

Short Course Minexcellence

(Courses are free of charge for registered participants)

Course 1. Friday, November 26

Program Short Course 1

Economía Circular en Minería: Procesos minero-metalúrgicos sin la generación de residuos y efluentes tóxicos para el medio ambiente

Cuando	26 de noviembre. 09:00 AM a 1:00 PM (zona horaria Santiago, Chile)
Instructor	Dr. Ing. Gerardo Zamora Echenique , Profesor Titular Carrera de Ingeniería Metalúrgica, Universidad Técnica de Oruro, Bolivia
Duración	4 horas

1. FUNDAMENTACIÓN TÉCNICA

La producción minero-metalúrgica, en el marco de la economía circular, deberá desarrollar sus procesos extractivos no sólo atenuando los efectos de impacto negativo al medio ambiente que generan cada una de las operaciones unitarias involucradas; sino que también, creando soluciones innovadoras que permitan disminuir los consumos de agua y energía; pero además, tratando que los residuos generados puedan ser objeto de reprocesamiento o reutilización en el cierre ambiental de los sitios de almacenamiento de residuos generadores de drenajes ácidos de roca; permitiendo así, un claro beneficio económico, social y ambiental para la industria minera.

El curso pretende introducir a los participantes a las bases técnicas para la implementación de la economía circular en el procesamiento minero-metalúrgico a objeto de que esta actividad extractiva se desarrolle sin la generación de residuos y efluentes tóxicos para el medio ambiente.

Los conocimientos adquiridos en el curso permitirán a los participantes alcanzar los siguientes resultados de aprendizaje:

- Conocimiento de los efectos económicos, ambientales y sociales de la industria minero-metalúrgica desarrollada linealmente en los ámbitos mundial e iberoamericano.
- Identificación, clasificación y valoración de desechos y residuos minero-metalúrgicos (Un nuevo filón minero a explotar).
- Desarrollo de las bases técnicas para la implementación de la ECONOMÍA CIRCULAR en el procesamiento minero-metalúrgico en operaciones mineras.
- Análisis y evaluación de las posibles alternativas tecnológicas para el desarrollo de nuevas acciones conducentes a una economía circular en minería.

2. PARTICIPANTES

El curso es recomendado para técnicos, profesionales tanto de operación como ejecutivos y de nivel gerencial, vinculados al área de las ciencias de la tierra (mineros, metalurgistas, geólogos y de otras disciplinas afines al ámbito de operaciones mineras).

3. OBJETIVOS GENERALES Y ESPECÍFICOS

3.1 Objetivo general

El objetivo general del curso se circunscribe en desarrollar los conocimientos y habilidades para que los participantes puedan analizar, evaluar, diseñar conceptualmente y proponer alternativas de reconversión de desarrollos lineales a circulares en el procesamiento minero-metalúrgico a objeto de desarrollar procesos sin la generación de residuos y efluentes tóxicos para el medio ambiente.

3.2 Objetivos específicos

Los objetivos específicos del curso permitirán a los participantes:

- Analizar, evaluar y cuantificar los efectos ambientales, sociales y económicos de la aplicación de la economía lineal en el ámbito de plantas de procesamiento minero-metalúrgico.
- Desarrollar criterios de valoración para concebir alternativas tecnológicas que permitan la reconversión de procesos minero-metalúrgicos lineales en circulares, valorizando los residuos y/o los productos de deshecho.
- Analizar y evaluar propuestas de implementación de la economía circular en el procesamiento minero-metalúrgico desde el punto de vista técnico, económico, ambiental y social.

4. METODOLOGÍA

El curso se llevará a cabo bajo la modalidad virtual. La metodología de abordaje de las temáticas será basada **Totalmente en Estudios de Casos Prácticos.**

La actividad está dividida en dos partes, cada una de ellos incluirá una primera parte de exposición sobre la temática en estudio y posteriormente habrá una ronda de preguntas, discusión y reflexión por parte de los participantes.

El proceso de Enseñanza-Aprendizaje se desarrollará mediante presentación de diapositivas que serán proporcionadas a todos los participantes.

