

**Mining & Exploration: Management: Future of Mining: Leadership or Roadkill: Roundtable**

**2:00 PM • Monday, February 16 • 705**

Chair: L. Freeman, CH<sup>2</sup>M HILL, Denver, CO

**2:05 PM**

**The Future of Mining: Our Evolving Role in Global Society - A roundtable discussion of visions for mineral recruitment, education and talent development to better serve global society**

L. Freeman<sup>1</sup>, P. Highsmith<sup>6</sup>, M. Poulton<sup>2</sup>, M. Karmis<sup>3</sup>, P. van der Veen<sup>5</sup> and M. Hitzman<sup>4</sup>;

1Downing Teal Inc, Denver, CO; 2University of Arizona, Tucson, AZ; 3Virginia Tech, Blacksburg, VA; 4Colorado School of Mines, Golden, CO; 5Mining Consultant, Washington, DC and 6Resource Advisory Corporation, Denver, CO

Panelist will present talking points supported by a few slides, followed immediately by discussion among panelists and the audience. The goal of this session is to change the 'view point' on the relevance of mineral sciences and engineering in society with implications to recruitment, education, talent development (and funding). Over the next two generations we will see unprecedented increases in global affluence, resulting in unprecedented demand for all commodities including mined materials. The resource industries have the responsibility to provide the necessary natural resources. In doing so we have an opportunity to lead global sustainability by demonstrating how to 'share' global resources across cultural and stakeholder silos. Elements of this topic were introduced in a paper recently published by the National Academy of Engineering. Supplying Society with Natural Resources. The Future of Mining – From Agricola to Rachel Carson and Beyond. Freeman and Highsmith, 2014  
<http://www.nae.edu/Publications/Bridge/110801.aspx>

**Coal & Energy: Ventilation: Best Practices I**

**2:00 PM • Monday, February 16 • 503**

Chairs: **J. Brune<sup>1</sup>**, Colorado School of Mines, Golden, CO, **H. Dougherty<sup>2</sup>**, Virginia Tech, Newport, VA

**2:05 PM – Preprint 15-099**

**Modeling Leakage though Utilization of Modern Software for a Historical Silver Mine**

**J. Brune<sup>1</sup>**, **C. Pomeroy<sup>1</sup>**, **H. Mischo<sup>2</sup>** and **J. Weyer<sup>2</sup>**; <sup>1</sup>Colorado School of Mines, Golden, CO and <sup>2</sup>TU Bergakademie Freiberg, Freiberg, Germany

Mining began in the Erzgebirge region of Saxony, Germany more than 800 years ago. In one of the larger mines, Reiche Zeche, operated by the Technische Universität Bergakademie Freiberg (TU BAF), these old workings today offer an underground laboratory for teaching, research projects and university outreach activities. Since the

workings are so vast and contain century-old unmapped production stopes, ventilation becomes difficult as unknown and unmapped leakages take air away from where it is needed most. It is estimated that two-thirds of the air entering the intake shaft leaks through unknown drifts. Researchers discuss the development of a procedure to estimate the leakages in order to establish a functioning mine ventilation model for planning and emergency management purposes. The leakages are quantified by measuring in- and outflows of drifts, and modelled using modern visualization software. Researchers are using the model to develop a correct ventilation air balance showing where these leakages are occurring, and how much air is lost in each area. The final ventilation model will then be used to simulate air flows and escape scenarios in case of fire or water inundation.

### **Coal & Energy: Ventilation: Best Practices I**

**2:00 PM • Monday, February 16 • 503**

*Chairs: **J. Brune**, Colorado School of Mines, Golden, CO, **H. Dougherty**, Virginia Tech, Newport, VA*

**3:45 PM – Preprint 15-093**

### **Optimizing Nitrogen Injection for Progressively Sealed Panels**

***J. Marts, R. Gilmore, J. Brune, G. Bogin, J. Grubb and S. Saki**; Mining Engineering, Colorado School of Mines, Golden, CO*

