# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Australian Centre for Geomechanics</td>
<td>iii</td>
</tr>
<tr>
<td>Technical Reviewers</td>
<td>v</td>
</tr>
<tr>
<td>Preface</td>
<td>vii</td>
</tr>
<tr>
<td>Sponsors</td>
<td>ix</td>
</tr>
</tbody>
</table>

## Keynote Addresses

- Some comments regarding development drifting practices with special emphasis on caving applications
  W. Hustrulid, Hustrulid Mining Services, United States of America  
  Page 3

- Cave mining — 16 years after Laubscher’s 1994 paper ‘Cave mining – state of the art’
  G.P. Chitombo, Sustainable Minerals Institute, The University of Queensland, Australia  
  Page 45

## Monitoring

- Design and implementation of a damage assessment system at Argyle Diamond’s block cave project
  F. Fernandez, P. Evans and R. Gelson, Argyle Diamonds Pty Ltd, Australia  
  Page 65

- The critical earthquake concept applied to block caving — evidence for cooperative behaviour during failure
  H. White, Coffey Mining (NZ) Ltd, New Zealand; A. van As, Rio Tinto Copper Projects, Australia; D. White and B. O’Keefe, Coffey Mining (NZ) Ltd, New Zealand  
  Page 83

- A deformation monitoring plan for extraction level drives at Ridgeway Deeps block cave mine
  R.J. Lowther, Newcrest Mining Limited; and The University of New South Wales, Australia; G.W. Capes, Newcrest Mining Limited, Australia and G.B. Sharrock, Newcrest Mining Limited; and The University of New South Wales, Australia  
  Page 93

- Initial and east cave breakthrough events at Palabora Mining Company
  S.N. Glazer, Mine Seismology Consultant, South Africa and P.A. Townsend, Palabora Mining Company, South Africa  
  Page 107

- Microseismic tools for the analysis of the interaction between open pit and underground developments
  J.M. Reyes-Montes, Applied Seismology Consultants, United Kingdom; B.L. Sainsbury, Itasca Australia Pty Ltd; and University of New South Wales, Australia; W.S. Pettitt, Applied Seismology Consultants, United Kingdom; M. Pierce, Itasca Consulting Group, United States of America and R.P. Young, University of Toronto, Canada  
  Page 119

- Monitoring open stope caving at Goldex Mine
  M.R. Hudyma, Laurentian University, Canada; P. Frenette, Agnico-Eagle Mines Ltd, Canada and I. Leslie, Engineering Seismology Group, Canada  
  Page 133

- Instrumentation and monitoring of cave initiation at Telfer Mine
  M. Di Giovinazzo, Newcrest Mining Limited, Australia and U. Singh, Newcrest Mining Limited, Australia  
  Page 145

- Using the apparent volume parameter to estimate rock mass damage
  R. Dunlop, R. Parraguez and R. Zepeda, Codelco Chile, Chile  
  Page 157

## Subsidence

- An integrated finite/discrete element method – discrete fracture network synthetic rock mass approach for the modelling of surface subsidence associated with panel cave mining at the Cadia East underground project
  D. Elmo, S. Rogers, R. Beddoes, Golder Associates Ltd., Canada and A. Catalan, Newcrest Mining Limited, Australia  
  Page 167
Investigation of surface subsidence due to sublevel caving .......................................................... 181
T. Villegas, University of Sonora, Mexico; and Luleå University of Technology, Sweden and E. Nordlund,
Luleå University of Technology, Sweden

Investigation of caving induced subsidence at the abandoned Grace Mine ........................................... 189
D.P. Sainsbury, B.L. Sainsbury, Itasca Australia Pty Ltd, Australia and L.J. Lorig, Itasca Consulting Group
Inc., United States of America

Integration of 3D numerical modelling and InSAR deformation monitoring to characterise block
caving induced surface subsidence ........................................................................................................... 205
K.S. Woo, E. Eberhardt, Geological Engineering, The University of British Columbia, Canada; P. Ghuman,
MDA Systems Limited, Canada and D. Stead, Resource Geotechnics, Simon Fraser University, Canada

