Critical Minerals and Energy: Increasing demand, novel sources, and challenges

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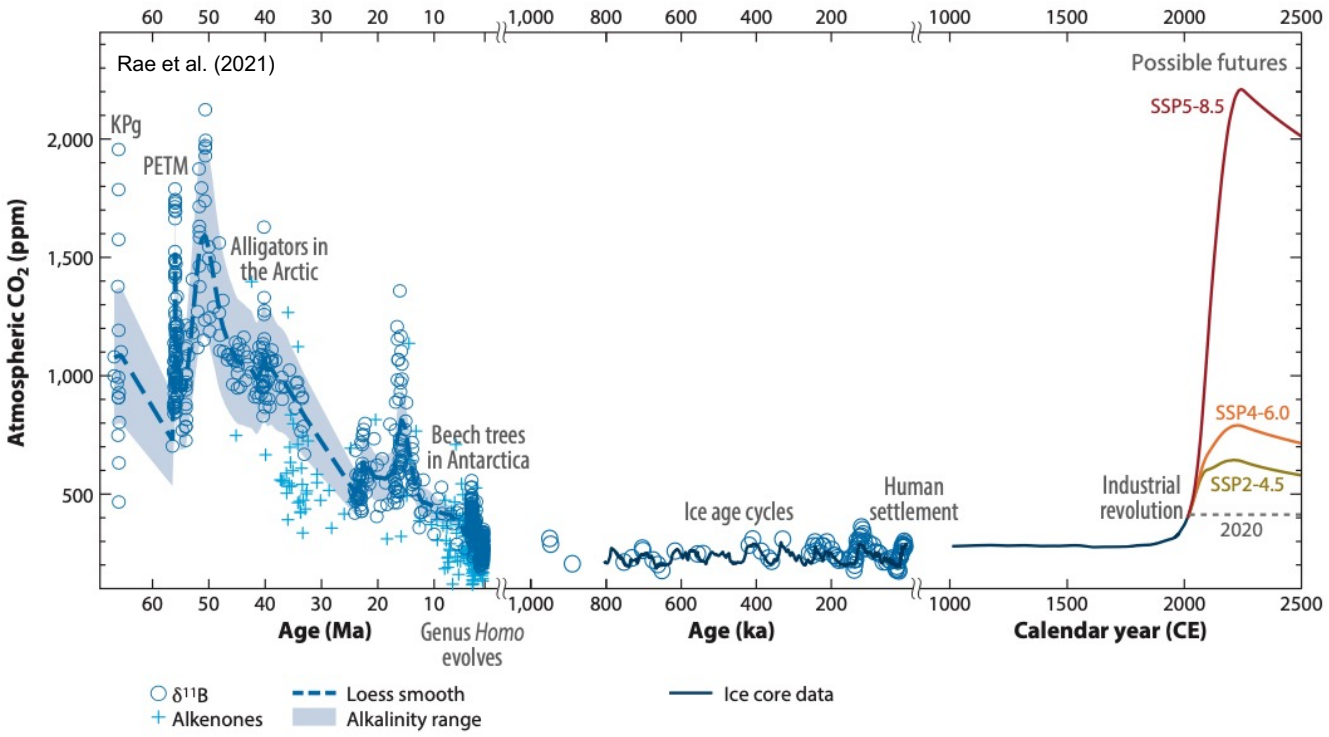
May 15, 2024

