APCOM 2017

APPLICATION OF COMPUTERS AND OPERATIONS RESEARCH IN THE MINERAL INDUSTRY

38th International Symposium

August 9 - 11, 2017

Colorado School of Mines
Golden, Colorado USA

Symposium Program and Agenda

Dr. Kadri Dagdelen
Chair of APCOM 2017

COLORADOSCHOOLOFMINES
EARTH • ENERGY • ENVIRONMENT

Venue Information

The Symposium venue is:

Green Center
Colorado School of Mines
924 16th Street
Golden, Colorado 80401

For questions or assistance, contact Continuing and Professional Event Services at 303.279.5563

Photography, Video, and Audio Recording

No recording of video or audio is allowed in the technical session rooms at any time. Photography is allowed only by those who have been granted permission.

Mobile Phones

Please have your mobile phone on silence during the Symposium.

Internet Access (Wi-Fi) in Meeting Area

Review instructions contained in your registration packet.

Parking

Parking regulations are strictly enforced on the Colorado School of Mines campus. All visitors to campus are required to pay for parking in all locations.

Payment for parking is made using the parking payment stations that can be found in Parking Lots O, CT, I, and J. The stations accept payment in cash and by credit card. Please be aware that you will be required to supply the license plate number of your vehicle when using the parking payment stations.

On-street parking may be available. Payment for on-street parking must be made using the payment stations in the parking lots. Please note that some parking areas are restricted/reserved and are not available for use by campus visitors. You are advised that you will be solely responsible for payment of any parking fines that may be issued for your vehicle.

Payment for parking on campus is required Monday through Friday from 7:00 AM until 5:00 PM. Parking is free all day on weekends and after 5:00 PM on weekdays.

About APCOM

APCOM was founded in 1961 by four American universities - the University of Stanford, the University of Arizona, the Pennsylvania State University, and the Colorado School of Mines - to promote the application of computer and operations research in the minerals industry. APCOM has become an international forum to present, discuss, and examine state-of-the-art and emerging technologies in the minerals industry. The APCOM event series has become a major driver of innovation in the minerals industry, facilitating the advancement of computer and operational research methodologies applied to the minerals industry. Thanks to the personal commitments of APCOM's loyal participants and supporters, the APCOM symposia continue to be a thriving success.

The APCOM 2017 symposium aims to further the APCOM goal of contributing to effective decision-making processes throughout the entire minerals industry. The technical program of this symposium represents a balanced mix of traditional areas of exploration, including geostatistics, mine design, production planning, investment analysis, artificial intelligence, simulation, mine automation, rock mechanics, mineral processing, and data management systems.

Symposium Agenda

TUESDAY, AUGUST 8

17.00 - 19.00 — **Green Center Lobby**

Opening Reception and Registration

WEDNESDAY, AUGUST 9

08.00 - 09.00 — **Green Center Lobby**

Registration

09.00 - 10.30 — **Green Center Metals Hall**

Keynote

Chair(s): Harry Parker, Roussos Dimitrakopolous

2293	Clark	United States	Building the Business - From Concept to Commercial
2354	Parker	United States	Optimized Project Targeting Using Conditional Simulation Post-processing for the Los Sulfatos Underground Porphyry Copper Project in Chile
2223	Verly	Canada	Classification and Dilution Study by Simulation of a Large Copper Deposit, Peru
2312	Camus	Chile	Mining Sequence and Mine Capacity in Open Pit Mining

10.30 - 10.45 — **Green Center Lobby**

Break (Refreshments are available)

10.45 - 12.15 — **Green Center Metals Hall**

01 Optimization Tools for Strategic Mine Planning and Scheduling

Chair(s): Kazuhiro Kawahata, Lawrence Clark

2230	Ota	Brazil	SimSched Direct Block Scheduler: a New Practical Algorithm for the Open Pit Mine Production Scheduling Problem
2323	Busche	United States	Evolution of the Scheduling Process "… a New Approach to Mine Scheduling."
2313	Maiti	India	An Efficient Algorithm for Open-Pit Mine Production Scheduling in Presence of Multiple Capacity Constraints
2304	Qureshi	Australia	Knowledge Based Production Optimization in Open Pit Mining Using Big Data Analytic

