate the tonnage-grade curves.

**2:45 PM**

Ore Control Technological Innovations at Peña Colorado Mine

M. Marin-Pasillas; 1, H. Hernandez-Guerrero; 1, S. Robles-Salazar; 1 and P. Pomplla-Rosales; 1; Peña Colorado Mine, Minatitlan, Colima, Mexico and 1Hexagon mining, Tucson, AZ

In mining, operations engineers and geologists process extensive data to extract valuable insights from the field. Their role involves converting this data into actionable knowledge, guiding crucial decisions for mining execution and production monitoring. Efficient communication tools are vital for relaying these decisions to stakeholders. This paper explores how adopting new ore control (OC) technology addresses these challenges, enhancing selectivity, performance, and data management, and minimizing planning-to-execution variance. The OC technology drives comprehensive operational enhancement.

**3:05 PM**

Improving Ore Control Best Practices at a RoM Heap Leach Gold Mine, Bald Mtn. NV

E. Herth; Tech Services, Kinross, Spring Creek, NV

Kinross owns and operates Bald Mountain Mine in White Pine County, NV. Bald Mountain is a surface Run-of-Mine heap leach operation. Since the oxide ore is hauled directly from the pits to the leach pads, continuous improvement of ore control best practices plays a primary role in the ultimate recoverability of gold. The absence of a mill at Bald Mountain means Ore Control is the key driver for managing metallurgical issues within the deposit. This presentation details the optimized best practices at Bald Mountain Mine.

**3:25 PM**

Geostatistical Evaluation of Polymetallic Veins

M. Portal Valdivia and L. Goicochea Sánchez; Mining engineering, Society for Mining, Metallurgy & Exploration, Cajamarca, Cajamarca, Peru

This study is carried out in the Zenit mining concession, which is located in the city of San Pablo in the department of Cajamarca in Peru. The Project has 33 mineralized structures and according to laboratory analyzes we have the presence of gold and silver. The geostatistical evaluation provides an analysis on the distribution of precious metals in the vein. This information is used to improve the efficiency of metal extraction and to reduce costs. The general objective is to evaluate the polymetallic veins (Au and Ag), for which the classification of resources (measured, indicated and inferred) has been carried out, taking into account the parameters of minimum distance from the composite, corresponding volume and tonnage calculation. In addition, an inventory of estimated geological resources was carried out with the block grades obtained to generate the tonnage-grade curves.

**3:45 PM**

The Reconciliation Rockshow

A. Davis; Technical Services, Maptek, Golden, CO

This is a sequel to last year’s “Ore Control Onion” talk at MineExchange. One layer of that onion that sparks much debate and discussion is reconciliation. Running reconciliation is not as straightforward and pleasing as a violin solo at a Kansas concert. Reconciliation is complex and if done right with all stakeholders involved can be orchestrated and delivered like a composition from Rush. This talk will highlight a case study where reconciliation was creatively completed to allow reports to be ran against resource and mine planning forecasts compared to what was encountered at production. Making data available to all stakeholders is key to the successful execution of any reconciliation program whether it is for geology, resource, mine planning, operations, or mill and processing. The information gained from the culmination of data can make impacts in the way we model, mine, and mill.
2:05 PM
Blasthole Mineralogy at Rio Tinto Kennecott
C. White, Geology, Kennecott Utah Copper LLC, South Jordan, UT
A notable lack of mineralogy data from the pit presents an opportunity to establish a more robust and sustainable method of acquiring mineralogy data on our incoming ore. Such data could aid in a proactive response at the concentrator for incoming ore as well as refine our mineralogical understanding of the ore body. The development of a new Blasthole sampling method addresses this issue by establishing a new sample stream of mineralogy data for targeted zones on a blast pattern. Samples are collected to represent each individual MET type encountered on a blast pattern and sent to Kennecott's Mineralogy Department for analysis. Scanning Electron Microscopes (SEMs) equipped with Mineral Liberation Analysis software (MLA) are used to determine modal mineralogy of the sample. The data are recorded and archived as a summary of bulk mineralogy by blasthole. Over time, the data open the possibility to map mineralogy in 3d space and could aid in validating current geologic models of the pit.

2:25 PM
Material Characterization for Mining, Metallurgy, and Environmental Planning
P. van Geffen; ERM, Vancouver, Canada, BC, Canada
Human-induced global warming is driving a shift towards low-carbon energy, increasing metal demand, while the mineral sector faces ever greater scrutiny for responsible resource extraction. This drives a need for a mining overhaul, improving practices across the value chain through innovation. In the past, geologists, mining engineers, and metallurgists would work in close collaboration, but specialization has led to disconnection between exploration and mining. A bridging discipline known as geometallurgy is now vital to reintegrate the functions of specialist teams. For example, the mineralogical composition of mined materials strongly affects metallurgical performance, including comminution, recovery, and concentrate quality, but also environmental issues such as metal leaching and acid-rock drainage. While detailed mineralogical data is commonly limited, multi-element geochemical data from thousands of drill-hole intervals can be used to approximate mineralogical composition. These data are vital for predicting and simulating downstream processes including mining, milling, waste management, and closure planning—providing critical insight for major investment decisions.

2:45 PM
Utilizing Big Data Statistical Techniques in Python to Optimize Geometallurgy Workflow for Metallurgical Test Work Sample Selection
M. Siddiqui, K. Erwin, R. Chandramohan, C. Meinke and S. Khan; Process Optimization and Debottlenecking Team, Ausenco, Vancouver, BC, Canada
High-quality sample selection for metallurgical test work is essential to a geometallurgy study, but the large multi-dimensional dataset makes sample selection a daunting task, as classifying the dataset while respecting its heterogeneity is difficult. This paper presents a streamlined approach for sample selection, utilizing custom-built tools in Python to standardize the methodology, saving time and costs. This approach uses the cumulative sum method, principal component analysis, and k-means clustering method to elegantly cluster the data and select representative samples. A case study is used to demonstrate the effectiveness of the methodology by selecting 40 samples for flotation test work.

3:05 PM
Methodology for Recovery Modeling of a Complex Sulfide Sequential Flotation Operation
J. Villanueva; Newmont, Denver, CO
Peñasquito is a mine operated by Newmont Corporation, located in the Zacatecas Desert. It is a polymetallic mine which produces lead and zinc concentrates with high gold and silver content through a sequential sulfide flotation plant. Dore from a pyrite flotation & leach process which follows lead and zinc flotation, is also produced. Changes to the operation were introduced in 2022 with the implementation of an organic carbon depressant in the Pb flotation circuit as a more efficient mitigation method than carbon pre-flotation. The secondary Chile Colorado Pit (sedimentary rock) has also become a main ore source since late 2022 which brought changes in mill feed mineralogy as well. Given the changes mentioned, recovery models were reviewed for operating/production data from 2021 until 2023 & updated to provide the best possible estimation of future plant performance and production. All models were built using regression analysis and evaluated based on the residual analysis for each model. These updated models provide the best estimation with the information on the ore and process available but as with any modelling process, error is inherent and cannot be expected to be precise.

TUESDAY, FEBRUARY 27 AFTERNOON
MINING & EXPLORATION: INNOVATION & TECHNOLOGY SOLUTIONS FOR MINING

North 222A
2:00 PM • Tuesday, February 27
Chair: A. Chapman, Peck Tech | A Caterpillar Company, Montreal, QC, Canada
2:00 PM
Introductions

2:05 PM
Can Artificial Intelligence be an Engineering Tool for Mining?
J. Ladegard; Stantec, Phoenix, AZ
Artificial Intelligence (AI) and generative design power everything from spam filters to autonomous vehicles. At Stantec we are advancing use of AI tools in engineering design to evaluate mining infrastructure. Challenged to redesign an existing headframe to increase hoisting capacity, Stantec utilized traditional modeling and engineering methods and tested AI tools to provide an alternate solution. This discussion presents a review of the process and AI tools used to design the headframe, the resulting AI design, a comparison to the traditional design, and key take-aways from the process including successes and opportunities for improvement.

2:25 PM
Outlining a Roadmap for the Deployment of a Digital Twin System for the San Xavier Mine Laboratory
V. Tenorio, A. Anani, G. Heath, N. Risso, D. Riley, N. Akbulut and J. Werner; Mining and Geological Engineering, University of Arizona, Tucson, AZ
Implementing a Digital Twin at the San Xavier Mine Laboratory (Sahuarita, AZ), requires a network redesign with a robust architecture. The goal is to create an ecosystem in which all personnel and equipment can be monitored in real-time from the University of Arizona campus, visualizing the site in a digital terrain model. Expected outcomes include data retrieval and analytics, the evolution of communications and safety protocols, tele-operation, and an innovated approach for managing the site with new supervision challenges. A timeline with expected commissioning benchmarks is also included.

2:45 PM
Mine Design and Planning, Electrification and Non-traditional Mining and Materials Handling at the Santa Cruz Project, Arizona
C. Shaw and S. Bull; Ivanhoe Electric, Casa Grande, AZ
Focused on Ivanhoe Electric Inc.’s mission to produce electric metals in an environmentally sustainable manner, The Santa Cruz Project in Casa
Grande, AZ is investigating several innovative solutions to develop green technology-focused mining in order to provide critical electric metal supplies to industry while minimizing the carbon footprint as much as possible. Utilizing modern electric mine technology, including electric equipment, state-of-the-art material handling systems, and renewable energy production, Ivanhoe Electric aims to maintain profitability while envisaging one of the lowest greenhouse gas emissions projections for any mine operation.

3:05 PM

**Improved Operations, Reduced Consumption, Safer Results: Next-Generation Shotcrete Technologies**

J. Van de Sande and J. Lavallee; Product Mangement, MacLean Engineering, Collingwood, ON, Canada

Advancements in technology for the shotcrete industry have allowed for numerous enhancements to the process, quality of the final product, and impact on the environment. Finding ways to optimize shotcrete operations to spray a safer final product, while improving how materials are utilized and reducing overall consumption, is possible with today’s technology. Due to advancements in LiDAR technologies to determine the sprayed depth of shotcrete, coupled with technology that allows for optimization of your batched material while reducing your accelerator chemical content provides new ways of approaching shotcrete that were not possible in the past. A reduction in accelerator chemical, using an efficient dispersal method along with near real time digital LiDAR scanning for sprayed thickness can provide improved strength generation characteristics and material application thickness estimations, while also providing savings & efficiencies throughout the process. In utilizing passive solutions that administer benefits that add value throughout the process while reducing operational expenditures and potentially decreasing re-entry times, is a true leap forward for the shotcrete industry.

3:25 PM

**Automated Rockfall Detection Using Thermal Imaging: Recent Developments in Tracking, Prediction, and Alarming**

B. Meyer1, L. Brown1, J. Keefer2, J. McNabb1, J. Potter2, R. Prescott2, B. Ross2 and C. Williams2; 1Mel & Enid Zuckerman College of Public Health, The University of Arizona, Tucson, AZ and 2Geotechnical Center of Excellence, University of Arizona, Tucson, AZ

Rockfall poses a significant safety hazard in mining operations. The ability to swiftly identify and alarm for rockfall and slope failures is a key factor in maintaining a safe and productive worksite. In collaboration with NIOSH and industry partners, we have demonstrated that thermal video may be used to observe and track rockfall events through a variety of precipitation, particulate, and lighting conditions. In this talk, we provide an update on our development of computer vision algorithms to automatically detect and track rockfall events in real time, with the goal of creating a low-cost monitoring and alarming system. We discuss recent developments in motion detection, tracking, and prediction, outlining heuristics to exclude non-rockfall events and methods to match detection parameters to site-specific conditions. We also consider the effects of video quality variations such as frame rate, noise, compression, and relative resolution on the system's ability to detect and alert for rockfalls. Empirical results will be presented using thermal video collected from a variety of mine sites and atmospheric conditions.

3:45 PM

**Battery Electric Haulage Analysis: Planning for Decarbonization in Surface Mining**

E. Rothweiler; Micromine, Golden, CO

As more mines take steps to reducing diesel emissions, companies are slowly moving towards battery electric haulage systems. This presentation explores the innovation of new software modeling methods which allow open pit hard rock mines to investigate the usage of battery electric equipment as means to achieve decarbonization goals. We reveal how new mine planning technology complements the integrations of battery electric trucks into surface mining fleets using cycle time analysis. This talk aims to demonstrate the powers of creating a digital twin of a low-carbon emission mine.

4:05 PM

**Using AR Assistance in Mine Rescue**

D. Demirkan1, A. Sega2, A. Mallik2, S. Duzgun1 and A. Petruska2; 1Mining Engineering, Colorado School of Mines, Golden, CO and 2Mechanical Engineering, Colorado School of Mines, Golden, CO

Search and rescue operations in mining heavily rely on humans. In the context of emergency situations within underground tunnels, the potential to employ sensory technology for navigation assistance holds the promise of saving human lives. Our research introduces a novel "device configuration" designed to enhance the performance of search and rescue teams. This setup incorporates the integration of LiDAR and thermal cameras into the Microsoft Hololens, facilitated by the NUC computer and ROS Bridge. Performance assessment involves quantifying the extent to which a user is willing to venture into a light-deprived section of the mine prior to necessitating supplementary illumination. The preliminary outcomes highlight the significant potential of augmented reality (AR) assistance in offering indispensable aid to first responders, thereby greatly augmenting the efficiency of search and rescue missions conducted during critical circumstances.

4:25 PM

**Data Mining for Geometallurgical Insights into Ore Processing Behavior**

L. Hutson1, I. Barton1, L. Hill1 and W. Stavast3; 1Mining Engineering, The University of Arizona, The University of Arizona, Tucson, AZ, US, academic, Vail, AZ; 2Mine Geology, Freeport-McMoRan, Morenci, AZ and 3Freeport-McMoRan, Tucson, AZ

The geological and geometallurgical characteristics of an ore body have a direct impact on the eventual processing outcomes for any mining operation, yet tracking and quantifying that impact is difficult due to the inherent complexity of the operation. Using a combination of discrete event simulation (DES) and data mining techniques, we investigate the high-level connection between the in-situ ore and downstream processing outcomes for a large copper porphyry deposit. Expected outcomes include an enhanced strategic understanding of the risk and uncertainty to the operation related to the geometallurgical characteristics of the ore body, as well as the associated financial sensitivities. Additional improvements to the model-mine-mill reconciliation process are also anticipated. Discussion includes an overview of project progress and preliminary findings, as well as consideration of potential follow-up work to ground truth any insights generated from the data mining model.

TUESDAY, FEBRUARY 27 AFTERNOON

**MINING & EXPLORATION: MANAGEMENT: STUDIES TO STARTUP: EXCELLENCE IN ESTIMATION THROUGH EXECUTION**

**North 222B**

2:00 PM • Tuesday, February 27

Chair: Z. Forest-Dupont, Stantec

2:00 PM

**Introductions**
2:05 PM
The Importance of Identifying the Right Mining Strategy to a Successful Mining Study
D. Meisburger and J. Smith; SRK Consulting, Denver, CO
Mining studies require a step-by-step process, progressing through various stage gates from exploration through to operation. As an industry, we are often tempted to expedite this process to generate quicker returns on investment. Nevertheless, the selection of an appropriate mining strategy is pivotal for the success of feasibility and pre-feasibility studies. Strategic mine planning requires more than generation of pit shells; it includes identification of a mining approach that optimizes blending for milling, optimizes phasing and dumping to minimize costs, and provides insights for detailed mine planning, permitting, and closure. The level of detail should be sufficient to validate the chosen strategy while allowing for the evaluation of many scenarios. This presentation aims to share insights gained from recent pre-feasibility and feasibility level studies where suboptimal mining strategies were pursued due to an oversight in earlier stages. We will also present our strategy for avoiding such situations in studies and discuss how strategic mine planning and tradeoff studies can be used to maximize an asset’s value while minimizing study costs and time.

2:25 PM
Selection and Application of Cut-off Grades in Underground Mine Planning—Practical Application
J. Barber1 and P. Schmidt2; 1UC Barber LLC, Prescott, AZ and 2Mineral, Metals, and Metals, Stantec, Chandler, AZ
This paper discusses the determination of Cut-Off Grade (COG), including all revenue and cost factors, and how to apply the COG in the world of engineering studies and mine planning for underground mines. Provides the practitioner with important considerations and practical methods to establish COG and methods of using the COG in the work of mine planning, including the application of MSO software.

2:45 PM
Building a Mine With Just a PEA
P. Daniels; SME, Aurora, CO
A PEA is a Preliminary Economic Assessment, one of the first steps in determining the economic viability of a mineral resource. Assuming positive results, the next steps in the evaluation process are the Pre-feasibility and Feasibility. But sometimes companies make the high risk decision to move forward with a project without any further analysis. This presentation will cover the best practices for technical reporting and cover some special scenarios where building a mine with only a PEA is not as bad as it seems.

3:05 PM
Missouri Cobalt Madison Mine Project—Helping to Fill the US Critical Minerals Vacuum
G. Sutton; Mining, Missouri Cobalt, Fredericktown, MO
The Madison Mine Project is a brownfield site in southeastern Missouri. Planning and Development of a new Underground Mine, Flotation Mill, and Hydrometallurgical facility began in 2021 after 3 years of cleanup of over 100 years of historic mining activities. This presentation will cover the history of the mining area, cleanup activities completed and current progress towards a fully integrated critical metals facility in southeast Missouri.

3:25 PM
Integrated Project Delivery Systems
M. Swanson, S. Immenschuh, C. Campbell, C. Smith and D. Acter; Operations, Cementation Americas, Sandy, UT
In recent years, advances in technology have created countless improvements across the mining industry. One area in particular is in the generation and collection of data, which can be utilized to track performance and influence decision making both in real time and in the longer term. These technologies and the data associated with them have allowed for Cementation to streamline and integrate our project delivery systems throughout the full life of mining projects, from estimation to completion and all phases in between. By integrating project estimation and planning, engineering, procurement, safety, performance tracking, maintenance, and cost and schedule performance analysis through Earned Value Management, projects are being delivered with continuously improving efficiency and quality. This presentation will discuss these tools and the technology behind them in further detail.

3:45 PM
Differentiating Feasibility Studies and Execution Estimates for an Effective RFP
R. Burton; Mining Engineering, Stantec, West Valley, UT
In project management, feasibility studies & execution estimates are crucial to a successful project. A study assesses the viability of a project idea, analyzing its technical & economic aspects. An execution estimate predicts the costs, resources, & time required to complete the project. Specific components are essential when crafting a request for proposals. The parts required can vary widely depending on the project stage. In the early stages, technical specifications & engineering details can be vague or missing altogether. In contrast, relevant project details are often available in later stages. Receiving proposals that will meet project requirements will depend on the project status and how consistent the level of detail is throughout the project documents. Identifying the areas that do not provide sufficient information will require more up-front work in preparing the request for proposal. If relevant project documents are available, less effort can be required. The crucial factor in receiving a quality proposal is effectively communicating key project objectives and understanding how to limit receiving proposals with different execution plans & varying project pricing.

TUESDAY, FEBRUARY 27 AFTERNOON
MINING & EXPLORATION: OPERATIONS: RECENT ADVANCEMENTS IN MINE OPTIMIZATION
North 222C
2:00 PM • Tuesday, February 27
Chair: T. Kosciolek, Coeur Mining
2:00 PM
Introductions
2:05 PM
Practical Applications of the Hill of Value Approach in Strategic Planning for Openpit Mining
R. Benito1, J. Lopez2 and H. Gamarras1; 1SME, Tucson, AZ and 2CIP, Lima, Peru
This article provides three practical applications of the Hill of Value (HoV) methodology within different stages of strategic planning for open-pit mining operations and projects. During the mine design phase, (i) a case study is defined by sensitizing the phase sizes, mining capacity, and cut-off grade (COG) policy with the aim of determining the optimal size while also reducing the analysis time associated with this stage. This stage is typically the bottleneck of the planning process. In the planning phase, (ii) the methodology is applied to determine the optimal sequence of multiple pits, aiming to identify the starting point of extraction that maximizes the project’s value. Lastly, (iii) the methodology is used to define optimal production rates, including mining capacity and processing capacity.
2:25 PM
Developing a Recourse Action to Survive Low Commodity Prices in Open Pit Mine Planning
L. Madziva, M. Pillalamarri and S. Chatterjee; "Geological and Mining Engineering and Sciences, Michigan Technological University, Houghton, MI and "Namibia University of Science and Technology, Windhoek, Namibia"

Valuation in mining investments is done under the assumption that a mine would operate at a constant commodity price throughout its life. However, commodity prices are constantly changing and yet pivotal to the mineral investment decision. This work aims to develop a model that integrates flexibility into mine planning to minimize the impacts of low commodity prices. The work was undertaken by integrating the commodity price forecasting methods with the stochastic minimum cut mine planning technique and devising a recourse action model was developed using the Cobb-Douglas production function in conjunction with the Lagrange model that solves the new production rate which minimizes losses during an extreme price decline.

2:45 PM
Improvement of the Hauling System Through an Idle Times Approach in Open Pit Mines
C. Estrella; Universidad Nacional de Ingenieria, Lima, Peru

Hauling material is the most complex system in a mine and is critical have the best performance, currently improvement have been done with the Fleet Management Systems, but the mines could get more if they define value generator targets of the system. At this mine, the coefficient of variation for the production is 15%, further analysis shows that 5-7% of this variation is attributed to operational problems but the 8-10% restant is caused by the assignability of the trucks in the system and if the variation reduces to 4-5% the production would increase in 2.9-3.0 Mt yearly. There are very variables that influence in the capacity and performance of a hauling system, but the variables with direct control through the use of a Fleet Management System are the idle times for the loaders and trucks. It was analyzed the data of nine months for the multiple relation between: production, idle times, operative times and productivity, then model the behavior of the system and find the ranges of the variables that maximizes the production. With this ranges of variables the reduction in the coefficient of variation of the production and the increase in the output was 4% and 2.9 Mt respectively.

3:05 PM
Breakeven, Cutoff, Production Capacity and Maximizing NPV
S. Chen; Mining, Chandler, AZ

Mineral deposits take years of exploration, interpretation, and quantification. After thousands of meters of drilling, logging, interpretation, modeling, data is given to engineers. What mining method(s) should be adopted, how to decide metal recoveries and processing methods, what are the mining and processing costs, what mining cutoff grade and what mining and milling capacity would yield the highest NPV? All these questions need to be answered in the studies before operations to make sure the high capital investment project to be economical and pay back to the investors. More on that, are the current running operations performing at the best on mining capacity, should an expansion be planned? current cutoff be lowered? It is quite a bit of analyzing and optimizing work but when being compared to the profit or benefit can be created, it is neglectable. This paper will analyze the breakeven grade calculation method, and the relationships among cutoffs, production capacities and the project NPVs.

3:25 PM
Design and Scheduling of an Open Pit Gold Mine with Improved NPV and Reduced Footprint Using Non-Planar Slopes and Direct Block Scheduling
G. Dulmage, L. Fava and S. Utilli; "OptimalSlope Ltd, London, UK and 2RPMGlobal, Sudbury, ON, Canada"

A novel strategic open pit optimization methodology is presented, employing non-planar pitwall profiles and direct block scheduling. The methodology maximizes net present value (NPV) and minimizes stripping ratio while maintaining the required factor of safety (FoS). A case study is presented, applying this methodology to an open pit gold mine. Taking into account the given stratigraphy, rock properties (unit weight and strength), FoS, and excavation depth, optimal slope shapes were determined for the pitwall of each mine sector. The profiles obtained were 4 to 8 degrees steeper than their planar counterparts exhibiting the same FoS. The adoption of overall steeper profiles reduced the amount of rockwaste and, consequently, the stripping ratio. The NPV of the strategic life-of-mine schedule was then optimized, generating a direct block schedule that adhered to the optimal slope shapes throughout the life of mine. Three scenarios were optimized to assess the benefits of the presented methodology: planar pitwalls with Lerchs-Grossman (LG) pushbacks, optimal pitwall profiles with LG pushbacks, and optimal pitwall profiles with direct block scheduling.

3:45 PM
Global Optimisation for Complex Underground Life of Mine Planning
B. Hollis and J. Richards; Deswik, Brisbane, QLD, Australia

Using mathematical programming to produce optimal life of mine plans for complex underground mining operations is still in its infancy and is highly sought after. This technique can produce provable optimal plans (almost always significantly better than those produced using simplistic resource levelling’ or more complex meta-heuristic techniques) and model a wide range of complex constraints that such plans need to conform to (e.g. blend, ventilation, production, backfill etc). Making it scale to solve for some of the worlds largest underground mining operations is the challenge. In this paper we describes how Deswik has successfully applied mathematical programming to truly enormous underground mining operations, and includes a range of case studies detailing the improvement this has brought, in some cases over 30% in NPV.

4:05 PM
A Q-Learning-Based Self-Adaptive Dispatching Algorithm for Intelligent Fleet Management Systems in Surface Mines
A. Hazrathosseini and A. Moradifar; Mining, Laval University, Quebec City, QC, Canada

Material handling in open-pit mines constitute a major expense in the operations. The industry often relies on conventional fleet management systems (CFMS) developed based on traditional OR-based algorithms to make optimal truck dispatching decisions. These systems, however, are unable to adequately capture the dynamicity and autonomy needed, especially in the era of Mining 4.0, thereby necessitating intelligent dynamic algorithms. This study presents a Q-learning-based intelligent fleet management system (IFMS) that enables agents (trucks) to make self-adapting optimal decisions by learning from their experiences in the mine’s environment. The proposed IFMS is founded on the integration of two main modules: The simulation module and the training module. While the simulation module emulates a real-world mining operation enhanced with a variety of dispatching and allocation features, the training module is responsible for training the agents. The combination results in a set of appropriate dispatching actions for a given state of the operation. Benchmarking the algorithm against some baselines demonstrated significant improvements in operational efficiency.

4:25 PM
Closing the Gap Between Long-Term Planning and Execution
A. Desjardins; RPMGlobal, Toronto, ON, Canada

All mining operations must create a long-term plan that returns value to stakeholders. The extended timeline of these plans means that the granularity of the plan is large. Expecting the work to be executed without these details causes miscommunication and incorrect prioritization of
tasks. Given the dynamic nature of mining the more often this plan can be refreshed, the better the guidance to operations. The plan for tomorrow must incorporate as much recent activity as possible and still be ready before tomorrow arrives. The plan must also be communicated in a way that is easily consumed by those executing the work. That means, for a short-term plan to be useful, it must include: Sufficient detail and accuracy, which includes progress to date. Integration to reduce workload, reduce human errors, and decrease time to produce. Visual communication to ensure full understanding. In this presentation, we will discuss the benefits of using software to accomplish the requirements outlined for short-term plans. We will also cover how the gap between long-term and short-term planning can be closed to provide execution teams with the best chance for successful implementation.

TUESDAY, FEBRUARY 27  AFTERNOON
MPD: CHEMICAL PROCESSING: CRITICAL METALS III: COAL FLY ASH, RED MUD, AMD

North 225B
2:00 PM • Tuesday, February 27

Introductions
2:05 PM

Development of an Adsorption Technique for Critical Mineral Recovery From Acid Mine Drainage (AMD)
P. Gallego and Q. Huang; WVU, Morgantown, WV

Treating acid mine drainage (AMD) to comply with federal regulations has posed a significant social, environmental, and economic burden for the coal mining industry. However, this challenge also presents an opportunity to develop innovative research for recovering critical minerals (CM) from AMD as a viable treatment. The primary objective of this research project is to establish a cost-effective adsorption technique for the recovery of multiple CMs from AMD. The investigation begins by analyzing AMD samples collected from various mining sites, characterizing their surface chemistry, the concentrations of CMs, and contaminants. In pursuit of such an adsorption technique, laboratory-scale experiments have been conducted to assess various adsorbent materials and identify the impact of several key operating parameters, such as the solution pH, adsorbent type, and reaction time. Nevertheless, the chemistry of AMD, characterized by high concentrations of heavy metals, requires the development of integrated process flowsheets that incorporate heavy metal removal before or after adsorption to enhance the purity of the CM product stream.

2:25 PM

Pilot Scale Demonstration of Rare Earth and Critical Element Recovery From Low-Grade Bituminous Coal Sources
A. Nawab1, R. Honaker1, J. Werner1, W. Zhang2, A. Noble2, M. Free3 and X. Yang3; 1Mining Engineering, University of Kentucky, Lexington, KY; 2Virginia Tech, Blacksburg, VA and 3University of Utah, Salt Lake City, UT

Rare earths (RE) and other critical metals (CM) are crucial for the development of cutting-edge medical, defense and renewable energy technologies. Rising geopolitical conditions have prompted extensive research on RE and CM recovery from secondary sources such as coal by-products. In this study, a pilot-scale investigation on RE and CM extraction from low-grade coal wastes was conducted with an objective to maximize both recovery and product purity while reducing the overall process cost. Various distinctly different circuit arrangements involving thermal treatment, leaching, solvent extraction, and selective precipitation were employed to achieve the required objective. The results demonstrated that high purity (>80%) RE-Oxide and metal sulfide products could be generated from the proposed process. A techno-economic study was performed based on a commercial system having a feed rate of 500 tph. The findings from the pilot-scale demonstration on RE recovery from coal wastes will be discussed in the presentation.

2:45 PM

Recovery of Rare Earth Elements From Coal Fly Ash Using Super Critical Fluid
u. veerla and L. Fan; MINING ENGINEERING, University of Alaska Fairbanks, Fairbanks, AK

In this research paper, we investigate the recovery of REEs from coal fly ash using environmentally benign supercritical fluids (SCFs) carbon dioxide (CO2). Additionally, the effect of tributyl phosphate (TBP) and nitric acid (HNO3) as complexing agents is explored to enhance the extraction efficiency. Supercritical fluids (SCFs) can penetrate and transport solutes from different matrices due to its high diffusivity, low viscosity, and liquid-like solvating. CO2 provides a good option as an efficient solvent since it has the benefit of easy-to-obtain a medium critical constant (Tc = 31.1°C and P = 7.38 MPa), as compared to other solvents. The experimental work involved the optimization of process parameters, including temperature, pressure, and solvent-to-solid ratio, to ensure maximum REE recovery while minimizing environmental impact. The experimental results were compared with conventional extraction methods to evaluate the effectiveness of SCFs in REE recovery from coal fly ash. Moreover, the influence of TBP and HNO3 on complex formation and separation efficiency was studied to devise a cost-effective and eco-friendly extraction process.

3:05 PM

Rare Earth Element Extraction from Subbituminous Powder River Basin Coal Fly Ash
H. Steiger; C. Young and T. Bayless; Metallurgical and Materials Engineering, Montana Technological University, Butte, MT

Coal fly ash has potential as an alternative source of rare earth elements (REEs) due to its abundant availability, fine particle size, and reasonable REE concentrations. A review of existing literature indicates that, in many fly ashes, the REEs are encapsulated in glassy aluminosilicate cenospheres which necessitates the use of costly, reagent-intensive roasting as well as harsh acids. However, ash produced from subbituminous Powder River Basin coal appears to be more leachable. This ease of extraction allows for the consideration of weaker organic acids with heightened selectivity and reduced environmental impacts compared to traditional mineral acids. Results obtained in the absence and presence of leaching aids are presented and additionally compared to the literature.

3:25 PM

Process Development for Critical Metal Recovery from Acid Mine Drainage Sludge
G. Gecimli, Q. Huang and V. Kejocevic; Mining Engineering, West Virginia University, Morgantown, WV

This research aims to develop a novel separation method to selectively recover critical metals (CMs) from an acid mine drainage (AMD) treatment sludge. As a result of hydrometallurgical studies developed, two separate concentrated solids containing 26 wt% Aluminum and 39 wt% Magnesium were produced from the sludge. In addition, a pre-concentrate with approximately 37.64 wt% Manganese, 0.27 wt% Cobalt, 1.12 wt% Nickel, 3.73 wt% Zinc, and 2.05 wt% REE was produced, requiring to be further processed to enhance the purity and generate individual CMs. An integrated process flowsheet will be developed at the end of the study to produce CMs from coal waste.
3:45 PM
Re-Mining Red Mud Tailing Waste for Rare Earth Elements Recovery
X. Zhang; Pacific Northwest National Laboratory, Richland, WA

Red mud, a tailing waste of the Bayer process used in aluminum production, emerges as a slurry from the caustic digestion of bauxite. For more than a century, the Bayer process has been responsible for producing over 95% of the global alumina, resulting in 1 to 1.5 tons of red mud per ton of alumina. Notably, red mud contains valuable elements like aluminum, iron, and various rare earth elements (REEs) (~0.1% in total, with a value of ~$1100 per ton of red mud). Despite the relatively low concentrations of precious REEs such as scandium (Sc, $4-5K/kg as Sc₂O₃) in red mud—typically in the order of 120 ppm or 0.012%—research focused on developing secure and efficient processes for selectively enriching REEs remains pivotal. In addition, the red mud's substantial alkalinity (with a pH >11) poses a significant environmental threat. Therefore, it is necessary to develop technologies for re-mining red mud to recover multiple resources and clean up this waste to reduce environmental pollution. Herein, we will provide a detailed mineralogical analysis of red mud and highlight the substantial strides achieved in advancing methods for recovering REEs, especially Sc from red mud.

4:05 PM
Carbon Mineralization and Metal Extraction from Coal Fly Ash: A Sustainable Resource Recovery
S. Cardosh1, B. Dantas2, D. Talan1 and F. Lima1; 1Mining Engineering, West Virginia University, Morgantown, WV and 2Chemical and Biomedical Engineering, West Virginia University, Morgantown, WV

Coal fly ash holds immense untapped opportunities for various elements vital for modern technologies. This study aims to develop recovery processes for multiple elements and use process system analyses to optimize the operating conditions. Experimental testing involves metal release, carbon mineralization targeting to produce calcium carbonate, and metal recovery to produce critical minerals through processes for multiple elements and use process system analyses to optimize the operating conditions. coal data generated so far indicates minimal critical mineral loss with approximately 20% calcium removal with water leaching, which is subjected to carbon mineralization. The remaining solution is treated with stepwise precipitation investigating the effect of different precipitation ligands for multi-element recovery. Characterization studies are performed to observe the mineralogical and morphological changes before and after treatment. Overall, the study offers waste minimization, advancing resource sustainability, and environmental conservation, especially carbon mineralization emerges as a transformative approach with considerable potential to reshape fly ash utilization and element recovery strategies.

TUESDAY, FEBRUARY 27 - AFTERNOON

MPD: CHEMICAL PROCESSING: INNOVATIVE METHODS IN METAL PROCESSING

North 228B

2:00 PM • Tuesday, February 27

Chairs: M. Strauss, Worcester Polytechnic Institute, Sparks, NV
Y. Shekarian, The Pennsylvania State University, State College, PA

2:00 PM
Introductions

2:05 PM
Modified Biopolymers as Acid Mist Suppressants in Electrowinning
M. Ribeiro, P. So and P. Wong; Mining, W-Tech Technologies Ltd, Delta, BC, Canada

During the last SME conference, we presented the laboratory test results of modified biopolymers as alternative surfactants to reduce acid mist emissions in copper electrowinning. In 2023, VanMist NCB was commercially tested in short and long trials and the results will be presented with dose comparison, mist suppressant ability and cost savings. In addition to that, tests were conducted in Zinc Electrowinning and VanMist NCB performance was compared to the current products being used.

