The First International Symposium on Ground Support in Mining and Underground Construction took place in 1983 under the theme of rockbolting: theory and application in mining and underground construction. This series of events has evolved over the years to cover all areas of ground support in mining and provide a documented timeline of the significant advancements in ground support technology and practice in the last 40 years. These are reflected in the improved safety statistics and performance of excavations.

Ground support remains the main means to manage rockfalls; one of the major risks in underground mines. The latest developments and applications of ground support in mining are of prime interest to mining practitioners worldwide where the objective is to mitigate rockfall.

Conference Chair

Associate Professor Johan Wesseloo
Director
Australian Centre for Geomechanics

Register your attendance at acggroundsupport.com/register
**Conference Program**

**Ground Support 2023**

**Day One: Tuesday 10 October 2023**

**07:30** REGISTRATION

**08:30** Welcome and introduction J Wesseloo, Ground Support 2023 Conference Chair, Australian Centre for Geomechanics, The University of Western Australia, Australia

**SESSION ONE: MONITORING (1) - SOUTH BALLROOM**

CHAIR A Page, Geotechnical Mining Services

**08:45** KEYNOTE ADDRESS: The ground support life cycle considering real-time ground-consumption monitoring W Bawden, Mine Design Technologies, Canada

**09:30** xCell Cyclops: a new technology for an efficient way of monitoring convergence in underground mines O Vallati, Sandvik, Australia; M Farrington, Agnico Eagle Mines, Australia; P Young, S Weaver, Sandvik, Australia

**10:00** Principal Sponsor address: Jennmar

**10:05** MORNING BREAK

**SESSION TWO: MONITORING (2) - SOUTH BALLROOM**

CHAIR P Mather, Regis Resources Ltd

**10:35** High-resolution ground-deformation and support monitoring using a portable handheld LiDAR approach S Mercer, J Morgenroth, RockMass Technologies, Canada; B Simser, Glencore, Canada

**11:05** Monitoring of rock mass movement using a distributed array of wi-fi enabled extensometers S MacGregor, P Seaward, SCT Operations, Australia; M Farrington, Agnico Eagle Mines, Australia

**11:35** Automated ground support deformation monitoring; a novel method with new opportunities for geotechnical engineers J Frankie, C Gonzalez, Caroni Geospatial, Australia

**12:05** Practical application of mXrap Damage Mapping application at Nova nickel mine M Lane, IGO Limited, Australia; D Cumming-Potvin, Australian Centre for Geomechanics, The University of Western Australia, Australia

**12:35** LUNCH

**PARALLEL SESSIONS**

**SESSION THREE A: SUPPORT FOR DYNAMIC CONDITIONS (1) - SOUTH BALLROOM**

CHAIR L Moreau-Verlaan, RockEng Inc., Canada

**13:35** Estimate of ground support response under dynamic loads at El Teniente mine, Codelco, Chile M5 Celis, RA Parraguez, Codelco, Chile

**14:05** Empirical charting for dynamic ground support at Flying Fox and Spotted Quoll mines J Graham, U Waheed, IGO Limited, Australia; PA Mikula, Mikula Geotechnics, Australia

**14:35** Evolution of dynamic rock support systems at the El Teniente mine TE Rojas, A Muñoz, P Landeros Córdova, Codelco, Chile

**15:05** Case study: use of rebars with microalloyed steels in tunnels with induced seismicity A Muñoz, C Cifuentes, Codelco, Chile

**15:35** AFTERNOON BREAK

**SESSION THREE B: PORTALS AND LARGE CHAMBERS - FRESHWATER BAY ROOM**

CHAIR M Lane, IGO Limited

**13:35** Geotechnical challenges during excavation of Crusher Chamber 1, Andes Norte project, El Teniente mine R Valdivia, R Padilla, W Rodriguez, P Landeros Córdova, A Muñoz, E Rojas, Codelco, Chile