10.45 - 12.15 — **Green Center Petroleum Hall**

02 Characterizing Uncertainties of Geologic Models for Resource Estimation

Chair(s): Winfred Assibey-Bonsu

2334	Rolo	Brazil	Accessing Implicit Geologic Model Uncertainty Using Signed Distances

2288	Monreal Lopez	Chile	Express Modelling of Geology, the Road Without a Map
2343	Reid	United States	Confidence Limits Versus Drill Spacing - Sandstone Hosted Uranium Deposit
2309	Jewbali	United States	Developing an Optimization Framework for Drillhole Planning

12.15 - 13.30 Green Center Friedhoff Hall (lower level)

Lunch

13.30 - 15.00 Green Center Metals Hall

03 Towards Optimizing Ore Control in Open Pit Mining

Chair(s): Georges Verly

2322	Deutsch	United States	A Branch and Bound Algorithm for Open Pit Grade Control Polygon Optimization
2307	Gonzales	United States	Integrating and Reconciling Short Term and Long Term Mine Plans in a Complex Multi-Pit, Multi-Process Operation
2332	Perez	United States	Integrated Ore Control Process for Decision-Making Updating in Mine Planning Systems
2338	Mehregan	Iran	Developing a Computer Model for Optimization of Drilling and Blasting in Open Pit Mines from the Viewpoint of Technical, and Environmental Parameters

13.30 - 15.00 Green Center Petroleum Hall

04 New Technologies for Operational Environments

Chair(s): Rodolfo Ota, Rodrigo Peroni

2272	Bamford	Canada	Aerial Rock Fragmentation Analysis in Low-Light Condition Using UAV Technology
2296	Beretta	Brazil	Stockpile Volumetric Survey Using Aircraft Surveying In Comparison with Traditional Methods
2348	Ehrenfeld	Chile	Virtual Planning Room, Intelligent Cloud Software Platform for Mine Planning
2350	Watson	Canada	Utilizing a Mobile 3D LiDAR Scanner for Infrastructure Sizing Purposes

15.00 - 15.30 Green Center Lobby

Break (Refreshments are available)

15.30 - 17.00 Green Center Metals Hall

05 Operations Research for Improving Efficiency in Mining

Chair(s): Ady Van Dunem, Snehamoy Chatterjee

2320	Boede	Poland	Implementation of BIM (Building Information Modeling) at the German - Polish Construction Company HOCHTIEF Polska S.A. Case Study
2308	Schulze	Germany	Using Operations Research Techniques to Increase Efficiency in German Potash Mining
2315	Nagovitsyn	Russian Federation	A Conceptual Approach to 4D Modeling of Mining Technology Objects

2344	Moghanlou	Iran	The Necessity of Futures Studies Approach Implementation in Mine Planning

15.30 - 17.00 **Green Center Petroleum Hall**

06 Integration of Geometallurgy and Mine Planning

Chair(s): Hooman Askari, Sukumar Bandopadhyay

2347	Ehrenfeld	Chile	Geometallurgical Variables Characterization Using Hyperspectral Images and Machine Learning Technics
2291	Kumar	Canada	Introducing Geometallurgical Constraints into the Simultaneous Stochastic Optimization of Mining Complexes: Application at the Copper-Gold Mining Complex
2314	Bandopadhyay	United States	Dynamic Neural Network Based Model for SAG Mill Power Prediction
2331	Peng	United States	Cavitation Venturi Tube Design for Nano Bubble Column Flotation Using Computational Fluid Dynamics

THURSDAY, AUGUST 10

09.00 - 10.15 **Green Center Metals Hall**

07 Push Back Design Fundamentals

Chair(s): Chitopong Somrit

2333	Jelvez	Chile	MIP-Based Procedure to Pushbacks Selection
2340	Smith	Australia	A Comparison of DBS and Nested Pit Stage Design as a Basis for Strategic Planning
2349	Kawahata	United States	Open Pit Layback Design at Newmont's Twin Creeks Mine