The Challenge – limiting future CO_2

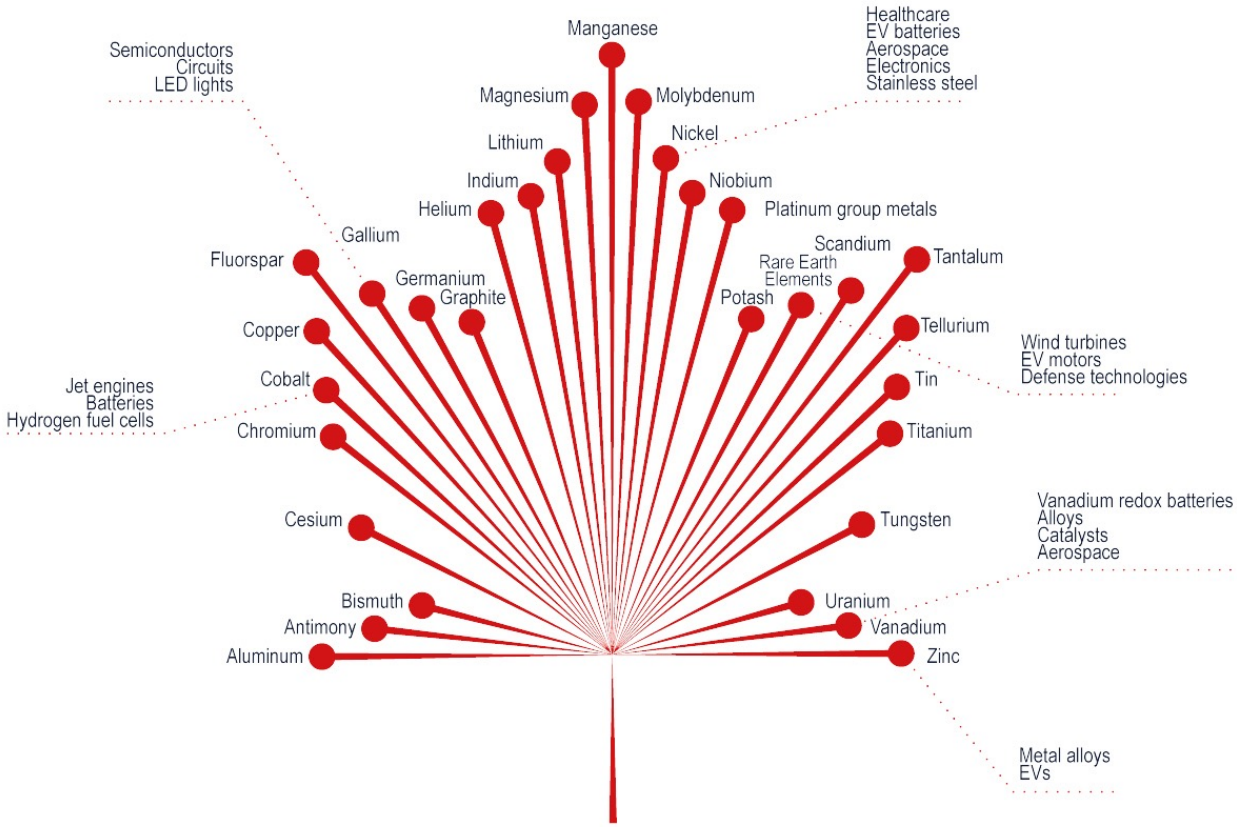


- Limiting future CO_2 emission will necessitate a transition to net-zero energy technologies.
- This will require a rapid transition to renewable energy sources and increased electrical storage capacity.

Transition to Net-Zero and Critical Minerals

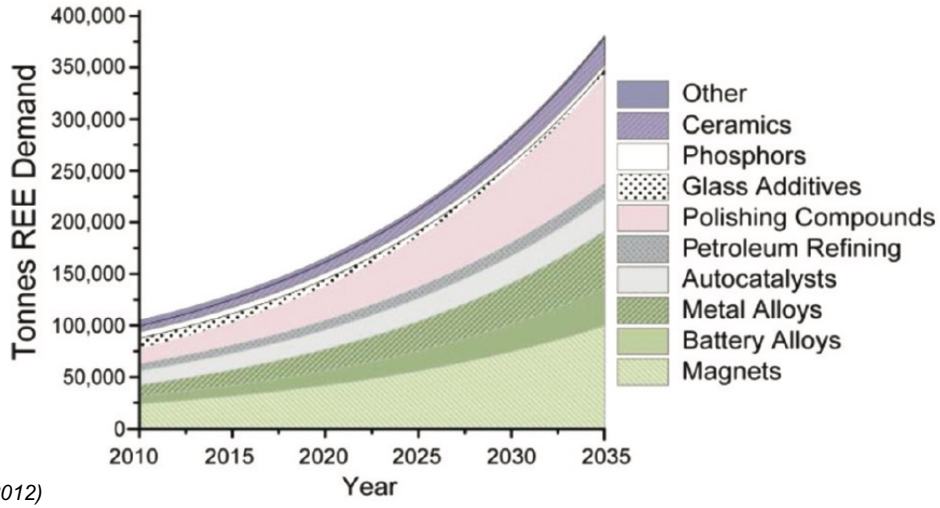
- The transition to net-zero will inherently create an increased demand for critical minerals.

- Canada has identified 6 priority critical minerals:
  - Cobalt, Copper, Graphite, Lithium, Nickel, and Rare Earth Elements

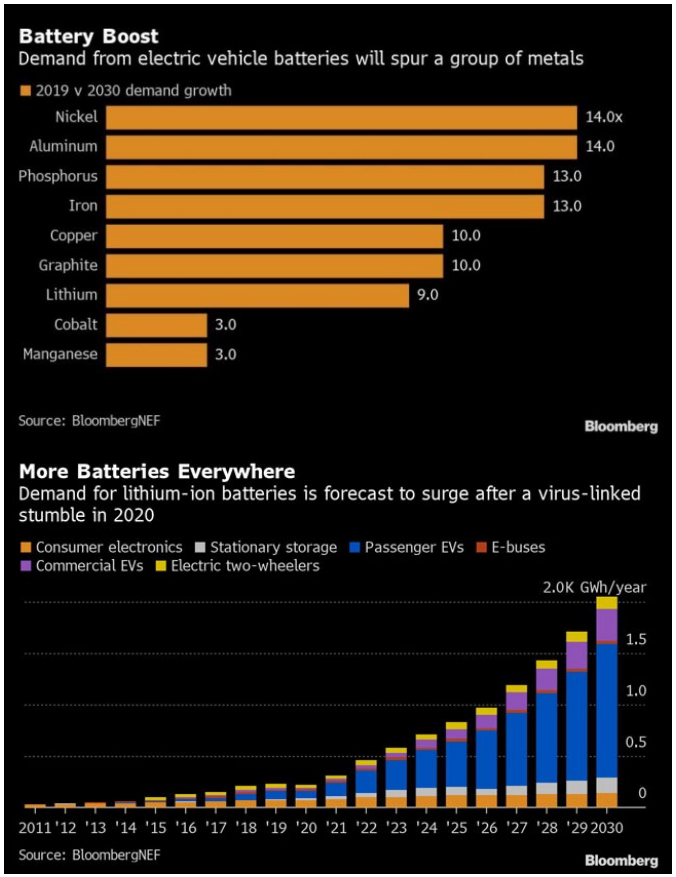


Growing demand Critical Minerals

- Significant increases in demand will be driven by the demand for batteries for passenger and commercial electric vehicles.

