



Green Mining Innovation (GMI) Workshop

Breakout Session Summary Report from the Dec. 13, 2018 Workshop

DATE OF SUBMISSION:

January 23, 2019

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Executive Summary

On December 13, 2018, CanmetMINING hosted a workshop involving members of the Green Mining Innovation Advisory Committee and other stakeholders. The workshop objectives were to:

- Review progress at the half-way point of CanmetMINING's five-year research plan, seek input on future research and how to increase its impact, and
- Obtain insights from participants to inform medium-term thinking on Canada's approach to green mining.

To inform CanmetMINING's medium-term planning, participants were asked what they see as the most important "new frontiers" for Canada over the next 10 years, with a focus on digital transformation, circular economy, and deep mining. In each of these areas, participants identified what they think the future of mining might look like, the most exciting innovation areas and current leaders, and what research, development and innovation is most needed. Participants saw potential roles for government (and more specifically, CanmetMINING and Natural Resources Canada) as follows:

Government Roles to Support Digital Transformation

- We don't need additional research in this area, but rather require system integration
- Support, collaborate and validate sensor work, especially regarding tailings quality. CanmetMINING can also help to identify what needs to be measured and how.
- Identify bottlenecks in the permitting and application process and address them.
- Demonstrate leadership in collaboration and partnership with Indigenous governments
- Identify and monitor international developments in this space. Benchmarking is not worthwhile, as this field is moving too quickly; however, government could disseminate information on emerging developments and best practices (e.g. best practices database).
- Help to demonstrate what can be done with data, how it can be useful and how it can add value.
- Consider incorporating a 'digital transformation field' for each new project.

Government Roles to Support Circular economy

- Provide good quality environmental performance benchmarks (best practices, metrics) for mining companies to compare themselves and demonstrate performance improvements.
- The desired Future State is branded, traceable, "responsibly-produced" products. Support development of responsible sourcing standards and communicate how Canadian companies are well-positioned to meet these standards.

Government Roles to Support Deep Mining

- Support Canada's branding, marketing and promotion as a centre of expertise in safe, deep mining, recognizing that we are already a world leader in this area.
- Support better collaboration and coordination across government, universities and industry, including through partnership and funding.
- Revise policy and regulatory requirements to reflect the realities of deep mining (e.g. ventilation and air quality).
- Support de-risking of technologies through more opportunities for demonstration, piloting, and testing (e.g. hydraulic hoisting, which has been around for a while but has not been taken up readily).
- Research and develop approaches to "underground" exploration (i.e. how to find deep deposits from the surface, not just by expanding the existing mine).

CanmetMINING's Impact

Participants indicated that, over the last four years, CanmetMINING has reinvented and revitalized itself. It was noted that they now: engage with a broader group of stakeholders, communicate better with industry and communicate Canada's message abroad, attract top talent in new hires, and provide a repository of expertise, including research on ventilation studies, artificial cables, and chromium. More specifically, participants noted that:

- Collaboration with CanmetMINING has raised the profile of participant organizations and supported participants as partners in innovation
- Technical experts from CanmetMINING have provided oversight and advice
- Some projects and conferences have led to the creation of new relationships and opportunities for collaboration
- Collaboration has improved with Universities

Opportunities to Enhance CanmetMINING's Impact

When asked how CanmetMINING could enhance its impact, participants had the following suggestions:

- **Align CanmetMINING's mandate** with the rest of the mineral and metals ecosystem to ensure they're on the right track, continuing to increase awareness of who's doing what to avoid duplication, and ensuring there is industry demand and a clear business case for each project
- **Improve communication** and outreach on social media, including about Canada's brand, collaboration with industry, R&D, demonstration projects
- **Improve visibility** of technology developed in Canada and "Made in Canada" branding, including through more consistent messaging and funding to support branding and promotion; could also promote Canadian-made technologies to federal government projects (e.g. facilitating connections to enable pilot / demonstration projects at federal mine remediation projects)
- **Increase engagement and collaboration with mining companies and MSS** (mining supply and services) sector in order to pool funding resources, increase technology adoption, encourage commercialization
- **Promote awareness of technologies nearing the marketplace** – have a platform to communicate what technologies are entering the market
- **Champion science that could inform the regulatory community** and facilitate changes to regulations (e.g. no air re-circulation, unless...)
- **Conduct international scans** and determine how Canada can best collaborate with international groups and disseminate information; consider the potential role for interchanges
- **Improve resources** to support Canadian companies conducting research, and to support pilot plants and demonstration projects (Note that strong support was expressed for a single window approach, as provided by the Clean Growth hub)
- Enter into **more Memorandums of Understanding**
- Continue to develop, promote and **expand the Lab Networks**

