2017 SMI HIGHER DEGREE BY RESEARCH CONFERENCE

3 NOVEMBER

INNOVATION AND SUSTAINABILITY IN THE RESOURCE ENVIRONMENT

HDR CONFERENCE SMI 2017

JKTech SMI Technology Transfer

Ausenco

UQ-CCSG Centre for Coal Seam Gas

AusIMM THE MINERALS INSTITUTE

The University Of Queensland AUSTRALIA

SMI Sustainable Minerals Institute

2017 SMI HIGHER DEGREE BY RESEARCH CONFERENCE

PROGRAM & PRESENTER ABSTRACTS

CONFERENCE OVERVIEW

9:30	Registration
10:00	Morning tea during poster perusal
10:30	Conference opening *Professor Neville Plint, Director of the Sustainable Minerals Institute*
10:45	3 minute thesis pitch presentations
12:00	Lunch
12:45	Nominated SMI student thesis presentations
14:15	Afternoon tea
14:45	Panel discussion: *How can researchers and industry work together better to improve innovative and sustainable practices in the environmental, social, safety and production aspects of the resource sector?*
15:45	Science fair of multi-format presentations *Posters, multimedia and physical model displays*
16:45	Presentation of prizes
17:00	Canapes & drinks

3 MINUTE THESIS PITCH

	Presentation Title	Presenter	School / Institute
10:48	The development of a novel method to predict breakage characteristics of core images	Anh Nguyen	SMI, JKMRC
10:52	Silica fouling in coal seam gas water reverse osmosis treatment	Chris Turner	Chem Eng
10:56	Developing a high voltage pulse testing facility for ore pre-concentration	Daniel Lay	SMI, JKMRC
11:00	Co-exploration of natural gas, shale gas, coalbed methane and tight gas in coal bearing strata in east Qinshui Basin: The geological characteristics, reservoir characteristics and gas-bearing system	Difei Zhao	China University of Mining and Technology
11:04	Learning from incidents through improved investigations	Eric Stemn	SMI, MISHC
11:08	Understanding the breakage behaviour of rocks in the context of weathering	Farhad Faramarzi	SMI, JKMRC
11:12	Regional groundwater recharge estimation in the Surat Basin	Gemma Bloomfield	SMI, CWiMI
11:16	Modelling turbulence in a conventional flotation cell - coarse chalcopyrite flotation	Germán Figueroa	SMI, JKMRC
11:20	A review of recent advances in simulation of gas hydrate formation deposition in the CCS pipelines	Hossein Dashti	UQ Energy Initiative

11:24	Reservoir storage capacity modification due to long-term CO2-rock chemical interactions: A rock mechanics prospective	Ifti Altaf	Chem Eng
11:28	Understanding sustainability performance in natural resource supply chains: An assessment 'from mine to car'	Jean-Pierre Imbro-giano	SMI, CSRM
11:32	Modification and processing of starches for increased productivity in mineral flotation	Lee Burns	Chem Eng
11:36	Economic growth, industrial development, consumption upgrade and evolution of high-tech urban mines in China: 2015-2050	Lyushui Zuo	SMI, CMLR
11:40	Rheology study of Lihir grinding circuits	Peter Legge	SMI, JKMRC
11:44	Mining without digging: The curious case of phytomining on sub-economic ore-bodies in tropical regions	Philip Nti Nkrumah	SMI, CMLR
11:48	Development of modified starch depressants to selectively reject carbonaceous minerals in the flotation of copper sulfide ores	Wonder Chimonyo	Chem Eng
11:52	Development of a method for quantitative estimation of CO2 leakage through abandoned wells	Younas Yousafi	Chem Eng
11:56	Digital twins of materials handling and dry comminution circuits	Ziming Ye	SMI, JKMRC

NOMINATED SMI STUDENTS

	Presentation Title	Presenter	School / Institute
12:45	Good work design: Strategies to embed human-centred design in organisations	Sara Pazell	SMI, MISHC
13:00	Linking comminution with recovery potential	Juan Jose Frausto Gonzalez	SMI, JKMRC
13:15	Natural caving systems as potential analogues to mining induced caving	Matthias Klawitter	SMI, BRC
13:30	In situ immobilization of heavy metals and passivation of sulfide minerals in lead-zinc tailings using phosphate	Felipe Saavedra-Mella	SMI, CMLR
13:45	Defining critical risks to the long-term viability of alternative water schemes	Camilla West	AWMC, and SMI, CWiMI
14:00	Satellite based vegetation indices and ground surveys to assess rehabilitation sustainability following fire	Phill McKenna	SMI, CMLR

PANEL DISCUSSION

Today's panel discussion focus question is:

How can researchers and industry work together better to improve innovative and sustainable practices in the environmental, social, safety and production aspects of the resource sector?

Panel Members:

Thu Nguyen, *JKTech*
Greg Lane, *Ausenco*
Andrew Garnett, *CCSG*
Diana Drinkwater, *Mineralis*
Alice Clark, *SMI*

Please write your questions for the panel down and place them in the box at the fron of the lecture theatre before the start of afternoon tea.

MULTI-FORMAT PRESENTATIONS

Presentation Title	Presenter	School / Institute
Microstructural and geomicrobial community characteristics of naturally formed hardpan at sulphidic mine tailings	Allen Liu	SMI, CMLR
How to see a mine: Contemplating a situated knowledges approach within post-mine planning	Amelia Hine	SMI, CMLR
Screening of nanoparticles for clay swelling inhibition in coal seam gas reserviors	Archana Patel	Chem Eng
Mine waste or future resource? Integrating industrial ecology thinking into a mine project	Eleonore Lebre	SMI, CMLR
Influence of muscovite in the flotation of pyrite and arsenopyrite	Erica Avelar	SMI, JKMRC
Hydro-economic modelling in mining catchments	Juan Ossa-Moreno	SMI, CWiMI
Effect of Alternative road salts on soil leachate quality	Karan Jain	The Pennsylvania State University
A study of participant experience in the community engagement processes for proposed coal mining developments in the Galilee Basin	Katie Meissner	UQ Business School

NMO correction in anisotropic and laterally heterogeneous media using simultaneous velocity variation with offset	Mohamed Salah Sedek AbdelHamed	SEES
Linking comminution properties of rocks with its textural characteristics at microscale	Pia Lois	SMI, JKMRC
The use of post-blast surface to predict internal blast movement	Raphael Picorelli	SMI, JKMRC
Hyperaccumulator discoveries through XRF scanning in New Caledonia	Vidiro Gei	SMI, CMLR
Ore pre-concentration using high voltage pulses	Wei Huang	SMI, JKMRC

ABSTRACTS: 3 MINUTE THESIS PITCH

The development of a novel method to predict breakage characteristics of core images

Anh Nguyen, SMI JKMRC

The technical and economic risks related to the uncertainties in geological variability and mineral extractability can only be reduced by increasing the geometallurgical understanding of the orebody nature. The geological and processing knowledge of the orebody can be defined by the physical cores and the library of core data. With the recent advancement in core imaging systems, a large volume of high-resolution core images can now be rapidly collected. In this thesis, the development of a novel method for rapid prediction of specific breakage parameters from core scan images is presented. The method aims to allow for a rapid and systematic assessment of the variability in breakage characteristics of a deposit with a reduced amount of physical destructive testwork.