5. PROGRAMA Y CONTENIDOS

PARTE I: EFECTOS AMBIENTALES, SOCIALES Y ECONÓMICOS DE LA APLICACIÓN DE LA ECONOMÍA LINEAL EN EL ÁMBITO DE PLANTAS DE PROCESAMIENTO MINERO-METALÚRGICO MUNDIAL E IBEROAMERICANO (2 horas)

Estudios de Caso:

- Contaminación por metales pesados en Sudbury/Canadá.
- Pasivos ambientales mineros y su impacto ambiental en España.
- Efectos de impacto ambiental en Aznacollar (España)
- Cierre ambiental de sitios de almacenamiento de residuos mineros (Perú).
- Cierre ambiental Kori – Kollo en Bolivia
- Gestión de aguas en cierre de la faena WISBUT (Alemania)
- Valoración del patrimonio Geo/Minero (España)
- Valoración del patrimonio Geo/Minero (Brasil)

PARTE II: BASES TÉCNICAS PARA LA IMPLEMENTACIÓN DE LA ECONOMÍA CIRCULAR EN EL PROCESAMIENTO MINERO-METALÚRGICO, VALORIZANDO LOS RESIDUOS Y/O LOS PRODUCTOS DE DESHECHO. (2 HORAS)

Estudios de Caso:

- Tratamiento de aguas ácidas de mina para su potabilización (La Paz – Bolivia)
- Tratamiento de aguas ácidas en interior mina para su posterior re uso en el procesamiento mineral (Japo – Bolivia)
- Remediar ganando. Caso Huanuni- Bolivia.
- Eliminación de Hg en procesamiento de sedimentos auríferos en la cuenca del amazonas (Sudamérica)
- Aplicación de la economía circular con el re uso de relaves previa desulfurización, en la etapa de cierre de sitios de almacenamiento de residuos generadores de DAR.
- Tratamiento de aguas residuales de operaciones minero-metalúrgicas para su uso en agricultura (Alemania).

A continuación se presenta un esquema tentativo que se podría considerar para definir el programa horario del curso.

HORARIO	DESCRIPCIÓN	RELATOR
8:45 – 9:00	BIENVENIDA AL CURSO	ORGANIZADORES
9:00 – 10:30	PARTE I: Efectos ambientales, sociales y económicos de la aplicación de la economía lineal en el ámbito de plantas de procesamiento minero-metalúrgico mundial e iberoamericano.	Dr.- Ing. Gerardo Zamora E.
10:30 -11:00	Preguntas y discusión	
11:00 – 12:30	Bases técnicas para la implementación de la economía circular en el procesamiento minero-metalúrgico.	Dr.- Ing. Gerardo Zamora E.
12:30 – 13:00	Preguntas y discusión	

6. CAPSULA BIOGRAFICA DEL INSTRUCTOR



Dr. Ing. Gerardo Zamora Echenique es Licenciado en Ingeniería Metalúrgica en la Universidad Técnica de Oruro, Bolivia. Tiene un Diplomado y Doctorado en la Universidad RWTH Aachen, Alemania. 30 años de Profesor Universitario en el Área de Hidrometalurgia y Electrometalurgia y 26 años en la del Medio Ambiente Minero en la Universidad Técnica de Oruro. <https://orcid.org/0000-0002-0245-4044>.

Profesor en Programas de Doctorado y Maestría en Metalurgia y Medio Ambiente Minero en varias Universidades de Perú; Ecuador; Chile; Brasil; Colombia y Bolivia. Profesor invitado en las universidad de Freiberg y TU – Berlin, Alemania. Tiene más de 30 artículos científicos publicados en revistas científicas internacionales indexadas. Es autor y coautor de 5 libros. Director de varios Programas de Postgrado nacionales e internacionales.

Reconocimientos

Ganador del Primer Premio en Investigación Científica y Tecnológica del Sistema Nacional de Universidades Bolivianas - Buenas Ideas 2016.

Ganador del Primer Premio en Investigación Científica y Tecnológica de la Universidad Técnica de Oruro en las gestiones 2016, 2017, 2018, 2019 y 2020.

Ganador del Premio al Mérito Científico de Universidad Técnica de Oruro (2019).

Ganador del Primer Premio Nacional en Investigación Científica y Tecnológica – Área Minería (2020).

Course 2. Tuesday, November 30

**Program Short Course 2
 Post-Graduate Industrial Mining Courses**

When	November 30 from 08:45 AM to 1 PM (Chilean Time)
Instructors	Amilton Sinatora, Vidal Navarro Torres, Iranildes Santos, Gustavo Pessin, Jose Jimmy Penagos and Markus Gastauer , Vale Institute of Technology, Brazil
Length	4 hours

Description: These are postgraduate courses aimed at training human resources in mine operations, mineral processing and automation, as well as sustainability in the mining industry.

