

**Mining & Minerals - Canadian Sustainability Perspective**

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Canada's long history of mineral development and production shows a track record of our industry continually rising to the constant new challenges and societal expectations for our sustainable performance.

By any measure, we have been successful. In fact I think it's fair to say that we are the world leaders in sustainable performance in our mines. This has been achieved through innovation, both technical and operational, and in close cooperation with the communities that we work in.

It's an ongoing process. Canada's mining industry, as part of our standard procedures, continues to innovate, to address sustainability requirements, and to respond to the needs of newly opened regions of Canada - where mineral development is occurring.

Mining in Canada tends to be located in the remote parts of the country, often in harsh climates, and frequently on traditional Aboriginal lands.

Where the ore grades are low, but still worth exploiting, we introduce very sophisticated processing equipment and operational processes to maximize production and minimize waste and emissions.

As we all well know, every step we take, every challenge we face, has attendant costs and risks. Mining is not an investment for people with weak constitutions. You need science, technical skills, project execution skills, and strict safety protocols; not to mention tight cost controls.

And continuous strokes of luck – which you cannot count on. So it's back to methodology, systems and management discipline.

In my view these are the key parts of sustainability that directly impacts profitability:

- Social Impact
- Safety
- Processing
- Energy and Water

### **SOCIAL IMPACT**

In the area of Social Impact Management, there are a variety of best practices, lessons learned and excellent project examples available. Companies that have built relationships with local communities, mitigated adverse impacts, and optimized opportunities typically participate in a variety of forward-thinking activities.

## The Stakeholders

Mining companies around the world agree that it's important to identify all key project stakeholders at the outset of project development. Key stakeholder groups often include governments, community leaders, businesses, non-governmental organizations, special interest groups, and Aboriginal or indigenous groups, as well as the principal shareholders, employees and suppliers. It is important to understand which groups might be affected by the project, which may have an interest in it, or which might have the ability to positively or negatively influence the project.

And when should you engage the Stakeholders? As early as possible. You need time to develop trust, set the foundations for relationship building particularly if concerns that are raised can be addressed through design changes.

## Aboriginal Engagement

In Canada, engagement with local Aboriginal communities is important. Aboriginal communities are often in close proximity to mine sites and typically, by law, require specific engagement and consultation approaches.

Canada's Aboriginal population growth rate continues to increase, and there is a large population of young people who will need safe and reliable employment. As you know there are a variety of public and private sector programs, initiatives and grants available to encourage Aboriginal education, training and employment in resource industry activities.

Cameco Corporation, the uranium miner, is a leader in Aboriginal relations. Cameco is Canada's largest industrial employer of Aboriginal people; 50% of Cameco's workforce is of Aboriginal descent and there is an Aboriginal on the Cameco Board of Directors.

Another way to involve Aboriginal communities in projects is by inviting elders to stay up to speed on project design and implementation.

## Community Sustainability

Mines and resource are finite. Sustainability must flow from long-term benefits of the project beyond the life of the mine. Mining companies are taking measures to improve community sustainability by providing:

- training on skills that are transferable to other projects or industries;
- building infrastructure (roads, water stations, etc) in areas that can also be utilized by community and benefit the larger area;
- considering culture, tradition and language during project design. By coordinating a three-tiered approach with government, industry and the public, it is also possible to align priorities and build on local assets and programs.

## **MINING, HEALTH AND SAFETY**

### **Overview**

Mining is undoubtedly one of the most challenging sectors in which to safely and profitably produce the resource needs for society. The good news is that the industry has improved its safety performance. For example, in British Columbia, in “the metal and coal mining sector, the injury rates have dropped by half in the last ten years, to 1.9 injuries per 100 worker-years.”<sup>1</sup> In Ontario, the statistics are much the same, and in most provinces the goal of zero injuries is fully embraced. Certainly within Hatch, No Harm has been a pillar of our approach to safety.

In Ontario mining is one of the safest industries in the province. Our safety record outpaces sectors such as manufacturing, services, forestry, construction, health care, municipal workers, agriculture and transportation.

According to the Ontario Mining Association, mining’s lost-time injury rate for 2008 was 0.6 per 200,000 hours worked, which is a 25% improvement compared with the lost time injury rate of 0.8 per 200,000 for 2007.

While this moves the sector closer to zero, there is still room for improvement. In other areas where we’ve made progress, the severity of injuries was reduced to 54 days from 136 days in 2007.

