Natural Resources Canada | Ressources naturelles Canada

# Advancing Canada's Critical Minerals Agenda: Innovation in Primary and Circular Recovery

**November 17, 2020**

CanmetMINING, NRCan

Canada

# BACKGROUND

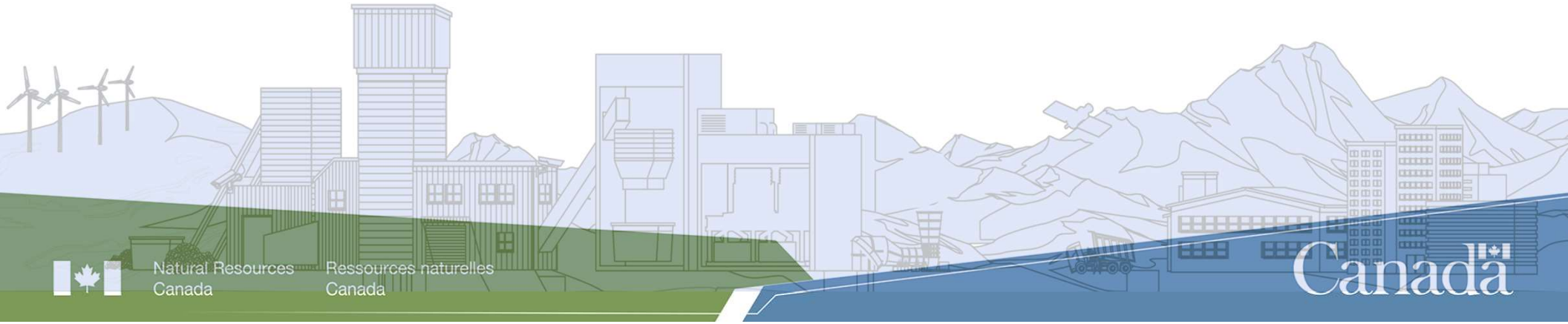
Globally critical minerals are in demand to feed clean tech, defence, medical, and high tech value chains

Opportunity for Canada as it is endowed with mineral wealth

However, without processing technology Canadian mineral deposits are of little value

## Science and Technology is needed to:

- Transform Canadian diverse and complex mineral inventory (primary and secondary) to critical materials
- Ensure processes and practices are environmentally sound and economically competitive

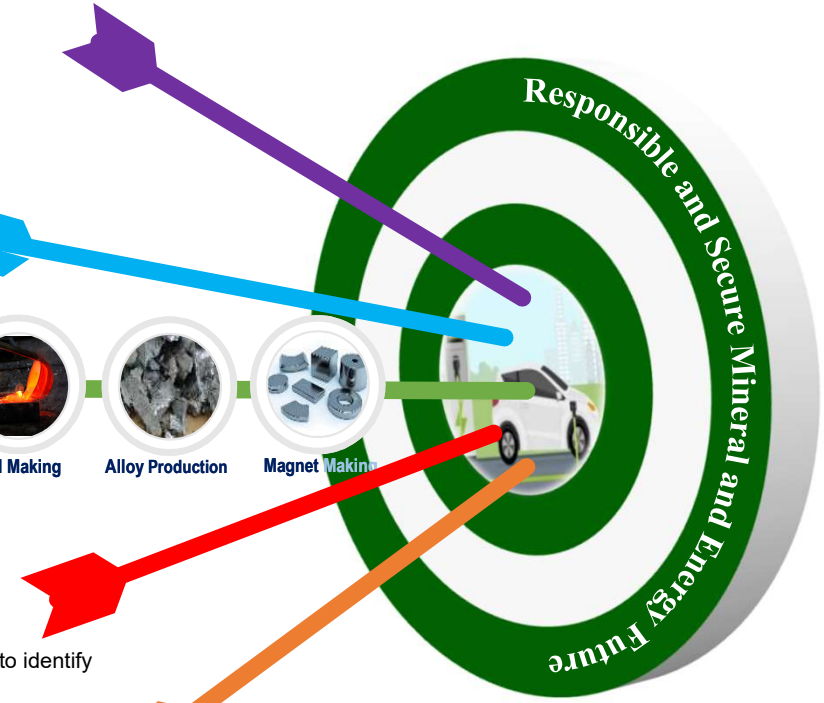


# NRCan CanmetMINING
## Critical Minerals R&D Program

**The next step towards launching a critical minerals industry and creating competitive value chains in Canada, by capitalizing on our Canadian advantages: established and coordinated industry network, technical expertise, and rich resources.**

### Embrace Environmental Social & Governance Standards

- Continue to advance green and sustainable processes and innovations
- Establish Canadian brand as ethical and transparent supplier of CM
- Uphold ISO standards in traceabiity and provenance
- Study opportunities to utilize tailings and process waste