09.00 - 10.15 **Green Center Petroleum Hall**

08 Stochastic Simulation Techniques for Uncertainty Characterization (I)

Chair(s): Gordon Seibel

2319	Braga Jr	Brazil	Merging Multiple Secondary Data with Response Surface for Collocated Co-Simulation of Geometallurgical Niobium Data
2328	Chatterjee	United States	Hybrid Wavelet and Support Vector Machine (SVM) Clustering Algorithm for Non-Stationary Geostatistical Simulation
2299	Qu	Canada	A Case Study on Geostatistical Simulation with a Trend

10.15 - 10.45 **Green Center Lobby**

Break (Refreshments are available)

10.45 - 12.15 **Green Center Metals Hall**

09 Stochastic Optimization for Mine Planning

Chair(s): Eduardo Moreno

2222	Kuckartz	Brazil	Mine Planning Under Grade Uncertainty and Slope Angle Evaluation
2326	Sattarvand	United States	New Approaches for Commodity Price Uncertainty Incorporation in Production Planning of Open-Pit Mines
2289	Rimélé	Canada	Open Pit Stochastic Optimisation with In-Pit Tailings Storage

2292	Saliba	Canada	Simultaneous Stochastic Optimization of an Open Pit Mining Complex

10.45 - 12.15 **Green Center Petroleum Hall**

10 Optimization Techniques for Underground Mining Applications (I)

Chair(s): Andrea Brickey

2327	Maturana	Australia	Uncertainty and Geometric Parameters of an Underground Target: Implications for Mineral Exploration
2221	Anani	Chile	Optimizing Room and Pillar Recovery and Production Rates as a Function of Panel Dimensions
2330	Roibal	United States	Determination of Friction Factor using Digital Method in Mine Ventilation Laboratory Network
2316	Liu	Australia	Numerical Modelling of Gas Explosions in a Development Heading of Underground Coal Mine

12.15 - 13.30 **Green Center Friedhoff Hall (lower level)**

Lunch

13.30 - 15.00 **Green Center Metals Hall**

11 The Use of Simulation in Mine Planning

Chair(s): Ernest Baafi

2329	Zeng	Australia	Using a Microscopic Simulation to Study the Impact of Match Factor in a Truck-Shovel Mining System
2346	Rubio	Chile	SIMPLAN a Mineplanning Tool to Facilitate Planning Under Uncertainty Through the Use of Machine Learning Algorithms
2317	Berner	Germany	Application of Discrete-Event Simulation to Long-Term Mine Planning
2300	Upadhyay	Canada	Simulation and Optimization of Mine Operations for Desired Grade Blending in Open Pit Mines

13.30 - 15.00 **Green Center Petroleum Hall**

12 Application of Customized Operations Research Techniques in Mining

Chair(s): Nelson Morales

2240	Van-Dúnem	United States	Solution Algorithms for the Multiple Time Period Block Sequencing Problem as a Max Flow Problem and Solving it by the Lerchs-Grossman and Pseudoflow Algorithms
2311	Somrit	United States	Max Flow – Lagrangian Based Phase Design - Application to Improving Mine Planning and Process Blending at Newmont's Carlin Operations
2336	Del Castillo	Canada	Dynamic Mid-Term Optimization of a Mining Complex Under Uncertainty
2220	Nagovitsyn	Russian Federation	Systemic Approach to Solve Mining Technology Tasks Based on Modeling Its Objects and Processes

15.00 - 15.30 **Green Center Lobby**

Break (Refreshments are available)

15.30 - 17.00 — Green Center Metals Hall

13 Application of Customized Operations Research Techniques in Mining

Chair(s): Juan Camus

2241	Dagdelen	United States	A New Linear Programing Approach to Determining Risk-Quantified Open Pit Mine Production Schedules Incorporating Mineral Resource Classification Categories
2310	Morales	Chile	An Integer Linear Programming Model For Optimizing Open Pit Ramp Design
2339	Chatterjee	United States	Risk Control in Production Scheduling By Considering Uncertainties in Resource Estimation
2263	Moreno	Chile	A Two-Stage Stochastic Model for Open Pit Mine Planning Under Geological Uncertainty