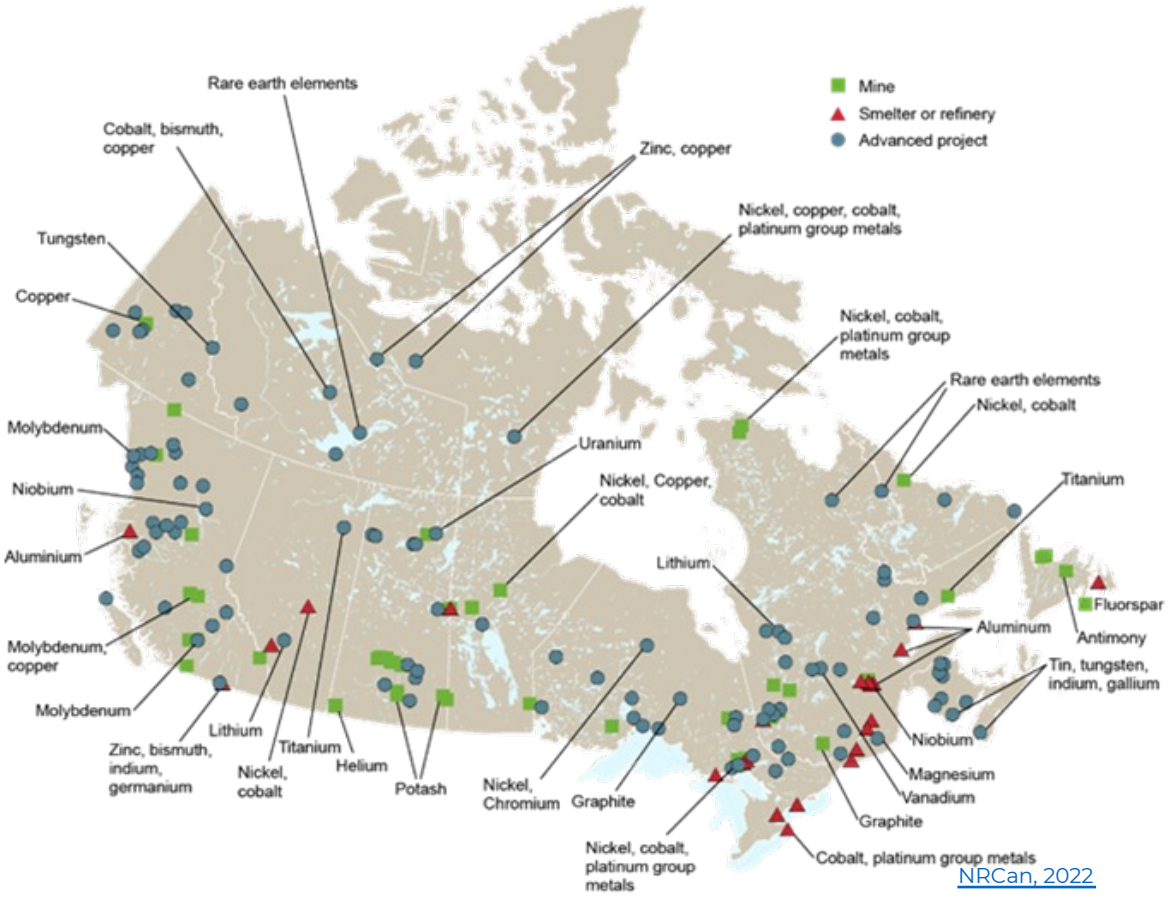


Alonso et al. (2012)



Critical Minerals in Canada

- Canada has several active or advanced projects targeting critical minerals.
- On average, traditional mines take 18 years to go from initial exploration to production.

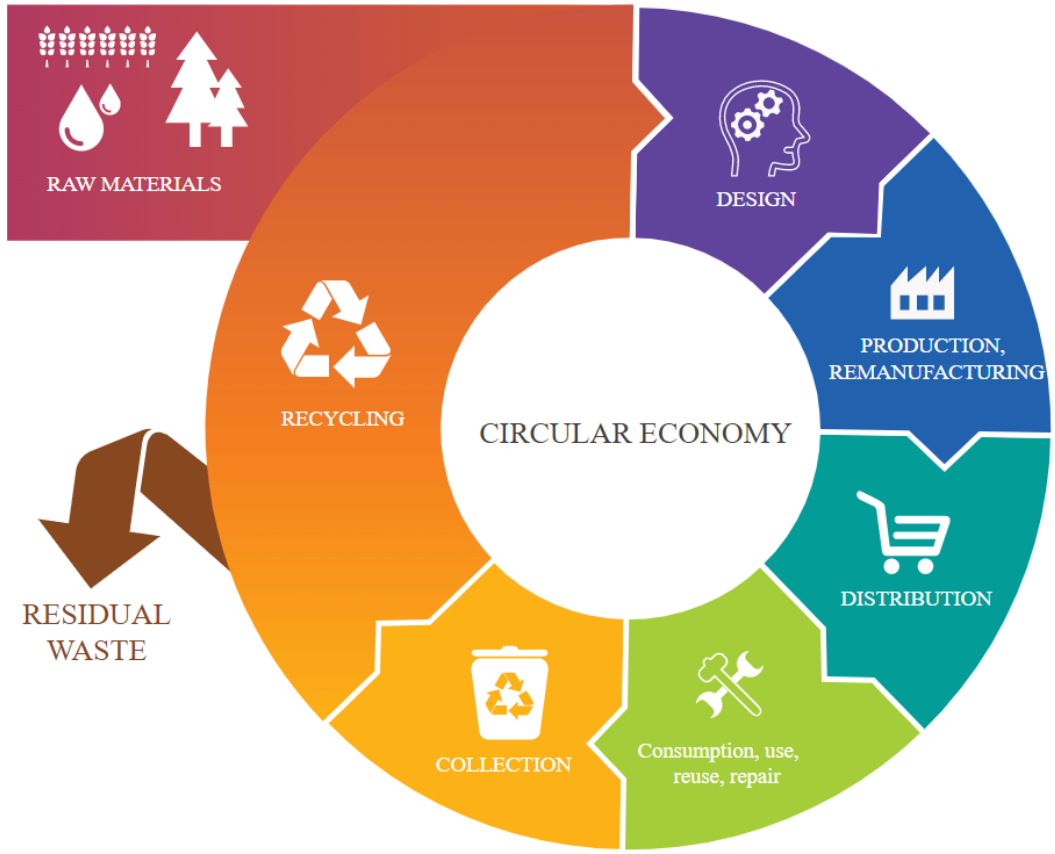


NRCan, 2022

Novel Sources

- To address increased demand for critical minerals, strategies are being geared toward generating a circular economy.