2:25 PM
Advanced Selective Electrowinning From Mixed Metal Streams: The Good/ The Bad/ and The Ugly
P. James; Blue Planet Strategies, Madison, WI

Advances in selective electrowinning provide new options in metals recovery from mixed-metals streams with compositions unsuitable for practical recovery via conventional commercial electrowinning technologies. DeMet™ technology leverages a high surface area dynamic electrode in conjunction with separated cathode and anode electrolysis chambers to exert greater levels of and new process control options to achieve superior target metals recovery performance and separations. This control is opening new doors in recovery of secondary and trace constituents present in mixed-metal solutions. Examples of recent results will be presented and discussed. Examples demonstrating good recovery and selectivity for desirable high-value trace constituent removal/recovery will be noted (the good). Separation and associated challenges for prevalent and similar constituents will be also examined (the bad). Removal/recovery of bad actors and potential hazards which are becoming more prevalent as lower grade and dirtier ore sources are being utilized will be noted (the ugly). Discussion of current efficiency and product purity as for application to selective electrowinning will be considered.

2:45 PM
Pilot Scale Testing of a Biooxidation Process to Produce Sulfuric Acid from Pyrite
R. Honaker1, J. Werner1, M. Free1, A. Noble1, D. Dailey1, S. Hornback1 and M. Munsterman1; 1Mining Engineering, University of Kentucky, Lexington, KY, 2Department of Materials Science and Engineering, University of Utah, Salt Lake City, UT and 3Mining & Minerals Engineering, Virginia Tech, Blacksburg, VA

The renewable energy transition has elevated the demand for metals that are extracted from their mineral form or end-of-life products using a leaching process. Sulfuric acid is the most used leivant due to its low cost. However, this advantage could change with the growth of critical metal production. The use of acidophilic microorganisms to decompose pyrite has the potential to produce low-cost sulfuric acid. Supported by laboratory studies, a pilot-scale system was designed, constructed, and tested for the continuous production of sulfuric acid from concentrated coal pyrite using two 11.4 m³ bioreactors. The findings from the pilot-scale tests and a techno-economic analysis will be the subject of this presentation.

3:05 PM
24-089
Unlocking Microbial Potential to Develop Innovative and Environmentally Responsible Technologies
D. Stigers, K. Radloff, M. Albright, D. Saran and K. Sorenson; Allonnia, Boston, MA

Biology opens a new frontier for the mining industry. With rising environmental concerns, the need to couple conventional chemical and physical technologies with sustainable approaches is pressing. At Allonnia, we harness microbial processes to create innovative and environmentally responsible technologies with broad applications. The native microbial community (microbiome) remains largely unexplored at most mining sites, unlike the geochemical aspect. The exploration of complex biological reactions that could transform mining technology is just starting and holds vast possibilities, spanning biocementation, carbon sequestration, ore beneficiation, water mitigation, bioreaching, metals recovery, and more. Allonnia has collected samples from mine sites in Australia, Africa, and North America to characterize the microbiome and
uncover the genetic potential present in mineral-rich environments. We are evaluating microbial metabolites that selectively solubilize gange from various ores. In addition, biological reactions hold promise as tailings stabilizers. Our early efforts illustrate exciting prospects for harnessing biology’s potential in mining.

3:25 PM
Innovative Methods in LIB Recycling: Waste, Carbon Footprint and OPEX/CAPEX Minimization
M. Strauss, Aqua Metals, Reno, NV

Many challenges exist for the scale up of battery recycling technologies. Some technologies produce large quantities of sulfate waste due to the use of alkali hydroxides, others have a high carbon footprint and fail to demonstrate complete circularity due to pyrometallurgy, and many have high OPEX due to high reagent consumption. Fortunately, various unit operations have been created or modified such that they do not create sulfate waste, use low temperature processing strategies that recovery graphite, and regenerate chemicals in order minimize reagent consumption. This talk will compare and contrast various LIB recycling strategies used at the benchtop and and scale around the world in order to improve extraction, separation and purification of battery metals.

3:45 PM
Energy-Relevant Elements Recovery from Carbon Reactive Minerals Using a Novel Technology—CMME
W. Zhang, B. Ji and Z. Zhou; Virginia Tech, Blacksburg, KY

CO₂-reactive minerals are not only perfect carbon sinks, but also promising sources of energy-relevant elements. Combining energy-relevant elements recovery with carbon mineralization will promote both energy-relevant elements production and negative carbon emissions. A novel technology called carbon mineralization/metal extraction (CMME) is being developed at Virginia Tech with support from ARPA-E. In this technology, an organic phase loaded with selective extractants is introduced during the direct carbon mineralization process and in the mineral dissolution step of indirect carbon mineralization process. The results obtained so far suggest that CMME has the potential to significantly enhance the production of energy-relevant elements.

TUESDAY, FEBRUARY 27 AFTERNOON
MPD: FLOTATION: FLOTATION EQUIPMENT
North 227C

2:00 PM • Tuesday, February 27

Chairs: R. Dube, Metso Outotec USA Inc, Centennial, CO
D. Lelinski, FLSmidth, Midvale, UT

2:00 PM
Introductions

2:05 PM
24-067
Optimizing the Froth Zone in Large Flotation Cells Through Innovative Spider Crowder Upgrade
G. Bermúdez¹, A. Jalili² and C. Cardoso¹; ¹Metso Canada, Burlington, ON, Canada and ²Metso Chile, Santiago, Chile

Bigger flotation cells can result in larger froth surface areas and longer froth transport distances, this has been credited to impact froth recovery. Thanks to recent advancements, the newer flotation machines can be designed with different launder and crowder arrangements to enhance froth management. Nevertheless, lower head grades, complex ores and even larger mechanical flotation cells can lead to insufficient froth collection, even if the cell is equipped with the most recent flotation advancements like the center launder design. Aforementioned issue can become critical at the end of the floatation row. Increased crowding has been proven to be a solution to overcome inadequate froth recovery. However, scaling-up crowders for larger flotation cells can rise challenges, particularly in terms of structural limits and design for service. This paper presents the development journey for the Spider Crowder Upgrade, an advancement to improve froth collection in large flotation cells that are already equipped with center launders.

2:25 PM
Improving Coarse Particles Recovery by Jig Flotation
M. Gupta¹, K. Huang¹ and R. Yoon¹; ¹Chemical Engineering, Michigan Technological University, Houghton, MI; ²Mining and Minerals Engineering, Virginia Tech, Blacksburg, VA and ³Chemical Engineering, Virginia Tech, Blacksburg, VA

Coarse particle flotation entails bubble-particle attachment in a fluidized bed to minimize particle detachment. Attachment of air bubbles to copper-bearing minerals, for example, reduces the effective specific gravity (SG) of the particles; therefore, they can be separated in a gravity separator. In the present work, we injected air bubbles into a jig flotation cell so that bubble-particle aggregates can enter the froth phase to be upgraded via the froth-cleaning mechanism. Laboratory tests conducted on the 212-600 µm materials of a rougher flotation feed increased the grade from 0.1-0.15 %Cu to 1.0-1.5 %Cu at 65-75% recoveries.

2:45 PM
The Development and Performance of the WEMCO II at 80m² and 250m² Industrial Scales
I. Coltrin¹, J. Bowden¹, D. Lelinski¹ and T. Sok²; ¹Product Line Management, FLSmidth and Co A/S, Valby, Denmark and ²R&D, FLSmidth, Midvale, UT

WEMCO flotation cell technology was first developed in the 1930s, updated in 1968 and has been the same ever since. Although this robust and impressive design has been a technology standard for many decades, FLSmidth has set out to improve the original design with a new rotor and stator configuration which improve hydrodynamic, kinetic, and metallurgical performance. 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 (80m²) cells installed at the end of a rougher row and provides qualitative data for performance evaluation. The South American installation involves a quantity of two WEMCO 250RT (250m²) cells installed second from the first rougher and second from the last scavenger in a row and provides quantitative data including airflow, power,RTD, solids suspension, and metallurgical performance. Theressults showed improvement in power, airflow, and metallurgical grade and recovery within a certain range of process conditions.

3:05 PM
Full-Scale Trial of the REFLUX™ Flotation Cell in a Copper Concentrator
B. Dabrowski, L. Christodoulou, D. Taggart and S. Saurabh; FLSmidth Inc, Midvale, UT

The mineral processing industry is in continuous pursuit of improvements in flotation performance. Incremental improvement gains are being achieved by incorporating design changes into established flotation technologies. The industry, however, is demanding a step change in performance. The hydrodynamics of traditional flotation is being transformed by the REFLUX™ Flotation cell (RFC™) as shown by various laboratory, pilot and industrial scale tests, with the technology proving to meet the challenge of delivering as a high efficiency flotation machine. Pilot testing campaigns have been conducted in various applications across a number of commodity types. Results from this testing consistently show that the technology improves the flotation system kinetics and can shift the grade-recovery curve. Recent efforts include the implementation of a full-scale RFC alongside a pilot-scale RFC installed in an operating copper concentrator.
Results show that at industrial scale the efficiency gains seen at pilot scale are repeated. An overview of the testing campaign along with the results from this work will be discussed.

3:25 PM

**Improved Process Efficiency and Stability Using Precise Actuator Positioning for Flotation Cell Air Flow Control**

*M. Ferra, Marketing, REXA, West Bridgewater, MA*

At copper mine in Nevada, the end user improved productivity using electro-hydraulic actuators to control air feed to the flotation cell. Accurate and repeatable air flow is important for efficient operation of large tank cells and reagent consumption. Feed air flow is restricted with a butterfly valve (BFV), but it is the actuator that is the final control element to correctly position the valve as commanded by the control signal. Conventional wisdom says that electro-mechanical or pneumatic actuators are a suitable choice to provide air flow by throttling a butterfly valve. Both types of actuators do not provide proper resolution (1%-3%) for the precise air flow control required. For controlling flow, it does not matter if the valve is a 10° BFV at 50% open, or a 4° BFV at 90% open. It is the ability of the actuator to adjust the throttling valve opening, specifically, the resolution of the actuator, which determines the precision of the air flow. Positioning resolution can be defined as the smallest position change an actuator can respond to. The end user replaced pneumatic actuators with REXA electro-hydraulic actuators, having a resolution of <0.1%. 

3:45 PM

**ERT Measurements in Column Flotation for Computational Modelling**

*v. vilayphone1 and C. Young2; 1 Metallurgical Engineering, Student, Butte, MT and 2Metallurgical Engineering, Professor, Butte, MT*

Electrical resistance tomography (ERT) allows gas holdup and first-order rate constants to be measured, ultimately allowing mathematical relationships to be determined for developing computational models. Results from previous studies with column flotation on systems containing only MIBC were duplicated, giving confidence in the measurements. Tests were therefore extended to include solids, namely hydrophobic talc in the absence and presence of a depressant and hydrophilic dolomite in the absence and presence of collector. As expected, gas holdup was shown to increase with talc in the absence of depressant as well as with dolomite in the presence of collector due to the solids being hydrophobic. Comparisons to other frothers are also offered.

4:05 PM

**Impact of Operating Parameters on the Metallurgical Performance of the Concorde Cell™**

*R. Dube and N. Kupka; Metso Outotec USA Inc, York, PA*

The Concorde Cell™ is a high-intensity pneumatic flotation technology dedicated to recovering fine and ultrafine particles. With its high energy dissipation and its fine bubbles, the Concorde Cell is typically used as a standalone unit, reducing energy consumption and plant footprint. The impact of operating and design parameters on the metallurgical performance of the Concorde, such as air-to-pulp ratio, wash water flow rate or Blast Tube residence time, will be presented using different ores, from lab to industrial scale.

TUESDAY, FEBRUARY 27 AFTERNOON

**MPD: PHYSICAL SEPARATION**

Sponsored by: **WEIR Minerals**

### 2:00 PM • Tuesday, February 27

**Chairs:** J. Alves, The Pennsylvania State University, State College, PA, Angola

**A. Cavendor,** Weir Minerals, Reno, NV

**2:00 PM**

**Introductions**

**2:05 PM**

**Magnetic Concentration of Allanite in the Halleck Creek Ore**

*M. Elseyh and R. Honaker; Department of Mining Engineering, University of Kentucky, Lexington, KY*

Allanite concentration from ore containing mostly feldspar was evaluated using dry and wet high intensity magnetic separators. The rare earth elements (REEs) were concentrated by a factor of around three by a pulsating WHIMS unit while recovering nearly 90% of the REEs and rejecting 70% of the total feed mass. Relatively coarse liberation characteristics provided an opportunity to upgrade using a dry rare earth drum. By varying process parameters, particle size-by-size recovery and grade responses were generated and optimized. A rougher-scavenger-cleaner circuit was designed based on the size-by-size performances. An effective dry-based upgrading of 1 x 0.15 mm Allanite is achievable while eliminating the majority of the below grade material prior to hydrometallurgical processing.

**2:25 PM**

**Optimizing Physical Separation Through Machine Learning Mineralogical Classification**

*M. Nicco1, D. Bednarski2, M. Herbelin1 and T. Wallmach3; 1Geometallurgy, ERAMET, Trappes, France; 2Digital Mining and Metallurgy, Eramet, Trappes, France and 3ERAMET, Trappes, France*

Real-time monitoring of the performance of mineral processing equipment, especially minerals separation, is crucial for cost-effective production. However, obtaining information on the mineralogy can often be tedious: results of quick chemical analyses, such as X-ray Fluorescence, only give elemental information and involved mineralogy analysis tools, such as X-ray Diffraction, require heavy sample preparation and longer analysis. Using the example of a heavy minerals sand mine, a program based on open-source resources was developed to determine the mineralogy and particle size distribution of production samples from photographs. The program is composed of two steps: segmentation of the particles then the classification of the particles using machine learning clustering and image recognition from a database of minerals built from reference samples. Results from the algorithm were compared to mineralogy obtained from SEM based automated mineralogy and particle size distribution measurements to validate the method. At the interface between research and industry, this web application is designed for daily use by metallurgists, geologists, and chemists to optimize physical separation.

**2:45 PM**

**Sustainable Sorting Systems for Complex Ores**

*S. Adewuyo and A. Anani; Mining and Geological Engineering, University of Arizona, Tucson, AZ*

Processing complex ore such as sulfides entails intensive grinding and complex beneficiation and pyrometallurgical techniques that are energy intensive and generate significant sulfurous materials into the environment. Emerging sorting technologies can improve the efficiency and environmental performance of complex ore processing by separating the ore particles based on their physical or chemical properties using sensors before downstream operations of the ores. This study presents challenges and opportunities for implementing sustainable sorting systems for complex ores to reduce comminution energy, improve downstream operations, and reduce tailing for environmental sustainability.
3:05 PM
24-007
Additives for Magnetic Separation of Iron Ore Ultrafines
K. Nunes, L. Bicalho, L. Faustino and W. Da Silva; Clariant Mining Solutions, Belo Horizonte, Brazil

Seeking to implement the Global Industry Standard on Tailings Management to improve the safety of their tailings facilities across the globe, mining companies are motivated to invest in new technologies to recover valuable minerals from tailings. One solution being evaluated is the use of magnetic separators to concentrate ultrafine tailings. However, this approach is energy intensive as it requires high magnetic fields to recover ultrafines, and usually results in low mass yields. Additives which modify pulp rheology and surface properties, or selective flocculate ultrafine particles, were tested to enhance the performance of magnetic separation. Promising results in laboratory scale testing different types of additives confirmed that it is possible to increase the mass yield, keeping the selectivity of this stage.

3:25 PM
Silt-Clay Separation Through Centrifugation, for Effective Clay Characterization and Subsequent Lithium Enrichment
A. Tita, E. Mends and P. Chu; Mining and Metallurgical Engineering, University of Nevada, Reno, Reno, NV

With the growing importance of lithium (Li) as a key component in energy storage technologies, the extraction of Li from other sources such as claystone, is being sought. Efficient Li extraction from claystones requires a comprehensive understanding of clay mineral phases and their structures. Claystones contain both clay and silt fractions, however, the latter hinders effective clay characterization. This study delves into the innovative use of centrifugation for silt-clay separation, with significant implications for clay characterization and subsequent Li extraction. Claystone samples were centrifuged under varying time intervals and rpms, followed by XRD and ICP analyses. It was observed that as centrifuge time increased to 90mins, and rpm increased to 4500rpm, the silt-clay separation greatly improved. Also, Li was enriched in the clay fraction by about 3 times, while calcium, a major impurity, was enriched in the silt fraction by about 6 times. These enrichments both serve as an important initial mineral processing step, resulting in considerable reduction of acid consumption during the leaching stage of Li.

3:45 PM
The Radflow Thickener Feedwell: Redefining Thickener Sizing and Flocculant Usage
A. Krassnokutski; Mechanical Engineering, University of Witwatersrand, Toronto, ON, Canada

The development of the novel Radflow™ thickener feedwell and its successful application is investigated. Typical thickener feedwell deficiencies were demonstrated, with scale model and Computational Fluid Dynamics (CFD) methodologies, and systematically overcome to ultimately culminate in an advanced feedwell design. Three Radflow feedwell case studies are then presented. These case studies demonstrate that the standard thickener design heuristics (rules of thumb) of limiting rise rates and flux rates are excessively conservative when operating a thickener with a more efficient feedwell design. Alternatively, it is shown that if the Radflow is used in conservatively sized or operated thickener, then it is unnecessary or even counterproductive to follow the standard practice of enhancing flocc settling as excess flocculant not only adds to additional operational expenses, but can also limit the achievable underflow density.

4:05 PM
FSI Analysis of Mud-Rake Interaction in a Full-Scaled Thickener
Y. Lu1, T. Sok1, F. schoenbrunn1 and J. Scott2; 1Ming R&D, FLSmidth, Midvake, UT and 2Thickener Product, FLSmidth, Midvake, UT

The rake mechanism is used to move the settled sediments to underflow. During the process, the surrounding mud would exert dynamic loads on the rake structure and cause deformation of the rake. It is therefore important to quantify the realistic load for an appropriate rake design, otherwise, a potential risk would remain due to the limited gap between the rake and tank bottom. To address this challenge, a one-way fluid-structure interaction (FSI) approach has been developed for a full-scaled thickener. ANSYS Fluent solver is used for the mud flow analysis. The converged solution is then mapped into the ANSYS Mechanical solver for strength analysis. With the predicted Maximum deformation of 6.5 mm, which is far less than the design tolerance (60 mm), it can be concluded that the current design is appropriate. This study has demonstrated that FSI analysis can be used to quantify the dynamic loads or identify any strength related issues for optimal design of a thickener, and it can also be applied as an effective way to troubleshoot an engineering problem during the field operation.

4:25 PM
24-095
A Hydrodynamic Approach for Sizing and Selection of Hydrocyclone—Parametric Scaling and Process Optimization
S. Urnak1, D. Switzer1, S. Pathak2, D. Watson3 and S. Hunter4; 1Weir Minerals, Cody, WY; 2Weir EnSci, Bangalore, India and 3Weir Advanced Research Center, Glasgow, UK

Hydrocyclone is a piece of equipment commonly used as a classifier in the mill circuit operation. Traditionally hydrocyclone performance are characterised by the classification efficiency parameter such as cut size (d<sub>50c</sub>), sharpness of separation (α) and bypass (R). A plethora of endeavours have already been made to develop parametric models to determine hydrocyclone performance correlating design and process variables. In contrast to those studies, we made an attempt to develop an approach to derive required design parameters purely from hydrodynamic principle that provides platform to optimize the operation of a hydrocyclones for a given application. In this selection methodology we calculated the differential pressure at the air core and also the tangential velocity at the boundary of the air core from the vortex principle in a confined geometry at different operating regime. A series of experiments were conducted where process parameters such as solid concentration and feed flowrate are experimentally studied to determine the key parameters.

4:45 PM
Impact of Particle Sizing on Bulk Solids Flow Behavior
M. Ray; Jenike & Johanson, Tyngsboro, MA

In the mining world, comminution and screening operations are crucial. There are various methods and technologies available for comminution and choosing the appropriate one can significantly affect the efficiency of energy usage, product quality, and the equipment lifespan. Similarly, screening methods can also have many of the same significant impacts. Both operations may lead to unintended consequences that can increase the risk of flow disruptions, downtime, and safety hazards. However, by assessing the physical, chemical and flow properties of the materials, conducting a thorough flow processing review, and performing PHAs and DHAs when necessary, it is possible to mitigate these risks before implementing comminution and screening processes and before purchasing equipment. This talk will discuss the critical steps required to ensure that new operations will function correctly and safely right from the start.
Copper ore is extracted from the earth and converted into Copper Concentrate which is smelted and converted into refined copper. Copper Concentrates have the presence of precious metals Ag and Au along with the Cu; therefore, the correct methodology and accuracy of the Ag, Au, and Cu content determination is essential for the mining and refining/smelting industries. There are various analytical methods for determining Ag, Au, and Cu content in Copper Concentrates and those methods will be discussed for each element supported by Round Robin data. Ag has been determined using ASTM 1998 procedure and Pd bead collection. Au has been determined via gravimetric (parting and weighing), Pd collection, and Ag collection depending upon the level of Au in the Copper Concentrate. Cu has been determined using titration and electro-gravimetric analysis. The methodology and results will be discussed and verified with Round Robin data collected by independent 3rd party institutions.

3:05 PM
An Analytical Method for When “Fire Assay Doesn’t Work on This Ore”
M. LeVier1 and K. Pereverzev2; 1K Marc LeVier and Associates Inc, Highlands Ranch, CO and 2Northwest Metals Group, Wheat Ridge, CO
Glamorous gold projects with promises of enormous profits have circled the mining industry for many years with the one problem, the ore can’t be measured using conventional fire assay. Some call these scams while others have some legitimacy. Fire assay does have some shortcomings but is still the most accepted analytical method for gold resource reporting. The advancement of ICP-MS capabilities over the last ten years has simplified the measurement of gold and other precious metals with results directly comparable to fire assay and with fewer complexities.

3:25 PM
The Gravimetric Determination of Low-Level Gold in Copper Bullion
A. Naujokas; Laboratory Director, Sabin Metal Corp, Scottsville, NY
The gravimetric determination of low-level gold in copper bullion poses several challenges to the analytical chemist. In fire assay, the sample size needed can add many extra steps to separate the gold from the copper matrix thoroughly and result in increased detection limits. Direct dissolves of the copper bullion suffer from issues such as: incomplete dissolution, interference from the matrix elements and varying solubilities of gold. This discussion describes an alternate method proposed and validated by the late Dr. Stephen R. Cooke that addresses and overcomes many of these issues using a mixed acid digestion of nitric/hydrofluoric acid and fire assay.

3:45 PM
Data Analysis After Metallurgical Sampling
J. Maki; Projects, Sibelco, Spruce Pine, NC
How do you ensure your recommended process changes will provide the expected results? This paper will summarize ways of analyzing data to help ensure viable conclusions from your process and sampling data. It will demonstrate how the challenges of mineral process sampling and how it can be misleading, difficult to quantify and even mask key process variables from being recognized. Hopefully, the presentation will not be as boring as the title appers.

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TUESDAY, FEBRUARY 27 AFTERNOON
TAILINGS: CASE STUDIES—ALIGNMENT WITH STATE OF PRACTICE AND NEW PARADIGM FOR TAILINGS MANAGEMENT
Sponsored by: Newmont

North 131B/C
2:00 PM • Tuesday, February 27
Chairs: D. Korri, Society for Mining Metallurgy and Exploration, Silver Bay, MN
C. Pecora, Hawcroft, Veneta, PA
2:00 PM
Introductions
2:05 PM
Downstream Improvements on Upstream Dams: An Owner’s Perspective of a Paradigm Shift
C. Winter; Cleveland-Cliffs, Inc., Hibbing, MN
Mining companies with tailings storage facilities that use the upstream...
construction method have been challenged to track the evolution of industry standards, assess risks, revise design and communicate design revisions with regulators. While best practices and industry standards have evolved in recent years as an attribute of continual improvement, the controlling standard in the design of many upstream dams is understanding the foundational strengths of hydraulically deposited tailings. Hibbing Taconite Company managed and owned by Cleveland-Cliffs, Inc, following best practices and industry standards began the re-evaluation of foundation strengths underlying a system of upstream dams in 2017. This paper explores the path that the Owner followed to understand the paradigm shift and construct downstream improvements. That path involved, tailings re-characterization, dam design revisions, operating plan reconciliation, budget revisions, wetland permitting, dam safety permit amendments, stormwater prevention plans, borrow materials studies, new concrete decant structures and the pursuit to cognize and be consistent with industry standards.

2:25 PM
Tools for Streamlined GISTM Benchmarking and Conformance Roadmapping for Non-ICMM Members
V. Maltais1 and L. Carr2; 1Environmental Social and Governance, Coeur Mining, Chicago, IL and 2Ramboll, St. Louis, MO
Coeur Mining, Inc. (Coeur) operates tailings facilities in Alaska, Canada, Mexico, and New Zealand. Coeur, as a non-ICMM member, is voluntarily aligning to the Global Industry Standard on Tailings Management (GISTM) as part of a broader commitment to environmental stewardship, safe tailings management and public engagement. Coeur’s decision-making inputs of aligning to the GISTM has included a self-assessment, a 3rd party assessment, the development of a roadmap for implementing GISTM conformance and increasing tailings disclosures. This presentation will focus on 1) Coeur’s rationale for aligning to the GISTM, as a non-ICMM member; 2) Coeur’s benchmarking tools, which assessed current GISTM conformance against 620 GISTM requirements and ICMM Conformance Protocols; 3) the process used to combine the granular GISTM conformance gaps into consolidated and actionable recommendations; and 4) the collaborative process used by Coeur’s site, corporate, and 3rd-party consultant team to develop GISTM conformance roadmap. This information will be useful for other non-ICMM members who are considering aligning to the GISTM or are early in the development of their conformance program.

2:45 PM
Tailings Management in Mining: Lessons Learned From Implementing the TMS and DBR Under GISTM
B. Roquete Cardoso de Meneses, J. Murillo Ruiz and A. Aguilar Fernández; Geosyntec, Madrid, Madrid, Spain
The mining industry, with its profound operations and potential environmental risks, has grappled with tailings management challenges for years. A significant step forward is the Global Industry Standard on Tailings Management (GISTM). At its core lie two critical documents: the Tailings Management System (TMS) and the Design Basis Report (DBR). These documents enhance safety and sustainability in tailings management, crucial in the wake of recent dam failures. The TMS offers a comprehensive framework for managing tailings, demanding rigorous compliance and integration with the Environmental and Social Management System (ESMS). Meanwhile, the DBR evolves as design assumptions or foundational knowledge changes, ensuring the design's ongoing relevance. Given the industry's scale and implications, the TMS and DBR provide an effective strategy, ensuring risk mitigation and application of best practices. This paper examines the TMS and DBR's nuances, their alignment with GISTM's objectives, and the lessons from their implementation. Ultimately, understanding these documents is paramount for the mining sector, guiding it towards safety, sustainability, and continuous improvement.
RONALD M. MARTIN; MARTIN VALUATION ASSOCIATES, LLC, TOLEDO, OH

Appraisal review is an essential component of the appraisal process for federally regulated financial institutions and for government entities. This presentation is designed to afford the attendees with an understanding of the review process and to assist valuation practitioners with pointers on how to get through such review process easily and avoid significant revision requests. Such considerations are of significant importance since reviewers are generally operating under a short time frame and problems in the appraisal can hold up the loan or eminent domain process, et al. The presentation will provide an overview of USPAP and bank regulatory requirements which appraisers and reviewer are obliged to comply with. In addition, common pitfalls/shortcomings in appraisal reports shall be covered in detail and with some suggestions as to how to better cover such considerations. This presentation will pertain to general commercial-industrial and special purpose property appraisals as well as to mineral property appraisals.

3:25 PM

Resource Evaluation of Construction Aggregate Deposits on Greenfield Sites—Ensuring a Realistic Appraisal
J. Partlow; AIPG, Tuscaloosa, AL

The primary factors for evaluating a mineral deposit include quality/grade, quantity, accessibility, and marketability. According to the Committee for Mineral Reserves International Reporting Standards (CRIRSCO) a mineral resource is a concentration or occurrence of solid material of economic interest in such form, grade or quality and quantity that there are reasonable prospects for eventual economic extraction. Mineral resources are subdivided, based on geological confidence, into inferred, indicated and measured categories. A mineral reserve is considered the economically mineable materials of a measured and/or indicated mineral resource. Classification into these categories depends on the types of data available, and the level of confidence to accurately predict continuity of geologic character. In addition, the stage of exploration or development is fundamental to the type of appraisal/valuation utilized. This presentation will discuss the factors for classifying an aggregate mineral deposit on a greenfield site, and methods for this type of appraisal. IIMA-Valuation Lessons Learned

3:45 PM

The Income Approach and Discount Cash Flow Analyses
B. Groff; Groff Engineering & Consulting LLC, Mt. Sterling, KY

The income approach to valuation can mean direct capitalization or yield capitalization, or it can involve a discounted cash flow analysis. This paper explores the differences between each approach and discusses the different methods and how to quantify the uncertainties of each is included as part of a discussion focused on developing credible value opinions.
how to improve team members speaking up to keep work safe and protect operations and assets. This session highlights a few of the most common sentiments that can hold back team performance and delves into some tangible ways to do work with more precision from a human performance perspective. Most organizations talk about ‘see something, say something’ when it comes to intervening to prevent unplanned events but could do more to equip teams with skills to actually do this, as well highlight the barriers to this desirable outcome. Please join our discussion of fostering precision to improve our safe operational results in mining.

9:25 AM
Reducing Downtime Related to Bulk Solids Handling Flow Issues
C. Hartford; Jenike & Johanson, San Luis Obispo, CA

Bulk solids handling systems are the arteries of a mine operation and if bulk solids stop flowing, then the lifeblood of the mine is restricted, and emergency procedures begin. Re-establishing bulk solids flow takes time resulting in loss of production and can lead to unsafe work conditions going against ESG goals of desiring energy efficient operations and good working conditions. To reduce or eliminate bulk solids handling problems requires an analysis of troublesome equipment—a transfer chute that experiences plugging, excessive wear, unacceptable dust generation, high belt wear, and product spillage, a stockpile that only functions at 10% live capacity, or a bin that plugs causing unreliable flow. Simulation tools, such as calibrated Discrete Element Method (DEM) models, is a type of digital twin can be used to build a virtual model of material flow through the plant such as bins, stockpiles, and transfer chutes. Then changes can be made in these virtual models, such as flowrate and material characteristics (higher clay/fines/moisture), to evaluate how the changes will respond in reality. Then design or operational changes can be planned for to ensure a successful change.

9:45 AM
Understanding and Optimizing Drive Pulley Traction
T. Wolf; Engineering, PPI, Ankeny, IA

Maintaining drive pulley traction is important for proper conveyor performance and issues can result in significant loss of production and cost. Most codes and handbooks use the Capstan or Euler-Eytelwein equation for drive traction design. This equation uses simplifying assumptions to achieve a relatively simple closed form solution. These assumptions being the components are rigid bodies and friction is constant. With significant safety factors on the friction coefficient our industry has successfully used this method to create safe designs in most cases. Reasearch has continued and newer understanding can create opportunities for refinement potentially resulting in lower cost drive designs and solutions for persistent drive slip issues. This paper will provide a foundational review of key historical variables such as belt wrap on the pulley, friction factors and the slack side belt tension. It will proved an understanding of newer concepts about belt and pulley lagging elasticity and friction factor variability. Physical testing will be presented to reinforce key concepts and provide evidence to dispel some costly misconceptions about drive slip.

10:05 AM
Operational Performance Case Studies of Durable Mechanical Splicing of Steel Corded Belts
B. DeVries; Flexco, Grand Rapids, MI

A new technology for the durable splicing of steel corded belts without vulcanization has recently been developed for belts rated ST2500 and less. An introduction of the salient technological features of this mechanical splice will be presented along with case studies of operational experiences. The durable nature and faster installation in emergency situations allows for increased conveyor uptime at full tension and capacity levels. Safety is enhanced due to available knife-less installation techniques. Case studies will also include using the mechanical splice to install belts with increased tension safety factor, but less damage and waste.

10:25 AM
Obsolete Gearboxes: Key Considerations and Steps to Replace Them
M. Clark and C. Crisp; Sumitomo Drive Technologies, Goodyear, AZ

Gearboxes age and can become obsolete or costly to repair as technology evolves. To address this, modernizing production equipment can alleviate supply chain, spares, and inventory issues. Mines can modify existing equipment to accept standard, modified gearboxes (retrofit), or opt for direct (drop in) replacements for easier installation. To make the best decision, producers must understand a gearbox manufacturer’s capabilities and the information needed for replacing old gearboxes to improve mining production reliability.

10:45 AM
Continuous X-Ray Inspection of Steelcord Belting: Prolonging Service Life, Performance, and Reliability
R. Butterworth; AFM Industries/Endurance Belting, Oshawa, ON, Canada

Steelcord conveyor systems are the lifeline of mining operations and are a critical part of the production process. The belting on these systems represents a tremendous investment so expectations on the belting is high. Performance, reliability, and longevity are key factors in ensuring a high return on investment by mining companies. This paper will introduce a new technology to North America for non-destructive inspection of the Steelcord belt carcass. It will review the technology inherent in this system and explain the benefits and differences between continuous x-ray and current magnetic scanning. The paper will identify the benefits of continuous length X-Ray and show examples and List the areas of protection: Mining staff, Production, Investment, Equipment The paper will also propose interesting ways for the technology to be implemented and combined with existing belt protection and monitoring systems such as rip detection systems, remote monitoring.

WEDNESDAY, FEBRUARY 28  MORNING

COAL & ENERGY: RESEARCH AND DEVELOPMENT

North 226B

9:00 AM • Wednesday, February 28

Introductions

9:05 AM

Wearable Sensors for Continuous, Real-Time Monitoring and Risk Assessment of Mine Workers Health and Safety
E. Widzyk-Capehart1, Z. Kiehl1, G. Kennedy1, J. Feeney2 and J. Ward2; 1Simtars, MSTRC, Resources Safety and Health Queensland, Redbank, QLD, Australia; 2Sentinel, Fairborn, OH and APTIMA, Fairborn, OH

Mine workers are continuously exposed to a host of non-fatal stressors and potentially fatal hazards: noise exposure, excessive vibration, poor air quality, toxicant exposure, ignition of combustible gases, equipment related accidents and thermal heat stress. Wearable or portable sensors paired with contextual analytics and an open architecture platform provide a means unobtrusively collect and fuse multimodal health and safety data in real-time to compute both acute safety and longitudinal health insights. This paper presents preliminary trial results, conducted by Simtars, Sentinel, and Queensland Mines Rescue Service in Australia, of the application of wearable sensor to monitor heat stress and associated environmental and physiological metrics of mines rescue personnel.
9:25 AM

Robot Deployment and Operations at Mine Incidents and Emergencies  
S. Sawyer and P. Schmidt; Pittsburgh Mining Research Division, Centers for Disease Control and Prevention, Atlanta, GA

The NIOSH Mining Program has three ongoing efforts to address Mine Emergency Robot needs for Incident/Disaster Response. In support of these efforts, NIOSH personnel have characterized robot operations from a user perspective, described situations in which robots and robot generated information might be used, and developed technical, environmental, as well as information dissemination requirements. This paper will discuss robotic missions during Mine Incident Response and architectures for sharing robot generated information throughout the Incident Ground. Finally, the paper will summarize NIOSH’s current robotic strategy and enumerate how the outcome of these efforts will address immediate and future robotic demands.

