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Critical Challenges. Practical Solutions.

Welcome!

CORE-CM
WILLISTON BASIN

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U.S. DEPARTMENT OF ENERGY | NETL NATIONAL ENERGY TECHNOLOGY LABORATORY

Energy & Environmental Research Center (EERC)

Williston Basin CORE-CM Initiative

Critical & Rare-Earth Elements Symposium

October 11, 2022

John P. Kay (PI)
Principal Engineer

Defining Critical Minerals

Critical Minerals

Are essential to our modern economy and national security.

Have a supply chain that is vulnerable to disruption.

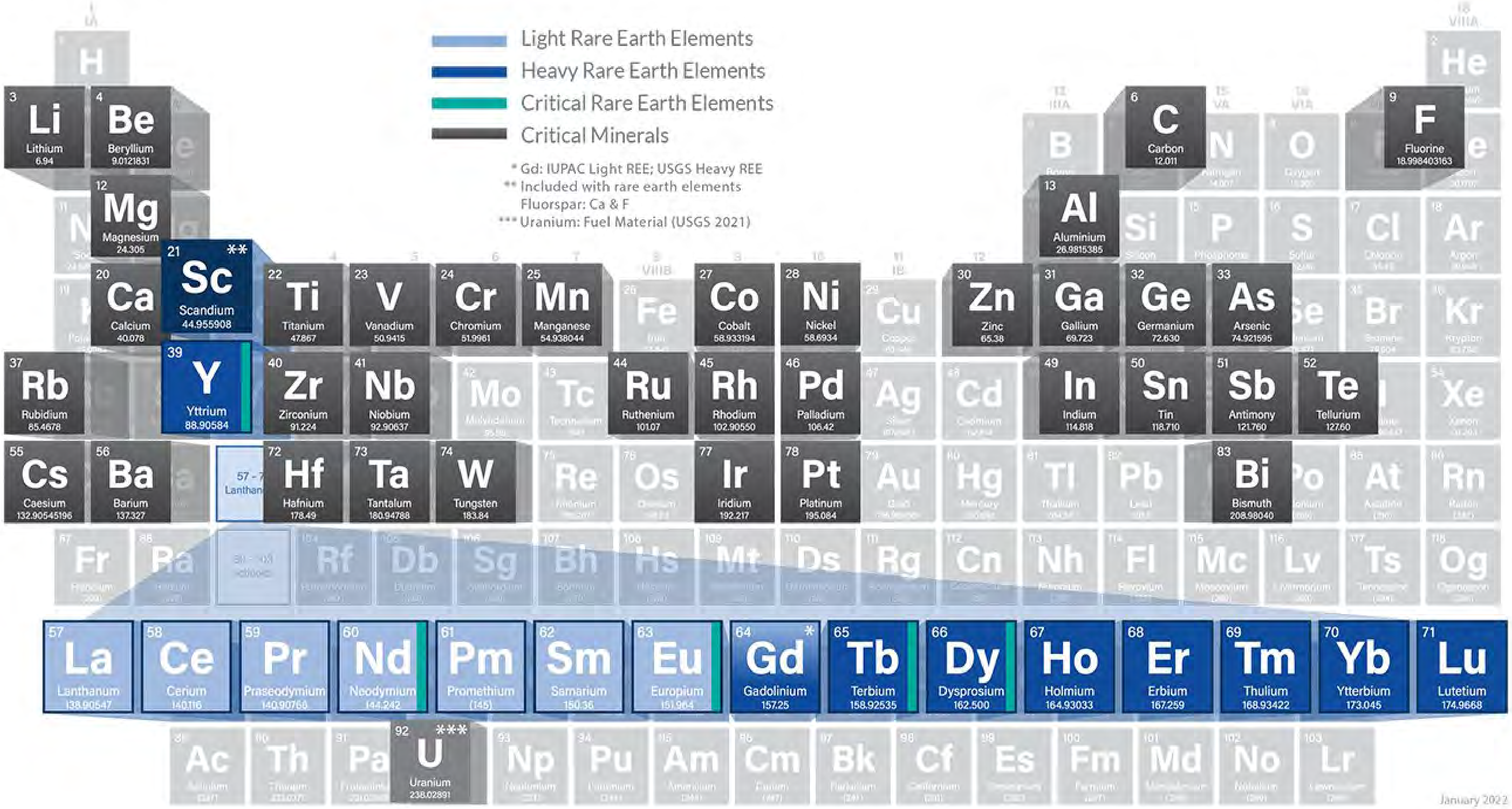
Rare-Earth Elements (REEs)