Researchers at Colorado School of Mines have developed computational fluid dynamic (CFD) models to study gas distributions and explosion hazards in longwall gobs. In underground coal mines, methane emitted from surrounding strata mixes with air from active mine workings and may form explosive gas zones (EGZs). Some western US coal mines are also prone to spontaneous combustion (spon com). Insight into oxygen concentrations in the gob is crucial for assessing spon com hazards and mitigation strategies. Nitrogen injection used in conjunction with progressive gob sealing can reduce EGZs and spon com hazards by forming a dynamic seal separating methane in the gob from air that ingresses from the face. This paper describes CFD simulations studying the formation of such dynamic seals by optimizing the nitrogen injection locations. The impact of nitrogen on oxygen ingress and formation of EGZs is discussed. Optimum nitrogen injection quantities and injection locations were determined. Dynamic seal formation is most effective if the headgate nitrogen injection locations are split between the first crosscut inby the face and a second location about 300 m (1,000 ft) further inby.

## **Mining & Exploration: Technology:**

### **Underground Mining Projects & Innovation I**

**2:00 PM • Monday, February 16 • 704**

*Chair: A. Nieto, Penn State University, University Park, PA*

**2:05 PM**

### **Applying Optimized Underground Production Schedules in the Real World**

***A. Brickey; Mining Engineering, Colorado School of Mines, Golden, CO***

Open pit mine production scheduling has advanced since the 1960's, while its underground counterpart is still relegated primarily to manual scheduling methods. We present the application of an underground production schedule optimization model at an operating mine. We discuss the application of the schedule and the flexibility built into the model that accommodate the needs of the operation. The results are compared with traditional scheduling methods.

**Tuesday, February 17, 2015**

**9am to 11:30am**

**Colorado Convention Center Room 605/607**

### **COLORADO MINES THE WORLD**

*Sponsored by: CAP Logistics*

*AV Sponsored by: Knight Piesold & Co.*

*Chairman: Karr McCurdy, President & CEO, Behre Dolbear, Greenwood Village, Colorado*

This session will review the activities of Colorado-based mining companies throughout the nation and the world, the activities of companies seeking to expand export potential for Colorado mineral products, and the latest influences on corporate developments, prospects and relocations. The Denver Gold Group represents more than 80 per cent of the world's publicly traded gold and silver companies, holding world class investor forums. Kinross Gold is one of the world's leading gold producers and has recently completed relocation to the Mile High City. Ambre Energy is building infrastructure to support the growing export market for western coal. And the **Colorado School of Mines**, one of the world's leading research universities and institutions of higher learning for engineering and applied science, is constantly evolving and innovating. Top officials from each of these organizations will outline key opportunities and challenges impacting the industry, and the important role that mining educators will play in preparing the next generation of industry leaders.

### ***Mining, M&A Activity and Trends in the Gold Industry: What's next?***

*Tim Wood, Executive Director, Denver Gold Group, Denver, Colorado*

*Kinross Gold: A Gold Mining Leader Relocates to Denver*

*Lauren Roberts, Senior Vice President – Americas, Kinross Gold Corporation, Denver, Colorado*

***The Colorado School of Mines: Educating the Next Generation of Industry Leaders***

***Dr. Priscilla Nelson***, Department Head and Professor, Department of Mining Engineering, Colorado School of Mines, Golden, Colorado

***Millennium Bulk Terminal Project: Expanding the Export Capacity for Western Coal***

*David Carlile, Vice President, Marketing, Ambre Energy NA, Salt Lake City, Utah*

**Mining & Exploration: Operations:**

**Hardrock Underground**

**9:00 AM • Tuesday, February 17 • 703**

*Chair: D. McDaniel, Nevada Copper, Yerington, NV*

**9:05 AM**

**A Comparison between Traditional Timbers and Rescue Struts for Mine Rescue Ground Control**

***A. Ahnhut, K. Jennings, A. Robles and J. Torma-Krajewski***; Colorado School of Mines, Golden, CO

Timbering has been the primary ground support method in the mining industry since the 1500s. This study compares the traditional method of timbering with that of Paratech Rescue Support Systems as it pertains to temporary ground support in the case of mine emergency response. The study, conducted at the Edgar Experimental Mine in Idaho Springs, CO, was intended to determine the strengths and weaknesses of each method including total time for installation, total support strength and ease of use. The cost of each option was also investigated. The emergency response sector of the mining industry is at a turning point and this presents a great opportunity to take a look at some of the technology that is currently in use by the fire service for stabilization of vehicles and collapsed structures and determine if it would be an option to integrate into modern mine emergency response.

