Natural Resources Canada | Ressources naturelles Canada

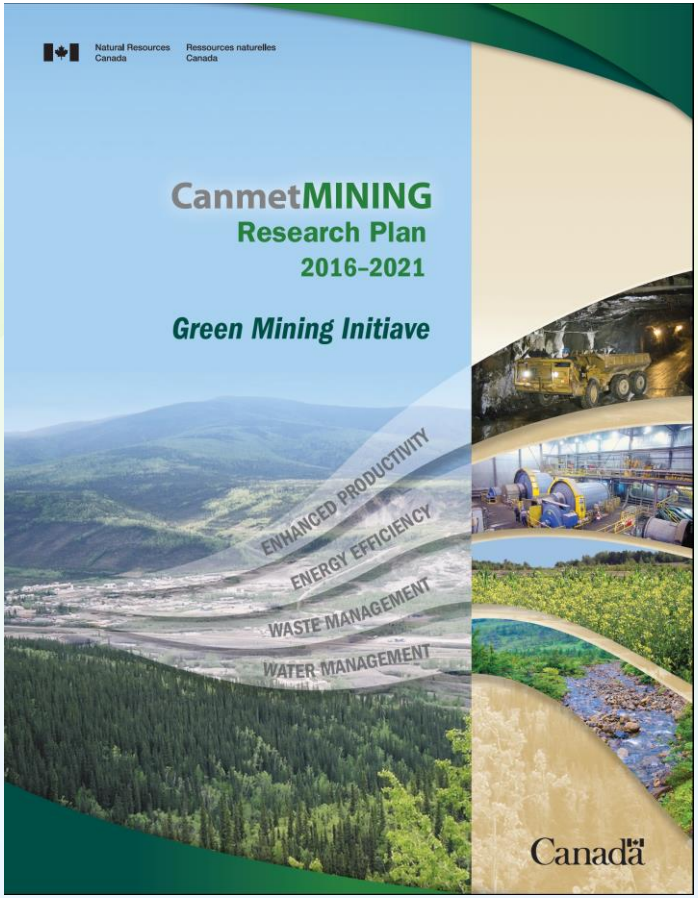
GMIAC – December 17, 2019

Green Mining Innovation

Janice Zinck and team

Canada

- New research plan achievements
  - For past 6 months
- New research areas and programs
  - Mining Value from Waste
  - Deep and insitu mining
  - Critical minerals
  - Battery chemicals
- Novel initiatives



Energy Efficiency

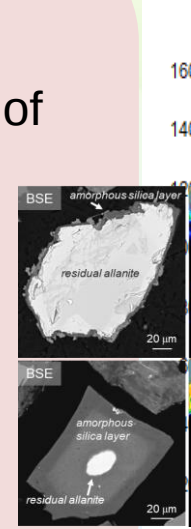
Develop technologies to reduce energy consumption in mining and milling

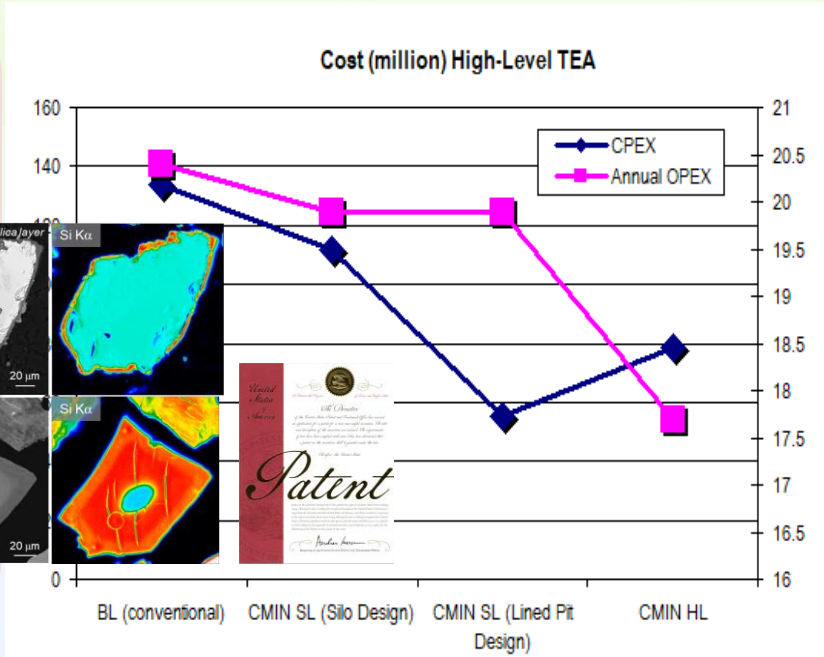
- Coarse particle flotation
  - $12.5M(US)/year in increased revenue
  - 3% increase in copper recovery
- 3D sensor for particle size distribution measurement
  - Patent granted
  - Technology licenced

