

ANNUAL REPORT 2012



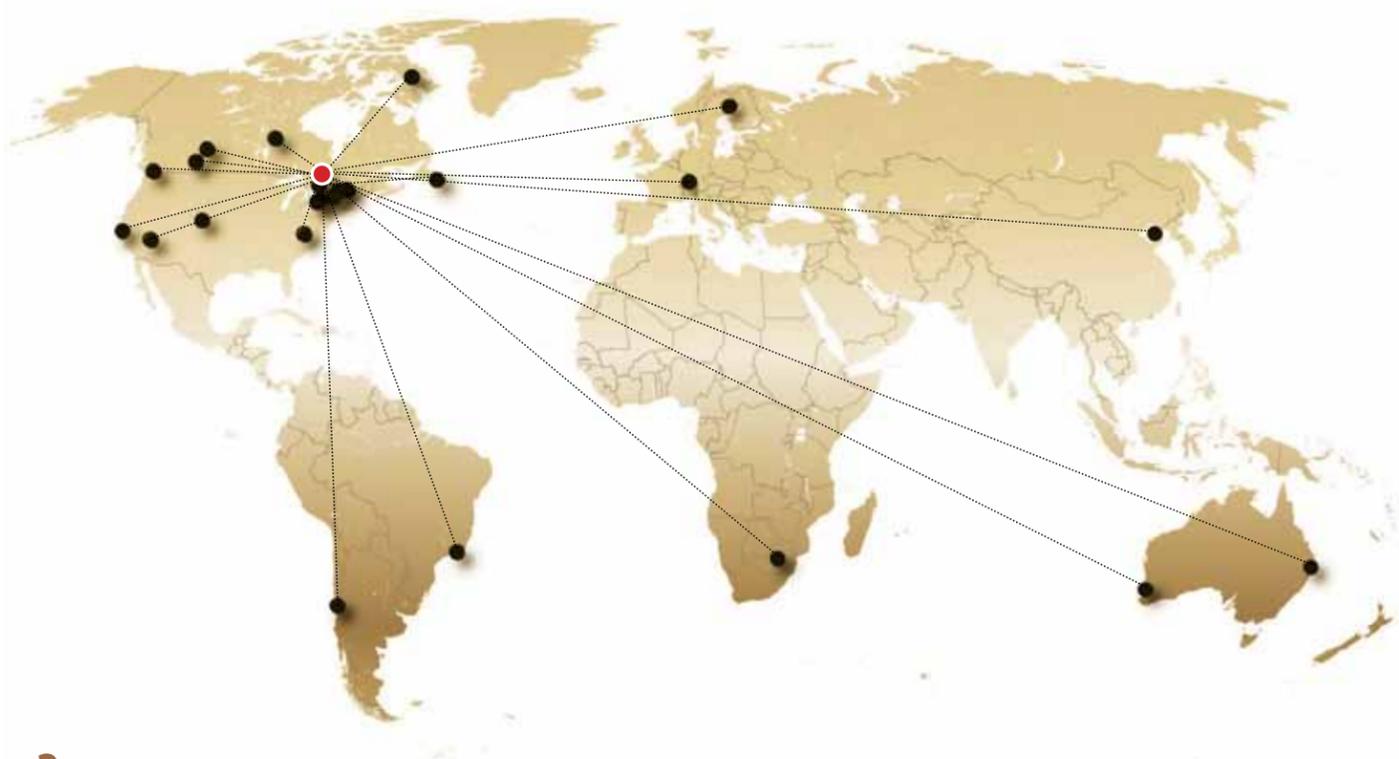
Fostering Innovation, Implementing Excellence

COLLABORATION. INNOVATION. EXCELLENCE.

The Centre for Excellence in Mining Innovation (CEMI) directs and coordinates step-change research in the areas of exploration, deep mining, integrated mine engineering, environment and sustainability in the metal mining industry. With a senior team of best-in-class program directors that provide knowledge and experience, CEMI supports applied research that extends from engineering and geology to include biology, chemistry, mechanical engineering, bio-chemistry and more. We recognize innovation as a three-phase process: research, development and implementation (R&D+I). With implementation, we turn innovative ideas into best practices.

CEMI's integrated model of research, development and implementation creates greater capacity for excellence in innovation and is designed to accelerate economic activity related to the mining industry. We do this by:

- 1 | collaborating with major Canadian and global mining companies, university researchers, research organizations, technical consultants, and innovative SMEs across Canada and in Australia, South Africa, Chile and the USA;
- 2 | facilitating industry-focused collaboration to advance research, development, implementation and evaluation of ideas that deliver innovative, comprehensive and cost-effective solutions;
- 3 | developing and nurturing future generations of researchers, industry leaders and highly qualified personnel by providing training opportunities and in-field access to facilities;
- 4 | implementing sound business practices with a focus on accountability, efficiency and effectiveness;
- 5 | attracting patrons and project sponsors from the global mining industry and Ontario and Canadian government funding.



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MESSAGE FROM THE CHAIRMAN OF THE BOARD



As Chairman of the Board of Directors for the last year, let me begin by saying how very pleased I am to serve CEMI in this capacity. I look forward to working with my fellow Board members during my tenure. I am committed to providing continued, strong and effective leadership as we move into the next stage of CEMI's growth.

First, I would like to thank the past Chair of the Board, Marc Boissonneault (Xstrata Nickel) for the strong stewardship he gave us. I would also like to thank our founding President and CEO Peter Kaiser for his outstanding leadership and vision of CEMI in its start-up phase over the last five years. Under his direction, CEMI more than doubled the initial

investment by the Ontario Government and CEMI's founding patrons, Vale, Xstrata Nickel and Laurentian University, laying a sound foundation for CEMI's future under new leadership.

CEMI is entering a new phase of growth and with it come changes in the leadership of the Corporation. I would like to thank Mr. Douglas Morrison for executing a smooth transition after his appointment as President and

CEO of the Corporation effective March 1, 2012. Mr. Morrison joined CEMI in 2011 as Vice President, bringing 15 years of experience in the Canadian mining industry and more than 15 years in international consulting. Given the many challenges our industry faces, his broad understanding of the issues will benefit CEMI as we begin to pursue new opportunities for growth and expansion.

There have been other changes of note to the Board this year and we are pleased to welcome Karen Clarke-Whistler, Chief Environment Officer for TD Bank Financial Group. A respected environmental scientist, Ms. Clarke-Whistler has worked as an environmental consultant on projects around the globe relating to sustainable development in the natural resource and energy fields.

Building on a solid foundation, despite the current turbulence, I am confident that CEMI is about to embark on a program of steady growth, based on the long-term demand-driven need for innovation in the industry. With an exceptional team to drive the organization, we will continue to strengthen our organization and with the help of our Patrons, Sponsors and Collaborators we will enable CEMI to fulfill its vision of becoming the leading source of innovation to the global mining industry

Sam Marcuson
Chair of CEMI Board

BOARD OF DIRECTORS



SAM MARCUSON
Chair of CEMI Board
Vice President
Vale Canada Limited



PETER K. KAISER
Vice President Research, CEMI
Director of the Rio Tinto Centre for
Underground Mine Construction (RTC-UMC).



MARC BOISSONNEAULT
Vice President of Sudbury Operations
Xstrata Nickel



CHRISTINE KASZYCKI
Assistant Deputy Minister
Ring of Fire Secretariat
Ministry of Northern Development
& Mines (MNMD)



FRED DELABBIO
General Manager
Underground Mining Innovation
Rio Tinto



NIGEL SMITH
Director
SNOLAB



DOMINIC GIROUX
President
Laurentian University



KAREN CLARKE-WHISTLER
Chief Environment Officer
TD Bank Financial Group



SUZANNE HERBERT
Former Deputy Minister
Ministry of Northern Development
& Mines (MNMD)



ANIL ARORA
Assistant Deputy Minister
Natural Resources Canada
Minerals and Metals Sector
(External Observer to the Board)



DOUGLAS MORRISON
President and CEO
Centre for Excellence in
Mining Innovation

MESSAGE FROM THE PRESIDENT



As the new President and CEO of the Centre for Excellence in Mining Innovation (CEMI), I would first like to express my sincere gratitude to our outgoing President and CEO, Dr. Peter Kaiser, who successfully founded the Corporation, and built an effective model for collaboration that enables university researchers, service and supply companies and mining companies achieve excellence in innovation. We are fortunate to have Dr. Kaiser continue with us in the role of Vice President Research, and Director of the Rio Tinto Centre for Underground Mine Construction (RTC-UMC). And I am especially grateful that I will be able to rely on his wise counsel for the next few years.

Leveraging on the strong foundations CEMI has built over the last five years, we are moving to expand the number of meaningful collaborations between mining companies, research institutions, academic researchers, the mining service and supply sector and government agencies. This will create new economic opportunities, addressing the important challenges that confront the global mining industry.

MAJOR EVENTS

2012 saw the initiation of the Rio Tinto Centre for Underground Mine Construction Program as well as the installation of instrumentation as part of the new Smart Underground Monitoring and Integrated Technologies (SUMIT) for Deep Mining program. Building on the success of the original Ventilation on Demand (VOD) project, CEMI is moving into the next phase for VOD production that will allow the optimization of future mine development and infrastructure, allowing for increased productivity at lower operating costs.

BROADENING COLLABORATION

With 30 projects currently underway in Deep Mining and Mine Construction, we are intensifying our focus on integrated underground mine engineering, and broadening support for CEMI from major mining corporations around the globe. We are actively developing projects to increase advance rates, production rates and the efficiency of materials handling, using our industrial experience to convert knowledge and creativity into practical solutions that can be implemented into routine operations. And in doing so we are continuing to attract collaborators from Quebec to BC and building relationships globally with organizations in Australia, the US, South Africa, and Chile.

Within Canada, we are strengthening our relationships with the other research and development organizations in mining and seeking to improve our involvement with a broader range of funding agencies. In Sudbury, we continue to cooperate with local research and development organizations (MIRARCO, CAMIRO and CANMET) to develop projects and deliver results to a number of client organizations. We are developing close working relationships with the Greater Sudbury Development Council (GSDC), the Sudbury Area Mining Supply and Service Association (SAMSSA), and NORCAT. These relationships will help all of us to identify innovation opportunities, accelerate pre-commercialization activities and facilitate implementation.

Within Ontario we are developing a strong relationship with the Ontario Centres of Excellence (OCE) and this past year CEMI was invited to deliver a major forum on mining with a panel discussion at the OCE's Discovery event, and this included representatives from LU, industry and the Ministry of Northern Development & Mines (MNDM). In May, we completed a joint project workshop with OCE and NSERC for \$2 million of research on the topics of Energy, Environment, Water & Productivity. And we are working with the Ontario Mining Association (OMA) by participating in OMA Board and Committee meetings, and by actively supporting several initiatives, including the CEO, Chris Hodgson's initiative to find support for forestry research that might benefit the mining industry.

Nationally, CEMI is working with CIM on ways of effectively communicating mining knowledge and we are cooperating with CMIC by assigning a Research Director to work as a part-time coordinator for the Mining Committee.

Our goal is to collaborate with as many mining research and development organizations as we can to reduce duplication and maximize the benefit of bringing fresh minds and fresh ideas to bear on problems that confront the industry. We hope that by increasing the scale and diversity of our network solution teams and enhancing their capacity for virtual interaction we will create a more interesting and productive intellectual environment in the service of the global mining industry.

OPPORTUNITIES AND CHALLENGES

The range of challenges the global mining industry faces creates tremendous opportunities for CEMI to grow. Northern Ontario is uniquely fortunate in the strength of the assets we have at hand: a higher concentration of mining experience and knowledge than anywhere in the world, combined with the living laboratories of the mines, the tailings management facilities and the rehabilitated environment that enable us to attract the expertise we need from around the world to progress further. Mining is a particularly important component of Canada's and Ontario's economy, but mining is a truly global enterprise and the kinds of improvements we can develop in Ontario's mines have direct and immediate application to underground mines elsewhere. The opposite is also true: the contributions CEMI is making to mines that will be developed in other countries will eventually bring benefits to the local mines. And we fully expect the local service sector will be able to spread these benefits throughout the industry globally while generating economic activity locally.