Silica fouling in coal seam gas water reverse osmosis treatment

Christopher Turner, Chemical Engineering

Silica fouling during the reverse osmosis (RO) treatment of coal seam gas produced water presents a continuing challenge. The Australian CSG industry is currently projecting a peak water production of around 180 GL/year in Queensland alone, a significant portion of which is treated by reverse osmosis. Fouling of RO membranes by silica has a substantial impact on the performance of the water treatment processes and there is no alternative but to use a strong cleaning solution of either ammonium bifluoride or even hydrofluoric acid which run the risk of damaging the membrane. While there is already significant literature and industry knowledge of silica management in operating RO process, improved understanding of the underlying mechanisms that contribute to silica fouling and how they relate to silica management will reduce operating costs, improve reliability and improve utilisation of RO processes.

Existing studies have looked at aspects including colloidal silica solubility, silica polymerisation mechanisms, cleaning methods, and the impact of ions. However, a phenomenon mentioned in the

literature since the 1980s, the formation of a particularly problematic cement-like fouling layer, as opposed to the commonly observed particulate fouling, has not been investigated. From the current literature it is unclear whether this layer comes about from direct silica polymerisation on the membrane surface or by rearrangement of the conventional particulates based fouling layer, as proposed in Iler, 1979. Improved understanding of the nature of silica fouling and the correlation with reduced RO performance will allow identification of the best methods to mitigate these effects.

Developing a high voltage pulse testing facility for ore pre-concentration

Daniel Lay, SMI JKMRC

A novel ore pre-concentration method has been reported in previous PhD projects at the JKMRC. This method uses high voltage pulses to induce selective breakage in metallic ores, enabling size based separation of the fragmentation products into low and high grade streams. Previous work has been undertaken with a batch-operating laboratory machine installed at the JKMRC. For the mining and minerals industry to fully realise the benefits offered, this project aims to develop a proof-of-concept, continuously operating, high voltage pulse testing facility that incorporates this size based separation. Several ores will be tested to validate and further improve the design.

Co-exploration of natural gas, shale gas, coalbed methane and tight gas in coal bearing strata in east Qinshui Basin - The geological characteristics, reservoir characteristics and gas-bearing system

Difei Zhao, School of Resources and Earth Science, China University of Mining and Technology

It is a huge waste of resources if only coal or coal-bed methane is regarded as the target of exploration in coal bearing strata. Transitional upper Carboniferous Shanxi formation coal bearing strata in east Qinshui Basin is a mixed reservoir of coal-mud-sand structure

system with coal, organic-rich mudstone or shale, sandstone or tight sandstone, limestone interbedded deposit forming a comprehensive gas bearing system with several kinds of unconventional gasses jointly preserve. Multi-unconventional gases including coalbed methane(CBM), shale gas and tight gas are storaged in this transitional coal bearing strata, respectively. To study the geological characteristics, reservoir characteristics and gas-bearing system of Shanxi formation, we analyzed the sedimentary environment, mineral compositions, organic matter characteristics and pore development characteristics of different reservoirs. The results show that different gas-bearing systems exist in strata controlled by sedimentary environment and reservoir diagenesis with well-developed mudstone or shale as the separating layer. The micro reservoir space in mudstone or shale is generally developed in nano-scale resulting to the low porosity and permeability while coal, tight sandstone and limestone have larger pore size distribution and better permeability. Controlled by the geological characteristics, reservoir characteristics and gas-bearing system, different reservoirs have different pressure coefficients and thus a speculation was made that during the co-exploration the gas-bearing systems with higher pressure may reduce the production of low pressure gas- bearing systems.

Learning from incidents through improved investigations

Eric Stemn, SMI MISHC

Although there is generally a downward trend in the severity of accidents in the extractive industry, incident rate continues to be high and unacceptable. For instance, according to the International Labour Organisation, while mining employs around 1% of the global labour force; it accounts for 8% of the global work-related fatalities. The continuing prevalence of high workplace accidents suggests that the industry has failed to learn from its past events. Many scholarly works exist that discuss why failure to learn from accidents and incidents occurs even when investigations are conducted. However most of this research is conceptual or theoretical in nature with only a few studies are empirically based. Evaluating current incident investigation processes and practices is necessary to identify how to improve learning opportunities from incidents. This research begins

to address this gap by evaluating how investigations are carried out in the Ghanaian mining industry. The research adopts a case study methodology which involves conducted interviews, focus group discussions, document analyses and field observations. By adopting these methods, it is possible to capture the views and experiences of all relevant stakeholders. Preliminary results indicate that, within the industry, different conceptual views about the accident phenomenon, assumptions about how accidents occur, how they can be prevented and what constitutes a satisfactory investigation exist. These subsequently affect the quality of learning. These findings suggest that certain aspects of current investigation processes and practices require redesign initiatives in order to improve the learnings obtained from investigations.

Understanding the breakage behaviour of rocks in the context of weathering

Farhad Faramarzi, SMI JKMRC

My PhD thesis is centred on the development of new techniques for ore breakage characterisation and analysis to provide a more detailed picture of ore breakage variability.

Ore breakage testing data and its interpretation are key points in any plant design procedure. Hence, pitfalls inherent with average-based testing methods should be accounted in process design and be quantified to ensure the impact of ore-induced variance in process performance is handled. The most common methods of characterising ore fail to capture breakage variability. A novel single-particle impact breakage testing approach using JK drop weight tester has been developed at JKMRC, in which the actual comminution energy and breakage intensities are measured per particle. Results from the experiments carried out on four different ore types support the idea to extend the t10-ECS model developed by JKMRC to a comminution envelope, which further contains inherent variability in breakage characteristics of an ore.

Regional groundwater recharge estimation in the Surat Basin

Gemma Bloomfield, SMI CWiMI

Groundwater is a crucial resource used for many purposes including agriculture, resources extraction, and the public water supply. However, because of its very nature, it is difficult to study and is often poorly understood. In particular, groundwater recharge (the amount of rainfall that reaches the water table) is challenging to quantify as it cannot be directly measured. Consequently, it is inferred approximately from rainfall and other observable phenomena. This project aims to improve regional-scale groundwater recharge estimates by adapting existing tools to be applicable in geologically heterogeneous environments, using the Surat Basin as a case study.