**14:05** Ground support for large chambers at Didipio mine JM Bermas, DA Dumanageng, CG Reola, OceanaGold Philippines Inc, Philippines; PB Laurence, PB Laurence & Associates, Australia

**14:35** Mine portal design: considerations, methods and practices MU Dunn, Debswana Diamond Company, Australia; TT Parrott, Entech, Australia

**15:05** Automated reinforcement of orepasses in the Andes Norte project F Henriquez, R Navarrete, Codelco, Chile

**15:35** Adapting hollow bar: lessons learned A Bergman, E Fjellner, P Hallén, Boliden, Sweden; R Penczek, DSI Underground, Poland; R Pérez Hidalgo, Boliden, Sweden; F Scolari, DSI Underground, Italy; M Svanberg, DSI Underground, Sweden

**16:05** Design, development and testing of the Falcon Bolt R Galluzzi, M Holden, A Dodds, J Matthews, A Bennett, Jennmar, Australia

**16:35** Dynamic impact and static testing of self-drilling dynamic bolt types installed in Normet’s urea-silicate injection resin: a new path forward to reducing worker exposure to high-stress ground conditions A Punkkinen, Normet Canada Ltd, Canada; G Li, Queen’s University, Canada, and Hebei University of Engineering, China; A Taheri, Queen’s University, Canada

**17:05** Ground support methods for vertical development CG Scott, D Sidea, SJ Masters, pitt&sherry, Australia

**17:35** DAY ONE CLOSE

*Correct as at 3 October 2023 and subject to change. See acggroundsupport.com/program for updates.*

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**Conference Venue and Accommodation**

The ACG team is delighted to be hosting the Ground Support 2023 conference at the Hyatt Regency Hotel Perth. To learn more and book your accommodation, visit acggroundsupport.com/conference-venue
**Day Two: Wednesday 11 October 2023**

### SESSION ONE: DYNAMIC TESTING OF REINFORCEMENT - SOUTH BALLROOM

**CHAIR** D Sewnun, Australian Centre for Geomechanics

- **08:30** KEYNOTE ADDRESS: Laboratory-based drop testing of rock reinforcement **G Knox**, University of Toronto, Canada
- **09:15** A comparison between laboratory and in situ dynamic testing on the MDX bolt **B Darlington**, O Vallati, P Young, Sandvik, Australia

### SESSION TWO: SUPPORT FOR DYNAMIC CONDITIONS (2) - SOUTH BALLROOM

**CHAIR** I Morkel, IGM Geotechnical

- **10:15** Dynamic modelling of strainbursting around tunnels **A Rigby**, Institute of Mine Seismology, Australia
- **10:45** Delineation of hazard-based design events for dynamic support system analysis **N Dadashzadeh, L Moreau-Verlaan, K Kalenchuk**, RockEng Inc, Canada
- **11:15** Utilisation of seismic data in the assessment of displacement and energy demand imposed on ground support by strainbursts **D Malovichko**, Institute of Mine Seismology, Australia
- **11:45** Dynamic support evaluations for implementation by seismic hazard domains **K Kalenchuk, N Dadashzadeh, L Moreau-Verlaan, RockEng Inc, Canada**

### LUNCH

### SESSION THREE A: LABORATORY TESTING OF MESH - SOUTH BALLROOM

**CHAIR** W Duan, Westgold Resources Limited

- **13:15** A review of ground support mesh testing around the world **IG Morkel**, IGM Geotechnical, Australia; **PA Mikula, Mikula Geotechnics, Australia**; **RR Whiting, Rowland Whitting Technical Services, Australia**
- **13:45** Large-scale tests of weld mesh versus high-tensile chain link mesh on mesh overlap load transfer **R Brändle**, Geobrugg, Switzerland; **R Bucher**, Geobrugg, Australia

