

ANNUAL REPORT 2011



Fostering innovation through collaboration



CEMI
Centre for Excellence
in Mining Innovation

FOSTERING INNOVATION THROUGH COLLABORATION

The Centre for Excellence in Mining Innovation (CEMI) directs and coordinates step-change innovation in the areas of exploration, deep mining, integrated mine engineering, environment and sustainability for the metal mining industry. With a seasoned team of program directors, CEMI identifies, assesses and manages industry-driven applied research & development projects that extend from geology and engineering to the natural sciences. We recognize innovation is a three-phase process: research, development and implementation (R&D, I). With implementation, we turn innovative ideas into best practices.

CEMI offers a single point of entry for collaboration, knowledge resources and human resource capital, creating greater capacity for excellence in innovation and greater value to the economic development of the metal mining industry by:

- 1 | collaborating with major Canadian and global mining companies, universities, government researchers, technical consultants, and innovative SMEs across Canada, and around the world
- 2 | facilitating industry-focused research and innovation that advances concepts, processes and methodologies
- 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 global patrons and government funding



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MESSAGE FROM THE CHAIRMAN OF THE BOARD



The Board of Directors is pleased to look back to another eventful and successful year. Working in close collaboration with innovative industrial patrons – Vale, Rio Tinto and Xstrata Nickel – and a most collaborative institutional partner – Laurentian University – we have taken another important step toward expanding our mining innovation program.

In July of this year, the Ontario Government announced an investment of \$2.24 million from the Ministry of Research and Innovation's Ontario Research Fund-Research Excellence program in a new initiative called "Smart Underground Monitoring and Integrated Technologies" (SUMIT) for deep mining. With Laurentian University as the lead applicant,

and in collaboration with the University of Toronto, Queen's University, and academics from other research institutions, we have assembled a globally outstanding research team.

Over the past year, CEMI has developed into an organization that delivers valuable solutions to the mining industry and its stakeholders. With a focus on five strategic themes as detailed in this report, we are using our mines as "living laboratories" for mining innovation – a course of action that we shall hold as a Centre for Excellence in Mining Innovation.

As our start-up phase comes to an end, the Board is pleased with the many accomplishments set out in this annual report and proud of what the CEMI team has achieved with the initial investment by the Ontario Government and the Founding Members. But the job is far from complete, and we see CEMI continuing to play multiple roles: in providing leadership that encourages organizations and institutions in the mining innovation space to focus on industry's needs; to produce value for its stakeholders; and to facilitate step-changes in mining innovation by attracting sponsorships and leveraging funding for the most advanced research, development and implementation (R&D, I) activities.

In challenging operating environments, CEMI must be well organized and consistently execute R&D programs with successful implementation as its outcome. Our Ventilation on Demand project is a clear demonstration of this. With co-funding from Industry Canada's Community Adjustment Fund, a major collaborative effort, with an investment of \$8.5M, and key

contributions by Vale, Xstrata Nickel, NRCAN/CANMET, Bestech, Labrecque Technologies, Caterpillar, Symboticware, Simsmart, and Objectivity, VOD (Ventilation on Demand) was delivered in the short timeframe of 18 months. By installing, testing, and measuring the efficiency of new technologies, an important step has been made to decrease energy costs and related environmental impact as well as increase productivity. The program is fully aligned with the industry's vision and path, adding great value to our society as it assists in the reduction of energy consumption and thus, environmental impact.

This year, the Board welcomed a most innovative partner, Rio Tinto, in an exciting collaboration to establish the Rio Tinto Centre for Underground Mine Construction. With a funding commitment of \$10M over the next five years, this partnership demonstrates that CEMI's approach and now established track record in building successful solution teams is seen as an effective and most valuable means to assist industry.

These investments from multiple sources will strengthen Sudbury's position as a global centre for excellence in mining innovation.

On behalf of the Board, I'm pleased to welcome mining veteran, Douglas Morrison, as Vice President to the CEMI team, and congratulate him on his appointment as the Chair in Holistic Mining Practices. With extensive experience in the Canadian mining industry and more than 15 years in international consulting, he brings a broad understanding of the issues that confront the global industry now and into the future. Having worked in the past with CAMIRO, MIRARCO, and other R&D organizations, he will strengthen collaborations in Ontario and across Canada.

We thank all our stakeholders for their dedication and continued support of our mining innovation initiatives. By investing in CEMI, you invest in "Making Mining Innovation Our Business".

Marc Boissonneault
Chair of the Board

BOARD OF DIRECTORS



MARC BOISSONNEAULT
Chair of CEMI Board of Directors
Vice President of Sudbury Operations
Xstrata Nickel



FRED DELABBIO
General Manager
Underground Mining Innovation
Rio Tinto



DOMINIC GIROUX
President
Laurentian University



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Former Deputy Minister
Ministry of Northern Development
Mines & Forestry



WARREN HOLMES
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CHRISTINE KASZYCKI
Assistant Deputy Minister
Ring of Fire Secretariat
Ministry of Northern Development
Mines and Forestry



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Vale Canada Limited



NIGEL SMITH
Director
SNOLAB



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



PETER K. KAISER
President and CEO
Centre for Excellence in
Mining Innovation

MESSAGE FROM THE PRESIDENT



This annual report highlights activities undertaken during CEMI’s start-up phase: achievements with respect to human resource development; collaboration with private sector companies and academia; delivery of value through an applied technical program; and leverage of funding from national and international sources.

Thanks to the contributions of the founding members, CEMI was able to develop a unique model to accelerate and deliver mining innovation.

As a consequence, Mining Innovation has become CEMI’s Business, where innovation is delivered through:

- Research at collaborating academic institutions;
- Development with collaborating small and medium sized private sector companies (suppliers and service providers);
- Implementation of solutions by active in-mine R&D programs in close collaboration with our end-users, the most innovative mining companies.

Realizing that *there is no innovation without implementation*, this year, we focused on work in and around mines around the world and established contacts to expand our in-mine innovation development strategy:

- at Vale’s Coleman and Xstrata Nickel’s Nickel Rim South mines, on accelerating the up-take of Ventilation on Demand for two purposes: energy reduction and productivity enhancement;
- at Vale’s Coleman mine, developing new means to monitor and design for safe sill pillar extraction;
- a Boring System developed by Aker-Wirth, to establish a systematic data collection program in support of mechanical excavation; and
- at Codelco’s Chuquicamata mine on better data utilization by installing a state-of-the-art virtual reality facility.

The recently announced “Smart Underground Mining and Integrated Technology (SUMIT) for deep mining” program will help to expand our in-mine program with work planned at additional mines each of Rio Tinto, Vale, Xstrata, and at QuadraFX’s Victoria mine. Establishing these test sites is a strategically important step towards CEMI’s greater vision for Ontario, i.e., to establish a networked Deep Mine Observatory, similar to the highly successful SNOLab. Equally if not more important is the fact that this program will be delivered in collaboration with researchers from Laurentian University (lead institution), the University of Toronto and Queen’s University.

In support of this field-oriented mining innovation approach, we are in the process of entering into an agreement with IBM Canada to develop a data

integration prototype as part of SUMIT. For this project, IBM will make a substantial contribution under its “First in-kind Program”.

CEMI continues to use a three-step approach: First, to listen to potential program sponsors, second, to identify step-change opportunities to scope innovation programs and third, to assemble solution teams to deliver solutions and value in a timely manner. We provide a balanced mix of short and longer-term strategic programs to facilitate step-change innovations in our five strategic theme areas: FindMine, DeepMine, ConstructMine, ValueMine, and SustainMine. Increasingly, these five areas are becoming CEMI’s globally recognized core competencies.

By adopting a collaborative approach to address industry’s needs with outstanding solutions teams, we have been able to tackle new challenges and deliver value to our stakeholders. This approach changes the manner by which research, development and implementation (R&D, I) is conducted in Ontario and beyond. We have garnered continued support from our industrial patrons and adapted to expectations of new sponsors.

A COLLABORATION ACHIEVEMENT

This year’s *Innovation Showcase* brochure (at www.miningexcellence.ca) illustrates CEMI’s unique approach to innovation as a business, working with a wide network of collaborators or solution team members – our innovators. The showcase highlights some recent projects and initiatives in our five strategic theme areas. Most importantly, it identifies the depth and breadth of our sponsors and solution team members. We are fortunate to work with a wide group of outstanding individuals, SMEs, and institutions to deliver value – value with respect to HQP development, software tools, guidelines and manuals, technologies, and their implementation.