Enhanced Productivity

Rare earth elements

- Optimizing REE-silicate decomposition (mechanisms)
  - Drastic reduction in the temperature of decomposition
- Alternatives to conventional acid baking
  - Acid soaking
- Supercritical fluid extraction
- Significant reduction in capex and opex





Waste Management

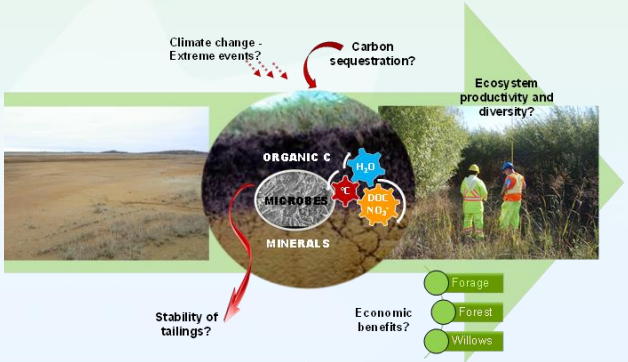
Best practices for waste management

Waste reprocessing and repurposing

- Preliminary IX experiments for metal recovery after bioleaching pyrrhotite tailings (Ni, Co, PGMs)
- Regenerated lixiviant and clean gypsum by-production, after gold recovery from historic tailings
- Desulphurization (90%) by bio-oxidation

Waste management and reclamation

- Effect of organic acid leaching (oxidized tailings)
- Effects of phosphate, nitrate and organic carbon
- Completion of metabarcoding (genomics)



Water Management

Develop technologies to reduce risks to the aquatic environment

- Water team rebuilt, new staff hired, facilities retrofitted
- Water recycle upside ~$500k of pay-metals (Ni/Cu) recoverable from thickener tank overflow
- Clean Growth STAC funded projects signed

➢ Pilot Testing of a Clean Nitrogen Reuse Process to Dissolve Precious Metals (COREM)

➢ Atmospheric plasma technologies to eliminate cyanides (U of Laval, COREM)

➢ Evaluation of electrocoagulation for water reuse and reclamation (E2Mertix)

Climate Change

Tools and best practices to adapt water and waste management practices

- Risk assessment of the risk of dust
  - Quantification and characterization
  - Detailed lichen sampling and dust sampling strategy developed
  - Geochemistry, mineralogy and toxicology on Sudbury lake sediment
  - Real time water quality sensors deployed, toxicity tests conducted
- Received data from over 4500 locations for Big Data trends analysis

Mining Value from Waste Program

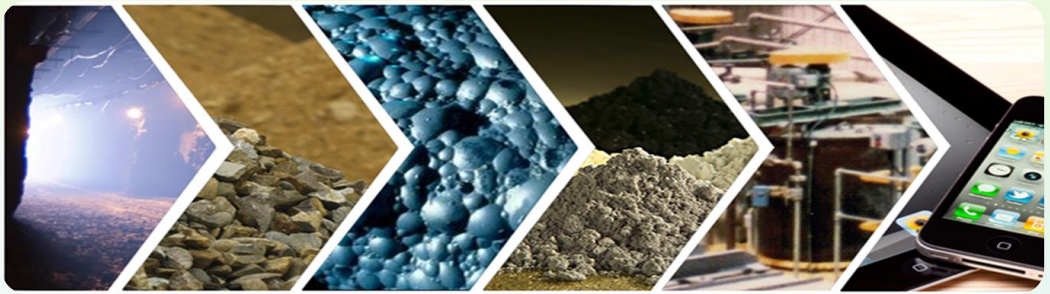
- EMMC called for Program expansion
- Alignment with abandoned mines remediation and circular economy
- New projects Clean Growth funded MagOne – Mg from asbestos tailings, Whitehorse Cu tailings
- Discussions on resource/reserve definitions
- Tax, regulatory, policy incentives
- Inventory of tailings for reprocessing purposes
- Program roadmap
- Steering committee to be established

Advancing the Critical Minerals Agenda

- Canada much further advanced than at start of program – in dialogue, technologies and politically
- Active engagement in taskforce on critical minerals, Canada/US joint action plan, and with other allied nations
- NRCan playing pivotal, leadership role in critical minerals dialogue at provincial, national and international levels
- Processing advances must move hand in hand with establishment of permanent magnet value chain outside of China
- Canada's role across supply chain to be defined