### SESSION THREE B: CORROSION - FRESHWATER BAY ROOM

**CHAIR** R Hassell, Mining & Civil Integrity Testing

- **13:15** An acidic water corrosive environment and ground support strategies at the Grasberg Block Cave mine, Indonesia **JPE Hamman**, REP Belseran, B Krisa, T Ramadhan, AY Sugiyanto, H Banda, PT Freeport Indonesia, Indonesia
- **13:45** Accelerated galvanic corrosion between graphitic rock from underground mines and metal coupons **C Stazick**, G Feagan, S Sunderman, Centers for Disease Control and Prevention, National Institute for Occupational Health & Safety, Spokane Mining Research Division, USA

### SESSION THREE C: PRE-TENSION - FRESHWATER BAY ROOM

- **14:15** A laboratory-scale dynamic test of load distribution elements at Rancagua testing facility **M Hinojosa, JA Vallejos, E Marambio**, Universidad de Chile, Chile; **G Fischer**, G von Rickenbach, Geobrugg, Chile
- **14:45** Importance and development of pre-tension on bolt support systems: implications to hanging wall beam stability **MN Masitse**, M Muzavazi, Mohlalefi Engineering, South Africa

### AFTERNOON BREAK

### SESSION FOUR: SUPPORT MECHANISMS - SOUTH BALLROOM

**CHAIR** A Kusui, Beck Engineering

- **15:15** Simulating static pull tests, shear tests and dynamic drop tests to identify basic parameters for subsequent support design **PM Dight**, Australian Centre for Geomechanics, The University of Western Australia, Australia
- **15:45** Performance in shear of mechanical hybrid rockbolts **G Knox, J Hadjigeorgiou**, University of Toronto, Canada
- **16:15** Effect of mobilised length on the performance of a paddled energy-absorbing rockbolt **DL Venter**, Epiroc, Australia; **G Knox**, Epiroc, South Africa

### DAY TWO CLOSE

**18:30** DINNER - OPTUS STADIUM

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**Keynote Speakers**

- **Dr Will Bawden**, President, Mine Design Technologies, Canada
  - **Keynote title**: The ground support life cycle considering real time ground-consumption monitoring

- **Greig Knox**, PhD Student, University of Toronto, Canada
  - **Keynote title**: Laboratory impact testing of rock reinforcement
Conference Program

Day Three: Thursday 12 October 2023

SESSION ONE: GROUND SUPPORT DESIGN AND MAINTENANCE (1) - SOUTH BALLROOM

CHAIR: J Burns, Rio Tinto, Canada

08:30 Numerical forecast of central access ground support behaviour at Cadia East PC1-2 E Ghazvinian, Itasca Consulting Group, Inc, USA; C Orrego, Newcrest Mining Limited, Australia; M Fuenzalida, Itasca Consulting Group, Inc, USA

09:15 Suggested framework for design effort and acceptance criteria for underground mine excavations MJ Dunn, Debswana Diamond Company, Australia; PHJ de Graaf, Anglo American, Australia

09:45 MORNING BREAK

SESSION TWO: GROUND SUPPORT DESIGN AND MAINTENANCE (2) - SOUTH BALLROOM

CHAIR: D Tyler, Newcrest Mining Limited

10:15 Vuggy and cavernous rock mass conditions: implications for the early detection, management, ground support and development of tunnels TT Parrott, Entech, Australia; L Montaldí, Regis Resources, Australia; S Muir, Entech, Australia; J Gibb, Entech, New Zealand

10:45 Evolution of ground support designs for blasthole stoping in kimberlite at Diavik Diamond Mine JM Burns, Rio Tinto, Canada

11:15 A numerical approach for a displacement-based ground support capacity consumption forecast S Dekhoda, Beck Engineering, Australia; F Reusch, G Putzar, Beck Engineering, Germany. Presented by A Kusui, Beck Engineering

11:45 LUNCH

PARALLEL SESSIONS

SESSION THREE: GROUTING - SOUTH BALLROOM

CHAIR: N Gamble, Glencore

12:45 Improving underground development cycle time using performance mine grouts A Safari, IGO Limited, Australia; P Jere, Sika Australia, Australia