9:45 AM

Analyzing the Effectiveness of Fire Suppression Systems to Extinguish a Fire on Mobile Diesel Equipment used in the Mining Industry  
J. Rowland, D. Bahrami, R. Thomas and L. Yuan; Fires Team, NIOSH, Pittsburgh, PA

To reduce the number of injuries resulting from fires on mobile, diesel-powered mine equipment, it is crucial to promptly suppress a fire once detected. The focus of this research was to determine the effectiveness of fire suppression agents. Large-scale tests were conducted using five different fire suppression systems based on: dry chemical, wet chemical, dual agent (dry and wet chemical), carbon dioxide, and water mist. Suppression nozzles were placed around the diesel engine where diesel fuel, engine motor oil, and hydraulic circulating oil spray fires were ignited. The results of this study can help mining companies and manufacturers by providing scientific-based data on the capabilities of the different fire suppression systems.

10:05 AM

Enhancing Robotic Perception for Autonomous Roof Bolting Using an Event Based Machine Learning Framework  
A. Marseet, R. Banerjee and A. Petruska; Colorado School of Mines, Golden, CO

Underground mine roof bolting is a crucial operation for miners’ safety and mines’ sustainability. Since roof bolting is still a manual or human supervised operation, miners’ safety is still at risk due to dust or rock falls. The authors propose a machine learning framework for autonomous roof bolting using Event cameras. Event camera, a cutting-edge sensor technology, is a novel sensor promising efficient solutions for the severe lighting conditions in underground mines which are high-dynamic-range, poor lighting, and spectral reflections from airborne dust. The proposed framework enables the segmentation of rocks from non-rock areas with 97% accuracy at small number of epochs using enhanced binary semantic segmentation machine learning algorithm. The model is tested on data collected from Edgar Mine. This enhanced model allows autonomous roof bolting which reduces miners’ exposure to perilous situations and revolutionizes the mining industry by promising fully autonomous underground mining.

10:25 AM

Examining Pull-Out Tests for Resin Grouted Rib Bolts: A Comprehensive Analysis  
K. Mohamed1, Y. Xue1, D. Guner1, A. Kirmaci2 and T.Sherizadeh; 1National Institute for Occupational Safety and Health, Pittsburgh, PA and 2Department of Mining and Explosives Engineering, Missouri University of Science and Technology, Rola, MO

Resin-grouted bolts stabilize yielded coal ribs in underground coal mines. To study their performance, researchers from NIOSH and Missouri University conducted pull-out tests in five U.S. mines. 44 tests were done with encapsulation lengths from 12 to 60 inches. Findings revealed failure patterns based on encapsulation length: shorter lengths failed at the bolt-grout interface, while longer ones suffered shear-induced breakage. Partially grouted bolts failed depending on coal strength, either at the grout-rebar interface or within the rebar. Numerical models were developed to simulate pull-out tests, aiding in designing support systems for safe and stable underground coal mining.

10:45 AM

Determination of Incombustible Content with Portable Spectrometers Using Chemometric Modelling  
E. Widzyk-Capehart1, S. D’Hyon1, S. Zeng1, A. Adoko2 and G. Kennedy; 1Simtars, Resources Safety and Health Queensland, Redbank, QLD, Australia and 2School of Mining and Geosciences, Nazarbayev University, Astana, Kazakhstan

Inertization of coal dust with stone dust is a common control implemented within underground coal mines to mitigate the hazard of a coal dust explosion. To achieve adequate inertization, the total incombustible content (TIC) of the coal—stone dust mixture is required to meet certain percentages depending on the risk level and relevant legislation. Current methods for determining the TIC of a mixture involves external laboratory analysis, colorimetric comparison, or the use of portable instruments. This study provides preliminary analysis to determine the TIC of a sample in real-time with chemometric modelling using a portable instrument system employing Near-Infrared or Raman Spectroscopy.

WEDNESDAY, FEBRUARY 28 MORNING

COAL & ENERGY: URANIUM PROJECTS, EXPLORATION, ASSESSMENTS AND INNOVATIONS

North 227B

9:00 AM • Wednesday, February 28

Chairs: K. Johnson, Barr Engineering Co, Minneapolis, MN  
B. Schiffer, WWC Engineering, Sheridan, WY

9:00 AM

Introductions

9:05 AM

Can Government Policy Changes Lead to a Revived Domestic Uranium Industry?  
W. Goranson; enCore Energy Corp., Corpus Christi, TX

Historically, the United States was a leader in the nuclear power industry that created the largest fleet of civilian nuclear reactors in the world. To get there, the United States instated policies during the Cold War that were designed to secure nuclear fuel for both military and civilian uses created a resilient domestic supply chain. The principal components of that domestic supply chain consisted of mined natural uranium, uranium conversion services, and uranium enrichment. Starting in the late 1980’s, those Cold War policies began to loosen, and by the early 1990’s, they began to disappear, in the name of global geopolitical stability. With the recent invasion of Ukraine by Russia along with other geopolitical events has lead to the U.S. government, through executive action and pending Congressional legislation, to implement policies to revive the domestic nuclear fuel supply chain from mining through enrichment. The positive action has looked upon as positive by most in the civilian industry, but will it be a case of government creating large market distortions that could do more harm than good?
9:25 AM
Regulatory Programs for In-Situ Uranium Resource Reporting: “Square Pegs, Round Holes?”
B. Schiffer; Environmental, WWC Engineering, Sheridan, WY
Most publicly traded companies that explore/develop or mine uranium via the in-situ recovery (ISR) method are traded in countries that regulate disclosures of mineral resources. This analysis focuses on regulatory programs in Canada, the United States and Australia with a focus on applicability of the regulations to uranium ISR. Applying these regulatory programs to uranium ISR can be difficult because of the unique nature of ISR in terms of resource or economic reporting, hence “square pegs, round holes.” The assumption in regulations that the only way a mineable mineral can be extracted is through underground or open-pit type methods, where the mineral can ultimately be seen, and resource/reserve estimates can be conclusively proven. Combined with the opaque nature (not traded publicly) of the uranium market, the stage is set for compliance complications for uranium ISR producers and explorers. Solutions for uranium ISR miners and explorers to this conundrum has been and should continue to be through education and communication with the regulatory authorities, along with preparation of robust and transparent reports.

9:45 AM
The Kaycee Uranium Project: Rebuilding an Exploration Model After a 40 Year Hiatus, Pitfalls and Opportunities
M. Travis; University of Wyoming, Laramie, WY
The Kaycee Uranium Project (KUP), located in the Southwest Powder River Basin of Wyoming, was last active in the early 1980’s with Washtenaw Energy Corp’s (WEC) exploration and development of the project. Roll-front uranium deposits are found within sandstones where oxygenated, uranium-bearing fluids within an aquifer drop out of solution at a redox boundary. This redox interface, or a “roll-front” is typically C-shaped in cross-section (concave upstream/oxide, convex downstream/reduced). At the KUP the main host rock is the Paleocene Fort Union Formation, comprised of fluvial sands, carbonate sandsstones, & bentonic mudstones and shales. Current involvement by Nuclear Fuels, Inc. (NFI) has focused on digitizing nearly 4,000 historic ‘e-logs’ (containing: geophysical data—Gamma, Resistivity, & SP (spontaneous potential) & lithologic logging, grade calculations, and down-hole surveys) for the development of a 3D model using this historic wealth of data. Nearly 40 years has passed since the last work has been done on the KUP, with many pitfalls and opportunities to be had therein as NFI rebuilds an exploration model after this significant hiatus.

10:05 AM
Radiation Exposures and Protection at InSitu Recovery Uranium Facilities
K. Milmine and M. Griffin; Strata Energy, Oshoto, WY
In-situ recovery (ISR) is a method of extracting uranium without open-pit or underground mines. A lixiviant solution is introduced into the ore body through a pattern of injection wells to dissolve the uranium from the sandstone host rock. Recovery wells then pump the uranium solutions to a processing plant. The plant typically involves ion exchange resins, elution and precipitation circuits, and drying/packaging the yellowcake. An advantage of ISR over conventional methods is the lower environmental impacts, due to minimal surface disturbance and aquifer restoration after operations. Modern ISR reduces human exposure to radioactive air particulates and radon by water reuse, largely closed plant systems, and vacuum dryers. Uranium miners often hear “Are you going to glow in the dark?” Although tongue-in-cheek, this line demonstrates common misconceptions about safety from uranium mining. Radiation exposures to workers at ISR facilities are low in general and operators take steps to reduce doses. This presentation discusses general radiation impacts at ISR facilities including safety aspects and controls, and comparison with other man-made and natural radiation sources.

10:25 AM
Persistent Secondary Contaminant Sources (PeSCS) at Former Uranium Mill Sites
R. Johnson1, R. Sultana1, A. Tigari1 and M. Kautsky1; Geochemistry, RSI EnTech, LLC, Grand Junction, CO; 2Geosciences, University of Wisconsin-Milwaukee, Milwaukee, WI and 3Office of Legacy Management, U.S. Department of Energy, Grand Junction, CO
The U.S. Department of Energy Office of Legacy Management (LM) has several former uranium mill sites where mill tailings have been removed, but groundwater uranium concentrations continue to be above standards. Regulations allow for a 100-year natural flushing period; however, this appears to be an overly optimistic timeframe at some sites. Based on solid-phase characterization from several sites, uranium PeSCS are primarily associated with the following subsurface conditions: 1) uranium sorption on sediments with high organic content, 2) highly soluble uranium associated with evaporites in the unsaturated zone, and 3) uranium in the saturated zone below former tailings impoundments co-located with precipitated gypsum and sorbed to or incorporated into precipitated Fe and Al oxides. Uranium release rates from the sediments to the water phase were evaluated using column studies and field tracer testing. The largest uranium release rate is from #2, but that release requires large recharge events that are difficult to predict. Using this new understanding of PeSCS, LM is updating 1) conceptual site models, 2) natural flushing predictions, and 3) potential remedial strategies.

10:45 AM
Geochemical Modeling for Remediation Design of Uranium in the Presence of High Concentration Ammonium Sulphate
P Nolan1, C. Mayer2 and N. Bezuidehout3; 1WSP, Novi, MI; 2WSP, Chattanooga, TN and 3WSP Canada, Toronto, ON, Canada
Predicting the mobility of uranium in the subsurface in support of remedial action can be challenging, especially where multi-compositional plumes exist. Here, we demonstrate an approach to modeling a density dependent plume of high concentration ammonium sulphate (>2.5 g/L) interacting with multiple historical uranium releases. HydroGeoSphere was used to simulate ammonium sulphate migration, the results of which were then integrated into a surface complexation based reactive transport model in PHAST for uranium transport using Python. The integrated model then allowed for full geochemical reactivity between the comimgled plumes and a better understanding of the geochemical processes at controlling uranium migration.

11:05 AM
High-Pressure Slurry Ablation (HPSA)—A Solution for Efficient and Effective Treatment of Abandoned Uranium Mine (AUM) Waste Rock
A. Halverson; Disa Technologies, Inc., Casper, WY
Thousands of abandoned uranium mines (AUMs) lie across the western United States posing health and environmental hazards to surrounding communities. Transporting all material or capping in place are currently the only options for remediation. Disa’s patented High-Pressure Slurry Ablation (HPSA) technology provides efficient liberation of uranium from hosted sand by utilizing particle-to-particle collisions, selectively fracturing uranium minerals from hosted sand grains without fracturing them. HPSA treated waste can be size separated into coarse cleaned sand and a contaminant concentrated fraction, significantly reducing hazards posed by the sites and extend disposal facility life allowing for a more economic and efficient solution. This presentation will primarily focus on the findings from Disa’s Treatability Study conducted with the U.S. EPA, Navajo Nation EPA, and Tetra Tech on AUMs on the Navajo Nation.

N. Bezuidenhout¹ and A. Lieu²; ¹Mining, WSP Canada Inc, Toronto, ON, Canada and ²Metallurgy and Process Engineering, NexGen Energy Ltd., Saskatoon, SK, Canada

NexGen Energy Ltd (NexGen) proposes to develop a new uranium mining and milling operation in northern Saskatchewan, Canada. NexGen adopted a proactive tailings management that includes the disposal of cemented uranium paste tailings and process wastes in a purposely built underground tailings storage facility (UGTMF). Predictive source-terms using a novel approach were developed for the UGTMF to support an environmental impact statement and meet Canadian Nuclear Safety Commission regulatory requirements. Source-term derivation included conceptualization of key mass transfer mechanisms, laboratory-based measurement of mass transfer processes and mechanistic modeling of uranium and radionuclide loading over a modeling period of 10,000 years.

WEDNESDAY, FEBRUARY 28 MORNING
ENVIRONMENTAL: DECARBONIZATION—SUCCESSFUL PROJECTS AND PATHS FORWARD
North 125A

9:00 AM • Wednesday, February 28
Chair: R. Furey, Stantec, Broomfield, CO

9:00 AM
Introductions

9:05 AM
Overview of the Decarbonization Journey in the Mining Industry
V. Gosteva, Asset Management, Newmont Corporation, Greenwood Village, CO

The mining industry is under pressure to reduce their greenhouse gas emissions due to the scientific data linking the release of greenhouse gases (GHG), such as carbon dioxide, with global warming. Many mining companies and companies in the mining value chain have set strategic targets with initiatives to address their GHG challenges. Mining companies can successfully decarbonize through a combination of solutions such as renewables, corporate power purchase agreements (PPAs), electrification, alternative fuels, carbon offsetting, energy data management, and smart infrastructure. Furthermore, creative approaches to public and private partnerships serve as a powerful vehicle to help accelerate the decarbonization efforts in the mining sector. Several case studies of successful projects and approaches to paths forward will be reviewed in this presentation.

9:25 AM
Rethinking Decarbonization to Increase Reliability in Your Plant
D. Richards; Mining, Burns & McDonnell, Phoenix, AZ

The mining industry has been pushing on all fronts for decarbonization: Solar, battery electric mobile equipment, efficiency upgrades, etc., but we small opportunities abound in our processing facilities. This presentation will focus on an approach to not only decarbonize Scope 1 emissions but to increase the reliability of plant operations, as well. A case study will be shared illustrating how this was achieved at a major gold mine in the western United States by channelling out of propane solution heater with an electric heater. The change will reduce the sites GHG emissions but also improve operational performance.

9:45 AM
Analysis of the CO₂ Emissions Impact of Deforestation and Mining in Madre de Dios, Perú
U. Saka, K. Pacheco Hague and S. Duzgun; Mining Engineering, Colorado School of Mines, Golden, CO

Madre de Dios in Perú is under severe threat of deforestation, due to the booming artisanal-small scale gold mining. In this study, with the aim to quantify the total impact of these operations on net CO₂ emissions, we calculate the extent of deforestation, estimate the carbon content and capture loss, and assess emissions directly generated by mining. Additionally, we consider emissions from the Interoceanic highway, which has contributed to the mining boom by providing easy access to the region. Our results imply that transportation and deforestation contribute to emissions more than mining; and provide recommendations to offset this during reclamation.

10:05 AM
A Practical and Sustainable Cost Optimization Framework for Improving the Energy System Efficiency in the Mining and Mineral Processing Industry
J. Azure, S. Frimpompong and K. Awuah-Offei; Missouri University of Science and Technology, Rolla, MO

Mining and mineral processing industry is energy-intensive and like any other carbon-intensive energy industry, contributes significant greenhouse gas emissions. The industry is actively exploring ways to enhance its energy efficiency and reduce carbon footprint to address Climate Change. One promising solution is optimizing the placement of renewable energy systems within mining and mineral processing facilities to improve their efficiency and reduce their environmental impact. This study introduces a mixed-integer linear programming optimization model that minimizes the costs associated with the supply, conversion, and storage of wind and solar energy and of carbon-based electricity in the mining industry. This study aims to develop an energy usage framework that decreases Scopes 1 and 2 emissions with the minimum cost. Results show that leveraging the energy mix with a 90% share of energy from solar, 5% from wind, and 5% from carbon-based energy yielded the optimal cost. Using renewable or carbon-based energy as the only source of energy to meet the same demand showed that carbon-based energy costs $88,151/KWh more. The empirical equation developed can be applied in any industry.

10:25 AM
When Low Hanging Fruit Isn’t Enough... Ensuring Your Operations Achieve Financial Goals and Decarbonization Commitments
D. Johnson; Stantec, Phoenix, AZ

When the low hanging fruit has been picked and teams are busy, improving the bottom line and reducing your carbon footprint requires a different approach. Today’s mining operations, the foundation of every supply chain, are expected to change faster than ever before. Learn how to successfully speed your delivery of financial and carbon reduction initiatives by leveraging a more holistic and Agile approach. Solve your challenges and de-risk innovative solutions, while building on familiar tools like energy management, operational audits, and Six Sigma. Unsuccessful pilots sap enthusiasm, time, and resources, as well as leave the original challenge unresolved. Using examples from projects that focused on identifying, scopeing, validating and/or delivering actionable, scalable, and non-disruptive improvements in operational, financial, and environmental performance, this session will share ways to overcome barriers to achieving success with your high priority initiatives. It will provide you with a guide to creating and executing a successful operational and capital roadmap for delivering on your most important goals, commitments, and success measures.
Ultra-Efficient Haulage: First Rail-Running Belt Conveyor—
to Carry 13,000Mtph in 2024
M. Lurie1, T. Turner1, C. Wheeler2, M. Carr2 and P. Robinson2; 1FL Smith Mining, Greenwood Village, CO and 2University of Newcastle, Callaghan, NSW, Australia

In 2024, the world’s first production conveyor system with the ultra-efficient Rail-Running Belt Conveyor™ technology (RRC) will haul up to 13,000mtph of ROM copper ore over a 3,000m route. An RRC system of this scale can save more than $2,000,000 per year in power costs compared to conventional belt conveyors, with CO2 reductions of 13,000mtpy. A second system of similar length will carry ore at 5,000mtph in July 2025. RRC arrives as the most energy-efficient bulk haulage technology at any scale now available to the mining sector. OPEX reductions will be in the range of 30% to 60% vs. conventional conveyors, varying by the application. Additionally, meaningful CAPEX savings for civils, erection and equipment supply will flow to owners, depending on the terrain, lift and climate. The RRC technology platform also offers a step-change in conveyor maintenance and safety, thanks to wheeled carriages that continuously circulate past an automated inspection and exchange point, eliminating fixed run-of-conveyor idlers. The RRC technology has come to fruition through a collaboration between FLSmith, the University of Newcastle (Australia), and a visionary top 10 global copper miner.

Systems Engineering Approach to Emission Quantification for DRI Grade Iron Ore Processing
K. Aydogdu and S. Duzgun; Mining Engineering, Colorado School of Mines, Golden, CO

This study employs systems engineering methods to calculate carbon emissions in the Direct Reduced Iron (DRI) grade ore processing. A system dynamics model was created to approximate carbon emissions within a sample DRI grade ore processing plant. Enhanced accuracy can be achieved by obtaining accurate power requirements for individual equipment in the plant, contributing to reliable emission estimation. The research emphasizes the significance of precise data for improving the reliability of carbon emissions assessments across DRI grade iron ore processing. By accurately estimating the carbon emissions in each stage, the emissions can be reduced accordingly.

A Sustainable Option to Traditional Polyacrylamide Flocculants
D. Normington and J. Rosas; Kemira, Mojave, CA

Traditional polyacrylamide (PAM) flocculants are manufactured using acrylamide monomer produced from fossil fuel based raw materials. Recently, a new way of manufacturing acrylamide from non-fossil fuel based raw material, such as biobased ammonia and acrylonitrile has been developed and implemented in Europe. The acrylamide is then used to manufacture a new series of products called Bio-balanced line of products. The Bio-balanced flocculants will yield a 50—95% reduction in carbon footprint depending on the amount of raw material substitution and provide identical performance to the standard grades. It is expected that the Bio-balanced flocculants will help customers reach their sustainability targets without the fear of changing the chemistry in their process. These products have already been implemented in several industrial operations in Europe.
treatment system installed in 2009 at the Iron King/Copper Chief Mine near Cottonwood, AZ, USA. The system is designed to treat MIW from two historical underground copper mines. Different technologies are often coupled together, with each technology targeting different subsets of constituents of concern. We assess the long-term effectiveness of a sulfate-reducing biochemical reactor (SRBR) and aerobic polishing cells for improving the quality of adit discharge. SRBRs increase alkalinity and pH of MIW while producing sulfide anions, which, in turn, remove aqueous metal ions through precipitation as metal sulfides. The aerobic polishing cells promote oxic conditions and remove residual constituents further improving water quality. We also discuss operational challenges faced since commissioning and highlight lessons learned in the hopes that other practitioners can also benefit from our experiences at this site.

10:05 AM
Passive Treatment of Mining Influenced Water: Case Histories behind 35 Years of Proven Technology Development
J. Gusek; Linkan Engineering, Golden, CO
Passive treatment of mine water is a process that has matured over the past half century from an emerging technology to a proven methodology, accepted by regulators, volunteer groups, and the mining industry. Systems are designed based on multidisciplinary engineering sciences including biogeochemistry, hydraulics, physics, microbiology, and agronomics to name a few. Groundbreaking milestones over the past 35 years overcome early misconceptions of passive treatment system design limitations including cold weather operation, longevity, sizing criteria, application in acidic MIW situations and more. The presentation will focus on key milestones via a series of case histories.

10:25 AM
Groundwater Contamination Left After Uranium Mill Tailings Removal, from Permeable Reactive Barrier (PRB) to Pump and Treat to Monitored Natural Attenuation (MNA): Is Over 1,000 Years for MNA a Reasonable Passive Treatment Approach? R. Johnson and R. Kent; Groundwater and Geochemistry Group, RSI EnTech, LLC, Grand Junction, CO
At the U.S. Department of Energy Office of Legacy Management Monticello, Utah, Processing Site, uranium concentrations in groundwater have remained above standards, even after the mill tailings were removed. A PRB installed as a demonstration project successfully removed uranium from the groundwater for a few years, but later became much less permeable due to calcite precipitation. The plugged PRB created enough saturated thickness to allow for a pump and treat operation. However, residual uranium continues to be released from the unsaturated zone below the former tailings impoundment. Groundwater flow and transport modeling indicates pump and treat for another 30 years does not remove enough uranium mass to decrease the remedial timeframe; hence, MNA is being considered. Modeling of the MNA scenario indicates groundwater uranium concentrations above standards for an average of 2,300 years (using multiple realizations). Reduction of this timeframe would require extensive removal of low uranium concentration (< 30 ppm) sediments. Supplemental standards were approved for the site, but site regulators are considering if long-term MNA is a reasonable passive treatment approach.

10:45 AM
Geochemical Controls on Mobilization of Metals From Mine Waste and Implications for Passive Treatment Amendments L. Figueroa and S. Doyle; Civil and Environmental Engineering, Colorado School of Mines, Golden, CO
Remediation of legacy mine waste piles options include integration of amendments in the top layer to promote to microbial immobilization processes and improve conditions for growth of vegetation. However, amendments have potential to mobilize metals in waste by introducing new chemicals and altering pH and redox conditions. Metal phases in fine grained weather materials with high metals content of lead, zinc, and copper were evaluated for the potential for these metals to be mobilized by a selection of amendments (topsoil, spent brewery grain, biochar, compost, and commercial soil media). After weathering for decades, the metals phases measured showed an evolution from sulfate phases to include sulfates, phosphates, carbonates, and phases associated with manganese/iron oxides. Sequential extraction tests demonstrated that extractable copper, lead and zinc was associated with manganese/iron oxides, suggesting an environmental risk should geochemically reducing conditions develop and mobilize metals in the fine-grained material after amendment addition. The importance of identifying metal phases present in mine waste prior to selecting amendments is highlighted by this study.

11:05 AM
Onsite Treatability Testing for Selenium Using Passive, Constructed Treatment Wetlands K. Lindstrom, R. Schipper and A. Dykstra; Barr Engineering Co., Ann Arbor, MI
Constructed treatment wetlands are being considered to treat selenium-impacted groundwater associated with an unlined coal combustion residual impoundment at a power generating facility in the Midwest. Site groundwater will be directed upward through the wetland by construction of a subsurface, low-permeability cutoff wall. Onsite testing was completed in two separate 150-gallon test cells to evaluate effectiveness and provide information for detailed design. The two cells incorporated site soils amended with woodchips/compost and were vegetated with cattails. The constructed wetlands demonstrated the ability to remove selenium from over 200 micrograms per liter (μg/L) to below 5 μg/L at hydraulic retention times down to 2.5 days. Testing results are discussed along with the potential use of this technology at mine sites.

11:25 AM
Sulfate Reduction in Bench and Pilot-Scale Passive Treatment Systems G. Fattore; Stantec, Denver, CO
The effectiveness of passive treatment technologies in removing sulfate and low metals concentrations in mine water was assessed in two bench-scale and one pilot-scale tests. The passive technologies used were biochemical reactors, sulfide polishing units, and aerobic polishing wetlands. Bench Test 1 and 2 were able to reduce sulfate from 3000 mg/L to 1200 mg/L and 150 mg/L to 5 mg/L, respectively. The Pilot Test results show that sulfate concentration was reduced from about 900 mg/L to 250 mg/L. Results from the bench and pilot tests suggest that passive treatment technologies are an option for treating mine water.
Developing and Maintaining a Service Line Inventory is no different. Learn from other mines' experiences on how to apply the Guidance and discover innovative techniques for building a defensible service line inventory. Advance your water stewardship by taking the inventory requirement beyond filling out a spreadsheet and turning it into a forward-looking tool you can leverage for years to come.

9:25 AM
Tools for Enterprise and Operational Water Stewardship in Water Stressed Regions
D. Stanley, H. Fleming, A. Yang and P. Guy; Environment & Water, Advisian, Mesa, AZ
Copper producers in many water stressed areas are engaged in a struggle with two geophysical realities which together have a compounding effect: lower and lower ore grades and the need for an increasing amount of water to mine and process them. The mine planning and operational decisions made in this difficult context, and the results of these decisions, are also taking up more space in the ESG reports than ever before, as global attention on water related matters has accelerated. The term "water stewardship", now in common use, illustrates the recognition by the industry that producers must make decisions regarding water that account for both operational needs and the long term needs of host communities. It also suggests that for the water related impacts of their business decisions producers are to hold themselves accountable and allow their stakeholders to do the same. Making decisions that align with water stewardship principles is greatly enhanced when producers have the necessary suite of modeling tools to predict outcomes, data visualization tools to measure and account for actual outcomes, and the standard operating procedures and staffing to effectively manage both.

9:45 AM
Enhancing Small-Scale Mining Operations through GPS Tracking Systems and Engine Immobilization for Controlled Equipment Usage in Restricted Zones
R. Ateng; Technical, Handson Systems, Accra, Ghana
This study examines GPS tracking and engine immobilization in small-scale mining to prevent unauthorized operations in restricted zones. The paper emphasizes potential benefits, including regulatory compliance enhancement, environmental sustainability promotion, and responsible resource management. Small-scale mining significantly impacts local economies and resource extraction. The absence of effective control often leads to environmental damage and safety issues from unauthorized activities. Integrating GPS tracking allows real-time equipment monitoring, establishing virtual boundaries, and alerting operators to breaches. Engine immobilization enhances these safeguards, preventing unauthorized machinery use. The study advocates Ghana’s government consider these technologies for addressing persistent unauthorized mining challenges.

10:05 AM
Predicting Tailings Degree of Saturation Using Hyperspectral Imagery and Machine Learning
J. Bindner, J. Scalia and C. Bareither; Civil and Environmental Engineering, Colorado State University, Fort Collins, CO
Acid generation in tailings can pose environmental risk if not properly managed. The degree of saturation of potentially acid generating tailings influences acid generation, with oxygen diffusion greatly reduced at high levels of saturation. However, there are currently no in situ tailings characterization technologies that provide high resolution estimations of saturation. Hyperspectral images contain information on a materials reflectance at many wavelengths in the electromagnetic spectrum and have shown promise for the prediction of soil moisture and density. The objective of this study is to better understand how machine learning can be used to predict tailings degree of saturation from hyperspectral imagery. Tailings samples were artificially prepared to have varying degrees of saturation and hyperspectral imagery was captured in the laboratory on prepared samples. A one-dimensional convolutional neural network was constructed, calibrated, and used to evaluate the algorithms efficacy at predicting tailings degree of saturation. Results indicate machine learning and hyperspectral imagery show promise for the in situ prediction of tailings degree of saturation.

10:25 AM
Environmental and Economic Benefits from Optimizing Cyanide Destruction Process at Gold Processing Facilities
K. Lyubetica, J. Jacobson, R. Agius, H. Liang and D. Kratochvil; BQE Water, Denver, Colorado, CO
The SO2/Air process is the most commonly applied cyanide destruction technology at gold processing facilities. It involves the oxidation of weak acid dissociable cyanide (WAD CN-) through the addition of copper(II) (Cu2+), as a catalyst, and sulfite (SO32-) normally as SO2/air or sodium metabisulfite (SMBS). This paper presents laboratory, semi-pilot and full-scale testing campaigns aimed to optimize several SO2/Air cyanide destruction circuits. The results showed the potential to reduce several millions of dollars per year in reagents costs and the production of a much cleaner effluent. Strategies for improving the cyanide destruction process include decreasing or eliminating copper dosing, when applicable, and the optimization of the sulfite dosage by minimizing the demand caused by thiocpecies in the circuit feed, among others. Details of the testing campaigns, along with full-scale implementation, will be discussed.

10:45 AM
Advancing Water Conservation, an ESG Initiative, Through Airth Ecosystem an Analytics Platform for Water Management: A Use Case at a Major Copper Operation
E. Fretheim and E. Anderson; airth.io, Oro Valley, AZ
airth.io is a vendor agnostic data and analytics company in the mining industry aimed at improving safety, operational sustainability, and productivity gains with a forward-looking approach. At its core, airth.io has built products by integrating advanced analytics and financial modeling to deliver tailored recommendations for clients. This abstract focusses on a use case at a large copper operation, where water trucks are used to reduce dust; generated from various activities i.e., loading, hauling, drilling and blasting. With no clear visibility to the amount of water consumed, applications in the field (haul roads, digging phase), it resulted in lost opportunity in conserving water usage. The Airth Connect and Aether analytics solutions enables efficient water management decisions based on predictive analytics and real time analytics. By continuously monitoring water usage patterns and quality metrics, supervisors can act proactively. In the above use case, the platform provided real time analytics to supervisors on water usage, its application—reducing overall water consumption by 5%-10%, thereby improving overall ESG kpis and water conservation efforts across the project.

11:05 AM
The Road Taken: A GIS Approach to Construction Quality Assurance
B. Eberle and C. Bolen; 1Stantec, Boise, ID and 2Stantec, Albuquerque, NM
Processing, visualizing and managing daily information overload is a challenge faced across the Mining sector that impacts the ability to make timely, informed decisions on our Mining projects. Stantec Consulting Services Inc. (Stantec) will highlight their road taken in the journey to provide value-added Construction Quality Assurance (CQA) services for mine reclamation projects. Stantec will detail the scalable, Geographic Information System (GIS)-based framework developed to digitally transform daily field activities, engage stakeholders, improve safety, build trust, and memorialize project knowledge in a dynamic, spatially intelligent, near real-time, web-based environment.
11:25 AM
Addressing Mineral Security, Environmental Stewardship and Renewed Community License to Operate & Trust Using Satellites and Hyperspectral Analysis
R. Weaver; Business Development, Orbital Sidekick, San Francisco, CA

Having long been promised, new satellite technologies are now on-line offering private operators access to hyperspectral data and actionable insights to aid in mining exploration, site development, production stewardship and site closure and restoration activities. This couldn’t come at a more needed time. With demand for battery and other critical and precious minerals at an all time high, the mining industry today is facing the greatest opportunity in our lifetimes. At the very same time, the industry is facing its greatest challenge as production in unfriendly regions is demanding expansive new production much closer to home while community trust and its license to operate seems to be at an ebb. This presentation will provide examples of insights from monitoring activities using customized tasking of the latest generation of satellite-borne hyperspectral sensors. And discussion will focus on how such tailored data collection and analysis can be applied to solve some of today’s most pressing mining lifecycle challenges.

WEDNESDAY, FEBRUARY 28 MORNING
GROUND CONTROL: FROM SURVEILLANCE TO PRACTICE
North 128B
9:00 AM • Wednesday, February 28
Chairs: M. Sears, CDC/NIOSH, Pittsburgh, PA
M. Van Dyke, NIOSH, Pittsburgh, PA

9:00 AM
Introductions

9:05 AM
24-087
Thermal Runaway Pressures as a Function of Free Space in Sealed Containers for Lithium Titanate Cells
C. Brown, T. Dubaniewicz, T. Barone and R. Thomas; CDC NIOSH, Pittsburgh, PA

Electric vehicles, powered by lithium-ion (Li-ion) batteries, are being developed by mining equipment manufacturers. Explosion-proof (XP) enclosures are designed to enclose electrical ignition sources to prevent the spread of an internal methane-air explosion to a nearby explosive atmosphere. NIOSH researchers used an Accelerating Rate Calorimeter (ARC) to force the thermal runaway of Lithium Titanate or Lithium Titanium Oxide (LTO) type 18650 cells and found an inverse power relationship between the TR pressure and available free space. Temperatures, gas amounts, and TR pressure-rise rates inside enclosures were recorded. The data indicates that with enough free space, the pressures can be lowered below the conventional pressure specification for XP enclosures.

9:25 AM
A Review of the Impact and Utilization of the MSHA Accident Dataset in Research Studies
H. Kaydim and D. Tuncay, Mining Engineering, West Virginia University, Morgantown, WV

The Mine Safety and Health Administration (MSHA) holds the crucial responsibility of enforcing safety regulations, providing safety training, and conducting mine inspections. They provide a publicly accessible accident dataset that includes mine and operator ID, accident time, location, type, source, victim’s job title, experience, injured parts of the body, number of days lost, and narratives of these accidents, among other information. This dataset is especially useful for analyzing the relationship between different parameters and accident occurrence. Different researchers focused on various topics using the MSHA accident dataset, such as equipment role in accident occurrences, rock falling injuries, and human factors. However, a significant challenge emerges due to the absence of a comprehensive tool for examining this extensive dataset. This study aims to explore how the MSHA accident dataset has been used in different research studies, highlighting how it plays a crucial role in improving safety. Additionally, this study proposes a practical analysis tool to make the dataset even more useful and accessible by turning raw data into valuable insights with machine learning.

9:45 AM
24-009
An Integrated Method to Classify Ground-Fall Accidents and to Estimate Ground-Fall Trends in US Mines Using Machine Learning Algorithms
G. Rashed, Y. Xue, C. Brown, Z. Khademian and K. Mohamed; NIOSH, Pittsburgh, PA

Ground falls in U.S. underground coal mines can lead to significant consequences including loss of life, injuries, damaged equipment, and production stoppage. Therefore, improving the safety of the workplace is of utmost importance for mine workers and the U.S. economy. The Mine Safety and Health Administration dataset provides short narratives for ground-fall incidents, however, it does not classify them based on the main cause of the incident which is necessary to research to address mitigation strategies. The main objective of this project is to develop a framework that includes: 1- Utilizing machine learning algorithms to categorize incident narratives based on the main cause of the occurrence. 2- Develop a user-friendly dashboard to illustrate injury/fatality rates in U.S. coal mines between 1983-2021. The developed framework was tested on a subset of the data and achieved on average F1-score of 96% in categorizing the incidents. The project’s outcome will help identify areas requiring additional research and innovative solutions to reduce severe occupational hazards.