But to help our collaborators take advantage of the opportunities and assets, CEMI needs a dedicated and cooperative team of experienced industry professionals. As CEMI moves into a new growth phase, we welcome the appointment of Damien Duff as our new COO, our new Research Directors Leon Botham (SustainMine) Seppo Haapamaki

(ValueMine) and George Hughes (Deep Mine, Value Mine), and the promotion of Shannon Katary as Director of Marketing and Community Relations, and of Alan Akerman as Research Director (ValueMine). And as Jane Djivré, Keith Bullock and Glenn Lyle move on to new opportunities, we recognize their valuable contributions over the years and hope to work with them in future.

Finally, I offer my appreciation to the members of the Board for their help in guiding the organization through the transition of leadership and the further development of our strategic direction. I thank each of you for your continued support of our mining innovation initiatives.

I look forward to leading CEMI into the next phase of its growth and to working closely with you all in what promises to be very exciting times.

Douglas Morrison
President & CEO

INNOVATION
EXCELLENCE

STRATEGIC RESEARCH PROGRAMS AND PROJECTS

FIVE CORE STRATEGIC RESEARCH AND DEVELOPMENT THEMES

With a strong and clear strategic focus, CEMI continues to meet the needs of the mining industry in five core research and development project themes: ConstructMine, DeepMine, ValueMine, SustainMine, and FindMine. The objectives of these strategic themes are to direct and coordinate step-change research in the fields of deep mining, exploration, integrated mine engineering and sustainability and to help develop core competencies and processes. Each is wide-reaching and helps to advance innovation and enrich knowledge for the metal mining industry.



Photo courtesy of Laurentian University

CEMI continues to demonstrate its effective management of large projects and its ability to generate substantial leverage funding. This is evidenced in the 2012 initiation of projects like the Rio Tinto Centre for Underground Mine Construction (RTC-UMC) Program and the significant progress made in the new Smart Underground Monitoring and Integrated Technologies (SUMIT) for Deep Mining program. With a \$2 million dollar mining research grant established in partnership with Ontario Centres of Excellence and Natural Sciences and Engineering Research Council of Canada (NSERC), CEMI is now supporting mining R&D in areas of productivity, water, waste and energy. CEMI has

become established as the leading centre for excellence in mining innovation. We have the knowledge, expertise, leadership capability and capacity to significantly strengthen the technical impact, productivity, and effectiveness within each of the strategic themes.

The five core research and development project categories provide CEMI with an opportunity to attract, develop, and train high quality personnel (HQP). We create opportunities to train and retain some of the brightest young minds in the country. We have strengthened academic linkages, working

with researchers from Laurentian University, Queen's University, Universities of Arizona and Toronto, University of British Columbia, University of Dalian, Colorado School of Mines and Delft University to seed fund ideas of benefit to the mineral sector. And our significant partnership with the Province's Ontario Centres of Excellence, in support of activities related to the jointly funded mining thrust, will go a long way to help create tools and techniques of real value to the mining industry.

Our strategic research and development initiatives are enabling researchers to pursue major federal and provincial grants with letters of support that open doors for funding. With expertise in determining appropriate funding paths, and the ability to help initiate, assist and review funding applications, CEMI is able to assist in the preparation of a multi-million dollar funding applications, like the federal application for a proof of concept project for Rail Veyor Technologies Inc.

CEMI shares the results of collaborative R&D initiatives with the mining community and the broader research community, by offering manuals and guidelines, lecture series, short courses, seminars, workshops and our Wiki, available on the CEMI website. We recognize and champion the idea that taking an idea from concept through implementation is the crucial step in innovation and the only way to ensure solutions are sustainable and economically feasible.

In the last year, we expanded our capability for the development, execution and management of major strategic research programs and to date have obtained the following research and resource funding:

- \$19.7 million for over 40 strategic R&D projects in the areas of exploration, deep mining, integrated mine engineering, environment and sustainability
- \$2.5 million to Research Chairs & Faculty
- \$2.2 million for SME-led projects to help bring innovations to development and potentially market them
- collaborate with over 30 professors and 60 co-op, undergraduate, graduate (MSc, PhD and PDF) students
- \$300K for the IPO over the next 4 years by the Greater Sudbury Development Corporation for the expansion and development of CEMI's Innovation and Prosperity Office, assisting in the

acceleration of Greater Sudbury small business innovation from "idea to implementation"

- \$6.7 in funding for SUMIT (Smart Underground Monitoring and Integrated Technologies for Deep Mining) to deliver on 18 work packages over 4 years
- \$300K in financial and in-kind support for the Rockburst Support Tool project, to aid in the development of a means to lower risks associated with microseismic activity in mines. This project is led by Dr. Ming Cai, MIRARCO/Laurentian University.



"CEMI has a proven track record to deliver key results to industry. Their experienced team of project managers, combined with their unique ability to link the right research organizations and consultants, adds value to our strategic underground mining research projects."

Fred Delabbio

*General Manager Innovation -
Underground, Rio Tinto*



Image courtesy of Vale



MINERAL EXPLORATION RESEARCH & GEOPHYSICS

The implementation of step-change research in the area of exploration (new deposits, expanded mines, mineral resource studies) and geophysics, both on surface and in underground exploration, is strategically important to mining sustainability.

Our industry-driven research focuses on:

- advancing knowledge of the Sudbury Igneous Complex, specifically within the footwall and offset geologic environments, where ore bodies can be valued at \$1000/t, or greater;
- identifying theoretical and practical solutions to issues related to: structure; geochronology; metamorphism/anatexis; and fluid transport, within the Sudbury Basin footwall optimizing future exploration success for high value Ni-Cu-PGM (Precious Group Metals) mineral deposits;
- developing new or improved geophysical detection techniques to optimize the chances of future exploration success.



MINERAL EXPLORATION RESEARCH & GEOPHYSICS

GEOPHYSICS RESEARCH

In February 2011, Dr. Richard Smith was awarded NSERC funding in the amount of \$895,000 over 5 years for his Industrial Research Chair in Exploration Geophysics. The position is sponsored by four industry partners-Vale, Xstrata Nickel, KGHM and Wallbridge Mining, each with large property positions and geophysical datasets in Sudbury. Five post-graduate students (3 masters and 2 doctoral students) are currently working on related projects with unprecedented access to properties, workshop facilities, boreholes, diamond drill core, previous datasets and company geophysical expertise during their studies.

The research being undertaken falls into four main research themes: integrated geophysical studies; physical properties measurements; geophysical data acquisition and processing; and new modeling, inversion and interpretation techniques. These projects are Sudbury Basin-focused and aim at extending the life of the mining camp.



This R&D program has been designed to increase the discovery and development potential of new ore bodies or mines through the creation of advanced geophysical tools. Developing new methodologies that lead to a better understanding of rock mass physical properties is also a research goal and is valuable in reducing the risk profile associated with underground mining. Furthermore, training students to become highly qualified personnel (HQP) with an understanding of new geophysical methods and how they can be used to explore for mineral deposits more effectively substantially speeds advancement in the mining industry.

PROGRESS AND ACHIEVEMENTS

Projects are on track and two are scheduled for completion (with the planned graduation of two MSc. students) in Fall of 2012. Conference and seminar presentations are being made throughout year to ensure knowledge transfer.

MINERAL EXPLORATION RESEARCH

5 projects have been initiated in the area of Mineral Exploration Research. Currently, 2 studies of the South Range rocks are underway, the first, a detailed structural and metamorphic analysis of footwall rocks PhD project, was completed in Q2 2012, and a second PDF project detailing petrologic, geochemical and partial melting studies of South Range rocks is scheduled to be completed in 2014. A PhD project examining experimental studies of the role of Bi, Te, As in PGE fractionation and remobilization during sulfide liquid fractionation metamorphism is scheduled to be completed in 2014 and experimental studies of the role of fluids in the modification and formation of Cu-Ni-PGE systems, PhD project will be completed in 2015. CEMI completed detailed petrologic and geochemical studies of the Parkin rocks, a MSC project in Q3 2011.

PROGRESS AND ACHIEVEMENTS

- Of the five projects initiated, two have been completed resulting in the training of one Masters student and a PDF (Post Doctoral Fellow). Three other PhD-level students are currently in training on their ongoing projects.
- Remaining projects are on track and achieving planned outcomes.
- Numerous conference and seminar presentations as well as annual field trips are being arranged for students providing necessary knowledge transfer to industry.

NEW PROJECTS UNDER REVIEW

TARGETING PRECIOUS GROUP METALS PGM

This project is designed to better understand the relationship between the nickel and copper sulfide zones and make it possible to target precious-metal zones in the future. The objective is to find and cost-efficiently access smaller "streams" of PGM that have traditionally been deemed to costly to mine.

Specifically the project will assess the potential for extracting the remnants of Copper Zones in existing mines at the north end of the Sudbury Basin. Over the last 30 years, several valuable Copper Zones have been discovered in the footwall of the Sudbury Basin, but despite the high value of PGM's

that accompany these deposits, no techniques have been developed to satisfactorily locate or vector similar deposits. Previously, a simple copper-equivalent evaluation of gold was used to cut off mining copper veins that were less than 50cm wide.

LITHO-GEOCHEMISTRY SOFTWARE

Litho-geochemistry software is being developed to facilitate molar element ratio analysis, a variation on Pearce Element Ratio analysis proven highly useful in mineral exploration as it can accurately quantify the degree of hydrothermal alteration, leading explorationists to ore.

The software is being developed jointly by Drs. Cliff Stanley (Dept. of Earth & Environmental Science) and Jim Diamond (Dept. of Computer Science) at Acadia University. It is currently in the 'alpha testing' stage. It works on any computer platform for which the Java computer language exists and produces camera-ready output of molar element ratio diagrams. Some of its valuable characteristics include: full error propagation which allows rigorous cogenetic hypothesis testing; material transfer effect representations for proper material transfer hypothesis testing; interactive data grouping and data symbol control allowing classification of samples on one or many molar element ratio diagrams.

Once 'beta testing' has been completed, this software will be available in the first quarter of 2013.

Two examples of output from the program are presented below.

The first figure, a cogenetic hypothesis testing graphical output from the program applied to historic litho-geochemical data from the McIlvenna Bay volcanic hosted massive sulphide deposit (Saskatchewan), illustrates how un-classified (or mis-classified) data (n = 1640) can be divided into

natural groups defining different lithologies. In this figure, yellow diamonds are felsic volcanic rocks, green diamonds are mafic volcanic rocks, green squares are gabbros, blue circles are migmatitic psammities and volcanic rocks of mixed parentage, purple hexagons are talcose rocks thought to be altered ultramafic flows, and red X's are chemical sediments (chert, banded iron formation, massive sulphide, and semi-massive sulphide). Note that error ellipses have not been plotted on this diagram because no replicate samples or reference materials are available to document data quality.

