34th Mine Seismology Seminar

26 May – 30 May 2024, Miraflores Park, A Belmond Hotel, Lima

Sunday 26 May 10h00 - 16h00	**Meeting of the International Research Advisory Board of the Institute of Mine Seismology**
Monday 27 May Copacabana Room 08h30 - 17h30	**Mine Seismology Seminar Day 1: Lectures and Presentations on the Applications of Seismic Monitoring in Mines**
Tuesday, 28 May Copacabana Room 08h30 - 17h30	**Mine Seismology Seminar Day 2: Lectures and Presentations on the Applications of Seismic Monitoring in Mines**

Courses and Tutorial

Sunday 26 May Pacifico Room 09h00 - 17h00	**Mine Seismology Primer** IMS Seismologists
Wednesday 29 May Pacifico Room 09h00 - 17h00	**Course: Ground Motion Hazard and Alerts** Dr. Aleksander J. Mendecki, Institute of Mine Seismology Dolf Bredenkamp, Institute of Mine Seismology **Tutorial: Time-lapse Changes and Healing of Earth Materials and Seismic Interferometry** Prof. Roel Snieder, Head of the Center for Wave Phenomena, Colorado School of Mines
Thursday 30 May Pacifico Room 09h00 - 17h00	**Course: Deformation Based Support Design and Rockburst Hazard Assessment** Dr. Peter K. Kaiser, President, GeoK, Inc. Dr. Dmitriy Malovichko, Institute of Mine Seismology Dr. Alex Rigby, Institute of Mine Seismology

For more information on registration, accommodation and social programme please contact frank.calixto@imsi.org

34th Mine Seismology Seminar – Day 1

Monday 27 May, 08h30 - 17h30, Miraflores Park, A Belmond Hotel, Lima

(Copacabana Room)

Welcome and Introduction: Reflexion on Current Status of Mine Seismology and Future Trends
Dr. Aleksander Mendecki, Chairman, Institute of Mine Seismology

Osinergmin, Mining and Risk-Based Control in Geomechanics
Rolando Berner Ardiles Velasco, Manager of Mining Supervision, Osinergmin, Peru

Effectiveness of Support Systems Considering Deformation-Based Support Design Principles
Dr. Peter K. Kaiser, President, GeoK, Inc., Canada

Coda Wave Interferometry with Applications to Mining
Prof. Roel Snieder, Head of the Center for Wave Phenomena, Colorado School of Mines, USA

Measured Moment Tensors and Modelled Increments of Strain
Dr. David Beck, Beck Engineering, Australia

Management of Induced Seismicity at Nexa Resources
Iván Uriol Cáceres Cuadros, General Management of Operations Development - Mining, Nexa Resources, Peru

Seismic Hazard Management at Cerro Lindo Mine
Walter Edinson Ramos Chavez, Superintendent of Geomechanics, U.M. Cerro Lindo, Nexa, Peru

Forensic Analysis of Relevant Seismic Event in El Teniente: July 24, 2023 Magnitude Mw 3.0
Carlos Rojas, Geophysicist - Seismic Unit, El Teniente - Codelco, Chile

Seismic Network and Information Analysis in El Teniente
Jacob Bustamante, Geomechanical Engineer, El Teniente - Codelco, Chile

Seismic Hazard Management in Yauliyacu Mine
Sebastián Huamancha, Superintendent of Geomechanics, U.M. Yauliyacu, Alpayana, Peru

Dynamic Support Design Using Seismic Data
Dr. Luis A. Mejía, Senior Geomechanics Consultant, RockEng, Canada

Seismic Monitoring at Catalina Huanca Mine and Transition to Caving Method
Gustavo Gruzado, Head of Geomechanics, U.M. Catalina Huanca, Trafigura, Peru

34th Mine Seismology Seminar – Day 2

Tuesday 28 May, 08h30 - 17h30, Miraflores Park, A Belmond Hotel, Lima

(Copacabana Room)

Welcome and Introduction
Dr. Daryl Rebuli, Managing Director, Institute of Mine Seismology

Analysis of the Caving Propagation Process and Surface Connection in MB N03, Chuquicamata Underground
German Ralil & Alexandra Quiroga, Chuquicamata - Codelco, Chile

Effects of Mining Induced Seismic Events and Blasts in Tailings Dams
Dr. Leonardo Santana, Technical Leader of Geotechnology , Tetra Tech Brazil

Back analysis of Caveability at a Panel Cave Mine
Miguel Fuenzalida, Principal Geomechanics Engineer, Itasca Consulting Group, Inc.

