



institute
of mine
seismology

29th Mine Seismology Seminar

05 – 07 May 2019, Mountain Shadows, Phoenix, Arizona



Sunday 05 May **Meeting of the International Research Advisory Board of the Institute of Mine Seismology**
10h00 – 17h00

Sunday 05 May Ice-Breaker hosted by the Institute of Mine Seismology
18h30

Monday 06 May **Presentations on Monitoring and Managing the Seismic Rock Mass Response to Mining**
08h45 – 18h00

Monday 06 May Dinner hosted by the Institute of Mine Seismology
19h00

Tuesday 07 May **Presentations on Numerical Modelling for Seismically Active Mines**
08h30 – 13h00

Training Courses, Mountain Shadows, Phoenix



05 May, 09h00 – 17h00 **Seismology Primer**, Dr Daryl Rebuli & Jacques Gerber

07 May, 14h00 – 18h00 **Deformation-based Support System Design for Burstprone Mines – an Update**, Prof. Peter Kaiser

For more information on registration, accommodation and social programme please contact Megan.Thompson@IMSeismology.org

Objectives of the Seminar

Considerable progress has been made in the quantification of seismic sources and in the quantification of seismicity. Most modern seismic systems and associated seismological software are capable to locate seismic events, including ray tracing, and to quantify seismic sources by seismic potency or moment and their tensors, radiated seismic energy and other derivatives. Seismicity is routinely characterised by its size and time distributions, including spatial and temporal clustering and migration, and by parameters reflecting changes in the strain and stress regime and the rheological properties of the rock mass deformation associated with the seismic radiation. Although seismic waveforms do not provide direct information about the absolute stresses and strains, they do provide useful information about stress orientation and about the spatial and temporal strain and stress changes. However, all these capabilities are not always translated into practical instruments to manage seismic hazard in mines.

We will discuss the latest progress in passive seismic monitoring, including seismic sensors capable of recording the strong ground motion. We will also review methodologies to assess the long, intermediate and short term seismic hazard, including the re-entry protocol and seismic TARP. It will include data selection, the issue of “the maximum magnitude event”, the power law size distribution and its intricacies, the GMPE - Ground Motion Prediction Equation, distribution of distances and mapping the ground motion hazard in space.

Most applications of modelling with seismic data to date are limited to qualitative correlation between location and mechanisms of events with the modelled stresses. We will report encouraging results on the quantitative correlation that makes it possible to improve numerical modelling. We will also discuss methodology of modelling the influence of hydraulic fracturing on stress redistribution.

Over the last few years we've made considerable progress in the quantification of rock mass properties and monitoring their changes in space and time. Recent advances in active seismic monitoring, seismic interferometry and ambient noise analysis achieve a resolution at least 100 times better than classical seismic velocity inversion. This is useful to monitor the real-time stress changes in 3D due to mining, as well as quantification of pillar strength and more accurate cave front tracking in block cave mines. These advances have also enabled us to directly image and monitor areas affected by mining activities where classical seismology has not been very effective, such as tailings dams, old mine workings and natural caves.

The main themes of the Seminar are:

1. Passive seismic monitoring, sensors and seismological processing.
2. Ground motion hazard: Probabilistic assessment and modelling hazard scenarios.
3. Numerical modelling for seismically active mines.
4. Modelling and analysis of the effect of hydrofracturing on stress redistribution.
5. In-Mine Seismic: In-mine exploration and rock mass characterisation using ambient noise, active and passive sources.

I'm asking all presenters to tell us: (1) why you did this work, (2) how you did it, (3) what you found, (4) what you think it means, and (5) what are the limitations.

Looking forward to see you in Phoenix in May 2019

Aleksander J. Mendecki

Chairman and Head of Research
Institute of Mine Seismology

29th Mine Seismology Seminar

Day 1: Monday 06 May, 08h45 - 18h00, Valley Room, Mountain Shadows, Phoenix
Monitoring and Managing the Seismic Rock Mass Response to Mining

08h45 | Welcome and Introduction

Dr Aleksander J. Mendecki, Chairman, Institute of Mine Seismology

09h00 | Anticipating Excavation Response before Selecting Support Systems in Burst Prone Mines

Dr Peter K Kaiser, Professor Emeritus, Laurentian University, Canada

09h30 | Identify Evolving Instability Hazards Using Measured Seismicity and Deformation