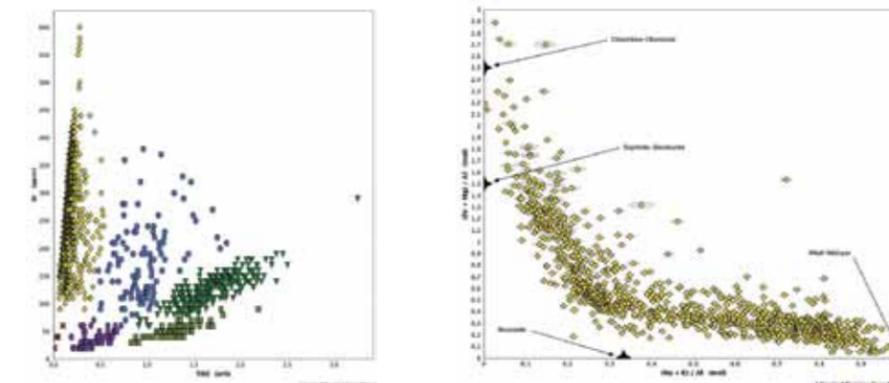
The second figure is a molar element ratio diagram of only the felsic volcanic rocks from the above dataset (n = 1059). Data that plot along the shallow sloping trend between the alkali feldspar and muscovite nodes are variably muscovite altered, whereas samples that are along the steeply sloping trend were completely muscovite altered and are now variably chlorite altered. This molar element ratio diagram illustrates that a (Na+K)/Al molar element ratio can be used to classify alteration in these rocks (values between 1 and 1/3 are muscovite altered; values between 1/3 and 0 are chlorite altered). As a result, this geochemical parameter can be used in these rocks to vector toward the most intense hydrothermal alteration (and thus, mineralization).

Note: assumed measurement errors have been identified so the program plots the two standard deviation error ellipses illustrating the propagated magnitudes of these errors on the diagram.

SOLUTION TEAM

Mineral Industry Research Centre (MERC), Benchmark Six, Department of Earth Sciences at Laurentian University, Acadia University; Vale, Xstrata Nickel, Wallbridge Mining and KGHM.

CEMI Project Leads: D. Duff, D. Morrison





RISK MITIGATION AND COST EFFECTIVENESS FOR MINING HIGHLY STRESSED ORE BODIES AT DEPTH

Research and development of new technologies and processes to ensure safe, profitable mining at depth, with a focus on risk mitigation, mechanized underground excavation, cost reduction, and productivity enhancement.

Our research in this area focuses on:

- understanding rock behaviour response to mining in order to mitigate and manage geotechnical risks
- alleviating the sensitivity to risk for mining investors by reducing the time required in developing a mine and ramping up production



SMART UNDERGROUND MINING AND INTEGRATED TECHNOLOGY OF DEEP MINES

The SUMIT program is developing and advancing smart engineering techniques, technologies and tools to facilitate step-change advances in productivity, efficiency and effectiveness of underground mining at depth in an economic and safe manner. Through collaborative research and development, SUMIT focuses on three major challenges associated with deep underground mining:

- 1. Mitigating Georisk:** Improved rock mass characterization through seismic, stress, strain and 3D geophysical investigations; other means to better interpret dynamic loading processes; and assessment of excavation vulnerability to better anticipate and minimize risk
- 2. Rapid Underground Development:** innovations to accelerate mine construction through effective monitoring of rockmass response to mechanized excavation, innovative material handling systems and unprecedented data integration capability for multi-disciplinary research approaches to increase economic returns while maximizing worker safety
- 3. Mine Sustainability:** footprint reduction in deep mines utilizing localized ventilation intensity, improved environmental controls and optimization of material handling systems.

SUMIT utilizes emerging technologies to provide innovative solutions for ground characterization, underground construction, and energy cost reduction. SUMIT has a current funding commitment of \$6.7 million from CEMI's patron sponsors, Rio Tinto, Vale and Xstrata Nickel as well as from the Ontario's Ministry of Economic Development and Innovation (MEDI). With the involvement of four collaborating Universities in Ontario (Laurentian, Queen's, Toronto and Waterloo) that bring 10 leading academics and a planned two dozen graduate students to the program, CEMI is facilitating the development of a rich partnership of academic and private sector research teams who are collaborating on 18 core projects in 6 research categories working on some of the most pressing challenges facing the deep mining industry.

MITIGATING GEORISK PROJECTS

- Rockmass behavior characterization; differential change measurement; optimal use of existing data; common earth activity models
- Quantify rockmass deformation to mining over time through automated characterization and change detection with 3D digitally scanned virtual excavation boundary & borehole models
- Laboratory and field-based approach to developing rockmass characterization capabilities using seismo-engineering
- Integrated seismic and deformation monitoring of rockmass behaviour
- Real-time monitoring of 3D seismic and other petrophysical data in deep mines
- Mine stiffness monitoring for fault slip control measures
- Direct measurement and mitigation techniques to assess and release stress in deep underground mines
- Development of techniques to assess fault stability
- GeoRisk for fault slip control
- Constitutive criteria monitoring mining and georisk

RAPID UNDERGROUND DEVELOPMENT PROJECTS

- Dynamic ground support research for more effective mine design
- Development of broadband strain sensor networks for deformation measurements in mines
- Seismic signal detection and processing for strainburst potential in TBS
- Automated monitoring of rock fragmentation underground, UMC & fragmentation

MINE SUSTAINABILITY PROJECTS

- Demand side energy conservation via Ventilation On Demand
- Demand side energy conservation via heat recovery, transport & storage
- Laying foundations for innovation in on-site supply side management via ventilation

The SUMIT Research teams have access to some of the world's deepest mines. These mines serve as "living laboratories" where underground research is being conducted at active mines sites in Ontario to optimize experiments, provide real-world outcomes and maximize the chance for research success. SUMIT is working towards the creation of a networked Deep Mine Observatory in Ontario. It is anticipated that these projects will put Ontario on the map as an international centre of knowledge relating to mitigating risk in mining.

ACHIEVEMENTS AND OUTCOMES

All necessary agreements to facilitate work (with government, industry) have been, or are in the process of being finalized. Research project scopes and budgets have been re-profiled to comply with new cash flow constraints imposed by the Ontario Government. Most work is still in the exploratory stage and researchers are focused on building staff capability to initiate identified projects.

Of the 18 sub-projects comprising the SUMIT program, research has already begun on 8 at all 3 of the institutions involved in the program – Laurentian University, Queen's University and University of Toronto, as well as at University of Waterloo.

7 MSc. students, 7 PhD students and 5 undergraduate students are involved. More students will join as the SUMIT projects ramp up this fall. 4 journal papers have been published and an additional 6 are being reviewed for publication. As well, 11 refereed conference papers were published and 23 conference presentations made. Projects underway include:

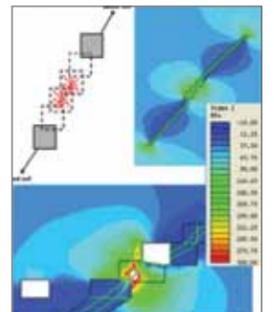
- Lab-based work on the design of new fiber optics based strain measurement devices and on optimizing the use of fiber optics as a means to lower the cost and more broadly measure strain in mines.
- Geophysical sensor deployment at one test site, aimed at measuring and monitoring rockmass performance in response to an approaching mining front. The aim is to "listen" to the rockmass and identify if any geophysical characteristics indicative of change or imminent failure of the rockmass can be determined.
- Laser-based technology to measure rockmass change and track displacement induced by mining is being tested, as are related inversion techniques to optimize the use of this technology for this purpose.



- Hydraulic fracturing technology to help characterize rockmass and manage stress distribution to lower the risk associated with strain bursting and stress buildup. In addition, a broader "hydro damage" project being initiated separately through CEMI.
- Hazard mapping and ground motion monitoring tools (software) are being developed as a means to enable geo-technical hazard assessment in burst prone mines and to facilitate dynamic ground support strategy selection.
- Demand side energy conservation via VOD and Heat Recovery to lay the foundation for innovation for on-site supply management. This will enable implementation of a progressive energy management practice for minerals operations; and develop approaches to model simple tri-generation systems for the distribution of environmental load in mines.

UNDERSTANDING HYDRAULIC FRACTURING THROUGH A MONITORED UNDERGROUND MINE-BACK EXPERIMENT

To advance state of the art use of hydraulic fracturing techniques for the Mining and Oil and Gas sectors, an experimental design and proof of concept study aimed at developing a fully monitored mine-back experiment in an underground mine has been initiated. This project will provide an opportunity for 4D geophysical monitoring and direct examination of hydraulic fracturing treatment within a well-characterized rockmass. The project will contribute to an improved understanding of the geomechanical processes that occur during reservoir stimulations as well as of the associated geophysical observables, while at the same time mitigating risks associated with potentially disruptive rockbursting in mines. Advances in the state of the art of hydraulic fracturing techniques for the Mining industry will:



- Provide more effective stress management at depth leading to enhanced **personnel safety** and capital asset protection
- **Increase the number of horizons/mining fronts** (mining intensity) representing a significant potential boost to mine productivity



- **Improve mine project NPVs** by using stress shedding/ de-stressing techniques to **mitigate risks associated with development delays.**
- Facilitate the use of mechanical excavation techniques in mines
- Enable advances in approaches to **in situ leaching** of ores in underground mines
- Provide **insights into mechanisms for stress transfer** and the potential to trigger seismic events on seismogenic structures near the frac treatment zone.

Innovative hydro-fracturing and waste injection technologies developed by the Oil and Gas industry now make it possible to not only fracture the ground but to further damage it by creating multiple fractures. Changing the ground compliance by filling those fractures with engineered materials (designed proppants) can lead to controlled redistribution of stress or shielding of sensitive locations where high stresses pose a threat. Technology has advanced to the stage where field tests are required to demonstrate rock mass modification at various scales (with low to high injection volumes and different rates) in a controlled and predictable manner.

ANTICIPATED IMPACTS

1. An understanding of the causes and effects of rock bursting in underground mines, namely the release of energy stored in the rock around excavations and in faults, near the fault tips and in splays;
2. Detailed comparisons of numerical simulations and in actual situ observations of induced fractures to clarify the geomechanical aspects and effects of fracture treatment;
3. The development of ways to characterize the subsurface better through pre- and post-treatment geophysical surveys including seismic and electromagnetic tomography;
4. Usage of target-surrounding sensor distribution to obtain a comprehensive microseismic event catalogue;
5. Monitoring of in situ stress changes during fracture treatment to calibrate geomechanical models and develop better stress management approaches;
6. Understanding of “mine system stiffness” and how it affects the brittle failure process and energy storage in rock masses containing “weak” structures with mobilization potential.

NEXT STEPS

A three-stage approach is recommended to produce value in a timely fashion with each stage to be completed within a 12 month period:

1. Stage I – Proof of concept and experimental design
2. Stage II – Instrumented demonstration project with mine-through trial after low-volume water and grout injection
3. Stage III – Instrumented mine-through project with high-volume injection to change rock mass behaviour and stress state, including tracers and proppant materials, perhaps including thermoelastic stress management techniques

GEORISK PROGRESS AND ACHIEVEMENTS

BURSTSUPPORT TOOL

To develop a better approach to dealing with dynamic ground support requirements in underground burst prone mines, CEMI and MIRARCO, with input from Vale in Sudbury and LKAB in Sweden, are developing an updated guidelines document. These guidelines build on geomechanics and rock support knowledge developed since the release of the Canadian Rock-burst Support Handbook in 1996.

Additionally, using these guidelines as a foundation, a software tool is under construction for use by rock mechanics engineers at mines. The software will help improve rock support design strategies in dynamic burst-prone areas, by enabling the selection of appropriate ground support elements when dealing with dynamic loading conditions in underground mines. This user-friendly, standalone software package will be designed so that outputs may be readily incorporated into existing modeling and visualization platforms at mines.

Dr. Ming Cai, from MIRARCO and Laurentian University, the lead researcher on this project was awarded an NSERC grant in support of the research component of this project in the amount of \$300,000. He is currently working with 2 MSc.students, 1 PhD student and a PDF on this project.

All seven chapters of the Guidelines Document for Practitioners have been written and are currently under review. A beta version of the software is being vetted by engineers at Vale and LKAB. Both the guidelines and software tool are expected to be released in 2013.



QUANTIFYING AND COMMUNICATING GEO TECHNICAL RISKS IN DEEP UNDERGROUND MINES

The GeoRisk current Best Practices Manual is designed to draw attention to the complexity of geotechnical risk at the various stages of project development and how this, if properly understood and addressed, can help to minimize the risk associated with mine design. The manual focuses on the idea of risk itself, specifically, the assessment, mitigation, and management of geotechnical risks in our deep underground mines. This project is currently seeking industry sponsorship.