1. Introduction

This document summarizes information and input gathered through breakout sessions held during the Green Mining Innovation (GMI) Workshop. The full-day workshop took place in Ottawa on December 13, 2018, guided by the following objectives:

- To review progress at the half-way point of CanmetMINING's five-year research plan, seek input on future research and how to increase its impact
- To obtain insights from participants to inform medium-term thinking on Canada's approach to green mining

Members of the Green Mining Innovation Advisory Committee and other stakeholders participated in the workshop. During the workshop, CanmetMINING representatives presented a mid-point review of their Five-Year Research Plan, including highlights from the first half of the five-year research plan and upcoming research planned to execute the rest of the strategy. The research plan identifies five priorities: Energy Efficiency, Enhanced Productivity, Waste Management, Water Management, and Climate Change.

To inform CanmetMINING's medium-term planning, participants were asked what they see as the most important "new frontiers" for Canada over the next 10 years. These new frontiers were grouped within four categories:

- Digital Transformation
- Circular Economy
- Deep Mining
- Other new frontiers that could disrupt, transform and enable green mining

Participants were divided into three break-out groups, one for each of the first three categories.

Participants were asked to consider the following questions when discussing their theme:

1. How do you see the future of mining in this frontier area?
2. What are the most exciting innovations?
3. Who do you see as the leaders and why?
4. What kind of research, development and innovation is most needed?

The results of this discussion are summarized in [Section 2](#) of this report.

After lunch, Dr. Magdi Habib presented on CanmetMINING's impact. Following the presentation, participants broke again into three groups and each responded to the following four questions:

1. Are you seeing the impact of CanmetMINING's work on your organization?
2. In your opinion, what should CanmetMINING do more of? Less of?
3. How can CanmetMINING increase the adoption of its technologies?
4. Are there initiatives you are involved in or aware of, where you think CanmetMINING might have value to add?

Groups reported back on each of the break-out discussion sessions and held a plenary discussion at the end of the workshop on how CanmetMINING can build on its strengths and continue positioning Canada as a leader in green mining. The results of this discussion are summarized in [Section 3](#) of this report.

During the workshop, a graphic recorder visually captured key messages and themes from the discussions. These images are included as [Appendix 2](#).

2. New Frontiers: Summary of Break-out Discussions

Many potential areas could be seen as “new frontiers” for mineral resource development, whether geographical (e.g. in new environments such as the far North, or offshore) or new ways of doing business. Participants broke into three groups to focus discussion on the “new frontiers” of digital transformation, circular economy and deep mining.

Participants noted that, in all of these areas:

- We are talking about more than mines – we conduct a lot of mineral processing. This needs to be integrated in any Canadian brand (i.e. “minerals and metals” branding)
- There is a strong government role to help de-risk new technologies through demonstration projects and scaling up
- There is value in technology showplaces where we showcase SMEs (e.g. NORCAT, Abitibi group)

2.1 Digital Transformation

Digital transformation has the potential to fundamentally change how mining is done, and could offer significant gains in productivity and competitiveness. This area covers a broad range of elements, including enhanced connectivity and enabling more autonomous mines.

Under the theme of Digital Transformation, participants identified the following sub-themes during a group brainstorming exercise:

- Support SMEs for “business alliances”
- Modelling for simulation
 - Ore body knowledge
 - Geology -> tailings
- Address skills gap and competition from other industries
- Cyber security
- Application of blockchain technology
- Use of enabling technology to support deep mining and electrification
- Align “cool” technology ideas with value within the industry
- Tell the good stories of outcomes to help build Canada’s brand
 - For example, profile how we have improved safety and environmental performance through technological advancement

Participants provided the following input related to each of the discussion questions.

How do you see the future of mining in this frontier area? What are the most exciting innovations?

