2:05 PM | 101G
Metrics and Methods for Assessing Resilience Impacts from Integrated Above- and Below-ground Urban Infrastructure
P. Nelson; Mining Engineering, Colorado School of Mines, Golden, CO
In order to make better decisions concerning the use of underground space, particularly in urban environments, the functions and operations of the human and physical infrastructure systems must be understood in an integrated framework with common and meaningful metrics and representations. Considering the importance of economics, sustainability and vulnerability to extreme events, decision makers need an understanding of the valuation for underground space as a resource in order to consider life-cycle engineering and trade-offs and pros and cons of above- and below-ground infrastructure investments. This paper discusses an appropriate framework and metrics for infrastructure analysis that can include complex systems representations for all sectors – physical, social, and environmental.

2:45 PM | L100G
The Grand Challenges of Social Licensing in Mining
B. Teschner, E. Holley and N. Smith; Mining Engineering, Colorado School of Mines, Golden, CO
Conflicts between mining companies and communities increasingly account for delays or stoppage of mining projects worldwide. Companies have invested millions of dollars into projects around the world only to find that they remain stonewalled by social opposition or challenged by legal issues. Gaining and maintaining a social license to operate is an increasingly important activity. But what are the most significant challenges that this generation of companies needs to solve in order to build sustainable relationships with stakeholders? Through a survey of reports, white papers, and online media, this talk examines the recommendations and focal points of intergovernmental organizations (i.e. International Finance Corporation and the United Nations), governments (US and Canada), and the mining industry (International Council on Mining and Metals and individual companies). The authors highlight the priorities of these stakeholders and identify points where research advances could improve the implementation of the mining industry’s social licensing goals. The presentation concludes by offering a list of “social licensing grand challenges” for the mining industry in the next decade.

3:05 PM | 101G
Effects of Heat and Water Saturation on Mode I Fracture Toughness (Kc) with Changes of Bedding Plane Orientations
V. Maruvanchery and E. Kim; Mining Engineering, Colorado School of Mines, Golden, CO
Fracture toughness, an intrinsic material property of rocks, can vary with temperature, water content, and bedding plane orientation of the rocks. The objective of this study is to identify the effects of heat and water saturation on mode I fracture toughness (Kc) depending on bedding plane orientations. The specimens of cracked chevron notchched Brazilian disks (CCNB) of a calcite cemented sandstone were categorized into three groups based on the orientation of the chevron notch with respect to the bedding planes (divider (D), arrestsor (A) and short transverse (ST)) and were subjected to three conditions: oven dried (control), furnace heated and water saturated. In dried samples, the Kc of D was 35.5% and 22.9% higher than A and ST, respectively while in heated specimens, the Kc of D was 10% and 18.7% higher than A and ST. In addition, the Kc of water saturated D samples was 6.1% and 18% higher than A and ST. The results suggest that heat and water saturation can significantly reduce the effects of bedding plane orientations on Kc. Also, our results obtained with environmental scanning electron microscope indicate the degrading effect of heat and water saturation on Kc.
9:05 AM | 200GH
Computational Fluid Dynamic Modeling of a Secondary Lead Reverberatory Furnace
A. Anderson, J. Gregor, G. Bogin and P. Taylor; R&D, Gopher
Resource, Tampa, FL; Metallurgical and Materials Engineer, Colorado School of Mines, Golden, CO and Mechanical Engineering, Colorado School of Mines, Golden, CO
A computational fluid dynamic (CFD) model has been developed to identify mechanical and thermal stresses that occur within the refractory lining of a secondary lead reverberatory furnace. Once a base case simulation was validated using data from an operation lead reverberatory furnace, predicted areas of high refractory wear were determined through the calculation of the temperature and velocity distributions within the furnace. The average burden surface temperature was also evaluated as this parameter was used as a measure of smelting rate. The CFD model was used to assess whether the predicted areas of high refractory wear could be minimized by various operational changes to the burden geometry and burner alignment. The results showed that the amount and location of the burner flame impingement was sensitive to changes in both burden geometry and burner alignment and greatly affected the overall flow patterns and heat transfer within the furnace. The results also indicated that there could be a tradeoff between smelting rate and refractory lifetime.

9:25 AM | 200GH
A Survey of Pyrometallurgical Arsenic Volatilization Techniques
C. Anderson; Colorado School of Mines, Golden, CO
This presentation will delineate the pyrometallurgical volatilization of arsenic from Anaconda copper smelter flue dust. In part, this smelter was built in 1919 and then subsequently operated by some of the ancestors of Dr. Anderson. Background information as to origin of these materials along with other noted technologies will be outlined. Updated statistical analysis will be utilized and presented to determine key parameters for successful selective Arsenic separations.

