

# Strategic Research Program to Develop Tactical Means for Risk Mitigation in Mining

D. J. Duff, H. Buksa and P. K. Kaiser

*Centre for Excellence in Mining Innovation, Sudbury, Ontario, Canada*

---

## ABSTRACT

A major challenge for the Canadian mining industry is to pursue ever-deeper orebodies if mining is to remain sustainable into the future. The ultimate test of successful deeper mines is to maintain the safety and risk profile at a suitable risk reward profile for investors. Deeper mines take longer to establish, consume more capital and are therefore inherently more risky to investors from the very start. Accordingly, strategic and tactical means must be found to drastically reduce the overall risks of mining at depth and produce rewards which justify the decisions to proceed.

One way to support such projects is to improve the risk/reward profile by focusing R&D on strategically important research directions that address and mitigate a myriad of possible problems that mining at depth entails. Since this is a daunting task, CEMI has, in consultation with its industrial partners, identified strategic research programs to develop tactical risk identification and mitigation techniques; whether from reducing the risk profile by extracting more engineering data from the boreholes at the pre-feasibility stage, to managing the various changes and challenges of the inevitable but unknown vagaries of each mine project through better mine design.

Mining research that is to be viewed as useful and successful must target knowledge leaders in the industry and academia and challenge them to devote the time to finding ways to lower the risk of mining at depth. Without mining industry leadership working with, through and in conjunction with research providers in the selection of and R&D on relevant themes for ongoing investigation, mining research providers will struggle to deliver what industry requires.

This paper presents an overview of challenges, opportunities and adopted approach. CEMI is currently in the process of developing networked solution teams to address the strategic mining industry research themes described in this paper.

E-mail Address: [dduff@miningexcellence.ca](mailto:dduff@miningexcellence.ca)

---

## 1 INTRODUCTION

As established mining camps in the western world continue to mature, the engineering focus has broadened to include dealing with the technical and economic challenges of:

- mining method selection and design,
- the appropriate development approach;
- optimal mine ventilation strategy and design and
- dealing with people and materials logistics.

Mining in Canada is planned or is already taking place at depths in excess of 2,550 m. Xstrata Copper's Kidd Creek Mine D (shown left); Vale Inco's Creighton Deep; Agnico Eagle's Laronde mine and Goldcorp's HGZ zone are perhaps the most representative examples.

At each of these mines, operators and planners are faced not only with the abovementioned issues but, compounding their difficulties, is the not uncommon situation whereby as deepening and new mine construction are occurring normal mine

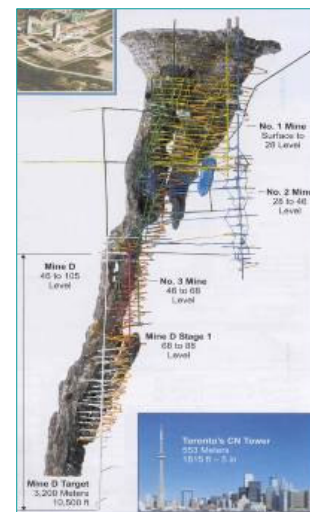
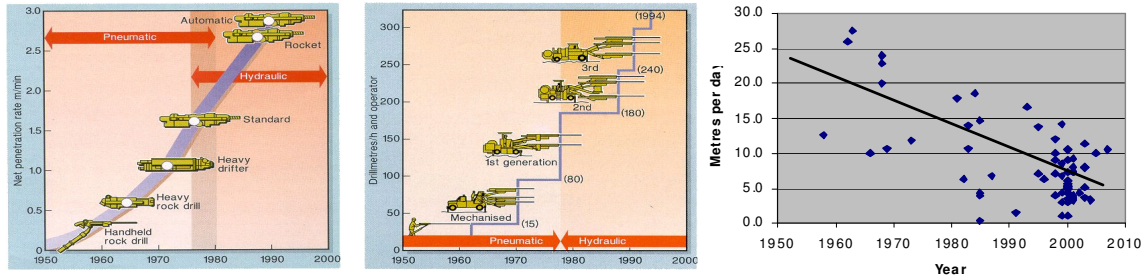


Figure 1: Kidd Creek Mine

operations are being sustained.

A colleague of ours once likened this scenario to “performing heart surgery on someone running a marathon at the same time”- a somewhat comedic assessment of the huge number of challenges this undertaking poses from a design, planning, implementation and operational perspective.

