

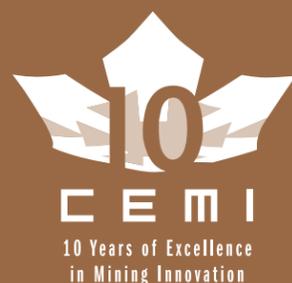
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CEMI

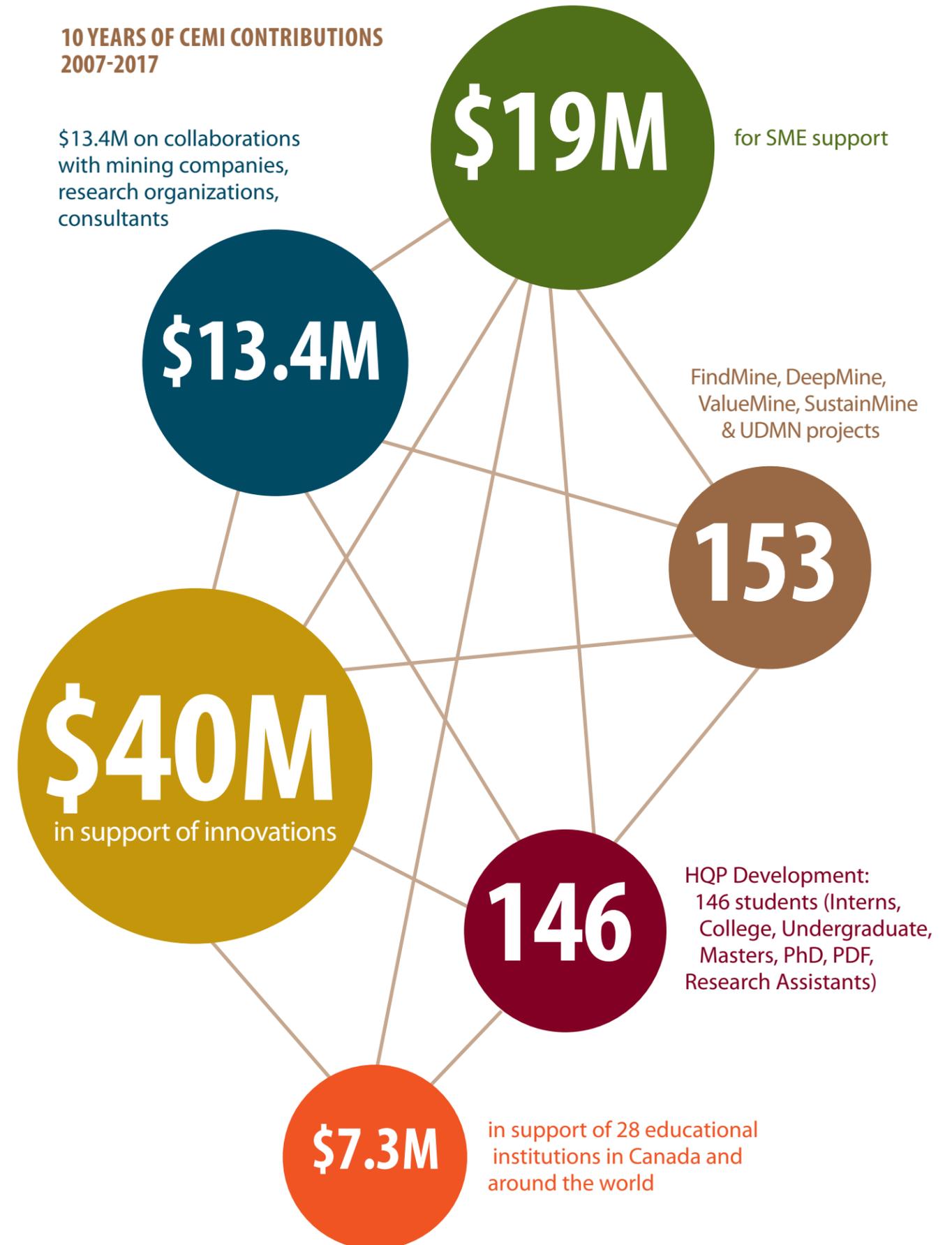
10 Years of Excellence
in Mining Innovation

ANNUAL REPORT 2017

**CEMI HELPS SOLVE MINING
INDUSTRY CHALLENGES BY
DELIVERING COMMERCIALY
VIABLE INNOVATIONS TO IMPROVE
SAFETY, PRODUCTIVITY AND
ENVIRONMENTAL PERFORMANCE.
WE HELP MINING COMPANIES
ACHIEVE BETTER OPERATIONAL
PERFORMANCE FOR A FASTER
RETURN ON INVESTMENT.**



**10 YEARS OF CEMI CONTRIBUTIONS
2007-2017**



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MESSAGE FROM THE CHAIRMAN OF THE BOARD

On behalf of the Board of Directors, I would like to thank Douglas Morrison and the CEMI Team, our collaborative partners and the members of the Board for their dedication in driving the national mining innovation agenda forward this past year. 2017 marks CEMI's 10-year anniversary in achieving successful mining innovation for the global mining industry.

CEMI celebrated "10-Years of Successful Innovation" at this year's PDAC. Highlights of the event included: a discussion on the technical results and outcomes of CEMI's innovation work by theme; a panel discussion with mining experts on innovation requirements; and special acknowledgments from CEMI's original founding members. Guests included Mark Cutifani, former COO of Vale, Dominic Giroux, former President of Laurentian University, Rick Bartolucci, former Minister of Northern Development and Mines, representatives from Vale, Sudbury Integrated Nickel Operations – A Glencore Company, MP Marc Serré, MP Paul Lefebvre from the Federal Government, the Ontario Government, the Ontario Mineral Industry Cluster Council (OMICC) and many others who played a key role in the establishment of CEMI over the last a decade.

CEMI is privileged to have worked with so many innovative partners, including academic institutions, consultants, mining companies, SMEs and government agencies that have helped to develop best practices and technologies aimed at improving the efficiency of mining operations.

We continue to build on our core advantage, our ability to draw on and work with the best teams, worldwide, to close the Innovation Gap,

and help make Canadian companies leaders in mining innovation. We thank the Greater Sudbury Development Corporation (GSDC) for their on-going support of localized commercialization through the UDMN Commercialization Attainment Program (CAP) and previously through the Innovation Prosperity Office.

The national business-led NCE, Ultra Deep Mining Network (UDMN), continues its work to help accelerate the time-to-market of innovations for its network members. Recent commercial successes, Maestro Digital Mine and Mira GeoScience, are the first of many network members to work towards getting their technologies commercialized and adopted into operating mines.

I would like to welcome our newest Board member who joined us part way through this fiscal year, Ms. Alicia Wood, General Manager, Marcotte Mining Machinery Services Inc. and CEO and creator of Covergalls. Her in-depth experience and insights regarding the mining service and supply sector, is critical in our role of supporting SMEs and helping them advance their technologies to the mining industry.

With the continued support of our partners, investing in CEMI means investing in Canadian ingenuity and business acumen to deliver our innovations to the global mining sector.



Roger Emdin
Chair of the CEMI and UDMN Boards





MESSAGE FROM THE PRESIDENT

2017 has been a seminal year for CEMI – we have completed 10 successful years of innovation. During this time, CEMI has received a total investment of \$114M from industry and government towards advancing new technologies and products, developing new processes, best practices, knowledge transfer, HQP development, and accelerating innovations to market by delivering commercially viable innovations that enhance safety, increase productivity and improve environmental performance for the mining industry.

We would like to thank our partners over the years for helping us achieve ten years of mining research and innovation and we look forward to expanding our network of solution providers as we step into the next decade of innovation and commercialization.

We have now completed the SUMIT Program Journal, a CEMI-managed and Laurentian University-led R&D report on the outcomes from a six-year collaborative research program that aimed to investigate innovative technologies for rock engineering and energy optimization approaches in underground mining. This online Journal is jointly distributed by through CIM and CEMI. This completes CEMI's transition from an organization focused on research to one that is dedicated to the demonstration, implementation and commercialization of innovations for the mining industry. And we are already beginning to see the first CEMI-funded innovative products and services enter the mining market. CEMI will, of course, continue to support both academic and industrial research projects, while internally, we focus on implementation and commercialization of outcomes.

Last November CEMI made an important submission to the Federal Government's House of Commons Standing Committee on Natural Resource, who sought advice on creating economic opportunities in the

mining industry. Government needs to create a strong foundation for future growth in mining by investing in developing the scale and range of the Mining Service and Supply sector companies in Canada. Already three out of four mining jobs are from this sector and this proportion will only increase as SMEs globalize their businesses and local mines automate their operations. The kind of strategic changes the industry needs to make will come increasingly, from the innovative minds in the SME community, but they need the supporting business framework of a government-funded innovation ecosystem to succeed. It is important for key stakeholders, like the government, to recognise that the cost and risk of innovation and commercialization - getting new products and services to market - is far higher, than for research projects. Without an effective innovation and commercialization framework to support research outcomes, very few innovation efforts will succeed, and the excellent work of researchers will continue to languish in reports, adding limited value to the economy and squandering the government's investment in research.

