

ANNUAL REPORT 2014

**"THE REAL VOYAGE OF DISCOVERY CONSISTS,
NOT IN SEEKING NEW LANDSCAPES,
BUT IN HAVING NEW EYES."**

MARCEL PROUST



CEMI
Centre for Excellence
in Mining Innovation

“CREATIVITY IS THINKING UP NEW THINGS.
INNOVATION IS DOING NEW THINGS.” THEODORE LEVITT

The Centre for Excellence in Mining Innovation (CEMI) directs and coordinates step-change innovation in the areas of exploration, deep mining, integrated mine engineering, underground mine construction, environment and sustainability for the metal mining industry. Our seasoned team of Program Directors lead industry-focused academic and applied research & development projects that extend from geology and engineering to the natural sciences. We offer a single point of entry for knowledge resources and human capital that enhances the scope, extent and impact of innovation for the metal mining industry globally.

At CEMI, innovation is regarded as a three-phase process: research, development and implementation (R&D+I). With implementation, innovations are demonstrated for operational integration to facilitate improved mine performance and for commercial potential. CEMI creates greater capacity for excellence in innovation and adds greater value to the economic development of the metal mining industry by:

- 1 | encouraging cross-sector collaboration with Canadian and global mining companies, universities, government researchers, technical consultants, and innovative SMEs across Canada and around the world
- 2 | facilitating industry-focused innovation that advances new practices, processes, methodologies or technologies for improved productivity and cost efficiency
- 3 | developing and nurturing the future generations of researchers, highly qualified personnel and industry leaders by providing training opportunities and in-field access to facilities
- 4 | implementing sound business practices with a focus on accountability, efficiency and effectiveness that are socially responsible and attuned to community needs and expectations
- 5 | attracting global patrons, sponsors and government funding



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“THROUGH OUR PARTNERSHIP WITH CEMI, WE ARE ABLE TO COLLABORATE ON INDUSTRY-LEADING INNOVATIONS. TOGETHER WE GENERATE NEW IDEAS THAT MAKE MINERAL EXPLORATION AND DEVELOPMENT MORE SUSTAINABLE FOR THE BENEFIT OF EACH OF THE COMMUNITIES IN WHICH WE OPERATE.”

CONOR SPOLLEN, VICE PRESIDENT NORTH ATLANTIC PROJECTS, VALE

MESSAGE FROM THE CHAIRMAN OF THE BOARD



On behalf of the Board of Directors, I would like to thank everyone involved at CEMI—Board, staff and collaborators—for their efforts to move CEMI forward over the past year. Together we are leading the way in developing new and innovative technologies and bringing them to market.

This year marks a new chapter in CEMI’s history with the success of our submission to the Federal Business-Led Network of Centres of Excellence (BL-NCE). This resulted in an award of \$15 million to CEMI’s Ultra-Deep Mining Network (UDMN) and positions Canada in a global leadership role in mining

innovation and as a knowledge-centre in ultra-deep bulk mining, ensuring that we remain the premiere natural resource investment destination of choice.

The UDMN award is important also because it recognizes the broad range of issues that CEMI seeks to address—not just technology itself but how humans will engage with technology and how communities will engage with resources industries. By focusing on identifying new funding sources and cultivating relationships with a broader range of corporate sponsors, CEMI is on the way to ensuring its long-term continuity and prosperity.

The Board too, is evolving to meet the needs of the future and I want to officially welcome our newest board members: Melanie Paradis, Senior Communications Advisor at Vale, and Ron Schwartz, Managing

Partner, Adante Consulting Inc. I would also like to take this opportunity to thank Fred Delabbio, General Manager, Underground Mining Innovation at Rio Tinto, for his dedicated efforts to establish the Rio Tinto Centre for Underground Mine Construction at CEMI, and for his support to CEMI over the last four years on the Board. We look forward to working with his successor. I also want to congratulate George Ross, Deputy Minister with the Ontario Ministry of Northern Development and Mines, who is moving to Yukon to serve as Deputy Minister of Energy, Mines and Resources. George has been a key advisor to CEMI over the past three years.

This year also marks the end of my term on the Board. It has been a privilege serving on the Board over the past five years and as Chair in the past year. On behalf of the Board, I am pleased to announce that Roger Emdin, Manager, Sustainable Development, Sudbury Integrated Nickel Operations — A Glencore Company, will be the incoming Chair.

Collectively, everyone at CEMI want to thank our Patrons, Sponsors and Collaborators for their dedication and continued support of our mining innovation initiatives and so helping to make CEMI Canada’s leading source of mining innovation.

Dominic Giroux
Chair of CEMI Board

BOARD OF DIRECTORS



DOMINIC GIROUX
Chair of CEMI Board
President
Laurentian University



DAVID WILICK
Mining Regional Leader — North America
GE Mining Solutions



GEORGE ROSS
Deputy Minister
Ministry of Northern Development & Mines



FRED DELABBIO
General Manager
Underground Mining Innovation
Rio Tinto



ROGER EMDIN
Manager, Sustainable Development
Sudbury Integrated Nickel Operations
A Glencore Company



NIGEL SMITH
Director
SNOLAB



KAREN CLARKE-WHISTLER
Chief Environment Officer
TD Bank Financial Group



RON SCHWARTZ
Managing Partner
Adante Consulting Inc



CONOR SPOLLEN
Vice President, North Atlantic Projects
Corporate Office Base Metals
Vale



MELANIE PARADIS
Senior Communications Advisor
Corporate Office Base Metals
Vale



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



MARIAN CAMPBELL JARVIS
Assistant Deputy Minister – Minerals and Metals Sector
Natural Resources Canada



DOUGLAS MORRISON
President and CEO, CEMI
Network Director, UDMN
Chair in Holistic Mining Practices

MESSAGE FROM THE PRESIDENT



We look back on 2014 as a seminal year in the development of CEMI, with major new funding announcements from all levels of government, the expansion in the range of technical disciplines, and the addition of staff with business experience to our technical team. We have seen significant growth in our relationships with the mining service and supply sector and in the support we have from mines operating in Quebec. Combining these relationships with our continuing involvement with major international mining companies, we are very pleased to be working with some of the most forward-looking companies engaged in the global mining industry today.

The most important event of the past year was the success of our submission to the Federal Government’s Business-Led Networks of Centres of Excellence (BL-NCE) program—the Ultra-Deep Mining Network (UDMN)—that will focus on the changes the industry has to make to continue bulk metal mining below 2.5km depth. This result was truly a team effort, not only the CEMI staff, but also members of the Board, especially Roger Emdin (Sudbury Integrated Nickel Operations – A Glencore Company) and from other collaborators such as Dr. Dean Millar (MIRARCO); Dr. Maurice Dusseault (University of Waterloo); and Larry Matthews (ConocoPhillips).

NEW FUNDING

This was the first submission to the BL-NCE Program from the mining industry and since the award is one of the largest investments in mining innovation by the Federal Government, the Minister of Natural Resources (formerly Minister of State – Science and Technology), Greg Rickford, was pleased to make the announcement of the \$15M award in Sudbury, as well as announcing the other three awards to the manufacturing, pharmaceuticals and aviation industry sectors. In addition to being a significant financial award, it recognizes the importance of addressing

social and health issues as well as technology issues for bulk mining to be successful at much greater depths, and it reinforces the need to focus on the commercialization of solutions. This award provides major impetus to CEMI’s technical and commercialization initiatives and will encourage further expansion in the number of organisations that actively participate in CEMI’s projects and programs.

We are very fortunate to have received significant financial support from the Northern Ontario Heritage Fund Corporation (NOHFC) in the amount of \$783,916 for the Single Heading Lateral Development project that aims to significantly increase advance rates in underground mines. We look forward to further support for our initiatives in improving the techniques for managing mine waste and introducing technologies to support the responsible development of mineral deposits in the remote Far North.

BUILDING RELATIONSHIPS

CEMI was a major supporter of the Ontario Chambers of Commerce (OCC) effort to produce the report “Beneath the Surface: Uncovering the Economic Potential of Ontario’s Ring of Fire.” We participated in all of the events – as a panelist in Toronto and as the panel moderator in Thunder Bay, Sudbury and Timmins. CEMI continues to work with the OCC to help ensure the importance of the mining industry is recognized by Chambers of Commerce across the Province.

The Rio Tinto Centre for Underground Mine Construction (RTC-UMC) has been an important part of CEMI since its inception in 2010 and with the retirement of the Founding Director, Dr. Peter K. Kaiser, in June of this year, we would like to express our sincere gratitude for all his efforts to take this initiative forward. The new Director, Dr. Matthew Pierce from Itasca Consulting Inc., who will be assisted by Dr. Erik Eberhardt of University of British Columbia as Assistant Director, took up his new role as of July. Shortly after this transition, responsibility for the RTC-UMC was transferred within Rio Tinto from the Technology and Innovation Division to the Copper Division. We hope this will increase the level of engagement CEMI has with Rio’s copper mining operations and allow us to offer greater value to Rio Tinto through the productivity-related projects that are part of the UDMN.

ACHIEVEMENTS & APPOINTMENTS

In addition to our corporate developments, we want to congratulate those of our staff who achieved important personal goals this past year: Allan Akerman was awarded the CIM Community Service Award, well-deserved recognition for his commitment to the underground hard rock mining industry, his dedication to Vale (formerly INCO), CEMI and CIM; and Shannon Katary received a Northern Ontario Business Top 40 Under 40 Award and completed graduate studies from Queen’s University in Community Relations for the Extractive Industries. CEMI continues to grow and evolve and I would like to acknowledge the newest members of the team over the last year: Brian Jones, Vice President Business Innovation; Pat Dubreuil, R&D Program Director; Diane Lepage, UDMN Administrative Coordinator; Eric Maag, Director, Innovation & Prosperity Office; Vern Drylie, R&D Program Director, Environment & Sustainability; and Rocky Webb, Project Manager Underground Projects.

SETTING UP FOR FUTURE SUCCESS

With the achievements of this past year, CEMI continues to add to our existing strengths in mine design and geotechnical risk reduction by making significant progress in the areas of mine productivity and mine waste management. Most importantly, we are now poised to focus on the critical process of commercializing the technical developments we have worked on over the past two years, to help improve the performance of existing mining operations and accelerate the development of new mines. We aim to accomplish this through our partners in the service and supply sector, helping them to meet the needs of mines in Canada and around the world and so increase economic activity here at home.

With project participants based in several Canadian Provinces, CEMI is now the national leader in mining research, innovation and commercialization, and from this foundation we seek to expand Canada’s role in improving the performance of the industry globally. With active projects in every aspect of mining operations from mineral exploration, mine development, production efficiency, energy consumption, human factors, environmental impact and post-closure

land use, CEMI has developed a comprehensive approach to mining innovation, integrating excellence from the areas of science, engineering, social, medical and business. CEMI believes that the success of mining as a productive, safe and environmentally responsible industry in the future, more than ever before, depends on such a multi-disciplinary approach. Much more work is needed to address the challenges of our industry, and we invite new Patrons, Sponsors and Collaborators to join our efforts in driving mining innovation in Canada and worldwide.

As always, our success can only happen with a dedicated team of individuals that have the curiosity, drive and passion to make a difference. I am fortunate to work with such a dedicated team, and express my sincere appreciation to them.

Douglas Morrison
President & CEO
Centre for Excellence in Mining Innovation

STRATEGIC RESEARCH PROGRAMS AND PROJECTS

CEMI LEADS MINING INNOVATION IN 5 CORE STRATEGIC THEMES

CEMI continues to fulfill its mandate to lead step-change innovation in the mining industry through its focus on five core strategic areas of exploration, deep mining, integrated mine engineering, underground mine construction, and environment and sustainability. Since 2007, CEMI has led by directing and co-ordinating innovation through the key project categories of FindMine, DeepMine, ValueMine, ConstructMine and SustainMine by introducing new practices, procedures, techniques, technologies and knowledge to help generate significant improvement in the performance and safety of mines.