The OMA points out that “Credit for these stronger safety performances reside on the shoulders of every individual who works in the industry. The statistics are moving in the right direction because of the personal diligence on the safety front and concern for oneself and his and her colleagues.”

Mining invests more than \$2,200 per employee annually in safety training. Clearly, mine workers in Ontario are trained better, both before they start working and throughout their careers than employees in most other industries.

While Ontario’s safety performance in the mining industry is certainly worthy of recognition, no one, says the Ontario Mining Association “would consider resting on their laurels.”

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<sup>1</sup> Source: WorkSafeBC statistics

## The Air We Breath

Three common trends are evident in today's underground mining; mines tend to be deeper, higher productivity requires increased use of mechanized equipment and third, the occupational exposure limits for workers are becoming more stringent. These three trends all have a common thread...the need for fresh air. As mines get deeper into the earth, miners have to deal with the increased heat. Diesel equipment, widely used in many underground mines; need to breath, and the exhaust gases must be ventilated. The exposure of workers to dust, fumes, heat and gases is unhealthy and unproductive. Thermal stress is more than a comfort issue; heat may interfere with a worker's metabolism and cause health problems such as cramps, exhaustion, dehydration and heatstroke.

An underground mine environment is a complex ecosystem. The ventilation system must keep up with the demands of the operation of the equipment; virgin-rock temperatures increase with depth and autocompression. Autocompression is conversion of potential energy of the air at surface into heat when the air moves closer to the center of the earth. Deeper mining operations challenge engineers to provide safe work environments.

Below ground safety issues change, for example, mine ventilation management has evolved so that producers may safely mine deeper ore bodies while increasing energy efficiency. Providing adequate ventilation for the use of large diesel equipment and the maintenance of a healthy, comfortable environment for workers requires considerable energy and is very costly. For example, the Timmins Kidd Creek mine ventilation system efficiency needed an overhaul. It was necessary to reduce the mine's current and future power consumption and the associated costs, while improving the working conditions of the miners.

The designers proposed a smart ventilation system to supply air volume where it was actually needed, rather than relying on brute force to handle air requirements. Over the course of 18 months, production data was compiled and showed the need for a nimble ventilation system.

The analysis showed that for optimum mine operating efficiency and worker health; ventilation had to be redistributed on an as-needed basis very quickly. Redistribution frequency was increased from a weekly to a daily basis, reducing the average energy demand by 40% and peak power demand by 26%.

Today the ventilation department evaluates the needs and produces a distribution plan for the upcoming week. This system achieves a better distribution of available air to the areas where the activity is conducted. The new strategy provided an enormous cost improvement through the simple process of turning off the fans when they were not needed.

The Kidd Mine has developed a system whereby safe ventilation is maintained for the mine, yet the total air volume requirements (and therefore electrical power requirements) are reduced. In other words, air is sent only to places that require ventilation to maintain a safe working environment for the workers in those places

## **Ground Stability**

Deeper mines mean rock mechanics can become challenging. At its most basic level, the challenge is to ensure that the mine itself is safe to work in. The biggest single factor in mining is that the removal of the ore causes the natural ground pressure in the earth to redistribute, which causes high stress concentrations around the extracted ore zones. This is also the general location where the mine access tunnels are located to enable the ore extraction. Review of the life cycle use of the different access ramps and drifts can move most of these out of harms way; however, capital versus operating (rehabilitation) costs need consideration.

Ground stability and worker safety are dramatically affected by the mine design which includes location of the tunnels, opening size, shape and of course, the characteristics of the rock. For example, ground can be affected by the presence of contacts between 2 types of rock, dykes, or faults which can be at any orientation. The different rock types usually have different strength and behavior properties, i.e. some are brittle, while others are more yielding. The result is further ground stress concentrations. Excessive stress can result in micro seismic events (mini-earth quakes), wall shearing and sloughing, or even the failure of ground support in the back (ceiling) of drifts.

Operations of safe mines sometimes have bad luck. For example, rockbursts and falls of ground are among the major causes of serious mine accidents. In Ontario “one third of all fatal accidents and a large proportion of serious injury incidents that occur in hard rock mines ... result from falls of ground and rockbursts.”<sup>2</sup>

The first line of defense to creating mine safety is to modify the mine design so there is minimal creation of the stress concentration areas or development that passes through these areas and thus reduce exposure of workers and equipment to potential rock bursting or falls of ground. Tools like 3D stress modeling, micro seismic monitoring systems, and management of the extraction sequence have been in use for several decades with ongoing incremental improvements. What is new is the innovation of visualization tools and techniques that turn many types of highly complex data into meaningful knowledge and graphics that can be explained to the non-geomechanics specialists; i.e. geologists, mine designers, mine management, and the miners.

