Energy & Environmental Research Center (EERC)

Williston Basin CORE-CM Initiative

DE-FE0032060

John P. Kay
Energy & Environmental Research Center

U.S. Department of Energy
National Technology Laboratory
Resource Sustainability Project Review Meeting
April 2 – 4, 2024

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Project Overview

- DOE – $1,500,000 + $500,000 additional
- North Dakota Industrial Commission Lignite Research Program – $875,000
- North American Coal Corporation – $75,000
- BNI Energy – $75,000
- Minnkota Power Cooperative – $25,000
- Basin Electric Power Cooperative – $25,000
- Total – $3,075,000

- Period of Performance: October 2021 – June 2024 (33 months)

Williston Basin CORE-CM Project Team

Project Team

UND Energy & Environmental Research Center
UND College of Engineering & Mines Research Institute
UND Nistler College of Business & Public Administration
Pacific Northwest National Laboratory
North Dakota State University
Montana Tech University

Sponsors

U.S. DOE National Energy Technology Laboratory
NDIC Lignite Research Program
Basin Electric Cooperative
BNI Energy
Minnkota Power Cooperative
North American Coal Corporation
Critical Materials Institute (Ames)
Current Lighting Solutions

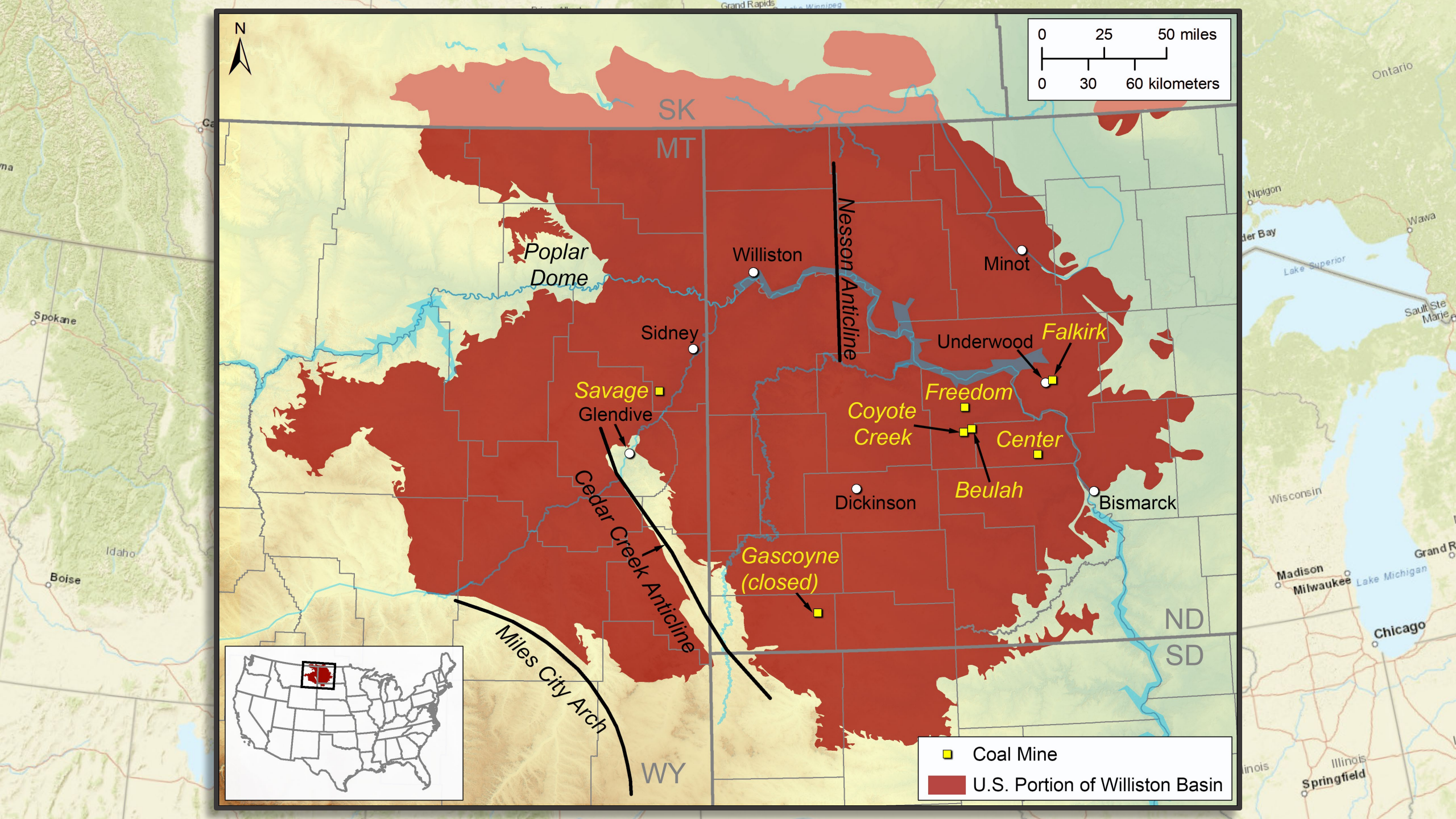
CORE-CM
WILLISTON BASIN

In Collaboration With

Lignite Energy Council
North Dakota Department of Commerce
North Dakota Governor's Office
Semplastics
Western Dakota Energy Association
North Dakota Geological Survey
South Dakota Geological Survey
Illinois Geological Survey CORE-CM Team
University of Alaska CORE-CM Team
University of Utah CORE-CM Team
Wyoming School of Energy Resources CORE-CM Team

Objectives

Building partnerships; assessing resources, markets, and infrastructure; identifying data gaps; and establishing potential technology and business development pathways. Anticipated project outcomes include a database of known CM resources, e.g., coal deposits and waste streams; plans to address infrastructure and supply chain gaps; recommendations for CORE-CM technology development; and technology training and outreach plans.


N
0 25 50 miles
0 30 60 kilometers
SK
MT
ND
SD
WY
Poplar Dome
Williston
Nesson Anticline
Minot
Sidney
Underwood
Falkirk
Savage
Glendive
Freedom
Coyote Creek
Center
Beulah
Dickinson
Bismarck
Gascoyne (closed)
Cedar Creek Anticline
Miles City Arch
Coal Mine
U.S. Portion of Williston Basin

