Natural Resources Canada | Ressources naturelles Canada

Collaborative Initiatives to Advance Mining Innovation

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Green Mining Innovation Workshop
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Canada

Green Mining Innovation

In collaboration with partners from across Canada's mining innovation system, CanmetMINING develops and de-risks green mining technologies and practices

Green Mining

economically competitive
+
environmentally sensitive

CanmetMINING and Green Mining Innovation

Economically Competitive and Environmentally Sensitive

Green Mining Innovation (GMI)

- Reduce the environmental impacts of mining
- Improve the competitiveness of Canada's mining sector

Addresses Industry Priorities and Challenges

- Improving energy efficiency and reducing GHGs
- Minimizing wastes
- Increasing productivity
- Expanding mineral resource potential

Aligns with the Government of Canada's Agenda

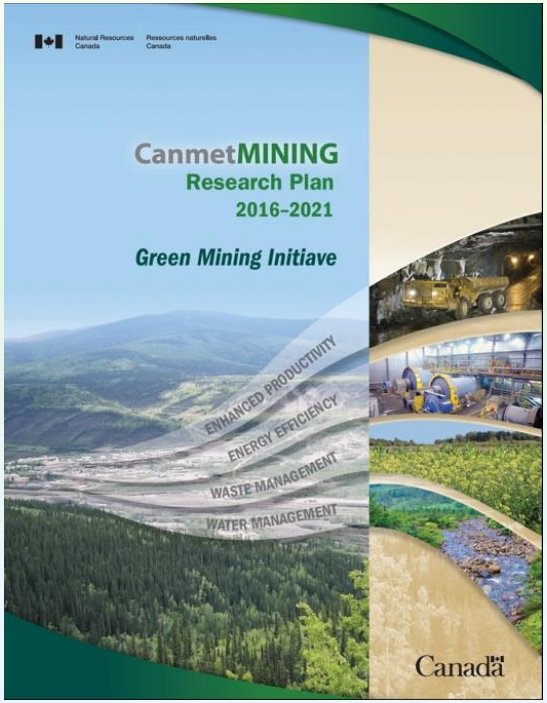
- Clean technology / clean growth
- Climate change
- Watershed protection
- Economic competitiveness of the natural resources sector

Contributes to the Public Good

Supports:

- Environmental assessments
- Metal mining effluent regulations
- Water quality
- Tailings management

Highlights from 2017/2018 and Next Steps



- **Energy Efficiency**
- **Enhanced Productivity**
- **Waste Management**
- **Water Management**

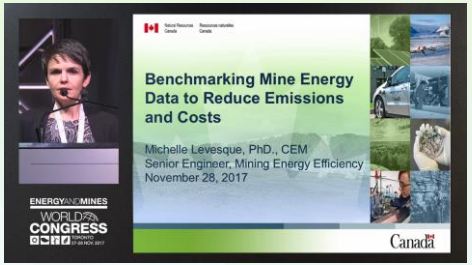
Goal

Canada's mining industry is globally more competitive and environmentally responsible

Energy

Achievements

- Developed an online energy benchmarking program for mines, in collaboration with partners



Next Steps

- Analytics and Artificial Intelligence for mine energy management
  - Issues of lack of granular data on energy use, lack of resources for bringing together and analyzing data from disparate sources, lack of tools for real-time monitoring, etc.
- Sensors and communication networks (Internet of Things)

Energy Efficiency in Comminution

Achievements

- 3D rock size sensor prototype (patent pending)
- Advances in coarse particle flotation → significant energy decrease
- Consortium on high pulse voltage test work established

Next steps

Mine to mill and pre-concentration
National collaboration to be established

Rare Earth Elements: Ore to Oxide

Focus on Canadian minerals/ores to produce viable flowsheets for each of the three ores

http://reechromite.ca

Achievements

Developed a **probe** to measure mineral process chemistry in **real time** under harsh reaction environments

Validation of the patent-pending Direct Oxalate Precipitation method on a industrial pregnant leach solutions

Demonstrated potential for application of **ore sorting** technology for the pre-concentration of rare earth ores

Developed a promising **ion exchange** process for Th, LREE, and HREE separation from leach solutions

Development and initial testing of the **first solid-phase extraction method** designed for REE

Successful **synthesis** of Al_3Nd and $CeNi_5$ from Nd_2O_4 and CeO_2 via the Metalysis Process

Rare Earth Elements

Year 4 Work Plan:

- Flowsheet development for Canadian ores
- Compare existing, and develop novel acidic baking technologies
- Purification of REE precipitates
- Compendium of REE solubilities
- Further evaluation of REE ecotoxicity (advised by ECCC)
- Expanded effort in REE recovery from secondary sources
- Techno-economic assessments