13:15 Application of modern pumpable polyester resin to the mining cycle T Roberts, D Faulkner, Jennmar, USA; R Koekemoer, Komatsu, Canada

13:45 How the strength and deformability of thixotropic resins depend on their structure and what is the true thixotropic behaviour of the mixture M Petranek, Normet International Ltd, Czech Republic; S Korec, SChem a.s., Slovakia; H Galusová, K Jiříčková, SChem a.s., Czech Republic

14:15 Trial of high early-strength grout-hardening accelerating admixture for cable bolts M Lane, IGO Limited, Australia; M McInnes, Sika Australia, Australia

14:45 AFTERNOON BREAK

SESSION FOUR: STABILISING POOR GROUND - SOUTH BALLROOM

CHAIR: JP Hamman, PT Freeport Indonesia, Indonesia

15:15 A case study for rebar-reinforced shotcrete arches and void filling at the Grasberg Block Cave mine, Indonesia A Setiawan, B Cahyono, B Krisa, R Ginting, D Napitupulu, PT Freeport Indonesia, Indonesia

15:45 Stabilising drawpoints for breccia stopes CG Reola, OceanaGold Philippines Inc, Philippines; PB Lawrence, PB Lawrence & Associates, Australia; JM Bermas, DA Dumangeng, OceanaGold Philippines Inc, Philippines

16:15 Installation of lattice girders with Toussaint–Heintmann yielding elements in poor ground O Belov, Rio Tinto, Mongolia; T Roberts, Jennmar, Australia; KJ Ma, Jennmar, USA; J Ooi, Rio Tinto, Australia; B Baasanjav, Rio Tinto, Mongolia

16:45 FAREWELL ADDRESS AND CLOSE J Wesseloo, Ground Support 2023 Conference Chair, Australian Centre for Geomechanics, The University of Western Australia, Australia

Professional Development Hours

Attendance at Ground Support 2023 may entitle you to up to 20 PD hours.
Please email info-acg@uwa.edu.au for your certificate of attendance, post-event.

Conference Dinner

Venue: Optus Stadium, Victory Lounge, Access via Gate D
Address: 333 Victoria Park Dr, Burswood WA 6100
Date: Wednesday 11 October 2023
Time: 18:30
Dress: Smart casual

Registered attendees will enjoy an evening of networking, sweeping views and a sit-down, three-course dinner in one of Perth’s most exciting venues, Optus Stadium, situated on the banks of the picturesque Swan River.

Dinner is now SOLD OUT.

acggroundsupport.com

Correct as at 3 October 2023 and subject to change. See acggroundsupport.com/program for updates.
The Role of Numerical Modelling in Ground Support Design Workshop

9 October 2023 | South Ballroom, Hyatt Regency Hotel, Perth, Western Australia

From pre-feasibility studies to rehabilitation

About the Workshop

Mine-wide and detailed local-scale numerical modelling has become a standard tool for geotechnical decision-making throughout the mine cycle. The use of empirical methods, kinematic analysis and an evolutionary process of incremental support system improvements appear to dominate the ground support design and selection process during the mining cycle.

This workshop will explore the role of numerical methods in ground support design, and its strengths and limitations, as well as examine areas where value can be added with numerical modelling informing decision-making.

Several experts will present on different topics followed by a panel discussion to further explore some of the presented ideas.

