

# CAVING 2018 RECEIVED PAPERS\*

## KEYNOTE PAPERS

KEYNOTE: Optimising for success at the Grasberg Block Cave *R Campbell, Freeport-McMoRan, USA; H Banda, J Fajar, PT Freeport Indonesia, Indonesia; C Brannon, Freeport-McMoRan, USA*

KEYNOTE: Key geotechnical knowledge and practical mine planning guidelines in deep, high-stress, hard rock conditions for block and panel cave mining *D Cuello, G Newcombe, Newcrest Mining Ltd, Australia*

## CASE STUDIES

Underground mining at Ekati and Diavik Diamond Mines *J Jakubec, D Lagacé, SRK Consulting (Canada) Inc., Canada; B Boggis, Dominion Diamond Mines, Canada; Lyndon Clark, Philip Lewis, Rio Tinto, Australia*

Sublevel retreat mining in the subarctic: a case study of the Diavik Diamond Mine *PA Lewis, LM Clark, SJ Rowles, CP Auld, CM Petryshen, AP Elderkin, Rio Tinto, Canada*

Evaluation of caving as mining method for the Udachnaya underground diamond mine project *M Tishkov, M Vishnevskaya, ALROSA PJSC, Russia*

## CAVING MECHANICS

A re-evaluation of the conceptual model of caving mechanics *D Cumming-Potvin, J Wesseloo, Australian Centre for Geomechanics, Australia; SW Jacobsz, E Kearsley, University of Pretoria, South Africa*

Benchmarking and its application for caving projects *IT Ross, CaveConsult Pty Ltd, Australia*

Safely reopening a collapsed extraction level drive in a resource limited environment *NA Shea, RW Sinclair, TM Welsh, Climax Molybdenum, USA*

Investigating and assessment of effecting parameters on rock mass cavability in block caving mines using the decision making trial and evaluation laboratory technique *F Sotoudeh, R Rafiee, M Ataei, RN Masir, Shahrood University of Technology, Iran*

## DRAW CONTROL, FLOW MODELLING & FRAGMENTATION

Optimisation of the caving problem – a reinforcement learning approach *M Allan, Resolute Mining Ltd, Australia*

Full-scale experiments to measure the effect of cross-cut height on recovery in sublevel cave mines *AD Campbell, The University of Queensland, Australia*

The effect of blast ring burden and explosive density on fragmentation and ore recovery in sublevel cave mines *AD Campbell, The University of Queensland, Australia*

Hang-ups analysis and modelling for Cadia East PC1-S1 and PC2-S1 *R Castro, BCTEC Engineering and Technology, Chile; D Cuello, Newcrest Mining Limited, Australia*

Simulating gravity flow in caving mines through FlowSim *R Castro, A Altamirano, D Guzman, BCTEC Engineering and Technology, Chile*

Palabora Lift 1 block cave: understanding the grade behaviour *T Diering, Dassault Systèmes Canada, Canada; SN Ngidi, JJ Bezuidenhout, HD Paetzold, Palabora Mining Company, South Africa*

Influence of rock mass veining and defects on secondary fragmentation during block caving *L Dorador, E Eberhardt, D Elmo, University of British Columbia, Canada*

Grade control and segregation at New Gold's New Afton block cave operation, Kamloops, BC *MG Henning, New Gold Inc., Canada*

Application of mathematical modelling for draw control under material flow uncertainty *F Khodayari, Y Pourrahimian, University of Alberta, Canada; E Ben-Awuah, Laurentian University, Canada*

Cave to mill: improving value of caving operations *A Moss, B Klein, S Nadolski, University of British Columbia, Canada*

Presence of natural fracture as an indicator of operational difficulty for future cave operations *M Munkhchuluun, Oyu Tolgoi, Mongolia; D Elmo, S Nadolski, Institute of Mining Engineering, Canada; A Moss, Sonal Mining Technology, Canada; B Klein, Institute of Mining Engineering, Canada*

An approach to evaluating block and panel cave projects for sensor-based sorting applications *S Nadolski, B Klein, University of British Columbia, Canada; C JR Hart, Mineral Deposit Research Unit, Canada; A Moss, D Elmo, University of British Columbia, Canada*

Non-vertical cave and dilution modelling at New Gold's New Afton Mine *J Parsons, D Hamilton, New Gold Inc., Canada; C Ludwicki, Dassault Systèmes, Canada*

Testing the suitability of radio frequency identification device cattle tags for tracking block cave progression *ML Wilson, GJ van Hout, FF Dean, Rio Tinto, Australia*

## EQUIPMENT AND AUTOMATION

Underground roadway design considerations for efficient autonomous hauling *RJ Thompson, H Malekzhehtab, Curtin University, Australia*

Application of telepresence systems for accelerated re-entry and inspection after seismic events *J Cronin, Australian Droid and Robot, Australia; D Gilbreath, Rajant Corporation, USA*