### Establish Value Chain

- Extend technical and economic understanding of every step within entire value chain
- Advance creation of domestic value chain, attract end-users to Canada
- Establish Canada as competitive global supplier of CM

### Focused, Innovative R&D

- Continue to partner with stakeholders to identify and address remaining R&D gaps
- Customize research to maximize value from each Canadian projects
- Improve competitiveness of innovative processes
- Advance TRL of Made-in-Canada technologies through demonstration in pilot plants

### Develop Canadian Expertise

- Continue to train next generation of leaders, researchers and workforce in CM

# FROM ROCKS TO RESOURCES (REE + Chromite)



**Responsible development of REE and chromite to maximize Canadian value and benefits from the deposits**

**Mechanism:** Industry led, Canmet delivered

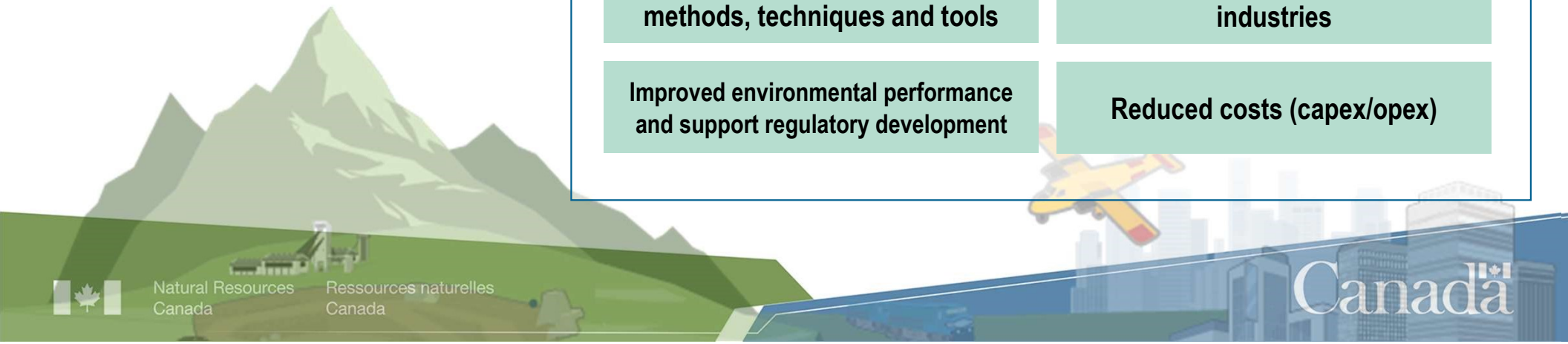
**Informed by:** Steering Committees and workshops

## Objectives:

- Address the R&D gap to bring critical mineral resources to market
- New technologies to "de-risk" the technical challenges

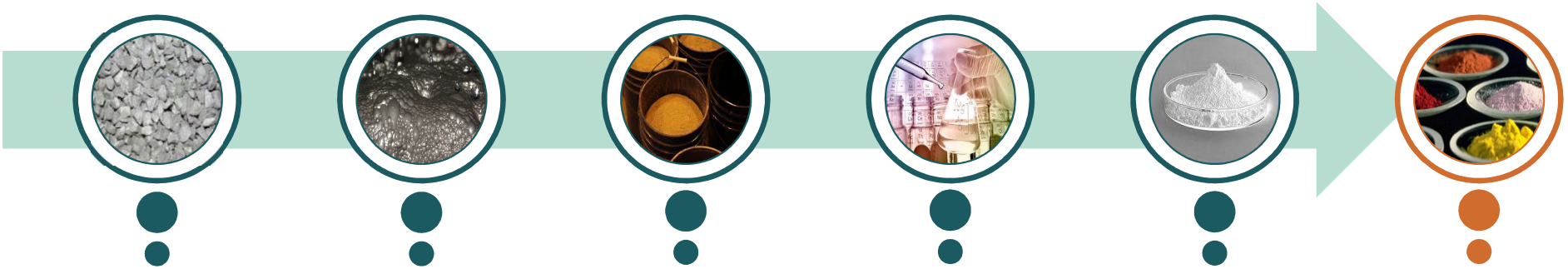
## Program Outcomes:

- Addressed processing challenges
- Establish Made in Canada technological solutions
- Develop novel and efficient methods, techniques and tools
- Trained HQP for these emerging industries
- Improved environmental performance and support regulatory development
- Reduced costs (capex/opex)



# ORE TO OXIDE (REE)

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



**Ores**

Torngat
Search
Avalon
Commerce
GéoMégA
Matamec

**Physical Processing**

Increasing recovery, flotation, mag/grav. Sep, calcination

**Chemical Processing**

Baking, cracking, leaching

**Impurity removal**

Fe, Ce, U/Th

**Mixed REE Oxalate**

**Refinery Grade Mixed Rare Earth Oxide**

**Foundational Science: Characterization, Process Chemistry**

**Environment: Geochemistry, Ecotoxicity, Waste Management**

# NRCan CanmetMINING
## Rare Earth Elements R&D Program

6 year (2015-2021) • $14 million program • "Industry led, CanmetMINING delivered"