Furthermore, our ability to develop faster has not improved significantly despite the huge increase in the sophistication and capability of today’s underground mining equipment. In fact the trend appears to be going in the other direction.



Courtesy: CAMIRO

(a) Drilling capability

(b) Drift/Tunnel advance rates in mining

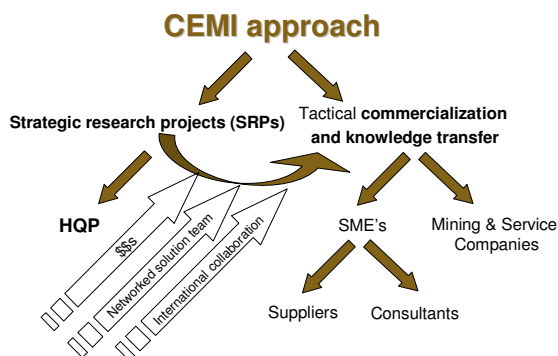
**Figure 2: Drilling and Draft/Tunnel Advance Rates**

Given these and other challenges and difficulties, it is self-evident that mining research needs not only to be well funded and undertaken by the most highly qualified researchers but, importantly, that close interaction and collaboration exists between those actually in need of solutions and researchers that can deliver innovations. Ontario’s Centre for Excellence in Mining Innovation (CEMI)- operated from Sudbury, is implementing a strategic approach to addressing this matter.

Exploration and mining companies have often complained that published mining research seems remote from and of little value to them in dealing with their day to day problems or, for that matter, those foreseen in the future. Researchers are perceived as being happy to “hole up in a corner someplace” and to not care about or be accountable enough for producing substantive value by addressing the real problems of mining in today’s world. To the contrary many outstanding researchers are eager to have an impact.

CEMI is advocating a strategy to ensure that researchers not only feel that their work is being appreciated and put to good use, but that their research topics are seen by industry as addressing the real needs of mine designers and operators of today and tomorrow.

### 1.1 THE CEMI APPROACH



**Figure 3**

With the support of its board of directors and under the directions of its research committee – comprised of representatives for its major sponsoring organizations and academic as well as private sector stakeholders – CEMI has developed a research and technology/knowledge transfer approach designed to focus on strategic research niches leading to the creation of new knowledge and innovations for the exploration and mining industry.

The need to adopt the strategic approach is driven primarily by industry’s desire to see applied research done in specific areas which are deemed of strategic importance and which affect its future ability to operate safely, sustainably and profitably.

The strategic research projects described below are in turn related to a strategy which, on the one hand, ensures the commercialization of new products and services through the involvement of small and medium-sized enterprises (SME’s) as well as exploration and mining company service providers, but which also provides opportunities for the education of the next generation of highly qualified professionals (HQP’s) through student participation.

As an overriding principle, CEMI will attempt to simultaneously capture three primary R&D drivers: needs, people and innovation.

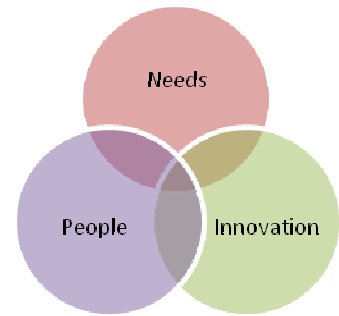


Figure 4

Needs have been and will be defined by industry but progress is only possible if the right and qualified people are in place to undertake the research, and if all efforts, whether fundamental or applied in nature, are focused on innovation.

## 2 STRATEGIC RESEARCH PROJECTS

At CEMI, strategic research projects are first and foremost industry-directed strategic ones. They cover topics which industry has prioritized for further research and which, at the same time, fulfill CEMI’s strategic objective to establish itself as a global leader in specific research niches. Four strategic Research Projects (SRP 1 to 4) have been initiated and one to two more will be added each year. Each SRP involves the close participation of an industrial sponsor and one to two independent strategic advisors.