CONTENT AND PROGRAMME

08:50 - 09:00	Welcome and Introduction to the Course	Amilton Sinatora (10')
09:00 - 09:50	Module 1: Specialization in Open Pit Mining, Geotechnics and Mineral Processing (Spanish & English)	Vidal Navarro Torres (40') Iranildes Santos (10')
09:50 - 10:00	Questions and discussion Module 1	
10:00 - 10:20	Break 1	
10:20 - 11:10	Module 2: Master & Specialization in Instrumentation, Information, Automation, Data Science of Mining (English)	Gustavo Pessin (50')
11:10 - 11:20	Questions and discussion Module 2	
11:20 - 11:40	Break 2	
11:40 - 12:30	Module 3: Tribology of Mining. Sustainable Use of Natural Resources in Tropical Regions (Spanish & English)	Jose Jimmy Penagos (10') Markus Gastauer (40')
12:30 - 12:40	Questions and discussion Module 3	
12:40 - 13:00	Conclusions and Closure of the Course	Vidal Navarro Torres (15') Amilton Sinatora (10')

TECHNICAL BACKGROUND

Instituto Tecnológico Vale, since 2013, has been implementing master's degrees, specializations and short-term courses aimed at the VALE's Company staff, with the participation of external staff in many programs. The general objective is to train the human resource at the Vale Company to contribute to achieving excellence in mining, for high productivity and low costs, with environmental protection and social responsibility.

GENERAL OBJECTIVES: Let know Vale (ITV) experiences in the pot-graduate mining industry courses.

- Objective 1: Share experiences on specialization in Open Pit Mining, Geotechnics and Mineral Processing
- Objective 2: Share experiences on master and specialization in Instrumentation, Control, Automation and Data Science of Mining
- Objective 3: Share experiences on Sustainable Use of Natural Resources in Tropical Regions

LECTURER(S) BIO



Vidal Félix Navarro Torres

2004: PhD in Mining Engineering at Technical University of Lisbon. 2004 – 2009: Two Post-Doctoral researches in Geomechanics and mining sustainability. 2018: Title of Full Professor in Mining at University of Sao Paulo. 1981-actual: Professional experience in underground and surface mining and tunnels in Peru, Brazil, Portugal and Mozambique. 2010-2013: Coordinator of Ibero-American research project Environmental Mining Sustainability and European research project Underground Coal Gasification & CO₂ Storage UCG&CO₂ STORAGE. 1985-ctual: Professor on Peruvian, Portuguese, Brazilian and Mozambique Universities. Author and editor of 10 books, 28 scientific papers, 80 congress papers, 55 consultancy works in geotechnics and mining. 2015-actual: Manager and Senior Researcher at VALE Technological Institute.



Iraniles Santos

Master (2005) in iron ore flotation and Ph.D. (2009) in Electrochemistry and effluent treatment, both from COPPE/UFRJ. Post-doctorate (2009-2011) in the area of bio flotation at PUC-Rio. Since 2013 I work as a researcher at Vale Technological Institute (ITV) in hydrometallurgy, flotation, pyrometallurgy, and electrochemistry. At ITV, I work as a collaborating professor of the Masters in Instrumentation, Control, and Automation of Mining Processes in partnership with the Federal University of Ouro Preto and supervise postgraduate students at ITV and Federal University of Rio de Janeiro.



Gustavo Pessin

PhD in Computer Science and Computational Mathematics from the University of São Paulo (ICMC-USP) with a sandwich period at Heriot-Watt University, Edinburgh, UK and post-doctorate in 2015 at the Massachusetts Institute of Technology (MIT). Between 2013 and 2017, he was a researcher at the Applied Computing Group at the Vale Technological Institute (ITV-DS). He is currently a researcher in the Robotics and Automation Group at the Vale Technological Institute (ITV-MI) and a member of the Graduate Program in Instrumentation, Control and Automation of Mining Processes (EM-UFOP/ITV). In addition, he is a Collaborating Professor of the Postgraduate Program in Computer Science (PPG-CC) at the Federal University of Pará (UFPA) and Federal University of Ouro Preto (UFOP).



Jose Jimmy Penagos

BSc in Mechanical Engineer and Master in Solid Mechanics (Universidad del Valle, Colombia - 2011). Ph.D. in Mechanical Engineering, in the Design and Manufacturing area, from the University of São Paulo (2016). R&D experience, especially in the abrasive wear phenomena and development of new wear-resistant alloys, participating in projects focused on the mining sector. Currently works as a researcher at the Technological Institute Mining Vale (ITV-MI) in the line of research in tribology, acting on projects related to the study of wear-resistant materials used in the mining operations, such as transfer chute linings, crushers, mill liners & grinding balls, belt conveyors, idlers, among others.