## **UCA of SME: Energy Pre-Developed Longwall Recovery Room I**

**9:00 AM • Tuesday, February 17 • 111**

*Chairs: **R. Henn**, Brierley Associates LLC, Littleton, CO, D. Klug, David R Klug & Associates Inc, Murray, PA*

**10:30 AM**

### **Evaluation of Maximum Permissible Permeation Grouting Pressure in Soft Ground**

***L. Porras**; Colorado School of Mines, Golden, CO*

A widely recognized rule of thumb in the United States dictates that maximum pressure in soils should be one half of a psi per foot of depth. Well-documented experience in the United States and other countries, however, has proven this rule of thumb to be overly conservative. It is always preferable to use the highest safe pressure, as this will expedite the work and force the grout into the smallest pores and cause it to penetrate farther, making the work more economical. It is to be expected that a higher pressure results in a larger effective radius and an optimal solution. The pressure has to be restricted to a level that is perceived to avoid undesirable hydraulic fracturing, jacking, or heave of the ground.

## **UCA of SME: Energy Pre-Developed Longwall Recovery Room I**

**9:00 AM • Tuesday, February 17 • 111**

*Chairs: **R. Henn**, Brierley Associates LLC, Littleton, CO, D. Klug, David R Klug & Associates Inc, Murray, PA*

**10:50 AM**

### **Geoelectrics-While-Tunneling: Influence of the TBM tunneling environment and implementation strategies through use of finite element methods**

***K. Schaeffer**; Colorado School of Mines, Golden, CO*

TBM tunnel excavation is susceptible to uncertainties and risk, which can be hazardous and costly to the excavation process. Methods that can continuously image the geologic conditions, in real-time ahead of the TBM, can help lower the uncertainty, and therefore, lower the risk involved during excavation. Electrical geophysical methods used in earth based applications, called geoelectrics, have been well established and can image ground conditions over many applications. It is unclear as to whether or not they can be as successful in a TBM tunneling environment. This presentation will speak to some of the complexities associated with the implementation of geoelectrics-while-tunneling and discuss some possible approaches for implementation through use of finite element modeling

## **Valuation I: Lessons Learned**

**9:00 AM • Tuesday, February 17 • 112**

*Chair: C. Wyatt, Behre Dolbear, Golden, CO*

**9:05 AM**

### **The Comparison Sales Approach to Valuation: Science or Black Magic?**

***G. Davis; Economics and Business, Colorado School of Mines, Golden, CO***

The comparison sales approach recommends that a target asset can be valued by finding sales of comparable properties and adjusting those sales for geological, geographical, political, and economic differences. The most common, and often only, adjustment is for size, where a per unit value is taken from the comparison sale and applied to the number of units of metal at the target property. This method assumes that project value is linear in scale, with an intercept of zero. The assumption has, to my knowledge, never been tested. In this paper I point out the linearity assumption made by this approach and show that it is unlikely to hold. The data I use for the analysis comes from engineering designs for an open pit copper project of the same grade and geology but of different scales. I also point out that much of the recommended practice of comparison sales has never been empirically validated, and as such this valuation method more black magic than science.

## **Coal & Energy: Mine Planning**

**2:00 PM • Tuesday, February 17 • 505**

*Chairs: N. LaBranche, Deswik, Brisbane, QLD P. Doig, Deswik Mining, Spring Hill, QLD*

**3:05 PM**

### **Open Pit Mine Production Scheduling with Stock Piling**

***M. Rezakhah and A. Newman; Economics, Colorado School of Mines, Golden, CO***

We present several ways of considering stockpiling in open pit mine production scheduling, including (i) individual stockpiles for each block, (ii) homogeneously mixed stockpile, and (iii) binned stockpiles with pessimistic grade estimates. We also present a new model to find a better lower bound for the problem. These models are formulated for a currently operational mine and compared to results without stockpiling in order to assess the benefits of stockpiling and to analyze the relationship between milling capacity and stockpiling value.