IDENTIFY, CHARACTERIZE, AND ASSESS

Assessment of Resources

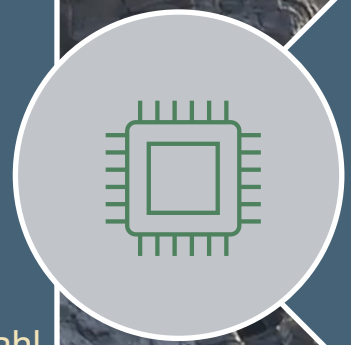
Task Lead: Ian Feole

Strategies for Infrastructure, Industries, and Business

Task Lead: Jason Laumb

Strategies for Waste Stream Reuse

Task Lead: Bruce Folkedahl



Technology Innovation Centers

Task Lead: Bruce Folkedahl

Technology Assessment, Development, and Field Testing

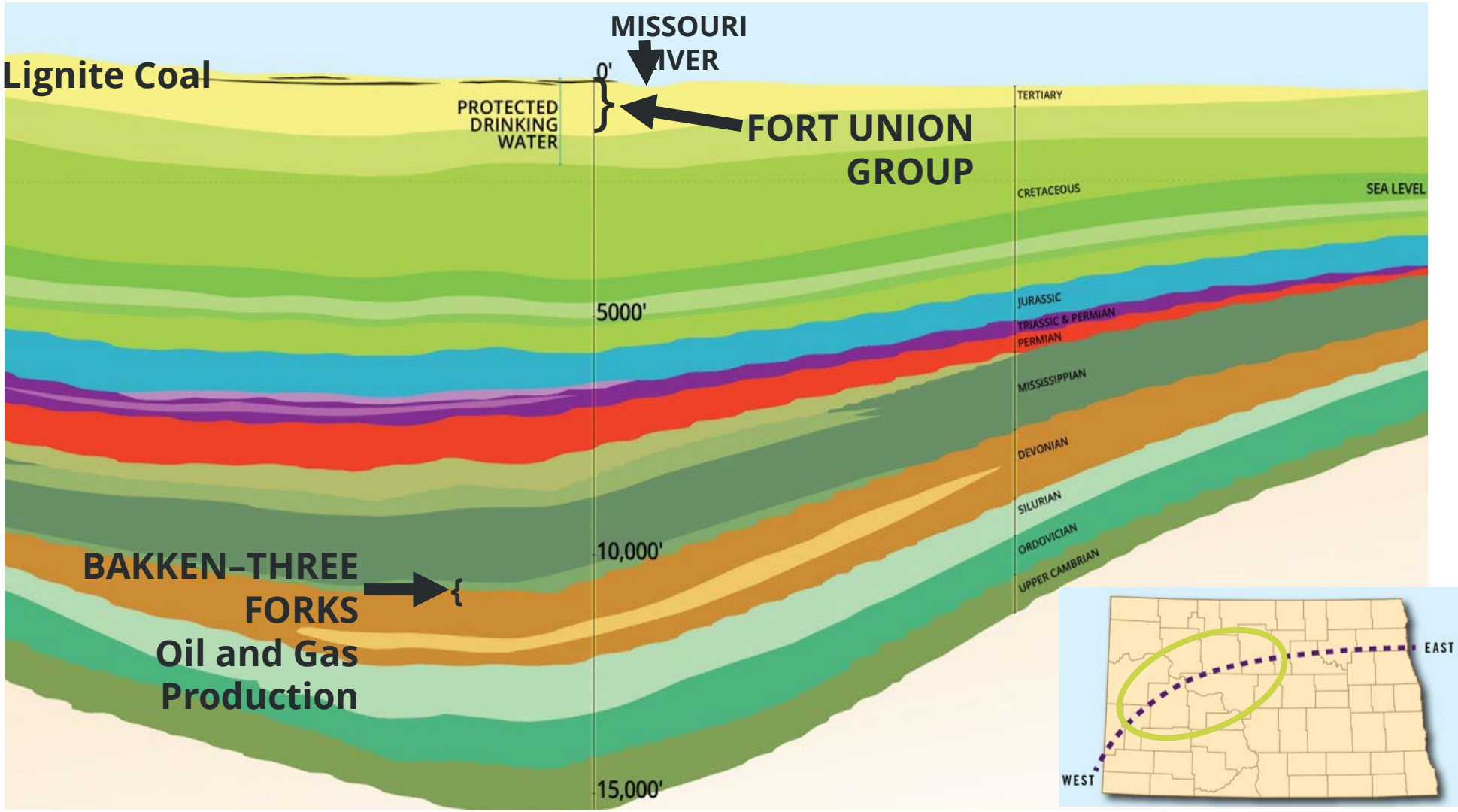
Task Lead: Nolan Theaker

Stakeholder Education and Outreach

Task Lead: Charlene Crocker

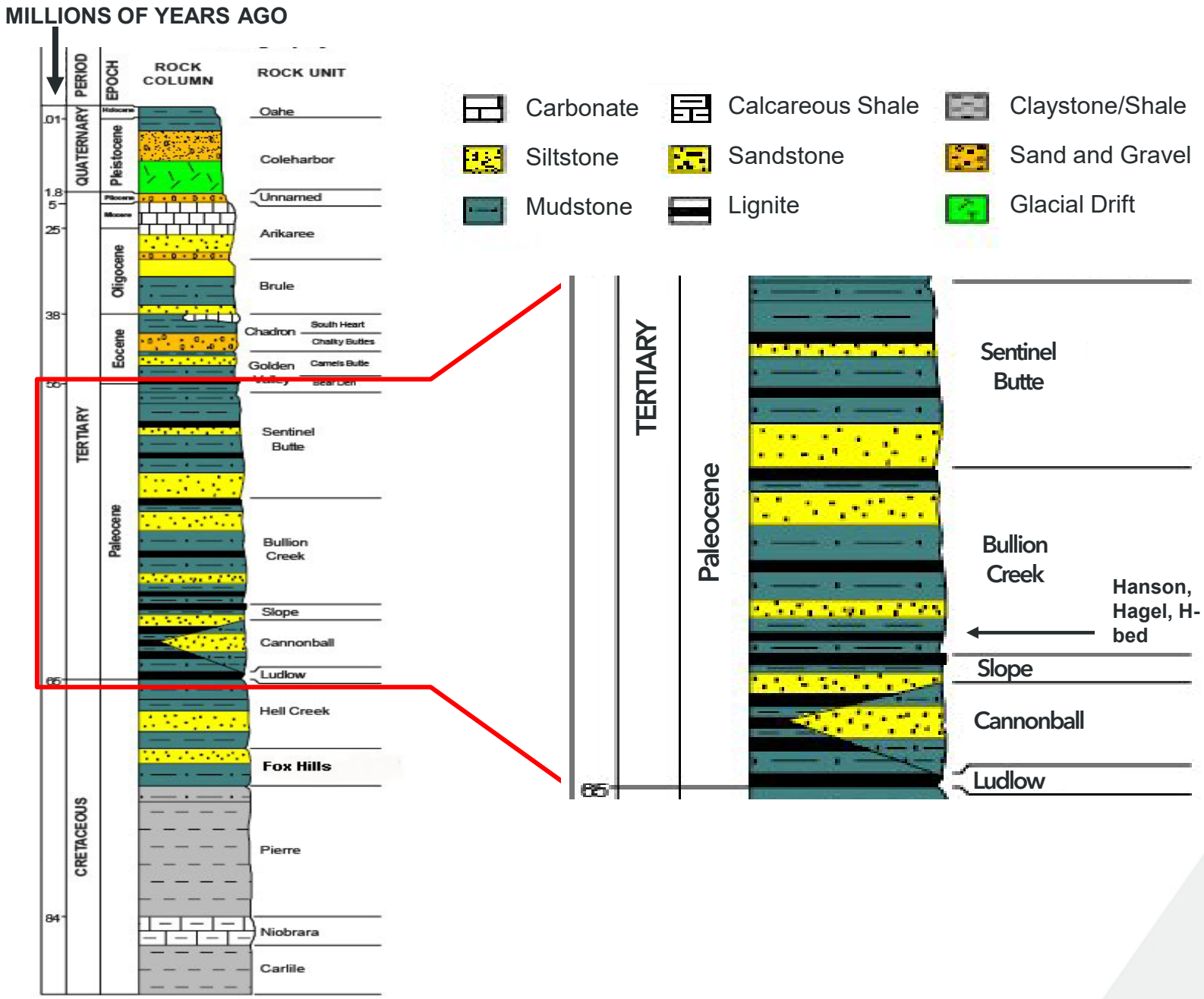
Lignite Coal and Waste Streams

North Dakota Williston Basin Cross Section



North Dakota Stratigraphy

- Most coal samples were collected from the **Fort Union Group.**
- Coal depths from surface outcrops to hundreds of feet deep.



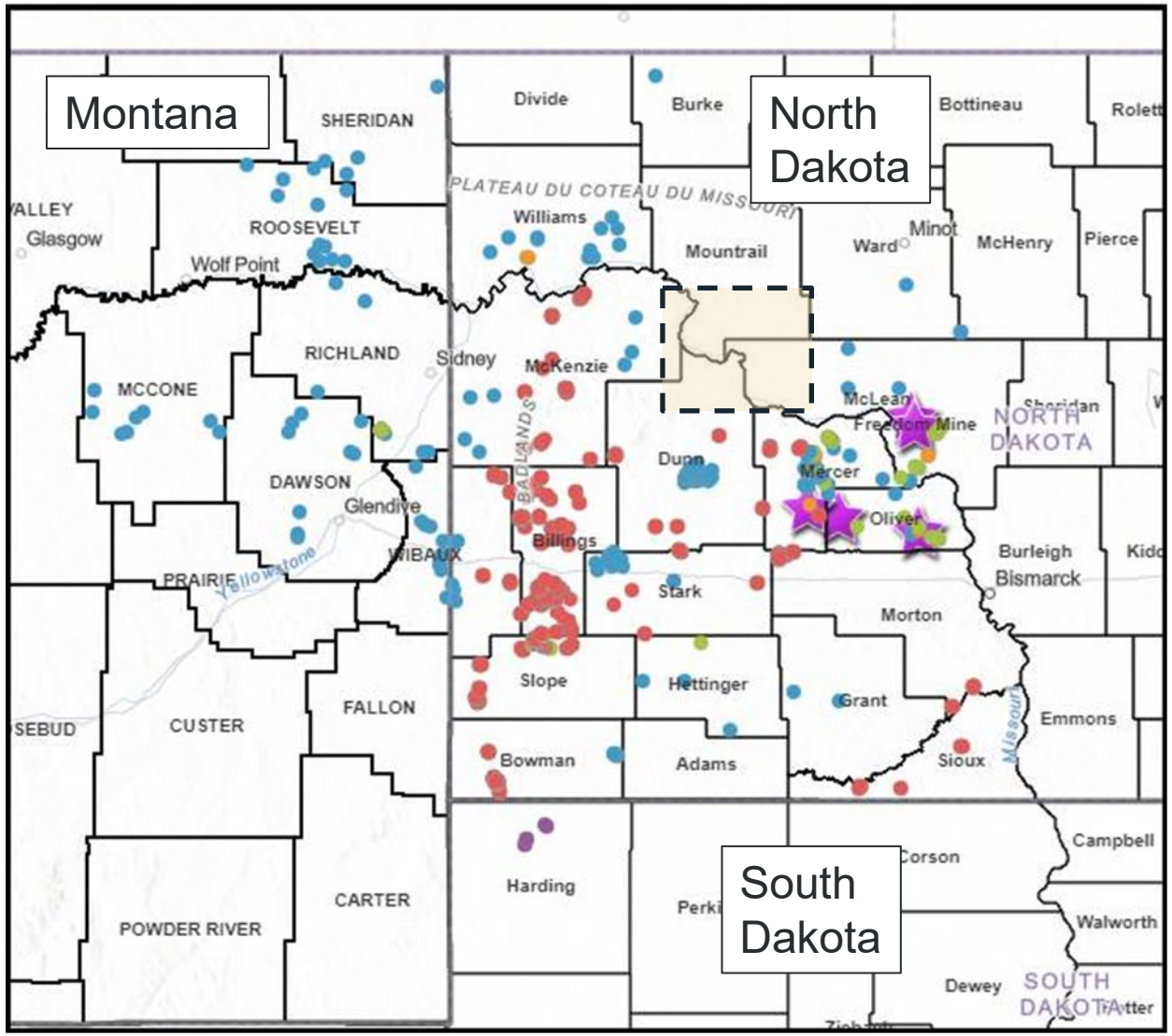
Data Sources: Critical Mineral Concentrations in Williston Basin Coals

- North Dakota Geologic Survey (NDGS)
  - Bulk of the data and most recent data
- Energy & Environmental ResearchCenter (EERC)
- UND College of Engineering and Mines Research Institute (CEMRI)
- COALQUAL Database (USGS)
  - Whole seam mixing
  - Older lab technology

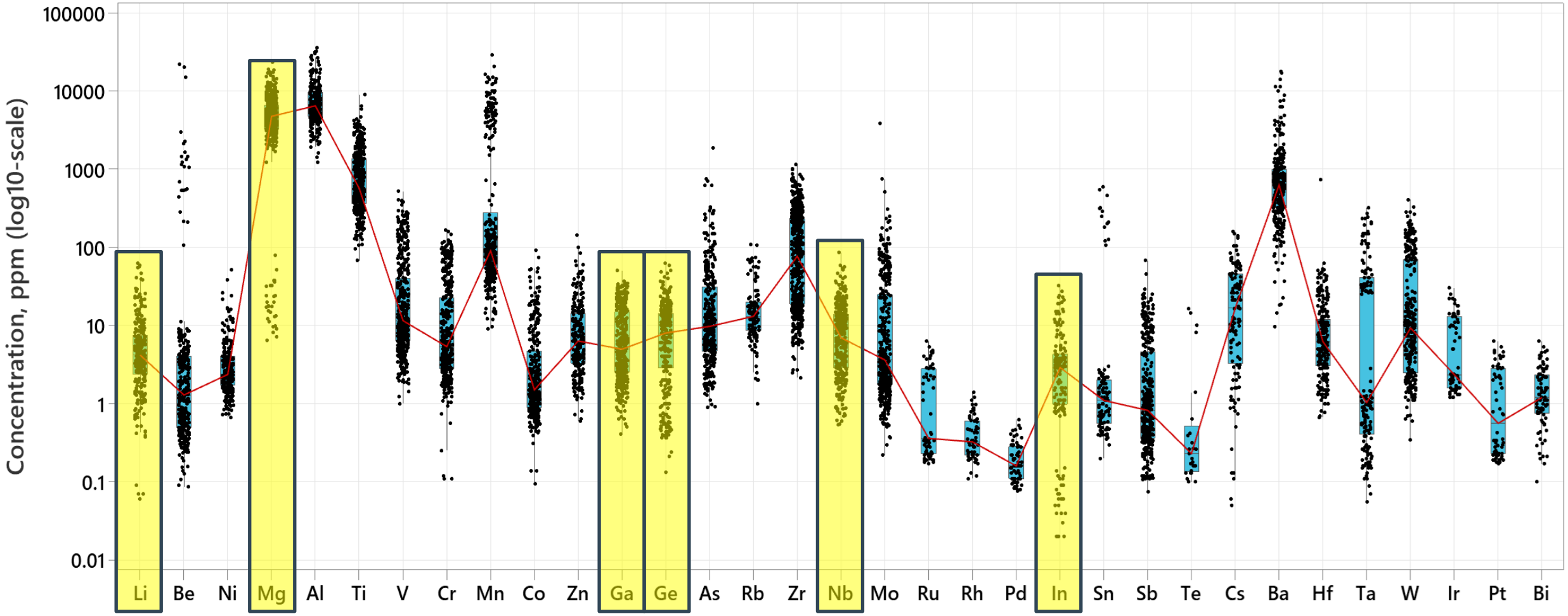
Core Samples Collected

State	Mine	Number of Samples
North Dakota	BNI	58
	NACC	71
South Dakota		14
Montana		29
	Total	172