The manual addresses the following questions: How do we quantify geotechnical risk and its impact on the bottom line for management personnel? How can we best communicate our understanding of and level of confidence in our assessment of geo technical risk? How can we identify and understand the sub-components of geotechnical risk? Using a process that borrows from the approach that geologists currently implement with regard to mineral resource estimates (inferred, indicated and measured), the project aims to establish an improved quantifying method aimed at identifying, reducing and communicating overall project risk for the underground mining industry. Dr. Suzanne Lacasse of the Norwegian Geotechnical Institute (NGI) has been engaged to help scope this 18-month project, which will be initiated in late 2012 or early 2013. Eight industry sponsors are required to help make this project a reality, with Vale already committed. To learn more about this project, contact Damien Duff to become involved.

STRUCTURAL GEOLOGY GUIDELINES FOR AIDING CHARACTERIZATION OF DEEP MINING FAULT BEHAVIOUR

CEMI is proud to announce the completion of the **Structural Geology Guidelines for Aiding Characterization of Deep Mining Fault Behaviour.**

The manual provides guidelines for improving current levels of structural geologic data collection and evaluation in rockburst-prone areas in underground mines. It was designed to help geologists and engineers better work together to understand and interpret rock mass conditions associated with faulting and fault slip type seismicity and the impact they can have on underground mine design and planning.



It is anticipated that the guidelines will have primary application in two key areas:

- structurally complex, high stress, rockburst-prone mine settings
- active and/or planned mines where rockbursting or disruptive seismic events are not currently known but, because of the geologic environment and/or mining depth, could activate potentially dangerous energy release conditions

In April 2012, a technical overview workshop was held as a pre-cursor to the full 2-day course offered in October, 2012. Video recordings of the half-day session can be viewed on the CEMI website. CEMI, together with Golder Associates and SRK Consulting hosted the full course, which was comprised of technical presentations and hands-on practical sessions.

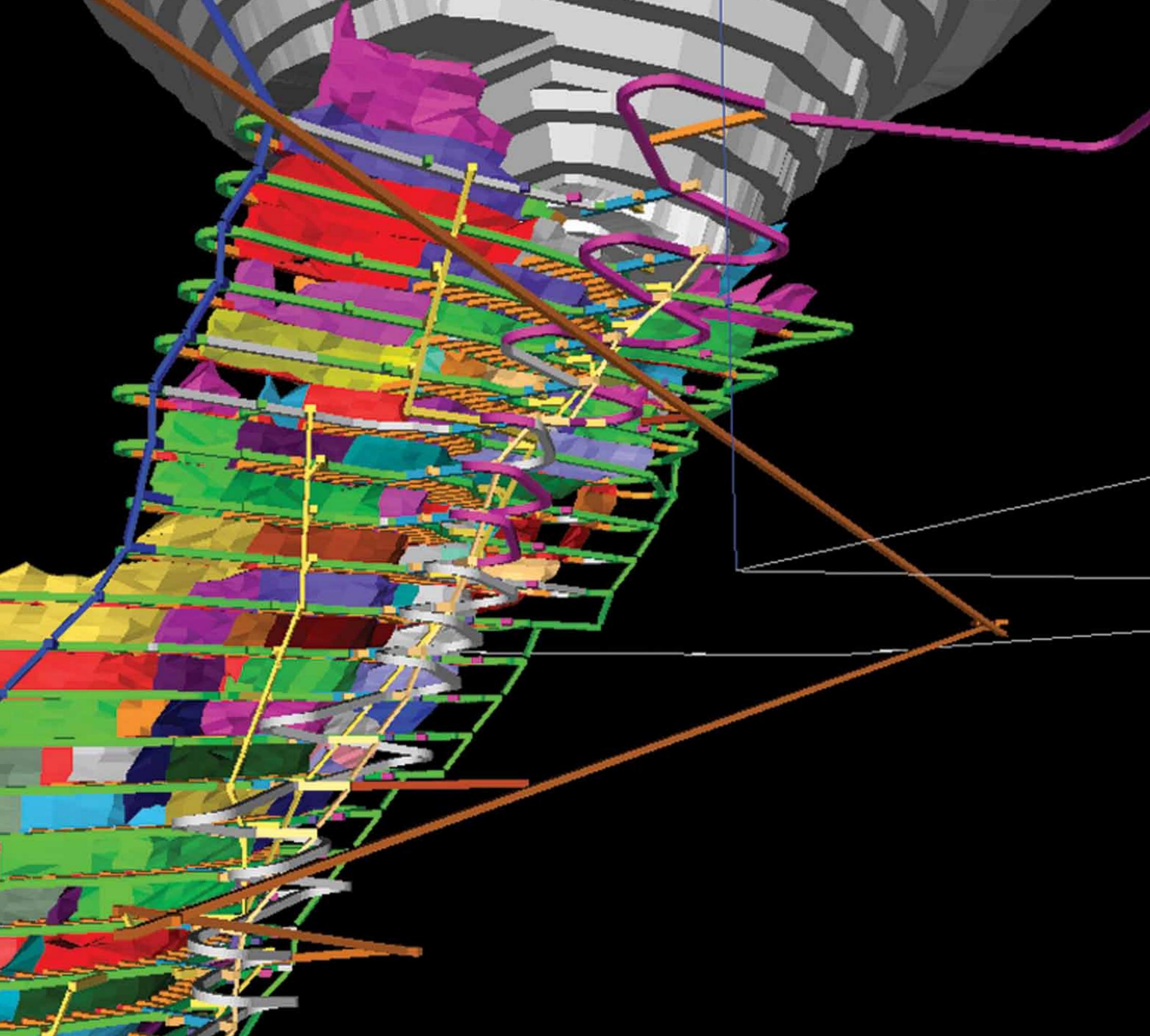
The course provided attendees with insight into: structural geology and other geotechnical aspects and risks posed in burst-prone mines; measurement of drill core and drift mapping; and the tools required to optimize design and response effectiveness during project/mine design, development and operation.

Approximately 90 representatives from major mining companies, junior exploration companies, consultancies, academia (professors, graduate and under-graduate students) were in attendance. Course instructors included: Trevor Carter, Principal, Golder Associates; Wayne Barnett, Principal Structural Geologist, SRK Consulting; Rob Bewick, CEMI Program Coordinator, Rio Tinto Centre for Underground Mine Construction; Benoit Valley, Senior Researcher, CEMI and Geomechanics Research Centre, MIRARCO.

SOLUTION TEAM:

Laurentian University, Queen’s University, University of Toronto, University of Waterloo, University of Alberta, University of Calgary, Carleton University, University of British Columbia, Vale, Rio Tinto, Xstrata Nickel and Xstrata Copper, LKAB and various consultants.

CEMI Project Leads: D. Duff, P. K. Kaiser, G. Hughes



MINE DESIGN TO EXTRACT OPTIMAL MINE VALUE WITH ENABLING TECHNOLOGIES

Strategic research and development in the areas of: Maximum Mine Value and Mine Design to enhance safety and performance, minimize impact and cost risk and emphasize best practices; Enabling Technologies that result in advances in data and knowledge transfer.

Our industry-driven research:

- identifies knowledge gaps and new approaches in mine design for the development of new tools or additional research to safely extract optimal value
- identifies energy savings through ventilation improvements
- aids in the training of young professionals



VENTILATION ON DEMAND FOR PRODUCTION

Building on the success of the original Community Adjustment Fund (CAF-VOD) project and on work already underway, Ventilation on Demand for Production (VOD4P) focuses on demonstrating the financial benefits of increasing production capacity using VOD where possible – while minimizing energy consumption when production capacity is not available. As a strategic mine-design tool, VOD4P will allow the optimization of future mine development and infrastructure, leading to higher optimization and productivity of mine resources – at lower operating costs. This will be achieved through the use of tactical production changes within a shift that enhance mine productivity and output to accelerate the process and maximize productivity of the mine.



VOD4P aims to accelerate and mature the VOD technology in use, add enhancements, and demonstrate how these technologies can be applied to increase production capacity.

The CAF-VOD project identified a number of limitations with the current understanding and application of VOD technologies. These included: quality of installation, location, tracking technology and accuracy, sensor type and functionality, and control algorithms. Certain aspects within these issues are installation-specific and, overtime, will be addressed by the system providers and equipment OEMs. The VOD4P project will focus on topics that are applicable across the industry, increasing the understanding, improving the speed and decreasing the risk of adoption.

The program is divided into the following 6 themes:

1. Environmental Contaminants: to specifically examine gaseous, particulate and environmental contaminants that may become the driving control parameters for a VOD system, including the exploration of “smart” sensors, using surrogate relationships for exposure or indicators of activity. Identifying what the best surrogate and indicator should be for their requirements and limitations. This forms part of the technology feasibility assessment elements. The project will also continue the in-mine monitoring programs, to determine what particulate and gaseous contaminant loadings exist, while the VOD system is operating in dynamic mode, responding to the movement of vehicles in and out of the auxiliary zones.

2. Engine Contaminants: vehicle based engine and ambient monitoring could become a significant long term risk mitigation strategy, providing an auditable means of “demonstrating best practice”, and the development of workplace hygiene monitoring programs that reflect active workplaces. Integration of mobile equipment-based environmental and engine exhaust sensors will be explored as a means of improving mine wide environmental monitoring, and assisting with a potential Quantity to Quality control transition. Identifying benefits derived from a real-time-production vehicle engine-exhaust-monitoring program will be evaluated. It is also expected that the detailed engine monitoring may identify maintenance issues with the engine and equipment mechanical systems, without requiring that the vehicle be taken out of service.

3. Modeling: production and air quality data collected in the operating mines will be used to verify the model’s production capacity projections. Additionally, the models will be modified so that ventilation constraints can be sent back to the discrete event model and used to test the possibility of increasing production, or identifying whether there were other hidden bottlenecks in the system. This component of the VOD4P program is particularly important as it may identify changes that can be made at the mine design stage or to production scheduling activities that will, with the use of VOD, provide additional production capacity in “ventilation constrained” mines.

4. Monitoring: based on the results of a post CAF-VOD review of 6 months of mine VOD data, there is a clear need to develop and document best practices to address the need to maintain sensor calibration for all in-mine sensors. High-level goals include transitioning from a compliance

monitoring mindset to a control mindset currently being used in most surface operations. Assessments will continue on environmental monitors, state monitors (including airflows in drifts and ducts) and on evaluating the overall capabilities of tracking systems and their importance to VOD control. The monitoring theme will include detailed field and laboratory studies to prove the capabilities.



Image courtesy of Bestech

5. Controls: the CAF-VOD project work highlighted a number of issues that need to be addressed if VOD systems are going to dynamically respond to vehicle movement and activity. VOD4P will look at a control strategy for:

- a) dealing with contention when more than one zone creates a demand that exceeds the possible supply;
- b) determining how sensor readings should be interpreted to provide effective control. The location of the sensors with respect to the workings, and the associated dilution and latency must be considered within any control strategy.

6. VOD for Caving: this component is specific to operators with large caving projects and is conditional upon receiving funding. Although still



under development, this theme will focus on the applicability of VOD technologies to the three major phases of cave developments: Infrastructure, footprint development and production.

As part of the programs funding package, a number of detailed deliverables will address issues that are of immediate importance to Xstrata’s Nickel Rim South and Vale’s Coleman Mine. It is expected that the findings from these work packages will be transferable to other mines in Xstrata Nickel and Vale’s Sudbury operations.

CAF-VOD modeling quantified that the payback on the capital and operating investment used to implement VOD increases dramatically when production is increased by scavenging air, from multiple locations, using dynamic VOD control. The VOD4P program will validate these theoretical findings and develop best practices to allow the implementation of the VOD4P within existing operations.