Canadian Chromite R&D Program

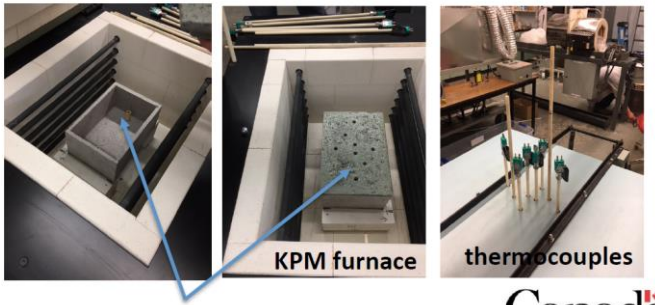
Achievements

Two patent pending direct reduction processes for chromite

Potential reactors for direct reduction and performed computational fluid dynamics modelling identified

Successfully completed **scaled-up experiments** on direct reduction of chromite

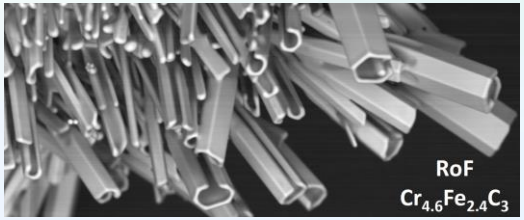
Successfully completed a **pilot-scale campaign** on generating smelter dust and slag needed for assessing the potential for Cr(VI) generation during smelting and quality of slag as a by-product



Invited as opening speaker at the International Chromium Development Association ('ICDA') Annual Meeting in Paris

Year 4 work plan:

- Characterization and beneficiation of furnace products
- Optimizing pellet make-up and properties
- Furnace tests
- Development of Cr(VI) sensor
- Slag quality/reutilization



Mine Hoisting and Ground Control Technologies

Achievements

- Successful completion of high performance synthetic rope underground field trials at Goldex Mine
- Non-destructive testing monitoring evaluated
- Started underground trials for National Research Council rock bolt sensor to assess performance

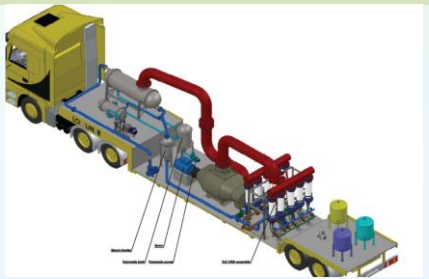
Water Management

Achievements

- Developed an effective process to treat mine and process water streams such as acid mine drainage
- SDTC funding was awarded for a 12-18 month field demonstration at a select mine site

Next Steps

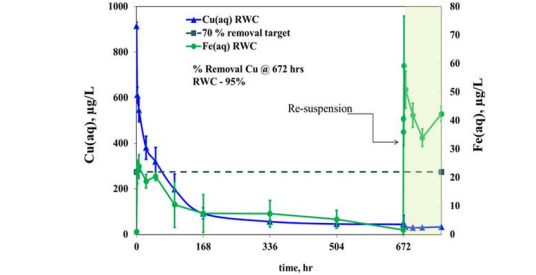
- Secure a mine site for the field demonstration project;
- Construct the mobile process train; and
- Support commercialization and uptake of the new process.

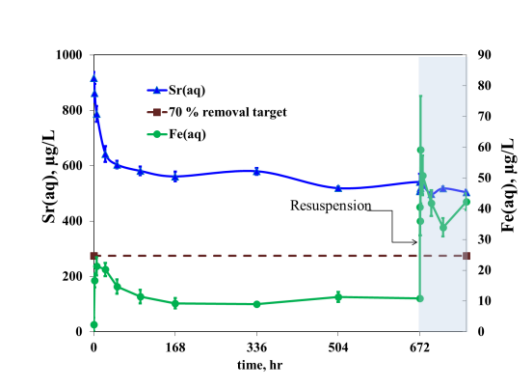


Fate and effect of metals

Achievements

- Developed lab method to determine the rates of removal of metals from the water column for environmental classification of metals
- This work contributed to the metals industry submission to the European Chemicals Agency, European Commission and OECD in April, 2018.