- Not rare but found together.
- Chemically similar and difficult to separate.
- Each having a different use.

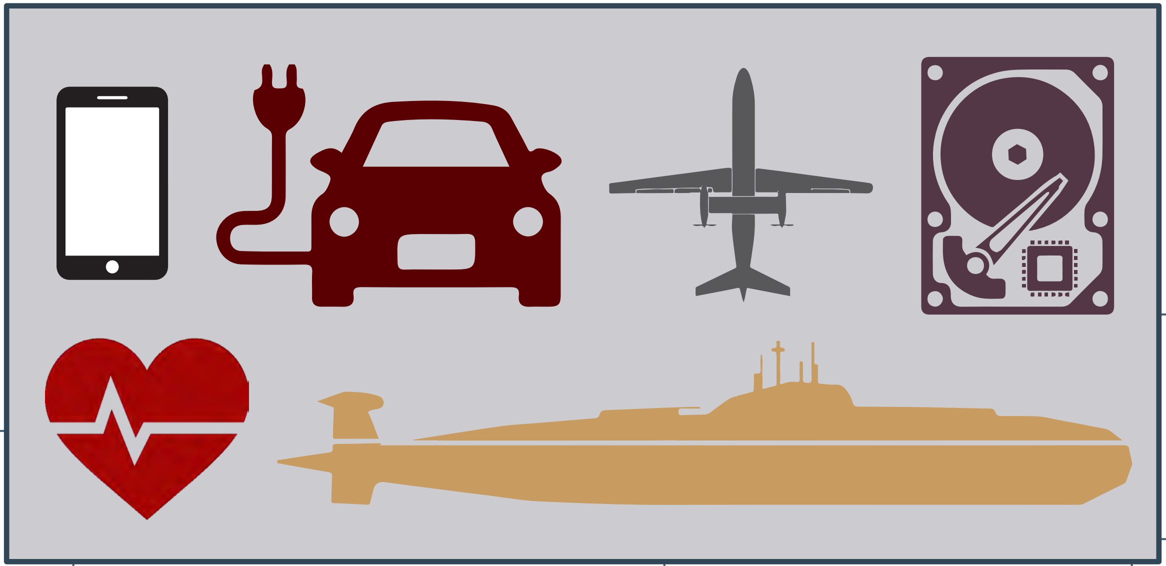
Critical Minerals (CMs)

- Catch-all term for the critical minerals that are not REEs.
- No other common factor.

What Are the CMs?