RIO TINTO CENTRE FOR UNDERGROUND MINE CONSTRUCTION (RTC-UMC)

The Rio Tinto Centre for Underground Mine Construction was established to support Rio Tinto’s Mine of the Future™ program. Research is focused on mechanical and mechanized excavation with both shaft boring and tunnel boring systems. Rio Tinto selected CEMI for its leadership and as an agent for collaborative research, in support of high speed underground mine construction. The Centre will scope and manage research with outstanding partners around the world to enhance ground and machine performance. Three prototype test sites will be instrumented to improve ground characterization techniques and to develop innovative support systems in highly stressed ground. Furthermore, machines will be monitored to improve equipment performance, assess construction logistics for optimal deployment and for tunnel and shaft boring technology.

This work recognizes CEMI’s role in promoting Canada as a centre for excellence in the areas of deep mine geomechanics, risk mitigation and underground construction. It provides opportunities for home-grown

researchers, the best in these fields, to work on solutions for construction challenges that the next generation of underground mines will face.

SMART UNDERGROUND MINING AND INTEGRATED TECHNOLOGY (SUMIT) FOR DEEP MINES

Funding from Ontario’s Ministry on Research and Innovation allows us to leverage substantial cash and in-kind contributions from Rio Tinto, Vale and Xstrata Nickel to find new knowledge- and technology-based solutions. Application of smart engineering principles is making game-changing advances in deeper mining operations. There are 14 initiated core projects that cover three major challenges of sustainable mining at deeper elevations: mitigation of geotechnical risks for workers and investors; rapid underground mine development with and for more efficient mine operations; and sustainability for mining in Canada through better management of energy, materials, and mine waste.

This research project brings together an outstanding group of researchers, consultants and industry experts from Ontario, Canada, and the world, to help develop smart engineering solutions for underground mines. The funding will support the work of more than 75 researchers and students.

CHAIR IN HOLISTIC MINING PRACTICES

One crucial component of a globally competitive organization is stability and visionary leadership. As Chair in Holistic Mining Practices and Vice President of CEMI, Douglas Morrison joins CEMI to implement a visionary five-year Research and Development plan that will assist in sustaining local mines, retaining jobs, opening new mines and creating new jobs. With an investment in the amount of \$823,000 by the Northern Ontario Heritage Fund in a Research Chair for Holistic Mining Practices, CEMI will be able to sustain and expand its mining innovation role.

Providing local innovators with easier access to large-scale research initiatives and encouraging greater collaboration amongst local agencies, allows CEMI to build on established expertise in areas of interest to the global mining community and to develop new or enhanced innovation. With extensive industrial experience, NOHFC’s investment in this Chair is an important step towards making Northern Ontario one of the best places for the global mining industry to find expertise — making the North part of Ontario’s knowledge economy as well as being a major component of the resource economy.

INNOVATION & PROSPERITY OFFICE

The establishment of an Innovation & Prosperity Office (IPO) was made possible by a contribution of start-up funds by the Greater Sudbury Development Corporation (GSDC) in the amount of \$75,000. The Office will assist in developing multi-partner, funding proposals and it will seek out and funnel R&D business opportunities to innovators in Sudbury’s mining community and Region at large. To this end, CEMI will identify innovation opportunities focus R&D funding to accelerate pre-commercialization activities.

GROWTH OF INNOVATION PROGRAM

Thanks to a substantial investment from the Ontario Government and our Founding Members, we have been able to deliver the program presented in this and previous annual reports. Innovation is a steady process that clearly cannot be started and completed in a short four years. In many sectors, it is understood that it takes between 10 and 15 years to bring an innovation to market. For this reason, we are pleased to report this year, that CEMI’s cumulative program funding, including pledged and leveraged funds, just exceeded the \$40M threshold. Since our inception, CEMI has been able to more than quadruple the original investment by the Ontario Government or CEMI’s Founding Industrial Members. This establishes a stable and strong foundation to expand our collective role in strengthening Northern Ontario as a “Centre of Excellence in Mining Innovation”. A centre that provides education, services, supplies and research and development for the local and global mining industry.

Last but not least, we thank the sponsors and organizers of the Northern Ontario Business Award (NOBA) for having selected CEMI for the prestigious Judges’ Award at its 25th anniversary. This recognition acknowledges and encourages us to continue our efforts in seeking active collaboration with Northern Ontario-based businesses. We will work with the City of Greater Sudbury and SAMSSA to identify potential innovations, link them to researchers who are able assist in bringing new ideas to the market, and thereby increase employment opportunities in Northern Ontario.

Much more work is still needed to address the challenges of our growing industry. We invite new patrons and sponsors to join our efforts in stimulating innovation and step-changes in mining in Canada and world-wide.

As always progress does not happen without a dedicated team, individuals that believe they can make a difference. Being fortunate to work with such a dedicated team, I wish to express my personal sincere appreciation to them.

Peter K. Kaiser
President & CEO

MESSAGE FROM THE VICE PRESIDENT



POSITIONING FOR THE FUTURE SUCCESS

During its start-up phase, we focused on issues identified by the Patrons and Sponsors as being of primary importance. Having taken action on these time-sensitive issues, we have recognized the industry's skill shortage, and with it, the need to broaden the range of technical disciplines that we draw upon to meet the industry's future needs, and the need to attract the best academic researchers we can find, regardless of their prior involvement in mining or in Canadian University mining departments.

Although some projects on underground mine performance have already been initiated, CEMI will intensify its focus on ventilation, improving drill-and-blast advance rates and materials handling. For the deepest underground mines, the energy cost of ventilation has become crucially important in the context of the current operating-cost profile. Drill-and-blast advance rates are now at historic lows but we believe dramatic improvements can be made within 1-3 years by revitalizing results from programs mistakenly abandoned over the last 15-20 years. The hoisting to surface of development waste and low grade ore is prohibitively expensive but this can be avoided by redesigning the ore-flow system to consume waste in stope backfill. Underground crushing to 4-inch minus would improve waste-in-backfill performance and would facilitate material sorting for sulphides and high-value mineralization, creating a product that is more amenable to pipeline transportation. Conventional hoisting is simply not applicable to ultra-deep ore, but revitalizing existing results on hydraulic hoisting research may accelerate the development of dense-medium hoisting as a viable alternative. We believe the discovery of high-value copper deposits in the Sudbury Basin is limited by current assumptions about the basin geology that should be re-examined as part of an effort to accelerate the development of new deposits.

DEVELOPMENT OF NEW STRATEGIC DIRECTIONS

For new mines, in Ontario or anywhere in the world, the most critical issue for obtaining a social license to operate is the possible effect on the environment caused by the disposition of tailings, waste rock and waste water. There are major opportunities for innovation in this field, both short-term and long-term. For the long-term issues, as the recent funded Chair in Holistic Mining Practices, I plan to focus some of my energy on identifying novel techniques that will yield research programs in improved metal recovery.

In the short term, although new tailings management facilities operate well, there are still improvements to be made, including the placement of tailings as thickened (densified) tailings or paste tailings, thereby improving process water recovery and recycle within the milling process. For tailings material with high sulphide content, the conventional approach of sub-aqueous deposition and flooded closure to minimize the generation of acid mine drainage is now very well understood, but even modern dams now require perpetual monitoring to cope with the advent of climate change.

The conventional design standard of a 1-in-100 year storm event is increasingly questionable as just in the last year there have been 1-in-300 and 500 year events that impacted several facilities in Northern Ontario and elsewhere. In future, many more extreme water over-supply and water under-supply events can be expected and CEMI plans to initiate a project that will connect satellite meteorological data to the monitoring data of tailings management facilities so as to better anticipate and manage weather events that can cause these facilities to exceed their operational parameters and adversely impact the environment.

In addition, many relic tailings facilities have failed and negatively impacted the reputation of the industry. CEMI plans to extend the TMF (Tailings Management Facilities) monitoring project to develop an integrated package of satellite communications, wireless instrumentation, data management systems and hazard monitoring protocols that will be a major step forward in providing advance warning and preventive control. We see delivering excellence in both meteorological and stability monitoring of tailings dams as a major contribution to waste management.

Finally, the most pressing need in the development of new mines around the world is the need for community consultation and social impact studies (CC&SIS) to be conducted in a systematic and professional manner. At present, the industry is served by several individuals who have extensive experience with rural and aboriginal communities in many parts of the world. But meeting the demand for new mines around the world will require the acceptance of a structured approach and the development of a supporting educational program if the extreme demographic gap that exists in this field is to be overcome. Although there is little research to be done, we believe that CEMI working with experienced consultants, industry representatives, Ontario university mining departments and PDAC, should be seen to be in the forefront of initiating such an effort.