Data Locations



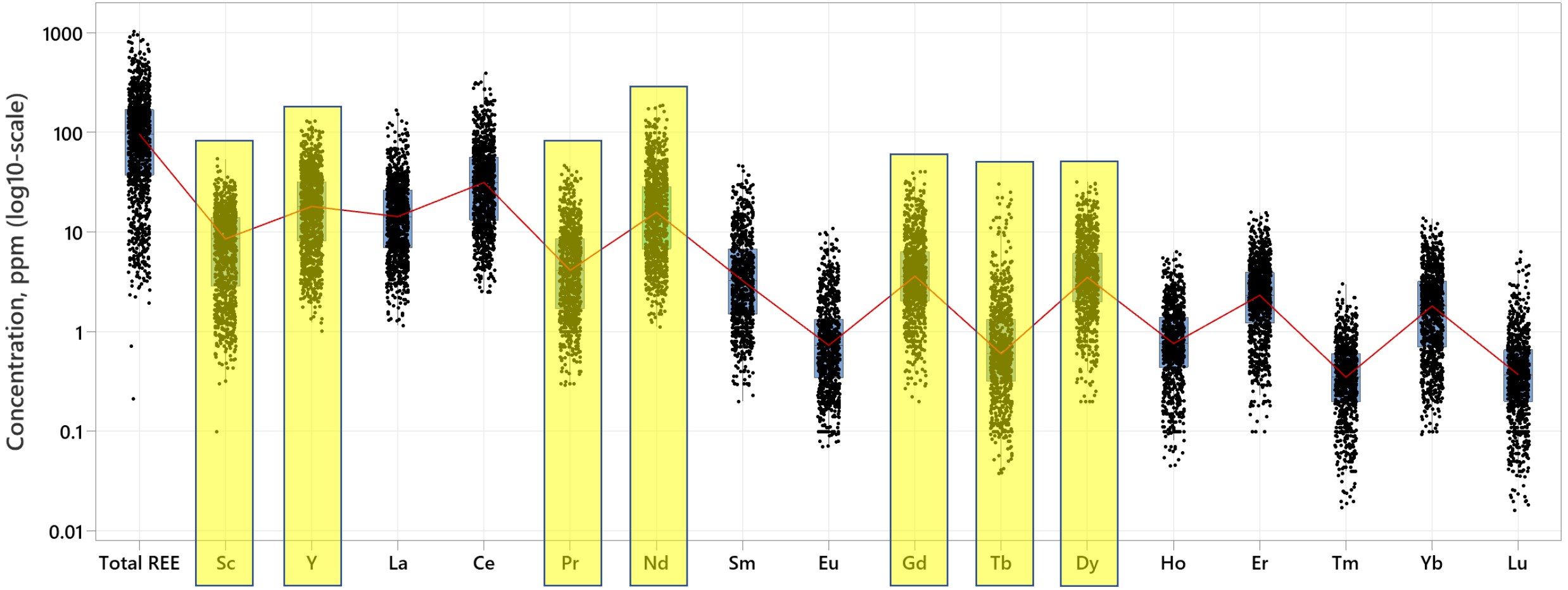
CM Concentrations Found in Williston Basin Lignite



High-Value CMs (demand and price)

Li – Lithium
Mg – Magnesium
Ga – Gallium
Ge – Germanium
Nb – Niobium
In – Indium

REE Concentrations Found in Williston Basin Lignite



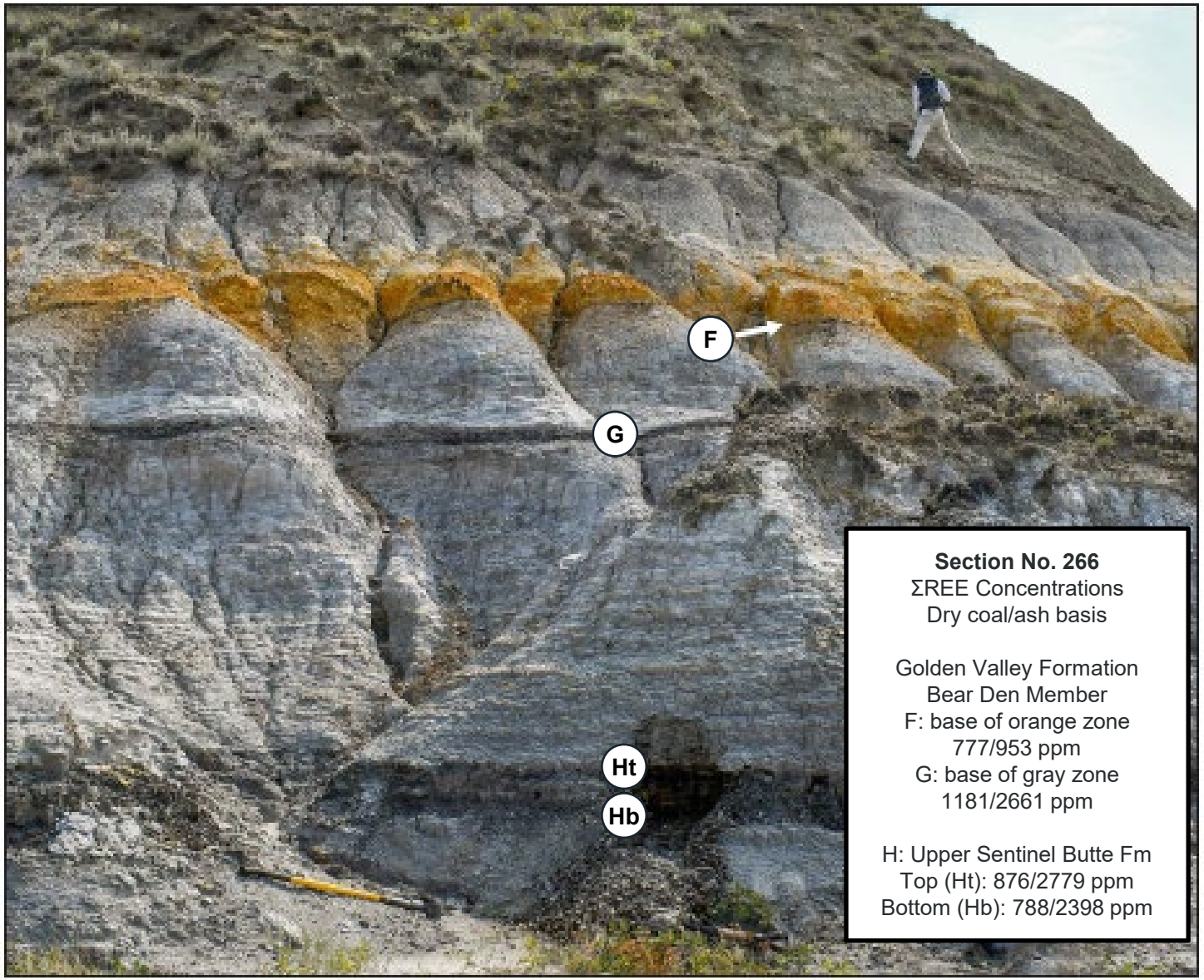
High-Value REEs (demand and price)

Sc – Scandium
Y – Yttrium
Pr – Praseodymium
Nd – Neodymium
Gd – Gadolinium
Tb – Terbium
Dy – Dysprosium

Recent Samples from NDGS

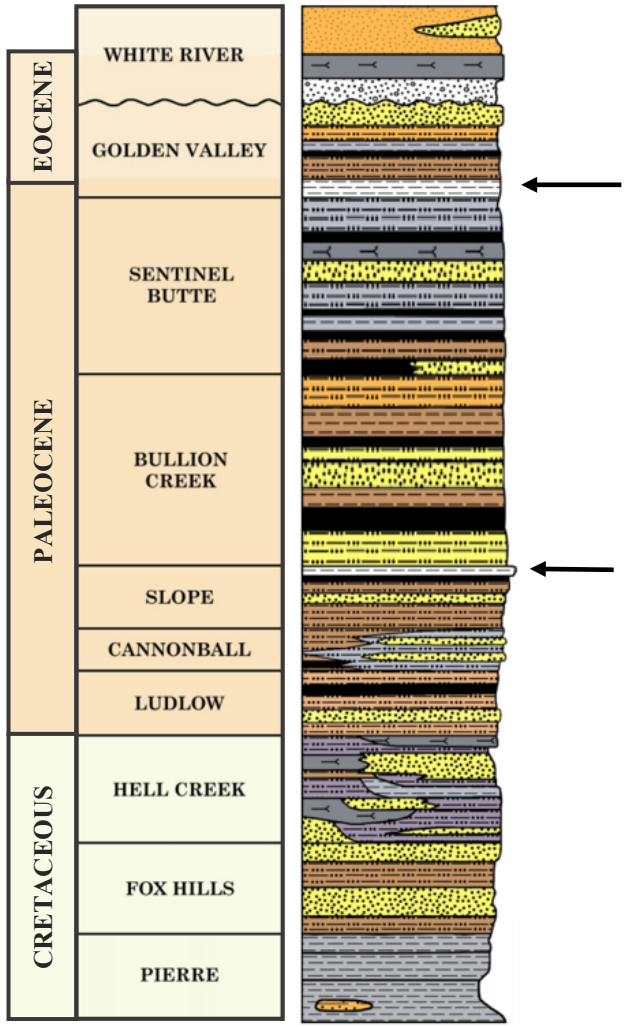
Bear Den Member of the Golden Valley Formation, Southwest North Dakota

Showing consistently high REEs and CMs.