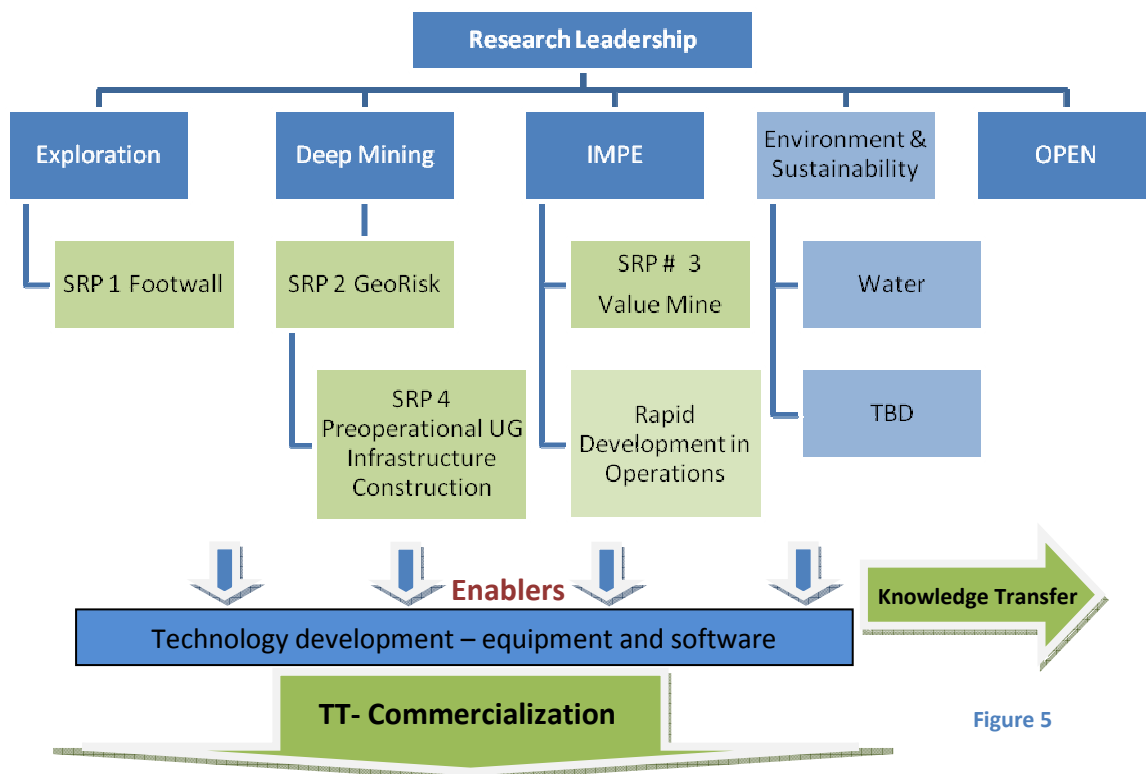


Figure 5

## *Strategic and Tactical Approaches in Mining 2008*

The research niche areas which form the focus of CEMI-sponsored research cover the fields of: exploration, deep mining, integrated mine process engineering and Environment/sustainability. CEMI will also consider project ideas in the OPEN theme to remain responsive to exceptional innovation opportunities. To ensure rapid implementation of research results, CEMI plans to enhance knowledge transfer through communication initiatives such as a publication series and short courses and to support the development of enablers, i.e. enabling technologies in the hard- and software sector.

### Sudbury Footwall Exploration Niche (SRP1)

While the other SRPs are aiming at the global mining industry, the SRP1 has a local focus because of the imminent potential for new ore discoveries in the Sudbury basin. Three projects are currently being funded, totaling some \$500K over 2-4 years, with researchers being based at the Mineral Exploration Research Centre (MERC) located at Laurentian University's Dept. of Earth Science.