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

Defense
Nd, Pr, Dy, Tb, Eu, Y, La, Lu, Sc, Sm

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

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

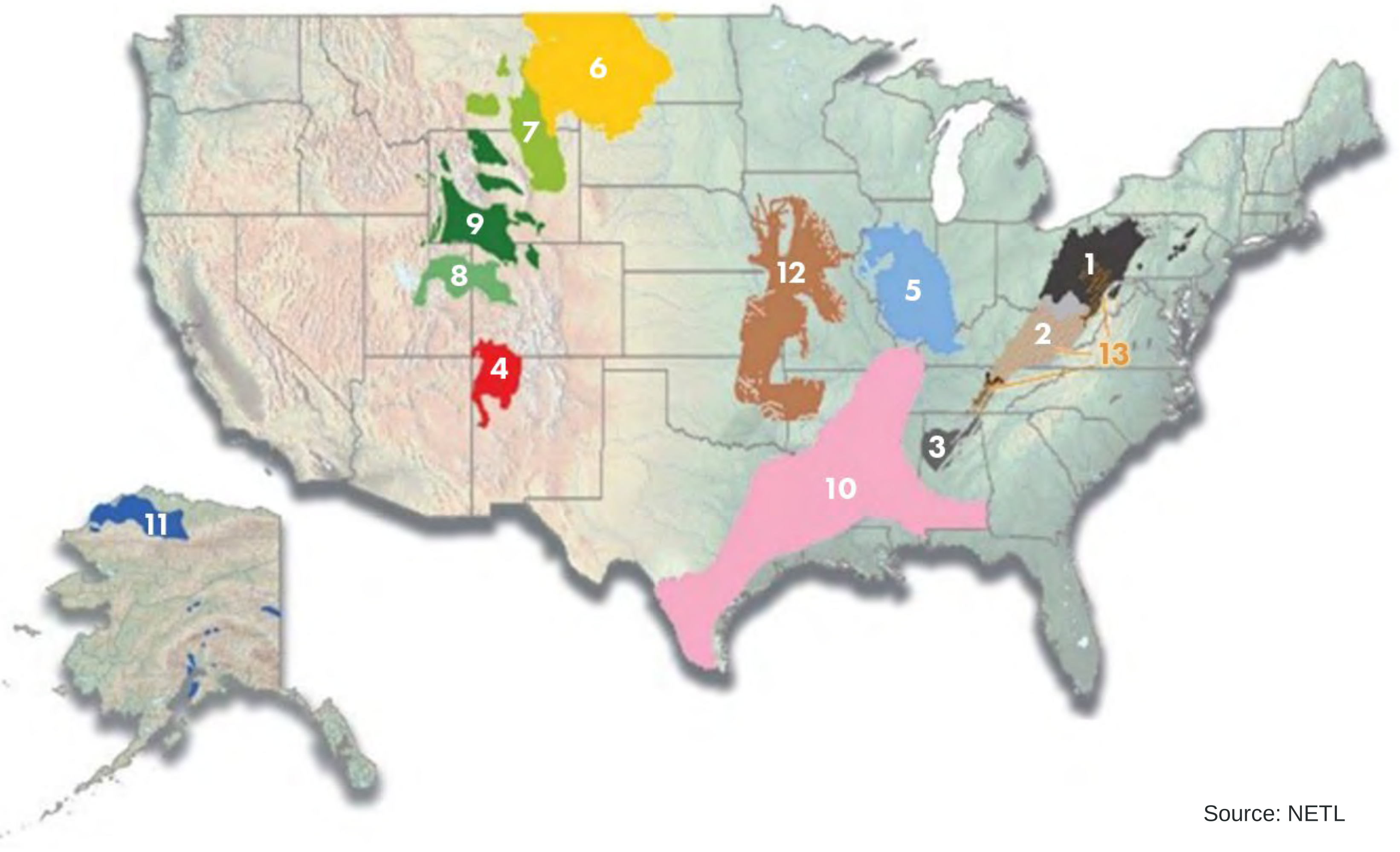
- **U.S. Department of Energy (DOE) National Energy Technology Laboratory (NETL)-led program**
  - Catalyst for economic growth
  - Job creation in energy communities
  - Energy communities not to be left behind
  - Domestic production of rare-earth elements (REEs) and critical minerals (CMs)
  - Strengthen our national economy and security

U.S. DEPARTMENT OF ENERGY | NATIONAL ENERGY TECHNOLOGY LABORATORY

13 Coalition Teams – CORE-CM Initiative

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

Program Support

CORE-CM WILLISTON BASIN

EERC UND UNIVERSITY OF NORTH DAKOTA

Project Partners

U.S. Department of Energy
North Dakota Industrial Commission
Lignite Research Program