10:05 AM
24-077
Quantifying the Texture of Coal Images with Different Lithotypes Through Gray-Level Co-Occurrence Matrix
Y. Xue1, K. Mohamed2, M. Van Dyke2, D. Guner1 and T. Shenzadeh1; 1 National Institute for Occupational Safety and Health, Washington, DC and 2 Mining Engineering, Missouri University of Science and Technology, Rolla, MO

The Coal Pillar Rib Rating technique has been developed to assist in rib support design in underground coal mines. One major challenge of the data collection process is the determination of coal strengths in the field, and coal lithotypes have been used to obtain the representative strength. Data collection process is the determination of coal strengths in the field, and coal lithotypes have been used to obtain the representative strength. In this paper, Gray-Level Co-Occurrence Matrix was used to analyze the textures of coal images collected in underground coal mines. The results show that the images of coal with different lithotypes have different textures, demonstrating the potential of classifying coal lithotypes using rib photos and easing the data collection process.

10:25 AM
Ground Control: From Surveillance to Practice
M. Van Dyke; Ground Control, NIOSH, Pittsburgh, PA

Attempts throughout the history of mining have tried to link geology to optimal roof support systems. This presentation will cover methods of collecting geologic data and converting it into usable information for engineers to design effective support designs. The geologic data collection topics will cover corehole drilling, e-log interpretations, fiber and video scope observations. Within the geologic observations certain conditions must be described such as bedding thicknesses, inclusions, and geologic contact changes that could affect the interpreted strength of the rock body. From the interpreted geologic description, geomechanical engineers must determine the appropriate support for the entry based
on many factors such as the availability, ease of installation of standing supports, length and diameter of roof bolts, and the best spacing between these supports based on the geologic assessment and the overall strength of the rock mass. The combination of an accurate geologic description and engineering support design will provide the best situation to ensure mine entries are safe and promote worker safety and health.

10:45 AM
24-049

Ground Control Monitoring: A Comprehensive Guide for Practitioners on Instrumentation and Data Acquisition Currently Used by the National Institute for Occupational Safety and Health (NIOSH)
T. Minoski, M. McElhinney, M. Mazzella, C. Compton and M. Sears; NIOSH, Pittsburgh, PA

The ground control teams at the Pittsburgh Mining Research Division (PMRD) of the National Institute for Occupational Safety and Health (NIOSH) are actively engaged in research to prevent ground failures that could result in injuries or fatalities among mine workers. These teams utilize a variety of field instruments to monitor changes in pressure, strain, vibration, and displacement within the underground mining environment. This paper provides a comprehensive guide on the application, installation, and data acquisition processes of these instruments. The data collected, when combined with geologic data and stress mapping, empowers mine operators to make informed, engineering-based decisions, especially in challenging mining environments.

11:05 AM
24-012

M. McElhinney, C. Compton, T. Minoski, M. Mazzella and M. Sears; NIOSH, Pittsburgh, PA

Researchers with the National Institute for Occupational Safety and Health (NIOSH) are frequently involved in field studies at collaborating mines. This paper details best practices associated specifically with instrumentation installation including the mitigation of hazards associated with proper equipment handling, drilling, and the mine environment. The information showcased in this paper can be used as considerations for industry practitioners such as mine operators, consultants, and academic researchers engaged in the installation of instrumentation in the field. This will result in enhanced safety of both researchers as well as mine employees who are tasked with conducting field studies.

11:25 AM

Review of Brittle Failure Mechanisms in Underground Excavations
M. Suner and D. Tuncay; Mining Engineering Department, West Virginia University, Morgantown, WV

Brittle failure in underground environments predominantly emerges as a sudden, fracture-propagating failure, typically absent or with minimum plastic deformation. This phenomenon holds significant consequences for both mine stability and the safety of mine workers. Brittle failure often manifests itself through the spalling of the excavation surfaces. Critical analyses involving the rigorous examination of in-situ stress conditions, intact and rock mass mechanical properties, and excavaion-induced stress perturbations have crucial importance. Through advancements in rock mechanics, researchers have quantified brittle failure mechanisms at both intact rock and rock mass scales, employing empirical and computational methods supported by field observations. These studies led to the establishment of constitutive models, which are utilized to further investigate the failure of the intact rocks and to simulate stress redistributions during underground excavations. Then, this presentation endeavors to offer a comprehensive review of brittle failure mechanisms, aiming to enhance understanding and facilitate the application of improved ground-control practices in underground stone mines.

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changes, such as ventilation upgrades and machine maintenance, provided valuable insights into their effectiveness in controlling respirable dust levels. This approach enhances workplace safety and supports informed decision-making and continuous improvement via increased data collection and monitoring.

10:05 AM
**Assessment of Sub-Micrometer-Sized Particles with Practical Activities in a Modern Underground Coal Mine**
Y. Chen, A. Munoz, C. Krause, J. Brune, and C. Tsai; University of California Los Angeles, Los Angeles, CA and Colorado School of Mines, Golden, CO

This assessment was designed to explore and characterize the airborne particles, especially for the sub-micrometer sizes, in a modern underground coal mine. Airborne particles of general area and related to personal in the mine were evaluated by using direct reading real-time instruments (RTIs) to measure area real-time particle number concentrations and gravimetric samplers to collect particles to obtain mass concentrations and characterizations. Area and personal airborne mine particles were collected via three samplers: a 37mm cassette (PVC filter), a 10mm Nylon cyclone with 37mm Zefon cassette (PVC filter), and a Tsai diffusion sampler (TDS). Particle morphology and compositions were characterized using electron microscope (EM). RTIs reading showed that the belt area (~34670 particles/cm²) had a greatly higher total particle number concentration than both the mine entrance and office building. The belt area not only exhibited the highest total particle number concentration, but it also had distinct particle size fractions. The data supports that small particles less than 300 nm are predominantly exist and associated with practical activities.

10:25 AM
**Contributions of Sources to Respirable Coal Mine Dust and Crystalline Silica in an Underground Coal Mine**
X. Wang, M. Elahifard, B. Osho, L. Chen, J. Chow, J. Watson and B. Abbasi; Atmospheric Sciences, Desert Research Institute, Reno, NV; University of Nevada, Reno, Reno, NV and University of Nevada, Las Vegas, Las Vegas, NV

Quantifying the contribution of different sources to respirable coal mine dust (RCMD) and respirable crystalline silica (RCS) in mining environments is important for dust control and exposure mitigation. This study collected ambient and source samples from an underground coal mine and conducted detailed chemical speciation. The effective-variance chemical mass balance (EV-CMB) model was used to apportion RCMD and RCS contributions from coal dust, fire suppression limestone dust, rock strata particles, diesel engine exhaust, and intake air. Among the three locations with the highest RCMD concentrations, the limestone dust contributed ~80% to the RCMD mass in the tailgate and return air, while coal dust contributed 51% to the RCMD mass at the longwall face. Intake air dominated the RCMD mass at locations with low concentrations, indicating that these locations were effectively ventilated by intake air. Diesel exhaust is a minor contributor to RCMD mass at most locations. Limestone and rock strata are the main sources of RCS, supporting the concerns for more RCS generation due to the more powerful mining tools cutting more into rock strata.

10:45 AM
**Sensor Fusion Approaches to Bridge the Gap Between Personal and Area Monitoring in Underground Mines**
K. Brown Requist and M. Momayez; Mining and Geological Engineering, University of Arizona, Tucson, AZ

The monitoring of respiratory exposures in underground mines is critical to successful operations. Respiratory exposures from various sources are of general concern, and regulations for dust and silica have recently been a major focus. Personal monitoring of miners is generally limited to one person, and area monitoring may not provide an accurate indication of exposure. With a well-calibrated mine ventilation model and sensor fusion methods, we propose a framework to estimate respiratory exposures for all miners based on RFID tracking and real-time monitoring. The proposed framework can be integrated in a digital twin of a mining operation to improve safety.

11:05 AM
**Case Studies of Video-Assisted Exposure Monitoring for Respirable Mine Dust**
E. Caulda, M. Yekich, J. Robinson, C. Valin and P. Knott; Pittsburgh Mining Research Division, NIOSH, Pittsburgh, PA; Covia Unimin, Independence, OH; Teck Resources Ltd, Toronto, ON, Canada and GCG Health Safety & Hygiene, Hendra, QLD, Australia

Real-time monitors can provide important information on the exposure of workers to respirable dust and spatio-temporal evolution of the concentration in the mining environment. The combination with video monitoring has been proposed as an approach to collect contextual information critical for analysis and decision making. The implementation of this approach is presented in this contribution through four cases studies from NIOSH researchers, an Australian consultant firm, and two mining companies in the US and Canada. The case studies will describe details and examples of data collection, data interpretation and manipulation and in general benefits and limitations of this approach.

11:25 AM
**What’s in the Dust? Application and Continuous Improvement of SEM-EDX Analysis to Advance the Understanding of Respirable Mine Dust**
D. Sweeney, E. Sarver and C. Keles; Mining and Minerals Engineering, Virginia Tech, Blacksburg, VA

It has long been understood that exposure to various respirable particulates can lead to long term health effects, and increasingly there is a focus on understanding the specific factors which are responsible. For example, the dramatic resurgence of lung disease among US coal miners has prompted significant research into dust characteristics and disease pathology. Over the past decade, our research team has been working to apply scanning electron microscopy with energy dispersive X-ray spectroscopy (SEM-EDX) to respirable coal mine dust samples from numerous operations. This technique is non-destructive and enables analysis at the particle level, but no standard method exists so we have worked to develop our own. This presentation will discuss our efforts towards continuous improvement, including a recent project to establish particle classification criteria that can account for loading effects on the sample substrate. This capability is particularly important for direct-on-filter analysis of mine dust samples since loading is difficult to control during field sampling.

WEDNESDAY, FEBRUARY 28 MORNING

INDUSTRIAL MINERALS & AGGREGATES: CRITICAL AND BATTERY MINERALS II

North 126A

9:00 AM • Wednesday, February 28

**Introductions**

9:05 AM
**Investigation of Process Intensification Role in Solid-Liquid Separation Techniques for the Recyclable Samarium-Cobalt Magnet**
Z. Nasrullah and O. Adebayo; Metallurgical and Materials Engineering, Montana Technological University, Butte, MT
To sustain the circular economy, defense applications, and other smart
technologies, recycling of Samarium-Cobalt magnets (Sm-Co) is critical.
In the past, solid-liquid separation methods have given good recovery
of Sm-Co, but have limitations associated with slow mass transfer,
and leaching time with Deep Eutectic Solvents (DESs). Our approach is
to improve the slow mass transfer and leaching time in the solid-liquid
separation methods while using DESs. In this research study, we will be
doing chemical leaching of Sm-Co with four different combinations of
DESs, which are proven to be green, non-toxic, biodegradable and selective.
To improve the slow mass transfer, and leaching time, the technology
of Resodyn Acoustic Mixer (RAM) will be tested. This new technology
intensifies mixing with the power of resonance and sound energy. It has
been proven to improve the adsorption kinetics and will be tested to
improve the leaching kinetics by our group. After leaching, the samples
would be tested with and without intense mixing. Leaching Efficiency
is expected to improve with a decrease in leaching time and increased mass
transfer. Such interesting findings will boost recycling of REEs.

9:25 AM
24-086
The Potential of Lithium: Peruvian Case
A. Huamán Cocrhua, J. Rosas Ventura and C. SOTO, Apurímac, Universidad Nacional Micaela Bastidas de Apurímac (UNAMBA), Tamburco, Abancay, Peru
This research work presents the situational description of the lithium
potential in Peru, specifically the Falchani Deposit located on the
Macusani plateau in the Carabaya province of the Puno region. This
deposit is estimated to possibly be the great southern reserve of Peru.
Likewise, it demonstrates the use of statistical techniques to model
and make predictions for this metal that enables the energy transition.
Academic sources were reviewed, allowing for a comparative approach
and future projection of lithium for its development in the mining industry.
A promising future for lithium can be indicated according to the findings,
such as by 2025 1.5% and by 2030 3.0% of the world’s lithium reserves
being located in Peru with respect to the global context.

9:45 AM
Determination of Rare Earth Element, Th and U Bio-mining
Extraction Efficiency From Coal Ore Utilizing Industrial Simulation Bioreactors
M. Martinez1 and B. Briggs2; 1Chemistry, University of Alaska Anchorage, Anchorange, AK and 2Biological Sciences, University of Alaska Anchorage, Anchorange, AK
Microbes are useful in developing new systems for mining Rare Earth
Elements (REEs). Conventional methods which boil sulfuric acid may
affect freshwater sources by contaminating them. This project assessed
microbial weathering processes at circumneutral pH to extract REE,
Thorium and Uranium, which are critical in energy technologies. United
States coal and Australian reference standard were extracted with
Shewanella oneidensis. Bioreactors were set up with 15.0 grams of ore,
purged with nitrogen gas at 0.5 sL/H, rotor speed 200 rpm, and 37C. Oxygen
was added in during cycling days for 2 hours. Two abiotic controls and
six biotic vessels were used. ICP-MS was used for metal quantification in the
resultant leachate. Coal and reference standard samples had 671.6 ppm,
and 258.46 ppm of total REEs. Bioreactors inoculated with S. oneidensis
extracted significantly more REEs than controls. Final bacterial cells
were concentrated and rinsed with diluted acid to determine metals
adsorbed as this may signify separation. p=0.023 for water rinse versus
dilute acid to detach REEs from the cell surface. The results indicate
biomining has potential to offer a sustainable method to extract REEs.

10:05 AM
Rare Earth Mineral Flotation—A Comparison of Silicates to
Oxides, Carbonates and Phosphates
A. Mamudu, T. Bayless and C. Young, Materials and Metallurgy, Montana
Technological University, Butte, MT
Rare earth minerals (REMs) are often recovered from ores using flotation,
a technique that selectively separates the REMs from gangue minerals
based on differences in hydrophobicity. However, flotation results are
usually inconsistent, a phenomenon attributed to the REMs being solid
solutions with varying concentrations of rare earth elements (REEs).
Previous investigators at MT Tech controlled the REE content by examining
“out-of-the-bottle” reagent-grade chemicals as pure synthetic REMs. After
monitoring collector adsorption on rare earth oxides (REOs), carbonates
(RECs) and phosphates (REPs), they concluded that REM flotation was
controlled by REM type and REE cation size and ultimately by coordination
number (CN) and lanthanide contraction (LC). These investigations
have now been extended to rare earth silicates (RESSs). However, in this
case, various types of RESSs were synthesized in the Metallurgical and
Materials Engineering labs at MT Tech. X-ray Diffraction (XRD) was used
to determine the RES types. While collector adsorption on the RESSs
was found to be comparable to that on REOs, RECS and REPs, results suggest
that the effects of CN and LC also depend on the RES type.

10:25 AM
Strategic Metals Recovery From Current Production and
Processing Streams
P. James; Blue Planet Strategies, Madison, WI
Hydrometallurgical process, bleed, and waste streams often contain
substantial amounts of secondary which are considered strategic metals
and may go unharvested or even lost as a result of conventional processing.
New evolving capabilities in selective electrowinning and electrolytic
neutralization are creating new opportunities to harvest such metals
during the normal course of primary product metal processing. Examples
of applying selective electrowinning and electrolytic neutralization to
illustrative target sources will be illustrated. Removal and separation
for recovery of recovery of selected strategic target metals present in
the mixed-metal production solutions presented. Higher tenor recovery
of lower-value strategic metals such as manganese and bismuth will be
considered as will lower tenor recovery of higher value constituents such
as rhenium and tellurium. Recovery levels, product purity and product
treatment unit cost ($/mass) will be examined for the note target metals.
Criteria to consider for site-specific application of the noted treatment
options will be discussed.

10:45 AM
China’s Influence on Cobalt
A. Gulley; U.S. Geological Survey, Reston, VA
During a 2010 diplomatic dispute, China blocked exports of rare earth
elements to Japan—leveraging China’s near monopoly to threaten
Japanese manufacturers of advanced technologies. Although this caused
near panic outside China, China’s influence over other critical minerals has
not been studied comprehensively. Here I estimate influence via overseas
ownership, offtake agreements and domestic production at each stage
of the cobalt supply chain from 2000 through 2020. The results show
that China is targeting cobalt materials required for battery production
and has swiftly attained near monopoly control of battery-grade cobalt
chemical production like that of rare earth elements in 2010.

WEDNESDAY, FEBRUARY 28  MORNING
INDUSTRIAL MINERALS & AGGREGATES:
INNOVATIONS IN INDUSTRIAL MINERALS AND
AGGREGATES II
North 125B
9:00 AM • Wednesday, February 28
Chairs: G. Tomaino, Minerals Technologies Inc, Easton, PA
B. Li, Michigan Technological University, Houghton, MI
9:00 AM  
**Introductions**

9:05 AM  
**Managed Aquifer Recharge as a Post Mining Adaptive Reuse**  
J. Sackrider; Westward Environmental, Inc., Boerne, TX

Exacerbated by recent drought conditions across the County, the availability of drinking water is a growing concern for people within and outside of the mining industry. Managed Aquifer Recharge (MAR) offers potential relief to depleting aquifers nationwide while simultaneously extending the functional life and benefit of quarries long after their reserves have been depleted.

10:25 AM  
**Achieving High REE Extraction from Hardrock Ores Using Innovation and Recognition of the Specific Ore Mineralogy**  
D. Connelly; Process, METSEngineering Group, Perth, WA, Australia

Achieving High REE Extraction from Hardrock Ores using Innovation and Recognition of the Specific Ore Mineralogy. D Connelly Principal Consulting Engineer, METS Engineering Group, Perth. Damian.Connelly@ metsengineering.com  
Keywords: mixed rare earth carbonates, rare earth elements, bench scale testwork, cracking, critical minerals, radioactive RE waste  
ABSTRACT The rare earth industry is currently undergoing an unprecedented resurgence driven by the electric vehicle revolution. Each rare earth orebody is different but invariably consists of several rare earth elements that need to be recovered for the process to be economically viable. This necessitates the use of multi-unit processes and the need to deal with complex chemistries. Thus, the process flowsheet, which can become extremely complex, is project specific. So, it is common to limit production to mixed rare earth carbonate products but still requires numerous testwork to optimise, rendering the development timeframe to take around six years at best.

9:00 AM  
**Introductions**

9:05 AM  
**Impact of New Technologies and Government Regulations on the Mineral Mining Industry**  
J. Cowie; Essential Minerals Association, Arlington, VA

New technologies have the potential to significantly impact the mineral mining industry in several ways. This presentation will discuss a myriad of advancements and their potential effects on mining minerals. Technologies that will impact mining include the following: Exploration and Surveying: Advanced Remote Monitoring and Automation: Internet of Things (IoT) devices and sensors, Digital Twin and Modeling, Data Analytics and Predictive Environmental Monitoring and Sustainability. Advanced Extraction Energy Efficiency Robotics and 3D Printing and Additive Manufacturing Resource Management. New regulations in the United States can influence mineral mining in various ways, including environmental protection, permitting processes, land use, and more. Environmental Protection Permitting and Approval Land Use and Access Restrictions, Community Engagement, and Social Responsibility. Reclamation and Closure Obligations. Waste Management and Tailings Disposal. Mineral Supply Chain Transparency. Climate Change and Energy Use.

9:25 AM  
**Well That Was Unexpected. Results From Siting a Water Well Location Using Resistivity to Image 1,000 ft. Into the Subsurface in Southwest Texas**  
M. Lee; Westward Environmental, Boerne, TX

Westward has been involved in the development of a large mining project in Southwest Texas for the last three and a half years. From a geology viewpoint, a lot has been done but there is still much more to do in this structurally complex area of Texas to adequately define the deposit. When your site is 7,000+ acres, that’s a lot of ground to cover and drilling it all is exceptionally cost prohibitive. When Westward was charged with determining the best location for a deep water well, the obvious answer was to not drill it. With the numerous faults identified in previous exploration and mapping events, we learned that the groundwater was highly compartmentalized in the area. Electrical Resistivity Tomography (ERT) was used to locate buried structure that would affect the direction of groundwater flow in the subsurface. Using a pole-dipole method and infinity node set up, Westward was able to image down to approximately 1,000 ft. along six separate profiles that covered ~16,800 linear feet. The results were mixed with a couple profiles showing what was expected, and a few that were far from what was expected.

9:45 AM  
**Who Turned on the Lava Lamp? How Volcanism in Southwest Texas Has Affected the Lay of the Land**  
M. Lee; Westward, Boerne, TX

When one thinks about Texas, BBQ and cowboys in wide open spaces usually come to mind first, not volcanoes. However, the Southwest Texas region is home to a prolific igneous field that made its mark on the landscape both on the surface and below. This area is part of the extensive Balcones Igneous Province. The igneous fields have many scattered extrusive features in some locations but most are intrusive and not visible. The United States Geological Survey (USGS), in conjunction with the San Antonio Water System (SAWS), arranged to have an aeromagnetic survey of the region flown in 2001, and published in 2007. The intent was to map the subsurface structure that could affect the flow of groundwater in the Edwards Aquifer. This aquifer has been designated by the Environmental Protection Agency (EPA) as a Sole Source Aquifer. The results from the survey indicate a complex subsurface with numerous structural controls that do not dictate groundwater flow, but also the location of several formations in the region currently being mined. This presentation will visit one area in the region where the structure has created a geologic upside down cake for groundwater and mining.
and ask ourselves ‘what value does this sampling deliver?’, we often struggle to construct a clear or rational answer. After posing this question to Newmont’s underground teams, we have begun reviewing existing processes to determine a balance between maximizing personnel’s time, reducing costs, and improving data quality while having a clear technical objective. The key focus is improving planning practices to support collection of high-confidence data for the business plan versus the regular fallback of last-minute production sampling.

9:45 AM
Enhancing Underground Reserves and Profitability: Leveraging Deswik’s Pseudoflow for Superior Results at Nevada Gold Mines
P. Schmiesing; Mineral Resource Management, Nevada Gold Mines, Banks, OR
Nevada Gold Mines achieved augmented underground reserves via Deswik’s Pseudoflow, elevating overall profitability while marginally reducing the head-grade. While the use of Breakeven Cutoff Grade (BCOG) is based on average mining costs, Pseudoflow enable precise economic scrutiny of mining task expenses. Pseudoflow facilitates inclusion of sub-BCOG mining shapes with efficient access development for instance, while excluding high cost mining shapes that are above BCOG, requiring extensive rehab or development for instance. In addition, Pseudoflow’s output identifies marginal areas primed for swift redesign. The result: amplified mine-wide profitability.

10:05 AM
Leveraging Ore Control for Conditional Simulation in a Large Open Pit Operation
P. Shepherd, C. Wilson and C. Da Silva; Nevada Gold Mines, Elko, NV
In [gold] mining, ore control ideally feeds into the resource and reserve modeling process and is used to calibrate models through reconciliation. Simulation data is commonly used in project evaluations to understand the project’s uncertainty and then is replaced by blast hole reconciliation data after production. At Nevada Gold Mines, as a best practice we are continuing the use of these simulations into production, which requires the calibration of the simulation to reconciliation data. Once calibrated the simulation can then be used to assist with short term ore control risks.

10:25 AM
Advancing Geological Understanding: Detailed Local Characterization of a Narrow- Vein Gold Deposit Using a High-Resolution Digital LiDAR Tool
I. Meghji; RockMass Technologies, Orillia, ON, Canada
The complexity of operations in an underground mine pose challenges in conducting comprehensive geological mapping. Typically, there is a short window of opportunity for access to active underground workings, and this issue is compounded with limited personnel. Geological complexities within the deposit are difficult to map precisely using conventional paper-based manual mapping methods. These methods require transcription, post-processing and integration of the data collected in order to be viewed in 3D geological modelling software. A case study is presented where detailed geological data is captured digitally in a localized area of a narrow-vein gold mine. The workflow consists of using LiDAR-based technology to: 1) quickly capture and geo-reference 3D point clouds, 2) map and digitize geological features, and 3) use a 3-Dimensional Axis Mapping (3DAM) algorithm to measure and digitize structural orientation data. The digital data is then integrated into industry-standard geological modelling software where it is combined with borehole data. The combination of these datasets results in more a comprehensive and accurate depiction of the geological features within the deposit.

10:45 AM
Mining Truths: Continuous Improvements for Global Reconciliation Systems
L. Osadchuk; Resource Modeling, Newmont, Calgary, AB, Canada
Mine reconciliation is not a one size fits all process. Newmont has a world-class portfolio that consists of multiple mining and processing methods. To report, investigate, and action meaningful reconciliation results, multiple considerations are applied using our global reconciliation reporting framework. Implementing and standardizing data-driven approaches to analyze stop e performance and polygon compliance will provide visibility into the trends and operational issues that drive mining performance. Furthermore, defining meaningful reconciliation practices for differing processing methods (leach versus mill) and underground mining methods (stopping versus caving) can also direct and improve business decisions. Thus, applying enhancement strategies to update global reconciliation systems positively impacts the effectiveness of reconciliation in identifying continuous improvement opportunities company-wide.

WEDNESDAY, FEBRUARY 28 MORNING
MINING & EXPLORATION: GEOSCIENCES: SME/ AIPG: GEOLOGICAL REVIEW OF CRITICAL MINERALS
North 223
9:00 AM • Wednesday, February 28
Chair: J. Brinton, Ridge Runner Consulting

9:00 AM
Introductions

9:05 AM
Mineral Prospectivity Mapping of the Carbonated Hosted REE Deposit of Mountain Pass, California, Using Geodata Integration
N. Esmaeilzadeh; Department of Earth, Environmental, and Atmospheric Sciences, Western Kentucky University, Bowling Green, KY
Rare Earth Elements (REE) are crucial for numerous high-tech and green industries. Their strategic importance necessitates the exploration and discovery of new deposits. Our research incorporated a multi-source geoscientific data processing framework, including geophysical, geochemical, geological, and remote sensing data, to generate mineral prospectivity maps. Fuzzy logic and machine learning models were combined to calculate the favorability for REE mineralization based on causative evidence layers. Geophysical data revealed detailed magnetic and gravity signatures, indicating potential REE-enriched zones. Geochemical data, including the distribution of key elements (like Ce,Nd), were utilized to understand the geochemical behaviors of REEs in the study area. Geological data, including lithology, structural geology, and mineralogical associations, were incorporated to add context to the mineralization processes. In addition, remote sensing data identified alteration zones potentially linked to REE mineralization. The resultant mineral prospectivity map showed several promising zones for REE mineralization, some of which coincide with known deposits, thereby validating our approach.

9:25 AM
Critical Minerals on Tribal Lands—Considerations of Sustenance Lifeways: An Overview of Mineral Exploitation Impacts
L. Suter; Natural Resources, Tohono O’odham Nation, Sells, AZ
Within the US there are 574 federally recognized Sovereign Nations, representing a diversity of ecosystem environments from sea to shining sea. The area of all reservations is 2% of the total area of the US and of the untapped critical minerals in the US, 97% of nickel, 89% of copper, 79% of lithium and 68% of cobalt—all considered key for energy transition—are on or within a few miles of tribal lands; which underscores the need for
additional considerations of Indigenous knowledge systems. In 2021, the census counted 9.7 million American Indian/Alaska Native people, which all have ties to their water, air, land, soil, and local food and resources to maintain traditional cultural customs, activities, and sustenance diets. Traditional cultural lifeways have not faded away as settlers intruded but today they are alive and vibrant, albeit potentially adversely impacted by natural resource degradation associated with mining. For policy makers and regulators, recognizing the role of tribal culture in decisions is important. Braiding Indigenous knowledge systems with scientific best practices (Indigenization) is key towards influencing positive protective mining policy.

9:45 AM
20-044
Geochronology and Critical Mineral Potential of Selected Laramide Porphyry and Related Deposits in Southwest New Mexico
K. Stafford; V. McLemore; and N. Iverson; Mineral Engineering, New Mexico Institute of Mining and Technology, Socorro, NM and New Mexico Bureau of Geology and Mineral Resources, Socorro, NM

Southwestern New Mexico is part of a large belt of Late Cretaceous to Eocene copper porphyry deposits found in New Mexico, Arizona, and Mexico. These deposits are the result of arc magmatism that occurred during the Laramide orogeny. Recently, attention has been brought to other commodities that can be extracted as by- and co-products, many of which are critical minerals. A new compilation of the geochronology of these deposits shows two main pulses of magmatism that produced mineralized deposits and, along with new dates by the author, shines new light on the geologic history of these deposits and the role it plays in critical mineral abundance.

10:05 AM
The Hermosa Critical Minerals Deposit—A Geological Overview and Exploration Learnings
R. Wilson; South32 Inc, Tucson, AZ

In this talk, we will discuss the geologic setting and exploration learnings for the Hermosa Project. The Hermosa Deposit is a critical mineral polymetallic carbonate replacement and skarn deposit located in southern Arizona. The project comprises the zinc-lead-silver sulphide Taylor mineral resource, the manganese oxide Clark mineral resource, and the copper-sulfide Peake Prospect mineral resource. The Taylor mineral resource contains 153 million tonnes, averaging 3.53% zinc, 3.83% lead, and 77 g/t silver. Copper intercepts at the Peake mineral resource include 139m @ 1.88% copper. The deposits are hosted in Permian carbonates of the Naco Group and Jurassic/Triassic volcanics. Mineralization is interpreted to be related to the Laramide Orogeny and nearby copper porphyry deposits. Exploration geophysical methods to date include magnetotellurics, direct current induced polarization, VTEM (versatile time domain electromagnetic), magnetic, gravity, DHLEM (downhole electromagnetic), and passive seismic surveys. All the surveys had varying degrees of success for geological interpretation and exploration targeting.

10:25 AM
Intelligent Critical Minerals Exploration in Missouri for Boosting US Smart Technologies
S. Adiwokor and S. Frimpong; Mining and Explosive, Missouri University of Science and Technology, Rolla, MO

In 2021 and the beginning of 2022, the prices of many critical minerals increased broadly and were accompanied by high volatility, especially for Tin, Nickel and Lithium. However, geopolitical tension and COVID-19 pandemic have resulted in a canker currently known as “Chipageddon” defined as global silicon chip shortage. The USGS must identify requisite remediation to this economic disruption stemming from 2020, and this effort has contributed to the revision of the critical minerals list from 35 to 50. Hence, the rise of global exploration and investment in critical mineral development by 20% from 2021. This paper attempts to utilize machine learning and geospatial intelligence to explore critical minerals to bridge the gap between the demand and supply of these minerals. The authors acquired geologic data, mine locations, supply weights developed by USGS as the key datasets centered in Missouri. The two methods adopted were supervised learning and suitability analysis. Supervised learning aimed at detecting critical minerals with the peak demand in Missouri. Finally, the suitability analysis points out potential mines and prospective critical mineral location that can be mined.

10:45 AM
Natural Graphite Exploration Project in South Korea
S. Shin, S. Jeong, S. Oh, M. Yi and S. Cho; Mineral resources research division, KIGAM, Daejeon, Moldova (the Republic of)

Electromagnetic (EM) survey of drone based is a challenging topic in geophysics. The EM survey is effective to identify underground conductors. Natural graphite is electrically conductive as metals. We presented 3D electrical resistivity tomography (ERT) results identifying the conductive bodies in a graphite deposit, South Korea in 2023 SME annual conference. We conducted the EM survey in the graphite deposit again to demonstrate its applicability. Before the field survey, we checked stability of the EM system. We were able to obtain acceptable signals. The EM system consists of drone, receiver, transmitter, and electric cables. We spread the electric cables as a ground loop around the survey area and then connected both ends of the electric cables with the transmitter. The receiver was hung under the drone. The EM survey enables us to efficiently acquire data in extensive area with small persons compared to the 3D ERT survey. We obtained the acceptable EM results comparing the 3D ERT results. We believed that the EM survey is applicable to graphite deposits.

11:05 AM
The Geology and Ore Deposit Model of the High-Grade Emily Manganese Deposit, Cuyuna Range, Minnesota
D. Peterson; Big Rock Exploration, Duluth, MN

The Emily deposit is the highest-grade manganese resource in the USA. The deposit is located along the western margin of the Paleoproterozoic Animikie Basin and is hosted by the Emily Iron Formation, a shallow water Superior type iron formation. Recent work by Big Rock Exploration on a drilling program for Electric Metals has identified coherent zones of high-grade mineralization (30 to ≥40 wt.% Mn) over a 1.2-kilometer strike length. An ore deposit model has been developed that incorporates the oxidation of primary thin-bedded manganese-iron carbonates into massive manganese oxide through early folding and prolonged periods of weathering, oxidation, and erosion.

WEDNESDAY, FEBRUARY 28  MORNING
MINING & EXPLORATION: GEO SCIENCES: YOUNG GEO SCIENTISTS IN THE WORKPLACE: PANEL DISCUSSION

10:00 AM
Introductions
E. Freeman

10:15 AM
Roadblocks & Breakthroughs Facing Young Geoscientists in the Modern Workplace
E. Freeman Hobler; University of Alaska Anchorage, Anchorage, AK

This discussion focuses on the challenges facing recent geoscience graduates in the modern workplace. Current roadblocks include technological...
disruptions, interdisciplinary demands, and sustainability goals. This abstract emphasizes the need to address these challenges to support young geoscientists’ careers while ensuring industry has a pipeline of qualified candidates. The integration of AI, machine learning, and big data in geoscience has changed the current job landscape and requires new skills like coding. However, some graduates lack exposure to these skills, suggesting improved training and mentorship is needed. Secondly, collaboration across disciplines is often neglected in education, but remains vital for tackling issues in the geosciences. Communication skills are also crucial for interacting effectively with diverse groups of professionals. Lastly, as sustainability gains importance, geoscientists must gain transferable skills from resource-focused fields to renewable energy and eco-friendly practices. In summary, addressing the challenges facing young geoscientists can be achieved by transforming policy, and fostering more collaboration between industry and education.

WEDNESDAY, FEBRUARY 28 MORNING
MINING & EXPLORATION: INNOVATION & TECHNOLOGY: AUTOMATION ACROSS THE FULL MINING LIFECYCLE
North 225B
9:00 AM • Wednesday, February 28
Chair K. Jenkins, Rio Tinto
9:00 AM
Introductions

9:05 AM
Drilling Revolution: Unleashing A.I. in Auto Drill Solutions for Enhanced Mining Efficiency
C. Stacy and K. Moran; Hexagon, Golden, CO

Optimizing drilling efficiency is paramount in maximizing operational productivity in the mining industry. This abstract presents a compelling case study of a mining site that harnessed Artificial Intelligence (A.I.) in an Auto Drill System, resulting in a substantial boost in drilling production and operational performance. The cutting-edge A.I. Auto Drill System integrates sophisticated automation with advanced drill control mechanisms. By leveraging precise algorithms and real-time data analysis, the system achieves faster, more accurate drilling, reducing downtime and significantly enhancing productivity. This presentation showcases real drilling results and operator feedback, along with the functional benefits of adopting this technology, including insights into change management. Mining professionals will learn about seamless A.I. Auto Drill System integration and its profound impact on productivity, driving operational efficiency and profitability. Join us to explore the future of mining through transformative A.I. technology.

9:25 AM
Underground Wireless Communication Technologies: A Case Study in Chile
M. Saavedra, M. Risso and M. Momayez; Mining and Geological/Geophysical Engineering, student, Concepcion, Chile

Wireless communication in underground mines has been a focal point of many investigations in the recent past, primarily due to the integration of novel technologies such as IoT systems. Several factors must be considered to select the best communication technology. This encompasses the mine layout, the type of operation, the environmental conditions, the voice, video and data transmission requirements, and cost. In this study, we provide an overview of the criteria governing the selection of wireless communication frameworks for underground applications. A case study conducted in an underground mine in Chile is presented. The objective is to relay the status of working areas, equipment and worker location, air quality and stability of the underground openings. We propose a communication system based on a MESH topology employing portable devices. Upon evaluating these factors, it becomes imperative to opt for a communication technology that enables reliable data collection and transmission to the control room, thereby ensuring that communication is not interrupted during critical mining operations.