- ✓ Catalyst for Canadian REE industry by galvanizing stakeholders & experts
- ✓ Innovated 14 new/improved processes (TRL 3-5) suitable for use by Canadian projects with $50M+ in potential CAPEX reduction
- ✓ Developed federal expertise in REE

Develop new technologies to "de-risk" the technical challenges

Address the R&D gap to bring critical mineral resources to market


- Developed 16 research scientists & post-docs at NRCan
- 13 students trained in REE (~$0.8M in student employment)
- Reached 210 Canadian stakeholders in technical workshops and meetings
- Involved 63 researchers and REE experts in the 46 contracts funded (~$3.5M)

- Improved flotation recovery on all 6 ore samples studied
- Reduced $46M CAPEX and $3.5M OPEX for one Canadian project
- Reduced flotation reagent usage by over 50% for one Canadian project
- Completed 7 economic assessments on processing options

- 33 peer-reviewed publications in journals and conferences
- 63 research reports available at REEChromite.ca website
- Scientific advances disseminated at 8 technical workshops
- Developed 3 Canadian certified reference materials ($132K in sales to date)

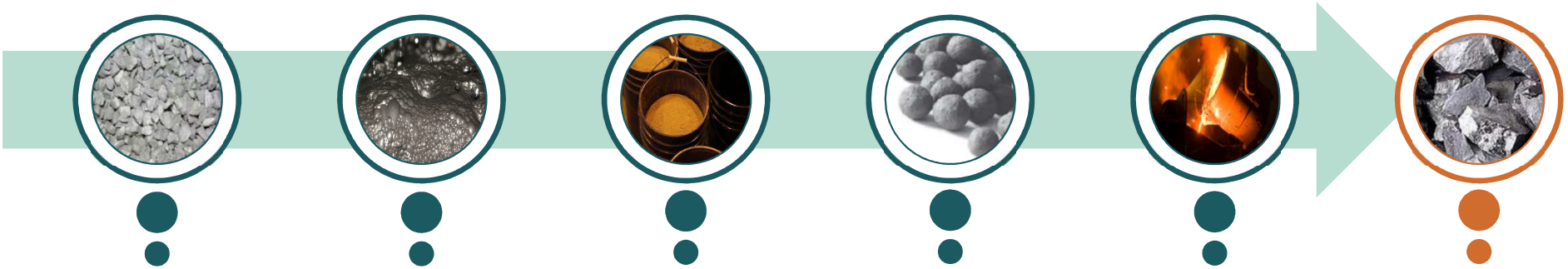
- Critical Minerals Task Force
- U.S. Joint Action Plan
- Global Rare Earth Industry Association
- Active in developing ISO standards on REE
- Continual engagement with specific US, EU and Australian stakeholder

- Toxicity tests data generated and used to derive federal Water Quality Guidelines
- Guidance documents on NORM and waste management for REE industry
- Life-Cycle Analysis of processing
- Identified routes to recovery REE from secondary sources

- 14 new/improved processes developed, offering $50M+ in potential CAPEX reduction over conventional process
- 6 patented or patent-pending processing technologies
- 1 piloting facility