Using the CEMI concept of testing and demonstrating research ideas in “living laboratories”, project partner sites will be used to validate VOD4P theoretical production improvements. These improvements will first be simulated using an expanded version of the VREX modeling framework and then tested at sponsor mine sites. The project will also look at how VOD may permit (or require) changes to current mine design best practice.

NEXT STEPS

The VOD4P program will develop a system of metrics, best practices and analysis that will create a framework to help scope, assess, acquire, install and implement VOD technologies.

Field studies will continue to be used to validate the modeling results and will provide scientific data to assess the overall quality of the work environment. Particular emphasis will be placed on monitoring during VOD dynamic control.

As part of the CEMI mandate to promote technology innovation, part of the focus for VOD4P is to create the required support frameworks to allow new technologies to be implemented quicker enabling expected financial paybacks to be realized faster.



VALUE MINE

CEMI is committed to completing work packages for:

- Data Mining and Analysis of RFID Tracking Data.
- Blast Gas Clearance Analysis.
- Pressure differential Across Louvers.

It is anticipated that 3-5 highly qualified personnel (from academia) will be employed over the life of the project and that these individuals will find employment within the mining industry.

INTEGRATED DRILL-BLAST PROJECT



Current drill-and-blast advance rates are now at historic lows – less than 4m/day vs. advance rates of 12m/day less than 20 years ago. Today, the safest and most efficient tunnel-advance technique is the tunnel-boring machine (TBM). However, most underground base metal mines are too small and too irregular in shape to make use of this kind of technology. CEMI's Integrated Drill-Blast (IDB) process intends to demonstrate the effectiveness of a parallel-task approach by re-organizing traditional drill and blast processes and combining them with the operating principles of TBM. The IDB approach will require lower capital cost than the TBM approach, will accommodate complex geometries and will cope with the effects of high stresses and seismicity.

Four components are required for the development of CEMI's (IDB) process: a Face Clearing System (FCS); a Face Production System (FPS); a Ground Support System (GSS); combined with the All-round Canopy (ARC). With the development of these components, the IDB Process will be able to achieve the advance rates of 8 to 12m/day in drifts of 5m square face or larger, while improving upon the safety conditions offered in current drill-and-blast headings in rockbursting conditions. The IDB Process offers the potential to rejuvenate drill and blast productivity thereby increasing profitability of underground mining in ultra-deep, high-stress conditions.

NEXT STEPS

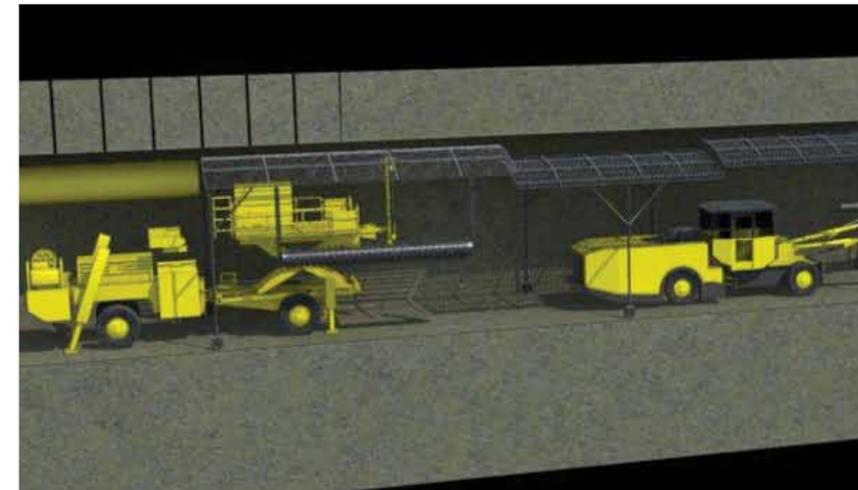
1. The conceptual design of the canopy is currently being completed and with approval from industrial sponsors a detailed project plan will focus on field trials beginning in Q2-2013.
2. The GSS systems are readily available and will require minimal cost
3. The equipment to make the FPS is readily available and with approval a detailed project plan will focus on combining existing components into one unit.

INTEGRATED PERSONAL PROTECTIVE EQUIPMENT (IPPE)

Over the last 30 years, personal protection equipment in mines has advanced, with the addition of hearing, eye and optional gas/particulate protection to traditional coveralls, boots and gloves. In addition, many miners now carry some form of wireless communication system. CEMI proposes to develop a new Integrated Personal Protection Equipment that will combine required protection with hands-free audio and visual communication systems. An option to provide cooling is also being considered.



The objective is to improve human productivity and safety underground. The IPPE approach creates the opportunity to improve on the level of protection offered by traditional PPE and allow the movement of expertise throughout the mine without moving people. This will increase the value proposition of an optimized human-driven production system – highly effective people underground, generating significantly higher value than at present. In addition to providing superior protection, improved comfort and ease of use, this will create a new image of the underground miner in the 21st century.



NEXT STEPS

CEMI is gathering existing expertise from Ontario and Quebec to develop the conceptual design for a work package proposal. The objective is to address current and future conditions in the deep mines in Ontario/Quebec while also addressing the more arduous conditions that exist in underground mines in Australia, the US and elsewhere.

SOLUTION TEAM

Université de Montréal, University of Waterloo
CEMI Project Leads: G. Hughes, A. Akerman, S. Haapamaki, D. Morrison

VALUE MINE



MINE DESIGN
OPTIMAL VALUE



UNDERGROUND MINE CONSTRUCTION FOR IMPROVED PRODUCTIVITY AND STABILITY

Safe, rapid, mechanized excavation of underground mine construction and ground control for mining at depth

Strategic step-change research and development in safe, rapid and mechanized development for underground mines as well as on mechanized selective ore extraction are being pursued by several mining companies including Rio Tinto, Anglo Gold Ashanti and Vale Canada Inc. Our research aims to overcome several challenges in mine construction, in particular, challenges related to introducing new technologies to perform well in naturally variable ground.

The program focuses on:

- implementation of new and innovative mechanized technologies, for improved speed and quality of underground infrastructure construction;
- ground control process assessment and development to support advances in rapid mechanised development systems for vertical and horizontal applications;
- assessment and advances in conventional drill and blast excavation processes; and
- use of Rail Veyor technology, with emphasis on geotechnical and fragmentation parameters.



More and more, mining is moving deeper underground as new ore bodies are identified further into the earth. Our Patron Rio Tinto alone anticipates more than 50% of future Copper production will be from deep underground operations. However, construction of underground mines can be a slow process that is technically challenging and expensive. Challenges include: rock behaviour problems and ground control issues which can lead to problems with machine utilization and performance issues and delays with elevated ground control costs which may consume much of the benefits gained from advances in mechanized high speed development. Creating next-generation technologies for mining operations that result in improved safety, greater efficiency, lower production costs, improved health and environmental performance with more attractive working conditions will be essential to the success of large-scale mining operations of the future.

RIO TINTO CENTRE FOR UNDERGROUND CONSTRUCTION (RTC-UMC) AT CEMI

With the transition of CEMI's former CEO, Dr. Peter Kaiser, to lead the Rio Tinto Centre for Underground Mine Construction as a division of CEMI, this Centre became fully operational during the year. The Centre's role is to create step-change advances in support of Rio Tinto's Mine of the Future™ program, enabling technology developments and implementation at mines, and adding value to Rio Tinto's mining operations. Research into mechanized excavation for both shaft boring systems (SBS) and tunnel boring systems (TBS), along with development of technology to better anticipate ground behavior, have been identified as key focal points for underground construction by the Centre. These are tied directly to the key driver for the development of large underground operations, namely more rapid development. In practice, this means faster development through optimal layouts, low risks for delays, cost reductions achieved through stable pillars and draw points design, stable raises and ore passes, and optimal support with less rehabilitation. A long list of projects in these areas is underway to find economic solutions that work with acceptable geomechanics risks.



With the first of the new technologies, the TBS produced by Aker Wirth, having just arrived at the trial site at Rio Tinto's Northparkes Copper Mine, in Australia, the Centre is ramping up to assist Rio Tinto in trialing this new tunneling concept. The Aker Wirth TBS utilizes an undercutting technique that offers a number of advantages to conventional disc cutting. Input from the Rio Tinto team has been added to learnings from an earlier concept trialed in the 1990's to develop this new concept. The second TBS Rio Tinto is preparing to trial, and is currently in fabrication by Atlas Copco. This TBS also utilizes learnings from previous Atlas Copco products and concepts, and combined with Rio Tinto team input, is designed to meet the needs of Rio Tinto's future underground mines. The 3rd new system under development is a Shaft Boring System (SBS) with Herrenknecht. This new SBS should dramatically improve the construction of deep underground shafts in terms of both safety and construction rates. Designs for this system are being finalized. It is estimated that by combining the benefits of these three systems, the construction period needed for an average block cave mine can be reduced by as much as 40%.

Since deep mining operations bring many other challenges, the Centre has worked closely with representatives from the majority of Rio Tinto's underground projects and operations. These include projects in Mongolia, Australia, South Africa, and the U.S.A.



Through these discussions, a technical road map has been developed that aims to create value through minimizing GeoHazards in underground construction. Addressing the strategic geomechanics issues of rock mass characterization for deep mines, specifically, the long-term technical goals of the Centre are to:

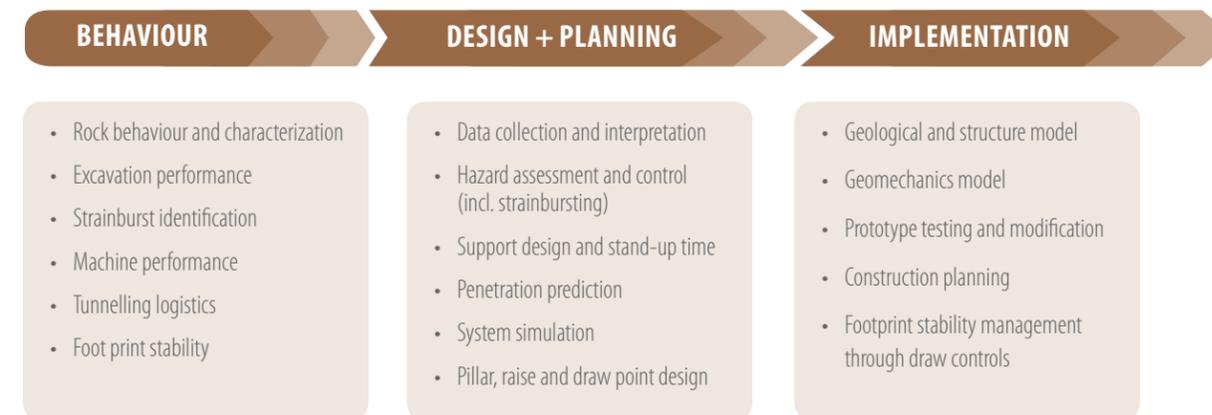
- Improve rock mass characterization techniques for footprint design using mechanized excavation and drill and blast techniques
 - Assist in ground characterization for mechanized excavation trials;
 - Guide data collection and interpretation for performance improvement;
 - Assist in extrapolating findings from trials to forecast TBS and SBS performance in other ground conditions;
- Improve excavation stability assessment and support selection for mine and infrastructure development.

The plan is structured to provide a continuum from rock mass behaviour monitoring through design and planning to implementation at trial sites and mining operations.

Given that geomechanics risks often lead to delays or sub-optimal solutions, geomechanical hazard (GeoHazard) management targeting step-changes in design optimization and cost reduction are a key mandate of the Centre.

The Centre plays a significant role in assisting in the development and implementation of innovative technologies, minimizing delays and creating value through speed and risk mitigation. For mechanization, the Centre largely focuses on matching technologies to the anticipated ground behaviour and optimizing the logistics during the operation of the equipment. Ultimately, the work of the Centre must contribute to the implementation of R&D findings, as step-change innovation will only be achieved if it is successfully implemented at mines. Hence, the Centre will increasingly focus on non-technology matters that will assist the mining operations in staying on schedule and on mitigating safety and investor risks.