- Novel sources for critical minerals are also being considered. These include previously underexplored resources and waste materials.



European Parliament

#3

LITHIUM

Li

3 6.94

PRIMORDIAL

Hydrogen, helium and lithium were the only three elements produced during the Big Bang.

BATTERIES

Lithium-ion batteries are used as the power source for our mobile phones and laptops.

SOFT METAL

Lithium and the other metals in group 1 are so soft that they can be cut with a knife.

#IYPT2019

#60

NEODYMIUM

Nd

60 144.242

SPEAKERS

Alloys of neodymium, iron and boron make the magnets in microphones, headphones, and speakers.

TANNING BOOTHS

Neodymium is in the glass in tanning booths which allows UV light through while blocking infrared.

LASER SURGERY

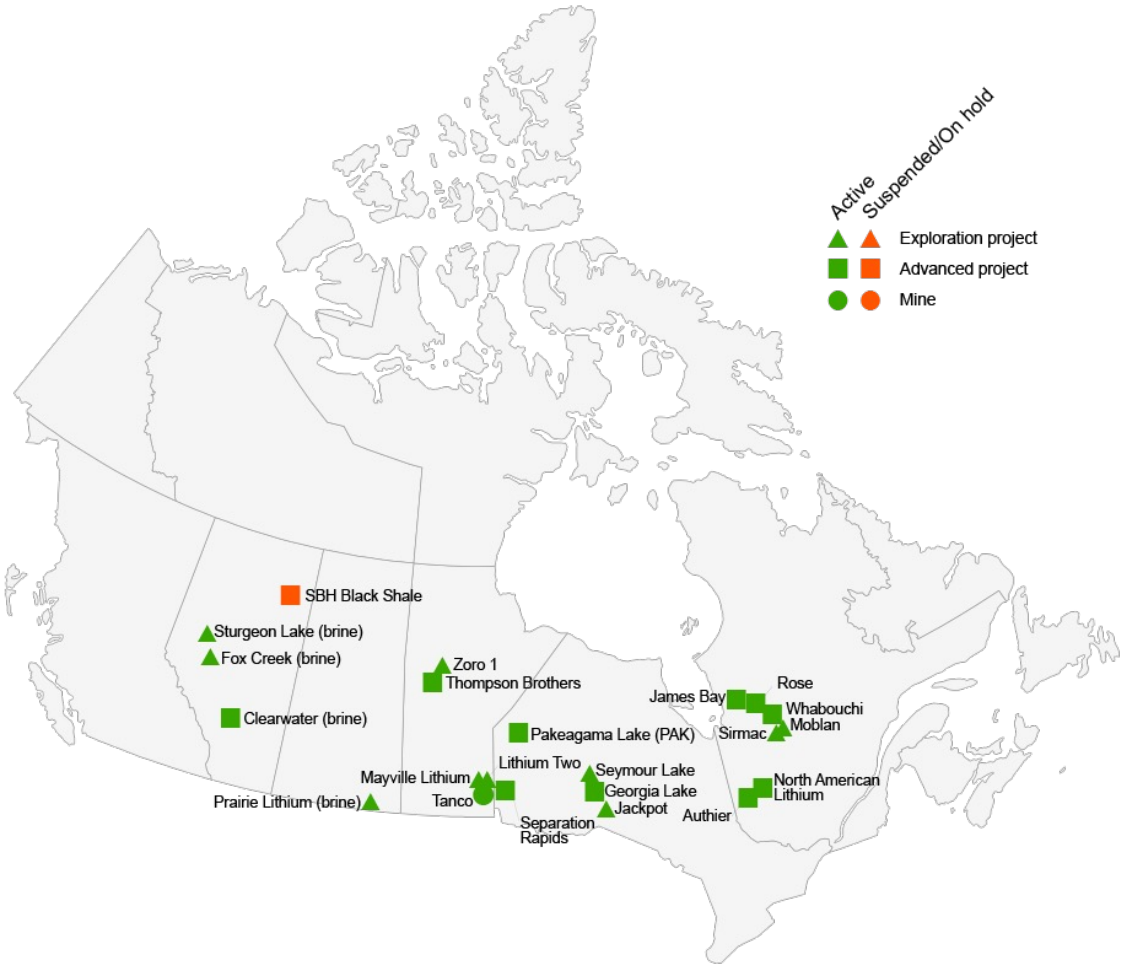
Neodymium glass is used to make lasers which are used in eye surgery and the treatment of skin cancers.

#IYPT2019

Lithium in Canada

- In western Canada, the exploration for and development of lithium projects is being focused on subsurface brines.