In summary, we intend to engage with the best scientists and engineers the academic community has to offer and use our industrial experience to convert this knowledge into practical solutions that can be implemented as routine into mining operations. We will intensify our focus on integrated underground mine engineering, and broaden the support for CEMI from other major mining corporations by expanding our scope beyond underground mining issues to cover aspects of environmental and social impact studies that are now a prerequisite for successful mine permitting and approval of mine closure plans.

Douglas Morrison
Vice President
Chair in Holistic Mining Practices

STRATEGIC RESEARCH PROGRAMS AND PROJECTS

CEMI DIRECTS AND COORDINATES STEP-CHANGE INNOVATION IN 5 STRATEGIC THEMES

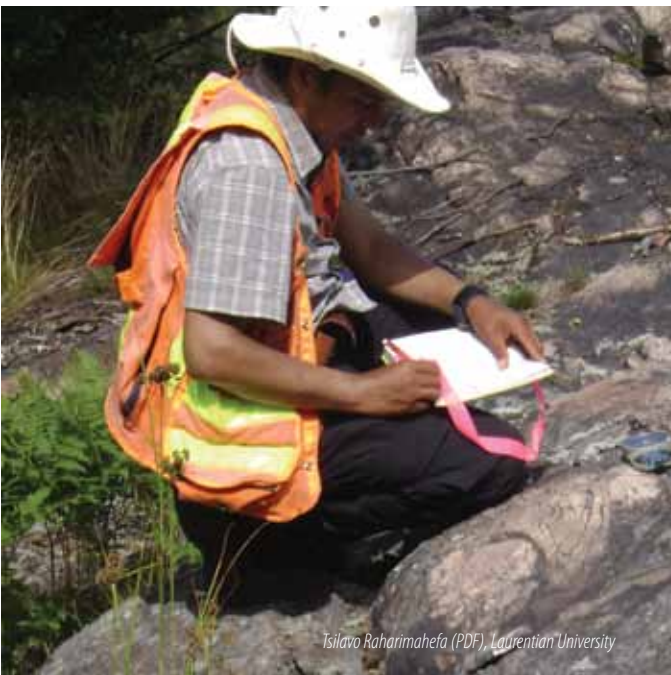
CEMI continues to demonstrate that it can effectively manage large projects, generate substantial leverage funding, and gain industry support. It has expertise, leadership capability and capacity to significantly strengthen the technical impact within each of the strategic themes, and therefore, become recognized as the centre for excellence in mining innovation. The objectives of these strategic themes are to meet the needs of the industry in the fields of mine engineering and sustainability and to help develop core competencies for the industry.

These strategic themes provide an opportunity to attract, develop, and train high quality personnel (HQP) and to create tools or techniques of real value to the mining industry. Since we recognize that implementation is crucial to the success of innovation, 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, and workshops.

CEMI's strategic focus has resulted in five core research and development project categories: ConstructMine, DeepMine, ValueMine, SustainMine, and FindMine. Each is wide-reaching and helps to advance innovation and enrich knowledge for the metal mining industry.

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:

- \$12.9 million for over 30 strategic R&D projects in the areas of exploration, deep mining, integrated mine engineering, environment and sustainability
- \$2 million to Research Chairs
- \$1.9 million for SME-led projects to help bring innovations to development and potentially market them
- collaborate with over 30 professors and 50 co-op, undergraduate, graduate (MSc, PhD and PDF) students



Isilavo Rahanimahafa (PDF), Laurentian University

"CEMI's research priorities, developed in partnership with our industry, focus on mining exploration, deep mining research, integrated mine process engineering, environment and reclamation and automation. These are areas of research that are critical to Vale's future success. The research work at CEMI will enable Sudbury to export its expertise and knowledge to the world. The benefits realized here will have applications around the globe, and will help solidify Sudbury's place as a leading global centre for mining and mining innovation."

Alex Henderson
General Manager, Mines Technical Services
Ontario Operations, Vale



MINE DESIGN TO EXTRACT OPTIMAL MINE VALUE WITH ENABLING TECHNOLOGIES

PROJECT LEADS: Glenn Lyle, Keith Bullock, Al Akerman

Strategic research and development in the areas of: Mine Process Engineering 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:

- focuses on the collaborative development of a Best Practice Handbook Wiki for underground hard-rock mine design that brings together industry thought leaders to contribute their mine design expertise
- 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

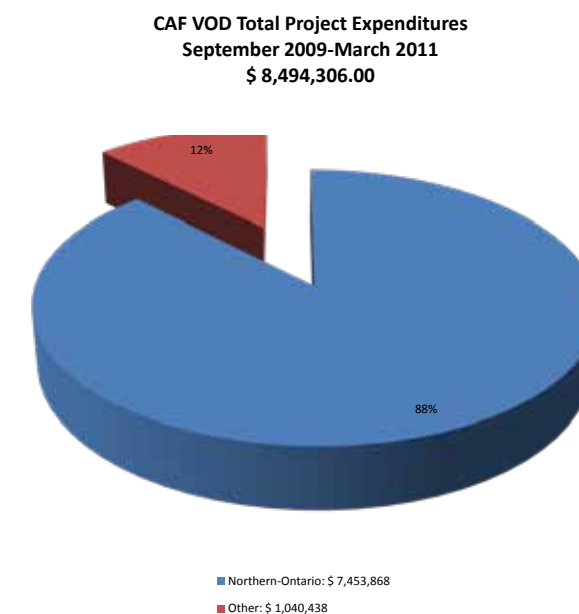
VENTILATION ON DEMAND

CEMI, in collaboration with Xstrata Nickel, Vale and CANMET, has completed the first phase of a Ventilation On Demand (VOD) research program aimed at gaining an understanding of how VOD systems affect the underground working environment from the perspectives of operational control, economics, productivity and industrial hygiene perspective.

The Ventilation On Demand (VOD) project comprised the installation of equipment at Nickel Rim South Mine and at Coleman Mine respectively, and the monitoring of components at these mines during operations. The equipment operated as designed and valuable data was recovered from both mines. The initial data interpretation has already provided invaluable insight into the challenges and potential solutions associated with operating VOD systems.

To accomplish these results, CEMI assembled and collaborated with a team of Sudbury area experts, comprised of industry, government, small medium enterprises (SMEs) and original equipment manufacturers (OEMs), and leveraged \$4.25 million dollars from Industry Canada's Community Adjustment Fund (CAF) with matching fund contributions from Vale and Xstrata Nickel for a combined project budget of \$8.5 million.

The project was designed to address three key components of the VOD systems: validate the business case for VOD; understand the work required to ventilate air quality requirements instead of air quantity requirements; and capture ventilation air sensor performance to understand required sensor locations, density, and maintenance requirements.



ACHIEVEMENTS AND OUTCOMES

The project supported and augmented Vale and Xstrata Nickel's existing VOD programs by installing monitoring equipment at Vale's Coleman Mine (Ore Body 153) and Xstrata Nickel's Nickel Rim South Mine. The team completed field at both mine sites and lab studies to analyze sensors for diesel emissions, the effects of pressure on sensors, and cross contamination of gas sensors. The field studies and the data collected from the underground monitoring allows for a detailed assessment and analysis of VOD capabilities under differing system operating characteristics.



Objectivity developed VREX, a financial model that links a mine's production with its ventilation network. This model can simulate the demands of the mine's production and compare it to the capabilities of the ventilation network. This allows for multiple scenarios of VOD to be evaluated. The VREX model makes it possible to determine and identify where VOD can bring the maximum benefit to a mining operation, and help prioritize where capital should be invested.

Extensive knowledge transfer was achieved as part of this project with technical presentations to organizations such as Ontario Mining Association (OMA), Mining Diesel Emissions Council (MDEC), Mining Legislative Review Committee (MLRC), Canadian Institute of Mining (CIM), and Maintenance Engineering & Mine Operators (MEMO). CEMI hosted a VOD workshop in June to advance this project to the next stage, trigger new collaboration, and raise awareness of the benefits VOD brings to industry.

The VOD project led to the establishment of a new company, Objectivity, which developed the analytical software. The project also assisted in the development and expansion of another SME, Symboticware, which applied its open protocol technology (Symbot) to collect valuable data from the mines. The collaboration with other local SMEs made this project a broadly-based community project. Finally, the spirit of collaboration amongst all participants, demonstrated that it is possible for the community of mine service companies to work together to benefit the mining industry. It serves to demonstrate recognition of the importance of ventilation to the future of the mines in Northern Ontario and the Sudbury Basin in particular.