Planning and Design

Block cave optimisation—a value driven approach .............................................................................. 219
C.A. Stewart, A. Allman and B.E. Hall, AMC Consultants Pty Ltd, Australia

Strategic considerations in block caving .................................................................................................. 231
R.J. Butcher and G. Smith, Barrick Gold of Australia Ltd, Australia

A new mine planning tool for sublevel caving mines ............................................................................ 237
D. Villa and T. Diering, Gemcom Software International Inc., Canada

The Goldex Mine mining method ........................................................................................................... 253
P. Frenette, Agnico-Eagle Mines Ltd, Canada

An alternative mining method at the Kvannevann Mine, northern Norway ........................................... 267
S. Nævermo Sand, Rana Gruber AS, Norway

New approach for rapid preparation of block caving mines ................................................................. 279
V. Encina, D. Méndez, C. Caballero and H. Osorio, JRI Ingeniería S.A., Chile

Shaft boring systems for mechanical excavation of deep shafts ............................................................. 289
C. Frenzel, Herrenknecht AG, Germany, F. Delabbio, Rio Tinto, Australia and W. Burger, Herrenknecht
AG, Germany

Lift and production limits for hoists and belt conveyors in underground mass mining operations ............ 297
J.C. Spreadborough, Parsons Brinckerhoff Pty Ltd, Australia

Geomechanics of Caving Mines

Interaction between a propagating cave and an active pit at Telfer Mine—Part I: interaction
management ............................................................................................................................................... 307
U. Singh, R.A. Dixon and C. McArthur, Newcrest Mining Limited, Australia

Interaction between a propagating cave and an active pit at Telfer Mine—Part II: monitoring
interaction .................................................................................................................................................... 321
R.A. Dixon, U. Singh and C. McArthur, Newcrest Mining Limited, Australia

Shotcrete thickness measuring using modern technology .......................................................................... 333
A.J. Loncaric, Stratacrete Pty Ltd, Australia and A.J. Loomes, Underground Survey Services
Pty Ltd, Australia

Block 4 geotechnics—past, present and future ...................................................................................... 341
C.A. Preece, De Beers Consolidated Mines, South Africa

Considerations in planning and implementing massive underground mines at depth ............................ 359
P.J. Bartlett, South Africa

Geotechnical characterisation—Cadia East panel caving project, New South Wales, Australia .............. 371
Caving 2010, Perth, Australia

A. Catalan, Newcrest Mining Limited, Australia and C. Suarez, Suarez and Associates Ltd, Chile

The role of geotechnical engineering during the prefeasibility studies and early works of Cadia East panel caving project, New South Wales, Australia ................................................................. 389

A. Catalan, F. Sinaga and I. Qudraturrahman, Newcrest Mining Limited, Australia

Lift 2 North extension cave performance ................................................................................................................... 407

S. Talu, Rio Tinto, Australia; A. van As, Rio Tinto Copper Projects, Australia; W. Seloka and R. Henry, Rio Tinto, Australia

Numerical Modelling

A discrete fracture network based approach to defining in situ, primary and secondary fragmentation distributions for the Cadia East panel cave project ................................................................................. 425

S. Rogers, D. Elmo, G. Webb, Golder Associates Ltd., Canada and A. Catalan, Newcrest Mining Limited, Australia

Multi-scale simulation of ground support designs for extreme tunnel closure ............................................................. 441

D.A. Beck, S. Kassbohm and G. Putzar, Beck Arndt Engineering Pty Ltd, Australia

Influence of major fault zones on 3D ground deformations caused by open pit block cave interactions........................................................................................................................................................................... 455

J. Severin, E. Eberhardt and K.S. Woo, Geological Engineering, The University of British Columbia, Canada

Geomechanical evaluation of macro-block caving options using 3D numerical modelling at Chuquicamata underground project in Chile ............................................................................................................. 469

E. Hormazabal, SRK Consulting, Chile; F. Villegas, VCP-Codelco Chile, Chile; F. Rovira, SRK Consulting, Chile and C. Carranza-Torres, University of Minnesota, United States of America

Interpretation of seismic data and numerical modelling of fault reactivation at El Teniente, Reservas Norte sector (RENO) ........................................................................................................................................................................... 483