- The “connected” miner is what we want to see; that is, miners using the technology with ease. Rate of adoption by the workforce is an important variable. Changing demographics may support more rapid adoption than we’ve seen to date. The connected miner may use things like augmented reality, the digital twin, holograms, etc.
- Using new technology may provide an opportunity to attract the new, younger workforce
- We will need enabling technology to support connectivity.
- Keep in mind the chain that connects data to communications to software
- Vision of fully autonomous mines - time frames will change quickly
- We will need enabling permits to allow / adapt for technological change

- Security of data, information, networks, and the cloud is an important consideration

Who do you see as the leaders and why?

- Newtrax – analytics, connectivity, blockchain
- Original Equipment Manufacturers (OEMs) are leaders in this area, and many are becoming more open to it, e.g. Epiroc, Sandvik
- Some mining companies are demonstrating leadership. For example, ArcelorMittal has incorporated digitization at their planning centre in Quebec, and have been hiring gamers
- Other vendors – LT Technology. For example, Ambra is a company that is growing quickly, and many of the mining companies want to work with them. They will need to manage their growth and scale up if they are to meet industry needs. There may be a role for funding organizations to support this scaling up, such as Business Development Canada (BDC) and/or Export Development Canada (EDC).
 - How does it work with all the other technologies (e.g. Ericsson)?
- Software and IT integrators, including the big companies (e.g. Microsoft and IBM)
- Telecoms have a role to play to support data needs, security
- Important to recognize that there is an ecosystem of players we need to work with and coordinate across them

What kind of research, development and innovation is most needed?

- We don't need additional research in this area at this point
- Requires system integration across these innovations
- There is a need and role for good, reliable sensors
 - The National Research Council (NRC) is taking a lead role here. CanmetMINING can support, collaborate and validate sensor work, especially regarding tailings quality. There may be a link between sensors that can provide good quality performance information that can be shared with the public and social licence.
 - CanmetMINING can also help to identify what needs to be measured and how
- Data management – how do we deal with terabytes of data?
 - Need clean data
 - Discrete data sets will need to be integrated
 - Will require some different skills
 - There are currently no “chief data officers” in the mining industry; this will likely need to change to enable technology adoption
 - Demonstrate what can be achieved with current technology and, from this, identify key gaps to be addressed
- Telemetry and location tracking provide a powerful combination
 - How do these work together to maximize productivity? We need to demonstrate how real time data can be used to correct / adapt behaviour in real-time
 - CanmetMINING has an important role to play to identify bottlenecks in the permitting and application process and address them
- Looking at digitization needs for mining at depth, continuous mining and electrification – this is an important area to continue advancing
- Development in the North and in many parts of Canada requires collaboration and partnership with Indigenous peoples
 - Need a bold vision of how to support and encourage this. There is a clear link here with the Canadian Minerals and Metals Plan.
 - CanmetMINING can demonstrate leadership, including through collaboration across federal and Indigenous governments

- To enable Indigenous peoples to participate in digital transformation and other projects, they will require advanced capacity building
- CanmetMINING has a role to play in identifying and monitoring international developments. Benchmarking is not worthwhile, as this field is moving too quickly. However, CanmetMINING could disseminate information on emerging developments and best practices (e.g. develop and maintain a best practices database)
- CanmetMINING can help to demonstrate what can be done with data, how it can be useful and how it can add value
- CanmetMINING could incorporate a digital transformation field for each new project
- There is a recognized need for strong cyber security
- This work should connect to the NRCan data and knowledge strategy

2.2 Circular Economy

The concept of a more circular economy is gaining traction. As explained by the Ellen MacArthur Foundation, “Underpinned by a transition to renewable energy sources, the circular [economy] model ... is based on three principles:

- Design out waste and pollution
- Keep products and materials in use, and
- Regenerate natural systems.”¹

Given the long life of many minerals and metals, and the volume of waste generated by the sector, participants began to explore what the concept could mean for mineral resource development in Canada and identify potential opportunities.

Under the theme of Circular Economy, participants identified the following sub-themes during a group brainstorming exercise:

- Canada-branded green commodities
- Potential to reprocess waste rock (and have waste rock displace new ore)
- Water use survey – best practices
- Bio-mining
- Continuous mining, both underground and surface mining
- In situ mining/processing

Participants provided the following input related to each of the discussion questions.

How do you see the future of mining in this frontier area?