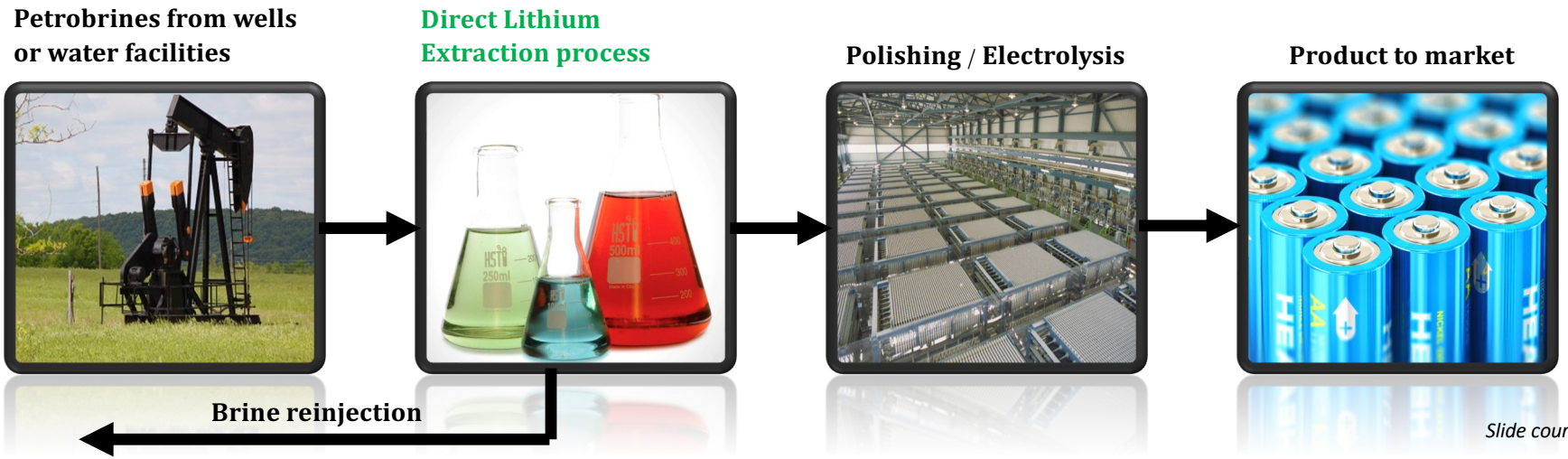
- These brines share similarities with salars in South America in that they have complex chemistries but have lower concentrations of lithium.



NRCan

Brine-hosted Li

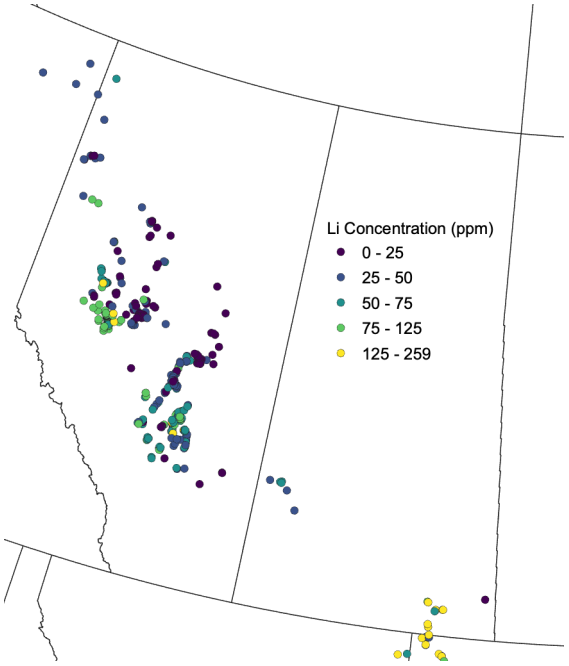
- The idea here is to extract Li from the brines through a direct lithium extraction (DLE) technology and return the brine to depth.
- An ideal DLE will have a high surface area, affinity for Li, and be re-usable. This will allow for efficient and rapid Li extraction.