CEMI's objective is to begin to transform the economic and environmental performance of mines in Canada and across the world within the next five years. We will focus on three activities: direct technical developments based on our experience of, and relationships within the mining industry; engage with innovative small-to-medium enterprises (SMEs) from the mining service and supply sector and beyond it; and expand the delivery of commercialization services to all of these organizations. We believe it is these organizations that are most likely to direct the shape of things to come by bringing something entirely new to the mining industry. And we will continue the work started in 2015 by CEMI's BizMine, to formalize the Mining Innovation Commercialization Accelerator (MICA) Network in the hope that this will grow to become the most effective investment model to support SMEs.

“CEMI'S ROLE IS TWO-FOLD: DEVELOP INNOVATIONS THAT LOWER THE COST OF MINING; AND REDUCE THE RISK OF INNOVATION.”
- D. MORRISON, 2017

The UDMN continues to be an excellent example of how to successfully deliver new technologies to the industry. Last fall, the UDMN Symposium announced three award winning members: Jannatec Technologies for Outstanding Achievement in Collaboration; Mira Geoscience for Outstanding Achievement in People Development; and Maestro Digital Mine for Outstanding Achievement in Commercialization. This past June marked the completion and launch of Electrale Innovation's Hydraulic Air Compressor (HAC) Demonstrator at Dynamic Earth, in co-operation with MIRARCO and Laurentian University. We are rightfully proud of the Network's achievements to date and the leadership of Managing Director, Bora Ugurgel who will see remaining projects through to equally successful conclusions. All of the Network's projects can contribute to making mining operations in Canada more cost-effective and the members fully expect to be able to continue these successes. We look forward to the opportunity for the UDMN to re-apply for a second round of funding from NCE so that we can continue to expand this national network in deep mining.

In July, CEMI partnered with CMIC in submitting the mining industry's Letter of Intent to the Federal Innovation Supercluster Initiative with the CLEER Program – an approach to creating a mining industry that is more *Clean, Low-energy, Effective, Engaged and Remediated* than at present. Our two Federal MPs, Paul Lefebvre and Marc Serré, strongly support the submission going forward to the full application stage. They are stalwart advocates for Sudbury, with its concentration and capacity for mining-related research and innovation institutions, to become the anchor node of a distributed network of centres of mining innovation across the country. CEMI successfully attracted over 40 SMEs to support the Supercluster submission, and confirmed the importance of this segment of the industry. Although most proponents were from Ontario, almost 20% came from BC, Alberta and Quebec and all provinces with hard-rock mines participated. Collectively, the SME community

provided 60% of the funding for the submission, a significant amount, when measuring the investment as a percentage of annual revenue.

This past year has seen the closure of mines that have been very important to Ontario's and Canada's economy, and more closures are scheduled. These closures, and the lack of new large-scale mines to replace them, emphasizes that change is urgently required – change in the way we find and develop new mines, in the way we operate existing mines and in the way we manage mine waste facilities through to final closure. These changes will have to be transformational rather than incremental and will need the active support of both senior levels of government. The Canadian mining industry is replete with examples of how our mining companies and consultants pioneered technologies and methodologies that were later adopted by the industry world-wide. Our national industry retains the necessary expertise, both modern and historical as well as international, to help realize the capacity of Canadian innovators to deliver the transformational change the industry needs and reclaim its global leadership role.

Finally, I would like to thank the Board of Directors for CEMI and UDMN for their efforts in sustaining and growing the organization. In particular, I would like to thank the Chair, Roger Emdin, and the Chair of the Audit and Finance Committee, Ron Schwarz, for their sterling services to the organization over the past year. We are grateful for the thoughtfulness, wisdom and commitment that all our members bring to Board meetings and we are sure that with the help and support of all our partners in innovation we can look forward to another year of challenge and success.

Douglas Morrison
President & CEO, CEMI
Network Director, UDMN

INNOVATION TO IMPROVE MINE PERFORMANCE

CEMI's primary innovation objective is to help transform the economic and environmental performance of mines within the next five years. CEMI is dedicated to delivering innovation through technical solutions to help generate significant improvements in the performance of mine operations. CEMI works to reduce the cost and risk of innovation, and co-ordinates and directs innovation in: exploration, deep mining, mine productivity, and environmental impact. It is the only not-for-profit organization in Canada to help facilitate operational acceptance and adoption of new technologies through commercialization.

ADDRESSING THE FUNDAMENTAL ISSUES:

Over the last two decades, the economic performance of many underground mines in Canada and around the world has been eroded by declining productivity, increasing mining cost, escalating capital cost over-runs and delays in the approval of new green-field operations.

The fundamental issues at the core of these challenges cannot be addressed by incremental change or minor variations to existing models. Nor is it affordable to take a long time to solve them – mines are closing and not being replaced. These challenges require transformational step change. It means changing the way mines are operated, the way underground equipment is maintained, the way people engage with the production system, the way cooling ventilation is delivered, the way mine tailings and waste-water are stored and treated, and the way mine closures are achieved.

AREAS OF INNOVATION FOCUS:

1. Improve the cost-effectiveness of mining.

Implement mine production processes that consume less time, less money and fewer resources: significantly

increase the amount and quality of ore produced; reduce the largest cost centres - labour & energy; and reduce the up-front capital investment to bring ore-bodies into production. The aim is to improve the return on investment (ROI) of mine operations and the net present value (NPV) of new mine projects.

2. Improve the impact of mining on the environment.

Technologies and processes to reduce the cost of managing tailings facilities and eliminating the need for long-term intervention and treatment; reducing the attendant risks and liabilities; and accelerating final reclamation. This approach provides greater assurance against the environmental impact that causes public concern. The aim is to improve the return on investment (ROI) by reducing the time to obtain mine permits and social license to operate.

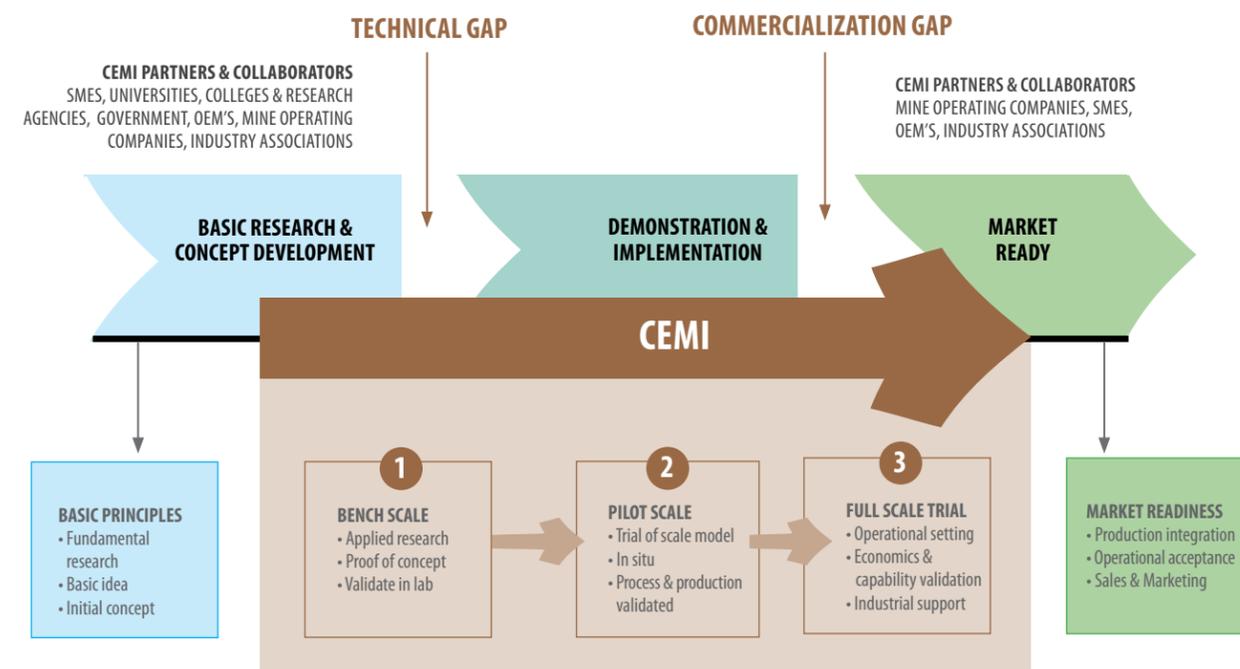
THREE TARGETED PROGRAMS

CEMI, with its experience and expertise, and through consultations with collaborators, has identified the most pressing industry technical challenges, investigated potential solutions and a suite of technical platforms to address them. These are:

1. Lean Mining Program: To increase the ROI and NPV of total underground mining. The program will include technologies: to accelerate tunnel development; increase the rate of flow of ore & rock; reduce the energy associated with moving rock; eliminate hoisting of waste rock; improve the grade and volume of ore hoisted; technologies to reduce the total energy required to ventilate mines; and extract value from underground mining data.