## GROUND SUPPORT

Rapid mine development using efficient in-cycle shotcrete *F Erismann, B Lindlar, Sika Services AG, Switzerland; M Corner, Sika Canada, Canada; C Munoz, Sika Chile, Chile; M Hansson, Sika Sweden, Sweden; R Erlangga, Sika Indonesia, Indonesia*

Influence of the undercut height on the behaviour of pillars at the extraction-level in block and panel caving operations *E Hormazabal, R Álvarez, A Russo, D Acevedo, SRK Consulting (Chile) S.A, Chile*

Discrete element modelling of a laboratory static test on welded wire mesh *E Karampinos, B Baek, J Hadjigeorgiou, University of Toronto, Canada*

An empirical comparison between new and existing laboratory-based, dynamic sample configurations *G Knox, A Berghorst, P de Bruin, New Concept Mining, South Africa*

Numerical modelling of dynamic testing for rock reinforcement used in underground excavations *E Marambio, JA Vallejos, L Burgos, Advanced Mining Technology Centre, Chile; C Gonzalez, MIRARCO Mining Innovation, Canada; L Castro, JP Saure, Compañía Siderúrgica Huachipato, Chile; J Urzúa, Teiko Ingeniería Ltda., Chile*

Using a structured data management system to improve mine development efficiencies *E Savage, T Moorcroft, Oyu Tolgoi LLC, Mongolia; S Talu, Rio Tinto, Australia*

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## INSTRUMENTATION

Development of a monitoring network for surface subsidence at New Gold's New Afton block cave operation MA Clayton, M Dugie, A LeRiche, C McKane, BGC Engineering Inc., Canada; A Davies, New Gold Inc., Canada

InSAR monitoring of subsidence induced by underground mining operations G Falorni, S Del Conte, TRE Altamira Inc, Canada; F Bellotti, D Colombo, TRE Altamira SRL, Italy

InSAR as a practical tool to monitor and understand large-scale mining-induced ground deformations in a caving environment K Mäkitaavola, B-M Stöckel, T Savilahti, Luossavaara-Kiirunavaara AB, Sweden; J Sjöberg, Itasca Consultants AB, Sweden; J Dudley, MA McParland, R Morin, MDA Geospatial Services, Canada

## MUD RUSH

Mud rush in the desert? Early cave management for the Carrapateena sublevel cave R Hocking, G Balog, T Ormerod, H Pearce, Oz Minerals, Australia

## NUMERICAL MODELLING

Automation in caving operations – the business case J Mowen, M Allan, J Cronin, Resolute Mining Ltd, Australia

Suggested methods for estimation of confined strength of heterogeneous (defected) rocks N Bahrani, Dalhousie University, Canada; PK Kaiser, Laurentian University, Canada; A Corkum, Dalhousie University, Canada

Three-dimensional simulation of cave initiation, propagation and surface subsidence using a coupled finite difference – cellular automata solution Y Hebert, G Sharrock, Itasca Australia Pty Ltd, Australia

Two-dimensional discontinuum modelling of large-scale footwall stability at the Luossavaara-Kiirunavaara AB Kiirunavaara sublevel cave mine M Svartsjaern, Itasca Consultants AB, Sweden; D Saiang, Luleå University of Technology, Sweden; K Mäkitaavola, Luossavaara-Kiirunavaara AB, Sweden

## PLANNING, DESIGN AND SCHEDULING

Developing caving projects using CaveLogic M Arancibia, F Soto, Maptek Chile, Chile

Integrated simulation and optimisation tools for production scheduling using finite element analysis caving geomechanics simulation coupled with 3D cellular automata S Arndt, Monash University, Australia; T Bui, T Diering, Dassault Systèmes, Canada; I Austen, Newcrest Mining Ltd, Australia; R Hocking, Oz Minerals, Australia

Grasberg block cave mine: cave planning and undercut sequencing D Beard, C Brannon, Freeport-McMoRan Inc., USA

Development and implementation of the short term activity tracker and mine control trigger response system C Chester, D Cuello, Newcrest Mining Limited, Australia; G Basson, Institute of Mine Seismicity, Australia

Maximising resource utilisation in scheduling of underground mining works of multiple faces D Cortés, Y Martínez, Codelco, Chile; M Silva, Züblin, Chile

Oyu Tolgoi cave mine development planning K Crook, F Prince, Rio Tinto, Australia

Footprint finder tool for sublevel caving T Diering, Dassault Systèmes Canada, Canada; F Breed, The De Beers Group of Companies, Canada

Overview of mine planning process for Oyu Tolgoi underground project S Fowke, B Groeneveld, Rio Tinto, Australia

Geotechnical data collection and approach to modelling for Cukaru Peki deposit K Llewelyn, SRK Consulting (UK) Limited, UK; J Jakubec, SRK Consulting (Canada) Inc., Canada; R Goddard, SRK Consulting (UK) Limited, UK; P Stenhouse, Polyphase Consulting Limited, New Zealand