VALUABLE INSIGHTS

It was found that tailpipe sensors for continuous operation can capture engine operation parameters and emissions, which can be related back to lab tests. This will allow for the prediction of diesel engine emissions at varying operating conditions and field monitoring will confirm operating conditions. The sensors identified that there are flow rate, cross sensitivity maintenance and placement issues. VOD cost benefits can be calculated using the VREX modeling tools. While VOD systems will reduce energy consumption, the biggest opportunity is in re-directing air potentially allowing for productivity gains and increasing overall energy efficiency. There is an opportunity to implement lessons learned from the VOD project into future mine designs.



Vale's Coleman Mine



Currently available VOD systems can alter and monitor flow rates, and many new areas for future work have been identified around how we use these commercial systems common for all users. The first phase of VOD has positioned the mining community to better understand the current ventilation practices, and identify the work required to advance the necessary knowledge to significantly improve how a mine can operate efficiently.

NEXT STEPS

A peer review by leading international ventilation experts determined that there is still considerable work to be done to advance the state of ventilation on demand. The next phase of the work (VoD2) will include ventilation for production; engine emissions monitoring, the creation of a best-practices guide; and additional in mine monitoring requirements. A multi-company consortium is being established to address these areas in the next phase of this project which is expected to be a 2-3 year, multi-million dollar project managed by CEMI in collaboration with industry, CANMET and SMEs.

SOLUTION TEAM

Key contributors and collaborators included Vale, Xstrata Nickel, NRCAN/CANMET, Objectivity, Labrecque Technologies, Caterpillar, Symboticware, Bestech, and Simsmart.



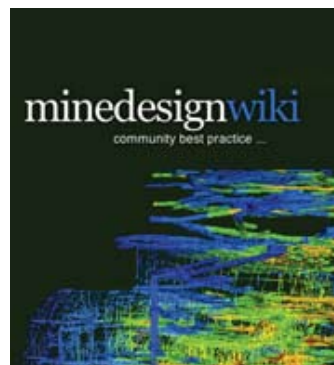
Left to right: Glenn Lyle, CEMI; Ed McLaren, Xstrata Nickel; Stephen Hardcastle, CANMET; Doug O'Conner, Vale; Andrew Dasys, Objectivity; and Cheryl Allen, Vale are members of the Ventilation on Demand Technical Committee. (missing from photo: Keith Bullock, CEMI and Erik Bartsch, Xstrata Nickel)

MINE DESIGN HANDBOOK – WIKI EDITION

Using the same model that has allowed Wikipedia to become one of the most successful and valued general information sources, CEMI created the Mine Design Handbook - Wiki Edition. The site is operational and the population of the site with data has begun. With CIM as a partner, the site will grow rapidly with data from a variety of sources.

The Mine Design Wiki will facilitate communication and inclusion of best practices based on experiences of professionals within our industry. It will aid in the training of young professionals during both their university and professional careers. It will emphasize best practices in mine design, preserve the value of the design process and highlight those gaps within mine design that would benefit from the development of new tools or further research. The wiki approach will allow for the discussion of concepts and practices and combine quality reference material with the experience of professionals within our industry.

Mine professionals are invited to join the community and comment on existing articles, thereby contributing to the robustness of mine design practice. Bringing together industry leaders to document their mine design expertise offer significant educational value for courses at universities and colleges. For more information contact wiki@miningexcellence.ca or visit our Wiki at www.minedesignwiki.org



SOLUTION TEAM

CIM, Queen's University, Objectivity

ADDITIONAL VALUEMINE PROJECTS COMPLETED:

Hoist Rope Inspection-EMAT Integration

Meyco Shotcrete Testing

Symboticware's Intelligent Monitoring System: SymBot

Baffin Island Intelligent Monitoring Project

Virtual Reality Laboratory at Codelco



"The future of mining, and in particular the future of mining in the Sudbury basin, will require significant development and adoption of innovative solutions. Globalization requires that excellence be recognized internationally and that recognition can only come if there is a sufficient drive and mass to develop leading capability. CEMI is a cornerstone within Northern Ontario for the development of that capability and thus contributes to the scientific, educational, engineering and mining communities in the north." – Andrew Dasys, President, Objectivity

"Symboticware has experienced first-hand how CEMI has led the entrepreneurial community by facilitating collaborations in the area of mining innovation. CEMI has provided the necessary knowledge-based network, capital resources and subject matter expertise for economic growth and development. CEMI's understanding of innovation creation, from "Idea" to "Commercialization", has also involved the development of SMEs led innovation projects. SMEs bring new mining technologies to market, which strengthen Northern Ontario as the leader in mining innovation."

*Kirk Petroski
President & CEO
Symboticware Incorporated*



DEEP MINE

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

PROJECT LEADS: Damien Duff, Peter K. Kaiser

The GeoRisk project comprises 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 sponsored research in this area focuses on:

- understanding rock behaviour response to mining in order to mitigate and manage geotechnical risks
- ways to alleviate the mining investors' risk sensitivity by shortening the time required to develop a mine and ramp up production
- more targeted R&D initiative called SUMIT



SUMIT Team : (Front left to right) Back row: Keith Bullock, Peter Kaiser, Mark Frayne, Jean Hutchinson, Claire Samson, Erik Eberhart, Jane Djivré, Benoît Valley, Ming Cai, Douglas Morrison; Front row: Richard Smith, Denis Thibodeau, Damien Duff, Brad Simser, and Bernd Milkereit. Missing from photo: Steve McKinnon, Mark Diederichs, Kaiwen Xia, Maurice Dusseault, John Harrison, John Hadjigeorgiou, Paul Young, Douglas Schmitt, Gary MacSporran and Dean Millar.

SMART UNDERGROUND MONITORING AND INTEGRATED TECHNOLOGIES (SUMIT) FOR DEEP MINING

In 2010, CEMI submitted a funding application to the Ontario Research Fund and in June of 2011 was awarded \$2.24 million towards a total project value of \$6.7 million for the SUMIT program. The SUMIT program focuses on three major challenges associated with deep underground mining:

MITIGATING GEORISK: improved monitoring and use of geoscience data for superior design and planning; risk management with improved ground characterization and fault slip control; unprecedented data integration and multi-disciplinary usage of it.

RAPID UNDERGROUND DEVELOPMENT: innovations to accelerate mine construction through better assessment of rockmass response to mechanized excavation, innovative material handling systems, and unprecedented data integration capability for multi-disciplinary research approaches.

MINE SUSTAINABILITY: Footprint reduction through energy production and energy optimization.

SUMIT is designed to formalize an approach to finding solutions for the mining industry as it deals with potentially damaging ground behaviour modification issues during the deep mining process. In particular, issues related to mitigating risks associated with fault slip-caused rock bursting will be a focus. Success factors will be measured by creating and quickly transferring new knowledge and technology advances to industry in order to address internal and external investor confidence-related issues.

Vale, Xstrata Nickel and Rio Tinto, will provide access to their mines for the purpose of taking measurements and conducting required experiments. These mines or "Living Laboratories" offer a rare opportunity to produce value-added research outputs and an enhanced success potential. Representatives from each of these companies have been heavily involved in the conceptualization of the research plan.

Initial work has commenced at Vale's Coleman Mine with collaborators from the three universities—Laurentian University, Queen's University and University of Toronto. Early results are being evaluated while future test plans are being formalized.

ANTICIPATED IMPACTS

- greater than 75 person units of training (a person unit is a single student year)
- 20 conference presentations & journal publications
- additional research funding
- establishment of national and international "living laboratory" test sites

SOLUTION TEAM

Laurentian University (lead institution), Queen's University, University of Toronto, University of Waterloo, University of Alberta, Carleton University, University of British Columbia, Vale, Rio Tinto, Xstrata Nickel and Xstrata Copper, LKAB and various consultants.

GEORISK PROGRESS AND ACHIEVEMENTS

While the overall goal is to facilitate step-change innovations, our short term focus is to produce tools and guidelines which have an immediate

positive impact when put on the desks of industry and educational practitioners within the mining industry.

To assist mine geologists and rock mechanics engineers evaluate at the very early phase of a mining project, data gathering on which blocks of ground may be more prone to rock bursts—an important day-to-day as well as mine design consideration for mining companies—CEMI's team has produced a manual entitled Structural geology guidelines for burst-prone ground. Released in the summer of 2011, the manual involved the joint efforts of Dr. Trevor Carter, Associates at Golder Associates Limited and Dr. Steve McKinnon at Queen's University. A short course for industry is planned for 2012, in an effort to transfer this important knowledge and a Wiki-format is being considered.