## **Research: NORA Safety and Health Research for Small Mines**

**2:00 PM • Tuesday, February 17 • 507**

*Chair: L. Saperstein, Missouri University of Science and Technology, Nantucket, MA*

**2:05 PM – Preprint 15-104**

### **Development of a Prototype Mine Dust Sampling Device for use in Underground Coal Mines**

***B. Goertz, K. Bakhsh, J. Brune, S. McDaniel and T. Rockley; Mining Engineering, Colorado School of Mines, Golden, CO***

Researchers at the Colorado School of Mines have developed a working prototype of a mine dust sample collection device designed to be used with a Coal Dust Explosibility Meter (CDEM). When used in conjunction with the CDEM, the device will be able to provide near instantaneous results on the quality of rock dusting in a tested location. To achieve this, the device provide a pulse of air to a testing surface and collect a sample of mine dust that will be representative of that entrained by a methane explosion. The use of both physical testing and Computational Fluid Dynamic (CFD) modeling have allowed researchers to refine the design to accurately represent the particle entrainment and optimize the sample collection size for the CDEM. The goal of this prototype will be to verify the versatility of the sampling configurations and understand the limitations of a final product design.

## **Coal & Energy: Surface Mining Processes and Emerging Issues in Reclamation**

**2:00 PM • Tuesday, February 17 • 503**

*Chairs: P. Conrad, Montana Tech, Butte, MT P. Tukkaraja, South Dakota School of Mines and Technology, Rapid City, SD*

*Sponsored by: **Civil and Environmental Consultants***

**3:25 PM– Preprint 15-122**

### **The Anadarko Conventional Mining Oil Shale Project: Cost - Environmental - Economically Sound**

***A. Schissler<sup>1</sup> and H. Nage<sup>2</sup>; 1 Mining Engineering, Colorado School of Mines, Littleton, CO and 2 Minerals Department, Anadarko, The Woodlands, TX***

Anadarko Petroleum Corporation owns extensive oil shale properties in southern Wyoming acquired as part of the original Union Pacific Land Grant of the 1860s. These holdings occur throughout the Green River Formation. Kinney Rim in the Washakie Basin was selected for further study due to proximity to infrastructure, ore grade, and low mining cost. The area is a low-overburden resource that can be developed using surface mining and conventional retorting. The purpose of this scoping study is to

present the results of environmental analysis and timeline, the mine plan, and surface ore processing for a 10,000 barrel per day operation.

## **International II**

**2:00 PM • Tuesday, February 17 • 108**

*Chairs: D. Malhotra, Resource Dev Inc, M. Gavrilovic, GR Engineering Services, Denver, CO*

**3:45 PM**

**What is Old Is New; 200 Years of Copper Mining, Milling, Technology and History at Allihies Parish, Beara Peninsula, Cork County, Ireland**

***C. Anderson and L. Harris; Colorado School of Mines, Golden, CO***

The recorded mining history of the Berehaven Mines at Allihies began in 1812 with copper production initially from the Dooneen Mine. Thereafter, other mines such as the Kealogue Mine and Mountain Mine also began operation and soon made this region the largest copper production district in the world. This presentation will outline the history of this mining region and its mining and milling methods and technologies. Also, the sociopolitical impact on the region and its emigrated descendants who departed to mining regions such as Mt. Morgan, Australia and Butte, USA will be elucidated first hand based on a recent site visit by the co-authors.

## **Mineral & Metallurgical Processing: Plant Design and Optimization**

**2:00 PM • Tuesday, February 17 • 708**

*Chairs: S. Holmes, Freeport McMoRan Inc, Morenci, AZ, D. Meadows, FLSmidth, Phoenix, AZ*

**3:25 PM**

**Alkaline Sulfide Leaching of Enargite**

***D. Alcorn, J. Longacre and C. Anderson; Kroll Institute for Extractive Metallurgy, Colorado School of Mines, Golden, CO***