The purpose of this project is to critically examine two common methods for estimating groundwater recharge in Australia; namely, the Chloride Mass Balance (CMB) method and near-surface water balance models, here represented by the Australian Water Resources Assessment modelling system (AWRAMS). The CMB method is the most common approach for estimating long-term recharge, and the AWRAMS represents the 'state of the art' in near-surface water balance modelling. The research will comprise three components: 1) conducting an uncertainty analysis on the CMB method using the model employed by the Queensland Government's Office of Groundwater Impact Assessment as a baseline; 2) baseline analysis, sensitivity analysis, calibration, and validation of the surface water hydrology model component of the AWRAMS, AWRA-L; and 3) exploring the usefulness of merging the CMB method with the AWRA-L model. It is hypothesised that the resulting integrated approach will produce more realistic recharge estimates than either of the methods when used individually.

Modelling turbulence in a conventional flotation cell – coarse chalcopyrite floatability

Germán Figueroa, SMI JKMRC

Turbulence is all around us - in a cup of stirred coffee, crashing pro-surf waves, in the wake of an air flight and solving difficult engineering

processes. A clear understanding of how this complex phenomenon affects processes is critical to improve their effectiveness. In the mineral industry, particularly in flotation, fluid turbulence affects the recovery of metals, however, incorporating turbulence into flotation rate models, which are critical tools for mining decision-making, is still a big challenge.

In flotation, turbulence has been studied extensively, but a comprehensive analysis involving important multi factors has not yet been implemented. Many previous studies suffered from limitations on their experimental approach, e.g., turbulence was measured changing few variables, using non-suitable techniques in small-scale or low density particles. In this research, to better reflect industrial scenarios, a comprehensive analysis of turbulence effects was developed through studying coarse chalcopyrite floatability in a 60 L batch cell with an Outotec impeller. Turbulence was measured using a novel piezoelectric sensor suitable for 3-phase slurries. Energy dissipation and hydrodynamics, gas dispersion, viscosity, and solids suspension were also measured.

The experimental results allow the identification of the most critical factors and effects, revealing that the chalcopyrite recovery/rates are highly dependent on the energy distribution promoted primarily by the impeller size and operation influenced by the air and solids concentration.

The outcomes of this research permit to evaluate how we should incorporate turbulence in our flotation modelling, enabling tools that can be used to support more sustainable practices in the mineral industry.

A review of recent advances in simulation of gas hydrate formation deposition in the CCS pipelines

Hossein Dashti, UQ Energy Initiative

Anthropogenic carbon dioxide (CO2) emissions from different industrial processes contribute toward the rise in global temperatures recorded in the last century. CO2 capture and sequestration (CCS)

could play a crucial role as one of a portfolio of solutions to addressing the issue of global warming. CO2 transport from capture sources to storage sites is one of the main parts of the CCS infrastructure that needs to be optimised in order to reduce the capital and operating and maintenance costs. Recent developments have increased interest in the optimisation of the CO2 transport to achieve the most cost-effective system design. Gas hydrate formation in the different stages of CCS is one the challenges that attract much attention in the industry. CO2 hydrates form when CO2 gases are in contact with water molecules under equilibrium thermodynamic conditions of low temperature and high pressure. This research aims to explore a systematic overview and comparison of different models in the public literature to simulate the flow of the CO2 in the pipelines with emphasis on the CO2 hydrate formation. The findings showed that much research had been focused on the thermodynamic and fluid mechanics simulation of the hydrate formation in the CO2 pipelines while in the real cases the process of CO2 hydrate formation accompanied with kinetic models. The impact of the impurities in the CO2 pipelines is another challenge that has not received enough attention in the literature.

Reservoir storage capacity modification due to long-term CO2-rock chemical interactions: A rock mechanics perspective
Ifti Altaf, Chemical Engineering

Controlling climate change by limiting the concentration of CO2 in the atmosphere has become one of the key objectives for the developed world. A significant amount of effort, both in time and resources, are being allocated for this task in hope to leave a better and sustainable environment for the generation to come. Australia is no different, and Governments, both in federal and state levels are exploring the option for effective and efficient emissions control. One of the ways to achieve the set emissions targets is by employing the Carbon Capture and Storage (CCS) technique. Safe, efficient and effective long-term storage of CO2 requires a thorough understanding of the geomechanical processes involved. These processes include: understanding the current stress conditions, understanding the effect of pressure and temperature changes introduced due to injection,

and understanding the mechano-chemical interactions between the rock and the injected CO2 after an exposure for an extended period of time. I plan to carry out experiments to understand the effect of extended exposure to CO2 on the elastic and rock strength properties of the sealing shale caprock. Furthermore, I plan to explore the effect of these mechano-chemical interactions on the stress distribution around the discontinuity and the subsequent effect on the stability of this sealing fault. This would eventually impact the total storage capacity of a fault block while ensuring safe and sustainable Carbon Capture and Storage application.

Understanding sustainability performance in natural resource supply chains: An assessment 'from mine to car'

Jean-Pierre Imbrogiano, SMI CSRM

Corporations are challenged to increase their accountability on social and environmental impacts. Two dozen initiatives exist requiring the mining sector to reveal its practices for the common good. Regulators place additional demands, while big companies in the sector establish programs for the inclusion of suppliers into these processes. A positive result is that these efforts have led to the diffusion of best practices. On a more negative note, mining companies have become subject to multiple audits, and also apply the same approach to their suppliers. This may lead to situations of many-sided controls with a tendency to increase complexity, overlap, and compliance costs.

It is not clear to date how far these developments are justifiable. From a company perspective, efficiency of auditing is a major concern. Researchers point even to limited inferences to be made from current audit and standard practices. It is unclear whether proclaimed tools, mechanisms, and structures are effective, as performance evidence is scarce.

This research argues that we do not yet adequately understand how sustainability performance occurs in businesses, to justify the approaches taken. The project is exploring sustainability performance along an automotive supply chain and has two aims: First, to improve

our understanding of the opportunities and challenges in working with organizations on sustainability targets; and second, to provide a rationale for the need to complement or replace rather short-sighted controls with longer-term collaborative learning programs, which may align more to the interests and realistic capability development of both upstream and downstream industries.