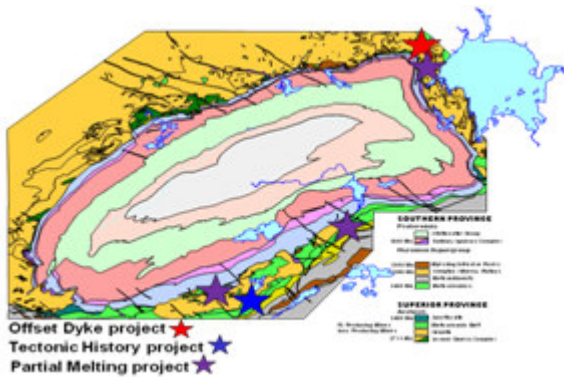


Figure 6

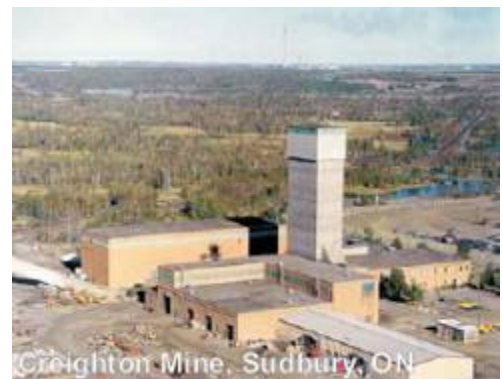
footwall orebody by FNX. Each has reported high grade intersections suggesting NSR values higher than previously reported in the Sudbury basin.

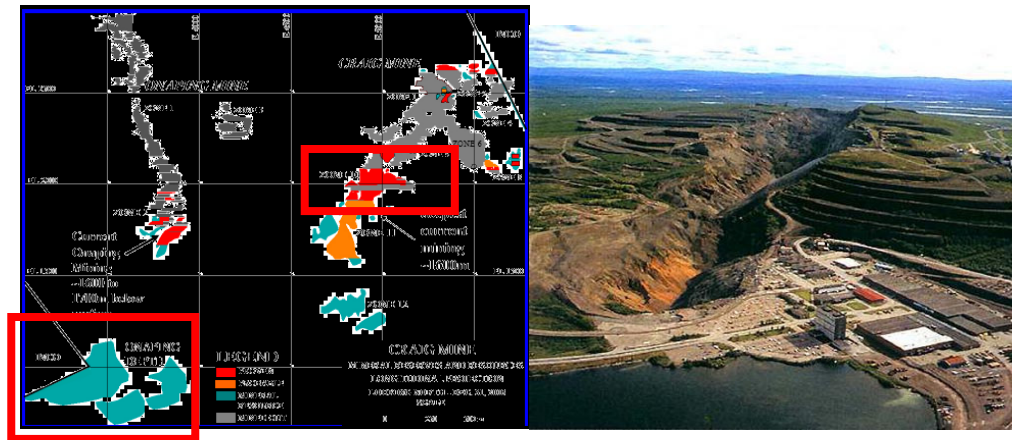
### Deep Mining Niche (SRP2)

Currently a project focused on evaluating and mitigating the risks associated with mining in high stress, structurally complex ore zones is underway. Identifying the risks associated with mining at depth as early as possible and developing new and innovative ways to mitigate and manage those risks is the goal of SRP2.

Using a newly-constructed common earth model, datasets from the Xstrata Nickel Craig Mine Zones 10-11 area in Sudbury will be examined to determine if problems encountered during mining could have been anticipated sooner and more appropriate risk mitigation strategies implemented.

Similar datasets from Vale Inco's Creighton and Garson mines in Sudbury and from LKAB's Kiruna Mine in Sweden will also be used during the project thus enhancing the opportunity to learn from a variety of case histories involving difficult mining situations.





(a) Craig location relative to Onaping Depth (b) Kiruna mine (LKAB)

Figure 7

### Integrated Mine Process Engineering (IMPE) Niche (SRP3)

The SRP3 aims to develop innovative mine design systems to derive optimal value from mining operations. Building on Coates' approach when developing the pit slope project in the 70's, work is underway to produce a manual that will capture current best practice and global experiences in the mine design process. It is intended that this manual be used as a guide for junior staff at mines, for consultants serving mining companies, and as an academic tool to assist in the training of future mine engineers.

Most importantly, the manual will form the basis to develop CEMI's research approach to advance the state of the art in mine design for successfully achieving maximized value delivered by underground hardrock mines. The project should also lead to the identification of research gaps and thus new research directions.

This R&D focus is directly related to a Productivity Enhancement and Risk management program funded by the Ontario Innovation Trust as well as the PRIMO program lead by AMIRA International. Both programs are being undertaken at Laurentian University's MIRARCO in Sudbury.

Also falling under the integrated mine process engineering niche but with strong cross-links to the deep mining niche area is a strategic research project focused on the speed and quality of underground infrastructure construction (SPR4) in the pre-operational stage, i.e., for caving operations, and for mines that are already in operational.

### Underground Infrastructure Construction Niche (SRP4)



Reliable prediction and modeling of rock behaviour to properly select and implement underground construction and support technologies is essential for rapid development as more than 30% of the development cycle is used up by ground control measures.