2. Clean Mining Program: To reduce the time and cost of final mine closure through a suite of mine tailings reclamation technologies that can support permanent return of lands to their natural state or to a new desired

CEMI'S INNOVATION PROCESS



The Technical and Commercialization Gaps are overcome by three key steps of CEMI's innovation process—Bench Scale, Pilot Scale and Full Scale Trial

use. The benefits of this program include:

a. Reprocessing Tailings: Converting waste into concentrate and less hazardous by-product and capturing valuable materials for processing in an environmentally responsible way.

b. Removing Contaminants: Lowering or eliminating long term closure liability and making tailings more environmentally benign

c. Re-purposing Sites: Re-vegetation for dust control, opportunities for reforestation or agriculture, including bio-mass to energy programs.

3. Remote Mining: To accelerate mineral development in remote areas (eg. Canada's Far North), where no permanent road infrastructure currently exists, at lower capital cost and reduced environmental impact. Utilize the hoverbarge technology to help develop remote mine sites and improve community infrastructure prior to the development of permanent transportation routes. The technology will enable the rapid construction of alternative power generation systems, water treatment systems, and facilitate the delivery of construction equipment, modular housing, and medical facilities. This social infrastructure will help local communities prepare for employment at new mine developments.

CEMI'S INNOVATION PROCESS: THE ROUTE TO SUCCESSFUL ADOPTION

CEMI's Innovation Process helps to overcome the "Innovation Gap". The Innovation Gap includes two major impediments—technical and commercialization. Only when new technologies, techniques, processes and products gain operational acceptance, has the Innovation Gap been overcome. CEMI's Innovation Process helps to identify technically feasible solutions that are scalable and are economically viable.

Technical Gap: CEMI's experience and ability to access industry experts, technical support and cross-disciplinary teams can help overcome the technical gap by taking research outcomes first to proof of concept, lab validation and then on to pilot trials and full-scale implementation.

Commercialization Gap: CEMI's business acumen and insights of where the innovation fits within the mining process and experience of the industry supply chains, helps to navigate the commercialization gap that can delay or prevent industry adoption.

CEMI's Innovation Process closes the Innovation Gap. It is purposeful and systematic, ensuring innovations are technically feasible, sustainable and economically beneficial. Innovation outcomes that are practical, yet transformative for the industry, are becoming a hallmark of CEMI programs.

CEMI'S TECHNICAL AREAS OF INNOVATION FOCUS



**FINDMINE:
ORE DISCOVERY**



**DEEPMINE:
HEAT & ROCK STRESS**



**VALUEMINE:
MINE PRODUCTIVITY**



**SUSTAINMINE:
ENVIRONMENTAL IMPACT**



MINERAL EXPLORATION AND TECHNOLOGY DEVELOPMENT AT THE SUDBURY STRUCTURE

CEMI and the University of Western Ontario continue their partnership in studying one of the most important mining sites in Canada—the Sudbury Structure. The research projects are being conducted under the umbrella of the NSERC/MDA/CSA/CEMI Industrial Research Chair in Earth and Space Exploration, held by Dr. Gord Osinski, and includes students (3 MSc., 1 PhD, 3 PDFs, 2 undergrads) and a research engineer. The research has two goals.

The first is that the research continues to investigate the origin of Sudbury Breccia, host to footwall vein deposits, and Offset Dykes at Sudbury and their mineralization. This project is in collaboration with Wallbridge Mining Company Limited and a new partnership with North American Nickel and Mitacs.

Recent findings include:

- I. Pele Offset Dykes in the North Range have been determined to be the most evolved offset dykes found to date.
- II. The Foy and Hess Offset Dyke phases (QD and IQD) are similar in terms of major and trace element concentrations, and likely formed in one single event.
- III. Major and trace elements are consistent with the formation of Sudbury Breccia by in-situ melting and do not require a component of the SIC.

The second research goal is the development of state-of-the-art instrumentation and software for increasing rates of development and production in mines. This involves a new partnership between

CEMI, Mitacs and Western. The three major aspects of this initiative are the development of (1) vision-based instrumentation; (2) methods to increase situational awareness; and (3) techniques for automated data acquisition and classification. Early work in this area has resulted in the development of a tablet-based software for geological analysis of above and underground rock faces.



Student fieldwork in the Sudbury Basin

SUDBURY BASIN: STRUCTURAL CONTROLS ON THE PATHWAYS TO MINERALIZATION IN THE EAST RANGE

The Sudbury Basin, non-cylindrical fold basin, is demarcated by the layered 1.85 Ga Sudbury Igneous Complex (SIC). The eastern part of the SIC is transected by prominent curved faults. Folding of the SIC and adjacent rock units occurred in the brittle field. It is peculiar due to its petrographically distinct, but mechanically similar layers. The layers are characterized by low levels of solid-state strain, raising the question of how the layer contacts acquired their curvature.

The project, supported by CEMI and Vale, addressed this question, by developing a Geographic Information System (G.I.S.) based workflow to analyze fault slip data (Fig. 1); and the orientation and slip vectors of the faults in the East Range of the SIC. Slip vectors form clusters of normal and reverse slip along a given fault. The clustering can be interpreted as successive slip events during folding of the SIC. As the faults formed, most likely as planar reverse faults prior to folding of the SIC, they subsequently served as mechanically anisotropic elements to fold the SIC (Fig. 2).

These findings help to:

- (1) better understand the folding mechanisms of thick melt sheets in the upper crust;
- (2) explain apparently incompatible principal strain axes during progressive deformation;
- (3) efficiently analyze the orientation and kinematics of fault zones close to the Earth's surface.

To further investigate that faulting initiated folding in the East Range, kinematic restorations were performed on a drill core constrained industry 3-D model of the contacts of the SIC. The size and accuracy of the 3-D models, based on industry-wide data inputs, made it possible to accomplish kinematic restorations to illustrate the restored geometries of the SIC and faults. The restoration revealed both the primary thickness variations of the SIC and that the thickened parts of the SIC correspond spatially with known Cu-Ni-PGE sulfide deposits. Historically, kinematic restorations are rarely executed with deformed igneous rocks. It highlights the potential of 3-D restorations as a method to better understand mineral pathways in deformed igneous-metamorphic terranes. This project is now complete.

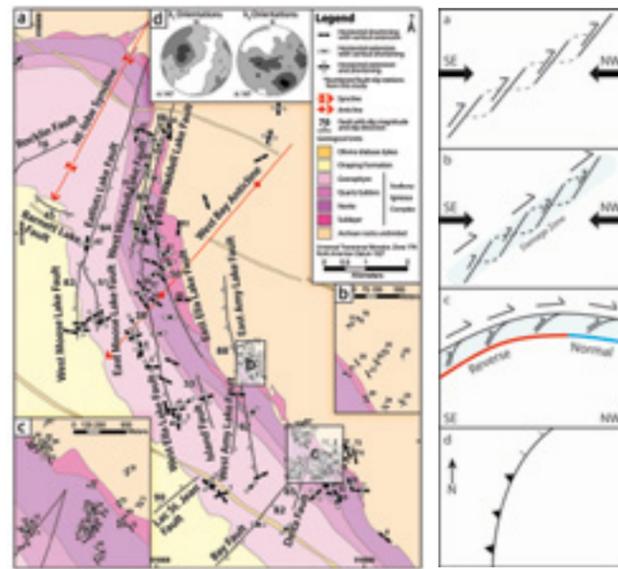


Figure 1: Principal strain directions in the East Range of the Sudbury Basin. (a) Geological map of the East Range displaying the orientation of local principal strain axes from this study (numbered stations) and from Riller et al. (2017) projected to map view. White triangles on faults show dip directions and numbers indicate average fault dips. (b) and (c) Close-ups of areas with a high spatial coverage of strain axis data. (d) Contour plots displaying the average orientations of shortening (λ_1) and extension (λ_3). Dark grey shades indicate strong clustering.

Figure 2: Schematic diagram displaying the evolution of first-order fault surfaces under NW-SE shortening indicated by black arrows. (a) Initial orientation of fault segments. (b) Fault segments coalesce to form coherent first-order thrust or reverse fault. (c) Folding of fault generates normal fault segment in the NW. (d) Map view of final fault trace.

MINING OBSERVATORY DATA CONTROL CENTRE (MODCC)

MODCC is a secure data repository for the global mining industry, located at the SNOLAB surface facility in Sudbury. It is where interdisciplinary data can be searched, analyzed and interpreted to gain new insights for improved exploration success and enhanced mine productivity. The goal is for the MODCC to become a powerful user and data-interpretation interface for mining and exploration related datasets. MODCC will become the mining knowledge hub in Northern Ontario, with enhanced



data analytics functionality that can be used by SMEs to aid in the development of mining related innovations for the global mining industry.

With support from the federal government, CEMI also established the **Smart Mining Demonstration Program**. The Program involves working directly with mining companies, OEMs and SMEs on data-driven projects, including sensors, connectivity, data management and analytics, all technology developed in Canada.