As traditional high grade copper resources are depleted, processing of unconventional complex lower grade resources becomes necessary. For example, enargite is a common copper sulfide ore with high amounts of arsenic. The arsenic can cause environmental problems when the concentrate is processed at a smelter. Hence, due to the increase in demand for copper containing products, there is a need to effectively process more complex ore bodies. In this study, industrial alkaline sulfide leaching was used to treat an enargite concentrate. After the concentrate has been leached, it can be sent to a copper smelter with greatly reduced penalties and a more favorable smelting contract due to the mass reduction. To build a leaching circuit to treat the concentrate would require a capital investment of about \$50 M USD and would offer (before taxes) a 9 month payback period. Over a 15 year life, an NPV of about \$500 M USD at an 8% discount rate and an IRR of over 130% are expected. This project confirms that an



alkaline sulfide leach is an applicable, economical and environmentally friendly method to remove arsenic and antimony from copper enargite concentrates.

### **Mining & Exploration: Management:**

#### **Mineral Economics**

**2:00 PM • Tuesday, February 17 • 706**

*Chair: R. Barickman, Eagle Mine, Marquette, MI*

**3:45 PM**

#### **Mining, Oil, and Income Inequality**

***G. Davis***; *Economics and Business, Colorado School of Mines, Golden, CO*

It is commonly presumed that economies specializing in mining and oil supply have high income inequality. The research testing this proposition is sparse, and the tests that have been undertaken are missing inequality data for the majority of mining and oil economies. This paper makes use of several new data sets that are comprehensive in their coverage of inequality in mining and oil economies to test the proposition that these economies have unusually high income inequality. The results in some cases confirm but in other cases refute the proposition, with the outcome depending largely on how mining and oil economies are defined and which countries are in the sample. On the whole, no general statement can be made regarding mining and oil extraction and income inequality. The result is important not only for the direct implication for extractive activity and social welfare, but it also implies that extractive economies are not doomed to slower growth as a result of high income inequality. The mining industry should embrace this result in its promotion of mining as a path to economic development.

### **Mining & Exploration: Technology: Technology Innovations in Mine Production Systems**

**2:00 PM • Tuesday, February 17 • 704**

*Chairs: L. Clark, Independent Consultant, Golden, CO M. Bartlett, Desert Falcon Consulting, Tucson, AZ*

**3:25 PM**

#### **The Off and Now on Again Case for Using Broadband Over Power Lines in Underground Mining**

***C. Brackpool***; *Mining Engineering, Colorado School of Mines, Golden, CO*

Given the increase in data requirements and desire for more robust safety communications in sub-surface mining, power line communications (aka PLC or BPL) is getting another look. For a decade several vendors explored injecting signals over distribution feeders. However, attenuation problems and interference from VFD motors, un-shielded cable, and transformers stalled development projects. A new group of non-mining BPL technologists have entered the industry to resolve issues and apply expertise in developing scale-able mesh networks leveraging existing power cabling assets. This compliments or is a replacement for fiber, wireless/radio, and Ethernet. The

critical requirement to re-purposing any proven utility grid telecom access infrastructure, into an underground natural resource extraction and processing, is an ability for repetition between BPL concentrators and their subordinate network and routing devices. We will compare the prior mining industry efforts with this renewed activity. The forward look, is anticipation of a growing sensing revolution that saturates IT networks with vast numbers of data point and aggregation nodes.

## **Optimization of Mining Complexes and Mineral Value Chains**

**2:00 PM • Tuesday, February 17 • 109**

*Chairs: **K. Dagdelen**, Colorado School of Mines, Golden, CO **R. Dimitrakopoulos**, COSMO Lab, McGill University, Montreal;, QC*

**3:35 PM**

### **Open Pit to Underground: Determining Crown Pillar Location Through NPV Optimization of Global Open Pit and Underground Production Schedules**

***K. Dagdelen and I. Traore**; Mining Engineering Department, Colorado School of Mines, Golden, CO*

Many Projects are being planned in the United States, Africa and South America with multiple open pits and some having underground extensions. The determination of location of the crown pillar where a deposit may be mined by both open pit and underground is critical to obtaining maximum NPV for a complex project. This decision is a function of mine and mill capacities, grade tonnage distributions, metallurgical recoveries and related mining as well as processing operating costs. This paper will present a NPV maximizing method for determining crown pillar location using combined global production scheduling optimization of open pits and the underground operation.