A second manual—GeoRisk- best practices -- is currently under development. It 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 is being created by Drs. Mark Diederichs (Queen's University), Benoit Valley (MIRARCO), and Peter K. Kaiser (CEMI) and it should be available in early 2012, possibly on-line on the CEMI website.

Sponsored by CEMI, Phase2stat™ software was designed as a tool to assist in reliable mine design approaches which incorporate statistical variability and geological material property uncertainties. The software was released commercially by RocScience in January 2011 and beta-version will be released in collaboration with the Department of Geological Sciences and Geological Engineering of Queen's University and RocScience.

The purpose of the GeoHazmap Tool, now marketed by Mira Geoscience in Montreal, and initially sponsored by CEMI, is to provide a weights of evidence-based approach to determining the potential hazard posed by fault slip-caused seismic events in underground mines. Mira Geoscience's extensive experience and track record in handling and analyzing geoscientific and engineering datasets to help create mineral potential maps for the exploration industry was utilized to identify geohazards. Vale and Xstrata Nickel kindly provided access to large datasets as well as their technical expertise to facilitate this project.

Users of the GeoHazmap Tool can be confident that hazards are determined on the basis of a thorough and comprehensive examination and evaluation of all possible contributing technical factors, including, but not limited to seismicity and microseismicity—the two inputs traditionally and most frequently used in ground failure hazard assessment. The tool offers mine design engineers the opportunity at the early project design stage, to virtually assess the impact on rockmass behaviour of their various mine

design scenarios, a critical capability not previously available to them. The concept has been picked up by Rio Tinto and have commissioned Mira Geoscience to develop a tool for caving operations.

Finally, in part to produce new knowledge as well as tools and guidelines designed to improve our ability to model and forecast future conditions



related to ground behaviour, QuadraFNX (QFNX) has offered its Victoria Project near Sudbury to CEMI, as a "living laboratory" for innovative ground characterization and to identify ways to optimize geotechnical risk reduction in deep mines. The approach will be to continuously collect geotechnical data from the exploration/development phase into the production stages and, by so doing, to gauge and improve our ability to model and predict rock mass behaviour in response to mine construction and production.

Additional GeoRisk (DeepMine) Sub-Projects under development include:

- Site Characterization Optimization in Sill Pillars
- Burst Support Tool
- Synthetic Ground Motion Assessment Tool (S-GMAT)
- Risk in GeoRisk Guidelines

SOLUTION TEAM

GeoRisk core contributors include Mira Geoscience, MIRARCO, Golder Associates, Institute for Mine Seismology, Vale, Xstrata Nickel, University of Toronto, Itasca Canada, Queen's University, and Laurentian University.



DEEP MINE



UNDERGROUND MINE CONSTRUCTION FOR IMPROVED PRODUCTIVITY AND STABILITY

PROJECT LEADS: Peter K. Kaiser, Keith Bullock

When developing new mines, time is money. Every day lost during the development of a mine can cost hundreds of thousands of dollars. For large mining projects, this daily loss may reach a million dollars.

Furthermore, as it is necessary to proceed with smaller excavations at depth, excavation rates by drilling and blasting becomes increasingly uneconomic and anticipated diesel emission restrictions will demand innovative material handling approaches. Mechanized excavation technologies and continuous mining methods thus become more attractive, but will require step-changes in mine development and selective ore extraction.

Strategic research and development in areas focused on safe, rapid, mechanized development in underground mines as well as on mechanized selective ore extraction, combined with a continuous mining process, are being pursued by several mining companies. Our current research aims at overcoming several challenges in the mine construction and mechanized excavation sectors, and in particular, challenges related to introducing technologies to perform in naturally variable ground. The program aims at:

- effective implementation of new and mechanized technologies for speed and quality of underground infrastructure construction
- advances in rapid mechanized development, both for vertical and horizontal applications
- ground control process assessment and development to support rapid mechanised development systems
- facilitation of the introduction of Railveyor technology, with emphasis on geotechnical and fragmentation parameters

Since there will always be a need for conventional excavation techniques, this program also deals with assessment and advances in conventional drill and blast excavation processes aimed at improvements in ground characterization for pillar design at depth.

RIO TINTO CENTRE FOR UNDERGROUND MINE CONSTRUCTION (RTC-UMC)

The recently established Centre for Underground Mine Construction, with an investment of \$10 million by Rio Tinto as a division of CEMI, is ramping-up its R&D program. Rio Tinto is placing its primary focus on its Mine of the Future™ program, conducting research into mechanized excavation

that consists of both shaft boring systems (SBS) and tunnel boring systems (TBS). However, related matters such as rock mass strength at depth and pillar design will also be included in the research program.

Several companies were invited to bring ideas and partner with Rio Tinto during the concept development stage. After a comprehensive analysis and selection process, two tunneling concepts and one shaft sinking concept were selected for further detail engineering. The two new tunneling concepts are being developed in partnership with Atlas Copco and



John McGagh and Peter K. Kaiser at the signing ceremony for the Rio Tinto Centre for Underground Mine Construction.

Aker Wirth, respectively. The shaft boring system is being developed by Herrenknecht. These technologies will enable faster development with target advance rates exceeding 10m/day, creating more cost-effective tunneling overall. This project will make mine construction safer and reduce construction time, as the continuous excavation feature can eliminate explosives, blast gases, and also reduce ground control risk increasing worker safety.

An integral component in ensuring consistent advance rates is the geotechnical parameters that play a key role in ensuring successful application of these step-function technologies. CEMI's expertise and R&D track record in this field will play a critical role in supporting this ambitious program. The initial focus of the Centre is to support the field trial of the first of two new tunnel boring systems at Northparkes (Australia). Of the 20 or so planned work packages, nine have been approved and are underway,

covering broad topics, research facilities and mine sites. Complementary studies to facilitate the application of findings to Canadian Mines are in the planning stages. The challenges to be overcome by the Centre include the need to develop innovative ground support systems that can be installed in parallel with rock excavation, ensuring sufficient stand-up time and the proper management of strainburst potential, and identifying the means to improve construction logistics.

PROGRESS AND ACHIEVEMENTS

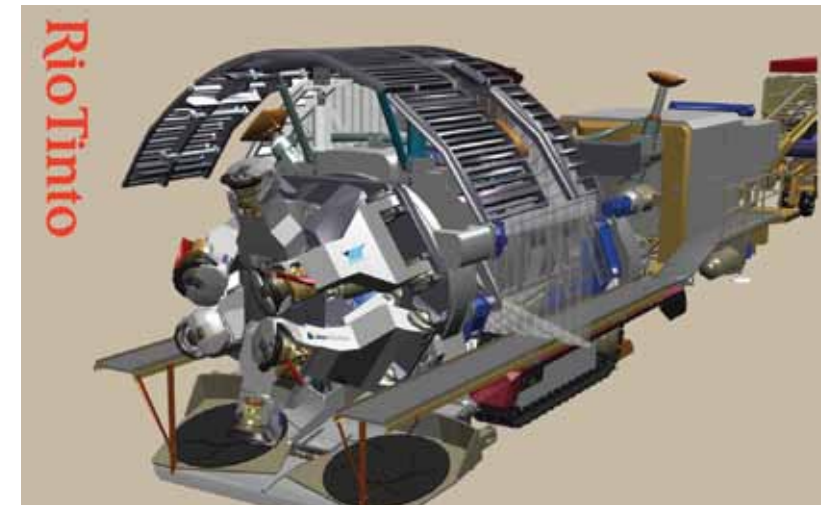
With the establishment of the RTC-UMC, CEMI and its solution team members will be working towards the implementation of mechanized tunneling and shaft sinking technologies in collaboration with companies in Canada, Australia, Chile, Germany, the Netherlands, the U.S.A., and in South Africa.

In the near future, field trials on the first TBS projects have begun. The second TBS trial is anticipated to begin in late 2012 and the SBS trial is planned to commence in 2013. Related projects include:

- ground control in mechanized excavations: shafts and tunnels
- strength determination for deep ore bodies based on borehole information
- development of innovative support systems for rapid installment
- strainburst control with rock support and de-stressing
- pillar design at depth

SOLUTION TEAM

The current program sponsoring mining companies include Rio Tinto (lead sponsor) with related work as part of the SUMIT program, co-sponsored at Ontario Universities by the Ontario Research Fund – Research Excellence programs. Collaborating organizations include Itasca U.S.; Herrenknecht AG; Aker Wirth; Atlas Copco; ROWA Logistics, MIRARCO, and Laurentian University, Queen's University, Universities of Arizona and Toronto, University of British Columbia, University of Dalian, Colorado School of Mines, Delft University, others to be determined based on required expertise.