Lead Organization

EERC

Principal Investigator

John Kay

Project Advisors

EERC Leadership Team
D. Laudal, UND IES

Core Team

UND IES; Pacific Northwest National Laboratory; UND Nistler College; North Dakota State University; Montana Tech; Critical Materials Institute

Industry, Governmental, and Research Resources

Williston Basin CORE-CM Initiative Members

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BASIN ELECTRIC POWER COOPERATIVE — A Touchstone Energy® Cooperative

BNI energy — AN ALLETE COMPANY

Current Chemicals

Minnkota Power Cooperative — A Touchstone Energy® Cooperative

North American Coal Corporation

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DISCLAIMER

NDIC Acknowledgment

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Today’s Objectives

- Share information we’ve compiled to date
- Outline the potential of the Williston Basin for domestic production of rare-earth elements and critical minerals
- Highlight the components necessary for successfully implementing production
- Next steps

You are a member of the team, and your input is important!

Agenda

Assessing Williston Basin's Resources
- Critical Minerals in Williston Basin Lignites
- Critical Minerals in Related Sources
- Evaluating Technologies

Lunch
- Perspective on the Future of Lignite Coal

Policy and Business Strategies
- Conceptualizing Policy and Regulations Panel
- Business Opportunities in the Williston Basin

The Road Ahead

CRITICAL MINERALS IN WILLISTON BASIN LIGNITES

Todd Brasel
Task Lead

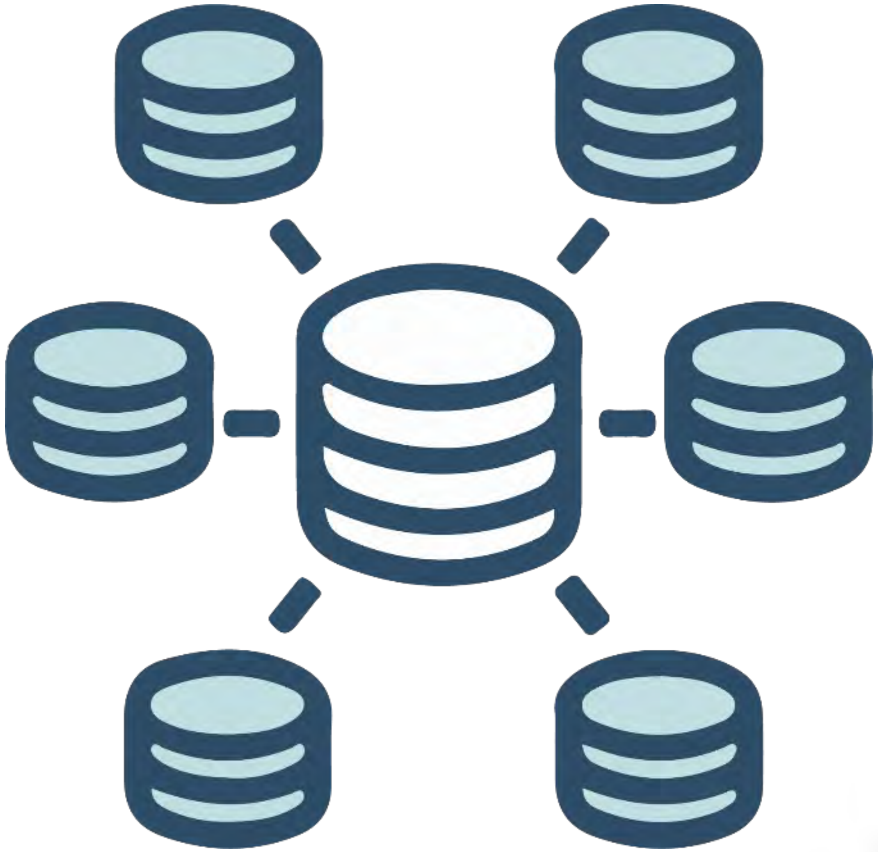
Team
Ian Feole – EERC

Topics Covered

- Data sources
- Data types
- Sample locations
- Critical minerals identified
- Geologic model
- Next steps