Y. Potvin, Australian Centre for Geomechanics, Australia; J. Jarufe, Codelco Chile, Chile and J. Wesseloo, Australian Centre for Geomechanics, Australia

Application of advanced numerical modelling techniques for the assessment of cavability, subsidence and airblast hazard in a sublevel cave mine........................................................................................................................................................................... 495

J.B. Albrecht, W.H. Gibson, A. Vakili, M.P. Sandy, AMC Consultants Pty Ltd, Australia and K. Ross, Red Back Mining Inc., Canada

Simulation of rock caving process using a mesh-free method ......................................................................................... 509

S. Karekal, CSIRO Earth Science and Resource Engineering, Australia; R. Das, CSIRO Mathematical and Information Sciences, Australia; L. Mosse, Leap Australia, Australia and P.W. Cleary, CSIRO Mathematical and Information Sciences, Australia

Sensitivities in the numerical assessment of cave propagation ......................................................................................... 523

B.L. Sainsbury, Itasca Australia Pty Ltd; and The University of New South Wales, Australia

Draw Control

Understanding the flow of caved ore and its influence on ore recoveries and dilution in a block cave ........................................................................................................................................................................... 539

T.G. Heslop, Mine Geotechnics (WA) Pty Ltd, Australia

Large-scale simulations of gravity flow in block caving ................................................................................................. 553

W.R. Hancock, D.K. Weatherley and G.P. Chitombo, Sustainable Minerals Institute, The University of Queensland, Australia

A hybrid methodology for secondary fragmentation prediction in cave mines........................................................................ 567

M. Pierce, Itasca Consulting Group Ltd, United States of America; D.K. Weatherley, Sustainable Minerals Institute, The University of Queensland, Australia and T. Kojovic, SimSAGe Pty Ltd, Australia
Development of the kinematic model to rapidly simulate the flow of caved rock for block caving

R. Castro, Mining Engineering Department, University of Chile, Chile; A. Tamburrino, Civil Engineering Department, University of Chile, Chile and F. Fernandez, Mining Engineering Department, University of Chile, Chile

Impact of poor fragmentation on cave management

S.N. Ngidi and D.D. Pretorius, Palabora Mining Company, South Africa

The Smart Marker System — a new tool for measuring underground orebody flow in block and sublevel mines

D.S. Whiteman, Elexon Electronics Pty Ltd, Australia

Installing Smart Markers to monitor Lift 2 North extension ore flow behaviour

S. Talu, Rio Tinto, Australia; A. van As, Rio Tinto Copper Projects, Australia; R. Henry, Rio Tinto, Australia; J. Hilton and D.S. Whiteman, Elexon Electronics Pty Ltd, Australia

Diameter of a draw zone — a case study from a block caving mine, Deep Ore Zone, PT Freeport Indonesia

H.A. Sahupala, PT Freeport Indonesia, Indonesia; T. Szewdicki, AusWest Pty Ltd, Australia and R. Prasetyo, PT Freeport Indonesia, Indonesia

Preconditioning

Measurement of hydraulic fracture growth in a naturally fractured orebody for application to preconditioning

R.G. Jeffrey, CSIRO Earth Science and Resource Engineering, Australia; A. van As, Rio Tinto Copper Projects, Australia; X. Zhang, A.P. Bunger and Z.R. Chen, CSIRO Earth Science and Resource Engineering, Australia

Simulating the impacts of hydraulic fracture preconditioning on cavability and fragmentation at the planned Cadia East panel cave

S. Rogers, D. Elmo, G. Webb, Golder Associates Ltd., Canada and A. Catalan, Newcrest Mining Limited, Australia

Estimation of rock mass changes induced by hydraulic fracturing and cave mining by double difference passive tomography

M.J. Pfitzner, Beck Arndt Engineering Pty Ltd, Australia; E. Westman, Mining and Minerals Engineering Department, Virginia Tech, United States of America; M. Morgan and D. Finn, Newcrest Mining Limited, Australia; D.A. Beck, Beck Arndt Engineering Pty Ltd, Australia

Microseismic monitoring of hydraulic fractures in block cave mines

P.J. Joubert, ISS International, South Africa

Author Index