A STRATEGIC AND DISCIPLINED APPROACH TO INNOVATION

The long lead times (3-5 years), the need for convergence of different disciplines and for cross-sector collaboration with industry, universities, research institutions and SMEs, makes the innovation process exciting and challenging for any business. CEMI's three-phase process, of research, development and implementation (RD&I), is approached with strong and clear focus to ensure purposeful, systematic innovation in each of our five core research and development project themes. Implementation is the element within the innovation process that considers operational viability. The result is a disciplined and strategic approach to innovation with measurable achievements of key industry performance indicators.

The step-change activities undertaken since inception have prepared the groundwork and set up a solid foundation for the next phase of CEMI's mandate: commercialization of the innovation and technology transfer to mining and allied industries in Canada and around the world.

INNOVATION HAPPENS WHEN GREAT IDEAS ARE DEVELOPED AND ACHIEVE OPERATIONAL INTEGRATION INTO MINING APPLICATIONS

Identification of new ideas is only the first step in a long aggregative process. Introducing ideas into the routine application of a mining operation is what makes it innovation. The difficulty in bridging the gap between good ideas and the implementation of these ideas into new processes, technologies or equipment is the innovation gap. The impact of which is a reduction in mine productivity and increased mining costs.

While investment in fundamental research is essential and will continue, real change in operational productivity is best achieved through applied research and practical demonstration projects. These projects require collaboration with the supply and service sector companies in addition to industry, universities and colleges as well as research organizations. CEMI has recognized this by ensuring that the three-phase innovation process includes oversight in terms of practical operational knowledge and business acumen.

Through the Ultra-Deep Mining Network (UDMN) and the Innovation & Prosperity Office (IPO) and with projects currently underway within CEMI's strategic pillars of FindMine, DeepMine, ValueMine, ConstructMine and SustainMine this approach of applied research and demonstration projects is already in place, with a wide range of collaborators and SMEs working together in moving proposals and projects forward.

CEMI's "Living Laboratories" (actual underground mine sites) ensures that we are collaborating with patrons, sponsors and partners at specific mine sites to research and assess the viability of innovations. This gives us access to the world's deepest active mines in Ontario where we have the ability to conduct real world underground research, optimize experiments and provide real-world outcomes. This has allowed us to successfully inspire and implement innovations that improve efficiency in mine development advance sustainability, increase safety, thereby enhancing productivity, performance and profit margins. It is the collaborative knowledge, disciplined approach and hard work of innovation that CEMI successfully integrates with its partners.

THREE APPROACHES TO IDENTIFY THE INNOVATION GAP

CEMI approaches innovation in a number of ways, depending on the need or scope. The first is when industry recognizes a need for innovation and requests it. This can be one company or a consortium of mining organizations. In this case, CEMI, in consultation with the consortium will manage the project in its entirety, identifying the scope, budget, matching funds, resources and timelines and set guidelines with respect to reporting and proprietary interests. The second is when an individual researcher, consultant, SME or entrepreneur presents an opportunity and requests CEMI's involvement to overcome a technical, research or commercial barrier to a solution that is partially developed or work-in-process. The third is when the CEMI team and its collaborators recognize that an innovation gap exists, but is not yet identified by the industry or service sector.

\$29.4
MILLION

for strategic R&D projects in the areas of exploration, deep mining, integrated mine engineering, underground mine construction, environment and sustainability

\$4
MILLION

in support of universities and colleges including 2 Research Chairs

\$12.3
MILLION

\$12.3 million in support of Canadian SMEs

28
UNIVERSITIES
& COLLEGES

Collaboration with over 28 educational institutions (universities and colleges)

121
STUDENTS

HQP Development in working with over 28 professors from different academic disciplines and 121 students (undergraduates, masters, PhD, Post Docs/Senior Researchers)

82%

of Evidence Network Survey respondents believe that CEMI contributed to their ability to innovate in the development of new products, processes or services

STRATEGIC RESEARCH PROGRAMS AND PROJECTS

In this case, CEMI plays a proactive role in initiating a program to develop possible solutions. CEMI's approach in this case is to start the process where novel ideas are explored, with participants from a variety of backgrounds to scope out possible viable options before engaging collaborators, industry and government for support. A recent example of this is the Single Heading Lateral Development project, initiated by CEMI, with the design and construction of the prototype contracted to Mining Technologies International (MTI), now owned by JoyGlobal. Funding for the project was provided by Northern Ontario Heritage Fund Corporation (NOHFC), in the amount of \$783,916.



Premier of Ontario, Kathleen Wynne, announcing funding in the amount of \$783,916 through the NOHFC for Phase One of the Single Heading Lateral Development project, at the Centre for Excellence in Mining Innovation.



CEMI team and collaborators with Premier Kathleen Wynne.

CEMI is excited about the collaborative innovation projects presented in this report and optimistic about the future. As we continue to integrate knowledge and seek innovative ways of addressing complex problems, we will build on our systematic, integrated innovation process. We thrive in a culture that fosters the highest calibre of creativity, collaboration and innovation implementation, a space that engages our local and global mining communities to work together towards innovation excellence.

“WE ARE MAKING SMART INVESTMENTS THROUGH THE NOHFC TO HELP SUPPORT INNOVATION AND JOB CREATION IN KEY SECTORS LIKE MINING. WHEN WE SUPPORT NORTHERN ONTARIO’S SUCCESS AND BUILD ON THE NORTH’S UNIQUE STRENGTHS IN MINING, WE ENSURE A MORE PROSPEROUS FUTURE FOR THE ENTIRE PROVINCE”.

KATHLEEN WYNNE,
PREMIER OF ONTARIO

IPO | INNOVATION & PROSPERITY OFFICE

The small-to-medium enterprise (SME) community has been an important collaboration partner for CEMI in the development of innovation excellence within the metal mining industry. CEMI understands the critical roles played by the SME community, through the development of new products, technologies, services and processes in bringing productivity gains and enhance profitability for large operating mines and mining companies.

However, there is a definite need to bolster the innovation capacity and speed to market of the mining supply and service sector in support of the mining industry. Mining companies are looking for support to make workflow changes a reality, based on new technologies and processes. These positive changes are far more nimbly provided by agile SMEs specializing in these areas rather than through direct investments on activities adjunct to the actual job of mining. In addition, the global demand for metals and minerals requires an accelerated rate for discovery and extraction and the need to mine more deeply. These needs present a sizeable opportunity for SMEs to deliver and it is the innovation gap that can only be fulfilled by the SME community.

In recognition of this, CEMI established the Innovation and Prosperity Office (IPO) in 2011, to help the SME community accelerate the development of innovation initiatives, to help bring them to market and to strengthen the



economic activity of the mining services and supply sector, especially in the Greater Sudbury area. The challenges faced by the SME community are:

1. Engaging in projects with, and gaining trust of mining companies in delivering the innovation
2. Accessing cash flow necessary to engage in R&D + I
3. Accessing additional research and technical resources and collaborative partners
4. Having the necessary skill set to navigate the complex commercialization cycle in order to bring the innovation to market

Through funding from the Greater Sudbury Development Corporation (GSDC), matching funds from CEMI and additional government funds, the IPO has been able to specifically connect and help SMEs with innovative solutions that meet the relevant needs of the mining industry. The SME community has to overcome many hurdles, especially limited resource capacity, in order to achieve operational adoption of their innovations. The mandate of the IPO is to create more opportunities for new projects, partnerships and investments to advance ideas from testing, implementation, and commercialization for the local SME Innovator community, through the following:

- Rigorous opportunity and feasibility assessment of innovative ideas
- Access to a R&D and knowledge (seminars, training, papers) pipeline with industry experts
- Provision of necessary industry linkages, networks, collaborations, and tools to help facilitate ideas and prototypes into viable innovations
- Leveraging R&D investments to lower investor risk and improve uptake
- Intellectual property management and overall business support
- Facilitate potential for resources including funding, facilities, technology, test locations
- Direct access to local and global partners to help accelerate innovation ideas into commercially viable products, tools and services

57 SMEs identified and offered support services

57

Facilitated 9 SME related research projects

9

83% of Evidence Network respondents indicated that CEMI contributed to Technology Development

83%

72% of Evidence Network respondents indicated linkages to Companies (networking)

72%

90% of SMEs anticipate a 5% increase in sales resulting in implementation of R&D into operations (Doyletech Report, 2010)

90%

Since launch, the IPO has delivered on its support of the SME community by closing the gaps that impede the development of innovation. Within CEMI, the IPO plays a major role in the engagement of SMEs, at a local level, across Northern Ontario and nationally. It is also a key supporter of the newly established Ultra-Deep Mining Network (UDMN), specifically in engaging SMEs for the commercialization of successful outcomes and in collaborating with other organizations in addressing the pressing needs for the ultra-deep environments.

The benefits of supporting the SME community impact not only the mining industry at large, but also through economic growth (job creation, income growth, increased productivity, exports) and social development (knowledge development, skill development, improved quality of life and diversity) in Northern Ontario and Canada.

Mr. Eric Maag has joined CEMI as Director of the Innovation and Prosperity Office. With over 20 years of experience in a number of marketing and business development and management roles in the mining industry, and as a past trade advisor for Northeastern Ontario, assisting SMEs to grow through exporting, he comes with a broad range of skills, knowledge and access to networks within the national and international mining community. He strongly believes that, “The IPO bridges the resource and knowledge gap by providing meaningful assistance for SMEs to overcome hurdles and succeed in commercializing their innovations.”



Contact him at: emaag@miningexcellence.ca to discuss opportunities for development of SME innovations.

“THE INNOVATION & PROSPERITY OFFICE (IPO) HAS BEEN SINCERE AND GENUINE IN TAKING THE DEPTH OF UNDERSTANDING TO HELP US DEVELOP AND GROW. THE IPO IS A CONDUIT FOR OPPORTUNITIES AND THEY HELPED US INNOVATE. SIMPLY PUT, WE ARE A BETTER COMPANY TODAY THAN WE WERE A YEAR AGO.”

DAVE DILLON, PRESIDENT, DURA 21

CEMI: INTO THE DEEP WITH INNOVATION

The Canadian hardrock metal mining community is poised to be the primary source of innovation for the underground mining industry worldwide because it currently has the competitive advantage in terms of geographical location and resident expertise. However, the window of opportunity is short. Recognizing this, CEMI, with a track record of innovations and collaborative networks in mine productivity, mine construction and high-stress conditions, led the way in establishing Canada's first Ultra-Deep Mining Network (UDMN).

This **\$46 million business-driven network** is supported by members of the mining and oil & gas industries, and with the active participation of small-to-medium sized enterprises, industry agencies, research facilities and academia. The goal of the UDMN is to help the mining industry develop and adopt commercially viable research and development projects that result in the deployment of proven innovative technologies.

Managed through CEMI, the UDMN aims to become the leading expert in Ultra-Deep (below 2.5km) research and innovation and to solve the challenges that impact resource extraction in these environments. By supporting solution providers capable of creating the industry-needed tools and technologies in the short term, it will lead the way in helping ultra-deep mines to operate more effectively and safely, generate more value, improve the human environment and enhance mine productivity.

THE CHALLENGE

Deep underground metal mines are the source of the specialised metals including nickel, chrome, molybdenum, lead, zinc, platinum and palladium – that are essential for the modern industrial economy. While the supply of commodity metals such as iron, aluminum and copper generally come from very large open pit mines, the specialised metals are largely produced by deep underground mines (> 2km below surface).

The need to fundamentally shift the design, development and operation of underground metal mines is driven by three converging factors: 1) The need for many of the large open-pit copper mines in the world to go underground while sustaining unchanged production levels; 2) The need to pursue specialised industrial metals to ever greater depths; and 3) The need to attract a new generation of well educated, socially diverse employees.

THE ULTRA-DEEP MINING NETWORK (UDMN)

The Network will lever collaborative and dedicated networked solution teams of leading experts in achieving innovations for the global mining industry within the ultra-deep mining environment. The approach is that of a joint business model where all members contribute to the cost, and benefit from the Network's successes, with the goal for driving innovative solutions and making deep mining fiscally viable for the future.