15.30 - 17.00 — Green Center Petroleum Hall

14 Short Term Mine Planning with Stockpiles

Chair(s): Benito Perez, Waqar Asad

2345	Perez	United States	Building a Stockpile Model for Modeling Gold Grade, Increasing Confidence and Reducing the Risk in Short-Term Mine Planning at Akyem Mine, Ghana
2302	Parmar	United States	Haulage Impact on Mine Cut-Off Grade Strategy at Freeport McMoran Sierrita
2276	Ben-Awuah	Canada	Application of Cut-off Grade Optimization for Hierarchical Oil Sands Production and Dyke Material Scheduling with Stockpiling
2297	Rezakhah	United States	Open Pit Mine Planning with Degradation Due to Stockpiling

18.30 - 21.00 — Green Center Friedhoff Hall (lower level)

Banquet

F R I D A Y , A U G U S T 1 1

09.00 - 10.15 — Green Center Metals Hall

15 Techniques to Improve Grade Estimates During the Resource Modeling

2337	Sullivan	Chile	Identification and Capping of Local Outlier Grades
2251	Seibel	United States	Utilizing Probability Assigned Constrained Kriging (PACK) and Leapfrog to Construct the Çöpler Resource Model, East-Central Turkey
2303	Anani	United States	Applying Tests of Spatial Dependence in Mineral Resource Exploratory Data Analysis

09.00 - 10.15 — Green Center Petroleum Hall

16 Optimization Techniques for Underground Mining Applications (II)

Chair(s): Erkan Topal

2275	Vásquez	Chile	Optimization of Mining Planning in Block / Panel Caving Mines Including Development Activities

2206	Brickey	United States	A Sliding Time Window Heuristic to Solve Large Underground Mine Production Scheduling Problems
2342	Moghanlou	Iran	Optimal Limit Analysis of Underground Mine Using Floating Stope Algorithm

10.15 - 10.45 Green Center Lobby

Break (Refreshments are available)

10.45 - 12.15 Green Center Metals Hall

17 Mathematical Models and Algorithms for Solving Large Scale Optimization Problems

Chair(s): Javad Sattarvand

2242	Van-Dúnem	United States	An Intuitive Exposition of the Bienstock-Zuckerberg Algorithm as Applied to the Open-Pit Mine Production Scheduling Problem
2321	Hazra	India	A Genetic Algorithm Based Approach for Simultaneous Optimization of Open Pit Mine Planning Parameters
2306	Molina	Chile	Analytical Properties of the Feasible and Optimal Profiles in the Binary Programming Formulation of Open Pit
2305	Molina	Chile	Characterizing the Optimal Profile of the Open Pit Problem in the Continuous Framework

10.45 - 12.15 Green Center Petroleum Hall

18 Stochastic Simulation Techniques for Uncertainty Characterization (II)

Chair(s): Jeff Sullivan

2335	Assibey-Bonsu	Australia	A Comparative Study of Indirect and Direct Localized Conditioning Modelling Techniques for Assessment of Recoverable Resources for Medium and Long-Term Mine Planning
2341	Pires	Brazil	Block Models Validation Using Distance Matrix, Multidimensional Scaling, and Hierarchical Clustering Analysis
2318	Bessin	France	Sensitivity Study of the Estimation Variance Approximation of a Quotient – Comparison with Conditional Simulations in the Mn Deposit of Bangombé (Gabon)
2298	Rezakhah	United States	Evaluating the TBM Utilization by Simulation Models

12.15 - 13.30 Green Center Friedhoff Hall (lower level)

Lunch

13.30 - 15.00 Green Center Metals Hall

19 Autonomous Loaders and Trucks - Evaluating Their Impact on Economics of Mining Operations

Chair(s): Klaus Boede

2324	Sattarvand	United States	Current State of the Art of Assisted and Autonomous Loading
2353	Dagdelen	United States	Equipment Replacement Analysis of Manual Trucks with Autonomous Truck Technology in Open Pit Mines
2325	Sattarvand	United States	Investigation of the Production Assurance Strategies for Shovel-Truck Haulage Systems Through Discrete Event Simulation

2301	Askari-Nasab	Canada	An Investigation into Dispatch Optimizers using Truck-Shovel Simulation and a New Multi Objective Truck Dispatching Technique

15.00 - 15.30 Green Center Metals Hall

Closing Remarks