Markus Gastauer

Currently, I am a researcher at the Instituto Tecnológico Vale - Desenvolvimento Sustentável (ITV-DS). I hold a postdoctoral degree in Ecology (Department of General Biology, Federal University of Viçosa, UFV, 2012-2016), PhD in Botany (Federal University of Viçosa, 2012), Master in Entomology and graduate degree in Agronomy (2005) at the University of Bonn. My research interests are mineland rehabilitation, forest and further ecosystem restoration, environmental monitoring, community ecology, soil-plant interactions, plant-pollinator interactions, forest succession and dynamics. I have more than 70 papers published in international scientific journals and supervise postgraduate students at the ITV-DS, Federal University of the Pará state (UFPA) and Federal University of Viçosa (UFV).

Course 3. Tuesday, November 30

**Program Short Course 3
 Technological Opportunities for Decision Making in Energy, Water and Emissions Management**

When	November 30 from 5:00 PM to 7:00 PM (Chilean Time)
Instructors	Marcin Ziemski, Mehdi Azadi, Liliana Pagliero, Mohsen Yahyaei and Douglas Aitken, Sustainable Minerals Institute International Centre of Excellence Chile (SMI-ICE-Chile), The University of Queensland, Australia
Length	2 hours

Description: The mining industry is responding to global challenges, such as climate change and water scarcity, by setting ambitious targets to reduce energy and water use and decarbonise the mineral supply system. To successfully achieve these targets, good decision making is imperative which must be supported by accurate data and analysis. In this workshop, researchers from the Sustainable Minerals Institute will present new tools and methods that are being developed within the Institute to support the industry in its decision making in energy, water and emissions management. In the breakout rooms for each topic the participants will have the opportunity to try the tools and discuss their development and implementation with the SMI researchers.

CONTENT AND PROGRAMME

17:00-17:10	Welcome and Introduction to the Course	Dr Doug Aitken
17:10-17:30	The context: energy, water and emissions in mining and the work of SMI	SMI-ICE-Chile/Dr Mohsen Yahyaei
17:30-17:40	Energy Curves	Dr Marcin Ziemski
17:40-17:50	Optimized Water Supply Planning Tool	Dr Liliana Pagliero
17:50-18:00	GHG Emissions Management Tool	Dr Mehdi Azadi
18:00-18:45	Breakout Room 1: Energy	Dr Marcin Ziemski
18:00-18:45	Breakout Room 2: Water	Dr Liliana Pagliero
18:00-18:45	Breakout Room 3: Emissions	Dr Mehdi Azadi
18:45-19:00	Conclusions and closing	Dr Doug Aitken

TECHNICAL BACKGROUND

Energy Curves

The Comminution Energy Curves are a resource developed at the SMI-JKMRC and made available to the mining industry to compare and benchmark comminution energy intensity at mine sites. The suite energy curves includes techniques to enable valid comparison of energy intensity in comminution circuits across different ore hardness, plant configurations, commodities, energy costs, grinding media profiles, peripheral equipment and more. Energy curves will be introduced, along with case studies of how they have been applied in industrial analyses to benchmark energy comminution energy intensity performance. Moves to expand the energy curves to the whole mine value chain as well as to transform them into emissions curves will be presented. See <https://smi.uq.edu.au/smi-projects/energy-curve>.

Greenhouse Gas Emissions Tool

The Greenhouse Gas Emissions Management Tool is designed to support the mining industry in improving its carbon footprint and energy consumption strategy and enabling decarbonisation in the industry. The tool uses a system thinking approach to identify the inherent dependency of the variables affecting the carbon emissions in mining operations and maps the greenhouse gas emissions within the operations. Furthermore, decarbonisation using emission mitigation pathways, based on our recent study published in [Nature Geoscience](#), is implemented in the model. The tool allows users to simulate emission mitigation scenarios and reduction targets and their effects on the entire production chain.

Smart Water Supply Systems Tool

The Sustainable Minerals Institute is collaborating with M.C. Inversiones (a subsidiary of the Mitsubishi Corporation) to develop smart water supply system planning tools aimed at identifying optimal water supply solutions based on integrating and sharing water sources and infrastructure in arid zones. The team are developing two tools: A comprehensive GIS-based tool aimed at water management specialists to identify and analyse water supply solutions that are sustainable and cost-efficient and a publicly available interactive

online tool aimed at non-expert stakeholders to generate dialogue between stakeholders and exploration of interconnected water supply options.