The new road map of the Centre is summarized in an activity matrix relating functions, such as people development, safety, development of innovative technologies and techniques, to technical objectives, such as rock mass characterization, tunnel and shaft construction, excavation and pillar stability and ground support.





PROGRESS AND OUTLOOK

The Rio Tinto Centre for Underground Mine Construction (RTC-UMC) at CEMI, is now fully operational and being lead by Peter Kaiser and Rob Bewick. The Centre supports Rio Tinto Innovation's Underground Team led by Fred Delabbio, part of the Rio Tinto Mine of the Future program™, which focuses on developing and testing new technologies in autonomy, underground tunneling and mineral recovery.

- Of more than 30 work packages under the RTC-UMC's program, ten are currently active (in 2012) and another ten are under development.
- The active work packages are related to assessing the performance of tunnel boring systems (TBSs), including data acquisition, supplemental rock testing, and the development of a rockmass model.
- As the first Rio Tinto TBS will cut rock late this year, work related to data interpretation is ramping up rapidly.

- Preliminary studies of test sites for the 2nd TBS and SBS are underway.
- New work packages are in the approval process to implement the tasks identified in the activity matrix.
- A study comparing TBM and drill and blast advances in civil construction has been commissioned and will be completed this year.
- The Centre is hosting Dr. Florian Amann from the Federal Technical University of Zurich, an expert in engineering geology and tunnel boring machine (TBM) performance, predominantly in the civil industry. Dr. Amann has been contracted to assist in the Centre's efforts to facilitate the introduction of TBSs and SBSs in deep mining.
- As outlined above, a roadmap for the Centre has been developed to guide future work. For this purpose, a workshop was held in Phoenix, Arizona earlier this year to discuss future needs and opportunities at Rio Tinto operations and projects.

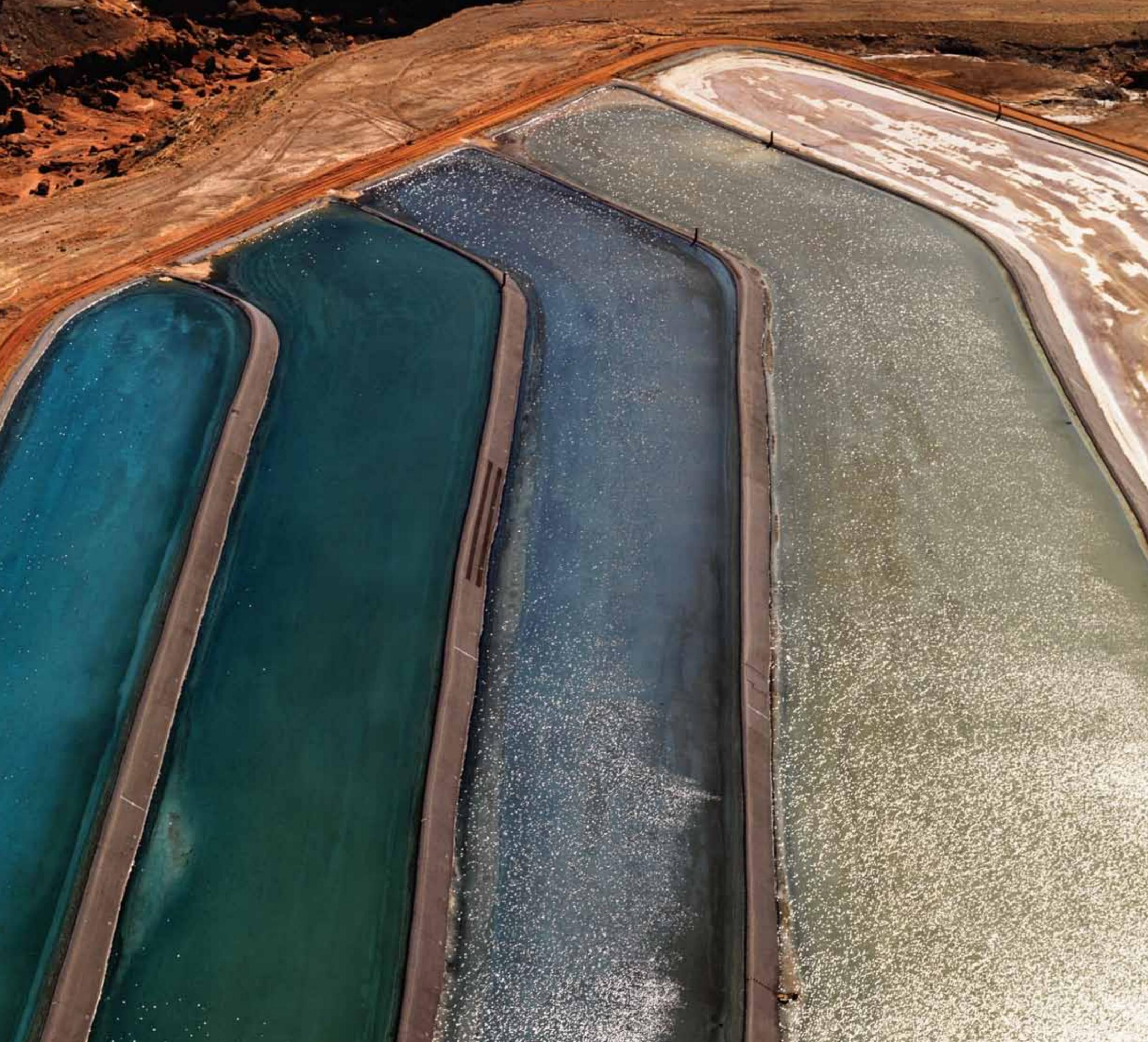
- A new major opportunity for CEMI and the RTC-UMC will present itself when the excavation of the Characterization Level at Resolution Copper Mine (RCM) starts after the shaft reaches the bottom at 2000m. In preparation for this development, RTC-UMC hosted a two-day meeting of experts to assist in the planning of the proposed characterization level at Resolution Copper.

SOLUTION TEAM

Collaborating organizations include Itasca U.S.; Herrenknecht AG; Aker Wirth; Atlas Copco; MIRARCO, and Laurentian University, Queen's University, Universities of Arizona and Toronto, University of British Columbia, University of Dalian, Delft University, The Federal Technical University of Zurich, and others to be determined based on required expertise.

CEMI Project Leads: P. K. Kaiser, R. Bewick





ENVIRONMENTAL STUDIES AND SUSTAINABILITY

Research is underway to try to identify processes that might lead to more environmentally benign results and better stewardship of mineral resources. The current strategy is to provide modest funding to initiate novel techniques or reconsider previously abandoned techniques for the secondary processing of mine waste and mine waste water. The outcome is to assemble a collection of processes that can be developed into future major research programs. Research in this area focuses on:

- initiatives to develop comprehensive remote monitoring packages for tailings management facilities (TMF) to: monitor potential geotechnical instability of containment structures; anticipate potential for over- and under-supply of water for aqueous cover to the tailings; and improve the reliability of performance of tailings management facilities, reducing the risk of environmental impact.
- initiatives to reduce potential long-term liabilities for mining operations by eliminating potential sources of Acid Mine Drainage or Metal Leaching to produce benign waste products
- initiatives to improve the recovery of metals from mine waste and waste water and potentially lead to a significant reduction of the footprint from mine waste and waste water
- initiatives to reduce environmental impacts from relic mine sites through improved treatment processes that allow recovery of saleable metals to offset long-term operating costs for treatment facilities



SUSTAIN MINE

SULFIDE TAILING REMEDIATION AND MATERIAL RECOVERY USING MICROWAVE IRRADIATION

The general objective of this new project is to find an alternate treatment for sulfide minerals, thereby reducing its quantity stored in mine tailings. The new treatment would allow for the recovery of valuable metals and limit the problem of acid mine drainage (AMD). Initial work has shown that, under appropriate microwave (MW) conditions, sulfides (S²⁻) can be effectively converted to elemental sulfur (S⁰). This project is focusing on pyrrhotite to determine the variations of power, frequency and duration that effectively remove sulfide and examine, the chemical characterization of the material after MW treatment.

CHAIR IN HOLISTIC MINING PRACTICES

CEMI has seeded several small chemical/biochemical projects looking at various aspect of treating sulphidic tailings, especially those that contain pyrite and pyrrhotite. This is primarily an effort to engage non-mining LU Faculty who can connect CEMI to a much wider scientific community, capable of addressing environmental issues as well as secondary extractive techniques.

Increased competitive economic interests related to water access and availability, as well as the cost of water for use in mineral processing, is driving the need for new approaches to sulphidic tailing treatment.

At relic mine sites across the Province, the potential exists to reprocess waste materials to recover previously left behind mineral values and reduce the long-term environmental impacts of these sites. New approaches to mineral processing and waste and water treatment that take advantage of remaining mineral values at these sites are currently being evaluated. CEMI is also evaluating whether these approaches can further reduce or eliminate the requirement for long term institutional monitoring and maintenance. The development of these new technologies would help to address the needs of government and the mining industry. Additionally, it may present economic opportunities for First Nations communities near these sites.

In Ontario, the 'Ring of Fire' mineral developments are being conceptually designed with conventional approaches. CEMI is taking a more innovative and strategic approach, using the 'Ring of Fire' development as the catalyst

to transform the social and economic conditions in the Far North and create an entry point for First Nations people into the northern economy. Our hypothesis is that tortation of equipment, supplies and the final end product of the mining operations. We expect this approach will accelerate the rate of development of mineral deposits and reduce infrastructure capital requirement in the short term. These 'Ring of Fire' developments can enable the establishment of manufacturing and support centres to meet the needs of development in the Far North while establishing commercial enterprises with the capacity to expand and accelerate the development of the Northern Ontario frontier communities and other northern environments.

PROGRESS AND ACHIEVEMENTS

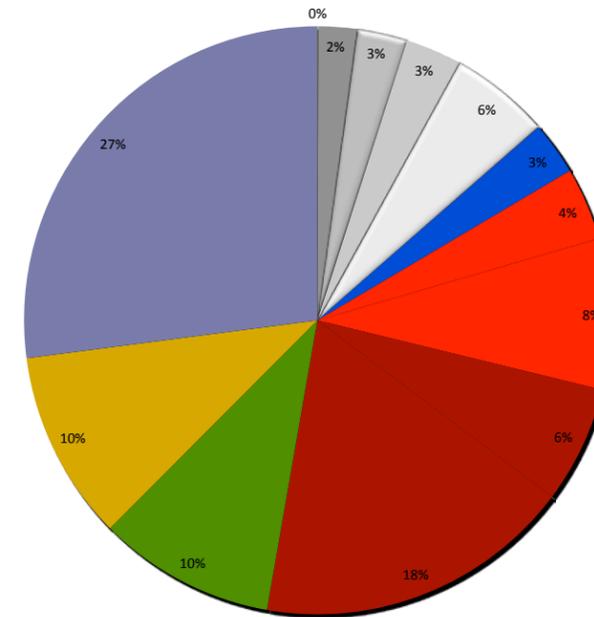
CEMI announced the appointment of Mr. Leon C. Botham, MSCE, P.Eng. as R&D Program Director. He is presently Vice-President, Mining at McElhanney Consulting Services Ltd., and in addition to his current role with McElhanney, he will be working with the CEMI team to assist and advise CEMI in the areas of Environment and Sustainability related to mining. In the role of R&D Program Director for Environment and Sustainability, Mr. Botham will work with other divisions within CEMI to identify research topics and will provide direction to, and monitor the performance of the researchers working on tailings management, waste geo-chemistry and biochemistry research projects. Mr. Botham will liaise with industrial clients who have projects with CEMI to identify potential research topics. He will also coordinate with other research centres to encourage collaboration on topics of interest.