- The sector is still relatively unfamiliar with “circular economy” terminology – it has more currency in the tech world (e.g. Apple) than among mining executives.
 - We need to engage industry using different terms
 - Mining is not circular, this is more about processing and manufacturing
 - This area involves providing inputs to manufacturing, consumer/society use, reuse/recycling, and sustainable development more broadly
- Areas of opportunity include:
 - Mine closure / rehabilitation

¹ Ellen MacArthur Foundation. <https://www.ellenmacarthurfoundation.org/circular-economy/concept>

- Net zero / zero waste mining
- Recycling
- Certification of life cycle
- Water reuse
- Circular economy concept is consumer driven (e.g. millennial consumers have a set of expectations that industry needs to respond to, such as responsibly-sourced rare earth metals in iPhones)
- What is the sweet spot for creating value in the sector from circular economy initiatives? A new market? Reduced production costs?

What are the most exciting innovations?

- Transforming scrap aluminum for use in more products through smelting/ technological innovation to not produce aluminum from bauxite
- Recovery and recycling of rare earth minerals
 - Traceability (Canada is leading working groups on this)
 - Engage more in supply chain and identify manufacturer expectations
- Optimizing processing/reprocessing of waste / tailings
 - Reuse opportunities for residuals
 - Benefits include reducing end of mine liability
 - Reprocessing fly ash and waste streams from oil and gas to extract metals
 - Technology exists to repurpose waste rock/ tailings, but driver / business case is needed (e.g. the Palabora mine in South Africa, which started operating in the late 50s, exemplifies how multiple minerals / materials can be extracted and sold)
- Water re-use (The Mining Association of Canada (MAC) has new protocol on water) and energy recovery
 - Lots of opportunities here, e.g. Mill water use
- Ore sorting, including high pulse voltage technology
 - Benefits include sending less waste to be chemically treated
- Smelting capacity
 - Use of existing infrastructure for recovered metals
- Electrify mining vehicles and adopt new business models for improving environmental performance (e.g. reuse, recovery), such as renting batteries

Who do you see as the leaders and why?

- We have the know-how and technology in Canada

What kind of research, development and innovation is most needed?

- There is a lack of benchmarks (best practices, metrics) for mining companies to compare themselves to and to hold people accountable with respect to good environmental performance.
- Canadian industry should get ahead of defining responsible sourcing, e.g. comparing Apple's requirements to Towards Sustainable Mining (TSM) coverage and identifying the gaps. TSM coverage gaps include conflict and pollution
- Data acquisitions systems (sensors, etc.) are required to measure and manage performance
- The desired Future State: branded "responsibly-produced" product

2.3 Deep Mining

Sizable reserves exist deep underground, but accessing them presents a range of technical and safety-related challenges in a tough environment. Under the theme of Deep Mining, participants identified the following sub-themes during a group brainstorming exercise:

- Rock burst control
- Mine safety – promote Canada’s good track record
- New equipment
- Longer community life
- Collaboration on evaluation of mining methods at depth
- Telecommunication, safety
- China – Canada certification of a deep mining innovation
 - Other international partnerships – South Africa?
- Energy consumption in deep/ultra deep mines

Participants provided the following input related to each of the discussion questions.

How do you see the future of mining in this frontier area?

- More mining will be deep, as surface deposits are depleted (i.e. deep mining will become mainstream)
- Operating costs – which are currently much higher at depth than for surface mines – will come down as deep mining becomes more common
- Energy consumption – which is currently intensive, particularly for underground mining – could be reduced
- Mining will be more autonomous (fewer people underground)
- Canada will market and promote its expertise in deep mining
 - Canada is already a world leader in this – much of our mining is over 850 m (what others consider deep), yet we don’t label that as deep mining; we need to reconsider our definition of deep and then market/promote our expertise (branding)
 - Canada has a reputation (Noble prize) as a leader internationally, and there is interest from China and South Africa in learning from us
 - Branding Canada as an expert in safe deep mining - get a global reputation in and recognition of our safety record
- Ideally there will be better connections between government, universities and industry
- Political / regulatory systems need to catch up to reflect the realities of deep mining (e.g. ventilation and air quality)
- Innovative mining methods (e.g. find new ways to avoid rock (rx) burst)

What are the most exciting innovations?