Integrated Critical Minerals R&D

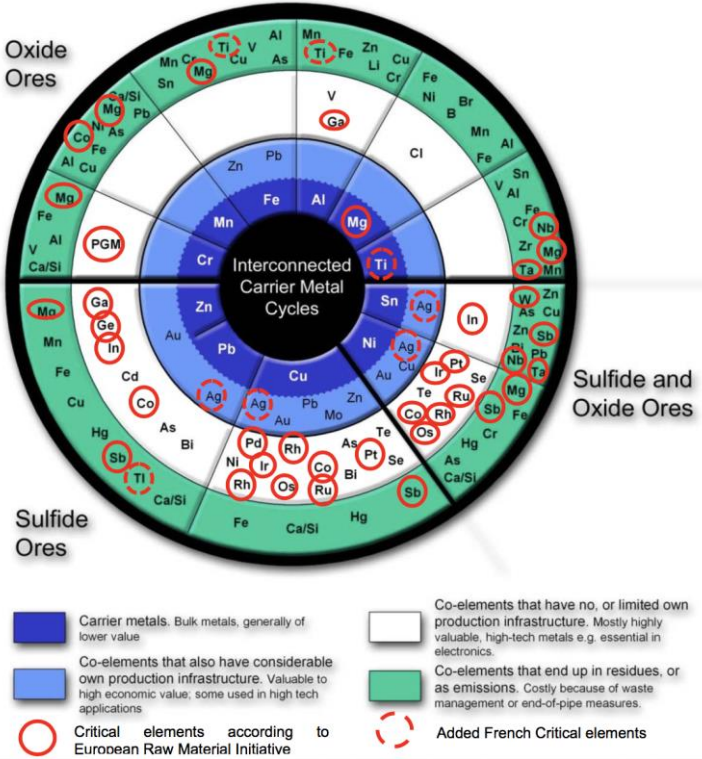
- Guided by industry, supply chain driven
- Addressing R&D gap to bring these high-demand resources to market
- New technologies to “de-risk” industry's technical challenges
- Established collaborative networks to advance R&D



REE R&D Program	Chromite R&D Program	Mining Value from Waste	Battery Metals

Critical Minerals - Secondary Sources

- Rare earth elements
  - Tailings (U, coal, oil sands), sludges, red mud, coal ash…
  - 600,000t REE
- Vanadium - petroleum coke
- PGMs, cobalt from pyrrhotite tailings
- Tungsten tailings
- Magnesium - asbestos
- Inventory incomplete
- No mining, minimal milling



Battery Supply Chain Opportunity for Canada

Current

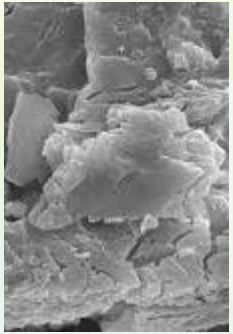
- Lithium
- Cobalt
- Nickel
- Graphite
- Manganese