ENVIRONMENTAL STUDIES AND SUSTAINABILITY

PROJECT LEADS: Douglas Morrison, Damien Duff

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; and anticipate potential for over-and under-supply of water for aqueous cover to the tailings
- initiatives that will improve the reliability of performance of tailings management facilities and reduce the risk of environmental impact
- initiatives that will 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

To underscore CEMI's commitment to sustaining mines and mining, it has also, with the support of the Ontario government, established an important R&D leadership position focused on identifying the opportunities for novel research in this area.

CHAIR IN HOLISTIC MINING PRACTICES

Part of the role of the Chair is to serve as incubator of ideas that have some promise and may develop into major research programs in the future. Currently, four seed projects have been initiated. One aims at breaking down pyrrhotite without releasing SO₂, thus potentially reducing acid mine drainage, while another focuses on the use of inorganic chemical compounds to extract specific metal ions. A third will use microbes to eliminate the source of acid mine drainage from tailings and, finally, a fourth will experiment with new forms of energy transmission on several mining-related processes. Each project constitutes a small, but important step. If successful, they could be combined with other novel processes to create a new way to achieve more sustainable ways for dealing with mine process waste.

In pursuing such relatively high-risk projects, we accept the possibility of failure; but without risk there is no innovation. And we accept that even

those results that do not take us close to the originally intended goal are not a waste of effort, but are solutions to questions we had so far failed to answer. They are the route to the solution of a problem we were so far unaware of.

In addition to these high-risk projects we will be working on developments that will have a high probability of success and the potential to have an immediate impact on mitigating the risks associated with the management of mine tailings. We think that the combination of practical and achievable short-term projects with investments in less predictable long term opportunities provides a good mix for tactical improvements and for strategic innovation.

PROGRESS AND ACHIEVEMENTS

Additional SustainMine projects include:

- PreCalcatOre
- Fugitive Dust Best Management Practice Plan (BMPP)
- continued support of Dr. Dean Millar's work in the areas of energy cost reduction in mines
- the sustainability aspects of Ventilation on Demand (VOD) project, as described under ValueMine



(left to right) Murray Scott, Mayor Marianne Matichuk, MPP Rick Bartolucci, Peter K. Kaiser, and Douglas Morrison at the NOHFC funding announcement for the Chair in Holistic Mining Practices.



NEXT STEPS

MIRARCO has conducted several successful projects focused on growing crops on tailings and CEMI will actively support the continuation and expansion of this work over the next three years. However, in order to expand the range of topics addressing issues of sustainability, several new programs are under development, focused on the current and future performance of tailings management facilities.

The stability monitoring of conventional tailings dams could be significantly improved with the development of an integrated package of satellite communications, wireless instrumentation, data management systems and hazard monitoring protocols. The operation of conventional tailings facilities is being increasingly challenged by climate change and conditions of either excess water storage or, alternatively, insufficient water coverage is being created. Improving conventional performance monitoring by linking it to satellite meteorological information would significantly improve the ability to stay within operational design limits.

SOLUTION TEAM

MineSense Technologies Limited, Xstrata Process Support (XPS), MIRARCO, CANMET and Golder Associates



"The growing success of CEMI has been evident by a broadening of its support and sponsorship base. These developments point to an increasingly larger circle of researchers, mining companies, mining service providers and educational institutions engaged in developing innovative solutions to challenges faced by the mining industry in far reaching jurisdictions. This latest trend unquestionably establishes CEMI as a highly reputable internationally networked innovation center both regionally and internationally."

Marc Boissonneault

Vice President Xstrata Nickel, Sudbury Operations & Chair of CEMI Board of Directors



MINERAL EXPLORATION RESEARCH & GEOPHYSICS

PROJECT LEADS: Damien Duff, Douglas Morrison

The implementation of step-change research in the area of exploration (new deposits, expanded mines) 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
- developing new or improved geophysical detection techniques to optimize the chances of future exploration successes

INDUSTRIAL RESEARCH CHAIR IN EXPLORATION GEOPHYSICS

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 and four post-graduate students (2 masters and 2 doctoral students) are currently working on related projects. The Chair is sponsored by companies with large property positions and geophysical datasets in Sudbury. Dr. Smith's students have unprecedented access to properties, previous datasets and company geophysical expertise during their studies. His research has 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 this 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, and mine mineral deposits more effectively, substantially speeds advancement in the mining industry.

PROGRESS AND ACHIEVEMENTS

Other geologically focused projects include:

- detailed petrologic and geochemical studies of the Parkin Offset rocks
- detailed petrologic and geochemical and partial melting studies of South Range rocks
- detailed structural and metamorphic analysis of footwall rocks in the South Range

NSERC funding led to two related projects that are underway:

- experimental studies of the role of Bi, Te, As in PGE fractionation and remobilization during sulfide liquid fractionation and during metamorphism
- the role of fluids in the modification and formation of Cu-Ni-PGE systems

SOLUTION TEAM

Mineral Industry Research Centre (MERC), Department of Earth Sciences at Laurentian University, Vale, Xstrata Nickel, Wallbridge Mining and QuadraFNX Mining.

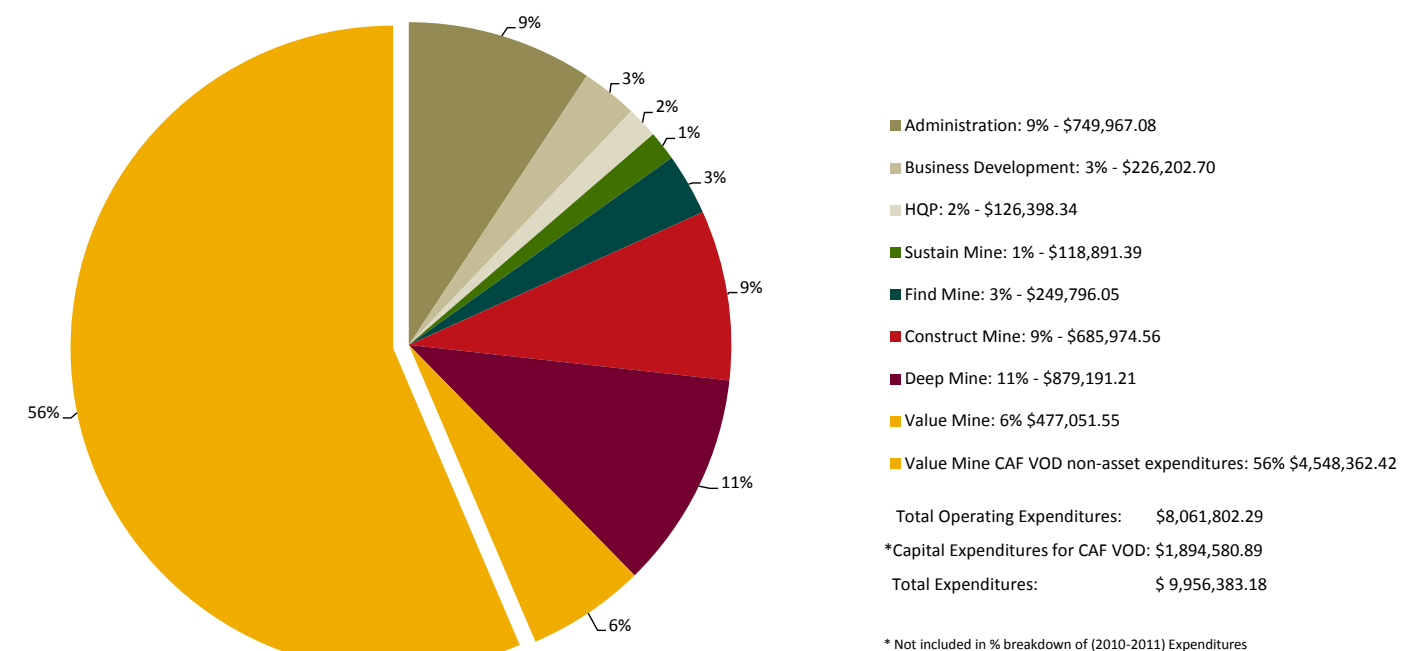


Michal Kolaj (M.Sc.) student

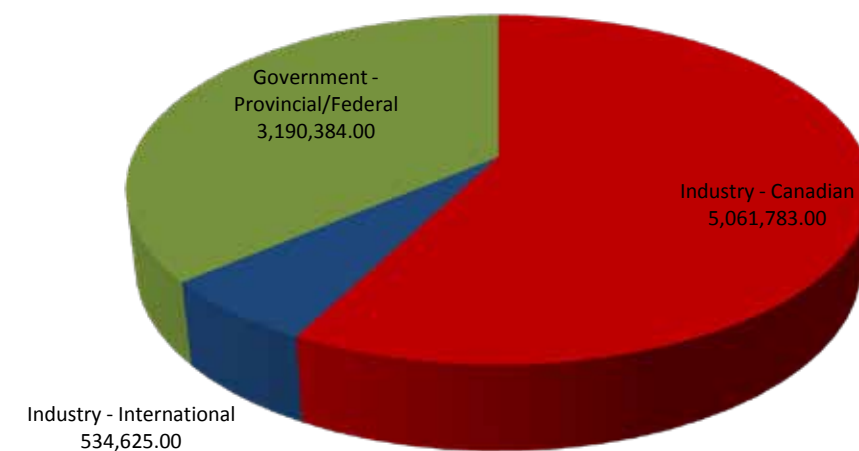


Dr. Richard Smith's students in the field (left to right) Michal Kolaj, Devon Parry, Josh Lymburner and Oladele Olaniyan.