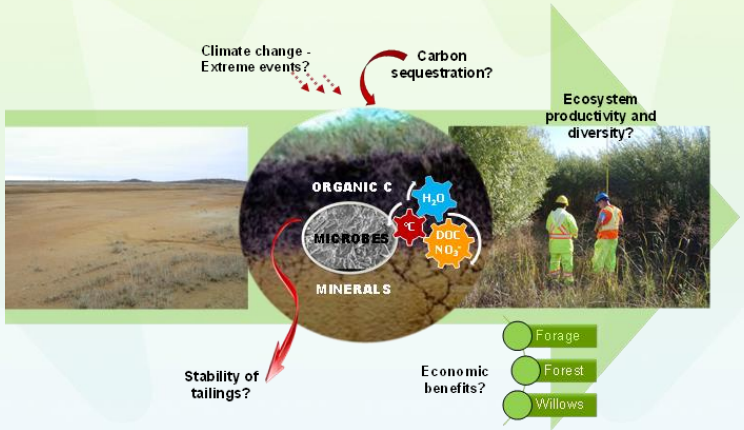
Next Steps

- Seek feedback from scientific and regulatory community
- Building acceptance of methodology (test protocol) – at global level
- Continued scientific work to address e.g.: 1) Criteria for substrate selection; 2) pH buffering and 3) Inter-laboratory comparison
- Application to climate change project

Organic Covers

Achievements

- Lab and field results show productive revegetation and improvement of pH and microbial diversity, which could result in $10s of millions in potential savings at closure
- Field data and feasibility study suggest organic covers revegetated with hybrid willows may result in economic benefits through energy production from biomass



Concerns

- Metal leaching and uptake by vegetation
- Long-term cover performance and sustainability

Next Steps

- Determine microbial recovery and stability of tailings covered with municipal biosolids
- Define best practices for organic covers usage to inform industry and regulators

Mining Value from Waste

Advancing a circular and low-carbon economy

Mine Waste
- High liabilities
- Environmental and social risk
- High metal content

Reprocessing

Low energy demand process

REE, gold, nickel, cobalt, etc.

Residues

By-product potential

Bio-fuel production
- Community energy
- Energy for operation
- By-products from bioenergy

Benefits

- Reduced liability and environmental impact
- Canada brand 'green' commodities
- Community benefits (jobs, energy)
- Low energy/GHG process
- Reduced mining footprint

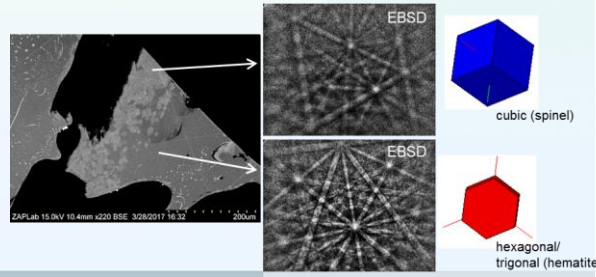
Mining Value from Waste

Achievements:

- Successful process development for both pyrrhotite and gold-bearing tailings
  - Ni (NiS) recovery and 98% of by-product iron magnetized
  - Gold recovery (80-95% sample dependant)

Next steps:

- Non-cyanide leaching for gold tailings and ore (consortium)
- Continue to expand program with other partners
- Five potential Clean Growth projects



Energy and Mines Ministers' Conference 2018

- August 12-14, 2018
- Two Green Mining Innovation Deliverables
  - National Collaboration Strategy Pilot Project (Mining Value from Waste)
  - Assistant to Mining Innovation (Version 2.0)

National Collaboration Strategy

1) Support a culture of communication and collaboration

2) Share resources and leverage existing strengths, tools and organizations

3) Build a culture of innovation

Short Term

- Enhance the existing Assistant to Mining Innovation portal
- Leverage existing working groups from government, industry, and supporting stakeholders

Medium Term

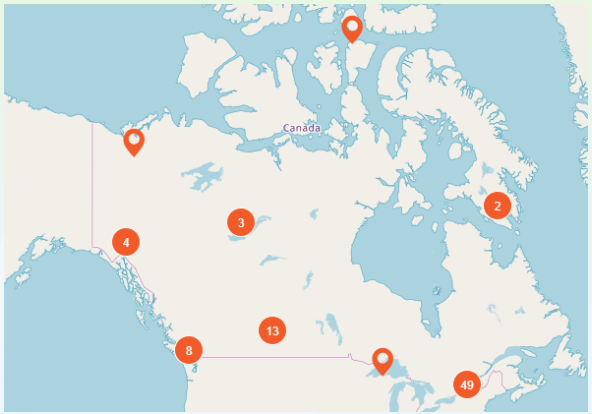
- Release publications about trends, challenges, innovations, and collaborations
- Assess public and private funding resources to seek alignment with initiatives that support collaborative opportunities

Long Term

- Consolidate existing technology road maps that highlight collaborative opportunities
- Communicate leading practices re: working within the regulatory environment
- Address challenges with the sector's public perception

Assistant to Mining Innovation

- A tool for collaborative innovation in the mining industry
- First version created for Energy and Mines Ministers' Conference 2017
- Upgrades underway for EMMC 2018 including key innovation projects and collaborating organizations
- Your organization can feature its projects, expertise and news on the site



For additional information, please contact:

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