## **UCA of SME: Energy Pre-Developed Longwall Recovery Room II (??)**

**2:00 PM • Tuesday, February 17 • 111**

*Chairs: **R. Henn**, Brierley Associates LLC, Littleton, CO, **D. Klug**, David R Klug & Associates Inc, Murray, PA*

**3:00 PM**

### **Laboratory Research on Soil Conditioning for EPB TBM Tunneling**

***Y. Wu**; Colorado School of Mines, Golden, CO*

*In order to fully investigate the properties of foam conditioned soils in EPB TBM tunneling, a Pressurized Testing Chamber (PTC) has been designed and developed by our group at CSM for evaluating the compressibility, shear strength, and abrasivity of foam conditioned soils. The testing system which includes foam generator, PTC, and tools is introduced in this presentation. In addition, experimental results of compressibility, shear strength, and abrasivity of conditioned soils are presented. The experimental results show that appropriate foam conditioning affects soil properties significantly and it improves the performance of EPB TBM tunneling.*

## **UCA of SME: Energy Pre-Developed Longwall Recovery Room II (??)**

**2:00 PM • Tuesday, February 17 • 111**

*Chairs: **R. Henn**, Brierley Associates LLC, Littleton, CO, **D. Klug**, David R Klug & Associates Inc, Murray, PA*

**3:20 PM**

### **Road Tunnel Fire Management Strategies**

***R. Ostoyich and J. Brune**; Colorado School of Mines, Golden, CO Colorado School of Mines*

In the United States, road tunnels of substantial length generally have a fire detection and/or mitigation system installed. While these systems are expected to enhance fire safety in the tunnels their key components are often operated individually from one another. Researchers believe there is a need to look at the overall system response to a variety of fire and ventilation scenarios, including ventilation controls and escapeway management, in connection with the fire detection and suppression installations to ensure appropriate incident management. Through computational fluid dynamics (CFD) fire modeling, researchers at the Colorado School of Mines are developing optimized strategies and best practices for response to fire emergencies in different major road tunnels with the goal to protect human life and property.

## **UCA of SME: Energy Pre-Developed Longwall Recovery Room II (??)**

**2:00 PM • Tuesday, February 17 • 111**

*Chairs: **R. Henn**, Brierley Associates LLC, Littleton, CO, **D. Klug**, David R Klug & Associates Inc, Murray, PA*

**3:40 PM**

### **Development of Boulder Impact Detection via TBM Vibration Measurement**

***J. Buckley**; Colorado School of Mines, Golden, CO*

This research investigates TBM vibration as an indicator of cutterhead impacts with boulders. An EPB TBM was outfitted with accelerometers to monitor vibration during excavation of the North Link light rail tunnel project (N125) in Seattle, Washington. Accelerometers were placed on and around the bulkhead, the nearest possible placement position where vibration from the cutterhead emanates. Joint time-frequency analysis of vibration response reveals that key frequencies are proportional to operating parameters and impacts produce broadband frequency bands. Further analysis will allow a single variable to be output to the TBM operator in real-time to indicate the likelihood of boulder impact.

## **Coal & Energy: Ventilation Innovations I**

**9:00 AM • Wednesday, February 18 • 501**

*Chair: K. Luxbacher, Virginia Tech, Blacksburg, VA*

**9:39 AM – Preprint 15-073**

### **Lessons Learned from Research About Methane in Coal Mine Gobs**

***J. Brune, J. Grubb, G. Bogin, J. Marts, R. Gilmore and S. Saki; Colorado School of Mines, Golden, CO***

Most, if not all longwall gobs contain explosive gas zones (EGZs), i.e., zones of explosive methane-air mixtures that can cause – and have caused – mine fires and explosions. If the coal is prone to spontaneous combustion, oxygen penetration into the gob must be avoided. This paper summarizes the significant research findings from five years of computerized fluid dynamics (CFD) modeling research conducted at the Colorado School of Mines (CSM) under funding from NIOSH. CSM Researchers have developed CFD modeling techniques to identify where and under what circumstances EGZs can form in longwall gobs and how EGZ formation and oxygen penetration depend on the ventilation method, face and bleeder ventilation parameters, injection of inert gases and the operation of gob ventilation boreholes. Recognizing these explosion and fire hazards is an important first step in improving the safety of longwall mines. CSM modeling research has shown that EGZ formation can be effectively controlled by adjusting ventilation parameters, choosing the proper ventilation pattern and injecting inert gases where necessary.