GENERAL OBJECTIVES

- To present current research on the development of tools designed to support the industry in their decision-making regarding energy, water and emissions management
- To allow participants to try the tools, ask questions and participate in a discuss regarding their development and implementation

LECTURERS BIOS



Dr Marcin Ziemski, Associate Professor, SMI-UQ

He has a broad background in technology, software, energy, process integration and minerals processing. He has lectured at UQ's department of Mining and Minerals Process Engineering, spent time at JKTech as a mine optimisation specialist, worked in energy trading and industrial energy management across the UK and Europe, and lead research in a variety of energy and emissions projects. This background, combine with his experience in leading manufacturing and 3D technologies at Dassault Systemes, has provided Marcin with expertise in mine-value chain analysis and optimisation, energy management in mining and technology evolution as it applies to the minerals industry. He re-joined JKMRC as Group Leader and formed Mine Energy

Transformation and Integration (METI) team. In 2020 Marcin was appointed to Program Leader for the newly structured Mine Energy Transformation and Integration group.



Dr Mehdi Azadi, Research Fellow, SMI-UQ

After completing his Bachelor and Master's degree in Chemical Engineering, Mehdi obtained his PhD in Chemical Engineering, at The University of Queensland to which he held one of Australia's most prestigious scholarship for research higher degree (IPRS). With an extensive knowledge base and broad skill set, he has forged a successful career that includes mining waste management, mineral processing, surface chemistry, particle technology, process engineering, separation technologies, and project management, all of which were developed and strengthened in the Academic, Resource, Mining, and Oil & Gas sectors.

As a highly competent research scientist and engineer in a multidisciplinary area, his work contributes to various industries by improving traditional methods and achieving higher quality products and a cleaner environment.



Dr Liliana Pagliero, Post-doctoral Research Fellow, SMI-UQ

During her career, Liliana has worked in government institutions, in Chile and in the European Commission, with the role of implementing and executing hydrological models as a support tool for the management of water resources and the formulation of policies at the basin up to scale continental scale. She has worked at Universities in Chile, Belgium and Australia; investigating the different hydrological processes and their interactions, including snow processes, flooding, agriculture and irrigation, erosion, water quality and climate change.

After joining SMI, Liliana has worked on a number of water-related projects in the mining industry from local to regional perspectives always in the context of the catchment and region they are located. Her work has evolved from considering only

technical aspects for water management to a more holistic approach that includes environmental, legal and social aspects through her participation in multidisciplinary projects.



Dr Mohsen Yahyaei, Associate Professor, SMI-UQ

Mohsen did his undergraduate study in Mine Exploration. In 2002 he completed his Master's degree in Mineral Processing and worked on the application of column flotation in Sarcheshmeh Copper Complex (Largest copper mine in the Middle East) as his Master's thesis. After the Master's degree, he worked with the R&D centre of Zarand coal washing plant in Iran for two years. Mohsen then moved to an operational role as plant manager of a Coal washing plant in Zarand. In 2007 he returned to University of Kerman to do his PhD, investigating the effect of liner wear in charge motion and power draw of SAG mills. He completed his PhD in 2010 and after working in several industry-funded projects in Iran, he joined JKMRC in 2011.

Mohsen has extensive experience in conducting applied research and over the past 15 years he has successfully delivered number of industry-funded projects. Mohsen is comminution specialist who has a strong desire to implement fundamental understandings in his research for offering solutions to minerals industry and also educate engineers and researchers with problem solving skills for tackling future challenges of resource industry.



Dr Douglas Aitken, Research Leader, SMI-ICE-Chile

Doug is a Civil and Environmental Engineer with a Ph.D from The University of Edinburgh, United Kingdom. His areas of specialisation include sustainable bioenergy pathways, life cycle analysis, water resource management, risk and opportunity analysis, and strategy development. He has gained academic experience through his doctoral work in the design and analysis of sustainable bioenergy systems, and post-doctoral research on the sustainability and economics of water management in the mining industry resulting in various publications in high-ranking journals. His professional experience has been in the development and management of interdisciplinary and collaborative industrial research projects that deliver solutions

encompassing the principles of long-term sustainability.

He is currently the Research Leader at SMI-ICE-Chile, developing and leading research projects focussed on improving the mining industry.