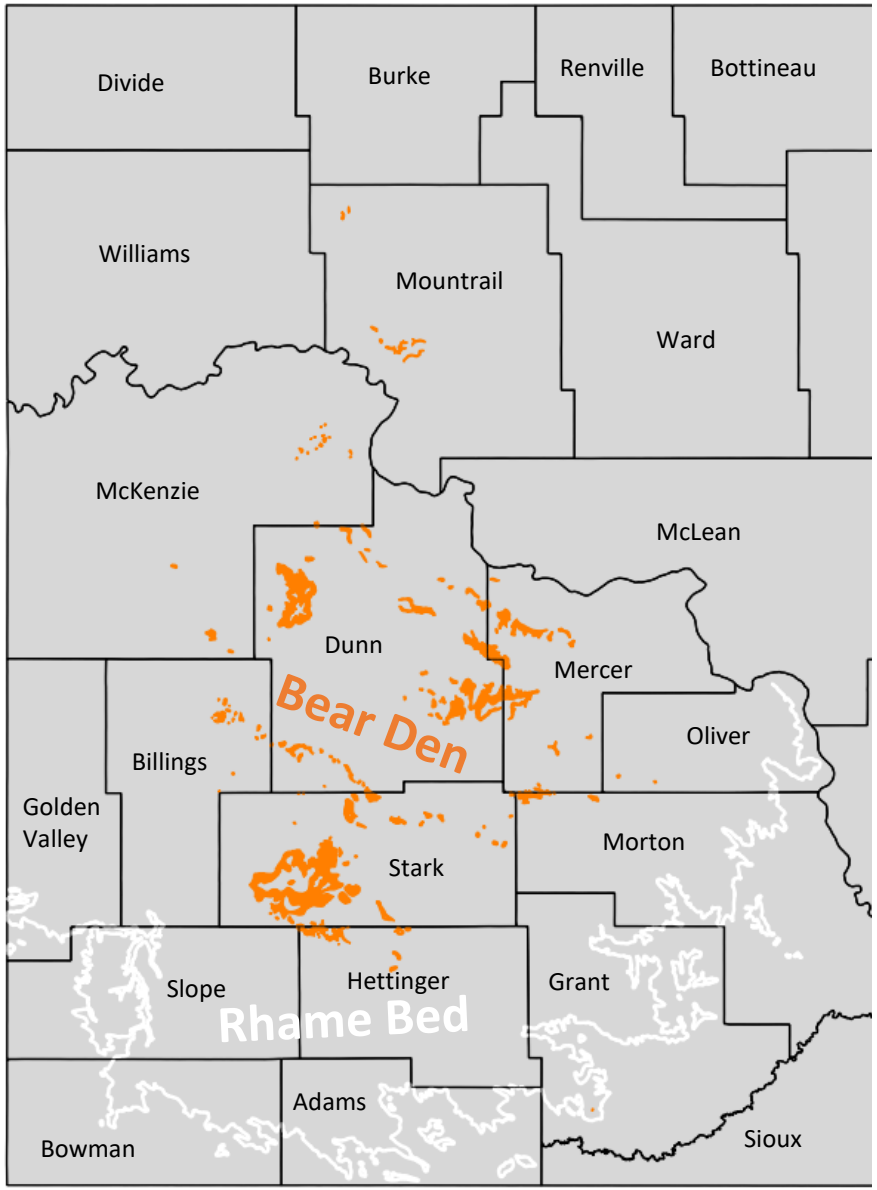


Report of Investigation No. 133 North Dakota Geological Survey; Edward C. Murphy, State Geologist; Lynn D. Helms, Director Dept. of Mineral Resources, 2023.

ND Stratigraphic Column



Western North Dakota



Courtesy of the North Dakota Geologic Survey

NETL Core Analysis

Acknowledgement:

Thomas Paronish
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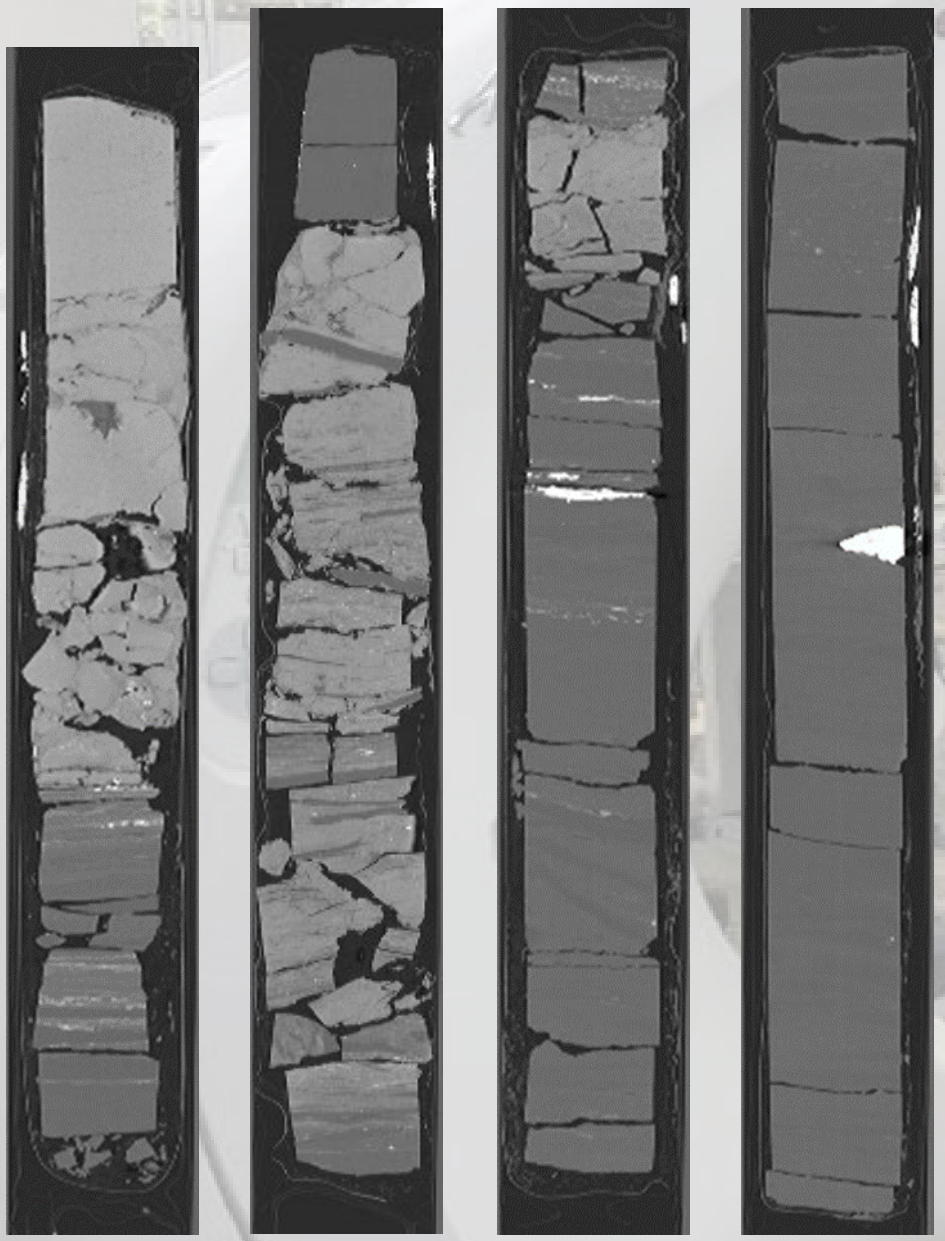
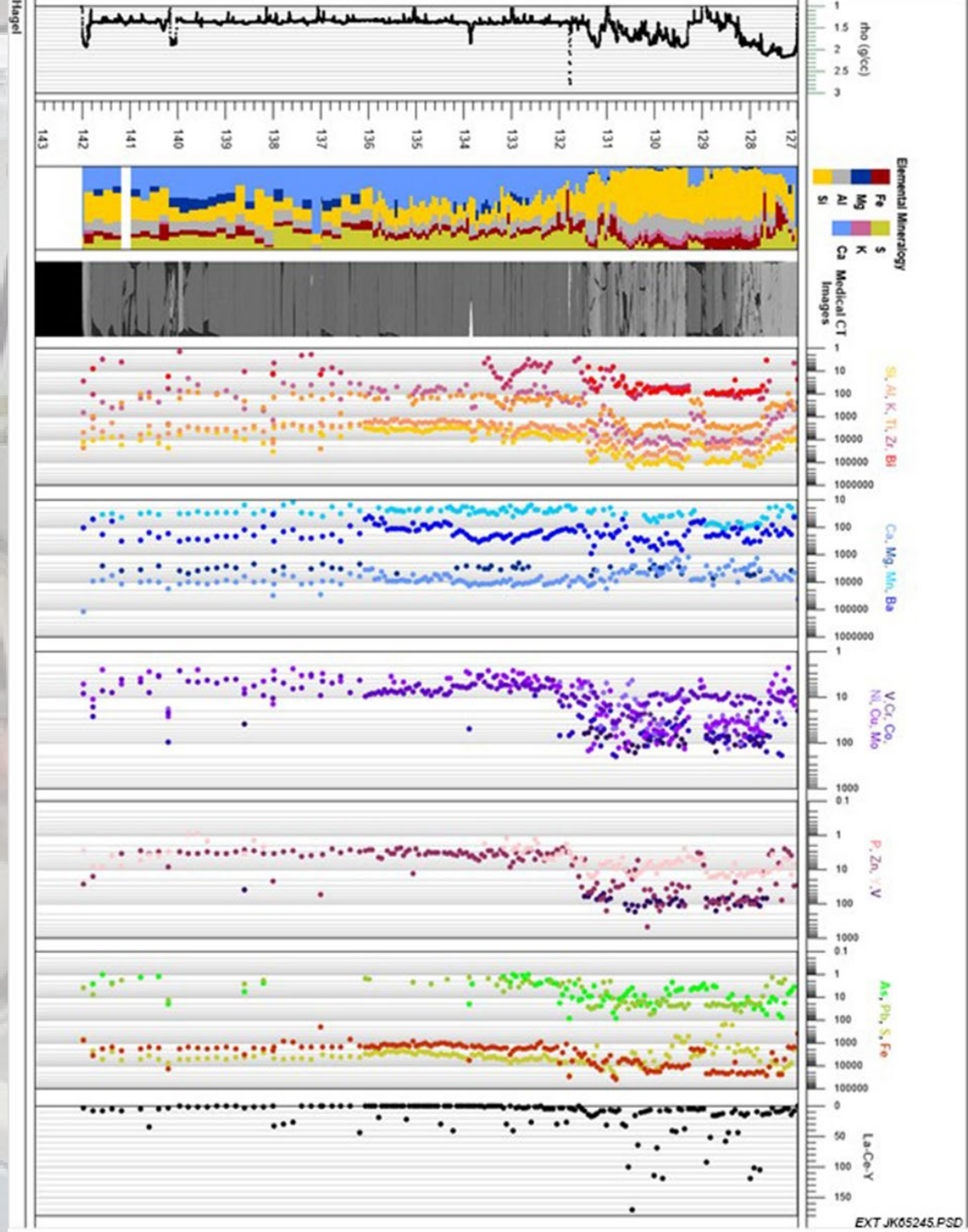
Jessica Drosche
Mathias Pohl
Terry Mckisic

