GMIAC Workshop – March 17, 2021

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GMI mandate

- The Green Mining Innovation Division undertakes scientific research and development to reduce environmental impact of mining while increasing economic competitiveness
- Delivering on the five research • priorities under three focus areas:
 - Net Zero Mine •
 - **Critical and Battery Minerals** •
 - **Climate Change** •

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Trends and Drivers

- Enduring priorities
 - Costs and productivity
 - ESG environmental/social/governance
 - Value extraction
- Emerging trends
 - Responsible sourcing
 - New value chains
 - Critical minerals
 - EV / grid storage batteries
 - Circularity

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GMI Research Priorities

Climate Change

- Big data to assess water impacts
 - Mitigating dust impacts

Energy Efficiency

- Energy efficient fragmentation •
 - Coarse particle flotation •

Environmental Assessment Reviews

CANADA IS THE LEADING MINING NATION

Waste Management

- Genomics for waste reclamation
- Radioactive waste management
- Bioleaching

Water Management

- Water recycle in mining/milling
- Ecotoxicity for regulations
- Membrane treatment

Enhanced Productivity

Unlocking resources, reducing costs, improving recoveries



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Rare Earth Elements - Ore to Oxide

Focus on Canadian deposits to produce viable flowsheets for each of the ores



Foundational Science: Characterization, Process Chemistry

Environment: Geochemistry, Ecotoxicity, Waste Management





Ring of Fire Chromite

Made in Canada Approach



Environment: Formation and mitigation of Cr(VI), slag utilization, GHG minimization



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Battery Minerals R&D Program

Working across Federal family to transform minerals into energy











Source: conventional, new and secondary sources

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Mineral: characterization. geometallurgy

Upgrading:

beneficiation, flotation physical separation

hydrometallurgy, pyrometallurgy, electrometallurgy

Recycling: metallurgy





Environmental management, methods, testing and certification



Mining Value from Waste

Advancing a circular and low-carbon economy





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Covid context

- Management and staff quickly adapted to use social discussion platforms to reduce challenge to manage staff remotely, especially some technical and scientific personnel
- Halted experimental work and shifted to data analyses, writing reports/publications; research planning and establish new collaborations to maintain a strong level of output
- Personal connect is lacking, virtual dialogues lack subtleties and casual communication but improvement are seen as staff learn this new way to work.
- Essential lab staff returned September 2020, reduced capacity
- No cases, strict workplace protocols
- Stakeholder and international relations strengthened
- Research and programs deadlines extended to September 30th



Engaging with stakeholders

- CanmetMINING workshops and webinars
 - Mining Value from Waste (April)
 - Chromite R&D (May)
 - Rare Earth Elements
 - Workshop (May)
 - Webinars (July (REIA), Nov, Dec, March)
 - Climate Change (Jan)
- Numerous domestic and international meetings, presentations
- Various conference presentations
- Early Covid outreach to numerous companies, ongoing dialogue



Technical Progress



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Environmental Impact Assessments

- EIS Guidelines review completed
 - Wasamac Gold (QC), Bending Lake (ON)
- EIS Information request sent
 - Lynn Lake Gold (MB), Valentine Gold (NF), Galaxy Lithium
- EIS review completed
 - Coffee-Gold (YT), Rose-Lithium (QC), Marathon Gold (ON)
- EIS guidelines (TISG) and proponent work plan review
 - Ring of Fire Community Access Roads (Webequie and Marten Falls)

*TISG - Tailored Impact Statement Guidelines





REE R&D

- Sc / REE recovery from Crater Lake Project Imperial Mining Group Ltd.
- Cost reduction for REE leaching / novel soaking method
- Optimization of REE acid baking & leaching of a Nechalacho
- Application of chelant-assisted electrodialysis in REE separation
- REE silicate decomposition mechanisms
- Optimization of radionuclides removal by ion exchange



- Additional Studies
 - Review on Nd-Pr metal production
 - Nd-Pr electrowinning study
 - TEA of REE electrowinning
 - SX separating factors
 - Review on rotary kiln materials of construction
 - Review on corrosion from Acid baking exhaust gas
 - Review on uniform corrosion
 - LCA of REE processing
 - Ore sorting study on the Ashram deposit