Modification and processing of starches for increased productivity in mineral flotation

Lee Burns, Chemical Engineering

Given the finite nature of our planet's resources, continuous mining of metallic ore reserves around the world is leading to a gradual decline in available ore grades. Furthermore, global demand for primary metals is predicted to grow well into the future, despite intensifying dematerialisation and recycling efforts. Hence, there is a clear need for continual improvement of separation efficiency in mineral processing to retain economic viability in the mining industry into the future.

Froth flotation is a separation process which is utilised extensively in the field of mineral processing for the separation and isolation of mineral species from ores. This technique employs the addition of reagents to assist in the separation of components. Starch, a polymeric carbohydrate used extensively within the food and papermaking industries, has previously been utilised as a reagent in the froth flotation of various mineral species, due to its widespread availability, low cost, chemical versatility, biodegradability and non-toxicity – not all of which are properties possessed by current widely-used depressants. However, it currently lacks the necessary selectivity which would allow it to compete with more common depressants such as lime, sodium sulphite, cyanide and dichromate on an industrial scale.

The purpose of my research is therefore to investigate the production of physically and chemically modified wheat starch via extrusion in order to gain a better understanding of how extrusion process variables can be controlled and subsequently utilised to

produce modified starches with improved selectivity in mineral flotation.

Economic growth, industrial development, consumption upgrade and evolution of high-tech urban mines in China: 2015-2050

Lyushui Zuo, SMI CMLR

High-tech minerals are essential for strategic emerging industries, and urban mines have become principal potential reservoirs of secondary high-tech mineral resources. In order to evaluate and track the trend of high-tech urban mines to understand their criticality and determine their potential and priority for high-tech minerals recovery, we develop a model with three dimensions - resource index (RI), technology index (TI), and environmental index (EI). This model is applied to data from China under the context of economic growth, industrial development and consumption upgrade. Furthermore, we establish a developing strategy matrix and put forward specific measures to develop high-tech urban mines in the future. The results show that, the economic growth, industrial development, and consumption upgrade lead to the evolution trend of comprehensive criticality of high-tech urban mines in China dividing into four clusters - sustainable growth, first increase and then decrease, continuous decline, and fading out. The distribution forms of high-tech urban mines in “RI-TI-EI” three-dimensional space change from inverted U magnet-shape in 2015 to diamond-shape, inverted sailboat-shape and rocket-shape in 2025, 2035, 2050, respectively. According to the research results, different developing strategies, key development strategy, digestion strategy, reserve strategy and transfer strategy, should be adopted for high-tech urban mines basing on their criticality in different periods. Wind turbines, fluorescence lamps, smart phones, EVs, Li-ion batteries, LCD/LED TVs, LCD/LED monitors, and computers are main reservoirs of secondary high-tech urban minerals for a long time, ought to be recycling focuses and deserve support of a long time, ought to be recycling focuses and deserve support of technology, fund and policy.

Rheology study of Lihir grinding circuits

Peter Legge, SMI JKMRC

Rheology is the study of the flow and deformation of matter. Rheological characterisation of mineral slurries offers the potential to improve many processes in a variety of different ways within the mining industry. The aim of this research is to successfully characterise the rheology of a clay-rich gold ore slurry which is complicated by the slurry being fast settling and containing coarse particles. Further research is planned to follow using the results from this study to optimise the Lihir grinding circuit.

Mining without digging: the curious case of phytomining on sub-economic ore-bodies in tropical regions

Philip Nti Nkrumah, SMI CMLR

Phytomining is an emerging technology in the mining industry that capitalises on the huge generation of waste material as a result of the continual decline in ore-grades. This innovative process consists of growing selected 'metal-loving' plants on mineralised soils, and recovering profitable metal products from the harvested biomass. Phytomining addresses environmental concerns, and has high economic returns. However, large-scale demonstrations are needed to provide 'real-life' evidence for commercial operations, especially in tropical regions where unrealised opportunities exist. This PhD research has successfully domesticated 'metal-loving' wild plants in tropical regions for phytomining operations, and improved on the metal-yield of such plants for higher economic returns and sustainable production. This novel study is the first to provide 'real-life' evidence of such a unique technology in tropical regions.

Development of modified starch depressants to selectively reject carbonaceous minerals in the flotation of copper sulfide ores

Wonder Chimonyo, Chemical Engineering

Application of starch as depressants started close to half a century

ago, a period when most mineral ores were still of high quality/grade. Back then there were also less stringent environmental regulations for application of inorganic reagents in depression of unwanted gangue Mineral ores have been deteriorating and industry is now forced to process complex low grade ores with large proportions of gangue. These ores are difficult and expensive to process, and with the use of starch as alternatives to inorganic depressants, the process has been less efficient, with poor selectivity and in some cases high reagent consumption. Subsequently, there are losses associated with the use of organic depressants during flotation and many research works conducted globally, indicated low recovery and poor separation between sulfides and carbonaceous matter, even when the valuables are completely liberated. This can be attributed to similarity in surface characteristics of the valuable minerals as well as the gangue materials e.g. hydrophobicity. Therefore, the study seeks to develop knowledge on the fundamental mechanisms to improve the specific interaction of modified starch with carbonaceous minerals to improve depression efficiency and process sustainability. This includes an in-depth study of the surface properties and structure of chosen carbonaceous material relative to functional groups of modified starch, and correlate to performance during flotation.

Development of a method for quantitative estimation of CO2 leakage through abandoned wells

Younas Yousafi, Chemical Engineering

Carbon capture and storage (CCS) is becoming one of the globally most advancing technologies to reduce greenhouse gas (GHG) emissions from the atmosphere. CO2 storage in depleted oil and gas fields and storage in deep saline aquifers are the most common methods for large-scale sequestration around the world. For a commercial CCS project, it is very important to understand the CO2 behaviour underground and its leakage pathways.

Generally, three conditions are required for CO2 leakage to occur: 1. A source of mobile CO2; 2. A driving force (head differential or buoyancy); 3. leakage pathway(in this case abandoned well). While newly developed wells are governed by regulations and designed to

sustain the integrity of storage sites, wells drilled and abandoned in the past considered to less strict governance, and therefore are subject to be the greater threat to long-term storage integrity.

This project will assess integrity condition of abandoned wells, particularly exploration wells drilled and abandoned decades ago with min construction standards. Assuming a tight caprock with min permeability, the cement/rock interface is the main leakage pathways for these type of wells under sequestration condition. An abandoned well in the Surat Basin that penetrates the aquifer will be studied for cement/formation bonding status at different conditions. Well integrity will be assessed based on the leakage rate and the cut-off recommended by IPCC. This study gives guidance to policy makers, regulators and CCS operators for a safe and commercial CO2 injection project in the Surat Basin in QLD, Australia.