NETL and NETL Support Contractor

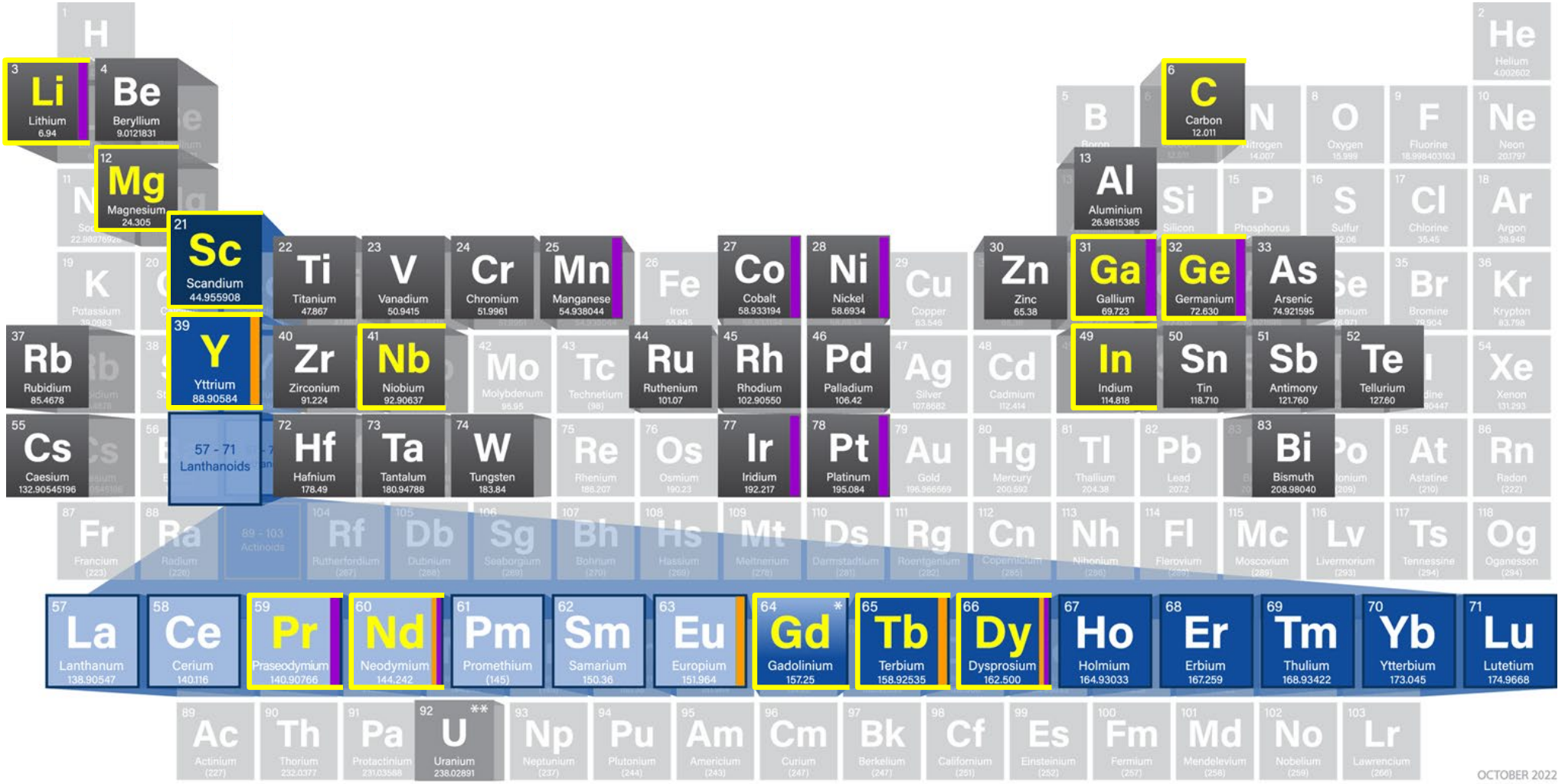




Elements with Greatest Potential to Contribute to the Williston Basin Market

Legend

- CM
- Light REE
- Heavy REE
- Critical REE
- Critical for Clean Energy Supply Chains
- Fuel Material
- C — Williston Basin Market Potential

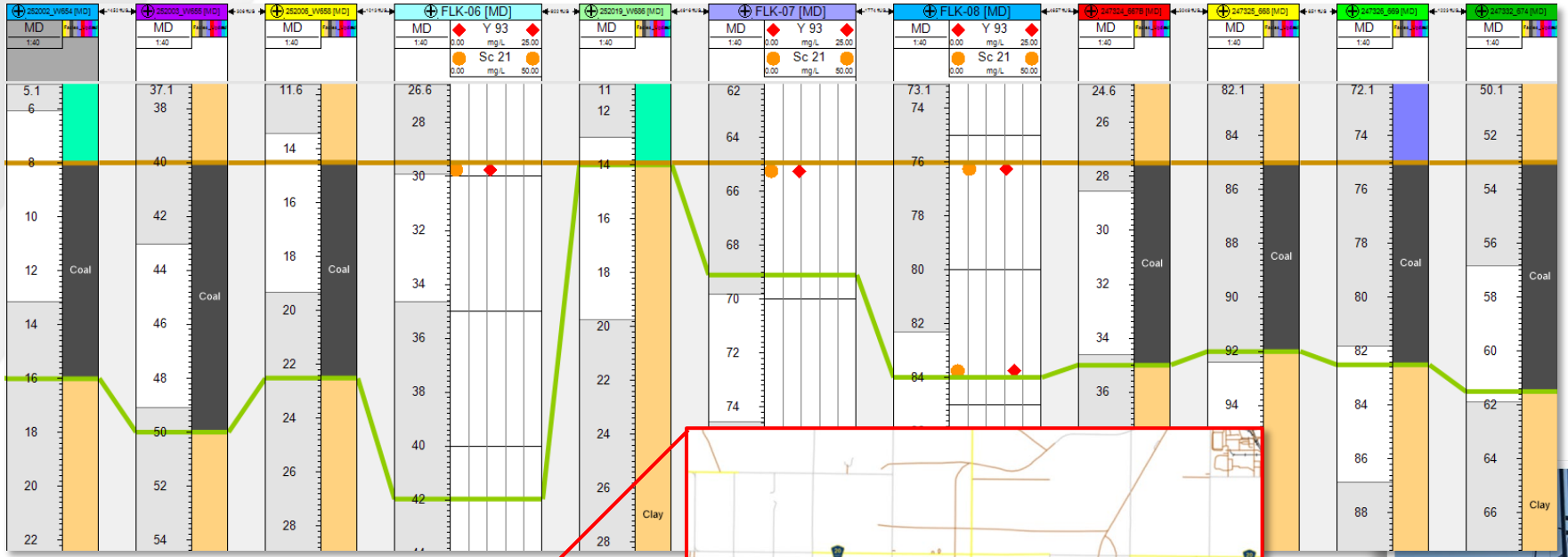


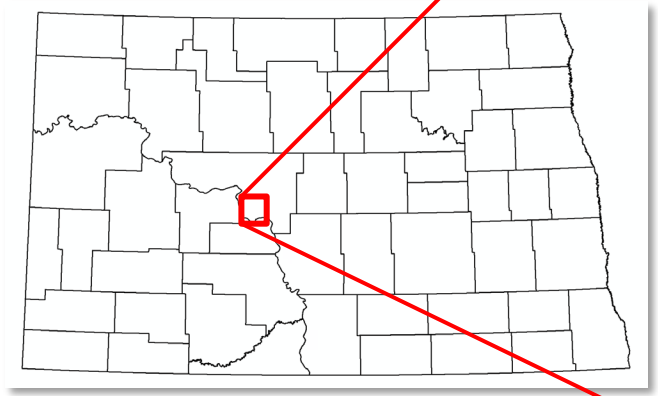
Geologic Model

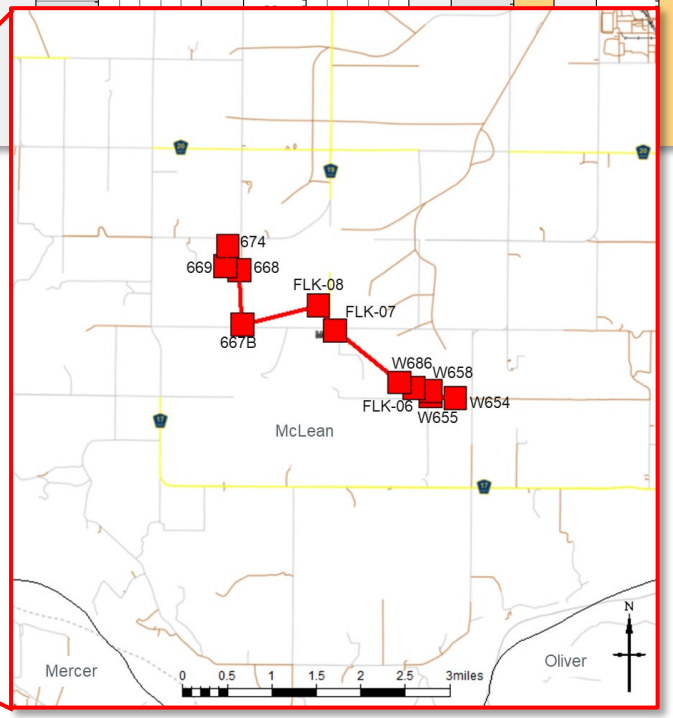
- Use publicly available data
- Lithology – rock type
- Coal seam depth and thickness
- REE and CM data

Coal Seam, Theodore Roosevelt National Park
Elinor Gates, from Flickr, all rights reserved.