Chromite R&D program

Additional studies

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- Knowledge transfer: FN communications
 best practices guidebook
- Ferrochrome benchmark review of Finnish environmental practices
- Ferrochrome benchmark review of mitigation strategy effectiveness
- Ferrochrome benchmark review application to the Canadian ferrochrome industry
- Characterization and geotechnical testing of ferrochrome smelter slag

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Lithium Recovery from Canadian Spodumene Deposits

- Natural spodumene is chemical ulletstability and current processes to release lithium are energy-intensive many involving an initial heat treatment up to 1000°C
- Current R&D: Development of • novel processes that drastically reduces the energy consumption to recover lithium in the hydroxide monohydrate form, an important precursor for cathode materials production





luble Li-rich reactive pro partially decomposed a-spodumene

release of Li from spodumene crystalline structure



characterizing Li exchange (mobility)





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Water research



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- Atmospheric plasma technologies for the removal of cyanides from gold mining processes – Laval
 - Commissioning and operation of a pilot vacuum membrane distillation (VMD) system.
 - Performed preliminary pilot tests on synthetic thiosulfate-based samples using reverse osmosis and VMD
 - Development of a two-step concentration process for synthetic feed samples
- Pre-concentration of water stream to supply cyanide regeneration process - COREM
 - Determined feasibility of concentrating cyanide in water stream by a 10x factor
 - Determined thermal stability of cyanide products at temperatures ranging from 40 to 80°C

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Water research

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- Demonstration of ECOTHOR technology in treating liquid effluents from mining operations – E2Metrix
 - Commissioning of a pilot-scale electrocoagulation system
 - Demonstration of ECOTHOR's capabilities in heavy metal removal
 - Commissioning of a ceramic membrane filtration system
- Mill water recycle Strathcona Mill, Glencore
- Water quality sensor NRC
- Chronic aquatic hazard classification guidance document
 - CanmetMINING's method forms part of Eurometaux's guidance for industry on the classification of metals and inorganic metal compounds for long-term environmental hazard





Climate change adaptation research

• Big data project

- 12,690 unique sampling locations, ~800,000 data points,, 1940- present
- Assess trends and inform decision making

Environmental genomics

 Experiments underway to assess the potential impacts of climate change on biogeochemistry of mine wastes and efficiency of organic covers

• Fate and effect of metals in a changing climate

- Field and lab tests completed
- Assessing the effect of various conditions on metal toxicity

Assessing saturated cover performance

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Waste management / utilization

Recovery of REE and Sc from coal ash

Optimization of Sc elution conditions

• Ni / Co recovery from pyrrhotite tailings

 Preliminary IX experiments to recover Ni and Co directly from bioleaching PLS without pH adjustment or iron removal

Reprocessing of tungsten tailings

- 60% footprint reduction by weight
- 90% desulphurization
- 80% tungsten recovery

• Pilot scale treatment of legacy radioactive waste

Demo scale next phase



Waste management / utilization



• ARD / Metal leaching database

- Compiled list of ~200 mining EA projects at federal/ provincial/ territorial levels
- Python code used to pull data from various datasets

Mining Value from Waste

- Tailings database and assessment tool for reprocessing
- Implementation plan
- Regulatory review underway
- Various technical projects

Reclamation using geomicrobiology and genomics

- Organic covers
- Willow plantations, DNA/genomics



Other research

- Assessment of mine waste management at Mont Wright mine
 - For ECCC, clarified federal expectations on effluent and mine waste management
- The application of machine learning to predict the product size of the secondary grinding circuit Canadian Royalties
 - Machine learning methods were used to develop algorithms to predict the product size of the secondary grinding circuit
- Equity Mine security review
- Measuring the fragmentation of the Canadian mining innovation ecosystem



Upcoming Events

- Webinar on REE separation technologies
 March 25th
- Mining Value from Waste WorkshopSpring 2021
- Webinar on Innovative Water Treatment Technologies for Mining Industry
 Climate change adaptation (water recovery and reuse)
 Critical minerals (recovery and separation of rare earth elements, lithium)
 Spring 2021



Planning for the future

- New research plan Sept 2021
- Potential funding for expanded programming
- Consultations with internal researchers, OGDs, external stakeholders
- Succession planning, new hires





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Razan G

Sean L

Samir S

Angela P

Amy C

Callum M

Richard G









Syed W







Liam R



Ashley N



Graham D



































Alexandra K











Jason C



Benny C

Tanya L

Kellie C



Bimpe A





Justin R

New Employees

2020-2021

Joanne W

Jennifer C

















Thank you!

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