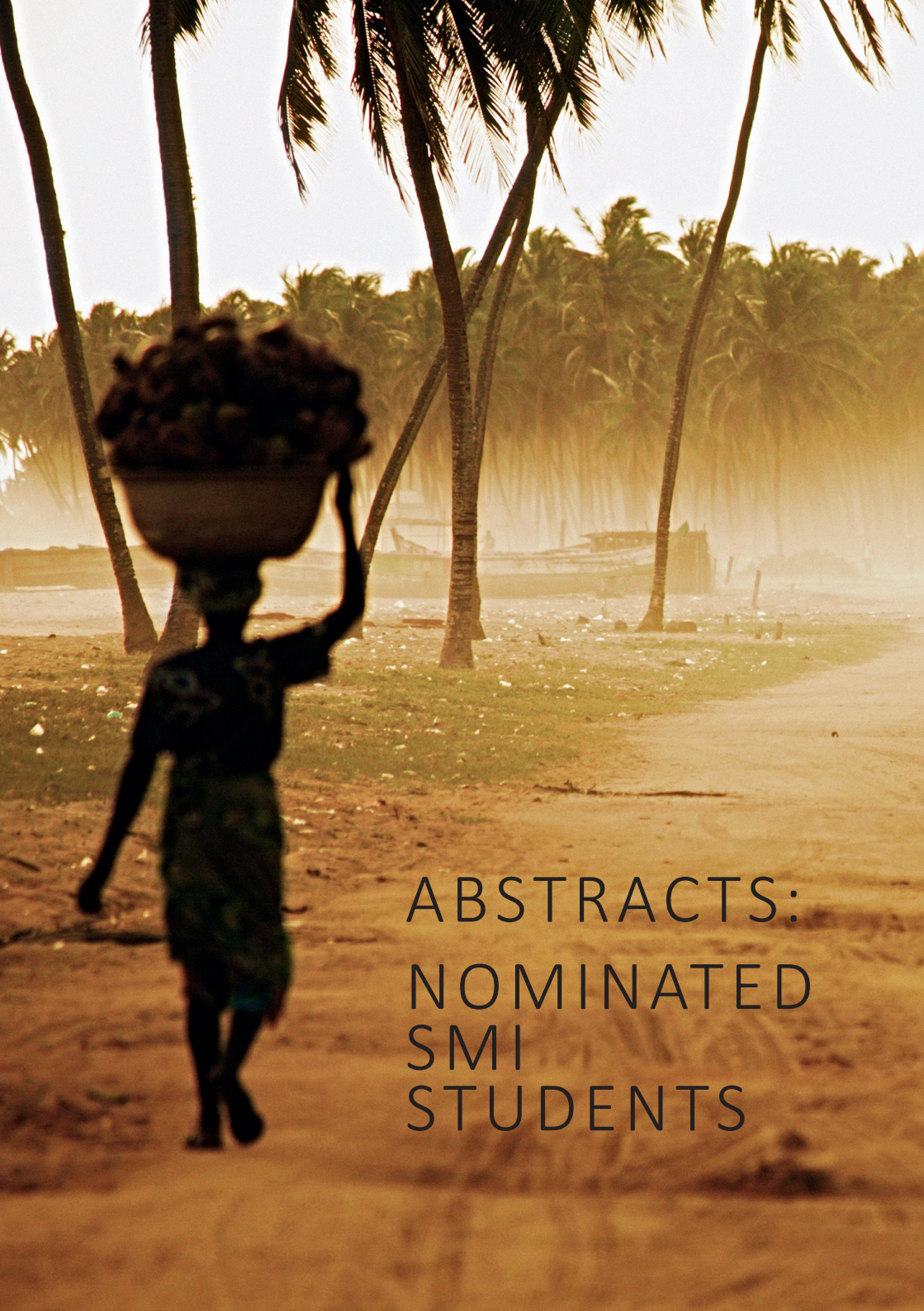
Digital twins of materials handling and dry comminution circuits

Ziming Ye, SMI JKMRC

It is well known that minerals are non-renewable resources. Therefore, how we implement innovation and sustainability in the minerals industry is vital to fulfilling our responsibility toward future generations. Dry comminution circuits are the first step in the process of liberating valuable minerals and separation, and the performance of this section plays a significant role in the overall performance of a processing plant. Due to the variation in characteristics of feed and fluctuations which are introduced to the process by addition of bins and conveyors, maintaining efficiency of dry comminution circuits has become challenging. Segregation in stockpiles, bins, and transfer-points and un-even or un-equal split in splitters makes control of the process challenging.

The performance of each unit is subjected to variations and changes depending on the dynamics of the system which depress the total circuit productivity below the ideal scenario. Therefore, developing digital twins to model the dynamic behaviour of materials handling and storage in dry comminution circuits can quantify the

impact of natural and process-induced fluctuations on performance of comminution and classification units. Digital twins will have the ability to simulate particle size segregation, un-even or un-equal mass splits, and lag times in bins, stockpiles, transfer-points and conveyors. This study introduces common issues that process-induced fluctuations by materials handling and storage will raise in dry comminution circuits and industrial examples for those issues will be presented. The paper also introduces the concept of developing digital twins for simulation and quantification of the impact of process-induced fluctuations on the performance of comminution and classification units.



ABSTRACTS: NOMINATED SMI STUDENTS

Good work design: Strategies to embed human-centred design in organisations

Sara Pazell, SMI MISHC

Good work design provides a framework for innovation and workforce engagement through design and re-design of daily job tasks. This project engages retrospective and formative review of participative ergonomics and human-centred design in heavy industry (mining, construction, and transportation). During this presentation, through case study review, participants will learn of the organisational drivers and methods that aided a mining conglomerate to significantly reduce musculoskeletal disorders and hand injuries. The findings, combined with literature review and formative analysis to determine methods for ongoing process improvement, have underpinned the early development of a maturity model for good work design. These early investigations may inform industry about work design practice that is award-winning, consistent with legislative framework, and evidence-based.

Linking comminution with recovery potential

Juan Jose Frausto Gonzalez, SMI JKMRC

Mining and metallurgy are processes of global interest. Proper quality and quantity, expressed as grade and recovery of the valuable minerals depends on the efficiency of comminution to liberate, and flotation to separate mineral species of interest from gangue. This project aims to investigate how to best prepare the mineral during grinding to optimize the metallurgical performance in the flotation stage. The investigation aims to link the comminution to flotation, emphasizing on delivering a product under the best conditions for flotation, i.e. proper particle size ranges and best liberation of species of interest. Alternatives on classification of particles such as fine screening will be evaluated as an alternative to replace hydrocyclones from the conventional classification processes.