The objective of the project is make a measurable impact on mining productivity and cost with a Canadian, community based engagement model, and an inter-operable digital technology stack. As part of this program, CEMI will build cross-sectoral relationships within Canada's digital technology ecosystem (eg. ACAMP, CENGN, Wavefront, C2MI, etc) to help accelerate the mining industry's ability to adopt and apply the relevant digital technology, such as next generation networking, IoT, AI, and microelectronics to help solve its challenges and enable rapid solution development.

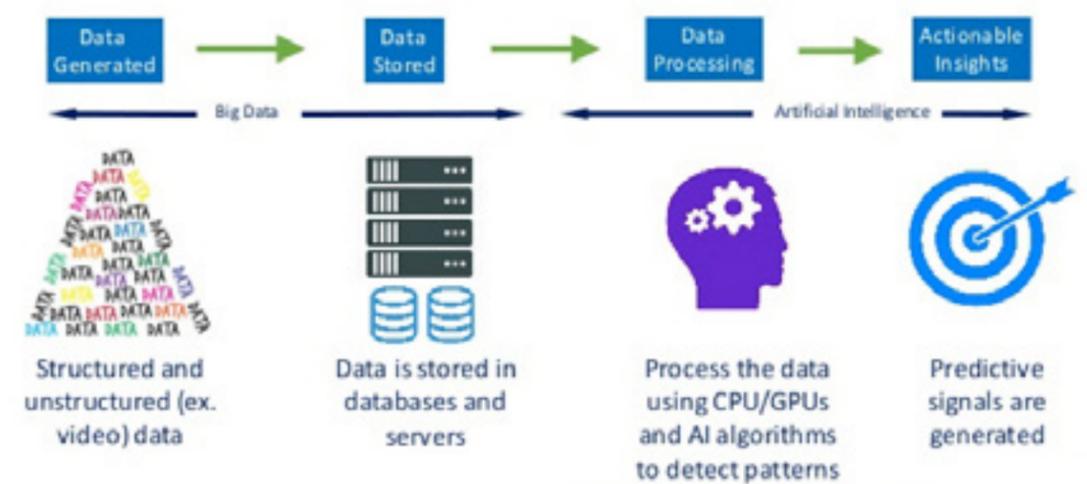
SUMIT PROGRAM JOURNAL

The SUMIT Program Journal authored by SUMIT researchers and students is now available. SUMIT - Smart Underground Monitoring & Integrated Technologies for deep mines, a \$6.7 million program is complete. SUMIT was managed by CEMI and led by Laurentian University, in partnership with Queen's University and the University of Toronto, and with contributions from University of Waterloo, University of Alberta, University of British Columbia and Carleton University. The SUMIT Journal details the results and outcomes of the six-year research collaborations aimed at investigating innovative technologies for rock engineering and energy optimization approaches in underground mining.



Supported by Vale, Sudbury Integrated Nickel Operations – A Glencore Company, Rio Tinto, and the Ontario Government. The SUMIT Program Journal is jointly distributed by through CIM and CEMI and is available for free at www.cim.org and www.cemi.ca.

DATA ANALYTICS: THE PROCESS



Manish Jain, Technology Entrepreneur

Central Processing Unit (CPU)/ Graphics Processing Unit (GPU)



DESIGNING NEW MINING PROCESSES: DISCRETE EVENT SIMULATION

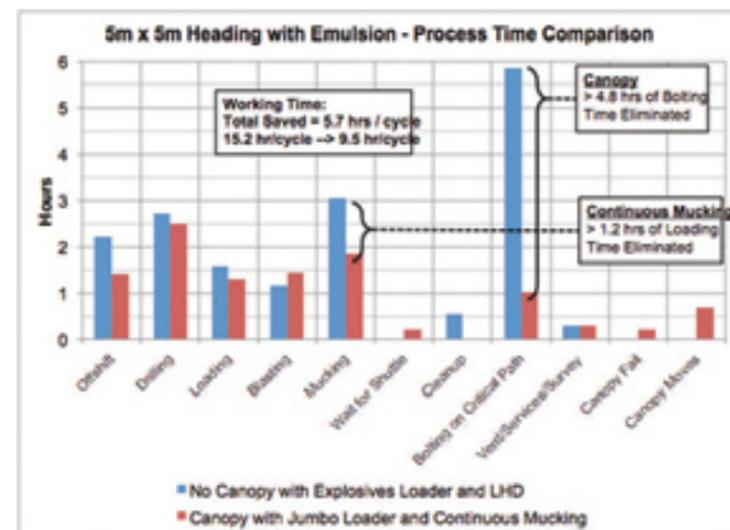
Designing or improving a mining process, requires that each aspect of the current process be defined, understood and critical problems identified. This is not always an obvious process. Managers and workers are sometimes too familiar with the existing processes and don't always "see" areas for improvement. Discrete event simulations allow us to do this. For many of CEMI's productivity-related projects, we have relied on Labrecque Technologies to conduct computer simulations of underground mining activities and processes to help identify areas of improvement. These simulations help to discover opportunities for incremental improvement and that can deliver significant time and cost savings.

The strategic value of this kind of simulation, and the expertise of Labrecque Technologies, cannot be over-stated. The simulations use bench-marked data from specific underground activities, such as underground backfill options, or the discrete event simulation software can be used to construct whole new processes from the basic actions in the sequence. These simulations are essential in demonstrating the potential value of new production processes, and help to justify

the expenditure of building prototype equipment necessary to execute a new process.

The value of the simulations for backfill options was invaluable. The simulation demonstrated the introduction of tailings paste backfill made available sufficient time in the daily shift schedule to increase the rate of production drilling, thereby, increasing the rate of production. In fact, the simulation revealed that no further improvement in the production rate could be implemented unless the backfill system has excess delivery capacity.

The work this past year on the Rapid Advance project for single drift headings, demonstrated the importance of the rate at which broken rock is removed from the heading. Having designed equipment and a sequence of activities that can remove rock at a rate of 300 tonnes per hour, the current project will apply a similar technological approach to multiple draw-points in an underground mine production setting. The complexity of level layouts, the logistics of mobile equipment and the constraints of ventilation can best be understood by Labrecque's simulation process. CEMI is looking forward to the simulation results of current project on Production Rates that we hope will demonstrate the value of developing a suite of equipment that will increase the rate of ore flow in mines while reducing the cost of operating labour and ventilation.



Results of simulation of 5mX5m Heading with Emulsion shows a significant reduction in time for 2 of the key process—Mucking and Bolting on Critical Path



TAILING REMEDIATION DEMONSTRATION UNDERWAY

The environmental impact of legacy mining and tailings sites come from heavy metal contamination in an acidic medium. Removing metals from mine waste and wastewater is critical to minimizing the impact on the environment. However, applying conventional technologies to remove these metals so as to achieve the ground and surface water discharge limits set by regulatory authorities (e.g. Ontario's Provincial Water Quality Objectives), is technically daunting and prohibitively expensive.

CEMI's objective is to develop a new approach to the disposition of mine waste, tailings and waste water from metal mines that is more effective, less expensive, lower risk and provides greater assurance of no adverse environmental impact. A further goal is to search out, verify and test a suite of novel technologies which can be utilized, when appropriate, and applied to a range of real conditions. CEMI's approach combines enhanced mineral processing techniques with improved water treatment processes to deliver cost-effective solutions for full and final site remediation.

LEGACY SITE DEMONSTRATION OF CEMI APPROACH

CEMI's approach got a major endorsement when a Sudbury-area SME, Footprint Environmental Inc., received regulatory permission to work on a legacy tailings site, utilizing a methodology which embodies all the principles for a more effective, less expensive and lower-risk path to final closure. These include:

- Site characteristics: prepare plan to promote full and final closure
- Second phase of mineral processing to reduce contaminants in tailings

- Secondary Concentrate:
 - contaminants + metal resources
 - low volume, transport off-site for further industrial processing

- Secondary Tailings:
 - contaminant level below natural bio mitigation capacity
 - permanent vegetation or waste-to-energy crops

Footprint Environmental Inc., worked closely with Tahgaiwinini Technical and Environmental Services Group and CEMI, to develop a comprehensive remediation plan. Process equipment has been installed on the site, and a process demonstration is expected in Fall 2017. Success will be measured by: recovery of valuable materials from secondary reprocessing; and site remediation to the stakeholders' plan for a full and final closure.

Verification of the site's remediation will be executed through the trial of another novel technique, continuous, autonomous, dissolved-metal monitoring, also a CEMI-SME collaboration. CEMI will provide support and partnership, where necessary, and promote a successful commercial trial of this innovative methodology.



Foreground of tailings

“IN CANADA, I SEE HOW FAR WE’RE SPREADING OUR INFLUENCE GLOBALLY... GIVE ME \$100 MILLION AND I’LL PUT IT BACK INTO CEMI.”