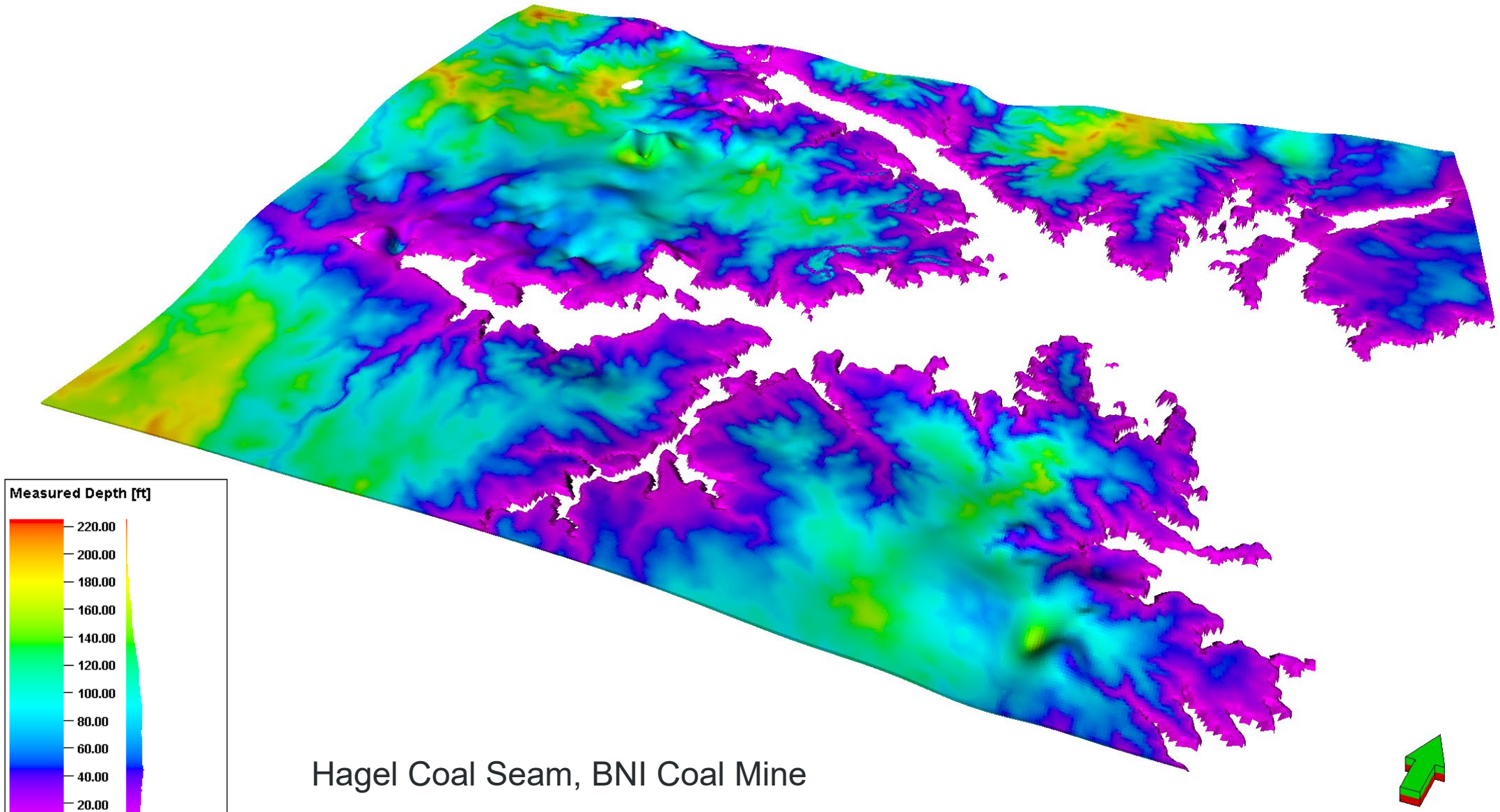
Geologic Model – Cross Section







Ongoing Characterization – Geologic Modeling



Hagel Coal Seam, BNI Coal Mine

Technology Assessment

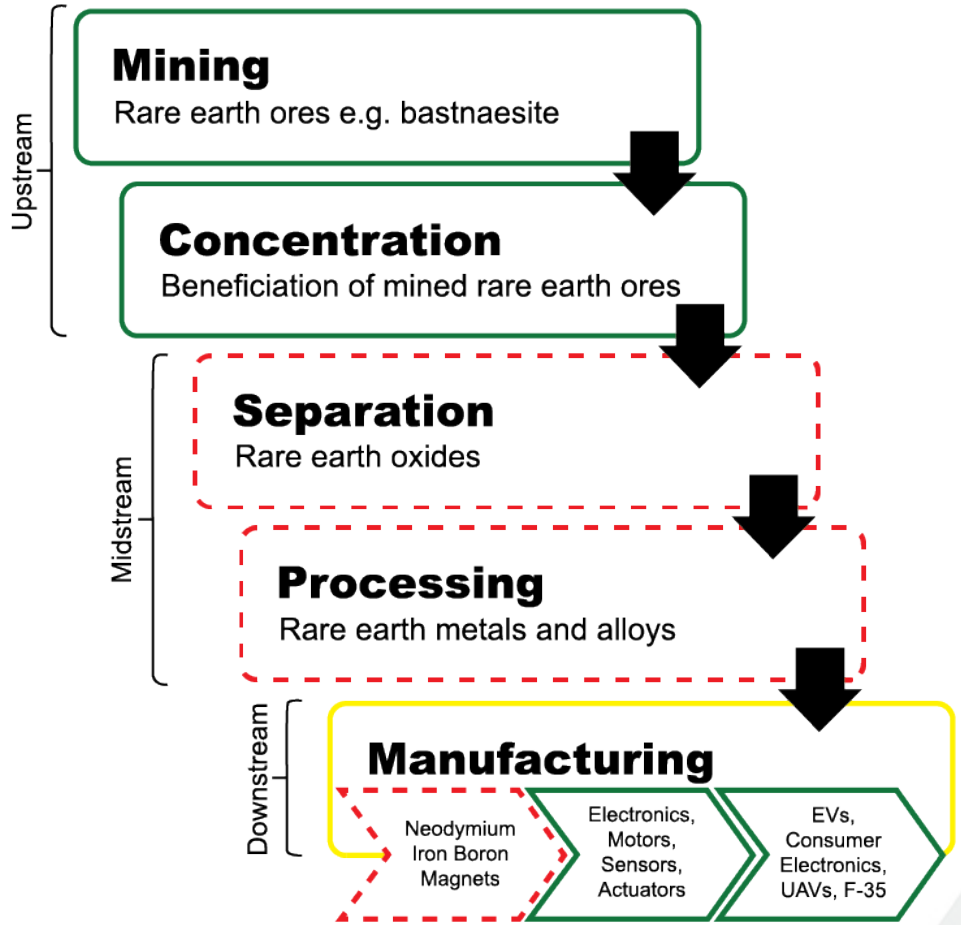
What Are We Trying To Achieve?

Identify technologies across supply chain to support REE/CM

- Which best utilize Williston Basin resources?
- Which can we use today?
- What impact might these have?
- Development of needed basinal products?
- Competitive advantage to use technology in the Williston Basin?

How do we fill these gaps?

- Technologies discussed from providers
- DOE- and DOD-funded projects



Assessment – Williston Basin Resources

- Coal and hard rock resources
  - Can these technologies use the W.B. low-rank coals?
    - What change is needed for them to?
  - What concentration/form of ore is needed?

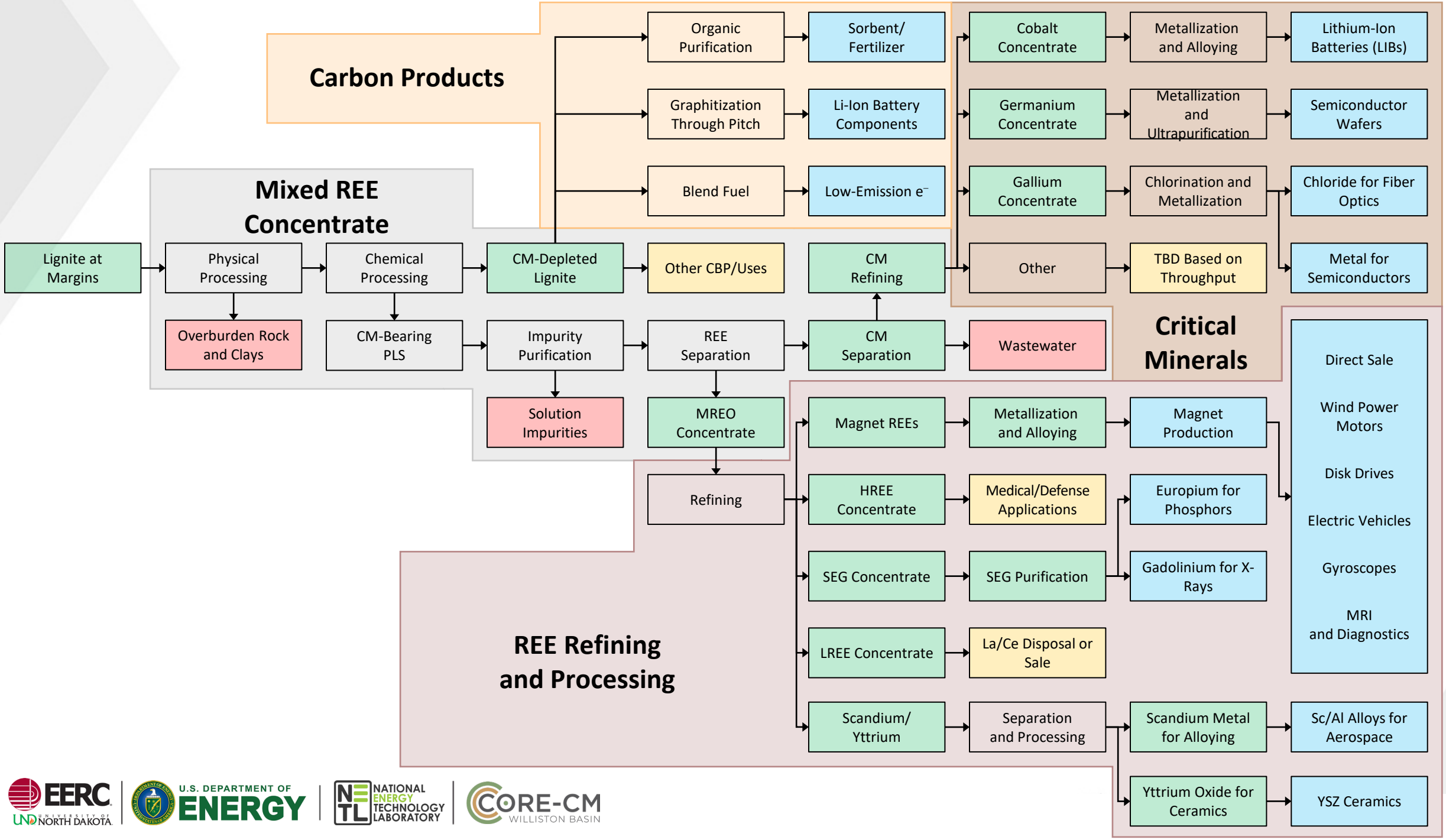
Image Credit: Lignite Energy Council – Falkirk Mine

- Non-rock resources
  - Are there REEs/CMs within non-mineral resources within the region?
    - Can technologies account for the impurities/non-valuable effects of these?

Image Credit: USGS – Bakken Formation Oil Well Pad

Assessment – Technology Readiness

- Identifying time-to-market for technologies
  - Scale of the technology tested
    - Beakers and grams?
    - Piloting and tons?
  - Risks with scale-up
    - Does the equipment to test it exist at commercial scales?
    - Are there permitting challenges associated with scale-up?
  - Does this work for the resources W.B. has?
    - Has it been tested on similar coals/ores?
    - Has it been tested with the W.B. resources directly?



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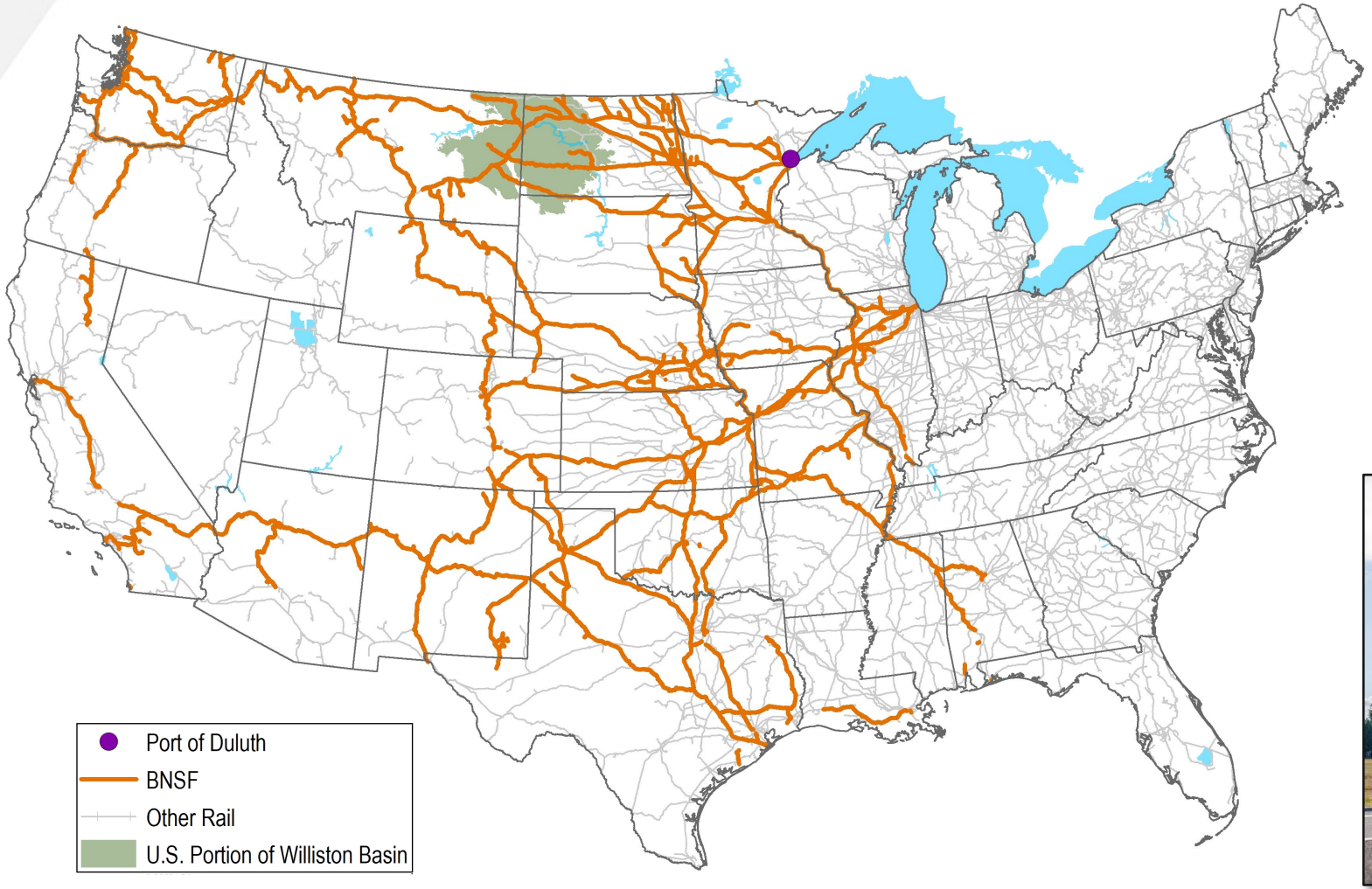
Infrastructure, Industries, and Business