Dr David Beck, Beck Engineering, Australia

10h00 | Attenuation - Detection of Fluid Saturation

Dr Leo Eisner, Czech Academy of Sciences, Prague

————— Tea Break ————

11h00 | On Rockbursts During Underground Construction of a Complex Hydro-electric Plant in Andean Region

Dr. Giordano Russo, Geodata Engineering, Italy

11h30 | Testing Energy Index as a Proxy for Stress in Deep Narrow Vein Hard Rock Mines

Kathryn Dehn, NIOSH, Spokane, USA

12h00 | Temporary Surface Seismic Deployments for Monitoring Mining Related Seismicity

Shawn Boltz, NIOSH, Spokane, USA

12h30 | Delineation of Fault Segments Using Seismic Source Mechanisms and Location Uncertainty

Stephen Meyer, Institute of Mine Seismology, Australia

————— Lunch ————

14h00 | Microseismic Monitoring Based Cave-back Prediction and Ground Pressure Controlling in Block Caving Mine

Da Zhang, Xiaocong Yang and Rui Dai, Institute of Mining Technology, Beijing General Research Institute of Mining and Metallurgy, Beijing, China

14h25 | Calibrating and Testing of the Forecasts of Seismic Hazard for Planned Mining Sequences

Dr Dmitriy Malovichko, Institute of Mine Seismology, Australia

14h50 | Physics-based Management Tools for Re-entry Rules and Exclusion Zones

Dr Willem de Beer, ESG Solutions, Canada

15h15 Re-Entry After Blasts and/or Large Events: Fixed and Dynamical Exclusion Times and Zones

Cornel du Toit, Institute of Mine Seismology, South Africa

15h40 | An Automated Triggered Action And Response Plan (TARP) for Mine Control Rooms

Gys Basson, Institute of Mine Seismology, Australia

————— Tea Break ———

16h30 | Using Seismic Noise Interferometry to Monitor Tailings Dams, Under-ground and Open Pit Mines

Dr Gerrit Olivier, Institute of Mine Seismology, Australia

16h55 | Mineral Exploration with Passive Seismic Tomography Using a Combi-nation of In-mine and Surface Arrays

Dr Gerrit Olivier, Institute of Mine Seismology, Australia

17h20 | Seismic Monitoring of the State of a Regional Pillar at Carola Mine in Chile

Dr Frank Calixto, Institute of Mine Seismology, Australia

17h45 | From Ground Motion to Damage: What We Can and Cannot Measure and Model and What We Can and Cannot Infer

Dr Aleksander J. Mendecki, Institute of Mine Seismology

19h00 | Dinner at Mountain Shadows Lawn North hosted by the IMS

29th Mine Seismology Seminar

Day 2: Tuesday 07 May, 08h30 - 13h00, Valley Room, Mountain Shadows, Phoenix
Numerical Modelling for Seismically Active Mines

09h00 | Simulating Persistent Sub-horizontal Jointing as a Seismic Source in Nar-row Vein Mining

Dr. Matthew Pierce, Pierce Engineering, Canada

09h30 | Linking Rock Mass Character, Brittle Failure, Seismicity and Support. Steps Forward for High Stress Mines

Dr Rob Bewick, Golder Associates, Canada

10h00 | Principles of Modelling the Effect of Hydrofracturing on Stress Redistri-bution in Hard Rock

Dr Vladimir Lyakhovsky, Geological Survey of Israel

10h30 | Modelling the Effect of Hydrofracturing on Stress Redistribution in Hard Rock Mines with Material Point Method

Gys Basson, Institute of Mine Seismology, Australia

————— Tea Break ———

11h20 | Modelling Seismic Wavefield Due to Finite Sources in Complex Mining Environments

Dr Ernest Lötter, Institute of Mine Seismology, Australia

11h45 | Crusher Chamber Location Assessment

Cristian Orrego and David Tennant, Newcrest Mining, Australia

12h10 | BEM Modelling of Pillars in Shallow Mines: Fast Solutions for Large-Scale Problems

Jacques Gerber, Institute of Mine Seismology, South Africa

12h35 | Modelling of Static Source Parameters of Seismic Events in Mines

Dr Dmitriy Malovichko, Institute of Mine Seismology, Australia

Post-Seminar Course

Tuesday 07 May, 14h00 – 18.00, Valley Room, Mountain Shadows, Phoenix
Deformation-based Support System Design for Burst Prone Mines
(an Update)

Course Instructor: Prof. Peter K. Kaiser.