9:45 AM
Machine Situational Awareness in Mining Systems: Addressing Special Circumstances and Barriers to Autonomy
S. Sbai and R. Bissonette; National Institute for Occupational Safety and Health, Washington, DC

This paper presents a comprehensive analysis of Machine Situational Awareness (MSA) in mining automation, encompassing human and equipment interactions with the overall system. Recent research projects undertaken by the National Institute for Occupational Safety and Health (NIOSH) have highlighted the significance of special circumstances and distinct requirements specific to the equipment aspect of the equation. The absence of a standardized framework has impeded the industry’s progress in implementing autonomy, especially in small mining operations. This study identifies the barriers hindering the implementation of autonomous systems and proposes a potential framework to address these challenges. Furthermore, relevant research is discussed to guide efforts in integrating autonomy while ensuring enhanced health and safety standards and minimizing associated risks. The findings presented herein are intended to enable sound implementation of technology that will prevent injuries and deaths.

10:05 AM
C. Sunderman, R. Jacksha and D. Snyder; National Institute for Occupational Safety and Health, Washington, DC

Wireless communication systems are critical infrastructure for the modern digital mine. These systems support operational efficiency and safety in many domains such as emergency voice communication, automation, sensing, control and personnel and asset tracking among others. It is often assumed that current regulations will ensure that these systems will operate interference free, thus providing mine operators a level of protection from their equipment being interfered with and/or liability for interfering with others, however that is not always the case. This study first clarifies the Federal Communication Commission rules governing operation of wireless communication systems at mine sites in the United States. It then goes on to identify several classes of wireless communication equipment. For each class both the degree of protection against outside interference and the potential liability for generation of interference to others is discussed. And finally, it discusses the implications for mine wireless operators and identifies some potential ways to lessen interference risk.

10:25 AM
Who Goes There? Creating Robust Object Detection and Multi-Target Tracking in Support of Autonomous Mining Equipment
M. McNinch and D. Terzi; National Institute for Occupational Safety and Health, Spokane, WA

Researchers at the National Institute for Occupational Safety and Health (NIOSH) are currently developing a supervisory system for autonomous mining equipment. This system will provide sophisticated multi-target tracking, real-time risk assessment, and intervention strategies to mitigate hazards to personnel. This paper will concentrate on the first piece of this endeavor: development of a robust, multi-sensor target tracking system. This study will include an overview of the sensor specifications, test scenarios, and algorithms used in development. The results will be presented, along with an analysis of performance and hardware requirements for implementation.
The mining industry generates a vast volume of data, necessitating robust data management systems and advanced analytics tools to enhance decision-making processes in mining production. Power BI empowers professionals to seamlessly connect and integrate multiple data sources, ensuring immediate access to real-time data. While Power BI serves as a robust tool, it’s worth noting that certain visualizations needed by geotechnical engineers might encounter limitations. This study delves into the feasibility of integrating Python programming within the Power BI dashboard to unlock advanced analytics, additional functionalities, and tailor-made visualizations. These additions significantly enhance the comprehension and effective communication of complex geotechnical information. Furthermore, the flexible nature of the dashboard allows for the seamless integration of supplementary data and visualizations based on the specific project scope and available dataset. This geotechnical dashboard in Power BI serves as a solution for analyzing, visualizing, and communicating geotechnical data, aiding in informed decision-making and efficient project management throughout various project stages.

**WEDNESDAY, FEBRUARY 28  MORNING**

**MINING & EXPLORATION: MANAGEMENT: PEOPLE MANAGEMENT: BUILDING AND MAINTAINING SAFETY CULTURES**

**North 222C**

9:00 AM • Wednesday, February 28

Chair: A. Kresler, OEM, White Pine, TN

9:00 AM

**Introductions**

9:05 AM

Maintenance Debt and Their Current and Future Impacts

A. Johnston; Sr, Denver, CO

Maintenance is a high-cost business with risks (apparent and hidden) associated with every decision. Costs are typically between 30%-50% of total operating costs and shifting the timing of activities can have huge knock-on effects associated with meeting the budget and changing the overall risk profile. This high-risk, high-cost environment makes it critical to understand and take control of what’s driving those costs. Balancing the day-to-day work with life cycle costing and strategy is one of the main challenges. This disconnect between the daily activities and the overall business plan creates difficulty in accurately forecasting and managing costs, equipment health, and labor. So as a maintenance professional, what are my options? How do I distill such a dynamic situation into something meaningful in real-time, so I can make the best holistic decision that delivers optimal asset performance over its life cycle? Effective asset management requires accurate dynamic life cycle modelling and analytics to create and evaluate multiple scenarios to determine the optimal strategy to deliver a sustained level of asset performance to meet corporate goals over the short and long term.

9:25 AM

Mining Equipment Management Performance Metrics Interpretation & Action

J. Hoffman; Global Mining, Caterpillar Inc, Tucson, AZ

Mining equipment performance metrics are critical tools to measure the efficiency & effectiveness of the maintenance department. Measurement is important but the next logical steps are to effectively interpret, prioritize, and define & implement actions to improve fleet performance. When effectively done, these actions significantly contribute to minimizing or managing maintenance costs, reducing cost per ton, and a more predictable mine. When not managed effectively, mining customers realize higher maintenance costs and are less competitive in the marketplace. This presentation will focus on how to interpret these metrics for maintenance & repair processes, how to identify opportunities, and logical steps to define what actions to take and how to prioritize.
9:45 AM
M. Ransom, Aspen Technology, Danbridge, TN
Mining is undergoing a digital transformation across the entire mining value chain. New technologies for prescriptive maintenance are changing the way mines operate, improving operational efficiencies while also lowering costs. Historical methods for performing maintenance do not create measurable value for consumers and do not factor in operating conditions that could impact the overall availability of the asset. In this discussion we will look at the successful implementation of a prescriptive maintenance solution at Evolution Mining’s Mungari operation in Western Australia, where they have seen immediate financial and operational successes due to improved asset availability. By taking a proactive approach to equipment maintenance, a mine can improve equipment reliability and optimize utilization. This can allow a mine to operate more efficiently, profitably, and reduce safety and environmental risks while quickly showing a return on investment.

10:05 AM
Prescriptive Partnerships: Leveraging OEM Services and Technologies in Predictive Maintenance Plans
C. Ewing, Parts & Services, Sandvik, Spring Creek, NV
Many mine maintenance programs, if they have not already, are in the process of transitioning from a reactive approach to a pro-active approach to the maintenance of their machines. In combination with optimized preventative maintenance practices, pro-active or predictive maintenance programs will help to improve the reliability of a mobile mining equipment fleet. In a predictive maintenance program data is collected from the equipment covered to determine the health and condition and determine whether action is required. There are no shortage of providers of telematics hardware and software aimed at helping to gain information and insights about machine health and performance but as the designers, manufacturers, and experts in the repair and maintenance of these machines the value of the solutions provided by the OEM for the machines in your fleet can not be understated. I plan to review and summarize these above benefits, using real world examples, and discuss the future possibilities of the partnership between operator and manufacturer in predictive and prescriptive maintenance operations.

WEDNESDAY, FEBRUARY 28  MORNING
MPD: ADVANCED PROCESS CONTROL & PROCESS OPTIMIZATION IN FLOTATION
North 227C
9:00 AM • Wednesday, February 28
Chairs: M. Carlisle, Newmont, Englewood, CO
J. Concha, Bechtel
9:00 AM
Introductions
9:05 AM
Impact of Improved Classification Efficiency on Flotation Recovery: A Monte Carlo Simulation Study
B. Zhang, Derrick Corporation, Buffalo, NY
Flotation recovery, a key performance indicator (KPI) in mineral processing, is influenced by various factors such as ore properties, flotation cell design, and added chemicals. While the effects of flotation cell design and reagents have been extensively studied, the influence of ore properties, specifically size distribution and liberation, on flotation performance is less explored. The classification stage in the flotation circuit plays a crucial role in determining the size distribution and liberation of the flotation feed. Various classifiers, including hydrocyclones, upstream classifiers, rake/ screw classifiers, and fine screens, are employed, each with different performance characteristics. Consequently, the circuit products from these classifiers exhibit distinct size distribution limits and properties, affecting flotation recovery. This study presents a methodology to quantify the impact of classifier performance on flotation recovery.

9:25 AM
24-075
Processing Marcasite Copper Ore with Iron Depressant, Hybrid Reagents, Advanced Data Analytics, VisioFroth and Breakthrough Expert Control of Entire Flotation Plant—Fundamentally Transforming Doe Run Buick Mill to Create Value and Expand Ore Resources
W. Mung1, A. Steimel1, A. Demi1, R. Hanning1 and B. Mangogna2; 1Southeast Missouri Operations, The Doe Run Company, Boss, MO and 2The Doe Run Company, Viburnum, MO
The Doe Run Company (Doe Run), a global supplier of lead, copper and zinc concentrates, and lead metal alloys, has deployed an innovative hybrid reagent system which includes an iron depressant to enable processing of high iron marcasite ores at the company’s Buick Mill. The deployment of this technology has increased the ability to produce saleable concentrates from high iron marcasite ore, thereby improving ore reserves. This system utilizes VisioFroth as a baseline and builds on its platform with a breakthrough expert control system to operate the entire flotation plant using VisioFroth as a soft sensor like x-ray fluorescence spectrometry (XRF) and its bubble characteristics as process parameters. This new deployment of technology utilizing Digital Control System (DCS) as its engine, PI software as its data hub and a second modern flotation reagent system has been finetuned with advanced data analytics and Machine Learning (ML) for limitless optimization of the mill’s operation. It has been deployed at existing mill infrastructure, fundamentally transforming Buick Mill.

9:45 AM
A Value Case for Accurate Online Flotation Reagent Control
D. Mares and M. Carlisle; SME, Englewood, CO
In any flotation circuit, being able to accurately control reagent dosage is important. This becomes critical when dealing with a poly metallic ore where different value metals and minerals are recovered in a sequential float. Critical control requirements include flotation feed rate, % solids, metal grades, and a well-designed automated flotation reagent dosing system. A case study from a polymetallic, sequential flotation circuit with all the available critical control requirements, except for an automated reagent dosing control system, showed that there is significant value lost when there is a reliance on operator intervention to manually control reagents, despite the presence of instream analyzers and an advanced IT backbone. Authors: Dalia Mares Mark Carlisle

10:05 AM
Industrial Scale Optimization of Rougher Velocity Profile Factors for Maximum Cu and Mo Recovery
M. Danisthwar; Mill Technical Services, Freeport-McMoRan, Wickenburg, AZ
This study investigates the influence of various rougher velocity profile factors (VPF) on the recovery of Cu, Mo, and the rougher concentrate flow in the concentrator. Six VPFs were tested through collaborative efforts over a month, with a year’s data considered for trend analysis. Each profile was tested for 24 hours and repeated at least three times. These profiles were tested on two trains of 6 cells. Approximately 80 parameters were examined, including operator feedback. Cameras were utilized to measure the linear velocities of bubbles in the cell. The profiles had a range of different settings of speeding up or slowing down the velocities. Therefore, an Advanced Process Control was employed to determine the set points to safely and efficiently achieve the VPFs. The profile resulting maximum
Cu and Mo recovery was selected based on statistical analysis, lowest difference between set points and present value, and operator feedbacks.

10:25 AM

Dynamic Water Management for Maximization of Copper Production
O. Bascu, OSB Digital, LLC, The Woodlands, TX

Low grade ores mineral processing plants require large amounts of energy and water to operate in a sustainable and profitable state. These ores present large variations in their mineralogy, metal content and hardness. Today, tight coordination between the mining product, grinding, classification, flotation and water recovery processing is a must. A Digital Twin was designed to increase the necessary water recovery to maximize the copper production rate in a low-grade ore industrial plant. A dynamic water management system was implemented to have the right rheological properties of the suspensions. The right particle size distributions products are monitored for both for flotation, flocculation and thickening. The implementation results are: a 40% increase in water recovery and the total copper production rate of 32%. These savings are very significant based on a zero-capital investment requirement and a minimum configuration time of Digital Twin. The OSB Digital Twin is built using the PI System data infrastructure and OSB Dynamic Grinding, Flotation and Thickening online dynamic models.

10:45 AM

Online Analyzers—What it is and What it is Not
K. Keet; Sampling, Preparation and Analysis, FLSmidth, Somerset West, Western Cape, South Africa

Many misconceptions exist around online analyzers which have over the years led to many poor applications and analysers eventually becoming white elephants on processing plants. This paper aims to summarise the criteria that should be considered when selecting online analyzers for specific applications. When applied correctly, online analyzers should have a very specific purpose aimed at contributing directly to the bottom line through either cost saving or the optimization of grade and recovery.

WEDNESDAY, FEBRUARY 28   MORNING

MPD: CHEMICAL PROCESSING: CRITICAL METALS II: BATTERY METALS

North 228B

9:00 AM • Wednesday, February 28

Chairs: B. Tanda, Albemarle Corporation, Kings Mountain, NC
J. Baron, Newmont, Weston, FL
S. Gostu, Glencore, Stamford, CT

9:00 AM

Introductions

9:05 AM

Kinetic Study of Cobalt and Manganese Precipitation in the Presence of Ozone: Impact of Process Parameters
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) are among the critical elements listed by the U.S. Department of Interior, and the U.S. is heavily reliant on foreign sources for these elements. Acid Mine Drainage (AMD) is one of the potential secondary resources of these elements. Recovery of these elements from AMD through precipitation requires elevated pH (~9) or the use of 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 aims to understand the effect of process parameters (gas-flow rate, initial ion concentration, stirring rate, and temperature) on Co-Mn precipitation through a statistically designed parametric study and using model solutions of these elements. Statistical analysis results showed that temperature and flow rate were the significant parameters in the recovery of Co, while flow rate and its interactive effect with temperature and with stirring rate emerged as the significant parameters for the Mn recovery. The activation energy values suggest that the oxidative precipitation of Co and Mn is most likely a diffusion-controlled process.

9:25 AM

Optimization of the Synergistic Leaching of Ni-Cu-Co from Nickel Sulfide Flotation Concentrates Using Response Surface Methodology
E. Mends, A. Tita, S. Hussaini, J. Thella and P. Chu; Department of Mining and Metallurgical Engineering, University of Nevada, Reno, Reno, NV

The recovery of nickel from secondary resources has become essential owing to the recent increase in the demand for nickel worldwide and the ongoing depletion of tractable high-grade deposits. The hydrometallurgical extraction of nickel as well as copper and cobalt from nickel-sulphide tailings is proposed in this work. Understanding leaching kinetics and evaluating leaching process parameters are very critical to achieving high metal recovery in hydrometallurgy. Accordingly, in this current work, response surface methodology (RSM) was used to statistically analyze and optimize process parameters, including leaching time, sulfuric acid, ethylenediaminetetraacetic acid, and ferric chloride concentrations, as well as temperature. The findings showed that while ethylenediaminetetraacetic acid synergistically improved the selectivity, the addition of ferric chloride increased leaching kinetics and overall Ni-Cu-Co recovery. This work also offers an essential pathway for further research into various metal recoveries from sulphidic ores, including chalcocypite.

9:45 AM

Ionic Mineral Technologies and Andritz Collaborate to Enhance Carbon Footprint Calculation and Reusable Energy Lifecycle for Lithium Grade Battery Materials in Greenfield Operations
A. Zeitoun1 and E. Lowe2; 1Mining and Mineral Processing, ANDRITZ INC, Salt Lake City, UT and 2CEO, Ionic Mineral Technologies, Vinyard, UT

In an electrifying race to satisfy the soaring appetite for environmentally conscious Lithium Grade Battery Materials, Ionic Mineral Technologies and fellow DLE (Direct Lithium Extraction) players are employing Process Simulation techniques to transition from pilot projects to fully-fledged production facilities. Ionic Mineral Technologies, a US based leading producer of next generation nano-silicon anode materials, is joining forces with ANDRITZ in an endeavor to provide a significant portion of their processing equipment for their commercial production plant. The partnership’s focus extends beyond conventional efficiency goals. It seeks to demonstrate the reclamation of up to 99% of chemicals usage through recycling technologies as well as the conversion of waste into value-added by-products. This integrated approach also encompasses a comprehensive control system and Operational Readiness package, ensuring process efficiency while embracing a sustainable, low-carbon, and reusable energy model to meet the escalating demand for EV batteries.

10:05 AM

Direct Extraction of Lithium from α-Spodumene by Salt-roasting and Water Leaching: Process Optimization and Kinetic Study
C. Subasinghe and M. Rezaee; Energy and Mineral Engineering, Center for Critical Minerals, College of Earth and Mineral Sciences, The Pennsylvania State University, State College, PA

Lithium (Li) has become an essential component in energy storage devices, driven by the expansion of renewable energy sources and the transition from fossil fuel-based energy generation. The demand for lithium has further intensified with the growing popularity of hybrid and electric vehicles (EVs) and its applications in various sectors such as nonlinear optics, high-temperature lubricants, alloys, and the chemical industry.
The conventional method for extracting Li from primary mineral source of Li (i.e., spodumene) involves complex and energy-intensive processes, including the conversion of naturally occurring α-spodumene to leachable α-spodumene through high-temperature calcination, followed by sulfuric acid leaching, and water leaching. To address these challenges, we have developed a patent-pending process for the direct extraction of Li from α-spodumene through low-temperature roasting with NaOH followed by water leaching. The paper present the process parameter optimization and kinetic study of this process.

10:25 AM
Sulfuric Acid Leaching of Lithium-Bearing Claystones: Identification of Influencing Factors and Optimization of Lithium Extraction Using DOE

A. Tita, E. Mends, S. Hussaini and P. Chu; Mining and Metallurgical Engineering, University of Nevada, Reno, Reno, NV

Sulfuric acid (H2SO4) is the conventional acid used in industry for lithium extraction from clays. Finding optimal ways to extract lithium with H2SO4 is pivotal. This study explores the utilization of Response Surface Methodology and Central Composite Design (CCD) technique using Minitab to model and optimize the effects of the various operational parameters on lithium extraction during leaching. The study looked at three key leaching parameters: temperature, acid concentration, and leaching time. These parameters were systematically varied across 20 leaching experiments using the CCD method, following a matrix design guided by software. From these experiments, empirical model equations were developed to correlate the three parameters with lithium extraction efficiencies. Subsequently, the goal was to determine to what extent the parameters were influential, and to maximize lithium extraction efficiencies. The predicted values for lithium extraction percentage exhibited a commendable agreement with the experimental results. The correlation factors, denoted as R², were found to be 98.49%, underscoring the robustness of the developed model in predicting lithium extraction outcomes.

10:45 AM
Hydrometallurgical Processing of Ni and Cu Concentrates

T. Xu1, B. Donovan1, C. Sirkoch1, J. Fitts1, D. Nagaraj1, R. Farinato1, O. Peters1, E. Dine1, B. Goldner2, G. Collins2, S. Banta2 and A. West1;
1Chemical Engineering, Columbia University, New York, NY and 2Talon Metals, Tamarack, MN

Ni sulfide ores often have significant carbonation potential. Improving yields of Ni and Cu from concentrates from Ni-sulfide resources can have several positive environmental, climate, and economic impacts. We have developed leach processes with remarkably fast kinetics even at room temperatures and atmospheric pressures. The process first selectively removes iron from sulfide minerals, resulting in iron-depleted solids, which contain most of the Ni or Cu and can be subsequently processed. We discuss studies on both Ni and Cu concentrates derived from the Tamarack resource, focusing on leach kinetics, and changes in mineralogy and composition of solid leach residue. We further discuss the potential of scale up.

WEDNESDAY, FEBRUARY 28       MORNING
MPD: COMMINUTION: COMMINUTION II

North 228A

9:00 AM • Wednesday, February 28

Chairs: A. Boylston, Metso Minerals, York, CO
N. Blumberg
E. Kaykay

9:00 AM
Introductions
10:05 AM
Understanding and Managing a Transition in Grinding Mill Media
B. Cornish; Grinding Media, ME Elecmetal, Port Douglas, QLD, Australia
There is currently a variety of grinding media suppliers available to mineral processing operations, and each will usually have a wide range of product sizes and types. As such, it is almost certain that Metallurgists and Process Plant Technical personnel will be tasked with managing a media transition project. This paper discusses the exponential decay mathematical model used to describe the process of new media replacing the incumbent, also known as a mill purge. Just as no two mills are the same, no two mill purge periods will be the same, and understanding the operation and the process will enable effective management of the transition. Included in this paper are Case Studies of SAG mill and ball mill media transitions.

10:25 AM
Obtaining and Measuring the Value of On-Line Measurement of Particle Size in Cyclone Overflow Using PST Technology
D. Medina; CiDRA Mineral Processing, Wallingford, CT
The humble hydrocyclone was first patented in 1891 and its fundamentals have changed little since, and it is one of the most under-sensored pieces of equipment in the mining industry given its critical job. The Particle Size Tracking (PST) technology enables real time measurement of particle size in the overflow of individual hydrocyclones. The maximum value can only be realized when the PST signals are incorporated into an automatic control system. We present recommendations for high-level control logic, as well as methods to measure the value delivered once the system is integrated into a control system by performing a properly designed on/off test.

10:45 AM
3D Characterization of Internal Fractures in HPGR Products by High Resolution X-Ray Computed Tomography
A. Erskine, J. Jin, C. Lin and J. Miller; Materials Science and Engineering, The University of Utah, Salt Lake City, UT
The internal fractures created by impact between particles during comminution are important for energy saving in the subsequent grinding or leaching kinetics for metal extraction. Because of the advancement of high resolution X-ray Computed Tomography (XCT) technology, the cracks inside ore particles can be analyzed in 3D with the smaller voxel size and better image quality. Discharge from a High Pressure Grinding Rollers (HPGR) plant has been scanned to characterize the internal fractures. The specific crack surface areas of ore particles in selected size fractions were determined by 3D image processing and analysis. Particle size distribution and specific crack surface area were correlated to the operating conditions of HPGR to provide suggestions on optimization.

11:05 AM
Hybrid Thermal Mechanical Pretreatment for Improved Ore Grindability
S. Adewuyi1, H. Ahmed2, H. Ahmed3 and A. Anani; ‘Mining and Geological Engineering, University of Arizona, Tucson, AZ and ‘Mining Engineering Department, King Abdulaziz University, Jeddah, Mecca, Saudi Arabia
Grinding is an important process of ore beneficiation which consumes huge energy. Pretreating ore before grinding has been proposed to improve ore grindability, reduce comminution energy and enhance downstream operations. This paper investigates hybrid thermal mechanical pretreatment to improve iron ore grinding behavior. Thermal pretreatment was performed using conventional and microwave approaches while mechanical pretreatment was done by pressure device using a piston die. Results indicate that conventional (heating rate: 10°C/min, maximum temperature: 400°C), microwave (2.45 GHz, 1.7 kW, 1 min), and mechanical (15 MPa, zero delay time) pretreatments improved the studied iron ore grindability by 4.6, 17.7, and 15.4%, respectively. Meanwhile, conventional-mechanical and microwave-mechanical pretreatments enhanced the studied iron ore grindability by 19.2 and 22.6%, respectively.
ONSITE PROGRAM

10:05 AM
New Development of Copper Extraction from Primary Copper Sulfides by Hydrometallurgical Process.
J. Lee; Mining Engineering, Colorado School of Mines, Golden, CO

Chalcopyrite is well known for its refractoriness and forming passive layer on the mineral surface. Different lixiviant and oxidants systems have been investigated to improve the overall extraction of copper. Pressure oxidation using autoclave also has been studied extensively and several new developments are currently being considered. Other options are Albion process, CESL process, bioleaching with extreme thermophiles, and Galvanox process. Newer lixiviants include glycine, methanesulfonic acid, and thiourea with several oxidants and leaching conditions. A newly developed method also showed almost 99% copper extraction from a chalcopyrite concentrate contains 85% chalcopyrite and 8% pyrite. The baseline sulfuric acid with ferric ion showed only 23% copper extraction. The passivation of chalcopyrite in sulfuric acid solution with ferric as an oxidant is well known and it happens when the solution potential increases above 550 mV-600 mV vs. Ag/AgCl. The main goal of the research is to maintain the solution potential below 500 or even 400 mV to avoid the passivation. The system is compatible with the current solvent extraction and electrowinning process without any modification.

10:25 AM
Bioleaching of Chalcopyrite and the Impact of Carbon Dioxide to Copper Extraction
E. Owusu-Fordjour, X. Yang, M. Free and J. Burke; Materials Science and Engineering, The University of Utah College of Engineering, Salt Lake City, UT

Mineral leaching with the assistance of microorganisms has been intensively studied due to its great potential in metal extraction processes that can lead to sustainable mining and metallurgical processes. Bioleaching is a sustainable mineral extraction approach for the recovery of copper from medium to low-grade chalcopyrite ores. The carbon reactive minerals in the gangue can be a great source for carbon sequestration through carbonation. 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 on leaching kinetics and efficiency. The role of carbon dioxide in bioleaching operation is important to extract energy-relevant minerals from sulfides and carbonated ores. This study focuses on the impact of carbon dioxide and carbonated minerals to chalcopyrite bioleaching operation, with investigation on strategies and principles in overcoming the chalcopyrite passivation during bioleaching process. For this study, bacteria will be acclimatized and adapted to high copper concentration for use in the biological leaching of chalcopyrite.

10:45 AM
Electrolyte Optimization for Leaching and Electrowinning of Copper Using the Copper-Ammonia-Ammonium Sulfate Solution
Z. Ali and J. Werner; Mining Engineering Department, University of Kentucky, Lexington, KY

Ammonia-based leaching of copper ores has been utilized historically and has applications in mining and recycling industries due to its benefits over acid-leaching systems. These benefits include lower environmental impacts, and leaching selectivity of certain elements, specifically ammonia sulfate solutions, towards copper. Although research has been conducted in this field and many questions remained unanswered with regards to the fundamental chemistry of this system. This work investigates the importance of major species (Cu(NH3)2+2 and Cu(NH3)4+2) in this system because of their impacts to leaching and copper electrowinning. A design of experiments was performed to determine the impact of pH and other variables on the maximum concentration of Cu(NH3)2+2 and Cu(NH3)4+2 and corresponding electrolyte behavior. Understanding of these fundamentals are critical to design the leaching and electrowinning current efficiency.

11:05 AM
Additive Management Improvements for the Electrowinning of Copper Anodes
J. Warburton; Metals Technical (Copper), Rio Tinto, Herriman, UT

Maintaining certain concentrations of thiourea, glue, and chloride ions in electrolytic solution is necessary to promote efficient and homogenous copper deposition in electrowinning. Over the past year, new practices have been implemented and standardized at the Rio Tinto Kennecott Utah Copper Refinery to improve the control of these concentrations within these set limits. Through a better understanding of plant processes, greater interdepartmental collaboration, and consistent daily checks, improvement was observed. Average current efficiency increased and varied less in the face of condition changes such as outside temperatures, varying pull cycles, and use of slightly out-of-spec anodes.

11:25 AM
Enhancing Copper Extraction Efficiency with Novel Leaching Agents Derived From Mine Tailings
A. Alsaťafiesh, A. Al-Rawajfeh, S. Al-Jawad and M. Wardeh; Natural Resources and Chemical Industries, Tafila Technical University, Tafila, Jordan

Acid leaching is a well-known method for extracting copper from ores, but the optimal leaching conditions may vary depending on the ore’s mineralogy and characteristics. Therefore, it is essential to investigate the leaching parameters to determine the most effective conditions for copper extraction from Jordanian copper ores. This research aimed to investigate the efficiency of a developed leaching agent derived from a specific mine tailing for the copper leaching process using Jordanian copper ore. The work’s scope involved grinding and sieving the copper ore, followed by characterizations using XRD, XRF, and ICP to determine its chemical composition and copper content. Additionally, mine tailings were collected and subjected to treatment processes to prepare a developed leaching agent (DLA). Several leaching parameters were modified. A comparison was made between the results obtained using the DLA and a traditional leaching agent (TLA) to assess the superiority of the developed technique. The results revealed that the DLA exhibited a higher copper recovery compared to the TLA. The DLA technique achieved up to 97% copper recovery, while the TLA yielded only 82%.

WEDNESDAY, FEBRUARY 28 MORNING

MPD: INNOVATION IN FLOTATION

North 221C
9:00 AM • Wednesday, February 28

Chairs: S. Merrill, FLSmidth USA Inc, FL Smidth, Salt Lake City, UT, Midvale, UT
M. Drexler, Rio Tinto Kennecott, Salt Lake City, UT

9:00 AM
Introductions

9:05 AM
Flotation of Pyrrhotite from Eagle Mine’s Tailings
K. Weaver; Technical Services, Eagle Mine, Ishpeming, MI

The conditions for pyrrhotite flotation from Eagle Mine’s tailings were examined. The removal of iron sulfides would limit acid mine drainage and produce a usable feed for mine backfill. The pyrrhotite surfaces were highly oxidized and produced a weak froth and low recoveries. Conditioning the slurry in acidic conditions, below pH 4.5, improved pyrrhotite flotation significantly, with recoveries up to 97% at a concentrate grade of 72%. With the clean surfaces, lime was added to a neutral pH to allow effective xanthate usage. Adding lime had very little effect on froth stability and recoveries after acid cleaning.
The effective flotation of coarse particles has been an attractive subject for the mineral processing industry for some time. Considering conventional flotation limitations, research and development activities have resulted in the commercialization of fluidized-bed flotation cells that have demonstrated their capabilities to push the upper particle size boundary. The Eriez HydroFloat™ technology has realized commercial success in several applications that have reported significant decreases in energy consumption while achieving high metal recoveries with minimal surface exposure. In this study, a laboratory scale HydroFloat™ unit has been utilized to study the recovery of complex massive sulfide copper minerals from a feed with a p80 of approximately 450 μm. Conventional and novel collectors have been evaluated on the basis of their adsorption kinetics and surface properties, and how these relations affect the overall efficiency of the HydroFloat™ performance. The preliminary results demonstrated that high copper recovery (>80%) with relatively low mass pull (<25%) can be achieved through the process. The findings from the experimental study will be discussed in the presentation.

**Enhanced Separation Performance for Fractionally Liberated Materials Using the HydroFloat™ Process Technology**

Y. Ozsoy1, R. Honaker1, M. Mankosa2 and T. Bhambanii3; 1Mining Engineering, University of Kentucky, Lexington, KY; 2Eriez Manufacturing, Erie, PA and 3Solvay, Stamford, CT

Sustainable production of critical metals and minerals for the global clean energy transition is an essential focus for mining companies worldwide. One area of technology in mineral processing that can potentially turn the dial for sustainable production of elements such as copper is coarse particle flotation. It has the potential to increase production of existing circuits without the addition of additional comminution energy, increase the recovery of valuable mineral where conventional technologies have failed and potentially improve the economics of previously uneconomical greenfield deposits. This paper will present a case study of the application of coarse particle flotation at Capstone Copper operations. It will provide an overview of the technology, present testwork results from Capstone Copper ores and propose the potential benefits to the business from an economic and ESG perspective.

**Coarse Particle Flotation Technology and its Application at Capstone Copper Operations**

B. Akerstrom; Capstone Copper, Globe, AZ

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**Secondary Copper Production from Rio Tinto Kennecott’s Slag Concentrator**

M. Drexler; Technical, Rio Tinto Kennecott, Salt Lake City, UT

Rio Tinto Kennecott’s flash smelter produces about 700kt per year of a fayaltite-based slag usually containing 2% copper. Copper is recovered by grinding and froth flotation in a ~2,500 ton per day concentrator, producing a 'slag concentrate'. This talk will provide an overview of the process and discuss improvement ideas. We will also share and discuss results of laboratory-scale work done to investigate the possibility of recycling spent furnace refractory in the slag concentrator, and slags from other furnaces.

**Enrichment Feasibility of Gold and Silver—Tellurides from Copper Tailings**

J. Corchado-Albelo, F. Nakhaei and L. Alagha; Department of Mining and Explosives Engineering, Missouri University of Science & Technology, Rolla, MO

Tellurium (Te), a critical element vital for solar energy technologies, faces heightened demand, necessitating enhanced production efficiency within supply chains. This research focused on improving Te enrichment from copper tailings (CT), addressing the loss of 90% Te during flotation. Gravity separation and flotation were performed utilizing the CT, and selected reagents were used for Te concentration tests. Comprehensive characterization analyses showed Te enrichment in the flotation streams. Notably, incorporating pyrite concentration enhanced Te recovery, achieving a 60% recovery at 14 ppm grade using a xanthate collector. Findings showed the feasibility of efficient pyrite-hosted tellurides recovery through preconcentration strategies and understanding the Te deportment process.

**Enhanced Separation Performance for Fractionally Liberated Materials Using the HydroFloat™ Process Technology**

Y. Ozsoy1, R. Honaker1, M. Mankosa2 and T. Bhambanii3; 1Mining Engineering, University of Kentucky, Lexington, KY; 2Eriez Manufacturing, Erie, PA and 3Solvay, Stamford, CT

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9:00 AM
Introductions

9:05 AM
Developing a Lithium Production Flowsheet From a Sedimentary Lithium and Boron Deposit
M. Osborne; SME, Reno, NV

Abstract: The ioneer Rhoyolite Ridge project is a greenfield mine and lithium production facility located in the Esmeralda County, Nevada. The project aims to produce 22 KtMpa of technical grade lithium carbonate and 174 KtMpa of technical grade boric acid from a sedimentary lithium deposit. Lithium and Boron are extracted from the Sedimentary Ore using sulfuric acid in vats and refined into technical grade products using a series of impurity removal, evaporation and crystallization unit operations. Sulfuric acid is supplied by an onsite sulfuric acid plant which also provides all the necessary heat and electricity for plant operation through heat recovery, precluding the need for grid connection and reliance of public power generation. The presentation will provide an overview of the Rhoyolite Ridge flowsheet and the decisions taken in developing a modern mine and production facility.

9:25 AM
Unlocking Efficiency and Sustainability: Transformation of Pinto Valley Mine from Legacy to Modern Marvel
M. Kime; Capstone Mining, San Tan Valley, AZ

Pinto Valley Mine, a legacy of BHP and currently operated by Capstone Mine, commenced operations in 1972 with a capacity of 45,000 TPD. Since then, the capacity has been expanded to 70,000 TPD. This paper presents the methodology employed to debottleneck and optimize the unit operations. Embracing the adage that “good metallurgists are first and foremost historians,” the study extensively delved into historical data and trends to comprehend prevailing operating conditions, existing controls, and unit process constraints. This exhaustive analysis facilitated the identification of opportunities for holistic enhancements spanning from the mine to the mill. The comprehensive initiatives encompassed the development of a robust recovery model, establishment of critical particle size distribution parameters for crushers and ball mills, modernization of conveyor, pumps, and cyclones, optimization of flotation reagent schemes, upgrading of tailings thickeners, and the implementation of process control automation.

9:45 AM
Building Mines Without Mills or Water
B. Hilscher and D. Kim; ABH Engineering Inc., Surrey, BC, Canada

As construction costs increase and access to capital remains uncertain many mining companies are looking for low capital methods to bootstrap their existing properties into production. Direct shipping ore has always been an option, but shipping costs eliminated the possibility for all but the highest-grade ores. By utilizing sensor-based ore sorting it is now feasible to create a high-grade direct ship ore through a mobile sorting system. Profits from the direct ship ore can be used to build a mill on site or advance other projects. As the process is dry the project can be advanced without water rights or tailings permits. Contract mining can be utilized to further reduce capital expenses. This paper will use results from deposits and operations to illustrate the potential to start new mines with minimal environmental impact and capital costs.