Data Sources: Critical Mineral Concentrations in Williston Basin Coals

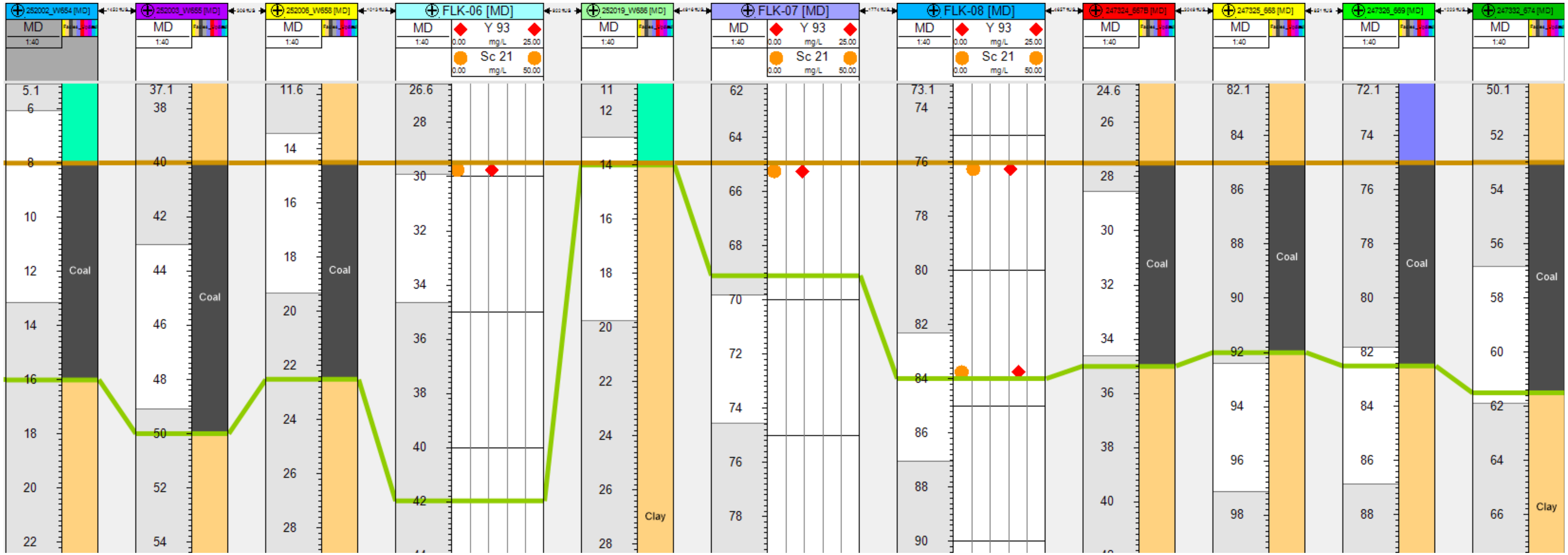
- North Dakota Geologic Survey (NDGS)
  - Bulk of the data and most recent data
- Energy & Environmental Research Center (EERC)
- UND Institute for Energy Studies (IES)
- COALQUAL Database (USGS)
  - Whole seam mixing
  - Older lab technology