2010-2011 Expenditures



2010 - 2011 REVENUE \$ 8,786,792



KNOWLEDGE TRANSFER



CEMI has been quite active fulfilling its mandate to transfer knowledge across the industry through a series of lectures, educational workshops, training and the dissemination of information.

LECTURE SERIES: The Lecture Series continues to feature technical presentations on a wide range of mining and engineering topics featuring academic and practicing guest speakers. The series highlights innovative research on topics relevant to the mining industry.

Live streaming video of its lecture series is provided for people unable to attend in person and for those in more remote areas, in Northern Ontario and beyond, to gain access to new knowledge. Video coverage of these lectures is available online at www.miningexcellence.ca



1. Dr. Paul Marinos, National Technical University of Athens presents: "Rock mass characterization; a vehicle to translate Geology into the design of Engineering Structures"
2. Dr. Peter K. Kaiser, CEMI presents: "GeoRisk - Rockmass characterization for mining at depth. Is status quo adequate? Is current approach a liability?"
3. Dr. Jean Hutchinson, Queen's University presents: "Borehole data collection for Empirical Classification vs Mechanistic Input: Are we collecting the right stuff?"
4. Trevor Carter, Golder Associates presents: "Structural Geology Guidelines as an aid in identifying fault slip-prone rockmasses"
5. Dr. Mark Diederichs, Queen's University presents: "Rockmass Characterization techniques used in Nuclear waste repositories - their potential relevance to our deep mines"
6. Dr. Claire Samson, Carleton University presents: "A laser

scanning approach to highlighting rockmass character at the exploration and at the underground mine development stage"
7. Brad Simser, Xstrata Nickel presents: "The Potential Negative Effects of Poor Rockmass Characterization Practices - an operator's perspective"
8. Dr. Denis Thibodeau, Vale presents: "Rockmass Characterization Practices and experiences at Vale in Sudbury"
9. Dr. Catharine Farrow, QuadraFNX presents: "An emerging powerhouse in copper mining - Quadra FNX's Victoria Ni-Cu-PGE Discovery"
10. Dr. Erik Eberhardt, University of British Columbia presents: "Impacts of Underground Mass Mining on Surface: Lessons Learned from the Palabora Cave-Pit Interaction Study"
11. Dr. Florian Amann, Swiss Federal Institute of Technology Zurich presents: "The role of brittle failure in sedimentary rocks in Swiss tunnel projects"

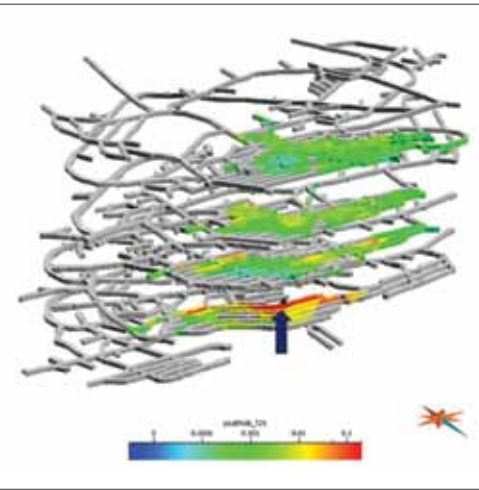
KNOWLEDGE TRANSFER

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



Dr. John McGaughey, President of Mira Geoscience presented, “Mira Geoscience’s Rock Property Database, Geohazard and Geotechnical Data Management Systems”

Rock property knowledge is central to understanding both geophysical data in mineral exploration and rock mass response in mining. Historically, little emphasis has been placed on quantitative understanding of rock properties in ore environments because interpretation methods have been primarily qualitative. Today’s twin challenges of deep exploration beneath cover and deep, complex mining, demand a much more analytically rigorous



approach to data interpretation and modelling, which often rests upon assumptions about the rock property distribution of the geological environment. The Rock Property Database System (RPDS) is a web-based, rock property database that integrates sample, wireline and literature-based rock property data and allows investigation and establishment of rock property “profiles” for geological environments. It is intended to follow a “wiki” model, inviting contribution of rock property data by its community of users, while

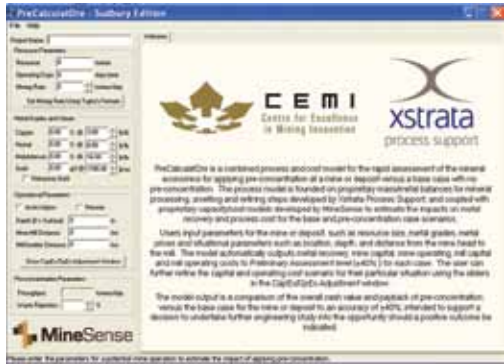
supporting both a public and private data model. We anticipate the rock property database will serve as valuable, central resource for a broad range of mineral exploration and mining professionals.

Significant progress has been made over the last few years in establishing a framework for quantitative estimation of geotechnical hazard in mines. The approach is based on modeling various hazard criteria and correlating them to a history of actual hazard experience. Successful CEMI-sponsored proof-of-concept trials have been conducted at both Xstrata’s Craig Mine and Vale’s Creighton Mine, where the hazard being investigated was fault-slip rockbursting. The analysis framework rests on a 4D statistical

back-analysis, which demands ready access to historical “snapshots” of the mine environment at the time of previous hazard events. In practical terms, this approach demands relatively good access to a historical trail of mine production and geotechnical data. Successfully addressing the data management challenges will yield huge benefits to future achievement in quantitatively evaluating and managing geotechnical hazards.

Dr. Andrew Bamber, Adjunct Professor in Mine-Mill Integration at UBC and CEO of MineSense Technologies Ltd. presented a short course titled, “Approaches in Mine-Mill Integration: Economic Evaluation of Pre-concentration Opportunities”.

Mine-Mill Integration encompasses a range of approaches for the integration of novel technologies into the mining system to improve the efficiency and effectiveness of the mineral extraction and beneficiation process, and therefore reduce energy and costs. Mine Mill Integration approaches include the integration of mineral sensing and sorting systems as well as systems for ore pre-concentration such as dense media separation into the mining system. Economic evaluation of these opportunities to integrate value-added technologies such as pre-concentration into the flow sheet, requires consideration of capital, operating and revenue impacts, both up and down the mining value chain. The course presented a comprehensive and systematic approach for interpreting results from pre-concentration testwork and discussed several case studies which fully described the opportunity to be considered.