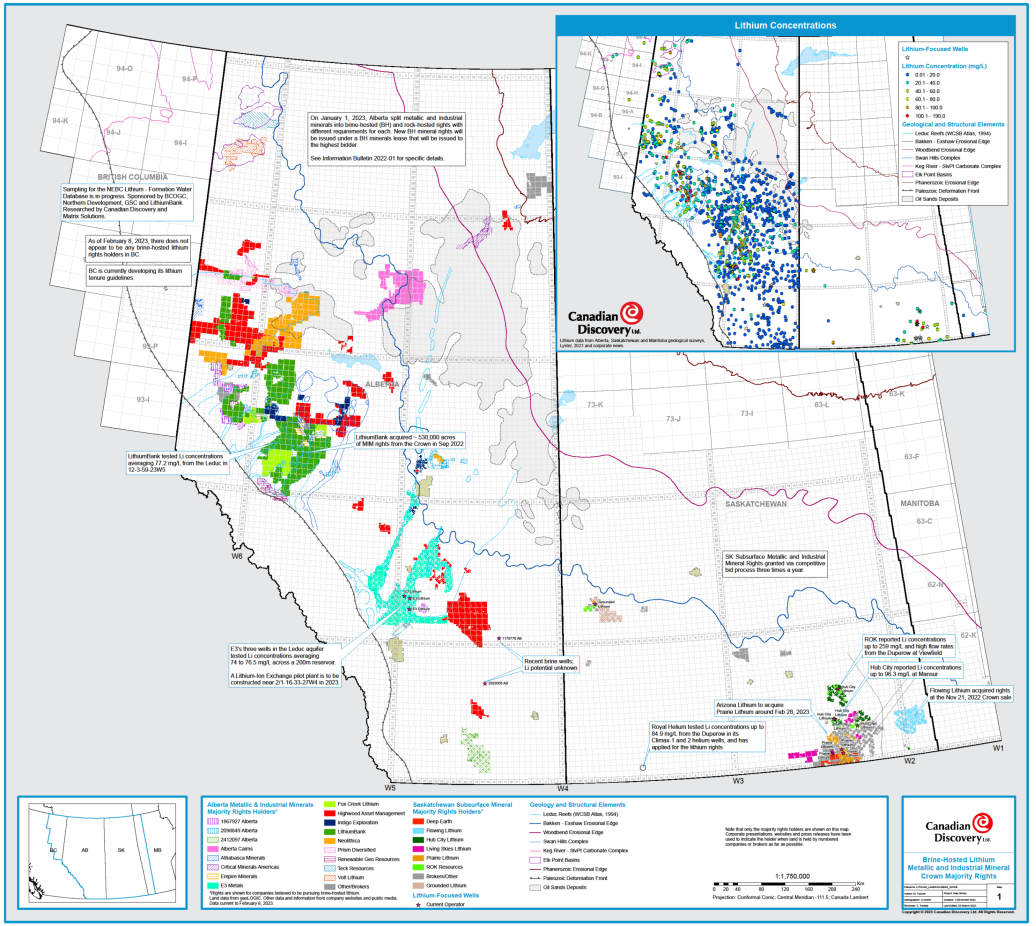
Slide courtesy of D. Alessi

Brine-hosted Li

Projects have mainly been guided by provincial sampling programs (i.e., SGS)



Data from AGS, SGS, U of A theses, industry press releases/43-101s

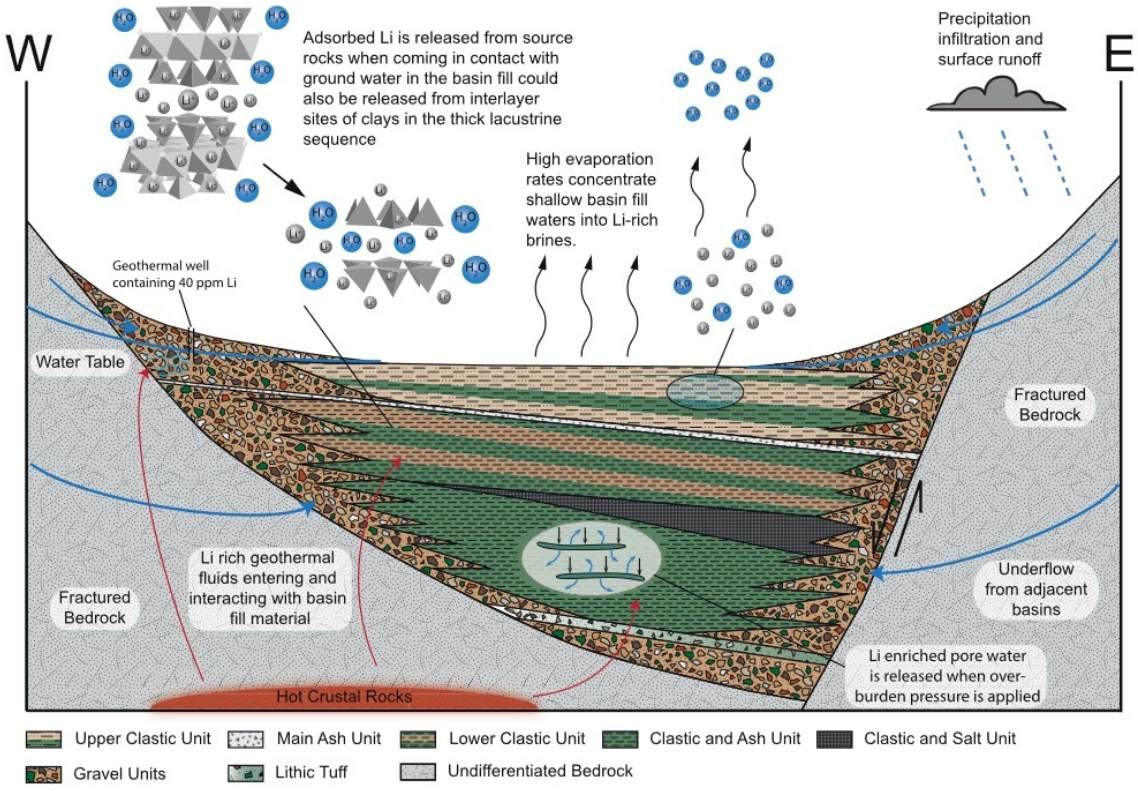


Courtesy of Canadian Discovery

Need for an exploration model

- One of the challenges to developing brine-hosted Li for DLE extraction is that we do not have an exploration model akin to petroleum systems.

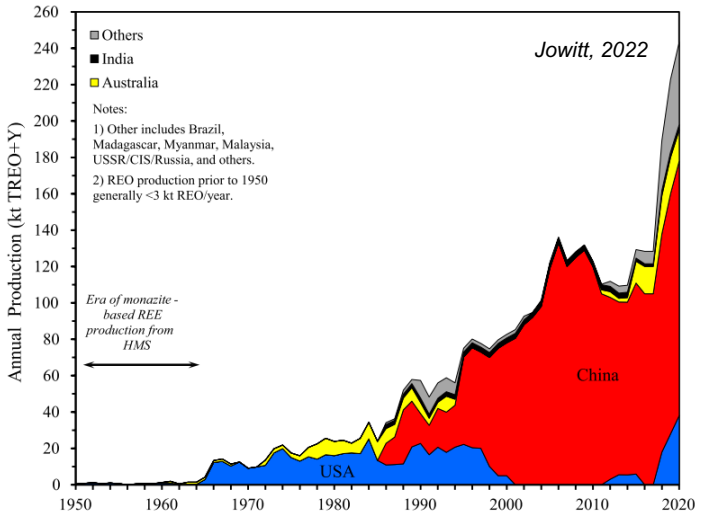
- This requires identifying the source and the mechanism of enrichment.