SOLUTION TEAM

MineSense Technologies Limited, Xstrata Process Support (XPS), MIRARCO, CANMET, Golder Associates, Laurentian University
CEMI Project Leads: D. Morrison, L. Botham

FINANCIAL STATEMENTS

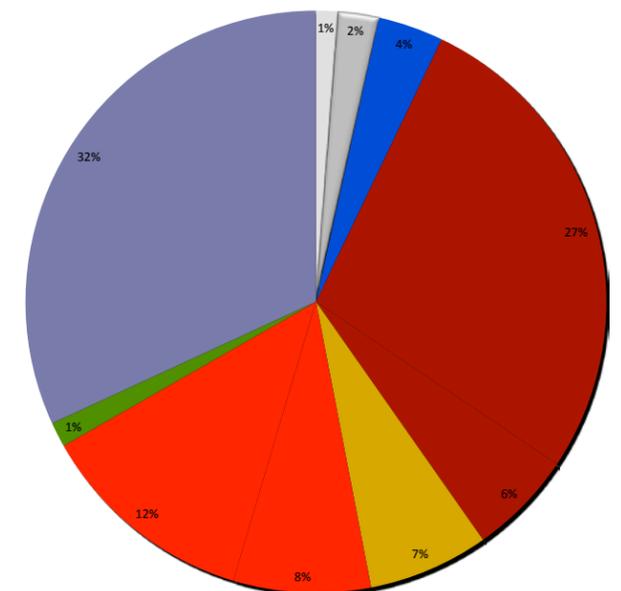
2011 - 2012 EXPENDITURES \$4,020,504



- Other: 0.05% - \$2,115.94
- Development: 2.12% - \$85,339.26
- Outreach Events: 2.77% - \$111,513.35
- SME Support: 3.09% - \$124,414.42
- HQP: 5.55% - \$223,186.54
- Find Mine: 2.91% - \$116,969.34
- Construct Mine: 4.01% - \$161,109.26
- Rio Tinto: 8.29% - \$333,402.37
- SUMIT: 6.43% - \$258,545.91
- Deep Mine: 17.52% - \$704,412.16
- Sustain Mine: 9.74% - \$391,556.09
- Value Mine: 10.45% - \$420,046.67
- Administration: 27.06% - \$1,087,892.69

2011 - 2012 REVENUE \$3,298,100

- HQP: 1.21% - \$40,055
- SME Support: 2.27% - \$75,000
- Find Mine: 3.64% - \$120,000.00
- SUMIT: 27.29% - \$900,000
- Deep Mine: 5.83% - \$192,160
- Value Mine: 6.71% - \$221,426
- Construct Mine: 7.64% - \$251,983
- Rio Tinto: 12.16% - \$401,124
- Sustain Mine: 1.39% - \$45,701
- Unallocated Funding: 31.86% - \$1,050,651



INNOVATION & PROSPERITY OFFICE (IPO) AT CEMI

The Innovation and Prosperity Office (IPO) at CEMI was established in 2011 and provides support for local small to medium enterprise (SME) innovators with ideas, products or services of interest to the mineral industry. The IPO acts as CEMI's liaison with local SMEs in order to accelerate the further development of their innovative initiatives and help bring them to market. The IPO also scans the globe for relevant R&D opportunities of benefit to local SMEs. Creating new opportunities for business-to-business collaboration and private-public sector linkages, the IPO supports the SME innovator community to access the resources and partnerships necessary to advance ideas to testing and implementation stages. It is a natural collaboration for CEMI, whose focus is to facilitate innovation and expand and strengthen the economic activity of the mining services and supply within the Greater Sudbury Area.

Specifically, working in partnership with SAMSSA (Sudbury Area Mining Supply and Service Association), the objective of the IPO is to create more opportunities for new projects, partnerships, investments and revenue for the local SME Innovator community. Increasing synergy between SME's and mining companies, the IPO works to access required resources and partnerships necessary to advance ideas to testing and implementation.

The Greater Sudbury Development Corporation (GSDC) pledged a \$75,000 contribution towards a pilot year at the IPO. In its first year, the IPO has:

- initiated contact with 27 SME's to identify innovation R&D funding that will accelerate pre-commercialization activities and generate economic development for the region.
- Identified 4 potential projects that can create innovative technology and products and offer a creative solution for the mining industry.
 - two projects are in the feasibility stage,
 - one project is currently being reviewed for funding application
 - one project is currently being matched with a technology partner.

The IPO at CEMI been awarded \$300,000 from GSDC (Greater Sudbury Development Corporation) for the next 4 years to support its efforts.

The case study below showcases the role of the IPO and its initial success. For more information on the IPO at CEMI, contact Bora Ugurgel.

DEVELOPMENT OF A COMMERCIALY AVAILABLE ELECTRONIC BOLT FOR WIDESPREAD UNDERGROUND USE: A COLLABORATION BETWEEN CEMI AND MANSOUR MINING TECHNOLOGIES INC.

Mansour Mining Technologies Inc. (MMTI) is Canada's only integrated manufacturer of strata support solutions for underground hardrock mines. In August of 2011, management decided to advance its technology portfolio. This required investigation into the feasibility of developing a technology that would allow serial production of a bolt with the capacity to relay information related to stress, strain, elongation, time and magnitude of stress event. The information gathered by the bolt would be relayed to a mine's geomechanics database in real time.

The initial scope of the project involved the integration of disparate existing technologies.



In December of 2011, IPO at CEMI organized a workshop attended by representatives of MMTI, Vale, Xstrata Nickel, KGHM, Barrick and various researchers from the academic community. The purpose of the session was to outline current and future ground control technology needs within the user community with an eye for gauging support for MMTI's project. The session was a resounding success with significant suggestions and support being offered for the outlined initiative.

Subsequent to the industry session, the IPO has provided significant assistance in identifying and establishing relationships with technology providers. MMTI's project has evolved from its initial scope to include requisite software and hardware to allow full wireless connectivity of each bolt to a mines communication system.

With the IPO's support, the project has yielded gains in industry support, evolving the scope of the deliverable and identifying and integrating key technology stakeholders. MMTI is now planning the next step of collaboration with the IPO, preparing for the testing of the pre-commercial prototype.

"MMTI's collaboration with CEMI carries with it significant benefit for both industry and MMTI. Of greatest importance is a high volume, easy to install bolt capable of relaying real time geotechnical information to a mine's rock mechanics engineers. The benefits are measured in terms of improved safety for underground personnel and higher assurance of capital excavation integrity. MMTI's gains in terms of commercialization of the device along with creation of a new business segment designed to help carry the business into the future. MMTI's intent is to continue to bring the future to the underground mining industry."

*Jean Guy Coulombe
President and CEO
Mansour Mining Technologies Inc*

"Working with the Innovation and Prosperity Office (IPO) at CEMI has opened doors to future opportunities for BESTECH to gain access to large international mining operations. With the IPO's connections and services, we were able to meet face to face with our clients' corporate team and inform them how BESTECH's products and services can improve operational efficiency and reduce costs. The assistance provided by the IPO was extremely beneficial to BESTECH and has enabled us to be one step closer to achieving the company's vision of being a globally recognized innovator of products and services. The IPO facilitated a meeting with senior representatives from a major mining company that would normally be very difficult for SMEs to arrange on their own. As a result of our participation in the IPO's programs, BESTECH has managed to create awareness of our products and services to an international market, which will in turn create sustainable jobs for the communities we work in."

*Pat Dubreuil, Vice President, Operations/
Sales & Marketing
BESTECH*

KNOWLEDGE TRANSFER

CEMI continues to actively fulfill its mandate to transfer knowledge across the industry through a series of lectures, educational workshops, and symposia and training tours.

THE CEMI LECTURE SERIES is designed to highlight innovative research on topics relevant to the mining industry and offers technical presentations on a wide range of mining and engineering topics. The series features leading academic and practicing guest speakers. Video coverage is made available for each presentation providing participants unable to attend in person and those in more remote areas, in Northern Ontario and beyond the ability to gain access to new knowledge. Video coverage of these lectures is available online at www.miningexcellence.ca

EDUCATION

CEMI hosts an educational Lecture Series and Short Courses designed to share knowledge and the results of collaborative R&D initiatives with industry, academia, consultants, and government.

LIDAR IMAGING FOR MINING: EXPANDING THE STATE-OF-PRACTICE WITH STATE-OF-THE-ART TOOLS

Lidar based technologies have the ability to generate highly accurate, spatially dense, fully 3-dimensional images of the physical world. Harnessing this imaging technology in active mining environments



Image courtesy of Matt Lato

has proven to be extremely valuable for design, planning, and safety of operations. Lidar can be used for tasks ranging from structural geology at the face of an advancing drift, to shotcrete thickness evaluation, to ore and waste stockpile calculations.

This 1.5 day course demonstrated and discussed practical examples of how the collection of lidar data: enables engineering decisions to be made with greater confidence and accuracy; provides the benefits of customized workflows and routines; and highlights the challenges of implementation. The course was presented by Matt Lato (NGI) and Dani Delaloy (Queen's University).

WEATHER VARIABILITY AND CLIMATE CHANGE: CHALLENGES AND SOLUTIONS FOR THE MINING SECTOR WORKSHOP

CEMI, Golder Associates, and MIRARCO hosted this one-day workshop which brought together climate change experts as well as mining practitioners to advance knowledge of climate change and its impact on mining operations, including the ways in which mine operators can assess and manage weather and climate-related risks. The workshop focused on the science of climate change including: drivers of adaptation planning and presenting methods to evaluate climate vulnerabilities and risks; practical examples of the application of such tools; and the facilitation of knowledge exchange between mine operators and various experts in the field of climate change adaptation.



Presenters included: Dr. David Pearson, Professor, Laurentian University; Mr. Robert Tremblay, Director of Research, Insurance Bureau of Canada; Mr. David Lapp, Manager of Professional Practice, Engineers Canada; Mr. Marc Butler, Director of Regulatory Affairs, Xstrata Nickel, Sudbury; Mr. Sean Capstick, Principal, Golder Associates; Mr. Leon Botham, CEMI Research Director, SustainMine & Vice President, McElhanney Consulting Services Ltd.; and Mr. Adam Chamberlain, Partner, Borden Ladner Gervais (BLG).



NEW ROAD: ONTARIO'S PATHWAY TO SOCIAL AND ECONOMIC DEVELOPMENT IN THE FAR NORTH SYMPOSIUM

INORD and CEMI hosted this Symposium focusing on the economic potential created by the Ring of Fire mineral deposits, and how it can work as a catalyst to help northern communities determine their path to economic development: building community while building wealth.

With the urgent need for change that exists in northern communities, and to facilitate the development of mining operations and other businesses, this symposium brought forward new ideas about infrastructure and social organization, in a discussion concerning economic development for remote communities.

The development of large-scale, base metal mining in the Far North has the potential to support an equal number of people and mines as can be found in Northeastern Ontario or Northwestern Quebec. This symposium focused on practical solutions to the problems that have long hindered progress including the implementation of sophisticated communication

technology, alternative transportation systems, alternative energy solutions and purpose-built housing. A broad range of possible solutions were identified that might be used to address the issues that confront the communities in Ontario's Far North.

Presenters included: David Robinson, Laurentian University; Dawn Madahbee, Waubetek Business Development Corporation; David Newhouse, Trent University; Jim Ireland, Hovertrans Solutions Pte. Ltd.; Stephen Newton, Discovery Air Innovation; Dean Millar, Laurentian University and MIRARCO; Leon Botham, CEMI Research Director, SustainMine & McElhanney Consulting Services; and Bret Cardinal, Cardinal Conley + Associates.

MINING PANEL AT DISCOVERY (OCE) CONFERENCE

CEMI hosted the first Mining Panel at the Discovery OCE (Ontario Centres of Excellence) conference in Toronto, highlighting Ontario's role in 21st century mining. CEMI invited key mining partners to share their research on: how to make mining more environmentally sustainable; the economic benefits of the "Ring of Fire" in Northern Ontario and beyond; and the need for highly qualified personnel from many scientific backgrounds to fill job opportunities in the mining industry.