— Rick Howes, President and CEO, Dundee Precious Metals, March 2017

2007

Sudbury Mining Research Cluster – CEMI, MIRARCO, CAMIRO, & MASHA

19 projects: Exploration; Integrated Mine Process Engineering; Deep Mining; Automation and Telerobotics; Environment & Reclamation

CEMI’s Approach to Innovation: **Research, Development, and Commercialization**

5 exploration projects with Laurentian University

Early Support of SMEs: Symbioticware’s Intelligent Monitoring System—Symbot; BESTECH’s, Ventilation on Demand—Mines Emission Reduction Initiative (VOD-MERI); Objectivity—VREX model

Ventilation on Demand (VOD) (2009-2011) Consortium of SMEs, industry and government with funding totalling \$8.5 million from Industry Canada’s Community Adjustment Fund (CAF); matching contributions from Vale & Sudbury Integrated Nickel Operations—A Glencore Company.



Fugitive Dust Best Management Practice Plan (BMPP)

International Fault Slip Control Research Initiative (IFSCRI) (2010-2011) Workshops with research & industry leaders to help minimize risks to mines and miners from fault slip events.

PreCalculatOre (2010-2011) Process & cost modelling tool—MineSense Technologies Ltd and Xstrata Process Support (XPS).



2011

2009

Burst Support Tool Software (2009-2010) Improves rock support design strategies in dynamic burst-prone areas; software commercially available in 2016.



2008

2003-2007 Ontario establishes **Ontario Mineral Industry Cluster Council (OMICC)** to develop the mineral sector.

OMICC Vision: **CEMI—Centre for Excellence in Mining Innovation.** Endorsed by Laurentian University and the City of Greater Sudbury.

Ontario Government contributes \$10-million; Vale & Glencore each invest \$5 million

CEMI incorporated as a Not for Profit; **Founding Executive Director—Dr. Peter K. Kaiser**



2010

Rio Tinto’s Centre for Underground Mine Construction (RTC-UMC) at CEMI (2010-2016) The \$10 million Centre for research in support of Rio Tinto’s Mine of the Future™ programme focusing on underground mining infrastructure & footprint reliability.

Industrial Research Chair (Dr. Richard Smith) in Exploration Geophysics (2010-2015) To increase discovery and development potential of new ore bodies through advanced geophysical tools

Smart Underground Monitoring and Integrated Technologies (SUMIT) for Deep Mines (2011-2016) \$6.7 million to facilitate advances in productivity, efficiency, energy optimization in underground mining. Online SUMIT Journal is available through CIM and CEMI.

Chair in Holistic Mining Practices (2011-2015) NOHFC invests \$823,000 for a Research Chair for Holistic Mining Practices. Douglas Morrison announced as the Chair and incoming Vice President, CEMI.

Innovation and Prosperity Office (IPO) (2011-2017) Greater Sudbury Development Corporation (GSDC) invests \$300,000 over 4 years, for IPO to help service & supply companies commercialize new products, technologies and processes.

2012-13

Coldblock Technologies Inc. (2012 - ongoing) Technical and commercialization partnership with ColdBlock™ Digestion, a sample digestion technology for dissolving solid matter into a solution for multi-element analysis.

Rapid Development Program (2012-ongoing) The Mine Development Canopy System (MDCS) for single heading lateral development. Nordic Minesteel Technology (NMT) is constructing and marketing commercial units.



Ultra Deep Mining Network (UDMN) 2014-2018 Federal Business-Led Network of Centres of Excellence (BL-NCE) awarded to UDMN. Managed by CEMI; with 76 network members and 24 projects on solving the challenges at ultra-deep.



2014

Douglas Morrison announced President & CEO

CEMI-OCE-NSERC Mining Partnership: \$2 million to fund projects in advanced manufacturing with potential for immediate benefit.

Structural Geology Guidelines for Aiding Characterization of Deep Mining Fault Behaviour Produced by CEMI and Golder Associates

Mining Observatory Data Control Centre (MODCC) (2012 - ongoing) NOHFC funding for \$750,000 for a secure data hub (storage & management).

Introduction of CEMI’s Bizmine Strategic Theme—BizMine focus on the analysis of the cost-benefit factors and commercialization support of CEMI’s technical areas of innovation.



National Mining Resolution to support Innovation to the Federal Government — Collaborated with Canadian Chamber of Commerce and Sudbury Chamber resolution. “Support Canada to become a Leader in Global Mining Innovation”

2015

UDMN’s Commercialization Attainment Program (CAP) (2015-2018) Greater Sudbury Development Corporation (GSDC) contribution of \$1 million to assist UDMN member mining supply and service companies in the Sudbury area.

Exploring the Structure of the Sudbury Igneous Complex to Understand How New Ore Bodies May be Discovered (2014-2016) CEMI & Vale support for Dr. Ulrich Riller (University of Hamburg) on geoscience research in Sudbury for Ni-Cu-PGE mineralization.



UDMN – Commercialization Award Maestro Mine Ventilation’s Environmental Air Quality Stations for Deep Mining receives the first UDMN commercialization award.

2016

Geoscience INTEGRATOR: Management of 4D Multi-Disciplinary Mining Data. Developed by Mira GeoScience to accommodate SUMIT data management. Now a UDMN project, to support, track, and report on 4D dynamic mine models and associated geohazards.

UDMN’s Commercialization Attainment Program (CAP) (2015-2018) Greater Sudbury Development Corporation (GSDC) contribution of \$1 million to assist UDMN member mining supply and service companies in the Sudbury area.

Exploring the Structure of the Sudbury Igneous Complex to Understand How New Ore Bodies May be Discovered (2014-2016) CEMI & Vale support for Dr. Ulrich Riller (University of Hamburg) on geoscience research in Sudbury for Ni-Cu-PGE mineralization.

CEMI Celebrates 10 Years of Innovation at PDAC with a Panel Discussion “Achieving Successful Innovation”

UDMN – Launch of Hydraulic Air Compressor (HAC) UDMN, MIRARCO, Laurentian University, Electrale Innovation Ltd. and Reasbeck Construction joint project.

Clean, Lean and Remote Programs to reduce the cost of production, energy and the environmental impact of mining operations; to increase mineral discoveries, mining openings & economic development in remote locations.





ULTRA DEEP MINING NETWORK (UDMN)

Canada's only Ultra-Deep Mining Network (UDMN) is a national \$35M Business-Led Network of Centres of Excellence (NCE), hosted at CEMI – Centre for Excellence in Mining Innovation. The Network continues to make strides in resolving the challenges of resource extraction in ultra-deep (below 2.5km) environments. The UDMN is composed of 76 members from the mining, oil and gas industries with active participation from small-to-medium sized enterprise (SMEs), industry agencies, research facilities and academia.

Now in its fourth year of operations, the UDMN projects are approaching completion in delivering new, commercially viable processes, products and best practices that the mining industry can adopt into operating mines in Canada and globally. Through the Commercialization Attainment Program (CAP), UDMN is providing business and commercialization services to its members and facilitating opportunities for these technologies to be pitched to mining companies and investors. The Industry Consultation Group (ICG) grew, with the addition of new private sector support from Goldcorp, Barrick Gold, Anglo American and North American Palladium. The ICG, a third party group of industry leaders, continues to play a critical role in evaluating the projects selected and determining a project's viability and potential to address the needs of the mining industry. UDMN is well on its way to helping the mining industry develop and adopt new technologies that will help the industry resolve challenges and thrive.



ROCK STRESS RISK REDUCTION

2016/2017 INVESTMENTS TOTALLING \$6,586,891

Improve the control of stability in deep underground excavations

Current Projects: 6 - \$983,278

1. Seismic Stress Inversion (ESG Solutions)
2. Development of a Numerical Model to Stimulate De-stress Blasting as a Stress Modification Technique for Deep Mining (Itasca Consulting)
3. Open Geotechnical Data Network & Data Analysis (Symboticware)
4. 4D Real Time Geotechnical Hazard Assessment and Reporting for Ultra-Deep Mining (Mira Geoscience)
5. Hydraulic Pre-Conditioning of Highly Stressed Rock Masses (MIRARCO)
6. Active Seismic Monitoring for Seismic Risk Reduction (Institute of Mine Seismology)



ENERGY REDUCTION

Improve the energy consumption profile of deep mines

Current Projects: 7 - \$1,841,276

1. Towards Freezing-on-Demand with Closed Loop Geothermal Systems (McGill University)
2. Improved Thermal Mass Utilization Decreasing Applied Ventilation System Energy Intensity (MIRARCO)
3. Determination of the Acceptable Geothermal Resource for Open Loop Systems (McGill University)
4. Wind2Ice: Low Cost, Low Carbon Creation of Ice to Cool Deep Canadian Mines (MIRARCO)
5. Electric Mining Machine for Personnel Transport (Tracks & Wheels)
6. Battery-Powered Underground Utility Vehicles, 150-250hp (FVT Research Inc.)
7. The Cryofan© Project for Ultra Deep Mine Chilling. (CanMIND Associates)