Natural caving systems as potential analogues to mining induced caving

Matthias Klawitter, SMI BRC

Mining and metallurgy are processes of global interest. Proper quality and quantity, expressed as grade and recovery of the valuable minerals depends on the efficiency of comminution to liberate, and flotation to separate mineral species of interest from gangue. This project aims to investigate how to best prepare the mineral during grinding to optimize the metallurgical performance in the flotation stage. The investigation aims to link the comminution to flotation, emphasizing on delivering a product under the best conditions for flotation, i.e. proper particle size ranges and best liberation of species of interest. Alternatives on classification of particles such as fine screening will be evaluated as an alternative to replace hydrocyclones from the conventional classification processes.

In situ immobilization of heavy metals and passivation of sulfide minerals in lead-zinc tailings using phosphate

Felipe Saavedra-Mella, SMI CMLR

Mine tailings are one of the critical challenges to the sustainability of mining and minerals sectors in mining countries (Australia, Chile, Peru, Canada, etc.). Exposed tailings without proper revegetation can cause many environmental problems. My project focus on the development of low-cost but effective chemical engineering technology to help rapid establishment of tolerant vegetation covering tailings landscape, e.g., for controlling dusts. However, metal(loid)s-rich minerals in tailings can cause phytotoxicity to plants when exposed to water and oxygen, such as those of sulfidic nature.

This project aims to develop field-feasible technology which is based on the induction and transformation of reactive minerals into encapsulated polyminerals of low energy which immobilize metal(loid)s through isolation and prevention mechanisms in which plant roots and microbes cannot access to. This technology is based on phosphoric acid-fortified phosphate (PAF-P) reactions with sulfidic minerals and poly-metals. It has been found that: PAF-phosphate

i) rapidly decrease the concentrations of soluble heavy metals by forming highly stable minerals; and by (ii) hindering the oxidation/ dissolution of reactive minerals (e.g. galena, sphalerite, pyrite, etc.) via microencapsulation. Field trials are to be conducted to tailor this technology for field operations, to establish a rapid vegetation cover and help initiate natural colonization and primary succession, thereby supressing dust containing heavy metal(loid)s spreading out to the environment.

Defining critical risks to the long-term viability of alternative water schemes

Camilla West, AWMC and SMI CWiMI

The continued development and operation of mining activities is contingent on the adoption of sustainable water management practices. Variable climatic conditions, changing regulations and environmental and social conflicts have influenced water supply security and impacted the productivity of mine sites worldwide. As a result, mining operations have been required to reduce water usage, increase water recycling and diversify water supply sources. However, the diversification of water services has not been without challenge; with mining proponents subject to infrastructure investment risk and the potential for stranded assets. Similarly, the urban water sector has suffered severe water supply security concerns and subsequent infrastructure investment challenges. The diversification of water services by the Australian urban water sector during the Millennium Drought (1997 – 2010) was prolific; with suggestions that over $4 billion was invested in inefficient water services, namely large desalination plants and recycled water schemes. A case study investigation of 21 recycled water schemes and a national survey of 88 water industry practitioners, revealed the prevailing factors in the premature decommissioning of recycled water schemes and the critical risks to the long-term viability of future schemes. The study findings highlight the variation in stakeholder risk perceptions and illustrate the influence of organisational, political and social factors on the long-term viability of infrastructure investment decisions. While focussed on the urban water sector, the study findings provide important insight and knowledge for the mining sector, both nationally

and internationally, pertaining to water service diversification and water infrastructure investment risk.

Satellite based vegetation indices and ground surveys to assess rehabilitation sustainability following fire

Phill McKenna, SMI CMLR

As open-cut coal mines progress towards closure, mining companies have an obligation to provide certainty to stakeholders that their rehabilitated landscapes have the capacity to withstand future environmental impacts such as fire and drought. This paper describes the use of remote sensing technology coupled with ground surveys to assess the resilience of mine site rehabilitation when challenged by wildfire conditions. An experimental fire was applied to 20 year old rehabilitation in a semi-arid environment in Central Queensland, Australia. A time-series of World View-3 satellite imagery demonstrates that within 2 years of the fire, vegetation indices Normalised Difference Vegetation Index (NDVI) and Normalised Burn Ratio (NBR) are higher than pre-fire levels; and when standardised for rainfall affects using control (unburnt) areas, the indices show positive trajectories towards pre-fire levels. Fire severity maps using differenced NDVI and differenced NBR indicate that the site received a heterogeneous burn and over the 2 year time sequence, dNDVI and dNBR recovery maps demonstrate the trajectory towards recovery. Ground surveys show that species richness, woody stem density, vegetation cover and grass biomass are either on a trajectory to pre-fire levels or have increased beyond pre-fire levels. Following two significant wet seasons, the results have provided the mine with confidence that rehabilitation at this site has the capacity to withstand impacts from a wildfire within the range of conditions.

ABSTRACTS:
MULTI-FORMAT PRESENTATIONS

Microstructural and geomicrobial community characteristics of naturally formed hardpan at sulphidic mine tailings

Allen Liu, SMI CMLR

Sulfidic tailings contain abundant reactive minerals rich in heavy metals, metalloids, and radionuclides, which may become gradually oxidized and weathered, thus releasing toxic elements/compounds into the environment. Hardpans are massively indurated layers, cementing tailing particles together to form a layer of physically dense and mechanically hard crusts under semi-arid climatic conditions. This study is the first to have uncovered a field case of a massive hardpan layer capping sulphidic Cu-Pb-Zn tailings and is located below root zones at Mt Isa mines, North Queensland, Australia. Two distinct forms of cementation textures in the hardpan profile were revealed: amorphous gypsum evaporites and Fe-Si polymerized gels. The amorphous gypsum evaporites were induced by co-dissolution of dolomite, while Fe-Si gels were clustered extensively and coated continuously on pyrite surface. Microbial processes were critical to hardpan formation. It was found that “Rod-shaped” bacteria fossils were present in hardpan. In addition, acidophilic Fe/S oxidizers were present in hardpan at neutral condition, most of them belonged to actinobacteria and gammaproteobacteria. The expected findings would provide the basis of in situ engineering of hardpan layer for achieving much improved environmental outcomes in terms of hydrogeochemical stabilization in sulphidic tailings landscape and sustainable plant communities.

How to see a mine: Contemplating a situated knowledges approach within post-mine planning

Amelia Hine, SMI CMLR

As an industry with a heavy focus on engineering, geology and earth sciences, an implicit bias toward positivism pervades mining practices and guides end of lifecycle landscape planning. During this post-mine planning the landscape’s contextual complexity is reduced, and an idealist but unrealistic reinstatement of the original ecosystem is prioritised by both government and company. This single, prescriptive approach to post-mine planning stands at odds

with the more nuanced reality of the landscape in its regional context.