- Advanced micro-seismic networks collect large amounts of data; use of machine learning on these big data sets could lead to predictive forecasting
- Advances in communications technology (e.g. fibre optics) enable communication between surface and depth, expanding the limits on the depth horizon and creating opportunities for tele-operations / remote access (autonomous vehicles at depth with human controllers at surface)
- Electrification of the equipment improves air quality, opening the possibility of recirculating air; laws would need updating to reflect that possibility
- New equipment and techniques improve efficiency, economics, and worker health and safety, for example:

- Pre-sorting at depth
- Synthetic hoisting cables
- Hydraulic hoisting (pipe-based transportation of ore)
- Mechanical cutting
- Cooling by liquid air (reduces energy consumption)
- Ventilation on demand
- New clothing that keeps workers cooler
- Dynamic rock supports and rock bolt sensors (exists in Canada and Europe, but needs more work)

Who do you see as the leaders and why?

- Canada generally for our experience in deep mining and specifically for our safety record, deployment of rock bolt sensors, and work on dynamic rock support
- Europe for its advancements in rock bolt sensors
- China
- South Africa
- NorthWest University
- Jannatec is developing clothing technology to keep workers cooler
- MineSense is advancing ore sorting at depth
- Several Canadian mining and mineral processing companies are leaders in new technology uptake, including:
 - Vale, Glencore, Goldcorp, which are adopting ventilation on demand (VOD)
 - Vale, Glencore, Agnico Eagle, Kirkland Lake Gold, which are leading application of dynamic rock support
 - Vale, Glencore, and Agnico Eagle, which are adopting updates in communications technology
- Technology suppliers are leading in:
 - Mechanical cutting (Sandvik, Kohmatsu, Epiroc)
 - Machine learning (Mira Geoscience)
 - Pipe-based transportation of ore (Cementation)

What kind of research, development and innovation is most needed?

- Additional research into mining methods, acknowledging that the needs of deep mining are specific and different from surface or shallower underground mining approaches (e.g. how to predict, prevent, or mitigate rock burst) – not just pushing deeper without changing the approach
- More opportunities for demonstration, piloting, and testing opportunities; the group saw a role for government to help with de-risking
- Research and develop approaches to “underground” exploration (i.e. how to find deep deposits from the surface, not just by expanding the existing mine)
- In addition to research, development and innovation opportunities and needs, the group identified a need for:
 - Updated branding that markets and promotes Canada’s safe operating record and our leadership and experience in deep mining
 - Government help to improve and enable uptake of new technologies (e.g. hydraulic hoisting, which has been around for a while but has not been taken up readily) by de-risking new technologies through funding or other partnerships
 - Partnership and funding to coordinate across the industry and researchers – risks Canada’s leadership reputation if we don’t contribute resources

- Changes to regulations to reflect the innovations, changes in available technology, and new approaches to mining (e.g. Ministries of Labour in Ontario, Manitoba, and Quebec do not allow air recirculation – which was appropriate when underground fleets were primarily diesel engines, but with more electrification, these laws become a barrier that limits innovation and/or uptake of new and beneficial technologies)

2.4 Other New Frontiers

Participants identified the following additional new frontiers during a group brainstorming exercise:

- Design flexibility after or in concert with permitting and security regulations
- International platform to promote and support innovation for SMEs
- Mine certifications to support supply chains
- Climate change adaptation
- Developing new mines
 - Keeping mines open
 - Low % ore = big open pit, big waste disposal
 - Canada owned test mine
 - Which industries will demand minerals and metals and how do we attract them and create demand for responsibly produced commodities?
- Intellectual property and branding of Canada's expertise (identify, protect, deploy into market)
- Small modular reactors (SMRs) in remote mining operations
- Canada's overseas operations
- Research conducted through university-government-industry partnerships; this could be facilitated through the CIM Council (Canadian Institute of Mining, Metallurgy and Petroleum)

3. CanmetMINING Impact: Break-out Discussions

CanmetMINING's work over the years has contributed to a wide range of results and positive impacts, both directly and indirectly. When asked about what impacts they've seen, participants provided the following input and suggestions for how this impact could be enhanced going forward.