Presenters included: Douglas Morrison, CEMI - Essential Innovation; Christine Kaszycki - Ring of Fire Overview - Economic Benefits to Ontario and Beyond; Brian Buss - A Mining Industry Perspective; Dr. Ramesh Subramanian - The Search for HQP in the Mining Industry; and Dr. Dean Millar - Towards Low Carbon Mining.



KNOWLEDGE TRANSFER

CEMI-OCE-NSERC MINING PARTNERSHIP FORUM

CEMI and the Ontario Centres of Excellence (OCE) hosted a one-day Mining Partnership Forum for over 150 attendees in Toronto, designed to: facilitate broad academic engagement with the mining industry; foster technological innovations; educate the academic community on the realities of mining in the 21st century; and highlight potential career opportunities for graduates. OCE and CEMI are working with the mining sector and NSERC to fund \$2 million in university and industry based, transformative R&D projects in the areas of Productivity, Energy, Water and Waste as it relates to Ontario's Mining Industry and its Value Chain.



The \$2 million joint program funds research projects in the area of advanced manufacturing that have the potential for immediate upstream or downstream benefit to the mineral industry. Projects leading to innovative, newly adapted or adopted processes, products or services will be co-funded by OCE, CEMI and NSERC for up to \$400,000 each (including a required industry cash and in-kind contribution). Participating companies will get full access to university researchers and graduates selected for funding. All project results will be used to the commercial advantage of these companies and/or their supply chain.

The successful forum attracted transformative thinkers and executives from outside the mining sector who brought cross-sector solutions to the table. The program was national in scope and open to all Canadian accredited universities and Canadian industry partners. Final selection of the winning proposals is currently underway.

Presenters included: Douglas Morrison, CEMI - Mining 101; Leon Botham, CEMI - Water and Waste; - Peter Kondos, Barrick Gold - Energy and Productivity; Jane Djivré, CEMI - Partnership Initiative Overview.



EDUCATION INFORMATION

BUILDING HUMAN CAPITAL- INVESTING IN STUDENTS

CEMI SPONSORED STUDENTS PRESENT THESES ON EXPLORATION & GEOPHYSICS AND GEORISK

CEMI sponsored students are offered an opportunity to present their theses to peers, professors, and key industry representatives. This series of presentations celebrates the efforts of up and coming researchers.

This year we provided students the opportunity to meet and present their ideas on Exploration & Geophysics and Georisk related research projects. Sponsored students also attended a key lecture presented by R. Mohan Srivastava, formerly with the Department of Applied Earth Sciences, Stanford University, currently at Benchmark Six, Toronto, Ontario on the topic of "Fracture Modeling: new ideas for mineral deposit development and production planning". Students also attended special lectures from Dr. Maurice Dusseault, Engineering Geology, University of Waterloo on "Potential of Thermoelastic Cooling For Stress Management".

The chart below highlights the research students who attended Dr. Dusseault's lectures and their theses presentations by specific topics:

We work with research institutions in Ontario, across Canada, and around the world, and engage with engineers and scientists in a range of technical disciplines in order to help the mining industry address the environmental challenges it faces. To date, we are funding work with collaborators at Université Laval, Queen's University, University of Toronto, University of Waterloo, Laurentian University and the University of British Columbia in Canada, Delft University of Technology in the Netherlands, Dalian University in China, Federal Technical University of Zurich and the University of Arizona. We plan to expand these relationships to other universities in Canada and internationally, at Colorado School of Mines (US), Camborne School of Mines (UK), and with Australian researchers in Perth and Melbourne.

By year-end 2012 CEMI will have contributed to the development of over 100 years of graduate-student development in exploration and mining related sectors (at 11 Universities/Colleges). CEMI currently collaborates with over 30 professors and over 60 co-op, undergraduate, graduate students (MSc, PhD) and post-doctoral fellows working on over 40 research projects.

GEORISK RELATED RESEARCH PROJECTS		
Connor Langford	"Reliability analysis for underground support design"	Queen's University
Gabriel Walton	"Dilation of yielding rock and rock masses (change modelling)"	Queen's University
Steve Gaines	"Stress state reconstruction or characterization from deep boreholes"	Queen's University
Jennifer Day	"Characterizing strength of rockmasses: influence of structure and confinement"	Queen's University
Cortney Paleske	"Discrete fracture network characterization – geological controls and evolution"	Queen's University
Nader Golchinfar	"Numerical simulation of brittle rock failure near underground excavation"	Laurentian University
Chris Groccia	"Quantifying Rockmass Bulking"	Laurentian University
Behrad M. Madjdabadi	"Numerical modeling of strain transfer from rock mass to a fibre optic sensor installed inside a grouted borehole"	University of Waterloo
Atena Pirayehgar	"Preconditioning hard rocks via Hydraulic Fracturing in mining process"	University of Waterloo

BUILDING HUMAN CAPITAL- INVESTING IN STUDENTS

EXPLORATION RELATED RESEARCH PROJECTS

R. Mohan Srivastava presented exploration research projects with the following students:

- Dr. Tsilavo Raharimahefa PhD: Structural, Metamorphic, and U-P Geochronological Evolution of the Southern Province, Sudbury, Canada
- Taus Joergensen PhD: Identification of Pyroxene Hornfels Facies Mafic Rocks within the Metamorphic Aureole of the South Range of the Sudbury Igneous Complex, Sudbury, Canada
- Fabio Cafagna PhD: Experimental Study of the Role of Semi-Metals on the Mobility of PGE
- Oladele Olaniyan PhD: Qualitative and quantitative integrated geophysical investigation of the Sudbury structure

- Josh Lymburner MSc: A Deep Electromagnetic Tool
- Michal Kolaj PhD: Mapping Laterally Varying Conductance Using Electromagnetic Gradients
- Devon Parry MSc: Borehole Geophysics: Downhole Logging and Comparison with Handheld Physical Property Measurements

DR. SAM SPEARING'S STUDENT TOUR

18 undergraduate students from the Mining Engineering Program at Southern Illinois University Carbondale travelled with Dr. Sam Spearing to see first-hand hard rock mining in Northern Ontario. This is the second visit that Dr. Spearing has made to CEMI and Northern Ontario. The students were treated to underground mine tours at Podolsky or McCreedy Mines by

KGHM; a Snolab tour; and visits to the Xstrata Nickel Smelter, Dynamic Earth, Laurentian University, and CANMET. Before departing south, Dr. Spearing was a guest speaker for CEMI's Lecture Series presenting: "Energy and energy options with specific reference to the USA" to a full house.

CEMI EXPLORES STRATEGIC PARTNERSHIP WITH BRAZIL'S SCIENCE WITHOUT BORDERS

Science without Borders is a large scale Brazilian national scholarship program that seeks to strengthen and expand the initiatives of science and technology, innovation and competitiveness through international mobility of undergraduate and graduate students and researchers. The program also stimulates the visit of highly qualified young researchers and senior visiting professors to Brazil.

Administered by the Institute of International Education (IIE), the undergraduate scholarship program is part of the Brazilian government's larger initiative to grant 100,000 scholarships to the best students from Brazil, allowing them to study abroad at the world's top universities for a year and serve a summer internship before returning to Brazil to complete their degrees. The Science Without Borders program is sponsored by the scholarship foundation of Brazil's Ministry of Education and sponsored by Vale's Technology Institute in Brazil.

CEMI hosted Dr. Luiz Mello, Director of Vale Technology Institute (ITV) and company, at a series of meetings with CEMI and Laurentian University's faculties from Engineering, Earth Sciences and Environmental Sciences. The meetings were designed to create a strategic partnership to develop cross-border co-operative student research experiences with mining companies.



1. Dr. Luiz Mello and guests from the Vale Technology Institute visit the Living with Lakes Centre with CEMI and LU 2. Exploration sponsored students with guest speaker R. Mohan Srivastava 3. Dr. Nigel Smith hosts the students and Dr. Sam Spearing from Southern Illinois University Carbondale 4. Taus Joergensen from LU presents, "Identification of Pyroxene Hornfels Facies Mafic Rocks within the Metamorphic Aureole of the South Range of the Sudbury Igneous Complex, On, Canada" at the Exploration Student Presentations

5. Nader Golchinfar from LU presents, "Numerical simulation of brittle rock failure near underground excavation." 6. Jennifer Day from Queen's presents, "Characterizing strength of rockmasses: influence of structure and confinement" 7. Guest Lecturer Dr. Maurice Dusseault, Engineering Geology, University of Waterloo presents, "Potential of Thermoelastic Cooling For Stress Management" to the Georisk students

CEMI TEAM



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R&D Program Director



ROB BEWICK
RTC-UMC Program Coordinator



LEON BOTHAM
R&D Program Director



DAMIEN DUFF
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R&D Program Director



JANE DJIVRÉ
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PETER KAISER
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Director of RTC-UMC



SHANNON KATARY
Director of Marketing and
Community Relations



NATALIE LAFLEUR-ROY
Finance and Operations



DOUGLAS MORRISON
President & CEO
Chair in Holistic Mining Practices



BORA UGURGEL
Innovation & Prosperity Office
Coordinator



KRYSTLE VENDETTE
Administrative Assistant

SOLUTION TEAM

INDUSTRY

Baffinland Iron Mines Corporation
Codelco
LKAB
Nuinsco Resources Ltd
Peregrine Diamonds
KGHM
Rio Tinto
Vale
Wallbridge Mining Company Ltd
Xstrata Nickel
Xstrata Process Support (XPS)

ACADEMIC

Cambrian College
Carlton University
CIMMR
Dalian University of Technology
Delft University of Technology
Laurentian University
Queen's University
Simon Fraser University
University of British Columbia
Université Laval
University of Toronto
University of Waterloo

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SNOLAB
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COLLABORATION

SPONSORSHIP

CEMI plays a leadership role in developing step-change innovation by providing a management interface between the mining industry in Ontario, academia, SMEs and service providers. These are the crossroads where industry knowledge, imagination and expertise exist to provide scientific advances, new ideas as well as the know-how, essential to turn ideas into workable solutions that can be implemented. CEMI's role is to engage with collaborators who have demonstrated excellence in their field, delivering innovation while helping to ensure that collaborators meet their individual measures of success.

PATRONS

CEMI Patrons recognize that to accomplish step-change innovation, there has to be support for an organization to play a critically important intermediary role between industry, academic researchers and other innovators. CEMI Patrons include Xstrata Nickel, Vale, Laurentian University, the Ontario Government, and Rio Tinto. Each of these CEMI Patrons are already innovators in their own merit, and understand that innovation is a managed process. The Patrons rely on CEMI to manage their effort towards step-change innovation, mitigate the impact of incidental failures and to learn from them to open new avenues of investigation towards future success.

SPONSORS

CEMI Sponsors are those organizations that recognize the need to make significant investments in order to influence major changes in the way their business operates. They acknowledge that supporting university researchers and innovative SMEs is crucial for creating innovative solutions. They help create an industry that offers dynamic and rewarding careers to the engineers, scientists and technicians of tomorrow. And they recognize the importance of providing support to projects in cash and in kind, that allows their financial investment in research to be leveraged to obtain additional funding from government agencies. CEMI Sponsors are committed to initiating and developing research programs that address the broader needs of the industry as part of collaborative projects, and are actively involved with projects on mine sites, working with academic researchers and innovators from the mine services community to investigate alternative approaches and implement possible solutions.

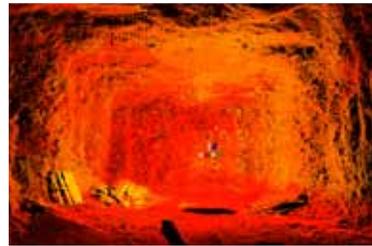
STEP-CHANGE
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RioTinto





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