## **Coal & Energy: Ventilation Innovations I**

**9:00 AM • Wednesday, February 18 • 501**

*Chair: K. Luxbacher, Virginia Tech, Blacksburg, VA*

**10:47 AM – Preprint 15-001**

### **CFD Study of face Ventilation effect on Tailgate Methane Concentration and Explosive Mixture of Gob in Underground Longwall Coal Mining**

***S. Saki, J. Brune, J. Marts, R. Gilmore, G. Bogin and J. Grubb; Mining Engineering, Colorado School of Mines, Golden, CO***

Main purpose of ventilation design is to provide sufficient quantity and quality of air to the workers and to dilute methane and other contaminants. It is generally felt that sending more air to the longwall face will improve methane dilution on the face and in the tailgate. However, computational fluid dynamics (CFD) modeling efforts at the Colorado School of Mines in NIOSH-funded research have found that higher face air quantities sweep more methane from the gob into the tailgate area, thereby negating the dilution effect. Increased face ventilation also increases oxygen ingress into gob area, thereby increasing the amount of oxygen available to form explosive methane air mixtures in the gob. In this paper, a parametric study of longwall face ventilation will be

presented. The paper will discuss the effect of varying the face air quantity on methane concentrations in the tailgate and explosive volume formation in gob. Counter to conventional wisdom, it appears that increased longwall face air quantities may increase the explosion hazard as they result in increased explosive gas volumes in the gob, along with increased methane quantities in the tailgate return.

## **Mineral & Metallurgical Processing: Separation: Pyrometallurgy**

**9:00 AM • Wednesday, February 18 • 712**

*Chair: U. Srivastava, Midrex, Pineville, NC*

**9:05 AM**

### **Pyrometallurgy of High Arsenic Copper Concentrates**

***P. Taylor**; Metallurgical and Materials Engineering, Kroll Institute for Extractive Metallurgy, Colorado, CO*

Various methods to treat high arsenic copper concentrates through pyrometallurgical processing are presented. Examples are drawn from various past and current operations and research. Some of the methods discussed include: controlled oxidation roasting, adaptation of some smelter technology to accept higher amounts of arsenic, complete oxidation with arsenic fixation; sulfation roasting; acid baking, soda ash roasting, and others methods. Other topics include: a short discussion of other antimony and bismuth impurities; the effects of arsenic on copper electro-refining and product purity; and methods for the ultimate disposal, or marketing, of the arsenic. Work being done at the Colorado School of Mines is also presented.

**1:30 - 2:00 PM • Wednesday, February 18 • CC**

### **Jackling Lecture: Unobtainium? The Future of Mining in the 21<sup>st</sup> Century**

**Murray W. Hitzman**, Colorado School of Mines

Global demand for mineral resources, including a number of elements that were once laboratory curiosities but are now critical for new technologies, will increase during the 21<sup>st</sup> century but will be tempered by the need to achieve high environmental standards to gain the social license required to allow mining operations.

Mining and mineral processing during the 21<sup>st</sup> century must become less intrusive and more productive. This may be achieved through discovery and mining of higher grade and smaller footprint deposits, development of better in-situ mining technologies, or sea-floor mining among other options. Improved utilization of what are currently mining wastes and mining openings (open pits and underground workings) can favorably impact both economics and public opinion. These probable changes in mining and mineral-processing techniques over the next several decades will have profound impacts on mineral exploration. Most mining companies are still exploring for conventional, low-grade, bulk-tonnage deposits. Given the long (and growing) lead time for discovery and development of mineral deposits, there is a danger of not having

enough “unconventional” deposits in the pipeline for future development. Mineral exploration will have to move from a dominantly geology-focused approach to one that better integrates geology with geophysics.