The Network will help close the commercialization gap by providing members with access to commercialization evaluation services and a chance to carry out prototyping and testing at actual mine sites. The private sector will further benefit from the validation of research findings and sharing of knowledge through collaboration with the SME and research teams, further increasing the relevance of research projects and the potential for project outputs to be implemented. This will increase industry's capacity and capability to advance innovations to market. Ultimately, the UDMN will lead the way for innovations to be commercially viable and build capacity to deliver new technologies to the Canadian and global mining industry.

THE NETWORK WILL TACKLE INDUSTRY CHALLENGES UNDER THE FOLLOWING STRATEGIC RESEARCH THEMES:

1. **Rock Stress Risk Reduction:** To improve the control of stability in deep underground excavations
2. **Energy reduction:** The 40% Mine; improve the energy consumption profile and cooling of deep mines
3. Novel methods of **material transport and productivity:** To increase the rates of development and production in mines
4. **Improved human health:** To enhance the human environment in deep mines

LEADERSHIP AND GOVERNANCE

Under the leadership of Mr. Douglas Morrison as Network Director, the UDMN, to date, has been actively engaged in identifying the needs of the industry and solidifying its governance structure. All members of the network are required to sign the Network Agreement. At the helm is Mr. Bora Ugurgel,

Managing Director of the UDMN and formerly, the IPO Founding Coordinator (enabling and empowering SMEs in Greater Sudbury). Mr. Ugurgel and Mr. Morrison are supported by Theme Leaders, a Management Committee and Board of Directors to assist in bringing this new organization to life.

NATIONAL RECOGNITION

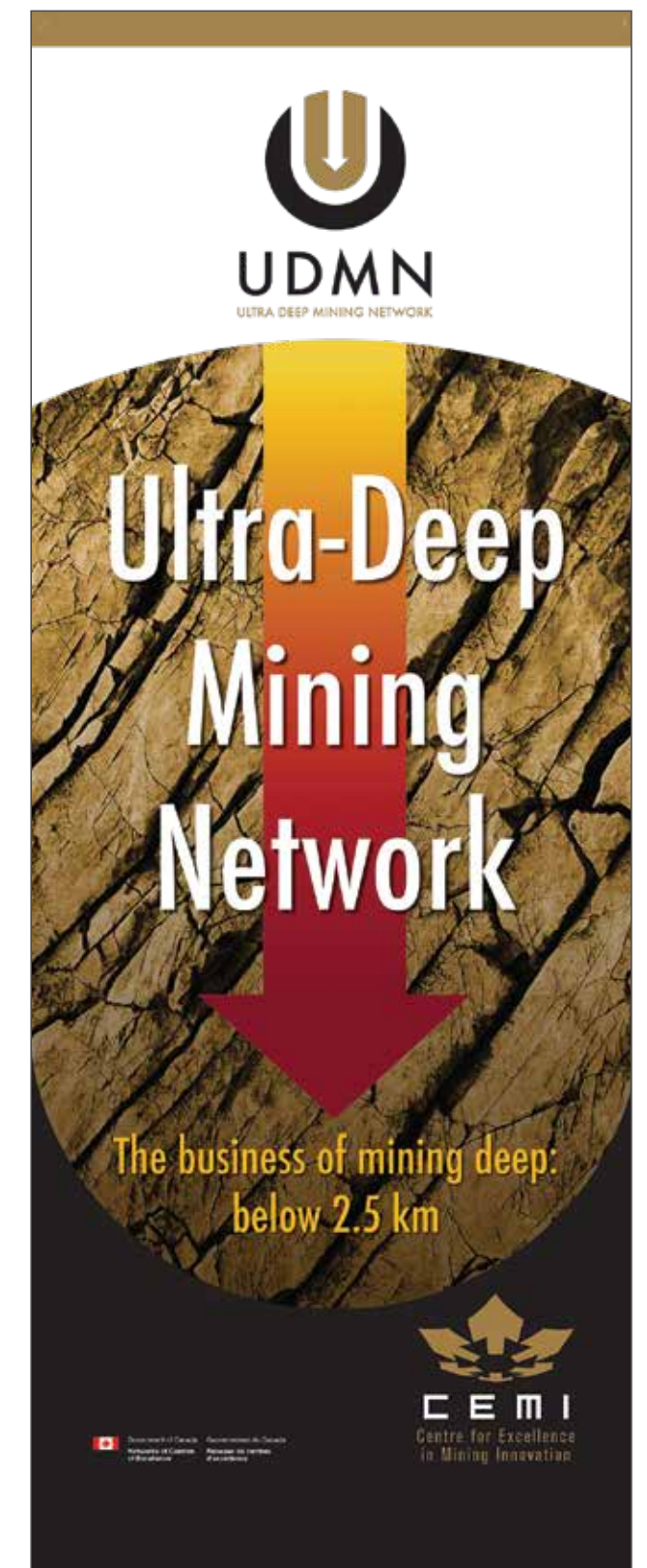
Recognizing the importance of deep mining research, the Honourable Greg Rickford, Minister of Natural Resources (formerly the Minister of State-Science and Technology) announced the winners of the Business-Led Networks of Centres of Excellence (BL-NCE) program on January 22, 2014, in Sudbury, Ontario. CEMI was selected as one of four recipients for its Ultra-Deep Mining Network (UDMN) proposal and awarded \$15 million. In conjunction with \$15 million received from the BL-NCE, the UDMN has also received significant partnership commitments of \$31 million in leveraged cash and in-kind contributions. Most importantly, the 49 letters of support for establishing the UDMN indicates the need and desire for such a network by the Canadian Mining and Resource industries to take the lead.

Minister Rickford, stated, "Our government is committed to supporting research that addresses private sector R&D challenges in key priority areas. The Business-Led Networks of Centres of Excellence program enhances private sector innovation by blending academic expertise with the private sector's drive to solve real-world challenges. These networks bring expertise and stimulate private sector investment in R&D, innovation and competitiveness. Right here in Sudbury, researchers are finding solutions to today's challenges in mining in order to foster growth and stimulate the development of this important sector to the economy of Northern Ontario."

Visit the UDMN website to learn more at www.miningdeep.ca.



Celebrating the funding announcement are Samantha Espley, Vale; Janet Walden, NSERC; Douglas Morrison, CEMI & UDMN; Greg Rickford, Minister of Natural Resources; Irene Sterian, Refined Manufacturing Acceleration Process; Sylvain Cofsky, Green Aviation Research & Development Network; Loretta Renard, Refined Manufacturing Acceleration Process; Mayor Marianne Matichuk.





MINERAL EXPLORATION & GEOPHYSICS

PROJECT LEAD: Damien Duff

Implementation of step-change research, in the area of exploration (new deposits, expanded mines) and geophysics, both surface and underground, that is strategically important to mining sustainability. Areas of interest include:

- The Sudbury Igneous Complex, specifically within the footwall and offset geological 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, to optimize future exploration success for high value Ni-Cu-PGM (precious Group Metals) mineral deposits
- Geophysical detection tools and techniques to optimize the chances of future exploration success through the analysis of geoscience data

ACQUISITION, PROCESSING AND INTERPRETATION OF GEOPHYSICAL DATA

The Industrial Research Chair (IRC) in Exploration Geophysics, led by Dr. Richard Smith of Laurentian University, continues to make progress in each of its four main research themes: Integrated studies; Physical properties; Data acquisition and processing; and New modelling, inversion and interpretation.

Since its creation in 2011, the IRC in Exploration Geophysics has initiated 10 projects, of which 6 have been completed and 4 are ongoing. During this time, 13 students collaborated on the research and have actively participated in the dissemination of results through publications and conferences.

Local industrial partners likewise have been instrumental in the research initiatives by providing access to datasets, sites and geophysical expertise. As well, 6 students have been “embedded” within local companies, thereby benefitting tremendously through this mentorship and support.

Further, 2 new software products, Gridsluth GX and a Matlab GUI (graphical user interface), have been made available to industry. The Gridsluth GX is a software application that was built as an add-on to the Geosoft Oasis Montaj. Developed by Dr. Smith, it is used to generate images that can help in interpreting magnetic data.

The Matlab GUI is a Python program that allows RIM data to be interpreted using a whole-space model. Some parts of the data can normally be fitted with the whole space-model and those parts that cannot are considered anomalous. This application was developed by Tomas Naprstek, MSc. candidate.

ONGOING RESEARCH:

Testing the feasibility of using electrical and magnetic measurements to monitor stress underground:

Christoph Schaub, MSc. candidate

To identify signals caused by rockmass strain that could prove the feasibility of a real-time underground geophysical monitoring system and potentially track stress change, and thereby lead to improved safety.

Measuring physical properties using hand-held tools at KGHM, Victoria Property: Melissa Pecman, BSc. candidate

The use of physical property measurements to augment drill core logging procedures and improve techniques for the recognition and sub-division of important lithologies.



Physical properties logging of drill core at the Victoria Project site of KGHM. Courtesy of Melissa Pecman

Lithological prediction using physical properties measurements: Omid Mahmoodi, MSc. candidate

To help geoscientists more effectively recognize and characterize potentially important rock units, which are otherwise visually unrecognizable from others, through the use of physical property measurements.

Studies in modelling the response measured with radio imaging method: Yongxing Li, MSc. candidate

Reviewing various RIM imaging methods through the investigation of the dampening effect on radio waves associated with RIM surveys. Early investigations indicate that results other than dampening occur. This will need to be investigated further and quantified in addition to also examining the imaging methods to see if they could be responsible for the effects.

COMPLETED RESEARCH:

Developing 3D model of the Sudbury structure using Geomodeller: Oladele Olaniyan, PhD candidate

Re-processing and re-interpreting existing magnetic data to refine the geological understanding of the Sudbury Basin.

Comparing the results of five magnetic susceptibility instruments: Deng N. Deng, MSc. candidate

Development of improved measurement procedures and instrumentation selection recommendations based on controlled experiments with 6 magnetic susceptibility meters, tools used for mineral exploration.

EM imaging using multiple transmitters: Joshua Lymburner, MSc. candidate and Michal Kolaj, MSc. candidate

The development of an approach to amplify weak signals produced by otherwise indiscernible and deeply buried conductors, like sulphide ore bodies. This was achieved by spatially stacking and combining EM receiver responses from different transmitter positions.

Application of the cross-hole radio imaging method in detecting geological anomalies, MacLennan Township, Sudbury, Ontario: Ladan Karimi Shairif, MSc. candidate

A case history investigation into the methods to optimize how RIM geophysical technology and the software used to interpret results could be developed. The result was a manual of guidelines based on the verification of the findings.

Interpretation of gradient measurements in ground EM: Michal Kolaj, PhD candidate

Development of two surface TDEM surveying methods to facilitate the mapping of conductance over “thin” targets. The method measures the vertical spatial gradient of the magnetic field for improved resolution/discrimination to produce a 2D (surface) map of conductance/resistance at each time channel/window.

Whole-space modelling of RIM: Tomas Naprstek, MSc. candidate

Investigation into how the signal produced by the RIM method changes when the system parameters or rock properties change. A better understanding of this would assist in the design of future surveys and data interpretation. In addition, a software-based modeler was developed, and shown to be an effective forward modeler of RIM data.

STRUCTURAL EVOLUTION OF THE EAST RANGE OF THE SUDBURY BASIN

The economically most valuable mineral resources associated with the Main Mass of the Sudbury Igneous Complex (SIC) occur either at the basal contact of the SIC, (i.e. contact deposits) or in host rocks close to the basal contact (i.e. footwall deposits). Transport and emplacement of respective mineral phases in the tectono-thermal aureole of the SIC depends significantly on deformation processes that occurred in the brittle to brittle-ductile realm. Furthermore, prominent faults formed or activated during post-impact deformation may have significantly displaced mineral deposits. Thus, knowledge of (1) the geometry of the basal contact, (2) the structural processes controlling transport and emplacement of Cu-Ni-PGE mineral phases and (3) a sense and magnitude of displacement on prominent faults, are paramount for mineral deposit exploration, notably in the East Range of the Sudbury Basin.