Numerical Modelling and Seismic Hazard Applied to Underground Mining Planning
Dr. Juan Andres Jarufe Troncoso, University of Santiago, Chile

Stress modelling in Rockburst Hazard Assessment
Dr. Alex Rigby, Institute of Mine Seismology

Utilization of Seismic Data in The Assessment of Displacement and Energy Demand Imposed on Ground Support by Strainbursts
Dr. Dmitriy Malovichko, Institute of Mine Seismology

Seismic Ground Motion Alerts
Dr. Aleksander Mendecki, Chairman, Institute of Mine Seismology

GMAS – Technology for a Real-time Ground Motion Alerts
Dolf Bredenkamp, Institute of Mine Seismology

Applications of DAS in Underground Mines
Gareth Goldswain, Institute of Mine Seismology

Seismic Hazard Management Plan: To What Extent Can This Hazard Be Managed?
Dr. Frank Calixto, Institute of Mine Seismology

Event Classification, Why It Matters And Implications of Getting it Wrong
Stephen Meyer, Institute of Mine Seismology

Using Seismic Ambient Noise Interferometry to Monitor Tailings Dams
Richard Gillies, Institute of Mine Seismology

Courses And Tutorial

Pre-Seminar Course - Mine Seismology Primer

Sunday 26 May, 09h00 - 17h00, Miraflores Park, A Belmond Hotel, Lima **(Pacifico Room)**

Instructors:
Dr. Frank Calixto, **Stephen Meyer**, **Andres Ambros**, **Dr. Daryl Rebuli**, Institute of Mine Seismology

1. Introduction and fundamentals of seismic monitoring in mines
2. Training in IMS Software (Trace and Vantage)
3. Maintenance of a sesmic system
4. Applications of mine seismology
5. Introduction to Rock-Burst Hazard Assessment

Ground Motion Hazard and Alerts

Wednesday 29 May, 09h00 - 13h00, Miraflores Park, A Belmond Hotel, Lima **(Pacifico Room)**

Instructors:
Dr. Aleksander J. Mendecki, **Dolf Bredenkamp**, Institute of Mine Seismology

1. Ground Motion Hazard
1.1 Ground velocity and displacements near seismic sources.
1.2 Peak Ground Velocity (PGV), Acceleration (PGA) and Displacement (PGD).
1.3 Duration of strong ground motion.
1.4 Cumulative Absolute Displacement (CAD) and Cumulative Absolute Inelastic Displacement ($CAID$).
1.5 Ground Motion Prediction Equation (GMPE) and its utility.
1.6 Seismic fragility curves and damage potential.
1.7 Ground motion hazard Assessment.

2. Ground Motion Alerts for Mines: GMAP and GMAS
2.1 GMAP is an influence based polygon-less two parameter method where one takes into account the influence of ground motion generated by all available seismic events, regardless of their location, on a particular working place. It is based on the rates of cumulative absolute inelastic deformation, $CAID$, and on its activity, $ACAID$.
2.2 GMAS is an influence based polygon-less two parameter real time system where $CAID$ and its activity $ACAID$ are automatically derived by the GMAS hardware unit from the recorded continuous data stream of ground motion.
2.3 Ground motion based fixed exclusion rules after blasting and after larger seismic events.

———- Lunch ———-

Time-lapse Changes & Healing of Earth Materiales

Interferometry

Wednesday 29 May, 14h00 - 17h00, Miraflores Park, A Belmond Hotel, Lima **(Pacifico Room)**

Instructors:
Prof. Roel Snieder, Head of the Center for Wave Phenomena, Colorado School of Mines, USA

1. Time-lapse Changes and Healing of Earth Materials
2. Seismic Interferometry

Deformation Based Support Design and Rockburst Hazard Assessment

Thursday 30 May, 09h00 - 17h00, Miraflores Park, A Belmond Hotel, Lima **(Pacifico Room)**

Instructors:
Dr. Peter K. Kaiser, President, GeoK, Inc.
Dr. Dmitriy Malovichko, Institute of Mine Seismology
Dr. Alex Rigby, Institute of Mine Seismology

Overview
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. Because gradual and sudden stress fracturing not only loads the support, but also deforms it, part of its load and energy-dissipation capacity is gradually consumed, leaving less and less remnant capacity at the time when the support is needed, i.e., during a rockburst. If the support capacity can be consumed by deformation, it can also be restored by preventive support maintenance (PSM).
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.

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