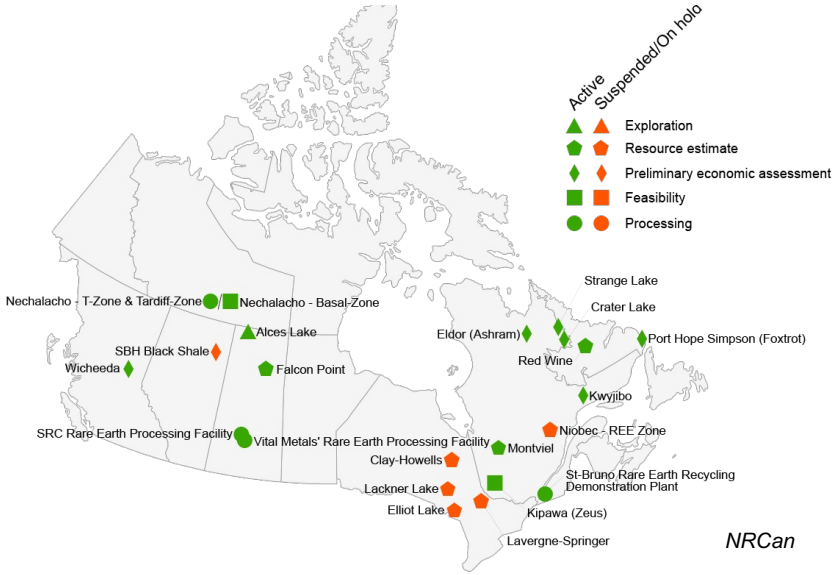


Coffey et al. (2021)

Rare Earth Elements

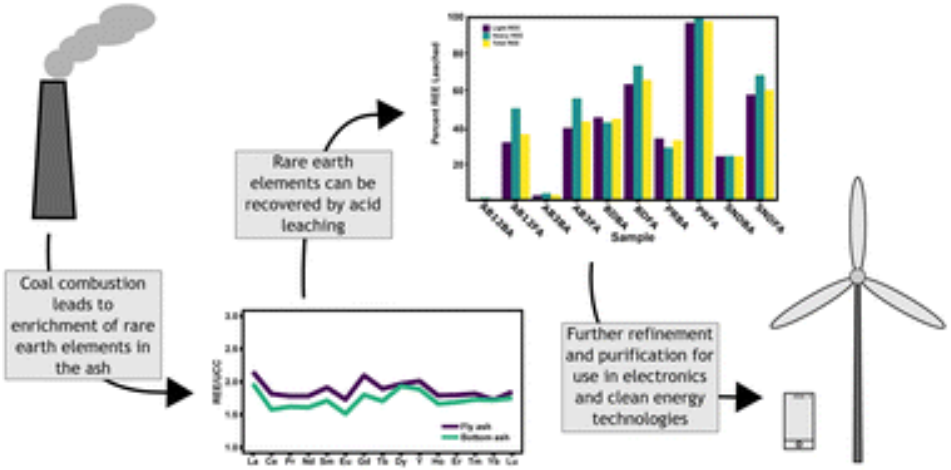
- Global production of REE is dominantly from a single country.
- Canada has several active or suspended exploration studies, but no active mines.
- To address increasing demand and a dominant single supplier, novel secondary sources may be required to address domestic supplies as traditional projects come on-line.



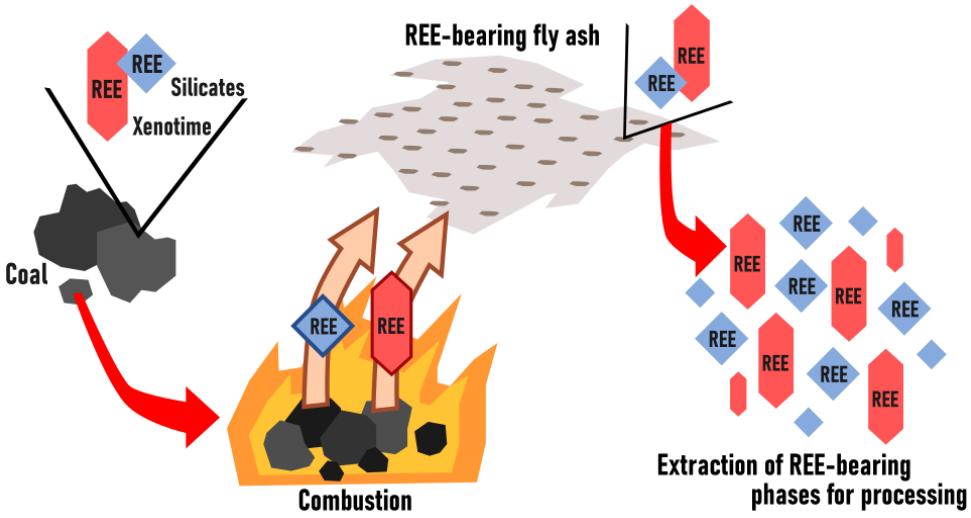


Coal Combustion By-products

- Coal combustion by-products (CCBs), such as fly-ash and bottom-ash, are a present waste stream that is being explored for its REE potential.
- This requires knowledge of how REE are bound in CCBs, and how this applies to designing efficient extraction processes.



Bishop et al. (2023)



Bishop et al., in review

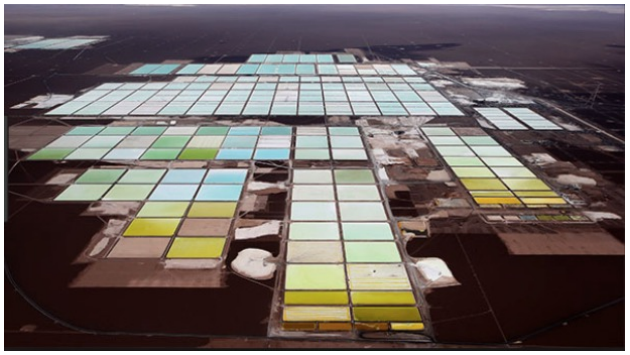
Social and Environmental Challenges

- Traditional mining operations tend to have large environmental footprints and may be associated with land disturbances, decreased biodiversity, significant water usage, and the generation of tailings.