This project, led by Dr. Ulrich Riller of the University of Hamburg, involves 3 graduate and 2 undergraduate students.



(L to R) Martin Clark (PhD candidate), Lisa Bendschneider (MSc. candidate), Dankrad Tielker (MSc. candidate), Ulrich Riller (Adviser), Björn Bombach (BSc. candidate), Torben Wüstemann (BSc. candidate), and Damien Duff, CEMI.



Students from Universität Hamburg. (L-R) Dankrad Tielker (MSc. candidate), Björn Bombach (BSc. candidate), Torben Wüstemann (BSc. candidate), and Lisa Bendschneider (MSc. candidate). Courtesy of Ulrich Riller.



The research encompasses structural and other field and remote sensing analyses, 3D-kinematic restoration and analogue modelling. The project is expected to significantly advance our understanding of the structural evolution of the East Range and has the following objectives:

1. Identification of the mechanism by which the SIC and adjacent lithological units were tilted.
2. Quantification of the displacement magnitudes on prominent faults in order to assess the degree to which SIC contacts are dissected, and more importantly, to correlate ore bodies across faults.
3. In-the-field examination of the geometric relationship among higher-order structures such as extension faults, shear faults and breccia zones with respect to prominent fault zones. This will be complemented by image analysis of high-precision digital elevation models.



Field crew from Universität Hamburg. (L-R) Martin Clark (Dr. Rer. Nat. candidate), Torben Wüstemann (B.Sc. candidate), Björn Bombach (B.Sc. candidate), and Lisa Bendschneider (M.Sc. candidate). Courtesy of Ulrich Riller



Professor Ulrich Riller (Universität Hamburg) introduces Sudbury lithologies to his students. Courtesy of Martin Clark

THE SEARCH FOR UNCONVENTIONAL ORES AT THE SUDBURY STRUCTURE: OFFSET DYKE AND SUDBURY BRECCIA-HOSTED DEPOSITS

A partnership between CEMI, Wallbridge Mining Company Limited, Mitacs and the University of Western Ontario has been established to study one of the most important mining sites in Canada—the Sudbury Structure. Together with Wallbridge Mining exploration staff, the project involves 4 graduate students (2 MSc., 1 PhD, 1 PDF) working alongside Dr. Gordon Osinski of the University of Western Ontario.

The primary research goal is to further the understanding of large-scale impact-related processes and structures that control mineralization in the more non-traditional Cu-Ni-PGE ore deposits distal to the Sudbury Igneous Complex (SIC)-footwall contact at the Sudbury impact structure. The research aims to answer a series of questions concerning the origin of Sudbury Breccia, host to footwall vein deposits, and Offset Dykes at Sudbury and their mineralization. The process includes the following:

1. Establish the exact genetic relationship between the SIC and the Offset Dykes by determining their structural controls; timing of emplacement; and controls on mineralization.
2. Establish a set of criteria to determine what makes a particular Sudbury Breccia (SB) locality more likely to host economic mineralization by understanding: what are the underlying structural controls on the formation/emplacement of SB structures and footwall ore bodies, including the role of pre-existing structures; what constraints do mapped SB structures provide on the original shape and orientation of the SIC and the nature of its now-eroded extents; and are the SB occurrences in different rock types and/or in different geographic regions (e.g., North Range vs. the South Range) fundamentally the same?



Adam Brody Coulter exploring the northernmost extent of the Parkin offset dyke.

MINING HIGHLY STRESSED ORE BODIES AT DEPTH

PROJECT LEADS: Damien Duff, Allan Akerman, Harvey Parsons

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. Areas of interest include:

- Understanding rock behavior 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

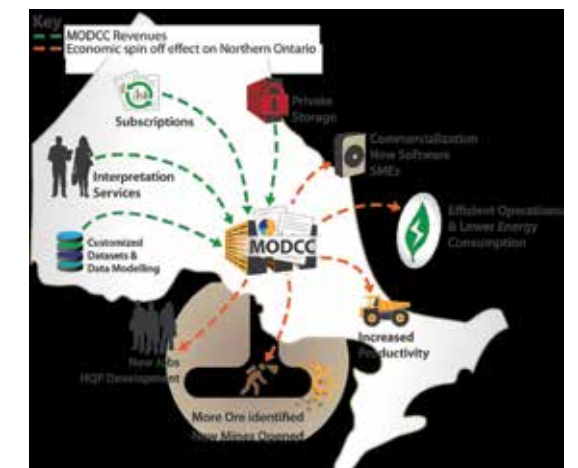
MINING OBSERVATORY DATA CONTROL CENTRE (MODCC) FOR NORTHERN ONTARIO

Data is the single most valuable commodity in the global mining and mineral industry. It is the foundation for decisions regarding safety, exploration, production and development, ongoing research and investment.

Within the industry, data is collected through exploration, surveying, drilling, blasting, assaying, transporting the rockmass to the mill, as well as characterizing the mine's geology and mine planning. The value of this data is unlocked when it is leveraged through innovative applied research approaches to create knowledge. It paves the way to establishing a competitive advantage.

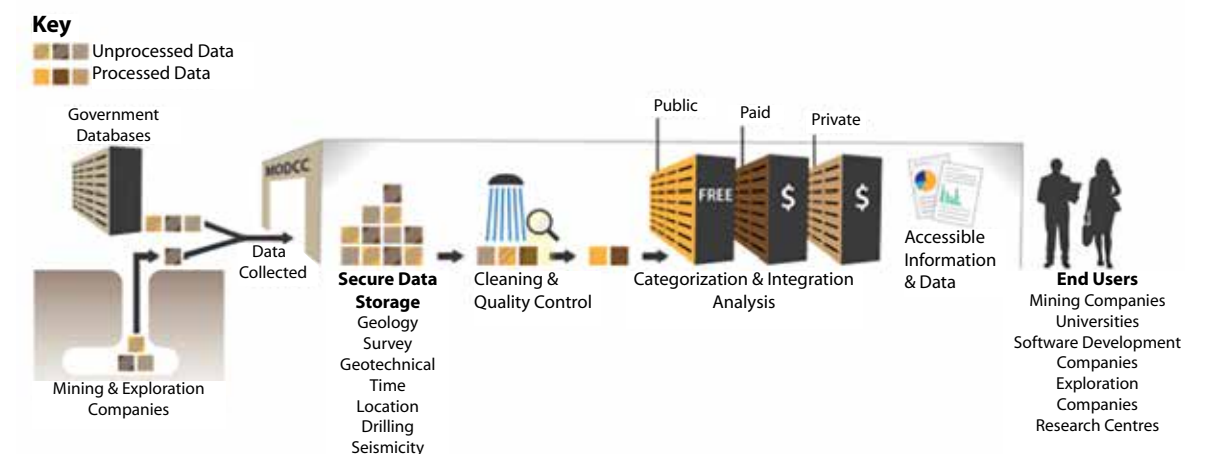
Unfortunately, mining industry datasets remain segmented, underutilized and at times unreliable. Since there are no industry standards regarding data collection, storage formats or methodologies, and no easy way to integrate data sets from different sources, it is common practice to discard data after a set period of time. The Mining Observatory Data Control Centre (MODCC) will serve as a secure hub to store and manage data for use by the global mining industry. To be

located in Sudbury as a surface installation at SNOLAB, MODCC will be a significant contributor toward economic development and investment in Northern Ontario. Created through the collaborative efforts of CEMI, SNOLAB, Canada Mining Innovation Council (CMIC), Mira Geoscience and Objectivity, with additional funding (\$750,000) provided through the Northern Ontario Heritage Fund Corporation (NOHFC), the MODCC will become the ideal "knowledge hotspot" for mining research and technical teams worldwide.



It will become a secure hub for mining and mineral data, where the quality and quantity of data can be assessed, analyzed and interpreted, to gain new insights for improved exploration success and enhanced mine productivity.

The project will be measured against its ability to realize its commercialization potential; meet its job creation targets; lead the promotion of innovation opportunities; achieve economic growth; attract new professionals to the region; help retain existing businesses and professionals; and improve the capacity and investment readiness of the community.





DEEPMINE | DEEP MINING

The MODCC facility will host offices and parking and provide support for personnel, software developers, customers and visiting scientists. The facility's proximity to SNOLAB will capitalize on their existing data integration and expertise, as well as the significant investments already made at the SNOLAB deep underground facility.

Objectivity and Mira Geoscience are also collaborating to build state-of-the-art data integration and management tools in support of MODCC. This has resulted in the development of a beta version of "Integrator", a 4-D underground mining data integration and sharing software tool for mining related projects. Currently hosted at Mira Geoscience's Montreal location, the "Integrator" will transition to MODCC servers upon completion of construction.

CMIC's Footprints, a geoscience data integration project identifying the multi-parameter 'footprints' of ore systems, has many complementary aspects with MODCC and will enable the development of a tripartite knowledge/technology transfer mechanism between the SME community, large multinationals and academic researchers.

Once complete, the MODCC will be a powerful resource for researchers and industry alike, providing a user and data-interpretation interface that searches, collects, filters and analyzes mining/exploration related datasets, with the ability to access and process wide-ranging analyses, unlike anything currently available to mining/exploration companies and researchers anywhere in the world.

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

SUMIT, having recently completed year three of its five year program, continues to develop and advance smart engineering methods, technologies and tools to facilitate step-change advances in productivity, efficiency and effectiveness in underground mining at depth.

Researchers and students from Laurentian University, University of Toronto, Queen's University, University of Waterloo and the University of British Columbia continue to demonstrate progress in 18 core projects, focusing on Geo-Risk, Rapid Underground Development and Mine Sustainability/Energy Optimization. At present, there are 59 SUMIT participants associated with the project, including 1 post doctoral fellow, 15 doctoral students, 16 master's students, 8 undergraduate students, 4 research engineers and 15 researchers.

To date, SUMIT researchers have made 48 conference presentations; had 18 refereed conference papers accepted; and 21 peer-reviewed journal articles published. A further 12 articles are currently in the review process. These publications have generated an impressive 71 citations in general literature to date.

Industry stakeholders can now access this vast body of work through a newly developed centralized digital online repository, with the ability to download up-to-date project files and engage with SUMIT researchers.

Two new 4D software tools, Integrator (Phase 1) and Sankey Trees have been developed and delivered as well as a workflow process for analysing lidar data. Sophisticated algorithms have been developed to enable easier interpretation of minute changes in development heading dimensions using lidar scanning thereby leading to a potentially more proactive approach to ground support strategies and design. Project results to date point to new and exciting ways to estimate and map energy usage at mining plants, making it possible to determine how to optimize the usage of otherwise waste energy products.

Additional activities include:

1. New easier to use wall-mounted geophysical sensors are being tested
2. Experimentation on sensitive fiber optics-based distributed arrays for use as a measure of deformation at a block scale in underground mines

A holistic approach to geotechnical risk assessment in mines is being explored. Preliminary results indicate that real geotechnical risk is an amalgam of contributing inputs comprised of elements involving: the mine design model; the rockmass model; the mining model and the geological/structural model among others.



Ramin Saleh and Derek Zwaan, University of Toronto, using a Scintrex gPhoneX Gravimeter and installing geophones on rockbolts. Photo courtesy of Chris Pritchard



Ken Nurse, University of Toronto. Courtesy of Chris Pritchard



Ramin Saleh, University of Toronto. Photo courtesy of Chris Pritchard

Most field work is being done at mines provided by industrial sponsors located in Sudbury, including Vale's Creighton and Coleman and Glencore's Nickel Rim South mines. Data sets are also being collected and used from additional locations, both nationally and internationally, forming the basis of ongoing work.