Advantageous Transportation Infrastructure



- Rail
- Truck
- Port in Duluth

Technology Innovation Centers

Creation of TIC Plans: Create the Innovation Pipeline

Identify Existing State/Regional Innovation Centers
Examples of Governance and Structure

Technology Innovation Centers and Business Incubators
- UND Center for Innovation
- NDSU Research Technology Park
- Grand Sky Business Park
- UND Tech Accelerator

Programmatic Centers (training and advice)
- Jamestown Regional Entrepreneur Center
- CTB (Center for Technology and Business) Bismarck

State Agencies
- Accelerate North Dakota
- State-Led Economic Development Regions

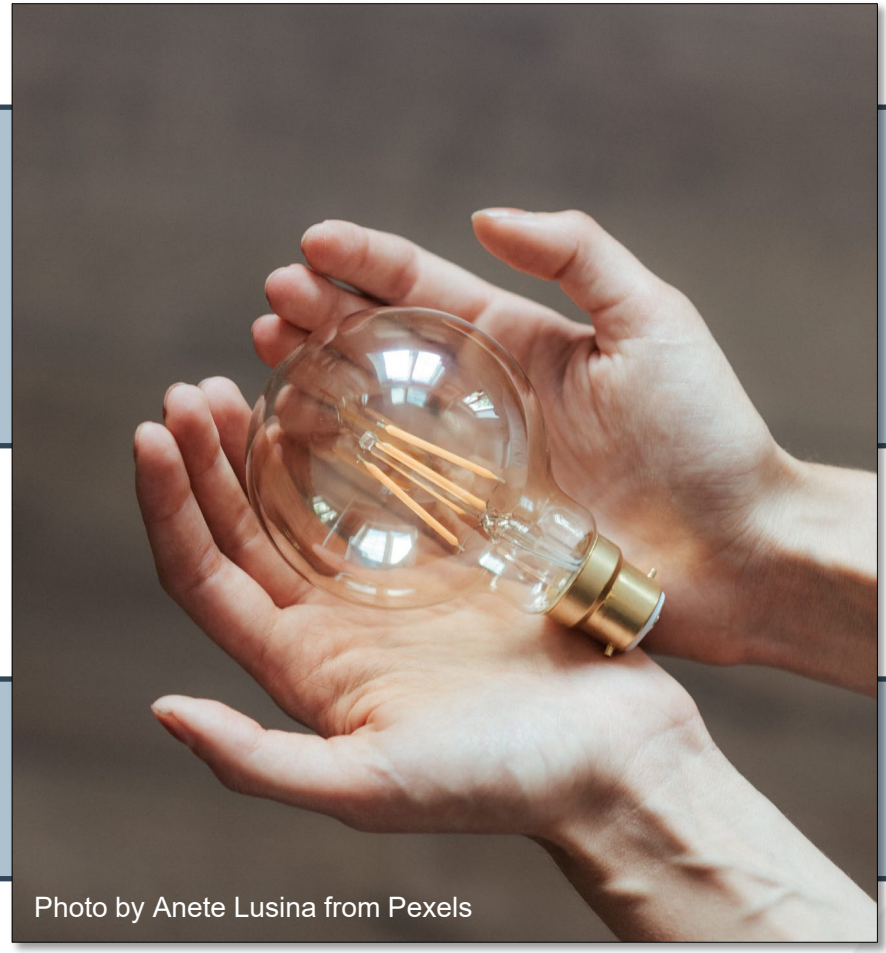


Photo by Anete Lusina from Pexels

Engagement and Outreach

Why Should I Care about Critical Minerals?

The Williston Basin CORE-CM Initiative

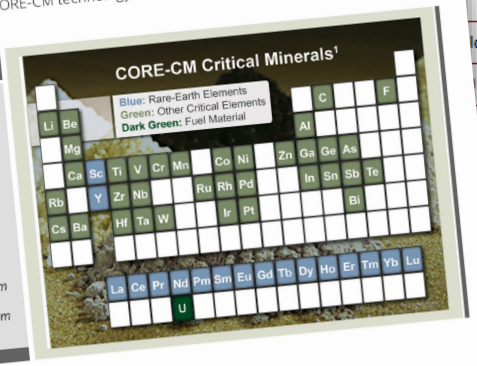
CORE-CM WILLISTON BASIN

The Williston Basin Carbon Ore, Rare Earth, and Critical Minerals (CORE-CM) Initiative is setting the stage for future expansion and transformation of coal use within the Williston Basin for the production of critical minerals (CMs), including rare-earth elements (REEs) and nonfuel carbon-based products. Phase I is focused on building partnerships; assessing resources, markets, and infrastructure; identifying data gaps; and establishing potential technology and business development pathways. Anticipated project outcomes include a database of known CM resources, e.g., coal deposits and waste streams; plans to address infrastructure and supply chain gaps; recommendations for CORE-CM technology development; and technology training and outreach plans.

What Makes a Mineral Critical?

With high demand and limited supply, these minerals and their elements are essential for everything from vehicles and mobile phones to food preservation and health care. Most elements are critical because no substitute exists. For example, chromium's unique properties are critical to the formation of stainless steel. REEs, in particular, enable portability, miniaturization, and technological advances; it takes nine different REEs to make an iPhone:

Y – yttrium
La – lanthanum
Ce – cerium
Pr – praseodymium
Nd – neodymium
Eu – europium
Gd – gadolinium
Tb – terbium
Dy – dysprosium



What Is the Benefit of the CORE-CM Project?

The overall goal is to secure a domestic supply of materials essential to health care, high technology, national security, and clean energy, which may catalyze economic growth and job creation. The United States currently imports most of the CMs and REEs needed for manufacturing, leaving the nation's economy vulnerable to supply chain disruption and raising concern about future demand for these metals. These imports include both raw materials and finished products. Developing a domestic supply chain would bring about sustainable opportunities for mining communities and extended usefulness for existing infrastructure.

Why Is Carbon Critical?

Carbon comes in many forms. Although coal is plentiful in the United States, another form of carbon, natural graphite, is not. Graphite is used in heat-resistant materials and is also essential for batteries, brake linings, lubricants, pencils, and steelmaking. Currently, the United States imports 100% of the graphite it needs.[2]

EERC

PROJECTS

Williston Basin CORE-CM

Setting the stage for future expansion in the Williston Basin

The goal of the Williston Basin CORE-CM project is to set the stage for future expansion and transformation of coal and coal-based resource utilization within the Williston Basin for the production of rare-earth elements (REEs), critical minerals (CMs), and nonfuel carbon-based products. The project will 1) assess the existing information available for

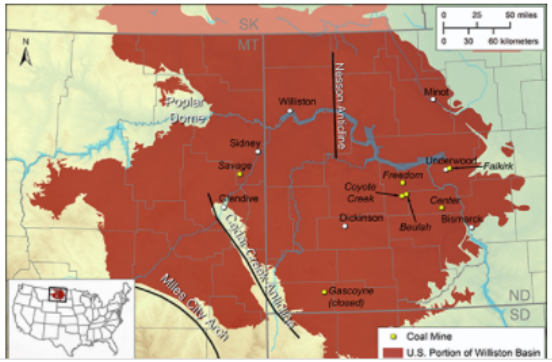
CORE-CM WILLISTON BASIN

elopment, innovation
gy development are
4) initiate stakeholder

Undeerc.org/wb-corecm

About the Williston Basin

The Williston Basin is a large sedimentary basin centered in western North Dakota with portions reaching into South Dakota, Montana, and Canada. It has a rich and extensive history of producing critical resources for the United States. Significant research has characterized REE and CM content in the lignite coals and combustion byproducts of the basin as well as exploration of technologies for extraction of these components. Additionally, recent research has also focused on the production of graphene, graphite, and carbon-based building materials from lignite coal.



Earth Elements and
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MENTS AND CRITICAL
NERALS

Healthcare
Transportation

rth Dakota's
Shales

This project, funded through the EERC's

Webinar Series Events

Critical Minerals: What, How, Why All the Hype?