3.1 Are you seeing the impact of CanmetMINING's work on your organization?

Participants agreed that they are seeing the impact of CanmetMINING's work. Specific comments and examples cited include:

- Over the last four years, CanmetMINING has reinvented and revitalized itself. It was noted that they now:
 - Engage with a broader group of stakeholders, including suppliers and international players
 - Communicate better with industry, and communicate Canada's message abroad
 - Attract top talent in new hires
 - Provide a repository of expertise, including research on ventilation studies, artificial cables, and chromium
- Collaboration with CanmetMINING has raised the profile of participant organizations and supported participants as partners in innovation
 - CanmetMINING allows participant organizations to have a role in defining areas where we can make a difference in Canada and internationally
- Technical experts from CanmetMINING have provided oversight and advice; have also participated in technical due diligence process
- The Mining Emissions Diesel Council (MDEC) (annual technical conference devoted to diesel emissions in underground mining) and mining value from waste conference led to the creation of new relationships and opportunities for collaboration
- Electrification project (with Hydro Quebec), including battery electric and hydrogen vehicles, is having an impact
- Collaboration with Universities, for example:
 - Chromium isotopes - biosolid for tailings covers
 - Use of facilities and sharing of samples
- CanmetMINING took on green mining when nobody was talking about it. The green mining policy and research stream is making an impact

Areas for Improvement

When asked about areas needing improvement, participants had the following suggestions:

- Visibility: It is important to continue over communicating to ensure there is better awareness of what is going on and what is available. Tied into this, CanmetMINING could increase its social media presence
- Deeper collaboration with private sector technology development (are we competitors or collaborators?)
 - Would like CanmetMINING to be aware of what Canadian companies are doing
- Some participant organizations feel like they have to "chase CanmetMINING down" in order to engage and collaborate with them (i.e. potential collaborators have to knock on Canmet's door; don't feel Canmet is knocking on their door)
- CanmetMINING requires more focus. Green Mining Innovation (GMI) should continually ask: Do we still need to do this?
- There is the potential to further increase collaboration with universities

- It would be helpful for CanmetMINING to explain ‘rules of engagement’ for companies headquartered outside of Canada (e.g. Rio Tinto, Glencore, etc.) so that their Canadian divisions can understand how they may be able to collaborate
- Support adoption of new technologies, which is where the big impact happens

3.2 In your opinion, what should CanmetMINING do more of?

- **Align CanmetMINING’s mandate** with the rest of the mineral and metals ecosystem to ensure they’re on the right track
 - Continue to increase awareness of who’s doing what to avoid duplication
 - Ensure there is industry demand and a clear business case for each project
- **Improve communication** and outreach on social media, including about:
 - Collaboration with industry, R&D, demonstration projects
 - End users
 - Where industry is suffering
 - Canada’s brand
- **Improve visibility** of technology developed in Canada and “Made in Canada” branding. To push Canadian branding, need:
 - More consistent messaging across government, industry, SMEs
 - More funding to support branding, e.g. site visits
- **Increase engagement and collaboration** with mining companies and MSS (mining supply and services) sector in order to:
 - Increase technology adoption
 - Encourage economic viability of technology
 - Encourage commercialization of innovations
 - Improve research on SMRs (small modular reactors)
- **Support federal policy and regulations** – ensure they take into account science and expertise
- **Conduct international scans** and determine how Canada can best collaborate with international groups and disseminate information
 - Interchanges could play a role and support our branding for Global leadership
- **Coordinate the development of a National Strategy** that:
 - Integrates industry and manufacturing (e.g. batteries, electric car, aerospace)
 - Focuses on end industry, not just mining (i.e. expand CanmetMINING’s mandate)
- **Improve resources** to support Canadian companies conducting research
- Enter into **more Memorandums of Understanding**
- Continue to develop, promote and **expand the Lab Networks**

3.3 In your opinion, what should CanmetMINING do less of?

- **Event organization** – while this is valuable, others could be doing this and taking lead roles
- **Duplication** – don’t lead on work that can be done elsewhere (e.g. universities); it was noted that, generally, universities do research at Technology Readiness Levels (TRL) 1-4, and CanmetMINING usually does research and development at TRL 3-7
- **Focusing on safety performance** – while safety performance remains important (and may help to start conversations), messaging needs to include a focus on productivity and profitability
- **Turnover** - Use fewer temporary employees and cyclical hiring processes to ensure greater consistency of relationships and expertise
- **Fewer “pet projects”**