MATERIAL TRANSPORTATION & PRODUCTIVITY

Increase the rates of development and production in mines

Current Projects: 5 - \$3,124,378

1. Rapid Lateral Development Canopy Phase II (CEMI)
2. TSL Guideline – Phase I (Industry Led)
3. Hydraulic Air Compressor – HAC (Electrale Innovation/MIRARCO)
4. Mobile Crusher/Sizer – Phase I (Industry Led)
5. Schedule Optimization Tool Plus – SOT+ (MIRARCO)
6. Attain Software Tool (MIRARCO)
7. Automated Rock Breakers (Rock-Tech)



IMPROVED HUMAN HEALTH & EFFECTIVENESS

Enhance human environment in deep mines

Current Projects: 3 - \$637,959

1. Thermal Garments (Jannatec Technologies)
2. Wearable Communications (Jannatec Technologies)
3. Environmental Air Quality Stations for Deep Mining (Maestro Digital Mine)

"The challenges it has chosen to tackle - those associated with extracting natural resources from deep deposits - are bringing together diverse disciplines to seek advancements ranging from improved methods of extracting resources to new ways of

protecting people who work at great depths below the earth's surface. I congratulate UDMN on facing these challenges and wish them continued success." - Jean Saint-Vil, Associate Vice-President, Networks of Centres of Excellence (NCE)

UDMN SYMPOSIUM: FACILITATING COMMERCIALIZATION

UDMN hosted its second annual Network Symposium in December 2016 to over 95 attendees. The Symposium provided a forum for Network Members to share progress and outcomes, pitch commercial results to industry leaders and end users. The two panel discussions at the conference provided insights on the industry's technical needs, industry trends, the challenges of the product adoption within operating mines and on commercialization services available to the Network membership.

The Acceleration of Commercialization panel, moderated by Adi Treasurywala, included experts from various fields: Sonia Tournay, Creatives Strategie Image (presented by Eric Maag), Chris Bown, Gowling WLG, and Ryan MacEachern, CAMESE.

Back by popular demand, the Industry panel shared their knowledge and experience on how mines implement new technologies. Panelists included: Ryan Roberts, Manager, Mine Operations, Glencore - Kidd Operations, Rick Howes, President and Chief Executive Officer, Dundee Precious Metals, Samantha Espley, General Manager - Mining & Mineral Processing Technical Excellence Centre Vale Base Metals, Peter Xavier, Vice President, Sudbury Integrated Nickel Operations - A Glencore Company, and was also moderated by Adi Treasurywala.

UDMN INAUGURAL AWARDS CEREMONY

UDMN's annual Awards Ceremony acknowledges the outstanding contributions made by network members to date. The Awards recognize and celebrate UDMN projects and Members with actual commercial sales, new jobs, development of HQP (highly skilled people) resources and new collaborations supporting a common business-led innovation goal. Award winners include:

OUTSTANDING ACHIEVEMENT IN COMMERCIALIZATION:

Maestro Digital Mine "Environmental Air Quality Stations for Deep Mining", for taking their UDMN commercially viable innovation to completion, achieving a commercial sale(s) and creating a new and important technical product category within the marketplace for use in mining operations.

Maestro Digital Mine's technical innovation, the first recipient of the award, ensures the safety of underground miners. Ultra-deep underground mines have challenging environmental conditions, including toxic gases from drill & blast operations or gases given off by the surrounding strata rock. Protecting miners from acute or chronic gas related health conditions is paramount for any responsible mining company. To ensure this, a variety of sensors transmit real time data from the underground workings to the surface control rooms. The use of sensors allows miners to return safely to their working areas more quickly, allowing significant productivity increases. However, the sensors are sensitive and require frequent maintenance and calibration, to maintain accurate measurements. The previous technology required underground calibrations at each individual location using test gases. However several physical and environmental challenges prevented accurate and repeatable calibrations of the sensors.

Maestro tackled this vital, life-saving application by designing and developing a digital gas sensor that can be calibrated on surface in a stable controlled environment. The digital sensors then can be "hot swapped" by a ventilation technician without the requirement of any sort of underground calibration.

Built upon the IoT (Internet of Things), the digital sensors have a complete suite of diagnostics to help determine the health of the complete system and provide maximum system uptime.

OUTSTANDING ACHIEVEMENT IN COLLABORATION:

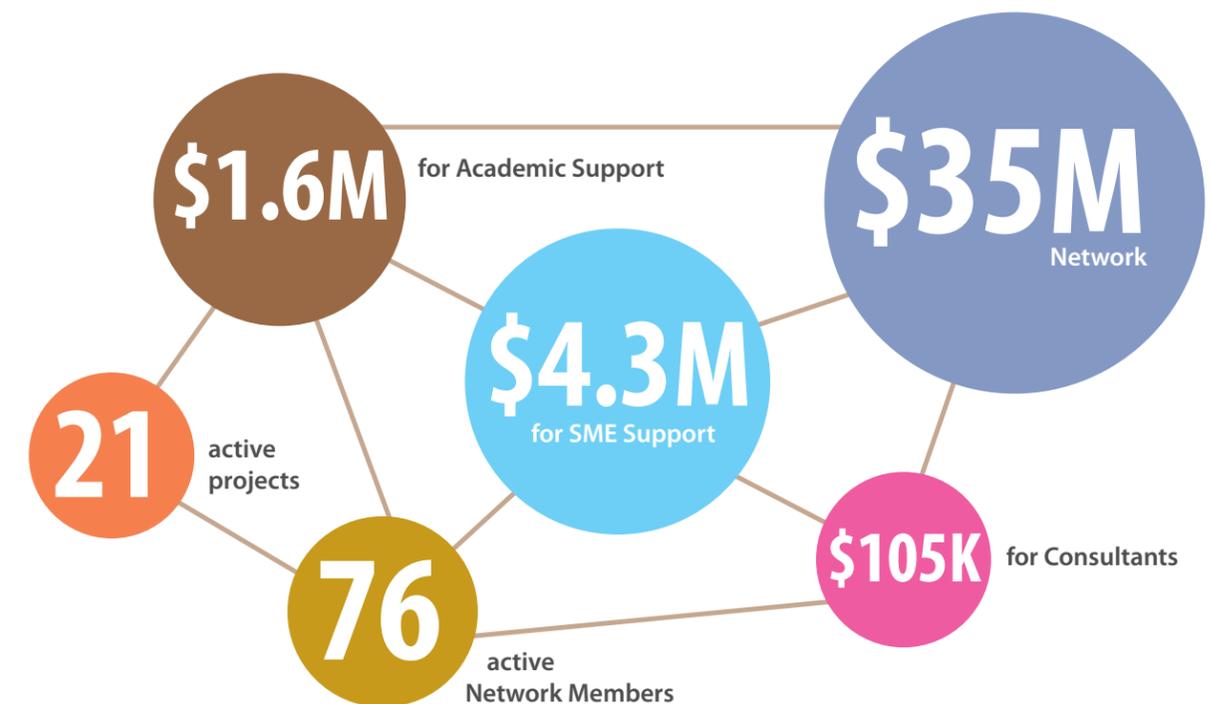
Jannatec Technologies: "Thermal Garments" received this award for demonstrating their outstanding ability to work collaboratively with traditional and non-traditional companies and organizations such as the OCE and researchers from George Brown College's School of Fashion Studies and the Olds College Apparel Innovation Centre.

Jannatec is developing an integrated solution for personal protective equipment that incorporates an active cooling vest system for miners with environmental and physiological sensors. Jannatec needed to design a new kind of coverall, one that could compliment the integrated thermal management system, meet safety standards and improve thermal comfort. Working with students and faculty at George Brown's School of Fashion, the team began a year-long collaboration to design and develop the coveralls from the ground up.

The team tested various materials to find the best options for breathability and durability. The design process included: concept sketches; selection of viable concept ideas into two alpha prototypes made up of different structures and materials. After careful evaluation of alpha prototypes, the team finalized the design and created two beta versions featuring the best materials. After undergoing thermal comfort testing at the Olds College Apparel Innovation Centre in Calgary, Alberta, the final details were determined. The first production version of the garment is currently being manufactured and are about to be tested underground.

Jannatec aims to commercialize the coveralls in the spring. This SME's foray into the thermal technology sub-market will help diversify its product offering and become a core component of the future of wearable electronic initiatives. By enabling miners to reach lower depths safely, the technology will open possibilities for companies to expand mining operations and potentially create new jobs in the field.

2017 UDMN NETWORK MEMBER SUPPORT



OUTSTANDING ACHIEVEMENT IN PEOPLE DEVELOPMENT:

Mira GeoScience: “4D Real Time Geotechnical Hazard Assessment and Reporting for Ultra Deep Mining” received the award for increasing the company’s capacity by hiring highly skilled people, significantly enriching the company’s ability to perform with a dynamic, talented and integrated team.

Geoscience INTEGRATOR, developed by Mira GeoScience, was originally conceived to accommodate the data management needs of SUMIT, a multi-disciplinary, collaborative research programme involving academic institutions, mining companies, SMEs, and managed through CEMI. Through Mira’s involvement in the follow-on “Mining Observatory Data Control Centre” (MODCC) project, exploration data themes and a powerful 3D visualization and query interface were added. Geoscience INTEGRATOR is now a UDMN project that supports, tracks, and automatically reports on 4D dynamic mine models (a new feature) and associated geohazards.