Improving development rates means, among other things, improving face utilization by: developing faster, excavating faster, developing continuous mucking methods, minimizing face time interference during primary support installation, better human resource management and improved data acquisition thereby enabling better

decision-making. This project will also focus on innovative ground characterization technologies and ground control techniques.

Enabling Technology Development

For research to find meaningful use and application in mining operations, a most strategic aspect will be to support efforts to integrate research findings through enabling technology and software developments. Since these enabling components are normally very costly and in general need close collaboration between research, entrepreneurs, and operations, it is envisaged that CEMI will not fully fund such initiatives but play a supporting role by providing complementary studies. As an example, CEMI is currently co-sponsoring research related to the Smart Rock project funded by Rio Tinto (Baiden *et al.*, 2008; MassMin'08) for real time sensing of muck flow in block cave mines.

**3 STRATEGIC HUMAN RESOURCE DEVELOPMENT**

Each SRP will be lead by one of CEMI's program directors (currently the authors). However, developing research leadership – people - to direct and undertake research work within these niches is of vital strategic (and tactical) interest. Hence, CEMI will put two Chairs in place, one on deep mining and one in geophysics. Two other Chairs will be funded by the OIT program (PERM).

In this regard, research chair positions comprised of respected and experienced researchers in their fields are being filled to either match the four strategic projects or to direct future projects, e.g., in geophysics. These chairs are to be based in Ontario, preferably at or affiliated with Laurentian University and its mining research centres. These chairs will assume overall responsibility for the development and execution of university-based research work.

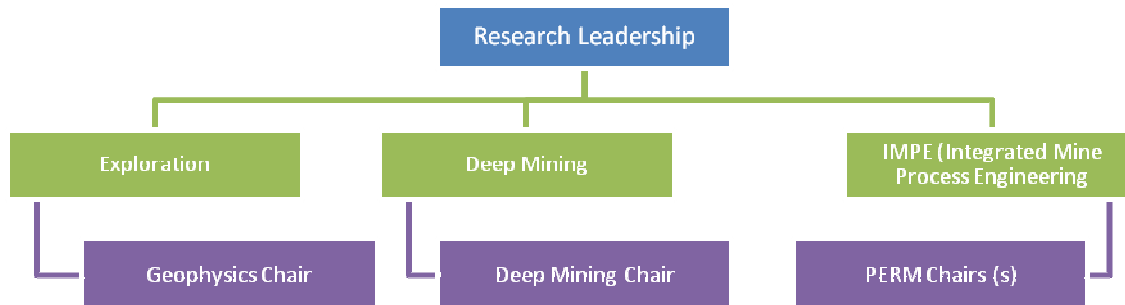


Figure 8

In this regard, research chair positions comprised of respected and experienced researchers in their fields are being filled to either match the four strategic projects or to direct future projects, e.g., in geophysics. These chairs are to be based in Ontario, preferably at or affiliated with Laurentian University and its mining research centres. These chairs will assume overall responsibility for the development and execution of university-based research work.

HQP for Research and industry:

There is no need to reiterate the desperate need for HQP in the mining sector. Hence, CEMI's programs must contribute to the development of HQP in a timely fashion. For this reason, some 15 exploratory projects have

been funded within the four niche areas established at CEMI, funded at approximately the \$2.2m level, with immediate plans for an additional six, costing more or less a further \$2m. The funding criteria for these projects requires the accelerated up-take of graduate students and need to link them to industry relevant topics (for more detail refer to [www.miningexcellence.ca](http://www.miningexcellence.ca)).

#### **4 NETWORKED SOLUTION TEAMS**

If strategic research projects within each of these niche areas are to truly meet the needs of industry; funding is only part of the equation for success. Having a network of the most appropriate and best qualified researchers and service providers to carry out the work is of critical importance.

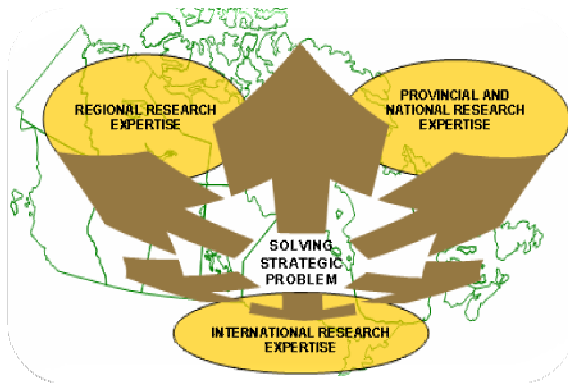


Figure 9

Establishing networks of expertise at the regional, national and international levels to *innovate* and undertake supporting R&D is considered of utmost importance for the long-term.