Finally, one patent has been filed and one new company established based upon research and development outcomes realized through SUMIT. Electrale, a Sudbury-based energy-focused start-up whose original provisional patent (involving energy optimization) was converted to a PCT (Patent Cooperation Treaty) application, allowing patent protection for a further 18 months while a national entry is formalized.

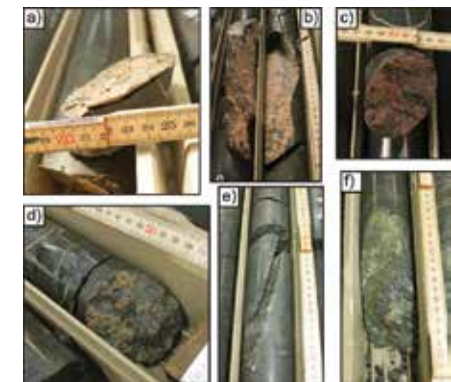
USING HYDRAULIC FRACTURING TO HELP MANAGE STRESSES IN DEEP UNDERGROUND MINES

Rock instability in deep mines has the potential to create two problems: 1) the possibility of rock bursts and strainbursts, which can compromise the safety of personnel and capital assets; and 2) significant disruptions to production schedules.

CEMI, in partnership with a consortium of companies and research institutions, has begun a 3 year research program to investigate the use of hydraulic fracturing, the mechanical process of fracturing the rockmass as a means to re-distribute stress in underground mining operations. Fracture network creation technologies, as well as the characteristics of the created networks, will be examined by undertaking a series of drill-through and potentially, mine-back experiments in active mines.

The research aims to better understand how to use hydraulic injection to manage stresses locally and potentially at a block scale; improve our understanding of the processes during hydraulic fracturing in tight shale formations; relate geophysical observables (e.g., micro-seismicity, stress change, tilt etc.) to the created fracture networks; and optimize modeling approaches for simulating hydraulic fracturing and hydraulic stimulation.

Phase I of the research program has begun with the completion of pre-experimental geosciences and geotechnical data collection and development of an experimental design framework. Dr. Benoît Valley, at Neuchâtel University, in Switzerland, is the technical lead on the project. He has been working at the Cadia East Mine test site in Australia to procure, install and stabilize all instrumentation, as well as complete necessary advance data collection to ensure the equipment is optimized for maximum scientific value. Preparations for a complete drill through trial have begun, alongside planning for phase 2 and 3 of the program. Actual experimental execution is anticipated in late October, 2014.



Core samples

BURSTSUPPORT TOOL- PHASE II

Phase II of the BurstSupport project aims to validate both the BurstSupport and S-GMAT design tools, each developed in Phase I of the project, through carefully selected case studies using active mine sites.

The current rock support design approach is based on anticipated ground motions obtained from scaling laws developed from the Canadian Rockburst Research Program in the 1990s (Kaiser et al., 1996). Case studies are needed to verify the use of scaling laws for design purposes. It is observed that the degree of rockburst damage may or may not be strongly associated with the level of ground motion at a specific location. This needs to be further clarified through forensic analysis of rockburst damage case histories using both the BurstSupport and S-GMAT tools.

The main objectives of this study are:

1. Select appropriate rockburst events from which the case studies can be completed
2. Collect data for conducting the respective case studies at the sponsors' mines
3. Conduct forensic analyses at each mine site using the BurstSupport and S-GMAT tools to verify the scaling law approach for design purposes. Correlate the rockburst damage with observed and simulated ground motions
4. Provide the basis for further tool development and rock support design rationale modification

Currently, the program is examining data from Vale's Creighton Mine in Sudbury; Glencore's Kidd Creek Mine in Timmins, and Newcrest's Cadia East Mine in NSW Australia.



VALUEMINE INTEGRATED MINE ENGINEERING

MINE DESIGN TO EXTRACT OPTIMAL MINE VALUE WITH ENABLING TECHNOLOGIES

PROJECT LEADS: Harvey Parsons, Allan Akerman,
Seppo Haapamaki, Pat Dubreuil

Strategic research and innovation in mine design to extract optimal mine value with enabling technologies. Areas of interest include:

- demonstrate new approaches to maximize access development advance rates while ensuring operator safety
- development of enabling technologies that can increase production rates and reduce overall production costs
- support the research necessary to develop the means of reducing energy costs for ventilation and cooling in deep bulk mining operations

SINGLE HEADING LATERAL DEVELOPMENT

Underground mine development has historically been a linear process, consisting of four activities – removing broken rock from the face (mucking), installing ground support, drilling the face (including the preparatory activities for drilling) and charging the holes with explosives and initiators. The sequential nature of these activities and the time lost to equipment entry and re-entry reduces face utilization and decreases the rate of advance.

CEMI's approach to drift development is to maximize utilization of the face. This approach has three phases of innovation:

1. Development of a canopy system designed to withstand falls of ground and rockbursts that will allow for the installation of ground support and the face drilling and charging activities to be performed in parallel;
2. Configuration of face drilling equipment to also load face holes while held captive at the face by the bolting equipment; and
3. Application of continuous mucking equipment to reduce mucking time.

The first phase in the development is well underway, with the design and testing of a protective canopy. With financial support provided through the Northern Ontario Heritage Fund Corporation (NOHFC) in the amount of \$783,916, CEMI contracted with Mining Technologies International (MTI), now owned by JoyGlobal, to design and construct a prototype canopy. The design incorporates two overlapping



Capacity Test #1 (Functionality test)



Capacity Test #1 (Functionality test)



Underground test at MTI test Mine

canopies: a face canopy to protect the face machine and operators; and a support canopy to protect the ground support equipment and operators. This allows the drilling and charging of the face to occur while ground support is installed behind the face equipment.

Using the former MTI underground test mine site, the canopy prototype underwent rigorous testing to determine its functionality and strength. A stress test using concrete blocks was used to determine the load bearing capacity of the canopy and preliminary results demonstrated the canopy can support 75 tonnes.

CEMI also engaged Labrecque Technologies Inc. to conduct simulation tests using the Arena software (Rockwell Automation). The simulations tested for several variations on the use of the canopy (including the effect of jumbo-charging, continuous mucking and various face diameters) in an effort to record the impact of each variation on the development process. The initial results are promising and will form further refinements of the design during future field trials of the canopy.

With initial testing of the first prototype canopy now complete, CEMI will redesign and build two new prototypes for additional testing in a drift advance scenario. Simultaneously, the groundwork for phase 2 and 3 of this project is being planned. The combined improvements resulting from Phase 1, 2 & 3 are expected to reduce the development cycle time and increase the advance rate to over 9m/day in a 4.5m square heading.



Canopy Test #2 (Strength test)



Canopy strength test with 75 tonne load simulation

LEANING THE UNDERGROUND PRODUCTION PROCESS – SIMULATION AND MODELLING

The leaning of a production process aims to reduce the cost-impact of innumerable inefficiencies in the process—exemplified by the auto industry from the 1980's onward. In that case it involved a myriad of small-scale changes—continuous improvements—that required intimate knowledge of the production process such that it can only be realized with the knowledge and experience of employees. The batch mining processes commonly used in underground base-metal mines is capital-intensive and highly discontinuous and the means of improving some fundamental activities can be investigated by process simulations and financial modeling, as a prelude to further leaning of the current processes. These simulations and models will focus on reducing pre-production capital outlay and the time to first production.

The current approach to access and mine a new orebody is to invest in mine infrastructure first, and then mine bottom-up using open-stopping with fill. The consequence of this approach is the delay in first production caused by the need to complete capital infrastructure to the lowest production horizon. Technical advances such as controlled fragmentation of ore and high-quality, high-strength paste-fill make it possible to consider top-down production using open-stopping with backfill. This approach allows for capital development to be made incrementally, developing no more than one or two levels below the lowest production horizon. The benefit of this approach is to reduce the up-front capital cost and shorten the time to first production, but at the expense of higher direct costs for blasting and backfilling activities.

CEMI is currently investigating this approach by modeling various options for mining a new orebody. The overall objective is to see if the operating performance of this approach, combined with other technical advances in ore transport made possible by optimal fragmentation can deliver a better rate of return on the capital employed (ROCE). The basis for comparison of the various options is production rate, cost, project net present value (NPV) and return on investment (ROI).



CONSTRUCTMINE UNDERGROUND MINE CONSTRUCTION

UNDERGROUND MINE CONSTRUCTION FOR IMPROVED PRODUCTIVITY AND STABILITY

PROJECT LEADS: Dr. Matthew Pierce, Dr. Erik Eberhardt,
Dr. Peter K. Kaiser

The RTC-UMC has the following areas of interest:

- Developing and designing innovative support methods for different excavation systems including shaft sinking and tunnelling logistics
- Advanced rock mass characterisation technologies for pillar design and underground excavation stability

CEMI'S RIO TINTO CENTRE FOR UNDERGROUND MINE CONSTRUCTION PREPARES FOR THE FUTURE

On June 2, 2014, the Centre for Excellence in Mining Innovation (CEMI) announced the succession plan for Dr. Peter K. Kaiser, Founding Director of the Rio Tinto Centre for Underground Mine Construction (RTC-UMC). Effective July 1st, 2014, Dr. Matthew Pierce of ITASCA (US) has been appointed as Director and Dr. Erik Eberhardt as Associate Director of the Centre. Dr. Peter K. Kaiser will assume the Senior Technical Advisor role while returning to Laurentian University as Chair for Rock Mechanics and Ground Control. This new leadership team has been mandated to accelerate and expand ongoing projects with the continued focus on delivery of value to Rio Tinto.



RTC-UMC transitional announcement in Vancouver, BC (Left to right): Allan Moss, Rio Tinto; Erik Eberhardt, Associate Director, RTC-UMC; Matthew Pierce, Director, RTC-UMC; Peter K. Kaiser, Senior Technical Advisor, RTC-UMC; and Douglas Morrison, President & CEO, CEMI

Since RTC-UMC was announced late in 2010 as a Centre to complement Rio Tinto's research centre program, the Centre has focused on Underground Mine Construction by undertaking research in support of Rio Tinto's Mine of the Future™ program and underground mining operations.

Director of RTC-UMC, Dr. Pierce commented, "My involvement as a researcher and reviewer with the RTC-UMC has convinced me that Rio Tinto is committed to advancing the state-of-the-art in characterizing rock masses for cave mining and in the design of associated infrastructure and ground support". The present work program is

focused on adding value to caving operations and accelerated research on geomechanics challenges of deep mining operations. The Centre developed a collaborative observational research approach, assisting the mines in collecting and interpreting data in support of innovation.

RESEARCH COLLABORATION

The RTC-UMC was fortunate to work directly with many Rio Tinto mines but also with collaborating mining companies.

- **Research with Rio Tinto Joint Venture Partners:** RTC-UMC actively engages in the extensive rockmass characterization and boltless shaft support development program at Resolution Mine, Arizona.
- **Research Collaboration with Freeport Indonesia Operations:** Centre has supported the development of human resources and collected valuable data for advances in support innovation. A highly innovative, deformation based support design concept is being actively pursued by the Grasberg mines.
- **Research Collaboration with Glencore's Nickel Rim South (NRS) Mine:** An extensive field investigation on pillar stability and related monitoring technologies has been facilitated by Glencore's NRS mine. A detailed monitoring program including measurements of stress change and deformations, laser-based convergence, and tomographic studies is being executed in a very short timeframe during three stope blasts.
- **Research Collaboration with Academia and Consultancies:** The solution providers for current projects enhance the Centres' capability and include: Golder Associates (geophysics and TBS data interpretations), Itasca (rockmass behaviour modelling and support), SRK (rockmass characterization), Augeos GmbH (tomography), ETHZ (rock characterization and support), UBC (rockmass characterization), SFU (Strainbursting), LU (rockbursting), U of T and QU (support design).
- **Research Training at RTC-UMC:** The Centre hosts two of Rio Tinto's graduate engineers in a one-year internship program since February 2014: Christopher Carlson, on the interpretation of data from the Deep Ore Zone at Grasberg operations; and Ko Korenromp on the back analysis of measurements from three Rio Tinto operations.