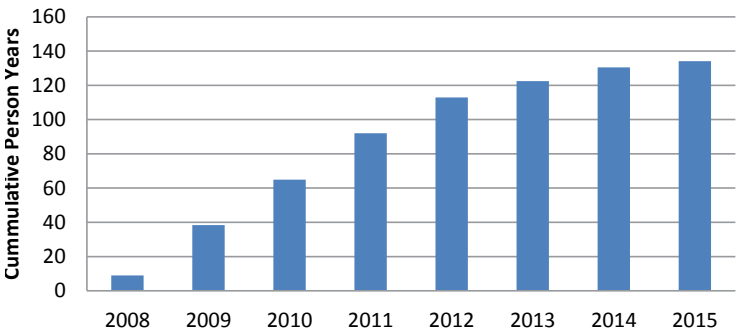


BUILDING HUMAN CAPITAL- INVESTING IN STUDENTS

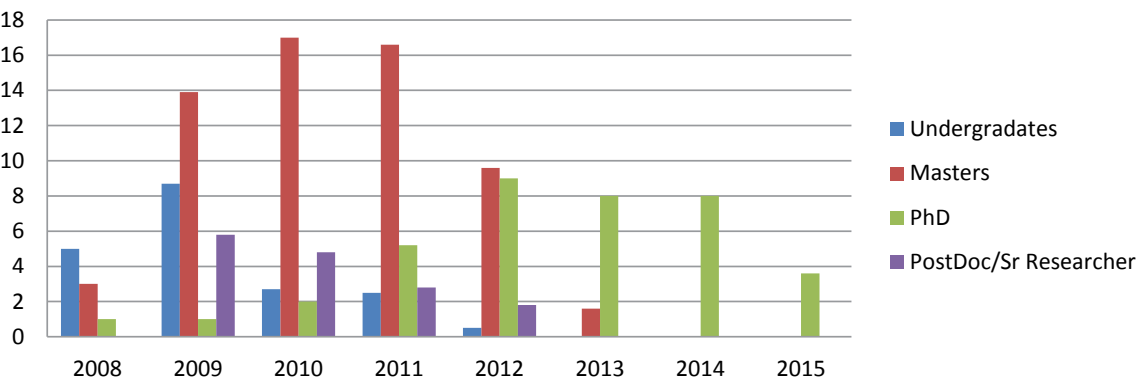
We work with research institutions in Ontario, across Canada, and around the world, and engage with engineers and scientists in a range of technical disciplines in order to help the mining industry address the environmental challenges it faces. To date, we are funding work with collaborators at Université Laval, Queen’s University, University of Toronto, University of Waterloo, Laurentian University, Delft University of Technology, and the University of British Columbia in Canada, and at Dalian University in China. 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 2011, CEMI will have contributed to the development of over 100 years of graduate-student development in exploration and mining related sectors (at 7 Universities). The cumulative student-years and allocation by degree are shown in the following graphs. CEMI currently collaborates with over 30 professors and 50 co-op, undergraduate, graduate students (MSc, PhD) and post-doctoral fellows working on over 30 research projects.

HQP Development



Total Students



BUILDING HUMAN CAPITAL- INVESTING IN STUDENTS

CEMI supported students are offered an opportunity to present their theses to their peers, professors, and key industry representatives. The series of presentations offers an opportunity to celebrate the research efforts of up and coming researchers! This year we provided students the opportunity to come together to speak about their GeoRisk related research projects. The students also got to listen to special lectures from **Stephen Flewelling**, Senior Vice President, Projects and Exploration at Xstrata Nickel; **Brian Buss**, Director of Project Development at Lake Shore Gold; and **Nigel Smith**, Director at SNOLABS.



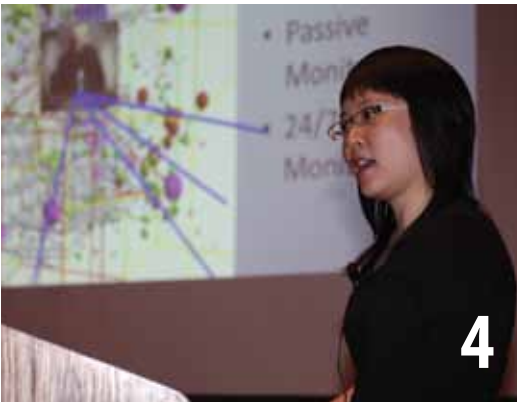
1. ROB BEWICK
PhD candidate, University of Toronto
Supervisor: Drs. Will Bawden/Peter K. Kaiser
Topic: Faulting Mechanics and Mining

2. LAWRENCE WAMBOLDT
M.Sc. student , Queen's University
Supervisor: Dr. Steve McKinnon
Topic: A Procedure for Determining Seismic Moment Tensors



3. JEFF BOYD
M.Sc. student, Queen's University
Supervisor: Dr. Steve McKinnon
Topic: Mining-Induced Seismicity and Stress Inversion

4. WINNIE PUN
M.Sc. student, University of Toronto
Supervisor: Dr. Bernd Milkereit
Collaborators: Benoît Valley, CEMI; Wei Qian, Caracle Creek International Consulting
Topic: Geophysical Time Series Data from a Stressed Environment



5. RAMIN SALEH
PhD candidate, University of Toronto
Supervisor: Dr. Bernd Milkereit
Topic: Towards Seismic Wave Propagation in a 3D Mine Model

6. CARA KENNEDY
B.A.Sc. student, University of Waterloo
Supervisor: Dr. Maurice Dusseault
Topic: Mine Strain Measurement using Fibre Optics Systems



7. GEORISK STUDENT GATHERING
(left to right) Jeff Boyd, Cara Kennedy, Ramin Saleh, Stephen Flewelling, Lawrence Wamboldt, Nader Golchinfar (M.Sc. student, Laurentian University, Supervisor: Dr. Ming Cai, Topic: Study of Depth of Failure under Dynamic Loading), Rob Bewick, and Winnie Pun

8. JONATHAN HORDO
M.Sc. student, Queen's University
Supervisor: Dr. Jim Martin
Topic: The Contribution of Geomechanics/ Engineering Geology to Mine Enterprise Value



CEMI TEAM



ALLAN AKERMAN
R&D Program Director & Operations



KEITH BULLOCK
R&D Program Director



DAMIEN DUFF
R&D Program Director



JANE DJIVRÉ
Business Development Director



PETER KAISER
President & CEO



SHANNON KATARY
Marketing and Communications



NATALIE LAFLEUR-ROY
Finance and Operations



GLENN LYLE
R&D Program Director



DOUGLAS MORRISON
Vice President
Chair in Holistic Mining Practices



JENNIFER THOMAS
Administrative Assistant



BORA UGURGEL
Innovation & Prosperity
Office Coordinator

SOLUTION TEAM

INDUSTRY
Baffinland Iron Mines Corporation
Codelco
LKAB
Nuinsco Resources Ltd
Peregrine Diamonds
QuadraFNX Mining Ltd
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

COLLABORATOR
Bestech
CAMIRO
Government of Canada
CANMET
CIM
City of Greater Sudbury
C-Core
Engineering Seismology Group (ESG)
Golder Associates
IBM Canada
Institute of Mine Seismology (IMS)
Itasca
Labrecque Technologies
LCG Energy Management
MERC
MineSense
Mira Geoscience
MIRARCO
Natural Resources Canada (NRCAN)
Northern Ontario Heritage Fund Corporation
NRC-IRAP-Industrial Research Assistance Program
NSERC
Nuclear Waste Management Organization (NWMO)
Objectivity
Government of Ontario
Penguin ASI
Precarn
Roctest
RocScience
Simsmart Technologies
SNOLAB
SRK Consulting
Stratos Inc
Symboticware

“CEMI has been and continues to be a strong supporter of all aspects of higher education and research that support the development of innovation in mining. They are an integral part of the mining industry, and particularly of the development of the human and intellectual resources that will form the critical underpinning for the growth and future of the mining industry in Northern Ontario.”

*Dr. Ramesh Subramanian
Director, School of Engineering
Laurentian University*

JOIN OUR EXPANDING NETWORK OF PATRONS AND SPONSORS

CEMI is established to play a leadership role in developing step-change innovation and 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 all collaborators who have demonstrated excellence in their field, to deliver innovation to meet the mining industry needs, while helping to ensure that collaborators meet their individual measures of success.

PATRONS

Last year, Xstrata Nickel, Vale, Laurentian University, and the Ontario Government, were joined by Rio Tinto as CEMI Patrons who recognize that to accomplish step-change innovation, there has to be support for an organization to play a critically important and stabilizing intermediary role. These Patrons, being innovators in their own right understand that innovation is a managed process. It is the key to meeting the challenges of the future. They know that it cannot be developed with short time-lines or as a linear process without some diversions along the way. The Patrons rely on CEMI to manage their effort towards step-change innovation, mitigate the impact of incidental failures and try to use 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. In doing so, they help create an industry that offers dynamic and rewarding careers to the engineers, scientists and technicians of tomorrow. Sponsors are committed to initiating and developing research programs that address the needs of the broader industry as part of collaborative projects. They 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 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. This allows CEMI to expand the project scope and allows the sponsors to accomplish much more than they could with their own internal R&D projects.

PATRONS AND SPONSORS WILL:

- guide the direction and priority of research initiatives and actively participate in research projects
- get access to funding and other resources (facilities; technology; site locations)
- lower investor risk by leveraging R&D investments
- gain access to senior program directors for effective research project management
- acquire access to research results on shared and single sponsored projects
- engage in the practical implementation of R&D results
- attend seminars, gain access to training and published findings
- gain access to CEMI's solution teams to collaborate with like-minded individuals from different areas of expertise

"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*

OUR PATRONS





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