Since the most innovative solutions to research problems are to be expected from as a diverse a stable of networked solution team members, the potential problem associated with small, local and single expert delivery approaches to problem-solving as identified to us by our industry sponsors - is therefore avoided. Likewise, a collaborative approach to projects is considered optimal to capitalize on complementary expertise and ensure speedy delivery of results. Industry expects it and researchers should benefit.

Networked solution teams are being assembled for each of the strategic research projects under the direction of an R&D Program Director at CEMI. A database of potential team members is being built for future reference on ongoing and future research projects.

#### **5 COORDINATED, COLLABORATIVE RESEARCH**

One of the de-enablers to focused research across this country has got to be the myriad of research organizations which exist. Little effective collaboration often exists among them and, from the perspective of the mining industry, unless one happens to occur in a community in which the company is established, may be viewed as deserving little financial or in-kind support.

Furthermore, there is little understanding by industry of the R&D focus which some organizations may be trying to establish and therefore little patience for a perceived lack of effort to join forces in addressing mining research and development needs. The belief is that research needs are being dealt with by too many disparate R&D entities and that instead of a focused effort likely to reap rewards, a diffuse less than ideal effort pervades.

Within Sudbury, indeed on the Laurentian campus, there are numerous organizations performing mining-related R&D. An effort to formalize collaboration or at least to enhance communication among them will be viewed as highly valuable.

Discussions have been held with two of these - CAMIRO (Canadian Mining Industry Research Organization) and the DMRC (Deep Mining Research Consortium)- to determine how more closely aligned approaches to R&D may evolve. It is proposed to coordinate strategic research direction in a matrix approach identifying lead (L), participating (✓), and non-participating (x) organizations or research groups to meet the R&D needs of industry.

## Strategic and Tactical Approaches in Mining 2008

CEMI will make an effort to further develop this approach with collaborating institutions and hopes that this will eventually be integrated into the pan-Canadian initiative of the Canadian Mining Innovation Council (CMIC).

PROJECT	CEMI	ANOTHER – 1	ANOTHER – 2	ANOTHER – 3
SRP – 1	√	X	√	L
SRP – 2	L	√	X	X
SRP - 3	X	L	√	√
SRP – 4	L	√	√	√

Note: checkmarks arbitrarily placed

Table: 1

Efforts will be aimed at finding ways to complement and enhance each other's research provision capabilities as well as to expanding the number of collaborating R&D organizations.

## 6 CONCLUSION

As mining in mature camps advances to greater depths it is important that research is actively directed at addressing the challenges which this poses. Specifically, research programs which involve the active direction and participation of industry itself are best placed to succeed in meeting its needs.

The Centre for Excellence in Mining Innovation (CEMI) aims to be a provider of world-class exploration and mining research by using an approach built around identified research niches which are considered strategic for stakeholders. The niches to date include; Footwall Exploration in the Sudbury basin; Deep Mining and Improved Mine Process Engineering. A fourth niche, still under development, deals with mining issues related to the environment and to sustainability.

CEMI delivery capacity will be enhanced through the establishment of research chairs in or related to the main niche areas and by supporting and funding these highly qualified and respected researchers and their students. Each, once in position, will be charged with leading and delivering research focused on respective areas of expertise.

Networked Solution Teams will ensure that the research capacity as well as capability to perform niche project-related research is optimal. This element is considered crucial in ensuring that new ideas and different approaches to problem-solving are brought to the table and executed using multi-disciplinary skills.

Finally, industry has indicated its preference for reducing the fragmented nature of mining-related research across this country a vision shared by the promoters of the Canadian Mining Innovation Council. CEMI is actively seeking to collaborate and form relationships with other exploration and mining researchers, research organizations, and enabling technology providers to address this problem.



CEMI is operating from the Willet Green Miller Centre  
933 Ramsey Lake Road, Sudbury, Ontario, Canada  
[www.miningexcellence.ca](http://www.miningexcellence.ca)