Drilling preparation for the installation of seismic sensors at Nickel Rim South Mine with Christopher Carlson & Ko Korenromp

DELIVERING VALUE TO RIO TINTO AND GLOBAL MINING

This year the Centre released a 110 best practice procedure for rockmass characterization in brittle rockmasses. The document covers logging, mapping, rock testing, and rockmass strength determination in rocks typically encountered in and near deep porphyry ore bodies. It will assist better mine design from a geomechanics perspective and allow better risk management, thus contributing to safer operations.

A second major deliverable planned for completion this year is an innovative support selection guide that is based on deformation-based support design principles developed by the Centre. It will be used to drastically increase the effectiveness of support systems.

RTC-UMC 2014 ACTIVITIES

The program entitled "Mine Infrastructure Construction and Footprint Reliability" was developed to improve productivity and safety at Rio Tinto caving operations through better understanding of extraction level behaviour under conditions in which spalling is the dominant rock mass failure mechanism. This has significant implications for extraction level design (including efficient and effective support) and suggests that it may be possible to maintain stable pillar cores on the extraction level even in lower strength rock at depth. This program will deliver value to operations through "enhanced footprint reliability", which implies less unforeseen rehabilitation, fewer losses of drawpoints, and thus fewer delays in ore recovery. This will help to ramp-up projects with less uncertainty while introducing more flexibility into the production schedules.

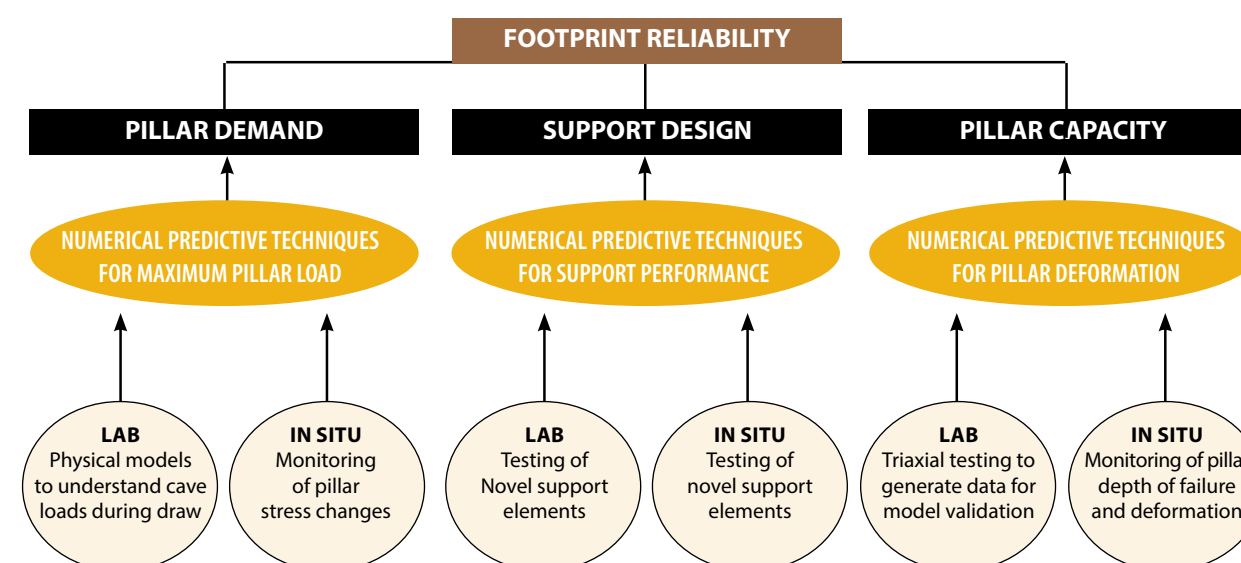
The program for the second half of 2014 and for Q1/2 of 2015 recognizes the need to anticipate both the demand on and capacity of extraction level pillars. On the demand side, there is currently limited understanding of cave loads and how they are impacted by the cave geometry, extraction level design, draw control, water ingress and time. In parallel, our ability to predict the capacity (deformation response) of the pillars will be limited until we can rigorously account for spalling modes of rock mass yield. A combination of experimental (lab), in situ, and numerical studies (Figure 1) are planned to substantially improve knowledge of and enhance predictive techniques for extraction level demand/response and support performance.

PREPARING FOR THE FUTURE

Finally, the new leadership team will put forward a budget for 2015 to complete the ongoing initiatives and a 5-year research plan for the second phase of the Centre.

Douglas Morrison, President & CEO of CEMI, reflected during the handover ceremony on the importance of the RTC-UMC at CEMI stating, "Rio Tinto's significant investment in RTC-UMC continues to put Canada on the map for innovation in underground mining. I would like to applaud the contribution of Dr. Peter Kaiser as Founding Director of the RTC-UMC and thank Rio Tinto for their continued support of CEMI in helping to create innovative solutions to some of the most challenging underground mining issues. We look forward to advancing the RTC-UMC as it heads into its next phase.

ENHANCED FOOTPRINT RELIABILITY





SUSTAINMINE ENVIRONMENT & SUSTAINABILITY

ENVIRONMENTAL STUDIES AND SUSTAINABILITY

PROJECT LEAD: Vern Drylie

Research and innovation projects focus on the identification of processes that can lead to more environmentally benign results and better stewardship of mineral resources. Areas of interest include:

- Reduction of potential long-term liabilities for mining operations through the elimination of potential sources of acid mine drainage or metal leaching to produce benign waste products
- Improving the recovery of metals from mine waste and waste water, for potentially achieving a significant reduction of the footprint from mine waste and waste water
- Reduction of environmental impacts of relic mine sites through improved treatment processes, allowing recovery of saleable metals to offset long-term costs of treatment facilities
- Development of comprehensive remote monitoring package for tailings management facilities (TMF) to monitor potential geotechnical instability of containment structures; manage for potential over-and under-supply of water for aqueous cover to tailings; and improving the reliability of performance of tailings management facilities

Vern Drylie, P. Eng, R&D Program Director of Environment & Sustainability projects, recently joined CEMI after having worked extensively in industry, with experience in mineral processing, precious metals refining and processing as well as significant knowledge in the areas

of manufacturing and process plant operations over the last 20 years. With a keen appreciation for the reduction of waste—both from an environmental and business perspective, Vern's perspective is to look at all the options—from considering new solutions, considering the problem from multiple points of view as well as looking at different ways to use existing technologies to solve the environmental challenges faced by the mining industry.

TAILINGS REMEDIATION INITIATIVE

The Tailings Remediation Initiative aims to demonstrate a viable and scalable mineral processing approach to facilitate the long-term sustainable remediation of abandoned/orphaned small-to-medium tailings sites (less than 1 million tonnes) that can pose significant environmental and financial challenges (ie. legacy costs of tailings) for both organizations and governments. The key challenge of these sites is the ability to access processing facilities without incurring prohibitive costs (ie. transportation, processing). The objectives of the initiative are primarily to:

- a) convert sites posing hazardous effects to humans, animals and plants to environmentally benign areas meeting government discharge standards to water and air
- b) minimize the cost of long term care and maintenance of the sites
- c) recover economic minerals in the form of saleable concentrates to assist in mitigating the cost of site remediation



Abandoned tailing site; courtesy of Vern Drylie



Typical historical tailings; courtesy of Vern Drylie

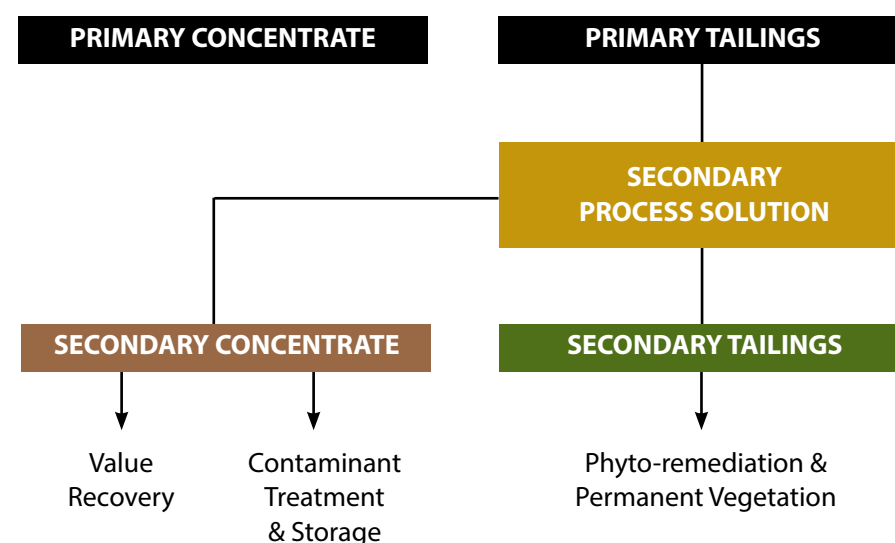
CEMI's approach is three-fold:

1. Secondary mineral processing to reduce contaminants in primary tailings
2. Extraction of Secondary Concentrate for recovery of usable metals (\$ value) and more environmentally more responsible containment/storage methodologies
3. Secondary Tailings with more manageable levels of contaminants for other remediation methodologies such as phyto-remediation

Laboratory studies indicate this approach can work, with close to 80% of contaminants within the secondary concentrate isolated, allowing for value recovery (saleable concentrate) and more responsible containment of the remaining concentrate.

A proposal and discussions are underway for on-site demonstration proposal with various partners to validate the laboratory results. If successful, the benefits are clear—the potential elimination or significant minimization of the cost of long term care and maintenance of these small-to-medium sized sites which number well over 5,000 across Ontario. The remaining secondary reprocessed tailing site then offers a larger range of options for end users such as forestry, biomass production, agriculture, aggregates, recreational or others.

CEMI APPROACH FOR PERMANENT TAILINGS MANAGEMENT



**“CREATIVITY,
AS HAS BEEN SAID,
CONSISTS LARGELY
OF REARRANGING
WHAT WE KNOW IN
ORDER TO FIND OUT
WHAT WE DO NOT
KNOW. HENCE, TO
THINK CREATIVELY,
WE MUST BE ABLE
TO LOOK AFRESH AT
WHAT WE NORMALLY
TAKE FOR GRANTED.”**

GEORGE KNELLER, ARTIST

As part of its mandate, CEMI actively sponsors, supports and disseminates knowledge related to relevant issues and research within the mining industry in two significant ways:

- 1. Providing access to innovative research, training and technical presentations and courses to industry personnel, including engineers, geologists, scientists, SMEs, academics and government.
- 2. Developing and nurturing the next generation of highly qualified personnel (HQP) and researchers by working with research and academic institutions in Ontario, across Canada and around the world.

SPONSORING KNOWLEDGE TRANSFER

CEMI actively sponsors and participates in a series of lectures, short courses, workshops, forums and industry conferences, with robust participation from collaborating industry partners, academic institutions and students, SMEs, and government.

MOLAR ELEMENT RATIO ANALYSIS: ITS USE IN LITHOGEO-CHEMICAL DATA INTERPRETATION SHORT COURSE

This 2-day short course presented the theory, principles and procedures of MER analysis. It discussed the practical considerations of sample preparation, sampling and analysis appropriate for the technique. As well, MERLIN, dedicated platform-independent software, developed by Cliff Stanley and CEMI, was also demonstrated. Using case histories from the Sudbury Irruptive, the course illustrated how the analysis can be directed toward solving petrologic problems. Results revealed how such analysis can complement petrographic studies.