Itasca Canada have pioneered the use of GoCAD™ as a tool to display 3D information of virtually any data type to aid in interpreting the results of modeling. A recent example is work conducted on a project with Vale Inco at the Creighton Mine as they plan to extend mining below 8,000 feet. Some challenges were experienced in mining above

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<sup>2</sup> Ontario Workplace Safety and Insurance Board statistics

this horizon; therefore, creating a calibration model was the first step. The model integrated micro seismic data over a 10 year period with empirically observed data and new 3D stress models. These correlated exceptionally well and created new insights and ideas when presented to mine staff. This led to revised planning parameters for the location of mine access drifts to keep away from high stress zones that would become highly seismic during the mining process. This predictive modeling was used in evaluating personnel access routes and requirements for second egress from some areas over and above the regulated requirements.

There are, of course, ways to improve ground support methods to further minimize the possibility of falls of ground. Traditional means of supporting ground include rockbolts and combinations of bolts and mesh screening. More recently, the widespread use of shotcrete (spray on concrete) has been included in the arsenal of support methods. A technique of delivering the shotcrete to deep mines via vertical boreholes has been greatly improved, bringing the logistics and cost of this method to practical levels. However, there are still challenges to making it practical for more mines.

Finally, let me discuss processing. Early mines in Canada were developed from well known deposits of high grade ore quite near the surface (low hanging fruit). Examples include:

- Cominco, Trail B.C. – Lead zinc
- Inco, Sudbury – Nickel, copper
- Dosco, Sydney NS – Iron & Steel

Most new mines have been established in remote northern areas with few ways to transport the ores. Process facilities were near the mines, hence until recently most of the new process facilities were built at or near the mines. Examples include:

- Sulphite smelters at Thompson, Manitoba, Kid Creek, Brunswick, and Flin Flon
- Uranium extraction at Gunnar and Blind River
- Mining and sand extraction at Syncrude, Suncor, Shell, Canadian Natural Resources in Alberta
- In situ oil sands mining at Connacher Oil and Gas, Conoco Phillips, Japan Canada, MEG Energy, Nexen, Petrobank, Petro-Canada and Husky in Alberta
- Diamond mining and sorting at Diavik, EKATI, Snap Lake, Victor
- Potash mines at Agrium, Potash Corp. Athabasca Potash and Mosaic in Saskatchewan.
- Areva and Cameco Uranium mines in Saskatchewan

Recent trends is to provide minimum processing at remote site and ship concentrates to existing processing plants in less remote regions, e.g. Raglan shipping to Sudbury and Voisey's Bay shipping to the Island and Sudbury.

In situ mining and partial processing within the mine is a further trend to increase recoveries, save GHG's, reduce water usage and reduce our mining footprint.

Technologies for mining and processing has led to large productivity improvements using beneficiation of low grade ores, oxygen enriched smelting processes and larger more intense process units as well as modified processes for improved emission controls and for using low-grade ores as well as recycled scrap. Examples include:

- Mobile in-pit crushing
- Fine grinding
- Column flotation
- High intensity oxygen smelting
- High pressure acid leaching
- In situ leaching
- Biological leaching

Fuels and water are becoming scarce and more costly. Therefore, more reliance on renewable energies are being tried and developed at many of our remote sites.

From 1960's onwards, emission abatement and inplant health and safety became much more important, similarly good progress was made in reducing liquid effluents and inplant working conditions were improved by clean plant design. Examples include:

Inco, Falcando and Noranda slashed SO<sub>2</sub> emissions by means of pyrrhotite rejection and oxygen enrichment.

The well developed trend of reducing emissions of toxic and nuisance materials to the environment must continue and now include GHG's. Proven methods on the air side include increased use of tonnage oxygen, efficient use of electrical energy, zero discharge for water systems and sale of non-toxic solids.

Managing air emissions from Canada's Oil Sands has become a focus and continual advancement in technology and energy efficiency has resulted in significant reduction in GHG emissions. An area where Oil Sands mining companies such as Syncrude and Shell are advancing technology by reducing the temperature of the process water used to separate the oil to achieve a 1/3 lower GHG emissions. Carbon capture and storage has the potential to significantly reduce GHG emissions.