Workshop facilitator

Associate Professor Johan Wesseloo
Director
Australian Centre for Geomechanics

WORKSHOP PROGRAM – 9 OCTOBER 2023*

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<td>08:30–08:45</td>
<td>Introduction Johan Wesseloo, Australian Centre for Geomechanics</td>
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<td>08:45–09:15</td>
<td>Looking for answers while stumbling through a maze of tunnels Frans Basson, Newmont Australia</td>
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<td>09:15–10:00</td>
<td>The application of elastic numerical modelling to guide ground support requirements in hard rock mines Gerhard Hofmann, AngloGold Ashanti, South Africa</td>
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<td>10:00–10:15</td>
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<td>10:45–11:30</td>
<td>Computer-aided ground support design – past, present and future Abou Vakili, Mining One Pty Ltd</td>
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<td>11:45–12:30</td>
<td>The role of numerical modelling in ground support applied to caving Ehsan Ghazvinian &amp; Miguel Fuenzalida, Itasca, USA</td>
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<td>12:15–12:30</td>
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<td>13:30–14:15</td>
<td>Forecasting ground support performance: numerical modelling across the entire mine cycle – proxies or actual mechanisms? Cristian Orrego, Newcrest Mining Limited</td>
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<td>14:15–15:00</td>
<td>Case studies – using numerical modelling in ground support design Ayako Kusui, Beck Engineering Pty Ltd</td>
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<td>15:30–17:00</td>
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<td>17:00</td>
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See acggroundsupport.com/numerical-modelling-workshop for workshop presenters and panellists.

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The ACG’s Online Repository of Conference Proceedings aims to provide the mining geomechanics fraternity with open access to peer-reviewed conference papers that may assist readers to maintain and develop their skills, knowledge and capabilities.

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The Ground Support for underground mines book, as well as many other ACG underground publications, is available for purchase online at acg.uwa.edu.au/shop/gsso
### Workshop on Deformation-Based Support Design and Rockburst Hazard Assessment

**13:00–17:00 AWST, 13 October 2023 & 07:30–12:00 AWST, 14 October 2023**  
Traders Lounge, Hyatt Regency Hotel, Perth, Western Australia

#### About the Workshop

This workshop focuses on support design for excavations in brittle rock, where displacements induced by sudden stress fracturing may consume much of the support’s capacity. It deals with the functionality of the support in deforming ground and with the consequences of mining-induced support damage. It offers quantitative means to estimate the capacity of integrated support systems and a systematic approach to compare it with the static and dynamic demands imposed on the ground support.

This workshop presents an integrated approach of deformation-based support design (DBSD) using support demand and support capacity-assessment tools, and an innovative approach developed in collaboration with Newcrest Mining for rockburst hazard assessment (RBHA) using geological, stress, mining sequence, ground support and seismic data.

#### Topics

1. Deformation-based support design
   1.1 Deficiencies of common support design approaches
   1.2 Overview of strainburst process and DBSD principles
   1.3 DBSD steps to overcome limitations of common ground-motion-centric design approach
   1.4 Motivation and justification of change in design method and need for change management
   1.5 Estimation of support demand
   1.6 Estimation of remnant capacity of integrated support systems
   1.7 Assessment of effectiveness of integrated support systems using the displacement safety margin concept

2. Rockburst hazard assessment
   2.1 Terminology – shakedown and strainbursting damage mechanisms, rockburst potential and rockburst hazard
   2.2 Input of rockburst hazard assessment – rock mass properties, geometry of excavations, stress model, seismic data, ground support
   2.3 Utilisation of seismic data – assessment of strainbursting depth and duration of bulking, probability and percentage of the dynamic realisation of extreme depth of failure, increase in the depth of failure and consumption of ground support capacity
   2.4 Calculation and presentation of results – mapping of parameters and results to tunnel nodes, displacement versus energy plot of ground support capacity and demand, safety margin of displacement, annual rate of exceedance of R0, R3 and R5 damage
   2.5 Utility of RBHA for forensic analyses and forecasting on future hazards

#### Workshop facilitators

**Professor Peter Kaiser**  
Emeritus Professor  
Laurentian University, Canada

**Dr Dmitriy Malovichko**  
Director and Head of Applied Seismology  
Institute of Mine Seismology

**Dr Alex Rigby**  
Senior Seismologist  
Institute of Mine Seismology

Learn more about the content and view workshop timings at [acggroundsupport.com/deformation-based-workshop](http://acggroundsupport.com/deformation-based-workshop)
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