10:05 AM
HPGR: Concept to Nameplate
T. Lundquist; Member, Madison, WI

High Pressure Grinding Roll (HPGR) installations and start-up can be considered challenging due to the relatively small number of references and limited amount of experienced personnel with HPGR process, plant design, installation, commissioning, and service experience. This session will explore lessons learned and different strategies to provide best possible outcomes for all HPGR projects and is based on hands on experience covering more than 10 installations over the last decade.

10:25 AM
Failure Analysis of Large Alloy Steel and White Iron Castings
R. Schrock and D. Demiglio; Technical, ME Global, Tempe, AZ

White iron and alloy steel mill liner castings as large as 5 tons are typically used in semi-autogenous grinding (SAG) mills, autogenous grinding (AG) mills, and ball mills to process mineral ores after primary / secondary crushing operations. Case histories will be presented on AG and SAG mill feed / discharge head liners, shell liners, and discharge grates that either fractured prematurely or did not perform as designed in service. Details related to the process of metallurgical failure analysis will be discussed on these large castings with lessons learned to avoid future failures and minimize the risk of costly downtime.

10:45 AM
Global Metrics at Your Fingertips—Assuring Productivity through Operations Support Networks (OSN)
L. Haifa and Y. Qin; Business Excellence, Newmont, Englewood, CO

Currently, processing data monitoring is performed in various ways and using multiple software and tools. Site-based engineers dive into data when top line KPIs are off target to find the root cause. It’s a reactive and manual process that takes hours to accomplish. In 2022, Newmont formed the Processing Operations Support Network (OSN) with the goal of analyzing data for anomalies, working with subject matter experts to define solutions for the inconsistencies in performance, ensuring improvements are sustained. The Processing OSN has partnered with our internal Analytics team to automate data analysis through development of standardized dashboards that proactively monitor up to 1500 site performance indicators. These dashboards will 1. visualize data in consistent graphs where KPIs can be monitored over time, 2. benchmark data across similar flowsheet plants and against best performance timelines, 3. alert OSN team on priority KPI adherence, 4. provide correlation statistics for ready identification of variation root cause(s). With global plant metrics at their fingertips, the OSN can assure productivity through minimizing valleys and identifying underperformance opportunities.

WEDNESDAY, FEBRUARY 28 MORNING
TREATMENTS OF TAILINGS—CASE STUDIES—ALTERNATIVE TREATMENTS OF TAILINGS

Sponsored by: Newmont

North 131B/C

9:00 AM • Wednesday, February 28

Chair: T. Sparks, Consultant
R. Parratt, Newmont, Englewood, CO

9:00 AM
Introductions

9:05 AM
24-084
Testing, Design, Commissioning and Operation—A Disc Filter Life Experience on a Backfill Plant
J. Hahn, Sales, BOKELA GmbH, Karlsruhe, Germany

The paper describes both, the design and decision making for the filters in a backfill plant in Europe as well as more then 10 years of operation and maintenance experience of the vacuum disc filters installed. It begins with the first step, the filter sizing based on a sample provided by the customer, followed by the commissioning of the filter units and reports
on the development of the filter performance during the following 10 years of operation. Based on the physical properties of the sample and the process targets of the client for the backfill plant, the paper shows the logic steps taken in the laboratory to ensure the target moisture, determine the required filtration area and filter size as well as the selection of the ancillary units and the formulation of the performance guarantee. The paper discusses some issues with filter operation during the commissioning phase and the actions taken. Finally, the paper concludes by highlighting the gradual change over the more than 10 years of operation and how this change affected filter performance and operating costs.

9:25 AM
Reducing Tailings With Sorting and Other Emerging Technologies
B. Hilscher and D. Kim; ABH Engineering Inc., Surrey, BC, Canada
Ore sorting increases mill feed grade and production by rejecting barren waste rock. By doing this the number of fine tailings created is greatly reduced. Companies often focus on the reduced costs and increased revenue, but the reduction of tailings has real economic and social benefits that should be considered. Any mine using sorting will see a reduction in tailings. By incorporating Co-disposal, dry stack and other emerging technologies, tailings ponds can often be eliminated without increasing costs. This paper uses results from major mining company operations to illustrate the potential reductions or elimination of sub aqueous tailings disposal.

9:45 AM
Dewatering Over 8,000 tpd of Copper Tailings at a Mine Site in Peru With the Largest Filter Press in the World. Case Study and “Lessons Learned”
K. Schrader² and A. Pezzi¹; ¹Marketing & Communications, Diemme Filtration, Lugo, Italy and ²Sales Department, Diemme Filtration, New Brighton, MN
The mining industry is being challenged to adapt to the environmental changes the world is currently facing with a focus on water scarcity, climate change and risk of tailings dam failures and the social pressure and changes the world is currently facing with a focus on water scarcity, climate change and risk of tailings dam failures and the social pressure and resulting improvements/optimization made during the operation of this first unit including insight gained from an integrated system called AIDA, providing analysis of data collected to create value to the end user, while increasing efficiency and availability and ultimately achieving the customer objectives as well as demonstrating Diemme’s commitment to sustainability in the mining industry.

10:05 AM
Full Scale Installation of Somerset Sub325 Dewatering Centrifuge: Dewatering of Ultrafine Tailings for Dry Stacking, Water Recovery and Valorization
M. Barish, T. Toney and J. Fisher; Somerset International, Sewickley, PA
Somerset International’s 2022 paper entitled “Applying Ultra-Fine Coal Dewatering Technology to Refuse Tailings Disposal” discussed new applications for the Sub325® Fine Coal Recovery System spurred on by the increased scrutiny placed on tailings disposal globally. Countries are limiting the use of wet tailings dams forcing plants to invest in dewatering solutions. Lab testing and small scale demonstrations have led to the development of the Somerset Sub325® Tailings Dewatering System. Somerset has embarked on full scale demonstrations and installations at plants in the United States, Morocco and Chile. These demonstrations have proven successful at their stated goals of dewatering ultra-fine tailings for slurry pond elimination, water recovery and waste valorization.

These demonstrations were performed during normal operating conditions with normal fluctuations in quality and flow. The ability to dewater -325 mesh material is a vital piece of processing capability for the continued production of global mining operations. Finding a low-cost, low-maintenance, high availability continuous solution to dewater tailings is imperative for operators in active and inactive mine facilities.

10:25 AM
Extending the Habitat of Viper Filtration. Implementing the Technology in the Americas
Q. Whatnall; Jord International, Denver, CO
There is an enduring demand for technology to fulfill the needs of large scale tailings filtration. This paper introduces such a technology, Viper, which has been adopted in the Australian mining industry, and discusses implementation in the Americas. The technology enhances dewatering performance through the addition of vibration to the process of conventional vacuum belt filtration, producing significantly lower moisture content filter cake such that it can be applied for tailings filtration. A Viper vacuum belt filter can also operate at a significantly higher production rate relative to conventional vacuum belt filtration. Critically, despite the addition of Viper modules, all fundamentals of vacuum belt filter plant design, operational and maintenance practices, which are generally well understood by the mining industry remain valid. Thus, providing a solution to help overcome cost and scalability deterrents of tailings filtration. There are now more than forty units operating at full-scale across numerous applications, including tailings, in Australia. In the Americas, there are numerous projects in implementation.

10:45 AM
Saving Water & Tailings Dam Space for Medium Size Mines— A Case Study Using Centrifuge Technology to Recover Process Water from Mine Tailings
E. Gentis and T. Ostrom; Mining, Flottweg Separation Technology, Independence, KY
Traditionally, tailings dams or a chamber filter presses are used to dewater tailings. This solution requires significant capital investment & infrastructure. Dams do not recover much process water, and presses are expensive and labor-intensive. Neither are portable. A reliable, portable and cost-effective alternative is explored here over a month-long trial of a decanter centrifuge specifically designed to withstand the rigors of a mining application. This trial proves it is possible to save +75% pond space or more, using a decanter centrifuge as a very affordable and effective alternative. As much as +80% of process water can be recovered. Between 98% and 99% of suspended solids are removed from the process water. The solid output is spadeable. Dry solid of >80%–86% was experienced in the steady state. These results were achieved without any polymer / flocculant / coagulant. Recovering reusable water from the tailings of a fluor spar / fluorite process plant with a suitably wear protected centrifuge decanter works extremely well.

WEDNESDAY, FEBRUARY 28 AFTERNOON
COAL & ENERGY: COAL MINE ROCK MECHANICS
Sponsored by: N

North 226A
2:00 PM • Wednesday, February 28
Chairs: Z. Khademian, National Institute for Occupational Safety and Health Pittsburgh Research Laboratory, Pittsburgh, PA
L. Fan, University of Alaska Fairbanks, Fairbanks, AK
NIOSH Gas Well Stability Research: Investigation into the Causes of an Anomalous Shale Gas Well Casing Deformation at a Deep Longwall Mine

W. Su; Ground Control Branch, National Institute for Occupational Safety and Health, Pittsburgh, PA

Following the first longwall excavation at a deep-cover gas well site, the pre-mining modeling prediction of longwall-induced casing deformations in the cemented production casing were in excellent agreement with post-mining Caliper survey results. However, after second panel mining, the post-mining Caliper survey revealed a large deformation near the top of the Pittsburgh Seam. The focus of this paper is to identify the possible causes of such an anomalous deformation. Very high longwall-induced casing stress and swelling of a thick claystone layer were identified as the possible causes. Leaving the production casing un cemented is identified as the best practice.

Validation of Modeled Rockmass Permeability Against Field Measurements in a Longwall Mine

Z. Khademian, M. Harris, K. Ajayi and S. Schatzel; Ground Control, National Institute for Occupational Safety and Health Pittsburgh Research Laboratory, Pittsburgh, PA

Predicting rockmass permeability is critical to evaluate various engineering designs, including estimating gas inflow to a longwall mine in the case of a hypothetical breach in the gas well. This study conducted field permeability measurements to validate a geomechanical model capable of predicting rockmass permeability during longwall mining. A series of slug permeability tests were conducted in an active mine in Pennsylvania. A model of the mine was constructed in 3DEC and permeabilities were calculated. The modeling results agreed well with the pre- and post-mining permeability measurements, showing the applicability of this tool for planning gas wells near mine workings.

Shale Digital Twin Construction for Multiscale Geomechanical Simulation: From Lab-Scale Specimens to Field-Scale Roof Modeling

G. Zhao1, D. Tuncay1, M. Suner1 and M. Ruan2; 1Mining Department, West Virginia University, Morgantown, WV and 2Computer Science, West Virginia University, Morgantown, WV

This research introduces a methodology for constructing a shale digital twin that facilitates mechanical response across both laboratory-scale shale specimen modeling and field-scale shale roof modeling using UDEC software. Specifically, we propose a physics-informed image processing method to extract a bedding plane geometry database, involving image stitching, edge detection, and point coordinate collection. The extracted database is utilized to develop shale specimen modeling, calibrated through strain-stress curve analysis and comparison of crack propagation behaviors. Then, for extending our approach to field-scale shale roof modeling, we propose the concept of representative bedding plane density, establishing a link between the shale specimen scale and the shale roof scale. Furthermore, shale roof modeling is calibrated through longwall mine instrumentation, including measurements of abutment pressure changes, roof deformation, as well as support bolt/cable loads. Finally, we reconstruct the shale digital twin of both the specimen and the roof, incorporating extracted bedding planes and calibrated micro-properties.

Improved Monitoring of Mining-Induced Seismicity and Mine Operations Using an Underground Distributed Acoustic Sensing Array

A. Ankamah1, J. Hole1, A. Touret1, E. Martin1, D. Chambers1, J. Beale1 and J. Garner2; 1Geosciences, Virginia Polytechnic Institute and State University, Blacksburg, VA and 2Geophysics, Colorado School Of Mines, Golden, CO

The planned roof collapse of longwall mining can induce hazardous earthquakes. To test improved earthquake monitoring methods, a fire-safe fiber-optic distributed acoustic sensing (DAS) system was deployed underground in an active longwall coal mine. In 7 weeks, hundreds of earthquakes were recorded at ~5.7-m station spacing along ~1.3 km of fiber. A pre-existing surface seismic network detects events down to magnitude -0.5 but is not capable of determining hypocenter depths above the ~0.5-km deep mine. Combining data from the underground DAS array and the surface seismometers, 75 earthquakes were relocated, and errors were quantified to document hypocenter improvements relative to the surface network. DAS accurately constrained earthquake depths of nearby events. The system also detected mining activities such as the operating longwall shearer, conveyor belt, pumps, and rail-mounted vehicles. This data can enable proactive equipment maintenance and enhance mining efficiency. Results indicate that the DAS system can effectively improve monitoring and characterization of mining-induced seismicity to mitigate seismic hazards during mining.

A Systematic Global Review of Factors Associated with Dynamic Failure Occurrence in Coal Seams

H. Lawson; NIOSH, Spokane, WA

A common factor associated with dynamic failure occurrence is change in internal pressure equilibrium due to methane generation within the coal seam and the creation of void space during excavation. However, the majority of U.S. dynamic failure cases occur within the Uinta and Piceance basins of the southwestern United States, where most coal seams are not thermally mature enough to produce significant amounts of methane. To better define how U.S. dynamic failure cases compare to international instances, a systematic review of dynamic failure case studies is performed on both an international and domestic basis. Constellations of causative factors as identified by mine operators are discussed on a regional basis and compared. The objective of this study is to describe dynamic failure occurrences in terms of regionally dominant mechanisms, such that individual study findings are not erroneously and globally applied.

Analysis of Mining-Induced Loads with Different Methods in Tailgate T-Junction During Longwall Mining Operations

C. Kaydum and D. Tuncay; Mining Engineering, West Virginia University, Morgantown, WV

Understanding mining-induced stress distributions is crucial for ensuring safe longwall mining operations. The tailgate T-junction in longwall panels is one of the critical areas characterized by high concentrations of mining-induced loads. Accurate load estimation is essential to adequately designing pillars and support systems. Various methods can be employed to calculate mining-induced loads for pillar design, including empirical, analytical, and numerical methods. Empirical methods, such as the analysis of longwall pillar stability (ALPS), are derived from a collection of case studies. Analytical and numerical methods can be utilized for further investigation of mining-induced loads. In this study, five distinct longwall mine case studies are analyzed. The mines differ in terms of depth of cover, seam thickness, and pillar designs across various regions. The tailgate T-junction, with sufficient panel advancement, is modeled for each mine using two different numerical methods (LaModel and FLAC3D) and compared with the empirical estimations. Results gathered from different load estimation methods are presented in this paper.
4:05 PM
Prediction of Ground Deformation Indices for Inclined Coal Seams
E. Maldonado, J. Romero and Z. Agioutantis; Mining Engineering, University of Kentucky, Lexington, KY

Full extraction methods, such as longwall mining, will result in surface subsidence. There are various ground subsidence prediction modelling techniques, such as numerical and empirical modeling. The Surface Deformation Prediction System (SDPS), which has been extensively applied to predict ground deformations in the US and elsewhere, utilizes the influence function method which is an empirical formation for subsidence prediction. The prediction methodology was developed and validated for horizontal coal seams. This presentation will focus on a technique which is being developed to model dipping coal seams using the influence function method. The modeling technique involves transforming a dipping seam to a horizontal seam and keeping the overburden depth for each prediction point the same. The methodology has been validated with a number of case studies available in the literature.

WEDNESDAY, FEBRUARY 28  AFTERNOON
COAL & ENERGY: RARE EARTH AND CRITICAL MINERAL ASSESSMENTS IN THE U.S. COALFIELDS
North 226B

2:00 PM • Wednesday, February 28
Chairs: R. Bishop, Virginia Polytechnic Institute and State University, Blacksburg, VA
A. Wendt, US Department of Energy, Washington, DC

2:00 PM
Introductions

2:05 PM
Consortium to Assess Northern Appalachia Resource Yield (CANARY) of CORE-CM for Advanced Materials
B. Arnold and S. Pisupati; The Pennsylvania State University, University Park, PA

CANARY CORE-CM is assessing and cataloging carbon ore (CO), rare earth element (RE) and critical mineral (CM) resources and waste streams in the Northern Appalachian Basin. Targets include acid drainage from abandoned mine sites as well as coal preparation refuse sites, fluidized bed combustor fly ash, bottom ash, and coal refuse feedstocks, historic metal mine wastes, coal underclays, produced waters, and coal for carbon and graphite production. This presentation will provide recent findings as well as discuss technologies for recovery of these elements and opportunities for Technology Innovation Centers and stakeholder outreach and engagement in educational activities.

2:25 PM
Core Characterization: Computer Tomography, Geochemical, and Core Petrophysical Workflows for Emerging Critical Mineral Plays
T. Paronish1, D. Crandall2, S. Workman1, M. Gill2 and K. Jarvis1; 1National Energy Technology Laboratory, NETL Support Contractor, Morgantown, WV and 2National Energy Technology Laboratory, National Energy Technology Laboratory, Morgantown, WV

The National Energy Technology Laboratory’s geoinaging lab in Morgantown, WV has been performing core characterization using multi-resolution Computed Tomography (CT) imaging and multisensor corelogger which allows for cm-resolution elemental and petrophysical measurements along whole core. This workflow has historically been used in unconventional gas plays and potential carbon storage locations. This rapid core characterization leads itself well as a first phase process in CM/REE evaluation efforts allowing for high-resolution, non-destructive investigation of elemental concentration using X-Ray Fluorescence and examination of core features through CT imaging.

2:45 PM
Uinta Basin CORE-CM Project Overview of Resource Assessment and Processing Pathways
M. Free, L. Birgenheier and P. Sarwat; University of Utah, Salt Lake City, UT

The long-term goal of the Uinta Basin CORE-CM project is to transform carbon and associated rare earth elements/critical materials resources in the Uinta Basin into important nonfuel and critical material products such as polymers, carbon fiber composites, lithium ion batteries, and high power magnets, which will help to create jobs and diversify the regional economy. The most extensive part of the project at this point is the characterization of the resource materials, particularly the rare earth elements and critical materials. In addition, a transformation of the resources into products requires a comprehensive understanding of the resources as well as related assessment of down stream processing and related workforce and infrastructure development. This presentation will provide an overview of the resource assessment and the assessment of processing technologies associated with this project.

3:05 PM
Rare Earth Elements (REE) and Other Critical Minerals in Late Cretaceous Coal and Related Strata in the San Juan and Raton Basins, New Mexico: Preliminary Observations
V. McLemore, E. Owen, M. Badonie, J. Newcomer and D. Shaver; NM/GBR/NM Tech, Socorro, NM

Critical minerals are becoming more important in our technological society because they are used in many of our electronic devices, batteries, and magnets. In New Mexico, low to moderate concentrations of other critical minerals are found in Late Cretaceous coal and related strata in the San Juan and Raton Basins. These rocks are being characterized as part of the DOE’s CORE-CM (Carbon Ore, REE, and Critical Minerals) program. The New Mexico coal, humate, and clincker deposits are relatively low in REE (<325 ppm TREE), Li (<90 ppm), V (<168 ppm), Co (<51 ppm), Ni (<108 ppm), Zr (<557 ppm), and many other critical minerals compared to normal economic deposits. Some of these rocks are enriched in AlO (<40%) and Sr (<3740 ppm), both critical minerals. Common minerals hosting the critical minerals in these rocks include clay minerals, zircon, and rutile/anatase. As the demand for some of these elements increases because of increased need and short supplies, the dollar value per ton of ore rises, enhancing deposit economics. Ultimately, economic potential will most likely depend upon production of more than one commodity, maybe even from coal, humate, and clincker deposits.

3:25 PM
Alteration and Geochemistry of Clinkers in the San Juan Basin, New Mexico
D. Shaver and V. McLemore; Bureau of geology and mineral resources, New Mexico Tech, Bosque Farms, NM

Clinkers are the result of a seam of coal catching fire and burning the surrounding rocks. The fires caused the surrounding rocks to be baked at high temperatures, removing organic material and partially forming glass. These rocks become hard, orange, and brick like, forming clincker. The purpose of the study is to determine their potential to contain economic levels of critical minerals, including Rare Earth Elements. Some clinkers contain over 200 ppm total REE.

3:45 PM
Evaluating Beneficial Opportunities of CORE-CM Advancement in the Central Appalachian Coal Basin
M. Corsi and R. Bishop; Mining and Minerals Engineering, Virginia Tech, Blacksburg, VA

CORE-CM initiatives, particularly in the Central Appalachian Coal Basin, present unique and unprecedented opportunities for the advancement of
environmental and social wellbeing. In addition to national security, one of the other primary goals of these initiatives are to uplift and revitalize regional economies which once thrived on coal mining. Environmental responsibility and fair treatment of Central Appalachian communities remain equally significant pursuits which must be evaluated prior to the commercialization of emerging CORE-CM production strategies. This presentation will consider the sustainability of both existing and proposed infrastructure surrounding these endeavors, and will estimate their potential impacts on the surrounding communities through the use of Geographic Information Systems (GIS) and other publicly available tools.

4:05 PM
Technology Assessment for Mining Critical Minerals in Central Appalachia
S. Schafnik, Z. Agioutantis and R. Bishop; Mining Engineering, University of Kentucky, Lexington, KY

The current geologic assessments in the Central Appalachian Basin show critical mineral concentrations are primarily in out-of-seam material. This paper discusses the change in the mining technology and methods that will allow for recovery, primarily from the mining operations, of the secondary material from active and mined-out areas. The technology review suggests that existing mining extraction technologies associated with Underground Mines (UG), Surface Mines, Highwall Mining (HWM), and Auger Mining, will require some minor reconfiguration for extraction of critical materials from in-place deposits. In general, the current extraction methodologies have been enhanced over many decades of mining to allow for efficient extraction.

WEDNESDAY, FEBRUARY 28  AFTERNOON
COAL & ENERGY: VENTILATION INNOVATIONS II
North 227B

2:00 PM • Wednesday, February 28

Chairs: J. Bowling, SRK Consulting, Clovis, CA
K. Raj, CDC NIOSH, Spokane, WA

2:00 PM
Introductions

2:05 PM
Longwall Gob CFD Simulation Permeability and Porosity Scalable Equation Fit GUI Interface

Students at Colorado School of Mines during a summer computer science field session developed a plug-in schema code for Ansys Fluent simplifying the controlled scalability of the Gilmore-Marts equation fits for longwall gob porous zone fluid flow parameters. The project aimed to detect the gob zone placement from the mesh zone and size of the mesh for the equations to be scaled across. This plug-in includes access to three validated data sets with vastly different flow parameters coming from one sub-critical panel, and two super-critical panels. Code is available at: https://github.com/qtflx/gob. Ansys Fluent multiphase fluid simulation plug-in for mapping volumetric strain increment and explosive gas zones within panels of gob from underground longwall coal and trona mining.

2:25 PM
New Methodology for the Optimal Selection of a Mine Ventilation System
D. Naupari' and L. Zamalloa'; 'Mining Engineering, Colorado School of Mines, Golden, CO and 'Mining & Flows, Chaclacayo, Lima, Peru

The development of a new mine offers the option for an early design optimization of the future mine ventilation system, providing a direct control in the planning process. The different variables to consider during this implementation process create a condition that, when an assessment of optimization alternatives is conducted, it is limited to an individual evaluation of each alternative. This is because the complexity of these systems impedes further level of analysis, ignoring some opportunities of improvement commonly associated with the distribution of ventilation raises or their future use as intakes or exhausts, impacting directly into the total power required by the system. This paper proposes a new methodology for the optimization of the ventilation system in a mining project at the prefabsibility stage, evaluating the capital development, associated equipment, operational costs and process scheduling. The result from this new approach is the determination of multiple design options that includes an optimization analysis of the economic parameters in the short-term due to the evaluated CAPEX, and in the long-term associated with the net present value (NPV).

2:45 PM
Pressure Balancing Tests at a Colorado Coal Mine
F. Calizaya, C. Kocsis, J. Johnson, T. Dealmiea and N. Nunesdeoliveira; Mining, University of Utah, Salt Lake City, UT

Two pressure balancing chambers were constructed at a Colorado coal mine to reduce the risk of spontaneous combustion. Each chamber was established by installing a Kennedy stopping at about 10 ft (3m) in front of an isolation seal, and equipped with two safety doors, a nitrogen injection system, and a set of environmental monitors. Several pressure balancing tests for different ventilation conditions were conducted in these chambers. During each test, pressurized nitrogen was injected into the chamber and the pressure differentials across the stoppings and seals monitored. This study presents a summary of the results achieved, lessons learned, and the basic requirements to operate a pressure chamber effectively.

3:05 PM
Mine Ventilation Pathway Simulation on a Hypothetical Shale Gas Well Breach Utilizing the Longwall Instrumented Aerodynamic Model (LIAM)
R. Kimutis, S. Schatzel, m. harris, M. Mazzella and M. Guiltard; PMRD/MSSB, CDC/NIOSH, Pittsburgh, PA

NIOSH researchers evaluated the impact of potential shale gas well breaches and subsequent gas inflow on selected mine ventilation systems of operating longwall panels using a 1:30 scaled Longwall Instrumented Aerodynamic Model (LIAM) and Sulfur hexafluoride (SF6) as a tracer gas. A series of tests were performed at 340, 400, and 500 cfm inflow levels utilizing different mine ventilation scenarios. Results suggest that the breached gas can be diluted to regulatory levels when the longwall panel is adequately ventilated. The results enhance the understanding of the gas inflow and mine ventilation system interaction and provide critical information to the industry and regulatory agencies for improving miner’s safety.

3:25 PM
Field Study to Demonstrate Portable FTIR for Respirable Silica Analysis in Coal Mines
G. Elie, A. Greth and E. Sarver; Mining and Minerals Engineering, Virginia Polytechnic Institute and State University, Blacksburg, VA

Overexposure to respirable crystalline silica (RCS) dust can cause respiratory diseases. To enable rapid determination of RCS in coal mines, NIOSH has developed a direct-on-filter analysis method using portable Fourier Transform Infrared spectroscopy (DOF-FTIR). In essence, the method can be used to estimate RCS mass using a 1-point scan on a respirable dust filter sample. Although the method has been extensively tested in the laboratory, it has not been widely adopted by industry. Here, we present a field study in an underground coal mine. The primary objective was to assess RCS concentration in key locations under different mining conditions, while demonstrating the DOF-FTIR capability to mine...
personnel. Standard gravimetric samples were used to collect respirable dust for the DGF-FTIR analysis of RCS mass, and continuous personal dust monitors were run in tandem to estimate time-weighted average respirable concentration—thus allowing RCS concentration to be estimated in the field. The 1-point scan approach was also evaluated as part of this study.

3:45 PM

Coal Mine Dust Lung Deposition Simulation Using MALDA
E. Medureira¹, W. Su² and P. Roghanchi³; ¹Mineral Engineering, New Mexico Tech, Socorro, NM and ²The University of Texas Health Sciences, Houston, TX

Despite attempts to minimize dust-related diseases such as CWP, an increase in exposure incidence was noticed by NIOSH. The study on dust deposition in the respiratory tract and lungs allows for a better understanding of how particle sizes, shapes, velocities, and airways diameter affect particle deposition, which leads to positive changes to dust exposure in mines. In this research, samples collected in US mines undergo intensive testing that simulates real-life conditions in a dusty mine opening. A Mobile Aerosol Lung Deposition Apparatus (MALDA) is used to represent the mine worker inside the dusty wind tunnel equipped with NIOSH-approved monitoring systems.

4:05 PM

Determination of Respirable Silica in CPDM Samples by Portable Fourier Transform Infrared Spectroscopy
A. Greth and E. Sarver; Mining & Minerals Engineering, Virginia Polytechnic Institute and State University, Blacksburg, VA

Per the 2014 Dust Rule, Continuous Personal Dust Monitors (CPDMS) are now the primary means of respirable dust monitoring in US underground coal mines while standard gravimetric samplers must still be used by the regulatory agency to evaluate respirable crystalline silica (RCS). The CPDM collects a physical sample on a borosilicate glass filter to measure mass concentration of respirable dust in real time, but RCS is not determined. On the other hand, portable Fourier Transform Infrared Spectrometer (FTIR) method has been developed to enable “end of shift” RCS measurement on gravimetric samples collected on polyvinyl chloride (PVC) filters, but most mines are no longer collecting these samples since adoption of the CPDM. Clearly, a method to apply portable FTIR to CPDM samples would be very valuable. To this end, the current study evaluates the feasibility of CPDM sample recovery and redeposition on PVC filters for FTIR analysis. Experiments were conducted on paired CPDM and gravimetric samples collected in a controlled laboratory environment, and will soon be extended to field samples.

WEDNESDAY, FEBRUARY 28 AFTERNOON

ENVIRONMENTAL: GEOSYNTHETICS APPLICATIONS

North 126B

2:00 PM • Wednesday, February 28

Chairs: M. Isola, Wood Group USA Inc, Tampa, FL
B. Moravec

2:00 PM

Introductions

2:05 PM

Designing Crusher Walls in Corrosive Environments
E. Michiels¹ and H. Hilfiker²; ¹Mineral PP, Tampa, FL and ²Hilfiker Retaining Walls, Eureka, CA

Designing a crusher wall on a precious metal mines presents unique civil engineering challenges. Contrary to retaining wall designs in commercial or highway markets, crusher walls are required to be constructed without a batter or essentially vertical. These extraordinarily tall vertical walls are required to sustain high lateral loads, high surcharge loads, hydrostatic pressures, settlement and compression as well as deformation at the front face. Cast-in-place concrete walls are cost prohibitive in most instances on walls over 30’. Rigid faced MSE walls can be constructed cost effectively and relatively quickly. The reinforcing elements of these walls can be limited in applications where the pH of the backfill is outside 4-9 range. This presentation will focus on the hybrid design approach by Hilfiker, where they combine their robust welded wire facing elements with geosynthetics, geogrids and polymer mesh to sustain elite cost-effective installations in these severe environments.

2:25 PM

Engineering a Large Eco Friendly Reinforced Sloped MSE Wall System to Increase the Size of a Flat, Work Area of a Mine
C. Andrade; Technical Sales, Maccaferri, Inc., Avondale, AZ

A Mine on the Mountains at southern Arizona was being developed for the extraction of Manganese, zinc, silver and lead essential for clean and renewable energy. The project required a Mechanically Stabilized Earth retention system with the purpose of expanding the flat working area of the mine and providing access to the underground tunnels. The expansion pad should be capable to withstand the loading of the heavy equipment used in Mining, the reinforcement elements of the wall needed to resist the very low resistivity and aggressive soil conditions for the backfill, capable to resist damage of installation, a system that was easy to transport due to tight access conditions, and to be capable for free drainage. A face system prone to vegetation was desired to merge with the existing vegetation of the area. An access road was planned downslope the wall. A Reinforced sloped system was selected, the fascia of the wall had an inclination of 70 degrees lined with an erosion control mat to promote vegetation, the wire basket units had galvanized wire with polymer coating, high tensile strip bonded geogrids with high tenacity polyester core. The wall is 1500’ long and 45’ in height.

2:45 PM

An Introduction To Electrical Leak Location For Geosynthetics In Mining
S. Calendine; Geoscientist, hydroGEOPHYSICS, Tucson, AZ

Mines rely heavily on non-permeable geosynthetic liners, particularly for critical applications like ponds, heap leach pads, and tailings piles. These indispensable liners are an impermeable barrier between contained materials and the underlying earth, crucial for protecting the environment and optimizing mining processes. Nonetheless, throughout their lifespan, these liners are susceptible to damage from various sources, such as installation mistakes, wear and tear, or environmental impacts. Undetected leaks can cause revenue loss, operational shutdowns, increased liabilities, and substantial environmental repercussions. Electrically-based leak location methods have been the primary tool for identifying these liner breaches for decades. This presentation will give an introduction to the four main methods of leak location typically used on geosynthetics liners in the mining industry: Spark testing, water puddle, dipole method, and pond leak location methods.

3:05 PM

Evolution in Geosynthetics Starts With Utilizing Data Technology
E. Bao; GeoCAAB, Plant City, FL

This paper focuses on the automation of the geosynthetics installation QA/QC process by way of software integration in the field data entry and office data management. Technology is essential to the advancement of geosynthetic installations, especially data application. If implemented appropriately, data application technology improves process efficiency. Users and downstream stakeholders of process improvements can then capitalize by delivering quicker, higher-quality, more economical products. The geosynthetics industry is lagging in the area of data application. From a feasibility perspective and assessing practical implementation opportunities, many workflows widely used for tracking geosynthetic installations and its associated means and methods are antiquated.
and, furthermore, lack reliable authenticity verification. The combination of room to evolve in practice and existing data requirements make the geosynthetics industry an ideal suitor for this technology integration. Software automation create a cyclical geosynthetics ecosystem that benefits the industry as a whole.

3:25 PM
Challenges Associated With the Design and Construction of High-Strength Geosynthetics Cover Systems Over Sludge Lagoons
C. Rodriguez, Technical Department, HUESKER Inc., Mount Holly, NC
Pond storage is the most common sludge management practice for residual materials from mining activities. These residual materials typically will have high moisture, low permeability, fine-grained distribution, and high compressibility (Zink 2013). The main challenge involving the capping/closure of lagoons and impoundments is the weak nature of the material being covered and the variability of its mechanical properties (i.e., shear strength). This presentation briefly describes the basis for the design of sludge lagoon capping system using high strength high modulus geosynthetics and as well as construction procedures employed on a few notable projects, geo-environmental challenges, and important findings for each of these projects and possible improvements to current practices.

3:45 PM
Improving Performance of Mine Process Ponds
N. Rauh; Mining, Agru America, Inc., Fernley, NV
Barren and pregnant ponds are used to store chemical process solutions at a mine facility. These ponds are often mandated to use multiple layers of geomembrane liners to minimize the chance of environmental contamination and include a leak detection system installed between the liners to warn the operator if any leaks occur in the primary liner. Historically, a double-lined pond consisted of two layers of HDPE or LLDE geomembrane with a geonet between the membranes to allow for flow should a leak arise. Agru America has created a structured geomembrane that eliminates the need for a separate geonet drainage layer improving technical performance of the system. This Integrated Drainage System (IDS) increases transmissivity while minimizing the chances of biological clogging, reduces installation costs and construction time, while also reducing the carbon footprint of the project. This presentation will cover the benefits of the Integrated Drainage System compared to a traditional double-lined pond based on numerous mine pond installations.

4:05 PM
The Use of Geotextile Tubes for Dewatering Mine Tailings in a Continuous Process of a High Production Iron Mine
N. Castro and N. Ruiz; GEOTUBE Systems, Solmax, Land O Lakes, FL
Since the early 2000's the mining industry has benefited from the use of geotextile tubes to dewater high moisture content materials generated from various mining processes. However, the use of the geotextile tubes for tailings dewatering gained strength after two major events involving the collapse of two tailings dams in Brazil, one in 2015 and then another disaster in 2019. Encapsulating mine tailings using geotextile containers has gradually been considered a safer and viable solution for preventing new accidents and for tailings disposal due to its potential for stacking. Geotextile tubes are great storage units for dewatered soil and critical minerals, which inspired the technical research department of a high production mine complex to develop a pilot project for a continuous process with the objective to monitor the dewatering operation, evaluate the possibility of recovering residual iron and storage potential industrial sand to supply the local market. Due to significant success, the project was expanded, and it is an ongoing operation. This paper presents relevant aspects of the geotextile tube technology, the research pilot project, and subsequent phases.