It is a true 4D multi-disciplinary geoscience data management solution, interfacing with visualization, modelling, query, and expert system applications to drive exploration and mining success. It enables the management of multi-disciplinary time-based data (primary data that is a function of time and the time-evolution of both data and models) in a flexible and easily extensible relational data model. Standard data import, ad hoc reporting, customized standard reporting, and report scheduling are all easily controlled from a web interface.

PROJECT LAUNCH: HYDRAULIC AIR COMPRESSOR (HAC)

In June, the Hydraulic Air Compressor (HAC) Demonstrator officially opened. The HAC is an industrial scale system for testing and demonstrating compressed air production using water. It is installed in a former elevator shaft at Science North’s Dynamic Earth in Sudbury, ON. This innovative technology provides an energy efficient alternative to conventional mechanical air compression and it promises up to 50% savings in lifecycle cost for mine operators and other industrial scale users of pneumatic power.

The UDMN HAC initiative is a joint undertaking of the UDMN, with MIRARCO Mining Innovation, Laurentian University, Electrale Innovation Ltd. and Reasbeck Construction.

This UDMN project had two phases, research and construction, with a total value of \$3.375 million. Significant financial contributions included: \$463,000 through the province’s Northern Ontario Heritage Fund Corporation (NOHFC); \$499,000 from the Independent Electricity System Operator’s (IESO) Conservation Fund; and \$620,000 from Electrale Innovation Ltd and MIRARCO, with contributions from Victaulic Canada and KROHNE Canada. Additional support was provided by Science North/Dynamic Earth, Vale Canada, the Ontario Trillium Foundation and the Canada Foundation for Innovation (CFI).

The HAC promises low cost, low carbon, energy efficient compressed air for all industries requiring pneumatic power. As part of the UDMN, the expectation is that HAC will help lower the cost of energy for mine operators, and help maintain the Canadian Mining Industry’s global competitiveness. One new use for the compressed air innovation by the HAC is for the refrigeration of ventilation air for ultra deep mine cooling. The team of innovators, scientists, engineers and industry will work collaboratively to prove energy efficiency of the systems and to investigate the feasibility for mine cooling, gas liquefaction and carbon capture. Electrale Innovation Ltd. www.electrale.com is exploring commercial opportunities for the technology. *For HAC Tour details contact Dr. Dean Millar, President & CEO, Electrale Innovation Ltd. at 705-918-1613.*



The HAC Pack

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COMMERCIALIZATION AT CEMI

A FRAMEWORK FOR INNOVATION SUCCESS

CEMI is unique in its ability to bridge the Innovation Gap, because it is structured to support innovation at every level. The four strategic areas of focus, FindMine (exploration), DeepMine (deep mining), ValueMine (mine productivity), SustainMine (environmental impact) help support the technical elements of mining innovation. BizMine (commercial viability), CEMI's fifth area of strategic focus supports the commercialization of mining innovation. Industry adoption of innovation can only be achieved through operational integration. CEMI's industry knowledge of where an innovation fits within the mining process and supply chain, is essential in helping achieve operational integration and delivering a viable, market-ready product, process, or technology. Together, these five areas of strategic focus help overcome the technical and commercial barriers that can hinder the acceptance of the innovation.

The benefit of managing both the technical and commercial aspects of innovation allows CEMI the ability to seamlessly navigate the work required in closing any existing gaps within the innovation process. It helps to facilitate the required communication and collaboration between the technical and commercial aspects and integrates the innovation operationally, while validating its market acceptability.

BIZMINE: SUSTAINING INNOVATION

CEMI has the skills and resources to develop and sustain innovation. It has the technical experience, business knowledge and industry insight; it has built networks and relationships and credibility over the last ten years; and it has the professionalism and know-how on managing projects—large and small—to manage the innovation process. All these are key elements for innovation success. The BizMine team engages with all sectors and disciplines—those that need, inspire, create, work, fund, buy and use innovation. CEMI's ability to manage cross-functional teams helps to bridge the innovation gap.

Understanding Industry Needs and working with Mine Operating Companies:

The BizMine activities and programs are focused on meeting the needs of mining industry, with the objective to address the root causes: productivity, profitability, costs (energy, labour), liabilities, sustainability, longevity of the industry (mine openings, social licence), ROI and NPV. Industry and Mining Associations provide insights on the issues and needs of the industry at large, facilitate co-ordinated advocacy work for the industry and provide networks for innovation support.

Knowledge Development

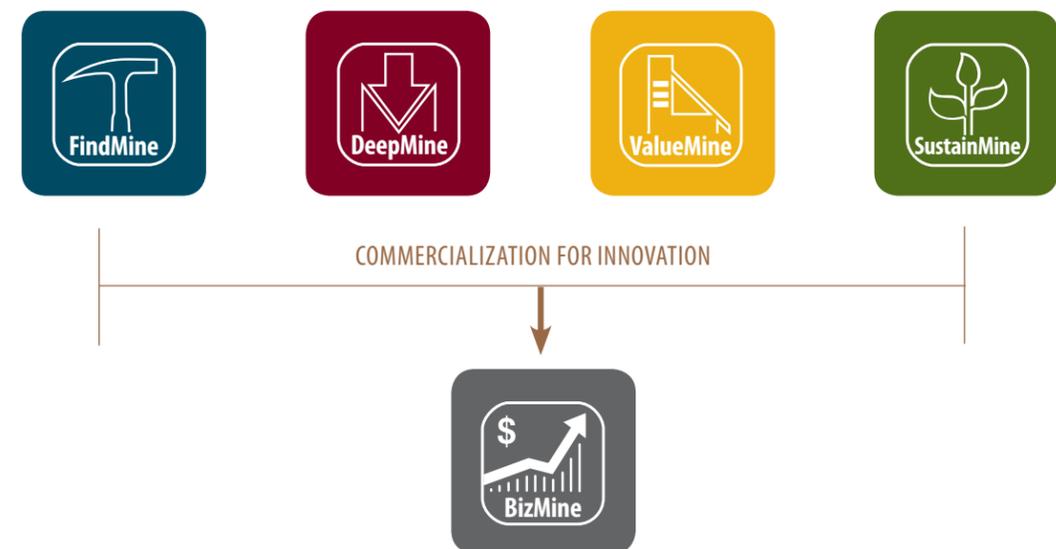
BizMine co-ordinates and collaborates with universities, colleges and research institutions to

help fund, develop and source knowledge in the form of research or applications that can impact innovation development. These organizations have the intellectual rigour, the essential iterative knowledge-building processes and access to diverse knowledge sources and data, a requisite component for innovation.

Working with Innovators—Service and Supply Companies

The CEMI BizMine and technical team work and collaborate with innovators, internal and external to the mining industry, to identify and source the knowledge (research), ideas, concepts, data and technical prototypes that could assist in solving the

COMMERCIALIZATION SUPPORT FOR CEMI'S STRATEGIC AREAS OF TECHNICAL FOCUS



CEMI's BizMine helps close the commercialization gap within the innovation process by helping ensure commercial viability of mining innovation within CEMI's areas of technical focus.

root problems. CEMI has built strong and trusting relationships, networks, and know-how to work with innovators. By partnering with service and supply companies, CEMI helps to overcome the constraints of size and resources, providing for both the technical and business guidance.

Program Development and Process Frameworks

With 10 years experience in managing large scale research and innovation programs, CEMI has developed a structured model to prioritize and evaluate innovation, with a formal process at every step to be able to manage and leverage government funds. The governance process, so important to managing funds, has been long established. This is particularly beneficial to government departments and agencies, looking to ensure that funds aid in the creation of jobs, industry development, management efficiencies and for social stability and economic development.

INNOVATION SUPPORT

The BizMine team also provides innovation support to SME organizations to help them overcome barriers to commercialization. These services have aided the members of UDMN in advancing their projects to commercialization. These services include:

Commercialization Assessments: Audits to assess the organization's ability or maturity in the areas of market knowledge, operational & marketing systems and tools, production readiness, human resource training, management systems, financial management and tools, funding sources and resources, logistical and decision making abilities, and development of the business model to support the innovation.

Case Study Development: Help in validating innovation by neutral organizations (academic, governmental, consultancies), public beta testing to prove economic and social value of the innovation.

Identification of partnerships and collaborative partners to help propel innovations forward such as intellectual property management, marketing partners (advertising, research, sales relationships, web and graphic design, branding) and sourcing funds.

Facilitating Networks to help uncover opportunities and identify potential partners at industry conferences and trade shows such as PDAC, CIM, MEMO, Conference Board of Canada's Council of Innovation and Commercialization and MineEXPO (Las Vegas).

Training: Providing support through lecture series and speaker presentations. Subject areas include: inbound marketing, dealership management, industry panels, innovation assessment and management seminars.