Future

- Lithium
- Graphene
- Vanadium
- Magnesium
- Sodium

Battery R&D Program – CMIN

Source:
conventional, new and secondary sources



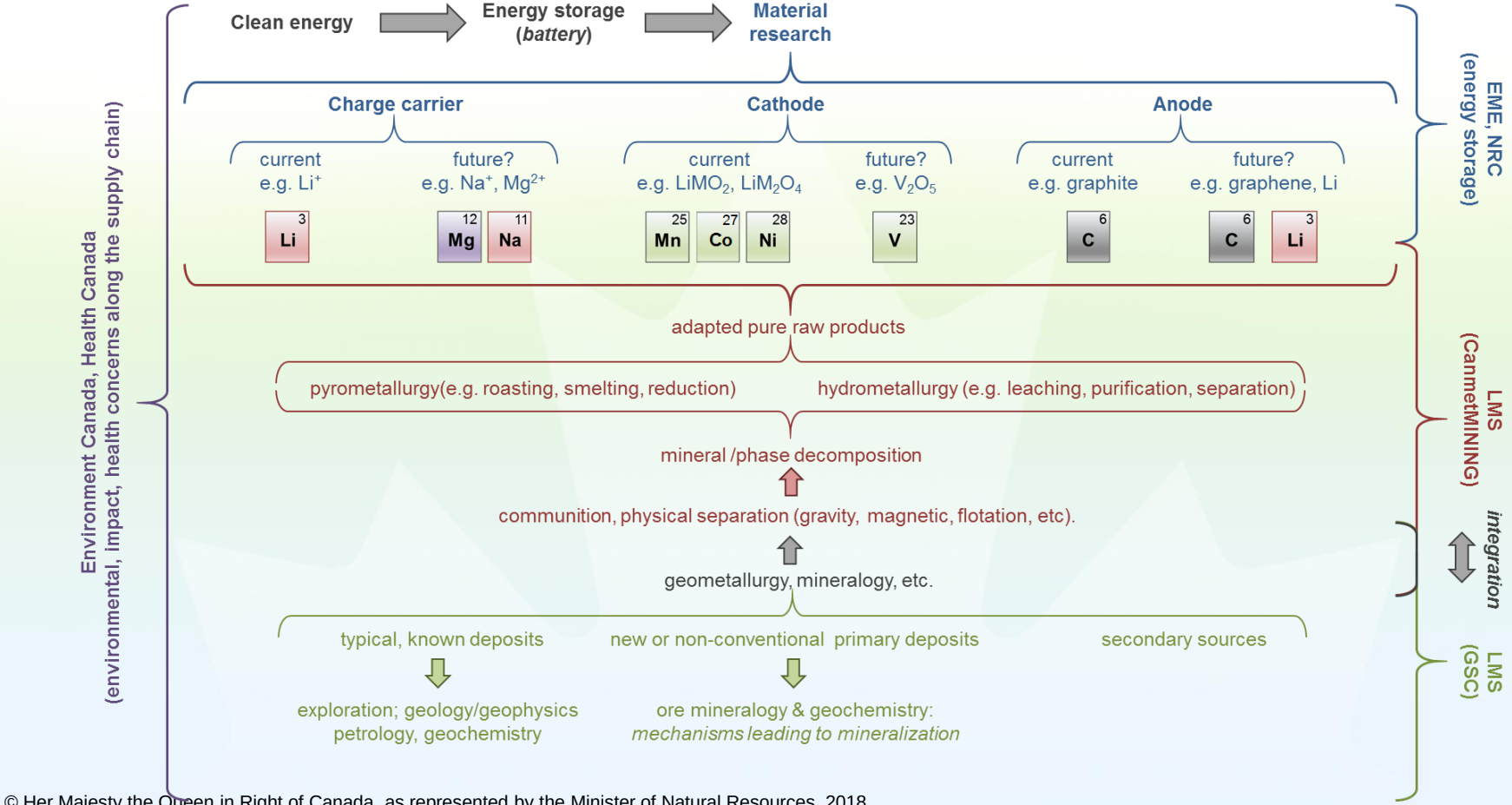
Mineral:
characterization, geometallurgy

Upgrading:
beneficiation, flotation physical separation

Battery chemicals:
hydrometallurgy, pyrometallurgy, electrometallurgy

Recycling:
metallurgy

Environmental management, methods, testing and certification



Deep and In-situ Mining

- More challenging deposits require unconventional approaches
- Rising costs and environmental pressures
- Focus on the following emerging areas:
  - Continuous mining
  - Microwave-assisted mechanical rock breakage
  - In situ recovery for hard rock ores in Canada
    - Fragmentation research

In-situ mining at the Beverley uranium field. ©Heathgate Resource

Novel Initiatives

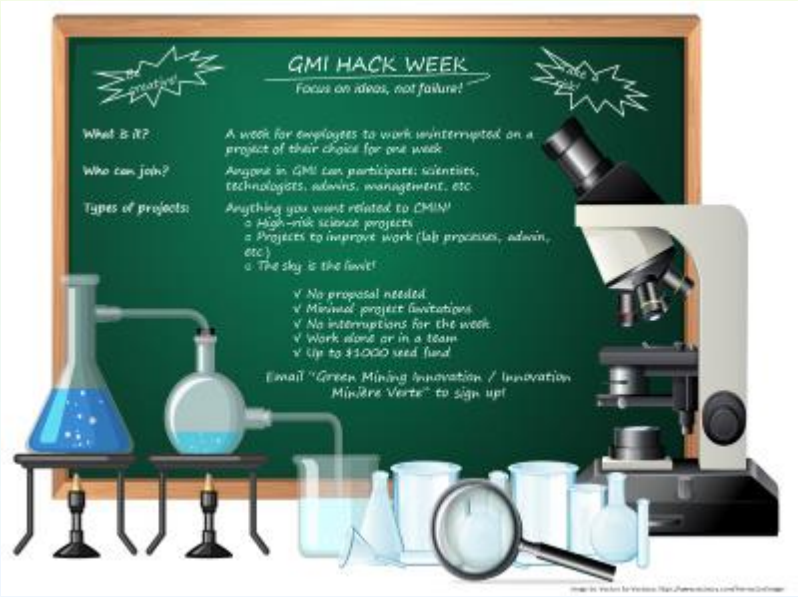
Science – Policy Field Camp

Looking to restart your STEM* career?

Apply to the Diversity in STEM Re-entry Program

REQUIREMENTS:

- Bachelor of Science or Engineering
- Women and/or Indigenous applicants
- 5 years outside of the STEM field



Next Steps

- Several challenging and exciting programs on the horizon
- Continue to strive for collaboration to achieve success
- Focus on advancing our processes and technologies along the TRL through partnerships, pilots and demonstrations
- Welcome all interested in collaborating


Source: Nordic E&MJ


Source: Fraser Institute

Discussion

THANK YOU

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