This research contemplates a subtle application of critical geographies in order to re-envision a post-mine planning process that responds more comprehensively to its context while remaining palatable to an industry that shuns subjectivity. The project aims to highlight the ontological multiplicity of the landscape to those deeply involved in the site, in order to expand thought processes and develop the capacity for shared knowledge and understanding.

Screening of nanoparticles for clay swelling inhibition in coal seam gas reserviors

Archana Patel, Chemical Engineering

Fines generation and the migration due to swelling of the smectite clays is a serious problem in the coal seam gas reservoir. Polar molecules, such as water, are absorbed on the interlayer sites of clay resulting in swelling; the swelling in turn causes fines generation. Fines migration reduces the gas permeability, damages pumps and leads to increased operational cost.

Clay stabilizers, such as inorganic salts and polymers, are used to control clay swellingMy research is into the potential of nanoparticles as clay stabilizers as the current commercially available options although cheap only exhibit a temporary effect. This presentation focuses on potential nanoparticles to prevent clay swelling in the coal seam gas reservoirs under formation water chemistry using model clay via visual swelling test.

Among six nanoparticles silica and magnesia nanoparticles have shown potential to prevent clay swelling. Nanoparticles have high surface forces which attract and retain clay fines and prevent them from moving to the wellbore region. Although nanoparticles have been reported for the clay swelling inhibition in the open literature, there is no clear explanation on the mechanism by which nanoparticles stabilize clays. Without any particular explanation or mechanism, it is theorized that the surface forces of the nanoparticles at their scale could be responsible for the stabilizing clay particles. This study

would aloso focus on the mechanism of clay swelling inhibition with screened nanoparticles.

Mine waste or future resource? Integrating industrial ecology thinking into a mine project

Eleonore Lebre, SMI CMLR

In our finite world the consequences of the continuously growing global demand for metals are becoming more and more concerning. This project raises the questions of what is currently unsustainable in mining practices and what would a more sustainable mining operation look like. In the search for answers, the project started with looking into the most critical problems the mining industry is facing: the consequences of ore grade decline, a lack of economic resilience, and increasing mining legacies.

Mining legacies are mainly constituted of giant mine waste deposits that are the source of important environmental damage as heavy metals inevitably leak into the environment; at the same time there is evidence that mine waste contains significant amounts of valuable metals that are currently lost while they could potentially be extracted. The research investigates how a more preventive and recovery-oriented approach to waste management could be both economically attractive and environmentally beneficial could potentially improve a mine's sustainability performance. This research project aims at testing the following hypothesis: such a waste management would improve a mine's sustainability performance by (a) increasing its resource efficiency, a responsible way to operate in a context of resource depletion and (b) enhancing its resilience, a critical aspect in a context of poor economic stability. In order to test this hypothesis the author developed an industrial ecology-based framework designed to both: quantify the benefits of a recovery-oriented waste management system through the use of a Life Cycle Analysis; and identify external and internal incentives to facilitate a desirable change in mining practices.

Hydro-economic modelling in mining catchments

Juan Ossa-Moreno, SMI CWiMI

Hydro-economic models are gaining momentum because of their capacity to model both the physical hydrologic processes and socio-economic factors of water. Agriculture, urban uses and environmental flows have received a lot of attention from researchers, as these tend to be the main consumers of water in most catchments. Mine water demand, although very important in several catchments, has received less attention and only few models have attempted to reproduce its dynamics with other users. This paper describes a project that addresses this gap, by developing a hydro-economic model in the upper Aconcagua River in Chile. This is a catchment with mining and hydro-power users at high altitudes, and irrigation areas in a downstream valley. A semi-distributed model developed within the Water Evaluation and Planning System (WEAP), was calibrated to reproduce water supply, and this was complemented with an analysis of the value of water for mining based on two methods; water markets and an analysis of its production processes. Other users were included through methods commonly used in similar models. The outputs help understand the value of water in the catchment, and its sensitivity to changes in climate variables, market prices, environmental regulations and changes in the production of minerals, crops and energy. The results of the project highlight the importance of merging hydrology and socio-economic calculations in mining regions, in order to better understand trade-offs and cost of opportunity of using water for an economic activity with high revenues, averse to water risks and with potentially large catchment impacts.

Effect of alternative road salts on soil leachate quality

Karan Jain, The Pennsylvania State University

Stormwater runoff in winter contains large amount of salts due to the application of deicing salts on roads and sidewalks for safety. This runoff drains to the side where the salts accumulate in soils and change its physicochemical properties. This study compared the impact of three alternative road salts to the traditional sodium chloride (NaCl). The four road salts used in this study were NaCl,

sodium acetate (NaAc), calcium chloride (CaCl2), and calcium acetate (Ca (Ac)2). The pollutants analyzed were Total Phosphorus (TP), Total Nitrogen (TN), Chemical Oxygen Demand (COD), Zinc (Zn), and Copper (Cu). This research study showed that applications of all salts significantly reduced the infiltration rate. The study also showed that the small loading of chloride-based salts (NaCl and CaCl2) had minimal impact on the removal and retention of metals or nutrients. However, applications of acetate–based salts increased nitrogen, phosphorus, and organic removal (measured as chemical oxygen demand [COD]), but did not have any effect on metals. This nutrient loss from the runoff water might have been caused by the growth of a microbial community in the soil. The growth of a microbial community as a biofilm on the soil surface may explain the potential changes in flow rate when acetate-based salts are used.

A study of participant experience in the community engagement processes for proposed coal mining developments in the Galilee Basin

Katie Meissner, UQ Business School

Alpha, located in Queensland's Central West, is a small remote cattle grazing community at the centre of proposed coal mining developments in the Galilee Basin. Alpha will bear the brunt of immediate economic, social and environmental impacts of these mines such as inflated living costs, dust, noise, lights, traffic, a fly-in fly-out workforce, and changes to essential groundwater supplies. State and federal regulation demands that project proponents engage with local communities as part of the mining assessment process. This study examines how citizens experienced the engagement process undertaken for four proposed mines through the lens of fairness and competence in environmental decision-making. The case study research methodology used semi-structured interviews and document analysis of relevant sections of the Terms of Reference, Environmental Impact Statement and Supplementary Environmental Impact Statements submitted by each proponent. The study found that while the community of Alpha welcomes the opportunity to develop their region and is mindful of the contribution that mining makes to the Queensland and Australian economies, participants

identified three negative aspects of the companies' community engagement during the requisite public consultation periods for the mines: a divide and conquer approach on behalf of the proponent; distrust of technical information supplied by the project proponent; and inadequate consideration for the cumulative impacts of four mines in a process structured to deal with each mine individually. The findings of this study are useful in improving engagement experiences for communities affected by new projects.