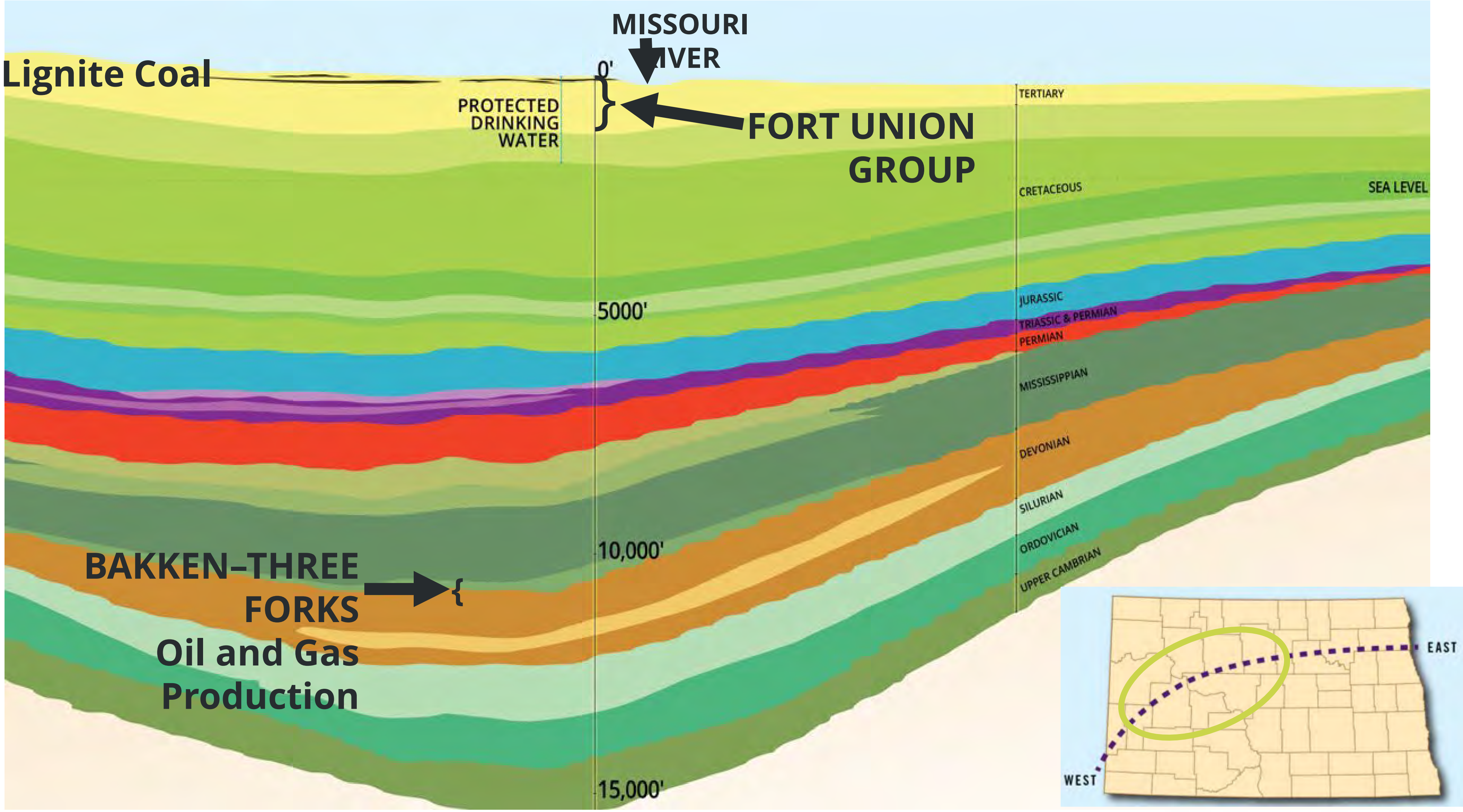
Data Collected

- REE and CM concentration data from lignite coal and coal-related material
- Geologic data (coal depth, thickness, rock type)
- Wireline well logs from mining companies