9:25 AM | L100C
Mine Explosion Hazards from Gob Breathing: Cause, Effect and Recommended Best Practices
S. Lolong and J. Bruner; Mining Engineering, Colorado School of Mines, Golden, CO and Deswik USA Inc., Denver, CO
In underground mining, the gob and other abandoned mined-out areas are generally not monitored, and therefore, gobs frequently contain methane forming explosive methane-air mixtures. These mixtures can migrate out to the longwall face and surrounding gob entries during the phenomenon known as gob breathing, which commonly occurs when mine atmospheric pressure changes. This paper summarizes the modeling research conducted at the Colorado School of Mines to investigate gob breathing and the associated explosion hazards. Researchers present a number of critical findings, including the intensity of explosive mixture outgassing in relation to the magnitude and rate of changes of pressure variations, the tolerable limits of pressure swings, the consequences of gob breathing to the mine, and the critical time span it occurs following the gob breathing. This paper also presents recommended best practices in preventing and mitigating the negative result of gob breathing such as the recommended locations for continuous mine atmospheric monitoring system.

9:25 AM | 101A
The Use of ImageJ to Investigate Geologic Effects on Open Pit Slopes
F. Wang and R. Kaunda; Mining Department, Colorado School of Mines, Golden, CO
When dealing with densely jointed or fractured rock mass in pit slopes, the traditional rock mass characterization systems have many parameters that are difficult to judge objectively and accurately. In this study, rock slopes were analyzed with ImageJ software and artificial neural networks to obtain parameters to assess the conditions of a slope and to evaluate stability conditions. The adopted method is found to be useful, especially for establishing models in weak or highly fractured rock mass characterization environments.

9:25 AM | L100J
Managing an Uncertain Future: Monte Carlo Simulation of a Real Options Valuation Model to Improve Investment Decision Making
B. Teschner, D. Berberich, J. Grubb and E. Holley; Mining Engineering, Colorado School of Mines, Golden, CO and Hecla Mining, Coeur d’Alene, ID
Mining companies have historically used deterministic discounted cash flow models to determine the net present value (NPV) and internal rate of return (IRR) of a proposed project. Typically, these values are used as the primary metrics to determine whether to advance a project. Unfortunately, these models do not tell the whole story; they inherently assume that the development decision must be made now and that revenues and costs will remain unchanged over the life of the project. This presentation shows a more robust model that addresses these shortcomings. We employ a real options approach to model management flexibility to delay construction into the future, and Monte Carlo simulation of commodity prices, capital, and operating expenses to determine a suite of project outcomes. The method increases the NPV of a project by incorporating the value of management flexibility. In addition, the method can be combined with a company’s risk tolerance to optimize the project hurdle rate, and the likelihood that the project will get built in the future. This presentation will demonstrate the method using a generic project where capital costs and future metal prices are uncertain.

9:45 AM | Auditorium Room 1
Performance Prediction of a Vertical Stirred Grinding Mill
Over the last decade, the performance and energy efficiency of stirred milling technology has become a preferred alternative to ball mills for fine and regrinding operations. The difficulty encountered in fine grinding is the increased resistance to comminute small particles when compared to coarse particles. Therefore, increased energy inputs are then necessary to raise the number of stress events in a mill to contribute to the comminution of fine particles. This work presents a hypothesis of a methodology to predict the product size distribution of a vertical stirred mill using a Bond ball mill. The Population Balance Model (PBM) was used to empirically analyze the performance of a vertical mill and a Bond ball mill. The breakage parameters obtained for both grinding mills are compared to determine the possibility of predicting the product size distribution of a vertical mill based on the results obtained from a Bond ball mill. The biggest advantage of this methodology is that most of the minerals processing laboratories already have a Bond ball mill to perform the tests suggested in this study.

9:45 AM | L100D
How to Maintain a Collegiate Mine Rescue Team, on the Example of Colorado School of Mines Student Mine Rescue Team
M. Hetherington, Q. Nguyen and J. Bruner; Colorado School of Mines, Golden, CO
The vigilant safety culture that has been established in today’s mining industry is an important aspect of the industry and should become a habit of young professionals as soon as possible in their careers. Because of this, mine safety programs are implemented into the mining curricula in many universities around the world. Some universities choose to extend their mine safety programs by hosting and training collegiate mine rescue teams that are fully certified and operational. Establishing and training a collegiate mine rescue team means that the university has to have meticulous planning, organization, and implementation. To maintain and improve the team and to run a consistently well trained team requires dedication, time commitment and financial resources. Researchers will discuss several necessities when establishing a new team, including how to build an equipment inventory, making networking connections for joint trainings, and sustaining financial support. This paper will present planning and strategy options, and how they are applied to the Colorado School of Mines Student Mine Rescue Team in order to maintain the team since the team’s creation in 2009.