NMO correction in anisotropic and laterally heterogeneous media using simultaneous velocity variation with offset

Mohamed Salah Sedek AbdelHamed, SEES

A clear seismic image is the key behind less risk in oil and gas exploration. Achieving this aim is quite a challenge, due to the complexity of the subsurface formations. One of these difficulties is related to what is called seismic anisotropy where the physical properties of the seismic wave change with different directions, making it difficult to enhance the signal to noise ratio through the stacking averaging method (recording seismic data at different directions but at the same point and do an average). Our research addresses this problem and successfully provides both the exact anisotropy value and the normal-move-out velocity of the seismic wave at each direction/azimuth independently. As the current techniques have to assume the type of the anisotropy before the processing of the seismic data, our technique doesn't follow this methodology. It simply gives every subsurface formation three possibilities: (1) isotropic; (2) anisotropic - where the geological formation changes the seismic velocity by increasing it, and; (3) anisotropic - where the geological formation changes seismic velocity by decreasing it. At each possibility we change the velocity simultaneously in each direction using a range that controls the maximum and minimum value of the velocity. We test each velocity independently and evaluate it using our formula, the process is repeated for every single velocity in each direction. The velocities that best correct the seismic data due to the anisotropy are chosen. We then extract the anisotropy values from the selected velocities using our new developed formula.

Linking comminution properties of rocks with its textural characteristics at microscale

Pia Lois, SMI JKMRC

Comminution of rocks is an essential but energy-intensive step in the mining process. Current comminution design, planning and control are based on test work and empirical models. These do not take into account either the physical properties of the rocks (strength, elastic modulus, fracture force) or its characteristics (mineralogy, texture, variability) as the relationship between them is not entirely understood. Consequently, current practices have limited prediction capabilities for the design of innovative grinding mills and for predicting the comminution characteristics of different ore types (Tavares, Austin, & King, 2006).

Previously published studies have shown that porosity of rock and the shape and size of mineral grains affect rock strength (Esamaldeen, Guang, & Ibrahim, 2014; Howart & Rowlands, 1987; Ozturk, Nasuf, & Bilgin, 2004). In order to represent the physical properties of every rock it is necessary to capture its inherent variability which is controlled by its characteristics. This study aims at understanding how the physical properties of rocks, measured at a scale relevant to milling, vary with the mineralogy texture characteristics. A novel methodology using the Single Impact Load Cell (King & Bourgeois, 1993; Tavares & King, 1998) has been developed to control sampling and breakage of each tested particle.

The outcomes of this work form a critical step in the understanding of textural rock characteristics and their variability, and their influence on the comminution properties of rocks. These findings are a step forward toward mechanistic models of comminution using physical and particle-based properties controlled by rock characteristics.

The use of post-blast surface to predict internal blast movement

Raphael Picorelli, SMI JKMRC

Ore loss and dilution occur when blast movement is not

considered in mine planning. The direct consequences are increased processing plant costs and loss of revenues. Grade Control techniques try to account for this movement. Currently, grade control techniques estimate blast movement based on the initial and final location of objects in the blast bench; the calculated result vector is then used to adjust the digging polygon to account for the movement. The issue is that the tools for measuring internal movement are estimations, not physical measurements. This study uses the actual post-blast surface to predict internal blast movement. The generated actual surface can be physically measured. The hypothesis is that actual surface of a post-blast is a manifestation of the internal displacement of rocks. Therefore, this surface could be used to understand the internal blast movement. This research makes use of an engineered blast movement model, idealized to predict the ore movement trend to work as a grade control tool for mining operations. The model uses as inputs the blast design and bench geometry, discretizes the bench into blocks, allocates initial blast energy, and then emulates the final resting position using a physics engine to simulate the movement dynamics. The model employs a calibration process to better fit the actual surface with the simulated surface. Blast Movement Monitors are used to compare actual material movement with corresponding block movement in the model.

Hyperaccumulator discoveries through XRF scanning in New Caledonia

Vidiro Gei, SMI CMLR

Hyperaccumulators are plants that have the unique ability to accumulate trace metals (e.g. cobalt, manganese, nickel and zinc) to extraordinarily high concentrations in their living shoots. They are receiving increasing academic interest because of their potential use in phytotechnologies. New Caledonia is global hotspot for hyperaccumulator plants, with 65 nickel and 11 manganese hyperaccumulator plant species recorded to date. X-ray fluorescence (XRF) devices can quantitatively determine elemental concentration non-destructively in as little as 30–60 seconds, hence the possibility to perform elemental analysis on vast numbers of stored herbarium specimens. XRF analysis was performed on over 12, 000 dried

herbarium specimens at the Institute for Research and Development (IRD) Herbarium in Nouméa, New Caledonia. Selected samples covered all available specimens in five plant families known to contain most hyperaccumulators, as well as a systematic screening of 1–4 specimens (depending on availability) of all species known to occur on ultramafic soils in New Caledonia. The XRF raw measured elemental values were corrected using regression fits for samples analysed by ICP-AES. Numerous marginal hyperaccumulator plant taxa for Ni, Mn, Co, and Zn were recorded however, only high range records (i.e. Ni >5000 µg g-1, Mn >20 000 µg g-1, Co >1000 µg g-1, and Zn 10 000 µg g-1) are considered: 87 taxa for Ni (including 68 new records), 68 taxa for Mn (including 59 new records), 8 taxa for Co (none previously recorded), and 4 taxa for Zn (none previously recorded). XRF screening of herbarium specimens has the potential to discover vast numbers of new hyperaccumulator species.

Ore pre-concentration using high voltage pulses

Wei Huang, SMI JKMRC

Globally, the mining companies are struggling to deal with declining head grades, increasing amount of energy input and generation of waste. This is mainly attributed to the fact that the existing mechanical crushing methods disintegrate rocks in an unselective fashion whereby all the feed particles, including all the barren particles that are of no economic values, are crushed to micro sizes to allow further beneficiation. The energy devoted to the waste rocks are deemed to be wasted, and it is imperative for mineral processing engineers to develop methods that would allow waste rock rejection at early stages.

The aim of this work is to employ the high voltage pulses (HVP) to achieve selective fragmentation so as to allow size-based separation method to be implemented. In addition to optimizing of the pre-concentration efficiency with the multiple particle test method (MP), the fundamental mechanisms regarding HVP propensity for the metal-enriched particles are probed using the synthetic particles. Furthermore, a case study is presented which identifies the overall benefits of HVP application in mineral processing.