CRITICAL MINERALS: WHAT, HOW, WHY ALL THE HYPE?

September 21, 2022
THANK YOU TO OUR SPONSORS
PRESENTERS

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Critical Minerals Play a Vital Role in Our Modern Economy and National Security
The United States is more than 80% reliant on imports.
We Are in a Unique Position to Be at the Forefront of a Nascent Industry

Factors that position us for success:

1. Reputation and research expertise.
2. Mining and processing experience.
3. Unparalleled lignite coal resources and energy development.
4. State governments supportive of natural resource development.
5. Basinwide collaborations will provide expertise to answer key research questions.
Webinar Series Events

**Critical Minerals: What, How, Why All the Hype?**  
September 21, 2022

**Today’s Critical Mineral Technologies and How to Move Forward**  
November 30, 2022

**Why Do Critical Mineral Business in the Williston Basin?**  
Our Strengths, Our Assets, Our Needs  
January 11, 2023

**Securing the Williston Basin’s Critical Mineral Future:**  
Findings and Next Steps  
March 2023
BRUCE FOLKEDAHL

Senior Research Engineer, Critical Materials
Energy & Environmental Research Center
University of North Dakota
Defining Critical Minerals

Critical Minerals

Essential to our modern economy and national security.

Have a supply chain that is vulnerable to disruption.

Rare-Earth Elements (REEs)

- Not rare but found together.
- Chemically similar and difficult to separate.

Critical Minerals (CMs)

- Catch-all term for the critical minerals that are not REEs.
- No other common factor.
What Are the CMs?
CMs in the Electronics Industry

- Transistors
- Solar cells
- LEDs
- Lasers
- Fiber optics

United States has no domestic source of two elements critical to electronics manufacturing: gallium and germanium.
Lithium-Ion Battery Materials

- CMs in batteries of all sizes, from hearing aid to grid scale: lithium, cobalt, manganese, nickel, and graphite.
- Heavy growth in all elements with electric vehicle (EV) industry and possible grid-scale energy storage.
- Doubling every 3–5 years.
Ultrarare Precious Metals: The Platinum Group

Uses

- Catalysts (catalytic converters in cars).
- Electrolysis for hydrogen.
- Other small, nonreplaceable applications in industry, medicine, and electronics.
- Investment metals—all over $1000 per ounce.

Platinum group metals are more abundant in meteorites than rock ores.

- Six metals that occur together.
- Five are CMs: platinum, palladium, iridium, rhodium, and ruthenium.
- South African mines produce more that 60% of the global platinum group metals market.
REEs: The United States Is More than 80% Reliant on Imports

Phosphors
- Eu, Y, Tb, Nd, Er, Gd (Ce, Pr)
- Cathode Ray Tubes
- LCD Lighting
- Fluorescent Lighting
- Medical Imaging
- Lasers
- Fiber Optics

Magnets
- Nd, Pr (Tb, Dy)
- Motors
- Disk Drives
- MRI
- Power Generation
- Microphones and Speakers

Metallurgical Alloys
- Nickel–Metal–Hydride Batteries
- Fuel Cells
- Steel
- Lighter Flints
- Super Alloys
- Aluminum/Magnesium

Catalysts
- La, Ce (Pr, Nd)
- Petroleum Refining
- Catalytic Converter
- Diesel Additives
- Chemical Processing
- Industrial Pollution
- Scrubber

Glasses and Polishing
- Ce, La, Pr, Nd, Gd, Er, Ho
- Polishing Compounds
- Decolorizers/Colorizers
- UV-Resistant Glass
- X-Ray Imaging

Other
- Water Treatment
- Pigments (Ce, Y)
- Fertilizers

Ceramics
- La, Ce, Pr, Nd, Y
- Eu, Gd, Lu, Dy
- Capacitors
- Sensors
- Colorants
- Scintillators
- Refractories

Defence
- Nd, Pr, Dy, Tb, Eu, Y, La, Lu, Sc, Sm

REEs: The United States Is More than 80% Reliant on Imports
REEs and National Security

Amount of REEs to Produce One Military Vehicle

F-35: 920 lbs.
Arleigh Burke DDG-51: 5,200 lbs.
SSN-774 Virginia-class Submarine: 9,200 lbs.

Source: Congressional Research Service
What resources do we have?
What Has North Dakota to Offer?

• World’s largest lignite deposit: 350 billion tons.
• Best identified coal seams.
• Some have high REE concentrations.
• The Harmon–Hanson coal seam in North Dakota has the potential to hold significant quantities of REEs.
What Has Montana to Offer?

- Less characterized coal seams.
- Montana Tech’s work on mapping coal seams has been a valuable source.

Photo by Marguerite, from Flickr
What Has South Dakota to Offer?