INNOVATIONS IN PROGRESS:

CEMI has entered into agreements with the following innovative companies in help to refine the technology and facilitate commercialization of their innovation for the mining industry:

Activated White:

Activated White has developed a patented technology that absorbs hydrocarbons, commonly related to oil and gas emissions and spills. This technology has many applications. It can be configured in air filters to capture diesel emissions from engines or into a format that can absorb and clean up spills. CEMI is working with Activated White to adapt this technology for resource extraction applications, and on finding ways to scale up and demonstrate the capacity of this technology.

RENIX:

The RENIX technology was germinated on academic research based in the agri-foods sector. The crux of the technology is its ability to purify materials used on a regular basis. CEMI and RENIX are collaborating on looking to find ways to detoxify continuous streams of contaminated water. The technology has proven successful in extracting metals at relatively small scale volumes of continuous water streams and for treating dissolved-metal in waste-water from mining activities. This technique offers not only flexibility in the capture of metal values in solution, but also the disposition, or separation, of the captured metals for recovery. The benefits of a successful application of the technology would include treatment of mine water from legacy workings, mine tailings treatment ponds, and water recirculation circuits of process plants.

10 YEARS OF SUCCESSFUL MINING INNOVATION

CEMI celebrated 10 Years of successfully executing mining innovation with a panel discussion on "Achieving Successful Mining Innovation". The event held at PDAC 2017, featured CEMI's current collaborative innovation programs as well as a panel discussion with industry thought leaders and significant contributors to global mining industry.

The Panel, moderated by Steve Paikin, host of TVO's The Agenda and Laurentian University Chancellor, shared their knowledge, insights and experience on innovation the mining industry still needs to achieve for future success.



"CEMI has continued to evolve to support the needs of the industry. The most important transition has been the focus on innovation at the high end of the technology readiness scale. CEMI continues to work with a wide range of mining service and supply companies, academic institutions, SMEs, OEMs and start-ups to bring new products and services to the market and I am honoured to have been part of their genesis.

– Mark Cutifani, CEO, Anglo American, March 2017

"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"

– Connor Spollen, VP North Atlantic Projects, Vale, March 2017

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

– Fred Delabbio (formerly) General Manager Innovation - Underground, Rio Tinto

The mining industry is going through a number of changes. We need innovation to thrive so that the mining industry can be competitive and prosper. CEMI is the go-to source to provide that innovation to the mining industry"

– Roger Emdin, VP, Projects, Harte Gold Corp & Chairman CEMI & UDMN Boards.

INVESTING IN CORE INNOVATIONS



\$28,271

Sudbury Basin Structure



\$3,130,432

SUMIT, MODCC, MOFRAC II, UDMN (Themes 1&2)



\$4,474,166

Rapid Development Program, Continuous Loading Systems, SOT+, UDMN (Themes 3&4)



\$168,536

Tailings Remediation, Water Quality Monitoring, Water Purification



\$2,113,340

Commercialization Services (IPO), Business Case Analysis, UDMN

TOTAL INVESTMENT IN CORE INNOVATIONS: \$9,914,745

During the 2016/2017 fiscal year, CEMI invested a total of \$9,914,745 into the development and implementation of step-change innovations. The graph reveals CEMI's financial contributions to its five core themes and a select group of the projects in progress during this period.

FINANCIAL STATEMENTS

CONSOLIDATED STATEMENT OF FINANCIAL POSITION

	APRIL 30, 2017	APRIL 30, 2016
ASSETS		
Current Assets:		
Cash	\$2,382,000	\$2,566,000
Short-term Investments	552,000	1,005,000
Accounts Receivable	4,118,000	2,516,000
Prepaid Expenses	11,000	29,000
	<u>\$7,063,000</u>	<u>\$6,116,000</u>
Capital Assets	27,000	42,000
Long-term Investments	24,000	58,000
	<u>\$7,114,000</u>	<u>\$6,216,000</u>
LIABILITIES AND NET ASSETS		
Current Liabilities:		
Accounts Payable and Accrued Liabilities	\$3,172,000	\$1,459,000
Deferred Revenue	1,413,000	1,871,000
	<u>\$4,585,000</u>	<u>\$3,330,000</u>
NET ASSETS:		
Unrestricted	2,502,000	2,844,000
Equity in Capital Assets	27,000	42,000
	<u>\$2,529,000</u>	<u>\$2,886,000</u>
	<u>\$7,114,000</u>	<u>\$6,216,000</u>

CONSOLIDATED STATEMENT OF OPERATIONS

	UNRESTRICTED	EQUITY IN CAPITAL ASSETS	APRIL 30, 2017	APRIL 30, 2016
REVENUE				
Research and Other	\$6,278,000		\$6,278,000	\$6,773,000
UDMN-Federal NCE	4,045,000		4,045,000	5,341,000
Investment Income	50,000		50,000	33,000
	<u>\$10,373,000</u>		<u>\$10,373,000</u>	<u>\$12,147,000</u>
EXPENSES				
Salaries and Benefits	\$2,210,000		\$2,210,000	\$2,002,000
Projects and Research	7,200,000		7,200,000	8,860,000
Office and General	1,305,000		1,305,000	1,078,000
Amortization of Capital Assets		16,000	16,000	18,000
	<u>\$10,715,000</u>	<u>\$16,000</u>	<u>\$10,731,000</u>	<u>\$11,958,000</u>
Excess/(Deficiency) of Revenue over Expenses	\$(342,000)	\$(16,000)	\$(358,000)	\$189,000

The financial information was extracted from the organization's audited financial statements. The complete audited financial statements can be found at the following location: www.cemi.ca

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- Newcrest Mining
- Newmont Mining
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SERVICE & SUPPLY

- 6Harmonics Inc.
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- CANUN International
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- Clickmox Solutions Inc
- ColdBlock Technologies Inc
- Covergalls Inc
- Deltion Innovations
- Deswik Mining

- DGI Geoscience
- Electrale Innovation Limited
- ESG Solutions
- Footprint Environmental Inc
- Force Engineering
- Fuller Industries
- FVT Research
- Geosystems L.P.
- Gerry Kinglsey
- Golder Associates
- Gowlings
- Hard-Line Solutions
- Hardware Solutions
- HoverTrans Solutions
- Industrial Fabrication Inc.
- Ionic Engineering
- Itasca
- Jannatec Technologies
- Komatsu Mining
- Kore Geosystems
- Labrecque Technologies
- Landmark
- LCG Energy Management
- Maestro Digital Mine
- Majic
- Mafic Studios, Inc.
- Mansour Mining
- MineSense
- Mira Geoscience
- Motion Metrics
- Newtrax Technology Inc.
- Noble Purification
- Nordex Explosives
- Objectivity
- Paterson & Cooke Canada Inc
- Pattern Discovery Technologies Inc
- Peck Tech Consulting
- Penguin ASI
- RailVeyor
- Renix
- Revolution Mining
- Rock-Tech
- RocScience
- Roctest
- Rodgers Mining Services
- Ronacher & McKenzie Geoscience
- Simsmart Technologies
- SRK Consulting
- STC
- Stratos
- Sturda
- Symbolicware
- Technosub
- Tracks and Wheels
- Equipment Brokers
- Wireless Sensor Networks

- Wip Ware
- XPS – A Glencore Company

ASSOCIATION

- Canadian Chamber of Commerce
- CAMIRO
- CIM
- Conference Board of Canada
- CMIC
- Dynamic Earth
- Mining Association of Canada (MAC)
- Mining Suppliers Trade Association
(MSTA) Canada
- Ontario Mining Association (OMA)
- PDAC
- SAMSSA
- Science North
- Sudbury Chamber of Commerce

RESEARCH & ACADEMIC

- Acadia University
- Boreal College
- Camborne School of Mines
at the University of Exeter
- Cambrian College
- Carleton University
- CIMMR
- CROSH
- Curtin University
- Dalhousie University
- Dalian University of Technology
- Delft University of Technology
- École de Technologie
Supérieure (ETS)
- Institute of Mine Seismology (IMS)
- Laurentian University
- MERC
- McGill University
- MIRARCO
- NGI
- NORCAT
- Northern College
- Queen's University
- Ryerson University
- Simon Fraser University
- SNOLAB
- Swiss Federal Institute of
Technology Zurich (ETH)
- Universidade Federal da
Paraíba (UFPB)
- Université du Québec en
Abitibi-Témiscamingue (UQAT)

GOVERNMENT

- CanmetMINING
- City of Greater Sudbury
- FedNor
- Government of Canada
- Greater Sudbury Development
Corporation
- Ministry of Northern Development
and Mines
- Natural Resources Canada (NRCan)
- Networks of Centres of
Excellence (NCE)
- Nickel Basin Federal
Development Corp.
- Northern Ontario Heritage Fund
Corporation (NOHFC)
- NRC-IRAP-Industrial Research
Assistance Program
- NSERC
- Nuclear Waste Management
Organization (NWMO)
- Ontario Centres for Excellence (OCE)
- Ontario Government
- Timmins Economic Development
Corporation



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