3.4 How can CanmetMINING increase the adoption of its technologies?

- Engage end users and intermediaries
 - To understand needs and connect those needs to technology developments
 - To involve end users in technological development, and potentially also in design and planning
- When a technology is close to market, have a platform for people to know what is available
 - Awareness – it was noted that increasing Intellectual Property (IP) outreach is a good first step
 - Identify the right supplier(s)
 - It was noted that event attendance is costly for companies focused on production
- Idea of an “experience center” where people can walk through and see emerging technologies working
- Make funding available for pilot plants and demonstration projects
 - Participants expressed strong support for a single window approach, as provided by the Clean Growth hub
- Speed and agility (move through TRL faster and commercialize or get to market faster)
- Support commercialization
- New model – need to get industry to contribute funding (e.g. 01% of revenues)
 - They will be more engaged and invested in attending events and contributing ideas
 - This will also help to avoid duplication in research and technology development

3.5 Are there initiatives you are involved in or aware of, where you think CanmetMINING might have value to add?

- Follow developments in other sectors beyond mining (e.g. nuclear energy, aerospace)
- Promote technologies developed by Canadian companies outside of CanmetMINING, particularly by facilitating connections with federal government projects (e.g. facilitating connections to enable pilot / demonstration projects at federal government mine remediation projects)
- CanmetMINING could champion science that could help inform the regulatory community and facilitate changes to regulations (e.g. no air re-circulation, unless...)
- CanmetMINING could conduct market trend analysis

4. Conclusion

CanmetMINING appreciates the participants' contributions and high level of engagement throughout the workshop. The Green Mining Innovation Advisory Committee will carefully review the input received during the workshop in order to prepare an action plan to address issues and advance ideas.

Appendix 1: Participant Agenda

Draft Agenda - Green Mining Innovation Workshop December 13, 2018 | Room 221 – 555 Booth Street, Ottawa, Ontario

<p>Theme: <i>New Frontiers in Green Mining Innovation</i></p> <p>Objectives:</p> <ul style="list-style-type: none"> To review progress at the half-way point of CanmetMINING’s five-year research plan, seek input on future research and how to improve adoption rates of its technologies To obtain insights from participants to inform medium-term thinking on Canada’s approach to green mining
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8:00 – 8:30	Registration - Please note that you will need valid I.D. to present to the Commissionaires in the lobby
8:30 – 9:30	<p>Opening Remarks, Strategic Context and the Canadian Minerals and Metals Plan</p> <ul style="list-style-type: none"> <i>Glenn Mason, Assistant Deputy Minister, Natural Resources Canada</i> <i>Pierre Gratton, President and CEO, Mining Association of Canada</i> <i>Magdi Habib, Director General, CanmetMINING, Natural Resources Canada</i> <i>Photinie Koutsavlis, A/Director General, Policy and Economics Branch, Natural Resources Canada</i>
9:30-10:30	<p>Half-Way There: The Mid-Point Review of CanmetMINING’s Research Plan and the Next Frontiers for CanmetMINING</p> <p><i>Presentations on R&D achievements and next steps, update on the Canadian Science and Engineering Laboratory Network, reporting back on the action plan</i></p> <ul style="list-style-type: none"> <i>Janice Zinck, Director of Green Mining Innovation, CanmetMINING</i> <i>Kristie Tarr, Director of Transformative Technologies and Specialized Services, CanmetMINING</i> <i>Nabil Bouzoubaa, Senior Science Advisor, CanmetMINING</i> <i>Laura Rostas, Senior Advisor, CanmetMINING</i>
10:30-10:45	Health Break
10:45-11:15	New Frontiers Discussion
11:15-12:15	Breakout Group Discussions on New Frontiers
12:15-13:00	Lunch and Ribbon-Cutting Ceremony (Room 221)
13:00-13:30	Plenary: Reporting Back from Frontier Discussion
13:30-14:00	Presentation on CanmetMINING’s Impact
14:00-14:15	Health Break
14:15-15:15	Group Discussion on how CanmetMINING can increase its impact
15:15-15:45	Reporting Back and Plenary Discussion: <i>How can CanmetMINING build on its strengths and continue to help position Canada as a leader in green mining?</i>
15:45-16:00	Closing Remarks

Appendix 2: Workshop Infographics

Figure 1: Progress to Date and Canadian Minerals and Metals Plan



Figure 3: Making an Impact