A systems approach to mining innovation D Morrison, V Drylie, Centre for Excellence in Mining Innovation, Canada; P Labrecque, Labrecque Technologies inc., Canada

Optimisation of the undercut level elevation in block caving mines using a mathematical programming framework R Noriega, Y Pourrahimian, WL Victor, University of Alberta, Canada

Chuquicamata underground mine design: the simplification of the ore handling system of Lift 1 P Paredes, T Leaña, L Jauriat, Codelco, Chile

Maximising volumetric efficiency for ventilation systems in temporarily reduced flow environments of block cave mines G Schult, B Prosser, SRK Consulting (U.S.) Inc., USA; D Brown, J Wolgram, Rio Tinto, Australia

Reducing geotechnical problems in block caving by increasing productive capacity KJ Shelswell, PO Labrecque, Labrecque Technologies Inc., Canada; DM Morrison, Centre for Excellence in Mining Innovation, Canada

Design of a new layout for sublevel caving at depth C Quinteiro, Luossavaara-Kiirunavaara AB, Sweden

## RESEARCH

Review and simulation of passive seismic tomography in block cave mining SG Afrouz, EC Westman, Virginia Tech, USA

Numerical simulations of a centrifuge model of caving D Cumming-Potvin, J Wesseloo, Australian Centre for Geomechanics, Australia; M Pierce, Pierce Engineering, USA; T Garza-Cruz, L Bouzeran, Itasca Consulting Group, USA; SW Jacobsz, E Kearsley, University of Pretoria, South Africa

Understanding and managing surface subsidence at New Gold's New Afton block cave operation AGL Davies, DB Hamilton, New Gold Inc., Canada; MA Clayton, BGC Engineering Inc., Canada

Strategy for mining research and development in the cave mining industry GA Ferguson, Seltrust Associates Limited, UK; D Cuello, Newcrest Mining Limited, Australia; P Gandara, Codelco, Chile Y Potvin, Australian Centre for Geomechanics, Australia; E Rojas, Codelco, Chile

The role of research in cave mining SD McKinnon, Queen's University, Canada; GA Ferguson, Seltrust Associates Limited, UK

Back-analysis of PC1 cave propagation and subsidence behaviour at the Cadia East Mine B Sainsbury, Deakin University, Australia; D Sainsbury, Noma Consulting, Australia; D Carroll, Newcrest Mining Limited, Australia

## SEISMICITY

Identifying a migrating stress front using apparent stress for an unplanned rock mass cave LG Brown, MR Hudyma, Laurentian University, Canada

Application of sequential spatial clustering and fractal dimension to caving seismic event parameters of time, distance and intensity DM Cortolezzis, MR Hudyma, Laurentian University, Canada

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Physics-based hazard assessment tools for developing blanket re-entry rules *W de Beer, ESG Solutions, Australia; L Smith, G Viegas, K Bosman, D Angus, ESG Solutions, Canada*

The influence of stress and seismicity on the performance of a sublevel caving operation *HCJ Esterhuizen, Ernest Henry Mine, Australia*

Leinster cave seismic risk management: a block cave solution *M Hopkins, R Rimmelin, A Landon, BHP, Australia*

Evaluating the effect on seismicity of a hydraulic fracturing trial using Bayesian data analysis *K Jonsson, J Martinsson, Luossavaara-Kiirunavaara, Sweden*

Tracking cave shape development with microseismic data *R Lynch, S Meyer, E Lotter, Institute of Mine Seismology, Australia; J Lett, Newcrest Mining Limited, Australia*

Analysis of damaging seismic event on 24 December 2011 in the Pilar Norte sector of El Teniente mine *D Malovichko, Institute of Mine Seismology, Australia; D Cuello, Newcrest Mining Limited, Australia; E Rojas, Codelco, Chile*

Microseismic monitoring of the Oyu Tolgoi Hugo North Lift 1 *JP Mercier, Rio Tinto, Mongolia; A van As, Rio Tinto, Australia; C Carlson, B Tumur-Ochir, Rio Tinto, Mongolia*

Rapid assessment of the spatial extent of strong ground motion in mines: ShakeMap approach *S Meyer, Institute of Mine Seismology, Australia; J Doolan, C Chester, Newcrest Mining Limited, Australia; G Basson, Institute of Mine Seismology, Australia*

Mapping cave front growth utilising the collective behaviour of seismicity and velocity fields *G Viegas, K Bosman, D Angus, ESG Solutions, Canada; W de Beer, ESG Solutions, Australia; T Urbancic, ESG Solutions, Canada*

Progression and management of seismic hazard through the life of Telfer sublevel cave *MJ Woods, ME Poulter, RG King, Newcrest Mining Limited, Australia*

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