Cross Section
Showing Coal Seam

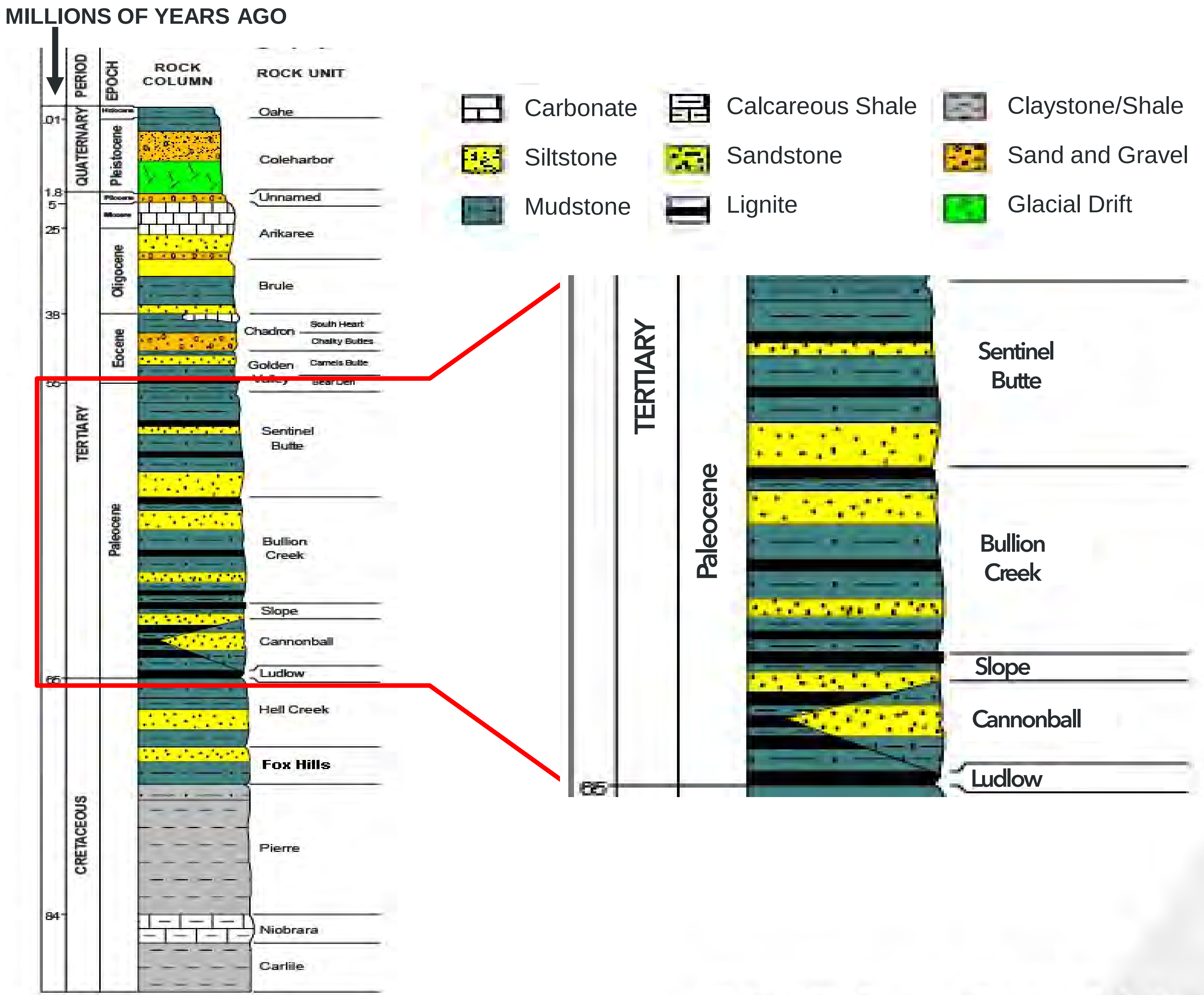


North Dakota Williston Basin Cross Section