WEDNESDAY, FEBRUARY 28 AFTERNOON
ENVIRONMENTAL: MINING HYDROGEOLOGY
North 125A
2:00 PM  •  Wednesday, February 28
Chair: C. Peters, Montgomery & Associates, Tucson, AZ

2:00 PM
Introductions

2:05 PM
Environmental Data Management Framework for Mine Sites
A. Wunsch and D. Ludwick; Colorado Geoenvironmental, SRK Consulting, Denver, CO
The types and magnitude of data collected at mine sites pose unique challenges. Instrumentation deployment is growing exponentially, automation is becoming commonplace, and the sophistication of data processing tools are evolving daily. However, data availability does not translate to data usefulness, which in turn hinders informed decision-making. Owners, responsible executives, and operators can be inundated with data, especially as emerging standards (e.g. GISTM) strongly suggest the implementation of a multi-disciplinary knowledge base. A wide variety of commercial tools exist to manage data, however they are often too rigid. SRK has developed a flexible data management framework to address these challenges. The principles of this framework include: • Assignment of data management responsibilities • Flexibility of data ingestion protocols • Centralized management with data mirroring • Data QA/QC with subject matter expertise. This presentation will discuss successful application of this framework to sites with over 100 years of historical data and high throughput of presentely-collected data, focusing on surface water, groundwater, and geochemical data.

2:25 PM
Oh, the Depths We Will Go…6,000!
M. Stacy; Stantec, Fort Collins, CO
Stantec collaborated with our client in the Green River Basin of southern Wyoming to complete a deep water supply well for a project. This project highlights the depths and extremes to which we have to go to find water supplies when surface water is not available or not cost effective. Our client was seeking to develop an in-situ trona mine to produce soda ash, and was required by the Wyoming Department of Environmental Quality to characterize the overlying and underlying aquifers for purposes of aquifer protection. They also wanted to develop a water supply onsite for recovery and processing of the ore. To determine whether groundwater could provide sufficient water for the project, Stantec designed and collaborated with National to complete a 6,000 foot deep well in the Wasatch Aquifer. Aquifer testing of this 6,000 foot Wasatch Aquifer well indicated it would yield up to 466 gpm, or 280 gpm on a continuous basis. Stantec also prepared a groundwater model of the potential impacts of pumping from the Wasatch Aquifer on local water rights.

2:45 PM
Will the Underground Mine Impact Surface Water Resources?—Considerations of Groundwater Flow System Connectivity
V. Tandon, J. Wartman and L. Kramka; Mining, Foth Infrastructure & Environment, Saint Paul, MN
Concerns regarding potential impacts to surface water resources from a proposed underground mine in Northern Minnesota were evaluated. Groundwater and surface water data were collected, and evaluations performed to demonstrate the limitations to the assumed “connectivity” between the deeper groundwater in bedrock within which mining is proposed and the shallow groundwater that is in hydraulic communication with surface water resources. Hydraulic testing, structural and flow data...
from exploration boreholes, delineations of scales of shallow active circulation and sluggish bedrock groundwater flow, along with data from legacy mining in the area were utilized to verify limitations to connectivity utilizing alternate hydraulic connectivity conceptual models.

3:05 PM

Hydrological Hazard Analysis and Mitigation of Regional Faults in Kucing Liar Underground Mine, PT Freeport Indonesia

J. Budiman, S. Nugraha, M. Satria, G. Tulak and A. Beaulavon; Hydrology, PT Freeport Indonesia, Bandung, Indonesia

This study explains hydrological hazard identification and mitigation associated with groundwater from regional faults crossing Kucing Liar (KL) Underground Mine plan. Previous study in 2000 stated a potential high water inflow from a regional fault in KL. Drilling was conducted to validate this assumption and also identified two other faults as a result. Drilling and heading development provided high water inflow and average elevation distance from water intersections to surface is approximately 1km. Water samples analysis shows that most of water samples contain HCO3-facies with low TDS. HCO3-facies is an indication of young groundwater with short travel time from recharge into discharge point. The data was also validated by a good statistical correlation between piezometer data and rainfall. This information is useful in identifying potential high-water inflow (transmissivity) and water quality (i.e., neutral pH and low TDS) from regional faults. It was used to develop dewatering and water source supply targeting these regional faults for mine and community. Initial dewatering drilling in 2023 provided good results with decreasing of water inflow in some of development drift.

3:25 PM

Numerical Groundwater Modeling to Optimize Brine Yield and Grade to Predict Economic Feasibility of Brine Mining Projects

N. Shepherd, Mining, Stantec, Salt Lake City, UT

Initial product yields are often critical to the economic feasibility of a mine. During these early years at evaporative brine mines, the operator must optimize brine production rates while minimizing operating costs associated with pond, trench, and well construction. In this case study, Stantec built a numerical groundwater model to iteratively assess brine yield and grade produced from numerous permutations of the trench network design. The findings demonstrate the power of predictive groundwater modeling to support brine mining operations and the need for robust hydrogeological assessments to understand the spatial variability of aquifer properties and brine grade.

3:45 PM

The Importance of Multiple Lines of Evidence for Successful Conceptual Site Model Development

J. Harvey; St Louis, Geosyntec Consultants Inc, Chesterfield, MO

If exceedances of inorganic constituents are identified above groundwater quality criteria at mining sites, it is common practice to determine if these exceedances should not be attributed to the mining operations. The same evaluations used to support these Alternate Source Demonstrations (ASDs) can also be utilized to characterize the natural attenuation processes. While ASDs may rely on sampling, and statistical analysis, many include an evaluation of natural or ambient conditions. Development of an integrated conceptual site model (CSM) which includes hydrogeologic and geochemical data can generate a much stronger argument. We present a few case studies that illustrate how the combination of multiple sets of technical data resulted in robust CSMs which explained the observed changes in groundwater conditions. At one site, the realignment of a stream during construction of a new landfill cell resulted in increased groundwater elevations, and increased chemical concentrations. In the second case study, artesian conditions and seeps were observed adjacent to a refuse disposal impoundment. These case studies document the importance of a integrated CSM for your site.

4:05 PM

Recipes for Success for Groundwater Modeling at All Stages of the Mine Life

B. Nock, C. Kikuchi, C. Cottingham, G. Nelson and T. Bailey; SME, Tucson, AZ

Groundwater flow models are used in the mining industry to support feasibility, permitting, water management, and geotechnical analyses. While all models must be based on a hydrogeologic conceptual model the design of each model is dependent upon the project goals. This talk will discuss each of these applications including permitting, mine dewatering, mine water supply, and slope stability. Regulators require models to project impacts to groundwater quantity and quality. Permitting models must consider impacts to other water users; impacts to surface water; the extent of drawdown/mounding; and subsidence. These models must encompass the entire impact area for the entire life of the project. Models used for mine water management typically have an operational focus and need to include groundwater-related components of the water budget; dewatering; supply; and infiltration or discharge. Mine water management models may also cover a smaller area and shorter duration. Models for slope stability analysis must represent the hydraulic properties of the rock, structural controls such as faults and fracture zones, and pore pressures at the scale required for geotechnical analysis.

4:25 PM

Coupling Conditioned Progressive Growing Generative Adversarial Networks and Ensemble Smoother to Deal With Uncertainties in Flow of Complex Aquifers

M. Tetteh; Geology & Geological Engineering, South Dakota School of Mines and Technology SME chapter, Rapid City, SD

A novel approach for hydrogeological model calibration has emerged by using deep generative models specifically, Generative Adversarial Networks (GANs) to generate realistic images of channelized aquifers and subsequently coupled with geostatistical algorithms to solve parameter estimation problems. This study focuses on utilizing an improved GAN called progressive growing generative adversarial network (PGGAN) conditioned to hard data for parameter estimation of complex facies models by coupling ensemble smoother with multiple data assimilation (ES-MDA) algorithm. ES-MDA has recently been incorporated into the field of hydrogeology for parameter estimation where aquifer parameters such as hydraulic conductivity are calibrated by conditioning on some dynamic data. A trained PGGAN will generate hydraulic conductivity fields by feeding it with latent variables and ES-MDA will be used to calibrate these hydraulic conductivity fields to match known hydraulic heads. The results show that coupling PGGAN and ES-MDA conditioned to hard data is able to calibrate hydraulic conductivity fields to simulate hydraulic heads that match the known hydraulic heads.

WEDNESDAY, FEBRUARY 28 AFTERNOON

ENVIRONMENTAL: SUSTAINABILITY & ESG DISCLOSURES

Sponsored by: BARR

North 127B

2:00 PM • Wednesday, February 28

Chairs: K. Brantingham, ARCADIS, Phoenix, AZ

K. Awuah-Offei, Missouri University of Science & Technology, Rolla, MO

2:00 PM

Introductions
2:05 PM
ESG Disclosures—Substance, Story and Supportability

E. Ahachich; Barr Engineering, Salt Lake City, UT

The ESG landscape remains crowded given rising expectations among investors and other stakeholders, with a continued focus on public commitments and transparency to progress. For mining companies, expectations continue extending beyond environmental factors to various social aspects, as evidenced by GRI’s new mining standard. While sustainability reports and frameworks address non-financial factors, they are still disclosures and should be treated as such. This requires deliberate internal coordination across functions given the breadth of material factors and stakeholder interests. This session will address things companies should consider as they work to tell their story in a supportable, repeatable and compelling way.

2:25 PM
A Pathway to Future Ready Mines: Integrating Environmental, Social, and Governance (ESG) Principles into Mining

B. Demircan; WSP, Phoenix, AZ

Responsible and sustainable mining practices are gaining prominence within the framework of Environmental, Social, and Governance (ESG) considerations. This abstract highlights the evolving landscape where mining companies are integrating responsible methods to minimize environmental impact, ensure community well-being, and align with societal expectations. Balancing resource extraction with environmental preservation is central to sustainable mining. ESG principles drive transparency, accountability, and stakeholder engagement, influencing decision-making in mining operations. This abstract emphasizes the synergy between sustainable mining and ESG, focusing on their collective role in reshaping the industry towards a more enduring model that addresses global concerns while meeting resource demands. Integrating ESG principles into the mining sector represents a paradigm shift that promises positive outcomes for both the industry and society at large. By adopting sustainable practices, fostering social inclusion, and enhancing governance structures, mining companies can navigate challenges and secure long-term viability.

2:45 PM
Conceptual Application of Digital Twins to Meet ESG Targets in the Mining Industry

R. Cranford; Mining, Minerals and Metals, Stantec, North Bay, ON, Canada

As the first step in the value chain, the mining industry sets the foundation for most industries to meet their environmental, social and governance (ESG) targets. Beyond providing sustainable materials, the mining industry is required to produce critical minerals needed for creation of sustainable technologies. With an ongoing debate on how ESG factors should be measured and inconsistent reporting between mining companies, there remains a gap in consistent and auditable progress in ESG reporting. This study evaluates the application of digital twin (DT) technology to bridge the gap in ESG reporting. By examining the use of DT technology through 30 case studies/theoretical applications across industries that share commonalities with mining, this study analyzes the opportunity to apply the technology to the mining industry. Successful implementation of DT technology will require the right people with the right capabilities. Though suggested that the mining industry should let other industries stabilize the DT market due to their history and investment in data systems, it is arguable through literature that solutions are available and scalable, and the time to wait is over.

3:05 PM
24-052
Impacts Of ESG on The Copper Supply Chain—The New Critical Mineral

C. Gámez Gonzales and A. Anani; Mining and Geological Engineering, University of Arizona, Tucson, AZ

The World Bank estimates that the demand for copper will increase by 500% by 2050. In August 2023, copper was identified as a critical mineral with a high risk of supply chain disruption. One of the identified disruptors of the supply chain is environmental, social, and governance (ESG) compliance. This study investigates the impacts of ESG on the copper supply chain by analyzing current ESG standards, company compliance through yearly reporting, and risk analysis implementation strategies and determines the effects of ESG standards on the supply chain. We break down the copper supply chain and identify  established international, national, and local ESG standards for each stage. Further evidence is gathered from company interviews. We also discuss the need for a standardized framework capable of assisting the copper industry with ESG compliance.

3:25 PM
Global Sustainability of Critical-Mineral Extractions: Implications for Sustainable Development

D. Agusdinata; Arizona State University, Tempe, AZ

The transition to a low-carbon economy depends on the availability of critical minerals such as lithium, nickel, copper, and rare earths. However, the increased demand for these minerals due to the adoption of clean technologies like electric vehicles can inadvertently lead to adverse effects on water resources, biodiversity, and societal well-being in the areas where they are extracted. Finding a solution to sustainability challenges in one area while avoiding the creation of problems in another presents a significant dilemma. In order to address this question, the paper will shed light on pertinent research findings and agenda. The paper will use a telecoupling framework to examine the intricate causal networks and influences that connect distant social-ecological-technical systems. Through various case studies, the paper will highlight the dynamics of socio-environmental impacts resulting from critical mineral extractions. Moreover, it will explore the potential and challenges associated with advancing the sustainable mining of critical minerals, aiming to facilitate the adoption of low-carbon technologies and the achievement of Sustainable Development Goals (SDGs).

3:45 PM
Reducing GHG and Fresh Water Consumption, A Pathway to Sustainability

D. McLane; Mining, Burns & McDonnell, Phoenix, AZ

Sustainability is paramount to the future of mines, both existing and new builds. Developing and implementing sustainability initiatives within our industry can vary drastically from site to site and company to company but there is one commonality—we are all doing it. This presentation will provide a high level overview of a sustainability program developed and implemented at six sites across North America. This program targeted low capital improvements with minimal impact to operations. Key findings from the program will be shared, highlighting the path from concept to implementation. This systematic approach will help our industry move plans into actions.

4:05 PM
Getting Ready to Assess and Manage Biodiversity-Related Risks

R. Jaffe and D. Heinze; Ramboll, Redmond, WA

Biodiversity-related risks are yet to be systematically accounted for by the mining sector. We gathered the latest reports and associated performance data for the 26 member companies of the International Council on Mining and Metals (ICMM), which follow similar principles and reporting standards, and used these data to evaluate the companies’ readiness to adopt the framework of the Taskforce on Nature-Related Financial Disclosures (TNFD) currently in development. Few companies addressed impacts on biodiversity, less than half mentioned ecosystem services, and slightly more than half referred to the mitigation hierarchy as a framework to manage biodiversity-related impacts. Most companies were thus unable to assess biodiversity risks and opportunities. Overall, we observed the absence of a unified approach to disclose biodiversity-related risks, even among a
group of mining companies that follow similar principles and reporting standards. One of the goals of our work is to help identify key obstacles to the implementation of the new TNFD framework in the mining sector.

4:25 PM  

**What Are the Most Influential Factors in Conducting a Sustainability Assessment of Deep and Large-Scale Open-Pit Mines?**  
M. Heydari and M. Osanloo, Mining Engineering, Amirkabir University of Technology, Tehran, Tehran, Iran (the Islamic Republic of)

In recent years, sustainability assessment has become a critical aspect of mining, particularly for deep and large-scale open-pit mines. The identification of influential factors in sustainability assessment is crucial for mining companies to prioritize their efforts toward mitigating the negative impacts of their activities on the environment. In this study, the Decision-Making Trial and Evaluation Laboratory (DEMATEL) technique has gained popularity as a useful tool for identifying the interrelationships among various factors and determining their relative importance. This study uses DEMATEL to determine the key factors that have the most significant impact on sustainability in deep and large-scale open-pit mines. The findings will help the mining industry focus on controlling and mitigating influential factors while also improving others that are influenced by them.

4:45 PM  

**The Potential Impacts of Gold Mining in Virginia**  
W. Hopkins1, K. Awuah-Offei1, J. Blum1, R. Bodnar2, T. Crafford3, F. Doyle4, J. DWYER5, E. Holley5, P. Locke5, S. Olson5, B. Schwartz5, G. Smith5, S. Wu5, S. Johnson5, M. Regier5, C. PHILIPS5 and C. ONUWEME5; 1Mining & Nuclear Engineering, Michigan University of Science & Technology, Rolla, MO, 2Virginia Polytechnic Institute and State University, Blacksburg, VA, 3University of Michigan, Ann Arbor, MI, 4University of California, Berkeley, CA, 5Barr Engineering Company (retired), Eko, NV, 6Colorado School of Mines, Golden, CO, 7Johns Hopkins, Baltimore, MD, 8University of Illinois Urbana Champaign, Urbana Champaign, IL, 9U.S. Geological Survey, Washington, DC, 10Montana Department of Environmental Quality, Helena, MT, 11Michigan Technological University, Houghton, MI and 12National Academies of Sciences, Engineering, and Medicine, Washington, DC

The National Academies of Sciences, Engineering, and Medicine’s Committee on Potential Impacts of Gold Mining in Virginia was formed following Virginia’s House Bill 2213 to: 1) review the geologic characteristics of the gold deposits and probable modern mining techniques that could be used in such deposits; 2) evaluate the potential impacts of those activities; and 3) assess the sufficiency of existing regulations in the Commonwealth. The committee found that most known gold occurrences in Virginia are and are mostly associated with metamorphic and igneous rocks in the Piedmont physiographic province. The major potential impacts of concern are related to surface water and groundwater contamination, groundwater table drawdown, remobilization of legacy mercury from past uses, rare but catastrophic events such as dam failures, and cumulative health effects due to interacting stressors. The committee found that Virginia’s current regulatory framework that is designed for industrial minerals operations is not adequate to address the potential impacts of commercial gold mining.

**WEDNESDAY, FEBRUARY 28  AFTERNOON**  

**HEALTH & SAFETY: NORA—APPLIED TECHNOLOGIES FOR SILICA DUST CONTROL**  

**2:00 PM**  
**Introductions**

**2:05 PM**  
**24-065**  
**NIOSH MINER Act Extramural Research for Silica Dust**  
W. Reed and G. Luxbacher; CDC/NIOSH, Pittsburgh, PA

Mine worker exposure to respirable coal dust and silica dust can result in coal workers’ pneumoconiosis and silicosis which are occupational respiratory diseases that have no cure and are ultimately fatal. In 2021 the Mine Safety and Health Administration reported just over 11,000 operating metal/nonmetal mines with the potential for silica dust exposure for just under 200,000 miners. The National Institute for Occupational Safety and Health (NIOSH) conducts respirable coal and silica dust research associated with mining under the Office of Mine Safety and Health Research. NIOSH respirable coal and silica dust research began under the U.S. Bureau of Mines (USBM) which initially examined silica dust, progressing to include coal dust, with a stronger focus after 1969 with the passage of the Federal Coal Mine Health and Safety Act. A review of extramural research to develop real-time respirable silica dust monitor is presented along with a brief history of silica dust regulation.

**2:25 PM**  
**Analytical Methods for the Analysis of Respirable Crystalline Silica in Metal/NonMetal and Coal Mines**  
S. Assemi1, E. Sarver1, X. Wang2, J. Miller3 and L. Pan3; Imessa Research, Salt Lake City, UT, 1Mining and Mineral Engineering, Virginia Tech, Blacksburg, VA, 2Materials Science and Engineering, University of Utah, Salt Lake City, UT and 3Chemical Engineering, Michigan Tech, Houghton, MI

Occupational exposures to respirable silica dust (RCS) remain to be a major debilitating, and in some cases, fatal health hazard, particularly among metal/nonmetal and coal miners. Evaluation of occupational exposure of RCS requires more accurate methods for its sampling, detection, and quantification. This presentation will involve an examination of the current RCS sampling methods, as well as a review of the analytical techniques for the detection and analysis of crystalline silica in respirable mine dust. In addition, some emerging technologies, the possible role of nanoparticles in RCS toxicology, and a new outlook to the metrics will be discussed.

**2:45 PM**  
**The Use of Ventilation to Assist in the Mitigation of Dust in Underground Mines**  
B. Prosser; SRK Consulting, Clovis, CA

The application of ventilation strategy is an important part of the mitigation plan when designing a ventilation system in a dusty environment. Dust suppression techniques (allayment sprays containing biologic and lignans), filtration, extraction, and sprays all can produce significant impacts on dust generation sources, however, in order for these techniques to be truly effective they must operate within a properly designed ventilation system. The overall ventilation system represents the primary method by which dust concentrations can be either diluted or segregated within the mining environment. This paper presents the overall ventilation system options commonly used within the mining industry to help mitigate dust sources in the underground environment. Practical observations and designs will be identified and described.

**3:05 PM**  
**Reducing Operator Exposure to Respirable Dusts—Tangible Highlights of NIOSH and Industry Partnerships**  
M. Yekich, J. Pattis and A. Cecala; PMRD, CDC/NIOSH, Pittsburgh, PA

NIOSH mining has conducted two decades of enclosure filtration research in both lab and field environments. This experience has led to the publishing of essential design considerations for effective enclosure air filtration systems. When these principles have been adopted by suppliers
Belle Fourche shale (BFS) is a bentonitic deposit prevalent in the northern plains of the United States. The mineralogy of BFS is such that it can be processed to form clay-based ceramics. However, upon drying from a green body the material is often subject to cracking. In this research a water-soluble polymer (polyacrylamide (PAM)) was investigated as stabilizing agent with processed BFS. Specifically, the drying rate of the clay-based ceramic was investigated as a function of PAM addition. In addition, the mechanical properties of the final fired ceramic were determined as a function of PAM addition. These results have implications for the use of BFS as relatively inexpensive material for construction materials including bricks.

3:25 PM

Impact of Particle Sizing on Bulk Solids Flow Behavior and How to Handle Those Fines
M. Ray and C. Hartford; Jenike & Johanson, San Luis Obispo, CA

In the mining world, comminution and screening operations are crucial. There are various methods and technologies available for comminution and choosing the appropriate one can significantly affect the efficiency of energy usage, product quality, and the equipment lifespan. Similarly, screening methods can also have many of the same significant impacts. Both operations may lead to unintended consequences that can increase the risk of flow disruptions, downtime, and safety hazards. Once material turns into powder with micron particle sizes, issues such as flooding, rate limitation, and caking all come into play. However, by assessing the physical, chemical and flow properties of the materials, conducting a thorough flow processing review, and performing PHAs and DHAs when necessary, it is possible to mitigate these risks before implementing comminution and screening processes and before purchasing equipment. This talk will discuss the critical steps required to ensure that new operations will function correctly and safely right from the start.

2:45 PM

Clamshell-Dredge Mining as a Solution for Mineral Excavation in Deep-Water Applications
E. ARCHIBALD; Manufacturer, Stoneboro, PA

This abstract reviews the introduction of a “Clamshell Dredge” into marine mining applications where greater excavation depth is needed. When marine operations exist where conventional land-based equipment can not reach required depths, the introduction of a floating clamshell-dredge can be a viable solution. Clamshell dredges typically have a digging depth capability in excess of 200’ below water; but can be designed for even greater achievable depth. Clamshell dredges typically provide additional value through their one-operator/one-machine performance. Reduction in required operators, as well as the removal of powered haulage provides both a safer work environment as well as the elimination of mobile equipment costs. This abstract will discuss; the process used for material excavation, the dredge’s onboard processing equipment, material handling, automation, power consumption, common high-level feasibility and due diligence performed to justify the capital investment, as well as all additional potential benefits.

3:05 PM

Replacing Smelting With Electrolysis to Enable the Domestic, Sustainable, and Economic Production of Copper
K. Greco; Still Bright, Newark, NJ

Reaching net-zero emissions by 2050 will require vast quantities of copper: the world will need 1.4 billion tonnes of new copper in the next 27 years. Chalcopyrite is the most important copper ore mineral, as it accounts for approximately 70% of the world’s copper reserves, and the total value of copper within these ores is approximately $20T. Currently chalcopyrite must be processed via smelting, which is environmentally harmful due to its reliance on burning fossil fuels to achieve the required temperatures, as well as the release of sulfur dioxide, trace quantities of arsenic, and other unsafe chemicals. Still Bright Inc. was formed in 2022 to commercialize novel reaction chemistry between vanadium (II) sulfate and chalcopyrite.
Vanadium (II) electrochemically reduces copper in chalcopyrite to copper metal, enabling complete extraction within 60 minutes. This signifies the fastest kinetics for copper extraction observed to date at room temperature and ambient pressure. This talk will outline technical results from the current lab-scale process, capable of processing 1 kg per day of copper concentrate, and discuss a path forward for commercialization.

3:25 PM
Recent Experiences with Reducing Iron Content for Hard Rock Lithium Production Using Sensor-Based Sorting
H. Cline; TOMRA Sorting Inc., Golden, CO
High iron content is a common contaminant in hard rock lithium deposits in the form of basalt or amphibolite which has a negative impact on lithium production. Most hard rock lithium beneficiation plants in use to date have used dense media separation (DMS) to reduce iron content. A challenge arises when the bulk density of the high iron content lithology presents a similar density to the DMS. The use of sensor-based sorting for reduction of iron-containing lithology using color, LASER, and X-Ray Transmission (XRT) sensors is proving to be an effective method while using less water and reducing energy consumption. The objective of this presentation is to present the background for the implementation of sensor-based sorting to reduce iron contaminants, to outline examples from recent test work, and to give examples showing how sensor-based sorting can be incorporated in processing flowsheets.

WEDNESDAY, FEBRUARY 28  AFTERNOON
MINING & EXPLORATION: GEOSCIENCES: INTEGRATED AND PRACTICAL APPLICATION OF ADVANCED COMPUTATIONAL GEOMECHANICS IN SOIL AND ROCK
Sponsored by: Knight Piesold Consulting

North 222A
2:00 PM  •  Wednesday, February 28
Chairs: R. Abousleiman, Knight Piesold and Co., Denver, CO
A. Rasti, Geomechanical Engineering, Socorro, NM
2:00 PM
Introductions

2:05 PM
Salt is Not a Steady-State Creep Material
J. Chieslar; AES, Inc., Piedmont, SD
Steady-state creep is increasingly used to model structures hosted in salt and potash. This is presumably due to the absence of representative constitutive models available in commercial geomechanics software. We consider a standard suite of tests performed on salt. These include creep, dilation and tension. These tests are fit to a simple material model and evaluated. Simulations of both room-and-pillar and solution mines are performed with varying degrees of completeness with respect to the constitutive model. Closures at key locations are calculated. This exercise quantifies the ramifications on closure (deformations) according to the various material assumptions. It is observed that both the creep transient and dilation contribute to closure. Furthermore, if a failure criterion is considered, dilation is the most appropriate candidate. It is insufficient merely to post-process a creep calculation to evaluate the potential for dilation. By its nature, dilation localizes and concentrates and therefore must be included in the constitutive calculation.

2:25 PM
An Enhanced Method for Rapid and Refined Analysis of Open Pit Rock Slope Stability
L. Zhang and H. Chen; University of Arizona, Tucson, AZ
I will present an enhanced method for rapid and refined analysis of open pit rock slope stability. The method was developed based on a 3D Hoek-Brown (HB) criterion and a customized genetic algorithm (CGA). The upper bound theorem of limit analysis is combined with the strength reduction method to determine the factor of safety (FS) of a rock slope with a potential failure surface (FPS). With the CGA to optimize the PFS, the minimum FS and the critical failure surface (CFS) are obtained. Besides 3D rock mass strength, the method can also effectively consider rock mass quality, disturbance to rock mass from excavation and blasting, and seismic effect of blasting. For convenient application of the developed method, an App was produced using a Python-based graphical-user-interface. With the App, the proposed method was validated by comparing it with existing solutions. Parametric studies were also performed to investigate the effects of rock mass properties, slope geometry and loading conditions on the FS and CFS. The results indicate that it is important to properly consider the 3D rock mass strength and the various factors when evaluating the stability of an open pit rock slope.

2:45 PM
24-088
Underground Mine Ramp Design for Beginners
W. Pariseau; Mining Engineering, University of Utah, Salt Lake City, UT
UNDERGROUND MINE RAMP DESIGN FOR BEGINNERS William G Pariseau, University of Utah, Salt Lake City, Utah Abstract Important features of rock properties, generating ramp meshes, and doing stress analysis based on the well-known finite element method is described in this contribution. Examples of switch-back (zig-zag) and spiral ramps illustrate the three-step procedure. Results for both types of ramps in the form of element safety factor plots illustrate practical design guidance obtained as easy as one-two-three.

3:05 PM
Dynamic Mechanical Characteristics of Microwave Treated Basalt and its Application in Hard Rock Excavation
R. Shu, G. Xu and L. Huang; ‘Missouri University of Science and Technology, Rolla, MO and Curtin University, Perth, WA, Australia
The study is focused on mechanical characteristics of microwave treated rock and the possibility to used for rock breakage. By carried out dynamic compressive experiment on basalt specimens which were heated by microwave, the dynamic compressive strengths of heated basalt specimens were obtained. In addition, a numerical simulation of microwave assisted TBM excavation is established. The results show that the dynamic compressive strength decreases significantly with the increasing irradiation power and irradiation time. When the irradiation power (P) and irradiation time (t) reach a certain value, the basalt specimens will be broken. There are two cases will lead the basalt specimen to be broken. A case is P = 3 kW and t = 120 s, and another case is P = 5 kW and t = 47 s. The specimen is damaged due to thermal shock caused by large thermal gradient, which is helpful to rock breakage. The simulation result indicates that the crack number of basalt will increase and the life and penetration rate of cutters could be increased if the thermal-mechanical rock breakage is applied in TBM, which finally could improve the efficiency and reduce energy consumption in hard rock excavation.
3:25 PM

**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.

3:45 PM

**Study on the Dynamic Behavior and Fracturing Mechanism of Granite**

C. He and B. Mishra; Department of Mining Engineering, University of Utah, Salt Lake City, UT

Numerical analysis was conducted to understand the effect of mineral constituents on the dynamic failure of granite rock. The efforts combined numerical simulation of the split Hopkinson pressure bar (SHPB) experiment, digital image processing (DIP) and the discrete element method (DEM). Results from the analysis showed that the type of mineral greatly influences the strength and fracturing of the granite. Minerals such as quartz and feldspar caused less fracture whereas biotite showed more damage. Strain rate and confining pressure also influenced fracture development in the granite. Higher strain rates produced more fractures and confining pressure reduced the development of fractures. Tension cracks was predominant followed by shear cracks.

4:05 PM

**Sonar Surveys to Adaptive, Body-Conforming Meshes for Solution Mines**

J. Chieslar, AES, Inc., Piedmont, SD

Subterranean voids such as solution mines are often defined via sonar surveys. Oftentimes these have obvious errors in geometry. For example, if the mine is used to dispose of waste that does not allow sound waves to penetrate, then voids are evident. Furthermore the resolution of the sonar surveys is much too fine to facilitate an efficient mesh generation exercise. We outline a procedure using solid modeling techniques to correct errors in the surveys and wrap the resulting geometry with a nurb (non-uniform, rational, b-spline) surface. The nurb surface is discretized to a resolution fine enough that it respects the geometry yet coarse enough to facilitate meshing queries, namely ray-tracing. Solid modeling techniques are then used to create a solid model defining the solution domain as well as mesh-refinement interfaces. Finally an adaptive meshing technique is deployed which is suitable for multi-scale modeling (large domains with localized refinement). The resulting meshing of bricks is topologically conforming, that is, no hanging nodes result, requiring multi-point constraints for a subsequent mechanics solution. It is also geometrically conforming at the mine interface.

4:25 PM

**Breaking Up with Excel: A Tale of Embracing Microsoft Magic for Open-Pit Mine Design**

S. Barcelona; Rio Tinto, South Jordan, UT

Unlocking innovation within open-pit mine design management, this study harnesses the versatility of Microsoft’s suite of tools to enhance communication, collaboration, and notification processes. By streamlining workflow through Microsoft applications, the abstract highlights a dynamic approach to address challenges of simultaneous changes and version control. Leveraging findings from user input, the study illuminates the efficacy of Microsoft’s tools in managing open-pit designs communications and approvals. By sharing this adaptable strategy, the abstract underscores its potential to improve mine design practices industry-wide, offering a cohesive, accessible alternative to specialized software. Transitioning from spreadsheets to Microsoft Teams marks a pivotal step towards mitigating common industry-wide communication and organizational hurdles.

**WEDNESDAY, FEBRUARY 28 • AFTERNOON**

**MINING & EXPLORATION: GEOSCIENCES: PRACTICAL EXAMPLES OF SURFACE GEOTECHNICAL DESIGN AND RISK MITIGATION**

Sponsored by: BARR

North 222B

2:00 PM • Wednesday, February 28

**Introductions**

2:05 PM

**A Method for Quantifying Geotechnical Risk**

B. Ruddy; Call & Nicholas, Inc, Tucson, AZ

There are multiple scenarios in which geotechnical risks present themselves in open pit mining environments. Often this risk is measured qualitatively, which can result in variation of the risk level depending on the person assigning the risk. However, by quantifying risk through the implementation of a geotechnical risk register using the following process: 1) determining the mode of geotechnical failure 2) determine the overall impact if the failure occurs 3) determine the likelihood that event will occur and 4) assign a risk score, geologists and engineers can determine appropriate controls to lower risk exposure.

2:25 PM

**Designing a Rockfall Testing Program for Open Pit Mines to Investigate Runout and Bench Catchment**

J. Bourgeois and S. Warren; National Institute for Occupational Safety and Health, Washington, DC

The potential of rockfall at open pit mines presents a continuous hazard to mine workers and is typically mitigated by designing catch benches at empirically determined widths. In 2019, geotechnical professionals in the open pit mining community requested that the National Institute for Occupational Safety and Health (NIOSH), in conjunction with industry, revisit and update current catch bench guidelines to better match acceptable risk tolerances for modern mining practices. To begin this process, a rockfall testing program was designed to gather empirical runout and bench catchment data at partnering mine sites in the Western United States. This paper presents a detailed description of each component of the rockfall testing program, including scouting and safety
plan development, equipment requirements, synthetic rock development for uniform testing across varying bench configurations, local rock collection for testing of mine specific geology, data acquisition during testing, and data processing. Additionally, this paper describes how the program has updated over time according to lessons learned during initial rockfall testing.

2:45 PM

Geotechnical Applications of Thermal Imaging: Observations and Recommendations

J. Potter1, B. Meyer2, L. Brown1, J. Keefer1, J. McNabb2, R. Prescott1, B. Ross1 and C. Williams2; 1Mel & Enid Zuckerman College of Public Health, The University of Arizona, Tucson, AZ and 2Geotechnical Center of Excellence, University of Arizona, Tucson, AZ

Thermal cameras in mining operations are predominantly utilized for equipment condition surveillance, personnel detection, and enhancing situational awareness. The University of Arizona’s Geotechnical Center of Excellence (GCE) has demonstrated the utility of thermal cameras for detecting rockfall events and is developing an automated system to monitor and alarm for rockfall hazards. Empirical data gathered during this project suggest a variety of additional geotechnical applications for thermal imaging, such as 1) Identification and potential flow estimation of seeps; 2) Use of large-area thermal comparisons to detect the presence of rock bridges or flakes with minimal connection to surrounding rock faces; 3) Detection of near-surface underground voids; and 4) Analysis of differential temperature characteristics of compositionally-diverse rock faces. This talk will explore thermal monitoring as an enabling technology, outlining technical challenges and addressing considerations when selecting thermal equipment for geotechnical monitoring, such as camera type, resolution, speed, sensitivity, field of view, fixed mount stability, and applicability of drone-mounted thermal cameras.

3:05 PM

24-001

A Case Study: Successfully Managing Excessive and Rapid Slope Deformation in an Open Pit Mine Utilizing Slope Monitoring Radar Systems

J. Ealy and C. Foster; Technical Services, KGHM, Ruth, NV

Maintaining stable high-walls can be a challenging task. Complex geological and structural features, alteration zones, and hydrological conditions must be well understood in order to design a safe mining environment. Economic considerations must also be taken into account as the mine operator must provide ore deliveries and protect reserves. However, even when good engineering practices are followed, and proper blasting and mining techniques are being implemented, slope movements may still occur. When these slope instabilities are minor, the mine is often able to continue operations with minimal impacts to safety or production. When these occurrences are excessive and coupled with high rates of movement, a robust monitoring system is crucial to continuing mining activities while protecting personnel. This paper summarizes the approach an open pit mine in Nevada took as excessive and rapid high-wall movement was experienced in an integral area. Creative mining approaches combined with slope monitoring radar technology was utilized in order to maintain successful and safe mining activities on and around active movement that exceeded 30 inches per day average velocity.