Dr. Peter K Kaiser, Professor Emeritus, joined Laurentian University in 1987 as Professor of Mining Engineering and Chair for Rock Engineering and Ground Control at the Bharti School of Engineering. He was the founding President of MIRARCO and later was seconded to the Centre for Excellence in Mining Innovation (CEMI) as Founding Director and then as Director of the Rio Tinto Centre for Underground Mine Construction.

Dr Kaiser is a specialist in applied research for underground mining and construction and brings extensive experience from both the industrial and academic sectors having served as consultant to numerous consulting engineers, mines, and public agencies. He is a Fellow of the Engineering Institute of Canada (EIC) and the Canadian Academy of Engineers and in 2013 was awarded the Julian C. Smith Medal of the EIC for "Achievement in the Development of Canada".

Dr Kaiser is the author of more than 300 technical and scientific geomechanics publications. In 2016, he has delivered the Muir Wood lecturer at the WTC and the MTS lecture at the 50th US Rock Mechanics Symposium.

Brief Description

As mining and civil tunnelling progresses to deeper grounds, mining-induced stresses cause rock mass failure of hard rock with static and dynamic impact on ground support. Both can lead to large bulking deformations that are imposed in a static or dynamic manner on the rock support. The course instructors have revised and significantly updated the Canadian Rockburst Support Handbook (1996) with a much greater stronger focus on strainburst assessment and related damage mitigation. This revision will be released in early 2017 as a Guide for Rockburst Support Selection and will form the background for this one-day course. During this workshop, brittle rock mass failure processes will be reviewed within a frame work of support selection for highly stressed ground. Static and dynamic failure processes will be discussed and illustrated on case examples. Deficiencies in current approaches will be discussed with the intent of pointing the way to more rational support design methods for conditions experiencing mining-induced stress change. This workshop is intended to stimulate discussion on the above-described engineering challenges. The presentations will cover limitations of standard support design by classification, aspects of deformation-based support design, limitations of ground-motion-based burst-support design, engineering challenges of strain-bursting ground, methods to control and mitigate seismic risk by use of support to mitigate damage. Reference material will be distributed to the registrants in electronic format. Specifically, Dr Kaiser will cover the following topics. (1) Elements of excavation design. (2) Geotechnical design process and quantification of variable design inputs. (3) Anticipating rock mass behaviour at depth. (4) Brittle failing ground and impact of rock mass variability. (5) Depth of failure in stress-fractured ground. (6) Bulking of stress-fractured rock. (7) Deformation-based support design. (8) Safety margins for support design and limitations of standard approaches. (9) Gabion support concept for stress-fractured ground. (10) Deformation-based support selection. (11) Unstable rock failure processes. (12) Mechanism of unstable rock failure in laboratory and in-situ. (13) Numerical simulation of unstable rock failure. (14) Strainburst assessment and strainburst damage mitigation. (15) Seismically triggered and mining-induced strainburst. (16) Dynamic support design principles for strainbursts. (17) Identification of burstprone areas. (18) Energy demand estimation. (19) Support selection. Some reference material will be distributed to the registrants in electronic format.

Pre-Seminar Course

Sunday 05 May, 09h00 – 16h00, Valley Room South, Mountain Shadows, Phoenix

Seismology Primer

Course Instructors:

Dr Daryl Rebuli and Jacques Gerber, Institute of Mine Seismology

Course Objectives. The objective of the course is to explain basic seismological concepts of seismic waves and sources to non-seismologists to facilitate better understanding of lectures, presentations and training courses offered during the Seminar.

Course Programme.

1. Objectives of seismic monitoring: rescue, prevention, hazard assessment, alerts and back analysis.
2. What is a seismic event, types of seismic waves, sources of seismic waves, acceleration, velocity and displacement of ground motion (particle velocity) vs. wave speed (propagation velocity).
3. Event locations and location errors, design principles of seismic network configuration, velocity calibration, calibration blasts and Wadati diagram.
4. Direct source parameters: origin time and location, Fourier transformation, frequency decomposition, spectra and spectral parameters, seismic potency, seismic moment, radiated energy, corner frequency and size.
5. Derived source parameters: static and dynamic stress drop, apparent stress, apparent volume, energy index.
6. Magnitude scales: local, moment or potency magnitudes, energy magnitudes.
7. Types of faults, radiation patterns and fault plane solutions, stress orientation.
8. Size distribution (Gutenberg-Richter relation), seismic hazard and risk, probabilities and hazard maps.
9. Clustering, time histories of seismic parameters, histograms, cumulative plots.

Presentation and the relevant publications will be available in electronic format.