# RING OF FIRE CHROMITE

## Made in Canada Approach



**Ores**
Noront
KWG

**Physical Processing**
Improve recovery / minimize waste

**Additives**
Fluxes and reductants

**Pelletizing /sintering**

**Smoking/ Reduction**

**Ferrochrome**

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

# SELECTED RESULTS



**New technology applications for REE –**
cleaner and less costly - supercritical fluid extraction and electrodialysis

**Novel "Made in Canada" technology**
developed for ferrochrome production, using direct reduction

**New processes**
for REE decomposition and impurity removal - reduced operating and capital costs

**Process optimization**
for improved recovery and cost reductions ($46M capital, $3.5M/a operating)

**New scientific knowledge**
on REE ecotoxicity to inform regulatory development (ECCC)

**Suite of novel technologies for these emerging industries**

# BATTERY MINERALS R&D PROGRAM

## Working across Federal family to transform minerals into energy

**Source**

Conventional, new and secondary sources

**Mineral**

Characterization, geometallurgy

**Upgrading**

Beneficiation, flotation physical separation

**Battery chemicals**

Hydrometallurgy, pyrometallurgy, electrometallurgy

**Recycling**

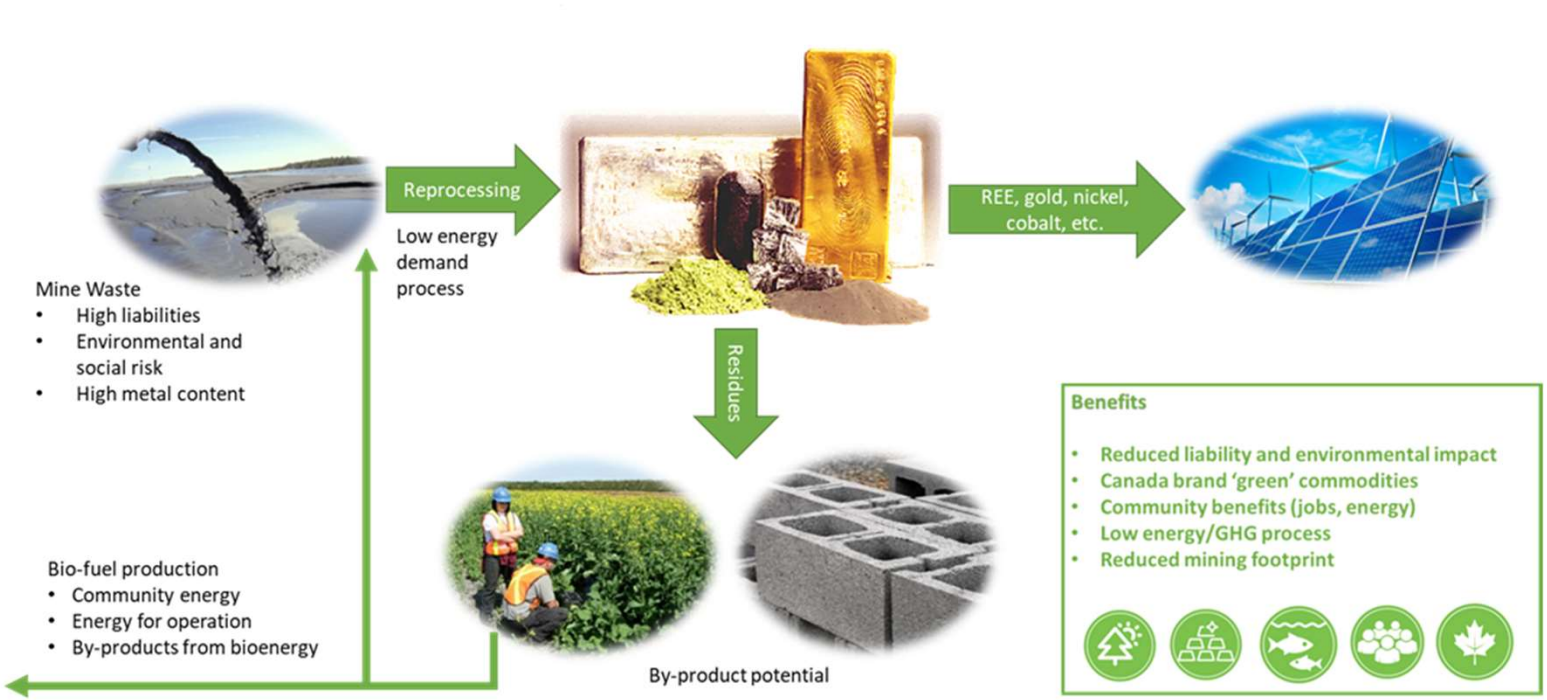
Metallurgy

**Environmental management, methods, testing and certification**

| 3 | 27 | 6 | 29 | 23 | 12 | 25 | 11 |
|---|---|---|---|---|---|---|---|
| Li | Co | C | Ni | V | Mg | Mn | Na |
| Lithium | Cobalt | (Carbon) Graphene | Nickel | Vanadium | Magnesium | Manganese | Sodium |

# MINING VALUE FROM WASTE PROGRAM

- Facilitate transition to a circular and low carbon economy
- Address legacy and waste management challenges through collective innovation
- Accelerate resource production
- Cost and energy efficient recovery of critical and valuable minerals




**Current projects**

| REE | 74 W Tungsten | 27 Co Cobalt | PGEs | 12 Mg Magnesium | 21 Sc Scandium |
|---|---|---|---|---|---|

# PLANS AND PROGRESS

- Program roadmap
- Areas of focus
  - Reduce environmental liabilities
  - Recover the metal values from mine waste
  - Produce benign tailings residue
  - Utilize mine waste as resources / by-product opportunities
  - Policy, tax and regulatory instruments
- Waste / tailings characterization and assessment
- Process development for various waste inventories

# CHALLENGES AND NEXT STEPS



**Build ethical, responsible and secure critical mineral value chains from conventional and alternative sources**

**Close cooperation and collaboration between stakeholders along value chain will be key**

**Success will take more time and effort than anticipated – very complex issues**

**Processing advances must move hand in hand with establishment of critical mineral value chains**

**Roadmap to build responsible and secure critical mineral value chains**