10:25 AM | 101F
A Review of Current Tailings Disposal Technologies
H. Lammers and L. Figueroa; Mining Engineering, Colorado School of Mines, Denver, CO
Technologies utilized for the disposal of slurry, paste, thickened, and filtered tailings include containment within impoundments, open pit backfill, submarine placement, underground backfill, tailings and waste rock combined disposal, and dry stack placement. Each technology has inherent environmental, social, and economic elements, and characteristics unique to the location of the disposal facility to be considered during the life cycle of the disposal facility. This paper presents environmental, social, and economic elements, and site-specific characteristics unique to each of the six identified tailings disposal technologies. Environmental elements include surrounding land, water disturbance; social elements include human health and safety, the political and regulatory climate, aesthetics of the facility, and post-mine land use; and economic elements include cost associated with processing, construction, operation, and closure. Site-specific characteristics include transport distance, facility capacity, and climate.
A Holistic Approach to More Sustainable Artisanal and Small-Scale Gold Mining Systems in Peru

N. Smith; Mining Engineering, Colorado School of Mines, Golden, CO

Artisanal and small-scale gold mining (ASGM) is a critical livelihood strategy for millions of people, but it is notoriously known for its environmental and human health risks. Because of these risks, ASGM activities are a concern for governments, development agencies, industry, and academia; however, projects promoting cleaner and safer technologies have had limited success. This paper proposes that some of the challenges to project implementation may be attributed to a lack of integrated technical and social data on ASGM systems. For example, social science analyses provide insights into the social and political context of ASGM, but pay too little attention to the technical processes involved with ore processing. Similarly, technical analyses involve close examinations of mercury use and its alternatives yet fail to explain why people continue to use mercury when they are aware of the risks. By reporting on a project involving engineering and social science faculty and students at US and Peruvian Universities, governments and NGOs, businesses, and communities, this paper demonstrates a holistic approach to promoting cleaner, safer, and more sustainable ASGM livelihoods in Peru.
The future success of the mining industry requires a new kind of engineer – agile in management of business and technology, strategic in acquiring and disposing of information and technology, project and risk management, finance, valuation, policy, and social license. Mines will develop and prepare graduates who will be effective in influencing change and in solving current and future mining problems in a comprehensive, sustainable, and holistic manner.

2:25 PM | 101A

Geologic Risk and Underground Construction
P. Nelson; Mining Engineering, Colorado School of Mines, Golden, CO

Population increase means underground space will become increasingly important. Construction costs have been increasing and performance of underground projects is intimately linked to the management of geologic risk for both construction and life-cycle performance of subsurface facilities. This paper develops a geologic framework to assess the state-of-practice and future possibilities for improved management of geologic risk, including risk avoidance, new materials and methods, ground improvement, life cycle engineering for sustainability, and better subsurface characterization. Some geologic risks have plagued for centuries, and new risks have arisen associated with new technologies. In addition, a better understanding of the spatial variability of rock structure is needed a priori, so that site investigations become increasingly confirmatory rather than exploratory.

2:45 PM | L100C

Efforts to Characterize and Mitigate Hot Work Accidents in Mining and Mineral Processing
E. Charrier, H. Miller and J. Steele; Colorado School of Mines, Golden, CO

Fires and explosions caused by hot work represent a serious safety hazard common to many primary industries, including mining and mineral processing. The National Fire Protection Association estimates that there is an average of 4,440 structural fires and eight fatalities annually that stem from hot work. Of these, welding and cutting torches account for over 75% of the fatalities. This paper outlines the conclusions obtained from analyzing accident data, derived from the Chemical Safety Board, CDC NIOSH, and other sources, to determine accident causation factors and whether the implementation of improved technology or engineering interventions are needed.

3:25 PM | 101H

Open Pit Mine Planning with Degradation Due to Stockpiling
M. Rezakhah; Economics, Colorado School of Mines, Golden, CO

The open pit mine production planning with stockpiling (OPMPS+S) problem decides when to extract each block of ore and/or waste in a deposit. In addition, this problem determines whether to send each block to a particular processing plant, a stockpile, or a waste dump. The objective function maximizes net present value (NPV), subject to constraints such as precedence, and capacities for mining and processing. Since the material within the stockpile is exposed to the environment, some time-dependent changes occur in the material's properties, which results in decreased value. In this research, we create three new linear-integer stockpiling models which consider degradation within the stockpile(s). We compare results from these models on a data set from an operational mine, and suggest the most accurate one. Finally, we show that the material degradation within a stockpile has a considerable impact on the value that a stockpile provides.