- Novel sources may help address these issues while meeting increased demand.

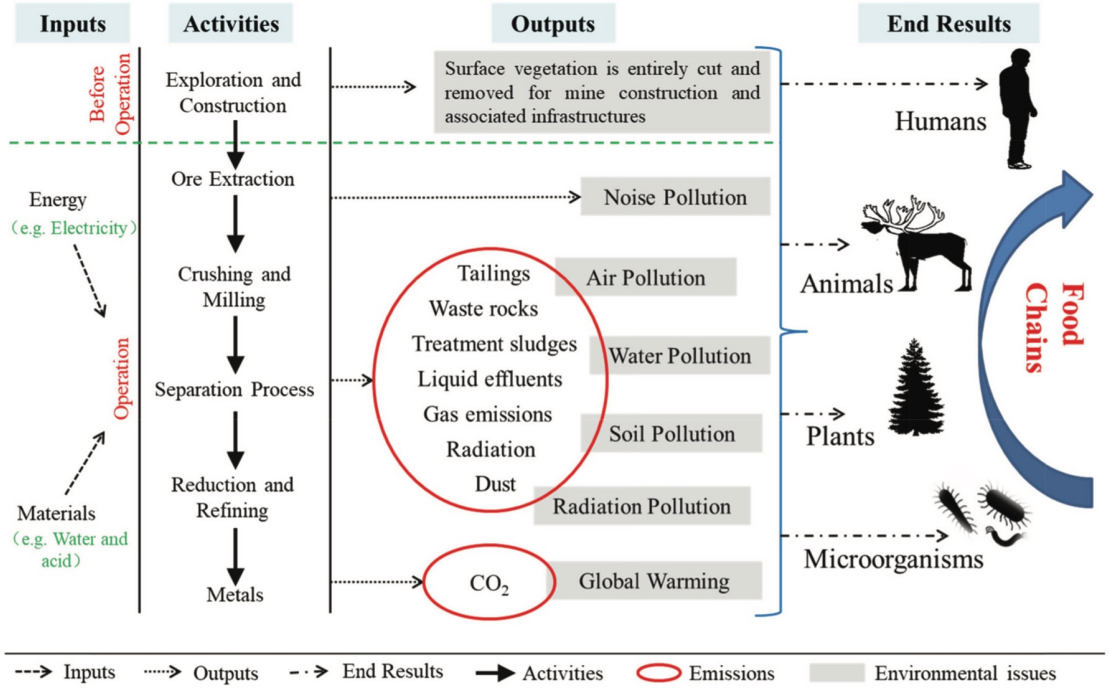
Bayan Obo, China

Salar de Atacama, Chile

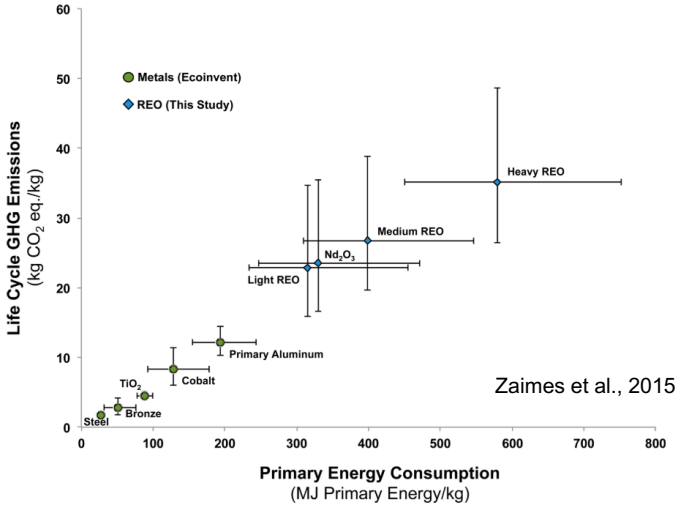


Greenbushes, Australia

Social and Environmental Challenges



Yin et al., 2021



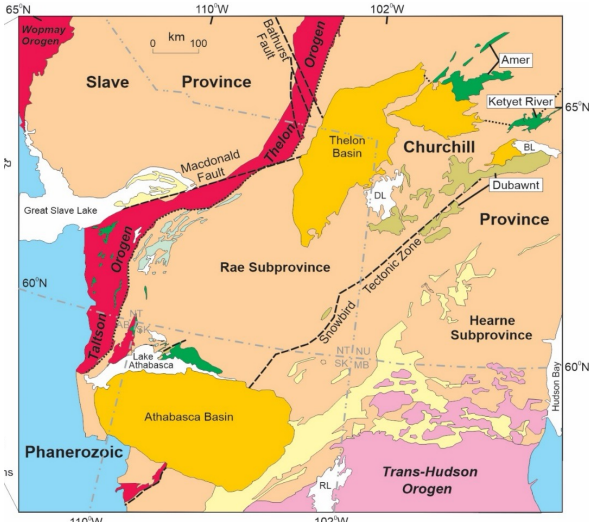
Zaimes et al., 2015

- Additional challenges come from the use of energy in producing the minerals needed for the net-zero transition, and the potential for downstream health effects.

Outlook

- Saskatchewan, and more broadly Canada, has significant potential to address increased demand for critical minerals (Li, REE, U, potash, etc.).
- Addressing this demand, however, will require innovation and insight to ensure it is done with environmental and social considerations in mind.
- This may include leveraging non-traditional sources (brines, CCBs, etc.) or how other efficiencies may be generated.

PC: L. Robbins



Ashton et al. (2013)