- No active coal mines.
- Needs characterization.
- Sample collection is planned.
Other Domestic REE Sources

Unintended production of REEs associated with U.S. coal mining potentially exceeds 40,000 tons annually. Of that, heavy REEs may exceed 10,000 tons annually.*


The U.S. uses approximately 6000 tons annually.
Elements with Greatest Potential to Contribute to the Williston Basin Market
Developing New Sources and Innovative Ways to Extract CMs and REEs

Existing Lignite Coal Mines

Produced Water

ND Shales: Pierre, Niobrara, Upper and Lower Bakken

Deep Unminable Coal Seams by In Situ Extraction
Coal Mining and CM Recovery Synergy

- Mining costs
- Transportation costs
- Processing costs: crushing and grinding

Potential for value-added recovery of CMs
Opportunity for the Williston Basin

Current
- Mining Operations
- Separation
- Intermediary Form
- Metal
- Alloy
- Consumer Goods

Generally Outside the United States
Limited U.S. Production
Inside the United States for Specific Applications

Possible Future
- Mining Operations
- Separation
- Intermediary Form
- Metal
- Alloy
- Consumer Goods

Conducted in the Williston Basin Region
Expanded U.S. Production
Inside the United States for Specific Applications
RYAN ELLISON

Founder, Director of Investor Relations and Business Development
Dakota Lithium
Vision for the lithium-battery supply chain by 2030, the United States and its partners will establish a secure battery materials and technology supply chain that supports long-term U.S. economic competitiveness and equitable job creation, enables decarbonization, advances social justice, and meets national security requirements.
Battery development and production are strategically important for the United States, both as part of the transition to a clean energy economy and as a key element of the competitiveness of the automotive industry.
MIDSTREAM
- Additional processing for battery-grade materials
- Cathode/anode powder production
- Separator production
- Electrolyte production
- Electrode and cell manufacturing

DOWNSTREAM
- Pack manufacturing
- End-of-life recycling and reuse

Electric Vehicles
Stationary Storage
National Defense
Aviation
# Missing Link – Battery Cathode Manufacturing

<table>
<thead>
<tr>
<th>Country</th>
<th>Cathodes Manufacturing (3 M tons)</th>
<th>Anode Manufacturing (1.2 M tons)</th>
<th>Electrolyte Solution Manufacturing (339,000 tons)</th>
<th>Separator Manufacturing (1,987 M sq. m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>United States</td>
<td>—</td>
<td>10%</td>
<td>2%</td>
<td>6%</td>
</tr>
<tr>
<td>China</td>
<td>42%</td>
<td>65%</td>
<td>65%</td>
<td>43%</td>
</tr>
<tr>
<td>Japan</td>
<td>33%</td>
<td>19%</td>
<td>12%</td>
<td>21%</td>
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<tr>
<td>Korea</td>
<td>15%</td>
<td>6%</td>
<td>4%</td>
<td>28%</td>
</tr>
<tr>
<td>Rest of World</td>
<td>10%</td>
<td>—</td>
<td>17%</td>
<td>2%</td>
</tr>
</tbody>
</table>

Carbon Ore, Rare Earth, and Critical Minerals Initiative (CORE-CM)

U.S. Department of Energy (DOE) National Energy Technology Laboratory (NETL)-Led Program

- Catalyze economic growth.
- Job creation in energy communities.
- Energy communities not to be left behind.
- Domestic production of REEs and CMs.
- Strengthen our national economy and security.
13 CORE-CM Initiative Teams

US BASINS
1. Appalachian Basin, North
2. Appalachian Basin, Central
3. Appalachian Basin, South
4. San Juan River-Raton Basin
5. Illinois Basin
6. Williston Basin
7. Powder River Basin
8. Uinta Basin
9. Green River-Wind River Basin
10. Gulf Coast Basin
11. Alaska Basin
12. Cherokee-Forest City Basin
13. Mid-Appalachian Basin

Source: NETL
Williston Basin CORE-CM Project Team

UND Energy & Environmental Research Center
UND Institute for Energy Studies
UND Nistler College of Business & Public Administration
Pacific Northwest National Laboratory
North Dakota State University
Montana Tech University
Critical Materials Institute (Ames)
Basin Electric Cooperative
BNI Energy
Current Lighting Solutions
General Atomics
Illinois Geological Survey CORE-CM Team
Lignite Energy Council
Minnkota Power Cooperative

NDIC Lignite Research Program
North American Coal
North Dakota Department of Commerce
North Dakota Geological Survey
North Dakota Governor’s Office
Northrup Grumman
Semplastics
South Dakota Geological Survey
U.S. Geological Survey
University of Alaska CORE-CM Team
University of Utah CORE-CM Team
Western Dakota Energy Association
Wyoming School of Energy Resources CORE-CM Team
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Critical Minerals – Why All the Hype?

Vital roles in our modern economy and national security.

Imported commodities that are vulnerable to supply chain disruptions.

Found in Williston Basin lignite and waste streams.

Williston Basin has potential to become a regional hub.
Webinar Series Events – Watch Your Email for Future Invites!

Today’s Critical Mineral Technologies and How to Move Forward
November 30, 2022

Why Do Critical Mineral Business in the Williston Basin?
Our Strengths, Our Assets, Our Needs
January 11, 2023

Securing the Williston Basin’s Critical Mineral Future:
Findings and Next Steps
March 2023
Opening Reception
Monday, October 10, 2022
5:30 – 7:30 p.m.
Northern Lights Atrium
North Dakota Heritage Center

Keynote Speaker
President Andrew Armacost
University of North Dakota

Topic
The Initiative’s importance to North Dakota and the Department of Defense

Symposium
Tuesday, October 11, 2022
10:00 a.m. – 3:00 p.m.
Bavendick Stateroom
National Energy Center of Excellence

Keynote Speaker
Commissioner Randy Christmann
North Dakota Public Service Commission

Topic
Bolstering the region’s economic future with lignite resources

Join Us in Bismarck!
Free admission.
Scan the QR code to register.
This event will not be recorded!
Questions?
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