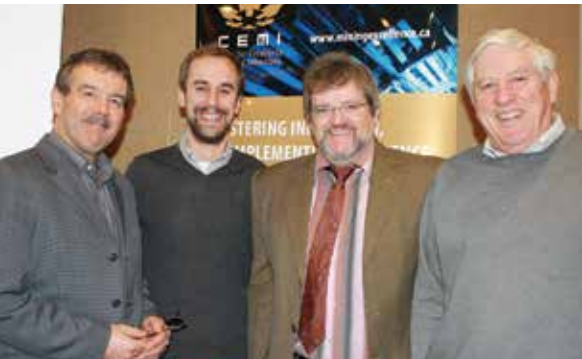
Course Instructor:
Clifford R. Stanley,
PhD, PGeo, Professor,
Acadia University

In conjunction with the Large Meteorite Impacts and Planetary Evolution V conference, the short course was well received by over 30 participants from around the world, including academics, government and industry. CEMI was also privileged to host the opening reception for the conference of approximately 300 people.

RELIABILITY METHODS IN THE DESIGN OF UNDERGROUND STRUCTURES SHORT COURSE

This 2-day short course summarized sources of uncertainty in geotechnical projects and presented a series of simple reliability-based tools to assist with uncertainty in design. A number of project examples from both the geotechnical and mining fields were presented to show the usefulness of these tools. Participants also had an opportunity to use geotechnical modeling software, courtesy of Rocscience Inc., to analyze a case study and assess the software performance for a series of design options. The short course concluded with a panel discussion to discuss how risk sharing can be better incorporated into the design process and contracts.

Held in Sudbury, ON, the event attracted a total of 32 participants from industry (mid-to-high management levels), government, SMEs, consultants and graduate level students from across Ontario.



Course Instructors: Connor Langford, PEng., Ph.D, Consultant, Rocscience Inc;
Mark Diederichs, B.A.Sc., M.A.Sc., PhD, Professor, Queen's University (centered),
with Damien Duff and Peter K. Kaiser

CIM 2014 CONVENTION

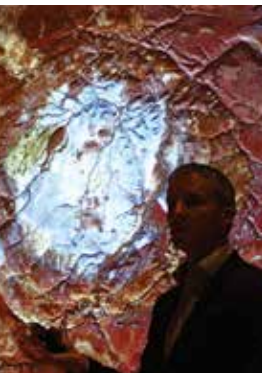
The 2014 CIM Convention in Vancouver, BC featured the launch of CEMI's Ultra-Deep Mining Network. Managing Director Bora Ugurgel was on hand to introduce the networks' four strategic themes and objectives, providing a high level summary of research activities that will be initiated throughout the next five years.

As part of the technical program, CEMI staff and research partners presented three papers at the convention. Damien Duff presented "Making Mines Safer through Innovative Approaches to Monitoring and Modifying Rockmass Behaviour during Extraction"; Allan Akerman presented "CEMI Rapid Development Program"; and Andrew Dasys presented "Increasing

Production Capacity with Ventilation on Demand – A New Paradigm for Enabling Production". Access to these presentations can found on the CEMI website.

In recognition for his commitment to the underground hard rock mining industry, his dedication to CEMI, for his support to the CIM and in particular, to the CIM Sudbury Branch, Allan Akerman received the 2014 CIM Community Service Award at the Annual CIM Awards Gala.

Ms. Michelle Levesque received second prize in the student poster competition at the convention for her work titled "How much does it cost to operate a mill below design capacity?" Michelle is a PhD Candidate at Laurentian University and researcher with MIRARCO and contributing member of CEMI's SUMIT program.



Dr. Gordon Osinski



Michelle Levesque, MIRARCO



Bora Ugurgel, Harvey Parsons, Allan Akerman, Eric Maag, Debbie Akerman,
Courtney Folz and Damien Duff

DISCOVERY OCE 2014 CONFERENCE

This government of Ontario sponsored conference showcases leading-edge technologies, best practices and research in Ontario. Participating sectors include health, manufacturing, digital media & clean tech, including energy, environment and water.

Recognized as a leader in mining innovation and encouraging collaboration opportunities with industry, small-to-medium enterprises (SMEs), academia, government and the investment community, CEMI continues to showcase important developments in the mining sector through its presence and active participation at this conference. CEMI continues its role in being the leading source for mining innovation in Canada.

Douglas Morrison, along with fellow "Cross-sector Innovation and the Convergence of Disruptive Technologies" panelists, Per Aage Lysaa, Gary Biermann and Brad Jackson, spoke to the effect ground breaking and innovative technologies have on various sectors of the economy, including new product applications, partnerships, and market competitiveness.

Please visit the Discovery OCE website to view a recorded video presentation of this panel discussion.



Brad Jackson, Celestica; Gary Biermann, Lockheed Martin Corporate Engineering and Technology;
Fred Christie, Independent Aviation & Aerospace Professional; Per Aage Lysaa, Lumigreen AS and
Intravision Systems Inc; Douglas Morrison, CEMI

PDAC 2014 CONVENTION

As part of the PDAC convention, CEMI hosted a FindMine (Exploration) Student Day to showcase 12 various exploration and geophysics based research projects sponsored by CEMI. Students and researchers from Laurentian University, Acadia University and the University of Western Ontario participated in the event, drawing in industry representatives, academia and various other CEMI stakeholders. The keynote address was given by Dr. Cliff Stanley, Acadia University on three CEMI sponsored research projects: 1. Chemostratigraphy of the Hanson Lake Assemblage, Flin Flon Greenstone Belt, Saskatchewan, 2. MERLIN Software Development, and 3. SOPP Software Development.

CEMI continues to encourage and oversee this program, assisting in the administration of each research component and facilitating the collaboration of partnerships between academia and industry. CEMI is proud to support the next generation of mining researchers and innovators.



FindMine students and professors at PDAC

ONTARIO CHAMBER OF COMMERCE LAUNCHES RING OF FIRE REPORT

CEMI was a major supporter of the Ontario Chambers of Commerce (OCC) effort to produce the report "Beneath the Surface: Uncovering the Economic Potential of Ontario's Ring of Fire." This report highlighting the potential economic opportunities for Ontario in the areas of: job creation, government revenues and increased GDP for Ontario.

CEMI participated in all of the presentation events (over 350 attended) – as a panelist in Toronto and as the panel moderator in Thunder Bay,

Sudbury and Timmins. Some of the other featured special guests included: Bob Rae (Chief Negotiator for Matawa First Nations), Bill Boor (President – Ferroalloys of Cliffs Natural Resources), Alan Coutts (President and CEO of Noront Resources), George Darling (Director of SNC Lavalin) and Hans Matthews (President of the Canadian Aboriginal Minerals Association).

The Ring of Fire is an unparalleled opportunity for the province to diversify its economy and solidify its place as a global leader in mining and mining technology. According to the report, within the first 10 years of its development, the Ring of Fire will make significant contributions to Ontario's economy, and will:

- generate up to \$9.4 billion in Gross Domestic Product (GDP);
- generate up to \$6.2 billion for Ontario's mining industry;
- sustain up to 5,500 jobs annually (full time equivalents); and
- generate nearly \$2 billion in government revenue, divided between the federal, provincial, and municipal governments.

The report concluded that within the first 32 years of its development, the Ring of Fire will generate more than \$25 billion in economic activity across numerous sectors in Ontario, of which mining is just one. http://www.occ.ca/Publications/Beneath_the_Surface_web.pdf

Innovation is key to unlocking the mineral wealth that lies in the Ring of Fire and creating the economic foundation of the Far North. CEMI is working to aid in providing innovative solutions to address the challenges of the Far North.



Sudbury audience at Dynamic Earth

CEMI LECTURE SERIES ON DEMAND

The CEMI Lecture Series continues to feature leading academic and industry keynote speakers from around the world on new ideas and innovations, industry challenges and relevant topics in the mining field. To further extend the transfer of knowledge, CEMI has upgraded its video coverage of lectures to High-Definition quality, and provides participants unable to attend, or in remote areas, with access. An online library, available at www.miningexcellence.ca showcases video coverage of lectures, symposia, short courses, workshops and conferences, and is an excellent source of new knowledge for the mining sector, which is accessed by an ever-expanding global audience of 1,500, interested in staying up-to-date with respect to new ideas and information.

Last year's lecture series attracted a total of 350 attendees and covered topics including:

1. "The Beneficial Effects of Meteorite Impact Events and Implications for the origin of the Sudbury Structure", presented by Dr. Gordon Osinski, University of Western Ontario.
2. "A Global Perspective of Sustainable Mining with Copper and Uranium as Case Studies", presented by Dr. Gavin M. Mudd, Monash University.
3. "Determining Stress from Deep Boreholes and Core", presented by Dr. Douglas Schmitt, University of Alberta.
4. "Deep Mining Exploration Reveals Ancient Waters of the Precambrian Shield", presented by Dr. Barbara Sherwood Lollar, University of Toronto.
5. "Source Mechanisms of Seismic Events in Mines" presented by Dr. Dmitriy A. Malovichko, Institute of Mine Seismology."
6. "Geometric crater floor Modification at Sudbury: Importance for Cu-Ni sulphide exploration", presented by Dr. Ulrich Riller, University of Hamburg.
7. "Ancient Pillars of Active Seismic Wisdom", presented by Dr. John McGaughey, Mira Geoscience Ltd.

1. Dr. Gordon Osinski, University of Western Ontario
2. Dr. Gavin M. Mudd, Monash University
3. Dr. Douglas Schmitt, University of Alberta
4. Damien Duff, CEMI; Dr. Barbara Sherwood Lollar, University of Toronto; Dr. Nigel Smith, SNOLAB
5. Dr. Dmitriy A. Malovichko, Institute of Mine Seismology
6. Ulrich Riller, University of Hamburg; Damien Duff, CEMI
7. Dr. John McGaughey, Mira Geoscience Ltd.



INVESTING IN KNOWLEDGE

DEVELOPING KNOWLEDGE – INVESTING IN STUDENTS

CEMI continues to develop and support researchers and students, highly qualified personnel (HQP), in all five of our strategic research themes. Since our inception in 2007, we have collaborated with 38 professors and over 121 students from 28 academic institutions globally who have or are in the process of completing their degrees while working on research programs at CEMI. These students include 3 college, 24 undergraduate, 47 MSc, 38 PhD students and 9 PDF working with over 40 research projects.

CEMI also recognizes the importance of encouraging and inspiring young students to pursue a career in the mining industry, at the elementary and high school level. CEMI actively promotes dialogue and involvement in local community student competitions and educational fairs within the Sudbury educational community.

2ND ANNUAL SUMIT (SMART UNDERGROUND MONITORING AND INTEGRATED TECHNOLOGIES) RESEARCHER WORKSHOP

In April, CEMI hosted its second Annual SUMIT Researcher Workshop in Kingston at Queen's University. The objective of the workshop was for researchers (8) and their students (25 graduate students) to provide status updates on their current projects, timing and location of experiments, work completed, and planned projects. The discussions allowed for collaboration, identification of potential synergies, and opportunities to optimize research outcomes. It also allowed for SUMIT stakeholders (mining companies, SMEs) to gain a common understanding of SUMIT and re-affirm the value of the program to the mining industry.



SUMIT researchers and students at the 2nd annual workshop. Credit: Photo courtesy of Gerry Kingsley

SUDBURY REGIONAL SCIENCE FAIR

On April 13th, 2014 the City of Greater Sudbury held its annual Sudbury Regional Science Fair competition at Laurentian University. Ms. Marika Moskalyk and Ms. Alexandra Millar, of Marymount Academy, received the CEMI Innovation Award for their project, titled "Green Gold: Phytoremediation of the Long Lake Gold Mine. The CEMI Innovation award recognizes an innovative project that helps illustrate the importance of mining research & technology development within society and/or the best project that contributes to the fields of earth sciences, geology, or engineering. As a sponsor now its third year and counting, CEMI aims to inspire and motivate students (grades 7-12) towards a science related career.