The geology of mineral deposits, metallurgy, and mining engineering while commonly thought of as “yesterday’s fields of research” are now critical if we are to sustainably develop technologies to meet tomorrow’s materials needs. However, investments in scientific and human capital in these areas by governments, industry, and academia have declined precipitously in the past several decades leading to a potential crisis for the future. Integrating the social and cultural aspects of mining with traditional economic and environmental analysis should produce creative approaches to the value-based, rather than strictly science- and engineering-based, challenges associated with the production of minerals. To survive and prosper, the mining industry will need to attract innovative people with excellent technical skills as well as scientists and engineers who are able to mediate between the technical world of mining and the social context in which mining takes place.

The future of mining in the 21st century will depend, to a great extent, on how well the mining industry meets society’s legitimate expectations for socially responsible, environmentally sensitive extraction of the materials needed to support living standards while keeping costs low enough to fuel worldwide economic growth.

## **Coal & Energy: Mine Emergency Response**

**2:00 PM • Wednesday, February 18 • 503**

*Chair: M. Trevits, South Park, PA*

**2:45 PM – Preprint 15-074**

### **Comparison of Coal Mine Emergency Management and Rescue Practices in Germany and the United States**

***M. Anderson**<sup>1</sup>, **J. Brune**<sup>1</sup>, **J. Kretschmann**<sup>2</sup> and **W. Hermülheim**<sup>3</sup>; <sup>1</sup> Mining Engineering, Colorado School of Mines, Golden, CO; <sup>2</sup> Mining Engineering, TFH Georg Agricola University, Bochum, Germany and <sup>3</sup> Mining Engineering Department, Technical University Clausthal, Clausthal, Germany*

This paper analyzes mine emergency management and rescue practices in German underground coal mines and compares them to those used in the United States. The German mining industry has developed these practices over more than 100 years, and they have successfully managed numerous fire, water inundation and ground control emergencies. The authors interviewed German mine emergency professionals about rescue team and emergency operations and will identify procedures and best practices that may be of interest to the United States mining industry.

## **Coal & Energy: Mine Emergency Response**

**2:00 PM • Wednesday, February 18 • 503**

*Chair: M. Trevits, South Park, PA*

**3:05 PM**

## **International Mine Rescue Comparison: Australia, Canada, Germany, and the United States of America**

***N. Henderson<sup>1</sup> and J. Brune<sup>2</sup>***; *1 Freeport McMoRan, Empire, CO and 2 Mining Engineering, Colorado School of Mines, Golden, CO*

Mine rescue is an important part of the mining industry and varies internationally. This paper will analyze the mine rescue structures in Australia, Canada, Germany, and the United States of America. The report will look at each country individually and cover the legal requirements, the membership qualifications, program structure, training systems and requirements, and strengths of each program. With mining being such a global industry, it is important to learn from the improvements other countries have made as well as to critically analyze the current systems for weaknesses.

## **Coal & Energy: Ventilation Innovations II**

**2:00 PM • Wednesday, February 18 • 502**

*Chair: K. Luxbacher, Virginia Tech, Blacksburg, VA*

**2:45 PM – Preprint 15-086**

## **Impact of Regulator Settings on the Formation of Explosive Gas Zones in Bleeder Ventilated Longwall Gobs**

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Researchers at the Colorado School of Mines have studied the influence of headgate side ventilation controls near the longwall start-up room on the formation of explosive gas zones (EGZs) in underground coal longwall bleeder ventilated gobs. In a project funded by the National Institute for Occupational Safety and Health (NIOSH) researchers developed a Computational Fluid Dynamics (CFD) model to study the formation of methane-air mixtures in the gob, start-up room, and bleeder entries. The relative change in size and location of EGZs are examined in response to ventilation controls in the headgate side bleeder entries near the start-up room. Modeling suggests that adjustments to the ventilation controls can be made to minimize the size of the EGZ. However the EGZ may form in or around active working areas regardless of the ventilation control settings. Research found regulators on the crosscuts into start-up room and first entry inby can force air into to crosscuts outby the start-up room causing more air to flow through the gob.