Developments in In situ mining of Oil Sands has shown promise of significantly reducing GHG's, water usage and footprint. Some examples of these technologies are:

In situ combustion (THAI™), electric heating (ET DSP™) and (N-Solv™) a condensing solvent technology that could potentially reduce GHG's by 85 per cent, eliminate the use of water and produce partially upgraded oil.

Both Provincial and Federal Governments have or are putting into regulations an improvement in GHG emissions or pay which will create additional funding for transformative technology development.

Many sustainability examples can be quoted in Oil Sand production such as CNRL's Horizon Oil Sands mine that was required to provide twice as much fish habitat as will be lost in the Tar and Calumet rivers due to the project. The lake design was based on four years of stakeholder consultation and scientific workshops. The lake covers 80 hectares and was designed to provide a variety of habitat types and spawning areas to support at least eight fish species important to the local community. Performance of the lake is exceeding expectations after the first year.

## **ENERGY AND WATER**

Mining is inherently energy intensive which consequently means large GHG emissions to supply and use this energy.

Together the mining and processing industries in Canada make up a significant part of total green house gas emissions and technologies are being developed to significantly reduce GHG emissions due to mining extraction and processing.

Some of the innovative ways to reduce energy requirements are:

- in the mine the use of fuel cells for underground vehicles is being tried
- new ventilation approaches
- productivity gains in the processing plants

Plants such as Oil Sand operations that require large amounts of steam are using co-generation to simultaneously create electricity as well as providing steam to the extraction facility. Excess electricity is sold back into the electricity grid.

In metal processing there are opportunities for recovery and recycling of waste energy available in many processes including capture of heat from waste gasses and more importantly heat from discarded slags which could reduce overall energy used by 25 – 35%.

Areas to improve costs, reduce GHG's and maintain sustainability are in renewable energy sources such as hydro, wind and solar. Examples of the use of captive hydro plants include Inco, Cominco and Alcan. A lot of work is being done on adaptation of wind energy to the Arctic ecosystem for future supply of energy to the mines and processing plants in these areas. With the advent of small nuclear plants nuclear could be another source of GHG free energy.

Carbon capture and storage (CCS) has been identified by Governments and researchers as a significant opportunity to reduce GHG emissions. CCS is well understood from a technical perspective, but widespread use is limited by challenging economics. Full CCS, including capture of CO<sub>2</sub> from combustion flue gases, will require significantly more investment and Government and industry are working to make it feasible in the long term.

Many mining and processing facilities are good candidates for the future adaptation of CCS.

Both mining and processing can potentially affect ground water quality and quantity. In general Environmental Impact Assessments are required to conduct extensive hydrological studies and to perform ongoing monitoring of surface and ground water resources that may be impacted by operations.

Groundwater management objectives include:

- Identify ground water contamination
- Maintain groundwater quality
- Prevent dewatering of aquifers

Water in the mining industry plays a critical role in many operations and industry recognizes that fresh water is an essential resource that must be used responsibly. Technology plays a key role once again in reducing the use of water and in maximizing water recycling.

Tailing ponds are an operating facility common to various types of surface mining including Oil Sands coal, metals, diamonds etc. The residuals from the separation process of the above facilities are transported for storage in large ponds.

Once in the tailings pond the residuals separate from the water. The water can be reused by pumping off the top of the pond but the harder to settle solids are left at the bottom in a mixture of water, clay and fine material.

The tailings ponds represent a hazard in most cases to fish life and water fowl as well as having a large foot print on the landscape. Most mining companies have and are spending extensive research on tailings as the industry continues to develop better technologies and approaches to tailings management in order to reduce the environmental impact. The goal is to reduce the volume of fine tailings generated and increase the rate of solidification.

## **REFLECTIONS**

As can be seen from the preceding discussions mining plays a key role in recovery and supply of resources in the world and is particularly important to Canada. It is equally apparent that the role of mining in the development of mining in undeveloped regions in a sustainable way is very important as is a continuing effect through innovation to lessen the impact on the environment and to increase the interaction with the local communities.

While the public has come to the conclusion that the world is running out of resources the truth is that we are running out of easy-to-recover resources. So the crisis is not the scarcity of resources but the scarcity of technologies and trained staff. It has been and will remain the Engineer's job to develop the technologies to recover the even harder to get at minerals and hydro carbons to deliver a sustainable benefit to all.

More specifically to Canada it is very important to re-establish strong alliances between Corporate stakeholders, Governments, local peoples and R & D sources to overcome commercial and jurisdictional conflicts to greatly enhance the innovation and competitiveness of Canadian mining.

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