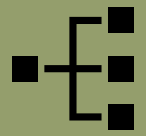
9.21.2022

Today's Critical Mineral Technologies and How to Move Forward

11.30.2022

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

1.11.2023



Critical Minerals from Lignite: The Process and Products

5.25.2023

Critical Minerals: Creating Jobs in the Williston Basin

9.06.2023

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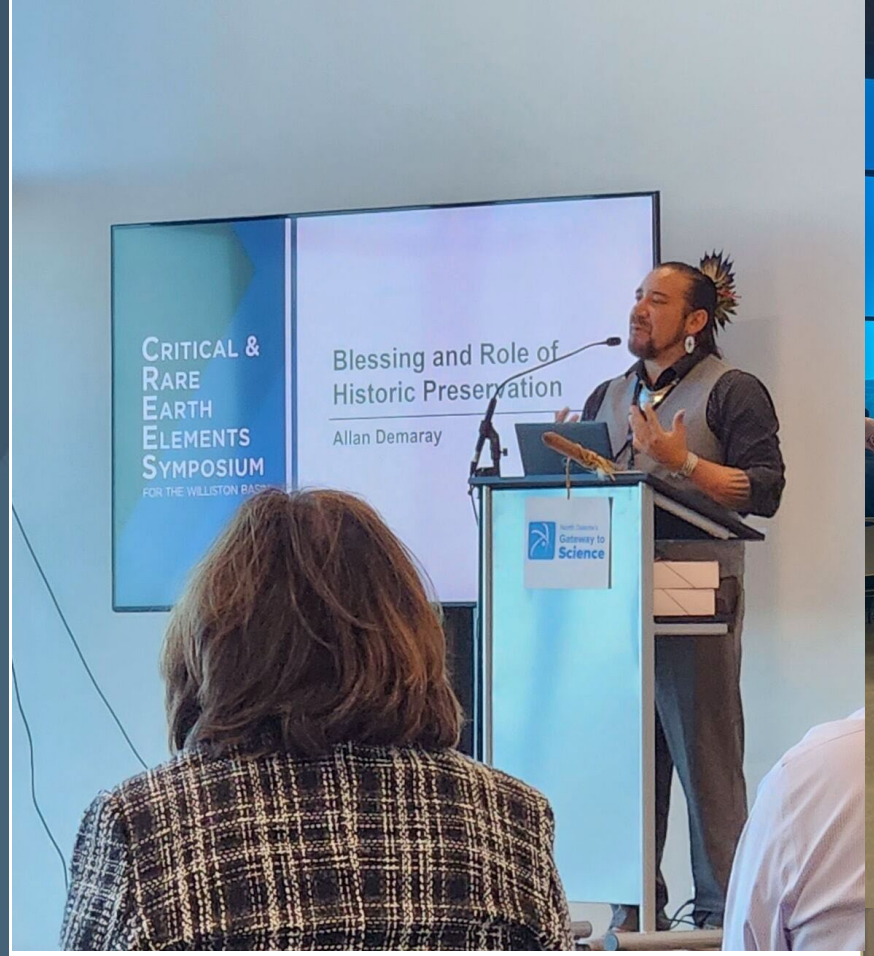
Critical Challenges. Practical Solutions.

CRITICAL & RARE EARTH ELEMENTS SYMPOSIUM

FOR THE WILLISTON BASIN



Two Annual Symposiums

- October 11, 2022
- October 10, 2023

End Products

- Characterization and data acquisition plans
  - Lignite resources
  - Related sources
- Technology assessment and field development plan
- Technology innovation center development plan
- Stakeholder identification, education, and outreach continued
- Summary of environmental justice considerations
- Summary of economic and workforce impacts
- Summary of environmental, health, and safety analysis

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THANK YOU

Critical Challenges. Practical Solutions.

DOE Acknowledgment

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NDIC Acknowledgment

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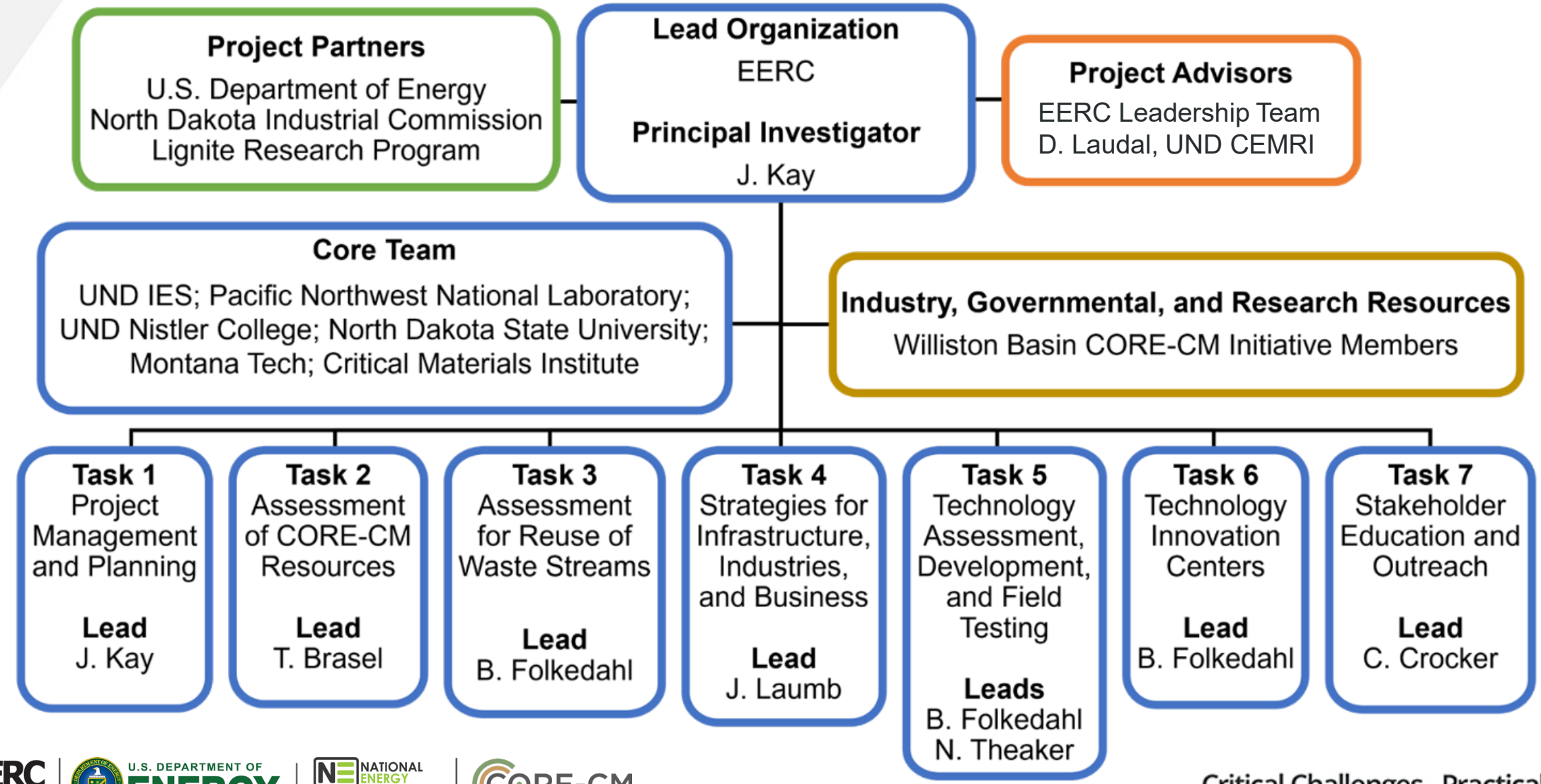
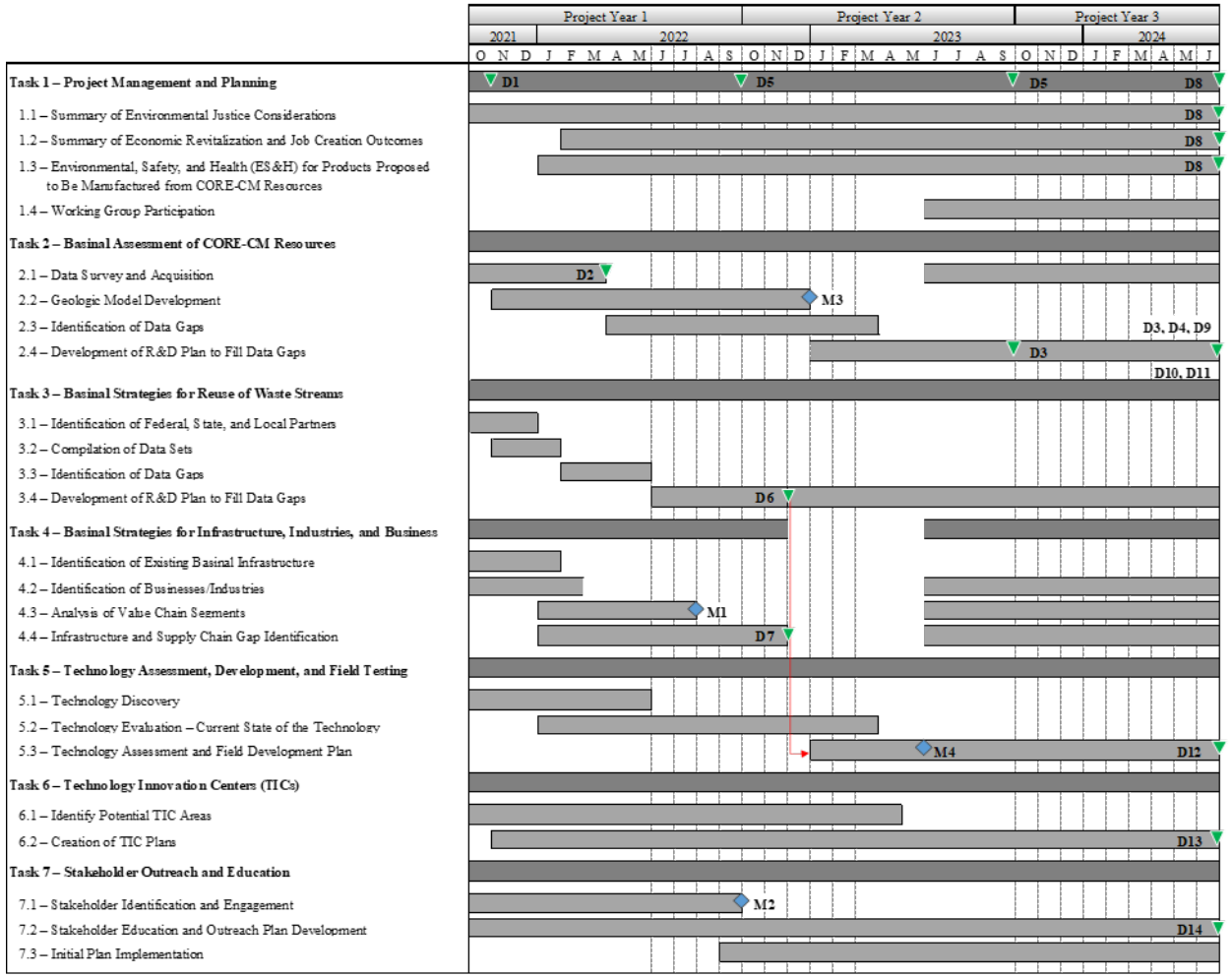
Appendix

Organization Chart



Gantt Chart



Key for Deliverables (D)	Key for Milestones (M)	
D1 – Updated Project Management Plan	M1 – Initial Analysis of Value Chain Segments Completed	Summary Task
D2 – Resource Sampling Plan (If Samples Collected)	M2 – Initial Stakeholder Engagement Meeting Held	Activity Bar
D3 – EDX FOA-2364 REE Researcher Database Template	M3 – Development of Geologic Model Structure	Deliverable (D)
D4 – Inputs for NETL REE-SED Sample Data Needs	M4 – Technology Field Testing Options Determined	Milestone (M)
D5 – Interim Reports		Critical Path
D6 – Initial Waste Stream Reuse Plan		
D7 – Results of the Basinal Strategies for Infrastructure, Industries, and Business Assessment		
D8 – Final Report		
D9 – Initial Basinal Resource Assessment		
D10 – Characterization and Data Acquisition Plan		
D11 – Resource Samples for Mineral Characterization and Analysis		
D12 – Initial Technology Assessment and Field Development Plan		
D13 – Initial Technology Innovation Center Plan		
D14 – Initial Stakeholder Outreach and Education Plan		SK 4/1/2024