Dr. Abou-Rabia, Laurentian University, Alexandra Millar and Marika Moskalyk, Marymount Academy

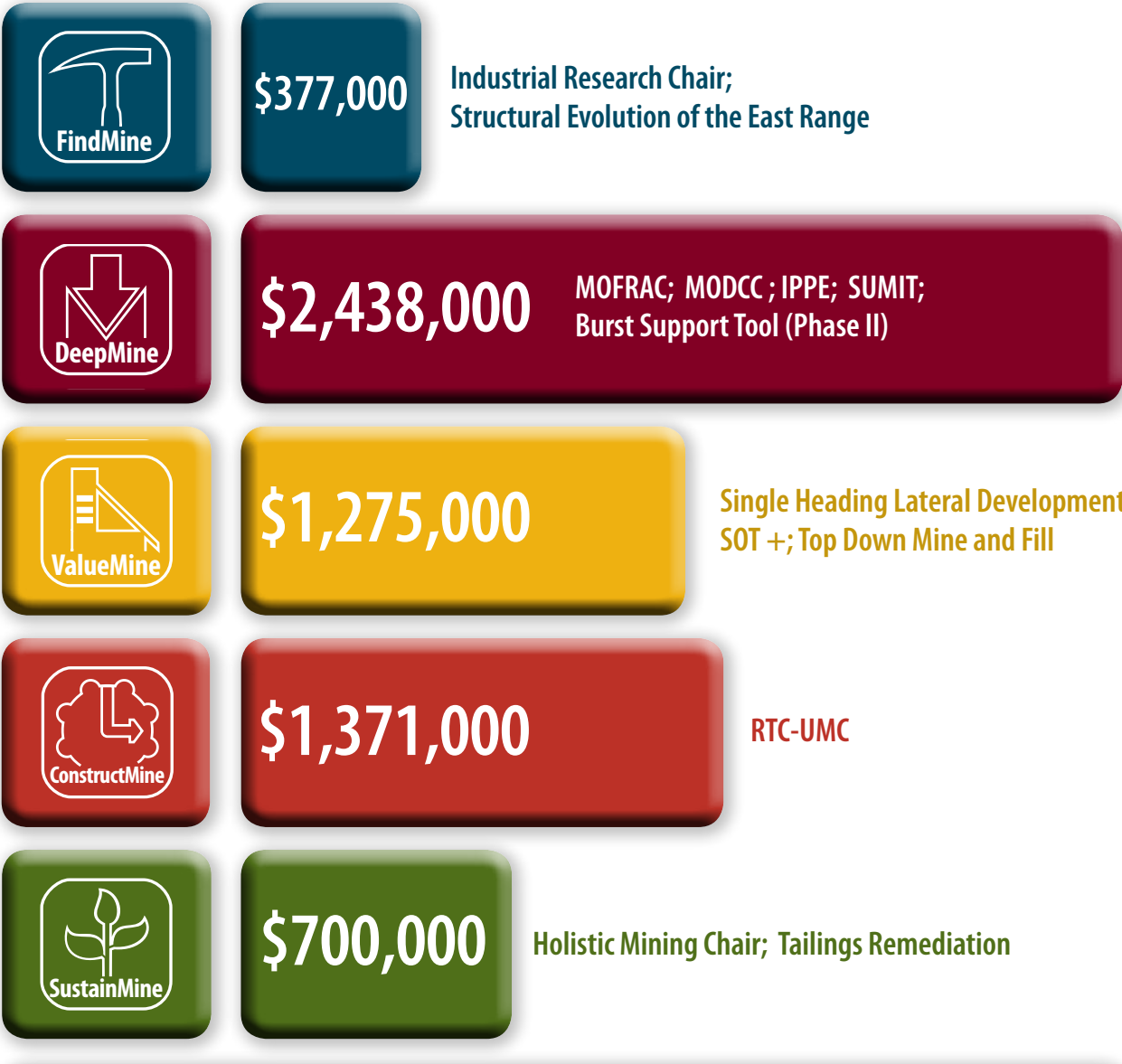
MODERN MINING TECHNOLOGY SUDBURY

CEMI continues to support Modern Mining & Technology Sudbury (MMTS), where over 800 elementary and secondary level students attended this week-long series of educational events. In addition to participating on the MMTS Committee, CEMI was actively involved in the Mine Opportunity Mining Games held at Dynamic Earth. The goal of the Games, with over 300 secondary students participating, is to educate youth about geology, engineering and mining as well as potential career opportunities in related fields.



Modern Mining Technology Sudbury week students participate in Mine Opportunity at Dynamic Earth

INVESTMENT IN CORE RESEARCH



TOTAL INVESTMENT IN CORE RESEARCH: \$6,161,000

During the 2013/2014 fiscal year, the Centre for Excellence in Mining Innovation invested a total of \$6,161,000 into the development and implementation of step-change innovations. The graph reveals CEMI's financial contributions to its five core research themes and a select group of the projects in progress during this period.

THE CEMI TEAM



ALLAN AKERMAN
R&D Program Director



VERN DRYLIE
R&D Program Director of
Environment & Sustainability



PAT DUBREUIL
R&D Program Director



DAMIEN DUFF
Vice President – Geoscience & Geotechnical



ERIK EBERHARDT
Associate Director, RTC-UMC



COURTNEY FOLZ
Communications Coordinator



SHERRY GREASLEY
Vice President – Business Operations



SEPPO HAAPAMAKI
R&D Program Director



BRIAN JONES
Vice President – Business Innovation



PETER K. KAISER
Senior Technical Advisor, RTC-UMC



SHANNON KATARY
Director of Marketing and
Community Relations



OLIVER KOSKI
Project Manager



NATALIE LAFLEUR-ROY
Finance and Operations



DIANE LEPAGE
UDMN Office Coordinator



ERIC MAAG
Director, Innovation and Prosperity Office



DOUGLAS MORRISON
President & CEO
Network Director, UDMN
Chair in Holistic Mining Practices



CHARLES NYABEZE
Director of Business Development



HARVEY PARSONS
Vice President – Mine Productivity



MATTHEW PIERCE
Director, RTC-UMC



MIKE RICHER
IT Administrator



BORA UGURGEL
Managing Director, UDMN



ROCKY WEBB
Project Manager

“SUCCESSFUL
INNOVATION IS NOT A
SINGLE BREAKTHROUGH.
IT IS NOT A SPRINT.
IT IS NOT AN EVENT
FOR THE SOLO RUNNER.
SUCCESSFUL INNOVATION
IS A TEAM SPORT,
IT’S A RELAY RACE.”

QUYEN NGUYEN,
PROFESSOR OF SURGERY,
SPEAKER, TED TALKS

SOLUTION TEAM

Our highly qualified network of major Canadian and global mining companies, universities, government researchers, technical consultants, and innovative SMEs, coupled with access to funding, allows us to facilitate key projects in exploration, deep mining, integrated mine engineering, underground mine construction, environment and sustainability, and enabling technologies.

PARTNERING FOR INNOVATION SUCCESS

CEMI has a mandate to lead and facilitate step-change innovation within the mining industry, through the introduction of new practices, processes, techniques, technologies or knowledge, all with the aim to generate significant improvement in the performance of mines, safely. CEMI is situated at the crossroads where industry knowledge, expertise, imagination, collaboration networks and practical management know-how exist to provide scientific and technical advances, essential to turn ideas into implementable solutions.

CEMI's role is to engage with all collaborators—the mining industry, academia, SMEs, research organizations, service providers and levels of government—to deliver implementable innovation for the mining industry, while ensuring collaborators achieve their individual measures of success. The successful achievement of innovation requires collaborators from all disciplines with the agility and mindset to build on fundamental and applied research findings with practical field trials and demonstration processes for operational integration.

INDUSTRY PARTNERSHIP

Mining organizations recognize that the accomplishment of step-change innovation is a managed process. They know it cannot be developed within short timelines or in a linear fashion without some diversions along the way. They also understand that it requires significant investments in order to influence major changes in the way their business operates. Mining companies can rely on CEMI to focus and manage efforts towards step-change innovation, while mitigating the impact of incidental failures and try to use them to open new avenues of investigation towards future success.

CEMI can work with industry partners in a number of ways. The first is as a direct request from a specific mining company. This requires a straight forward scope that will meet the specific needs of the organization. In effect, CEMI works as an extension to their research team, providing potentially unconventional ideas that, through applied research and the process of system design, can arrive at practical solutions that can be implemented in operations. The second, is when the industry collectively, identifies a problem that requires a solution. This requires agreement generally through workshop settings to help define and develop a detailed scope of work, with budget and schedule, and with some overall direction from industry participants. CEMI has participated and managed a number of these “directed process” initiatives, such as the university-based rockburst research and the current SUMIT collaboration. This allows for the sharing of resources, costs, knowledge and solutions for the industry as a whole, or at least for the collective participants.

Benefits of working with CEMI include the ability to guide the direction and priority of research initiatives and actively participate in the projects, shared costs and lowered investor risk, while taking advantage of the opportunity to access funding through CEMI and acquire research results on shared and single sponsored projects.

MINING SUPPLY & SERVICES COMPANIES

Supply and Service Companies, given constraints on size and resources, can partner with CEMI to collaborate on developing, refining, or demonstrating innovative solutions for the mining industry that they have encountered in the course of business. CEMI, through the IPO can help in filling the resource gaps by providing technical and business expertise, networks, facilitating joint ventures, guidance regarding IP concerns, collaboration and complementary partnerships and as well, research. CEMI can provide support by helping organization sort through the barriers to commercialization, including assistance in ensuring IP protection, applied research resources and facilitating collaboration with other SMEs in bringing together complementary techniques and technologies for a more complete product. For SMEs, the benefits are clear—the ability to grow and develop their business through new products, services, technologies and take advantage of market opportunities.

RESEARCH INSTITUTIONS

An essential building block required for the viable development of innovation is knowledge, both primary and applied research. Research institutions and universities provide the intellectual rigour required in the innovation process. Inherent in the process is the essential iterative knowledge-building process, while providing an environment for the development of highly qualified personnel, important for the future growth of the mining industry as a whole. With CEMI as facilitator and with the expertise in managing cross-functional teams with specific expertise, the ensuing collaboration can bring about viable solutions that can be utilized within a technology or commercialized. The SUMIT collaboration with over 18 core projects engaging universities across Canada is one such example. For research institutions, working with CEMI facilitates the leveraging of research funds, collaborations that can result in ground-breaking findings that can be published, and the potential for income streams from IP development and commercialization.

GOVERNMENT INSTITUTIONS

For government, innovation development and execution brings about clear economic benefits such as job creation, industry development, growth and the potential for a more robust economy. It also brings about corresponding social stability and the intellectual development through knowledge transfer that has far reaching benefits. More importantly, it allows for leveraged funding partnerships with industry, that is managed in a streamlined and efficient manner. The Ultra-Deep Mining Network (UDMN), managed by CEMI, is one such example. The UDMN received \$15 million in funding from the Federal Government through the Business-Led Networks of Centres of Excellence (BL-NCE), which was leveraged to a total of \$46 million through the involvement of the national mining, oil and gas industries, with active participation from SMEs, industry agencies, research facilities and academia.

CEMI provides the industry knowledge, experience and management interface between the mining industry, academia, SMEs, research organizations and service providers. It is committed to addressing the broader needs of the industry, collaboratively. As such, it is an ideal partner for innovation success.

**CREATIVITY IS THE
ACT OF TURNING NEW
AND IMAGINATIVE
IDEAS INTO REALITY.
CREATIVITY INVOLVES
TWO PROCESSES:
THINKING, THEN
PRODUCING.
INNOVATION IS THE
PRODUCTION OR
IMPLEMENTATION
OF A CREATIVE IDEA.
IF YOU HAVE IDEAS,
BUT DON'T ACT ON THEM,
YOU ARE IMAGINATIVE
BUT NOT CREATIVE.**

**LINDA NAIMAN,
CREATIVITY AT WORK**

PATRONS

GOVERNMENT OF ONTARIO

GOVERNMENT OF CANADA

RIO TINTO

VALE

SUDBURY INTEGRATED NICKEL OPERATIONS
- A GLENCORE COMPANY

LAURENTIAN UNIVERSITY



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in Mining Innovation

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