3:25 PM

A New Approach Managing Instabilities at Grupo Mexico ASARCO’s Ray Mine

L. Tejada Arata; Technical Services, ASARCO, Marana, AZ

Grupo Mexico ASARCO’s Ray mine is an open-pit copper mining complex. Ray mine has multiple instabilities but the critical is the southwest wall, which has experienced instabilities for the current and previous pushbacks. The instability is mainly controlled by major structures, poor rock mass, water management challenges, and artificial recharge. After analyzing previous instabilities, Ray mine has undertaken a proactive initiative to address hydrological and geotechnical opportunities. The new strategy includes a review of the surface water management strategy, major structures, mine dewatering, and slope depressurization to support the current slope design. In 2022, Ray mine started a new approach the pit dewatering at the pit bottom, which consisted in dewatering mine water in the not active ROM dumps. Ray mine’s new initiative promotes safe mining conditions by using slope monitoring systems to determine critical deformations, managing horizontal and reverse circulation drilling, controlling blast vibrations, and analyzing slope compliance. The intention of this paper is to present a new proactive mine geotechnical initiative while maintaining a safe mining environment.

3:45 PM

A Surface Geotechnical In-Pit Underground Portal Relocation: An Operations-Based Case Study

R. Sheets; Barr Engineering Co, Minneapolis, MN

Reactivation of highwall slope failures during adverse weather had intermittently impacted haul road access into a previously mined open pit. These impacts ranged from limited access to full closures; however, the greater impact was to an underground mine that was developed within the open pit. Following several significant precipitation events, a rapid snow melt greatly accelerated movements finally closing the haul road and destabilizing other past failures. In addition to re-designing the overall pit access, the decision was made to relocate the primary portal to a more stable highwall. An accelerated surface geotechnical review was required to advance the portal relocation; however, only existing information from past investigation, existing geology model, visual inspections, and slope monitoring data were available for the assessment—no new investigations or data collection could be completed within the allowable timeframe. The evaluation included a review of the geology, an assessment of the current highwall condition and previously observed performance, and a rockfall analysis to evaluate existing catchment above the proposed new portal location.

4:05 PM


A. Soni1, A. Wamweya1, H. Hazweze1, L. Tejada1 and L. Long1; Freeport-McMoRan Inc., Tucson, AZ and 1Itasca Consulting Group, Minneapolis, MN

During an open pit operation, undesirable waste rock or low-grade ore are placed in constructed fill dumps and stockpiles. The topographical conditions and physico-mechanical properties of these unconsolidated structures are unique and could pose significant risk to mine operations and workforce. This study evaluates stability of life-of-mine waste dumps and stockpiles using 3D numerical modeling and their interaction with the pit. The research also investigates the unique placement of a portion of these dumps on historical tailings and discusses safe practices for hazard mitigation. Ensuring stability and performance of these structures is key to maintaining a geotechnically safe open-pit mining environment.

4:25 PM

Use of Electrical Resistivity for Karst Hazard Identification on Active Dragline Bench in Central Florida

J. Woosley; Mine Planning and Geology, CEMEX, Miami, FL

Submerged dragline operations are common throughout Florida and are a critical component of the state’s industrial minerals, aggregate, and cement industry. Karst features can pose a serious safety risk to operators and equipment as well as be concentrated in impurities that can affect the final products. Electrical resistivity tomography is a highly accurate and low-cost solution for defining karsts in this region and has significant cost savings and operational benefits over traditional drilling and trenching methods. This paper will explain the background of karst topography and its effect on the operations; how the use of ERI has dramatically improved our understanding of the geology of the operation; and how we integrated these features into our site geotechnical model to allow us to safely operate in karst terrain.
WEDNESDAY, FEBRUARY 28  AFTERNOON

MINING & EXPLORATION: MANAGEMENT: EFFECTIVE ADVOCACY FOR MINING: A DISCUSSION WITH INDUSTRY TRADE ASSOCIATIONS AND ADVOCACY GROUPS: PANEL DISCUSSION

North 223

2:00 PM • Wednesday, February 28

Chair: A. Martin, Foth Infrastructure & Environment, LLC, De Pere, WI

2:00 PM

Introductions

2:05 PM

Effective Advocacy for Mining: A Panel Discussion with Industry Trade Associations and Advocacy Groups

P. Haarala; Coeur Mining, Herriman, UT

In a world of constantly changing politics and hot topic issues, how does mining continue to move forward? Are you interested in learning more about how industry organizations work together to help shape the future of mining? The panelists from mining industry trade associations and advocacy groups will give a brief overview of how their organizations support the industry and share their thoughts on a range of pertinent topics. The session will start with panelist introductions and an overview of their organizations. Then panelists will be given an opportunity to comment on industry topics: permit streamlining legislation, critical minerals and supply chain legislation, amending the mining law, influencing administrative policies, how we can help support advocacy efforts, and conclude with an audience Q&A. The panel discussion will be moderated by members of SME’s Government and Public Affairs Committee (GPAC) committee. Panelists—National Mining Association (NMA, Justin Prosser)—Women’s Mining Coalition (WMC, Emily Hendrickson)—American Exploration & Mining Association (AEMA, Mark Compton)—Arizona Mining Association (AMA, Steve Trussell)

WEDNESDAY, FEBRUARY 28  AFTERNOON

MINING & EXPLORATION: OPERATIONS: DIGGING DEEPER: UNEARTHING THE POWER OF CONTINUOUS IMPROVEMENT TO DRIVE EXCELLENCE IN MINING OPERATIONS

North 222C

2:00 PM • Wednesday, February 28

Chair: K. Toe, Nevada Gold Mines, LLC

2:00 PM

Introductions

2:05 PM

Drill and Blast Optimization

J. Heiner; Technical Services, Forte Dynamics, Bountiful, UT

Drill and blast operations play a crucial role in the mining and construction industries, impacting both safety and productivity. To enhance efficiency and cost-effectiveness, data-driven optimization must be used. By employing a systematic process, providing comprehensive training, and fostering collaborative environments, this approach aims to revolutionize traditional practices and unlock untapped potential for operational excellence. In conclusion, this abstract proposes a holistic approach to drill and blast optimization, integrating data analysis, process optimization, comprehensive training, and collaboration. Organizations can drive safety, productivity, lower cost, and sustainability improvements by leveraging data insights, streamlining operations, empowering the workforce, and seeking external assistance.

2:25 PM

Enhancing Mining Efficiency, Safety, and Sustainability Through Full Potential at Newmont’s Merian Mine

P. Hardien; Business Improvement, Newmont Suriname, Paramaribo, Suriname

Mining companies often operate in complex environments, where factors such as safety, operational efficiency, and environmental sustainability are of greatest importance. In this context, the concept of Continuous Improvement plays a big role in driving the success of mining operations. This paper takes a look at how Newmont embraces Continuous Improvement methodologies into their Full Potential program at the Merian Mine to optimize their processes, enhance safety measures, and contribute to sustainable practices. As the mining industry evolves, the principles of Continuous Improvement will play an increasingly critical role in shaping its future success.

2:45 PM

MILP Production Scheduling Models for Evaluating Continuous Improvement Projects

S. Hoerger; Peak View Mine Planning, Englewood, CO

Operators are under pressure to deliver continuous improvement projects to grow margins, offset inflation and counteract declining grades. Depending on how mine and process capacities interact with orebody characteristics, incremental tonnage increases rarely create equivalent metal production increases. In the worst cases, incremental revenues are eclipsed by the cost of higher tonnages. Mixed integer linear programming (MILP) production scheduling models can be used to evaluate if tonnage improvement projects will deliver value over all time periods and whether new bottlenecks will be created. The MILP models can evaluate the interconnected effects of mine and process capacities, mining locations, cutoff grades, stockpiles, and orebody grade/tonnage distributions. A case study compares potential value creation from a mine capacity increase, a mill capacity increase, or a simultaneous increase in both capacities. For perspective, project valuations for tonnage increases are compared against valuations for cost reduction projects and mine planning improvements such as phase design, dynamic cutoff grades and stockpiling.

3:05 PM

Mining and Technology—How do the Fundamentals of Your Mining Operations Measure Up?

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

The mining industry has become a big adopter of technology, with autonomous trucks, remote control, fleet management systems, and operator assisted equipment as examples. Technology is moving the industry forward on many fronts. Mining is not completely autonomous as people are still required to move material from point A to B in a large majority of mining operations. So how do the fundamentals of your load and haul operation measure up in today’s mining industry? Just what are the fundamentals of any loading and hauling operation in mining either as a surface or underground mine? Caterpillar has for decades identified four areas through countless studies and observations around the world that drive productivity and costs. These four areas are key for high productivity and lower cost per ton for both Haul trucks and Loading Tools: Payload Cycle Time Operator Effectiveness Hourly Efficiency Mining today requires specific skills set that can interpret machine data through the utilization of technology and then the ability to drive results in the mine’s operations. We will review the four key areas in detail and why they are so important to any mining operation.
3:25 PM  
**Utilizing Mobile Apps to Improve Efficiency, Increase Productivity, and Unlock New Technological Advancements in Mining Operations**

K. Slaughter and T. Miles; Application Engineering, Komatsu, Tucson, AZ

Recently, Komatsu has developed a suite of mobile and web apps using Microsoft Power Apps that can evaluate mining equipment applications and provide critical data. The app suite includes the Load and Carry Tool, used to analyze load and carry applications; the Loader-Dependent Truck-Dependent Matrix, used for productivity estimations; and the Trolley Feasibility Tool, used to assess the feasibility of trolley implementation. These tools are used to analyze productivity, economics, and other operation criteria for their given applications. This talk will provide a brief overview of the app suite and review how the utilization of these three apps allows Komatsu to aid sites in improving their operations.

3:45 PM  
**Leveraging Measurement While Drilling Data for Enhanced Mine Planning: A Data-Driven Approach**

T. Adebajo1, A. Anani2, S. Adewuyi1, T. Avenson2; 1Mining and Geological Engineering, University of Arizona, Tucson, AZ and 2Mining Engineering, Newmont Gold Cooperation, Cripple Creek, CO

This work presents the use of Measurement While Drilling (MWD) data to improve mine planning and resource extraction efficiency in the mining industry. MWD data holds valuable insights that can significantly improve decision-making during mining operations. This work builds a workflow that seamlessly analyzes MWD data, such as pressure, penetration rate, torque, rotation speed, and hole depth intervals, in 3D to reveal geological, geotechnical, and subsurface information within each mining bench. This enhanced understanding leads to optimized blast planning, efficient extraction strategies, and reduced production costs in mining benches. Furthermore, the approach enables proactive risk mitigation and ensures the safety of mining personnel.

4:05 PM  
**Technical Criteria of Mine Power Supply for Open Pit Mine Planning and Design**

M. Cachay1 and J. Adrizola2; 1Mining and Geological Engineering, University of Arizona, Tucson, AZ and 2Mining Engineering, Newmont Gold Cooperation, Cripple Creek, CO

One of the most important aspects of long and short term mine planning are the facilities related to the mine operation and development, among them, the power supply, which is an aspect that is not always taken into account in the design and progress of the mine, leading to impacts associated with higher costs and affecting the short term mine planning and associated productivity. This paper will consider the technical aspects to be taken into account for the selection of the energy supply according to the of the mine location characteristics and its design, as well as the variables for short and long term mine planning, in order to optimize resources and generate a robust mining plan. This is an initial summary, the final paper will have appropriate aspects of form (language).

### WEDNESDAY, FEBRUARY 28  
#### AFTERNOON

**MPD: CHEMICAL PROCESSING: PRECIOUS METALS**

Sponsored by: [WEIR Minerals](#)

North 230

2:00 PM • Wednesday, February 28

**Introductions**

2:05 PM  
**Thermochemical Model Comparison of Gold Sulfide Ore, Copper and Molybdenum Flotation Concentrate Pressure Oxidation Processes**

N. Duru; University of Nevada, Reno, Reno, NV

Refactory gold ores and flotation concentrates require an oxidation step prior to leaching. This study presents and compares sulfide gold ore, copper and molybdenum flotation concentrates pressure oxidation (POX) operational aspects, mass and energy balance models. Throughout study generation of the models both by simulation software and spreadsheet approach were showcased. The simulation models of each three POX processes were constructed by using enthalpy of formation of each element present within the autoclave feed material minerals. The results show the variances between the heat generation potential and coolant requirements due to the sulfide material variance between the ore and flotation concentrate processing.

2:25 PM  
**Gold Leaching Using a Green Solution Lixiviant for a Cyanide-Reduction Media**

R. Rodrigues Silva, J. Cervantes, G. Knesel and C. Monyake; Locus Mining Solution, The Woodlands, TX

Cyanide toxicity and their environmental impact are well known in the industry. Nevertheless, they are still used in the mining, galvanic and chemical industries. As a result of these industrial activities, cyanides are released into the environment and have an enormous negative effect. In the specific case of gold mining, it has been principally extracted in a cyanide process by leaching the ore with cyanide solution. This paper explore the replacement of NaCN by using a biosurfactant and/or combinations of biosurfactants, through an experimental design with more than 46 tests. The results are promising, with reductions of up to 71% of NaCN with high levels of gold recovery @ 90%, and NaCN replacements of up to 50% with gold recoveries higher than 90%.

2:45 PM  
**Refractory Gold Ores Treatment**

O. Restrepo Baena and D. Chaverra Arias; Materials and Minerals, Universidad Nacional de Colombia, Medellín, Antioquia, Colombia

From ancient times to the present day, gold has been widely valued by humans. For its extraction, cyanidation has been the process par excellence. However, to process the so-called refractory materials, which literally means "difficult to treat", it is necessary to establish alternative processes. In this case, direct cyanidation treatment provides unacceptably low or unprofitable gold recovery. Therefore, research should seek to improve gold extraction techniques as mineralogy becomes more complex, especially in refractory gold ores. Fundamental studies are needed to help establish processes that improve the treatment of these complex minerals. These fundamental studies should not be limited to cyanidation but should include all other possible economically and environmentally viable means of processing refractory gold ores. A better understanding of the thermodynamic extraction mechanisms and their relationship with the physicochemical properties of the minerals that make up the ores to be treated must be determined. In this research we are presenting our studies in gold refractory because copper, arsenic, tellurium, iron and carbonaceous ores in Colombia.

3:05 PM  
**Tellurides as Critical Minerals: A Review of Mineralogy and Efficient Processing Strategies for Tellurium, Gold, and Silver Recovery**

E. Amakye2; 1Mining and Geological Engineering, University of Arizona, Tucson, AZ and 2Cher Verde, Arequipa, Peru

Efficient Processing Strategies for Tellurium, Gold, and Silver Recovery

The results are promising, with reductions of up to 71% of NaCN with high levels of gold recovery @ 90%, and NaCN replacements of up to 50% with gold recoveries higher than 90%.
Gold recovery from carbonaceous ore at Lagunas Norte, Peru

R. Srivastava, M. DhePaganon and S. Crosby

The Lagunas Norte Mine has been in operation and was one of the most profitable Barrick mines from 2005 to 2018. During this period, the ore was primarily oxide ore, which was recoverable by conventional heap leaching. As the oxide deposits were depleted, the mine had to transition to processing stockpiled carbonaceous ore under the new owner, Minera Boroo Misquichilca S.A., a wholly owned subsidiary of Boroo Pte Ltd. WSP Inc. assisted with the engineering design of the new processing facilities for the treatment of stockpiled carbonaceous ore. This paper describes challenges encountered and overcome during the permitting and detailed design of the Lagunas Norte Carbonaceous Optimization Project. MBM aimed to increase gold and silver recoveries by treating the oxide ore using a new carbon classification system in conjunction with the carbon-in-leach (CIL) process followed by stacking the filtered residue at the existing leach pads.

Au Residue Reduction at the Carlin Roasters: Plant Benchmarking, Regular Team Technical Review, and Action Tracking

C. Shoell; Metallurgy, Nevada Gold Mines, Elko, NV

Nevada Gold Mines operates two of the world’s gold roasting facilities within twenty miles of each other in Carlin Nevada. For the past year the Metal Planning team has led a detailed review of production results between the metallurgy teams at the two facilities. Unlike in the past, now the two historically owned Barrick and Newmont roasting facilities have come together to review best practices, collaborate on similar projects and determine the most effective path forward. Actions are kept and monitored in the NGM Continuous Improvement Tracking System where documentation of findings are recorded for future purposes if needed. Overall, the roster teams have increased technical depth and diagnostic abilities which has led to a reduction in ounces lost to tails.

Microbial Bio-Processing of Preg-Robbing Carbonaceous Gold Ore

A. Kaah; Processing, McEwen Mining, Elko, NV

Gold deposits in northern Nevada have the occurrence of carbonaceous material that tends to adsorb leached gold in a phenomenon called preg-robbing. Processing of carbonaceous ore requires the use of a roasting facility to combust the organic carbon into CO₂ and CO. For heap leach operations, having carbonaceous ore on the leach pad causes a reduction in gold recovery. Bacterial pretreatment of carbonaceous ore was successful in reducing the preg-robbing potential of carbonaceous ore samples from the Eureka trend in Nevada. For a pulverized carbonaceous ore sample, a preg-robbing reduction of 74% (94.2% to 24.6% preg-robbing) was achieved at 24 hours. Under similar conditions, another carbonaceous ore sample achieved a preg-robbing reduction of 78.2% (89.2% to 19.4% preg-robbing) at 2 hours and 82% preg-robbing reduction at 24 hours. For a minus one inch sample bioprocessed in a VAT, a preg-robbing reduction of 79% (95.2% to 18.8%) was achieved at 2 days. This processing method could be an alternate method for pretreating carbonaceous ore for both milling and heap leach operations.

Advancing Heap Leach Real Time Analytics and Reporting Platforms Enabling Gold Miners at Improving Operations Using Airth ACT

L. Clark and E. Koc; airth.io, Tucson, AZ

With growing metal prices and increasing demand of gold, efficiency and forecasting of a heap leach process becomes important. Estimating recovery from a heap leach process is a challenge in addition to the difference in actuals vs forecast. To address above, airth.io implemented advanced analytics in modeling recoveries from a heap leach and improved reconciliation efforts between estimates and actuals. To share the success of machine learning models in better prediction, the next wave of advancement is with reporting the variance and data in a real time basis, which is a challenging problem considering heap leach activities are constantly draining solution. Airth. I0’s heap leach solution incorporates some of the challenges and built a platform that is unique for mineralogy and transforms 1. reporting of heap leach production 2. financial valuation of leaching process and 3. real time heap leach solution, enabling supervisors, planners and managers to address issues and improvement areas on a real time basis. The abstract plans to share the advancements made with the airth.io heap leach platform and its implementation at a gold mine.

Resolving Roaster Quench Scaling

N. Morrison, J. Thomas, B. Wilmot, C. Murray and K. Bakeev; Member, Lebanon, OH

Gold ore roasters utilize quench water systems to provide a temperature controlled calcine slurry to downstream leaching operations. Mineral scale that forms during quenching can lead to gas emission control issues, causing dust exposure and release, that will result in downtime to mechanically clean the system. A North American roaster operation that once required quench tank cleaning every eight weeks was extended to twelve weeks from the use of scale control treatments and other mechanical adjustments. An explanation of the problem is provided along with the causes and implemented solutions that resulted in improved safety, environmental and productivity.

The Measurement of Multiphase Flows in Mineral Processing Using Electrical Resistance Tomography

W. Xie; Chemical Engineering, University of Minnesota Duluth, University of Minnesota Duluth, Duluth, MN, US, academic, Duluth, MN

It is significant challenging to measure instantaneous local physical quantities for multiphase flows in mineral processing due to the lack of proper measurement tools. By measuring the conductivity distribution across a
ONSITE PROGRAM

measurement area, Electrical Resistance Tomography (ERT) has been applied in a wide range of scientific and engineering fields. In this research, three case studies will be used to demonstrate how ERT can be applied for measurement of multiphase flows including coalescence of flowing foams in flotation columns; turbulence in flotation cells; the sorting of liberated ore. As a powerful technique, ERT can have potential wider applications in mineral processing.

2:25 PM
Liberation Analysis and Froth Flotation of Critical Minerals and Material (CMM) from Mine Tailings
G. Kodali, X. Wang, J. Jin and J. Miller; Materials Science and Engineering, The University of Utah, Salt Lake City, UT

Producing value-added product from low grade ore/tailing stream is important to develop domestic supply chains for critical minerals and material (CMM). To achieve this goal, the advanced separation and/or extraction technology are essential. The effective liberation of critical mineral grains in the low-grade ore/tailing stream is fundamental for the advancement of froth flotation technology. The low grade/ tailing Ni samples was analyzed employing both Quantitative Evaluation of Materials by Scanning Electron Microscopy (QEMSCAN) and micro X-ray Computed Tomography (micro-XCT) techniques. These methodologies were used to assess the liberation of metal sulfides in two-dimensional (2D) and three-dimensional (3D) contexts, respectively. In addition, this study incorporates the results from initial flotation experiments, demonstrating effective recovery of CMM from mine tailings.

2:45 PM
The Recirculating Load in Flotation Plants: Just Like With Dogs, Chasing Your Tail Usually Gets You Nowhere
S. Merrill and D. Leinski; PLSmith Inc, Riverton, UT

Circulating loads can be a source of great frustration for flotation plant operators. While necessary in many cases to help minimize excessive losses in recovery while maintaining acceptable final product grades, at times operations tend to overcomplicate circuits due to excessive circulating loads which in turn can cause the entire circuit to be unstable and difficult to control. The purpose of this paper is to evaluate some of the benefits of simplifying the circulating load on a flotation plant. Laboratory testwork was performed taking feed from an existing flotation circuit. Multiple tests (both open circuit and locked cycle) were performed to evaluate the effect of simplifying the existing circuit. The results of these tests will be presented and discussed to support the argument that reducing the number of recycle streams in a flotation circuit can result in better performance in the entire circuit and simplify operation and maintenance of the plant.

3:05 PM
A study on Process Development of Fluorspar Flotation From the Zeerus Fluorspar Deposit
V. Truong1, S. Lee1, N. Steenkamp1, A. Daniel1, M. Valenta1 and M. Aghamirian1; 1Mineral Processing, SGS Canada Inc, Lakefield, ON, Canada; 2ERG Management (South Africa) (Pty) Ltd, Johannesburg, South Africa and 3Metallicon Process Consulting, Centurion, South Africa

Fluorspar is well-known as a primary material for fluorine products in various industrial fields. The Zeerus fluor spar is one of the largest deposits in the world with high potential of producing acidspar concentrates. A study on nine Variability samples and a Master Composite sample was performed at SGS Lakefield for a process development. The head grade on samples ranged from 14.8% to 28.4% CaF₂ and 0.04% to 3.54% S. The Master Composite contained of 17.9% CaF₂ and 0.98% S. QEMSCAN analysis determined 19.0% fluor spar, 64.6% dolomite, 5.95% calcite, 3.38% talc, and 1.83% pyrite; and fluor spar was well-liberated from other gangues. Flotation program was systematically studied on the Master Composite, which included the feed particle size, reagent type/dosage, and conditioning temperature. The upstream flotation of rejecting pyrite and talc was also performed. The study consisted of a series of batch flotation tests and a locked cycle test. Results confirmed the batch flotation performance and produced a 95.7% CaF₂ concentrate with 83% recovery. The outcome from this study has provided an important insight into a potential of producing the acidspar concentrate from Zeerus deposits.

3:25 PM
Flotation of Fine Lepidolite by Nanobubbles Combined With Mixed Cation/anion Collector
Z. Zhang and F. Jiao; Central South University, Changsha, China

Nanobubbles (NBs) have recently been used for fine particle flotation, and mixed cationic/anionic collectors have shown powerful effects in flotation of lepidolite. In this paper, NBs were combined with mixed cationic/anionic collectors, and the mechanism of both in the fine lepidolite flotation process was investigated. The results showed that the size of NBs was larger near the isoelectric point and NBs were more stable by co-interaction with the mixed cationic/anionic collectors. The effect of NBs under the action of the mixed cationic/anionic collectors has a slight disadvantage compared with that of anionic collectors and is similar to that of cationic collectors. The mechanism of the influence of NBs on the surface hydrophobicity of lepidolite was proposed, and the unstable effect of NBs on the flotation of fine-grained lepidolite was explained.

WEDNESDAY, FEBRUARY 28 • AFTERNOON

MPD: INNOVATION IN COPPER PROCESSING II

North 228B

2:00 PM • Wednesday, February 28

Introductions

2:05 PM
Surfactants Mechanisms for Acid Mist Suppression Using High Speed Imaging
A. Kakoria1, M. Zaid2, G. Xu2, H. Finnell2 and M. Moats2; 1Mining and Explosive engineering, Postdoctoral Fellow, Phelps County, MO; 2Mining and Explosive engineering, MST, Rolla, MO and 3Material Science, MST, Rolla, MO

During the copper electrowinning (EW) process, oxygen gas is generated on the anode, forming bubbles that rise to the surface and rupture at the air/solution interface. Acid mist is emitted, which harms employees’ health while also corroding equipment and the tank house environment. Although there are numerous methods for minimizing acid mist, applying anti-mist chemicals is the most cost-effective option currently in use. However, the hunt for an ecologically acceptable mist suppressor is hampered by the fact that the mechanism of acid mist generation and suppression is not entirely understood. In this study, we have used different surfactants with different concentrations to understand its effects on bubble generation and its conversion into acid mists. Largely to understand the effects of surfactants on bubble volume and its propagation through electrolyte. A high-speed video imaging/videoography (HSV/HSVV) is used to analyze the burstrupture process of bubbles at the solution/air interface at various bubble diameters.

2:25 PM
Diffusion Coefficient of Cupric and Cuprous-Amine Complexes in Ammonia Based Electrolyte
Z. Ali and J. Werner; Mining Engineering Department, University of Kentucky, Lexington, KY

Acid based electrowinning for copper recovery is an important and well-established process. However, in ammonia-copper electrowinning the fundamental properties such as diffusion coefficients of the electroactive species are not well documented. To better characterize this system...
multiple factors like concentration, temperature, and viscosity were investigated to determine their influence on copper diffusion coefficients. This work investigates these factors and their impact on the diffusion coefficients for Cu(NH$_3$)$_4$ and Cu(NH$_3$)$_2$ using linear sweep voltammetry via a rotating disc electrode. Understanding these variables is important to the proper design of an ammonia copper electrowinning cell. It is anticipated that this information will assist scientists and engineers to better understand this important system and increase the impact of ammonia systems in mining and recycling industries.

2:45 PM

**Bacterial Heap Leaching of a Copper Sulphide Ores Now Achieves High Recovery**

D. Connely; Process, METS Engineering Group, Perth, WA, Australia

Bacterial Heap Leaching of a Copper Sulphide Ores Now Achieves High Recovery D Connely Principal Consulting Engineer, METS Engineering Group, Perth. Damian. Connely@metsengineering.com Keywords: bacterial health, agglomeration, bacterial oxidation, chalcopyrite, heap temperature, high pressure grinding rolls, heap leaching, percolation ABSTRACT Significant advances in bacterial leaching of copper sulphide ores has been achieved and laboratory scale testing method for developing a commercial application has been established. Copper recoveries of up to 80% over 120 days is achievable. The success or otherwise of any project is determined by the ore type, testwork required, interpretation of testwork results, ore preparation prior to stacking, and agglomeration requirements. The critical issues that can make or break an operation include bacterial health maintenance, heap temperature control, adequacy of drainage, pad porosity and saturation, and pipe work and irrigation rates. These will be discussed in this paper.

3:05 PM

**Yanacocha Sulphides POX Circuit Design**

R. Frischmuth; Hatch, Missisauga, ON, Canada

The Newmont owned and operated Yanacocha mine in Northern Peru hosts refractory gold, silver and copper in sulphide ores within the existing operations. The Yanacocha Sulphides Project was initiated to develop an integrated process flow sheet to recover and produce gold, silver and copper from the ores using a combination of new and existing process equipment. The flow sheet includes a pressure oxidation (POX) circuit designed to treat a combined whole ore and copper concentrate feed. This presentation provides an overview of the Yanacocha Sulphides POX circuit design highlighting challenges and trade-offs completed to achieve the final design.

3:25 PM

**Simultaneous Moving Metal Forward And Value-Added Product Generation From Bleed Stream Treatment**

P. James; Blue Planet Strategies, Madison, WI

Selectively electrowinning metal from raffinates and bleeds provide a powerful evolving potential. DeMet™ technology can produce the target metal directly in a value-added form, an approach termed combined mining and manufacturing (cmm). Cmm enhances the value of the inventory metal (particularly relative to returning it to conventional electrowinning or solvent extraction/electrowinning second-pass recovery), capturing greater value. Normal metallurgical processing facilities can be enhanced with plug-in technology to garner this benefit. Conceptually cmm is akin to upgrading a conventional electrowinning facility to directly create product wire rather than plate cathode copper. Illustrative results of value-added copper product generation from a representative example hydrometallurgical source using DeMet will be presented. Metal inventory recovery (percent recovery), product form, and recovered metal purity will be examined. Economic considerations for the treatment (a new production route) to recover copper will be discussed and comparison of application of the conventional "second harvest" approach vs. the cmm product economic projections will be considered.

3:45 PM

**Autoclave Pressure Letdown System Design**

N. Wallace; Caldera Engineering, Provo, UT

In hydrometallurgical autoclave processes, the slurry pressure and temperature are reduced in one or more stages by flashing the slurry water to steam. The energy dissipated in these pressure letdown stages can damage inadequately designed equipment. Depending on the total number of letdown stages, shockwaves can form either inside or outside of the blast tubes. Understanding where the shockwaves are formed is critical for a well-designed and robust pressure letdown system. The fundamental physics of pressure letdown will be described with general industry trends.

4:05 PM

**Start-up Considerations for Acid Resistant Refractory Lined Autoclaves**

K. Brooks and J. Heestand; Knight Material Technologies LLC, Akron, OH

Acid resistant brick lined autoclaves are utilized in the pressure oxidation of gold, copper, nickel, and other metals. To manage line stresses during start-up of newly brick lined autoclaves, the current practice is to fill the autoclave with a suitable solution and ramp up the temperature at a defined rate until the operating conditions are reached. The start-up procedure concerns include the fill level, hold points, rate of heating and suitable solutions for start-up prior to the introduction of the process slurry. Other considerations are required for subsequent start-ups after repairs.

**WEDNESDAY, FEBRUARY 28 AFTERNOON**

**RESEARCH: RESEARCH: SPACE RESOURCES: CHALLENGES AND OPPORTUNITIES II**

North 126A

2:00 PM • Wednesday, February 28

**Introductory Session**

Chairs: M. Hassanalian, New Mexico Tech, Socorro, NM
H. Akbari, Kinross Gold Corporation, Woodbury, MN

2:00 PM

**Reality of Lunar Mining—It’s Not Earth!**

C. Salvino and M. Momayez; Mining Engineering, University of Arizona, Scottsdale, AZ

Successful lunar mining will be quite different from that on Earth. It is important to understand the geological history of the moon, environment, logistics, and goals; collectively "key lunar mining topics" (KLMT). These KLMT are critical in developing mining strategies, equipment, and staffing. Some of these KLMT are well known in the space community such as the abrasiveness of silica particles ("dust") on equipment, transportation cost, objectives (public vs private), delay in communication, lack of fluid and atmosphere. A more controversial KLMT topic is the origin of core lunar minerals and concentration ratios. Well known Earth based mining principles may not work; does the regolith function like a bank or loose cubic meter and what are the limitations/benefits of primary, secondary and tertiary rock breaking? One of the most fundamentally important KLMT is the mining of Helium-3; if successful, this could provide fuel for Earth based green energy fusion reactors for hundreds of years. However, Helium-3 mining has the potential to never get beyond theoretical. This study will include a broad review of a number of key KLMT to set the stage for successful lunar mining.
2:25 PM  
**Solving the Sampling Riddle: A Practical Approach to Develop a Core Shack of Moon Regolith Samples Using Autonomous Rovers**  
V. Tenorio, P. López Vidaurre and M. Bass; Mining and Geological Engineering, University of Arizona, Tucson, AZ  
The expansion of Lunar deposit exploration requires the systematic recollection of core samples for orebody definition and water content inventory. The rock collection performed by Perseverance Rover on Mars provides a living example of what can be done on the Moon for a mining-oriented sampling procedure, focused on icy regolith to be found in the vicinities of Shackleton Crater, at the South Pole of the Moon. Starting from scratch, the methodology includes the selection of a convenient area for placing the samples in special containers to avoid water sublimation. The logic used for maximizing the tasks in a 14-day period of daylight becomes critical for future missions, in where exploration time becomes critical for mining regolith under a tight schedule. A workflow diagram, the logic blocks for rover performance and a case study using actual Moon topography are presented.

2:45 PM  
**Updates on the Development of Autonomous Site Preparation: Excavation, Compaction, and Testing (ASPECT) Project**  
J. Rostami, C. Dreyer, A. Petruska and P. Van Susante; Civil Eng., Michigan Tech, Golden, CO  
As part of a NASA Lunar Surface Technology Research (LuSTR) a team of researchers are working on development of an autonomous robot that can develop a 10 m diameter landing pad without human intervention. The unit will be capable of scanning the surface of the moon and plan the movement of materials to prepare the landing pad with +/- 1cm from level. As part of the excavation activities, the robot will move the rock from the site, move lunar regolith from the higher elevation to lower depressions and compact the finished surface to 95% compaction. The system will include a dozer blade for movement of the regolith and to level the final surface and compact it. Lunar outpost is developing the rover and the team is working on the sensory systems to allow for full functionality of the rover to complete its tasks. The presentation will offer the status of the project and general overview of the design and sensory systems.

3:05 PM  
**Examining the Possibility of Using Nuclear "Micro Reactors" for Lunar Mining, Construction and Tunneling Applications**  
J. Smith; Space Resources, Colorado School of Mines, Orange Park, FL  
Lunar and deep space missions will require power-intensive base, mining and construction activities. Given the harsh surface condition, subsurface facilities could be constructed. Tunnel-boring machines may be good choices for building lunar subsurface habitation, research, industrial and recreational facilities, providing straightforward protection from harsh surface solar radiation, near vacuum, micrometeorites and meteorites, and wide diurnal temperature swings. Operations will require lightweight, energy dense, dependable, reliable and resilient power supplies. We compare past, present, and proposed fission and fusion micro reactor designs and solar plants. Current TBM designs and heat transfer challenges also are reviewed.

3:25 PM  
**A Review of Honeybee Robotics Excavation and Conveyance Technologies for the Lunar Surface**  
I. King and N. Traeden; Honeybee Robotics, Altadena, CA  
Honeybee Robotics is a leader in drills and excavation equipment for planetary exploration. In this presentation we present an overview of the technologies we have developed for the Lunar surface. This includes both our current slate of flight programs scheduled to travel to the Moon (TRIDENT Drill, Planet-Vac, LISTER) and our projects in development for subsequent surface missions, including advanced technologies for resource extraction and in-situ resource utilization. We will preface by describing the unique environmental conditions on the Lunar surface to baseline the challenges of technology development. The discussion will touch upon Exploration, Bulk Material Handling, and Mineral Processing.