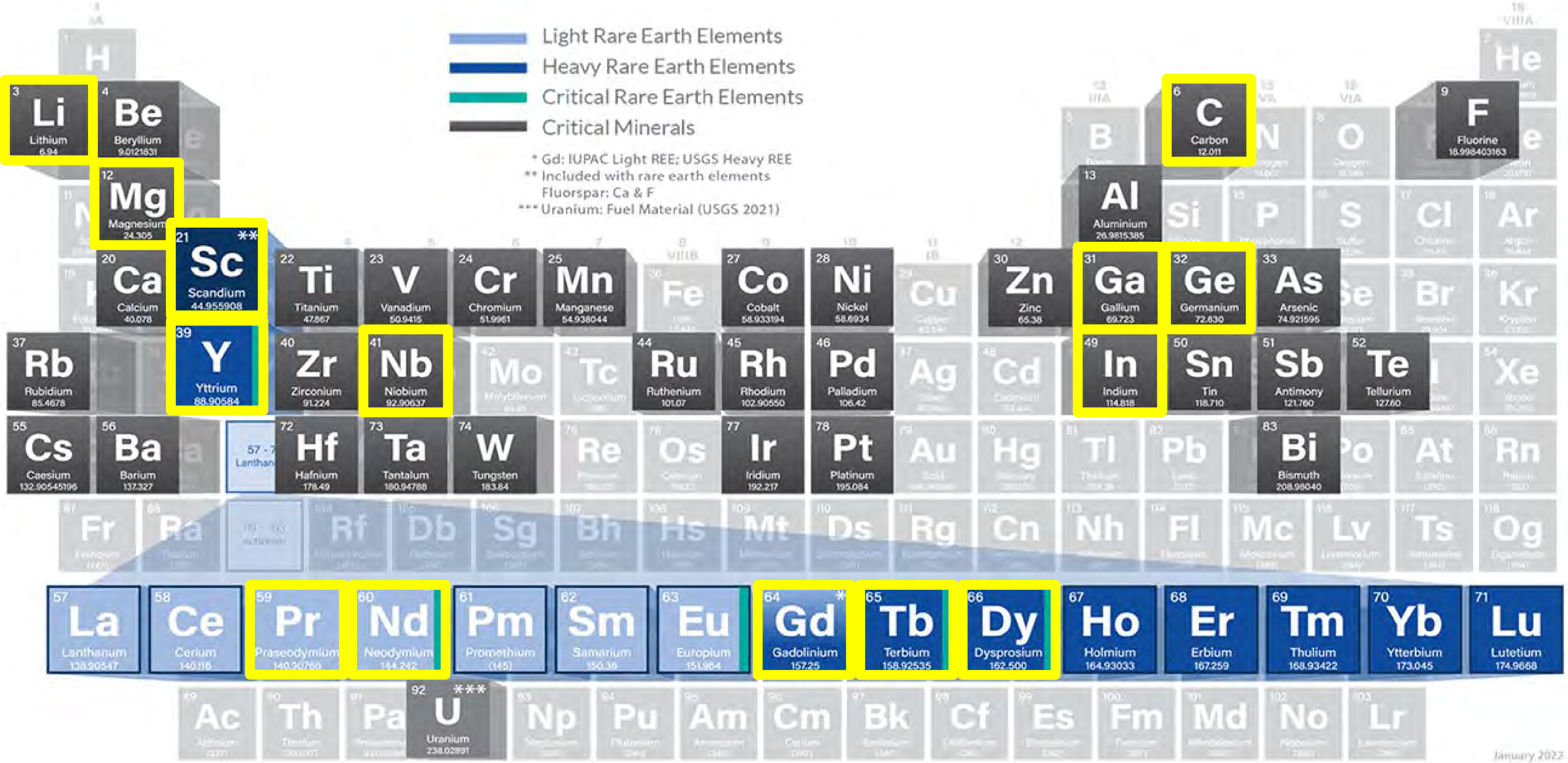


North Dakota Stratigraphy

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

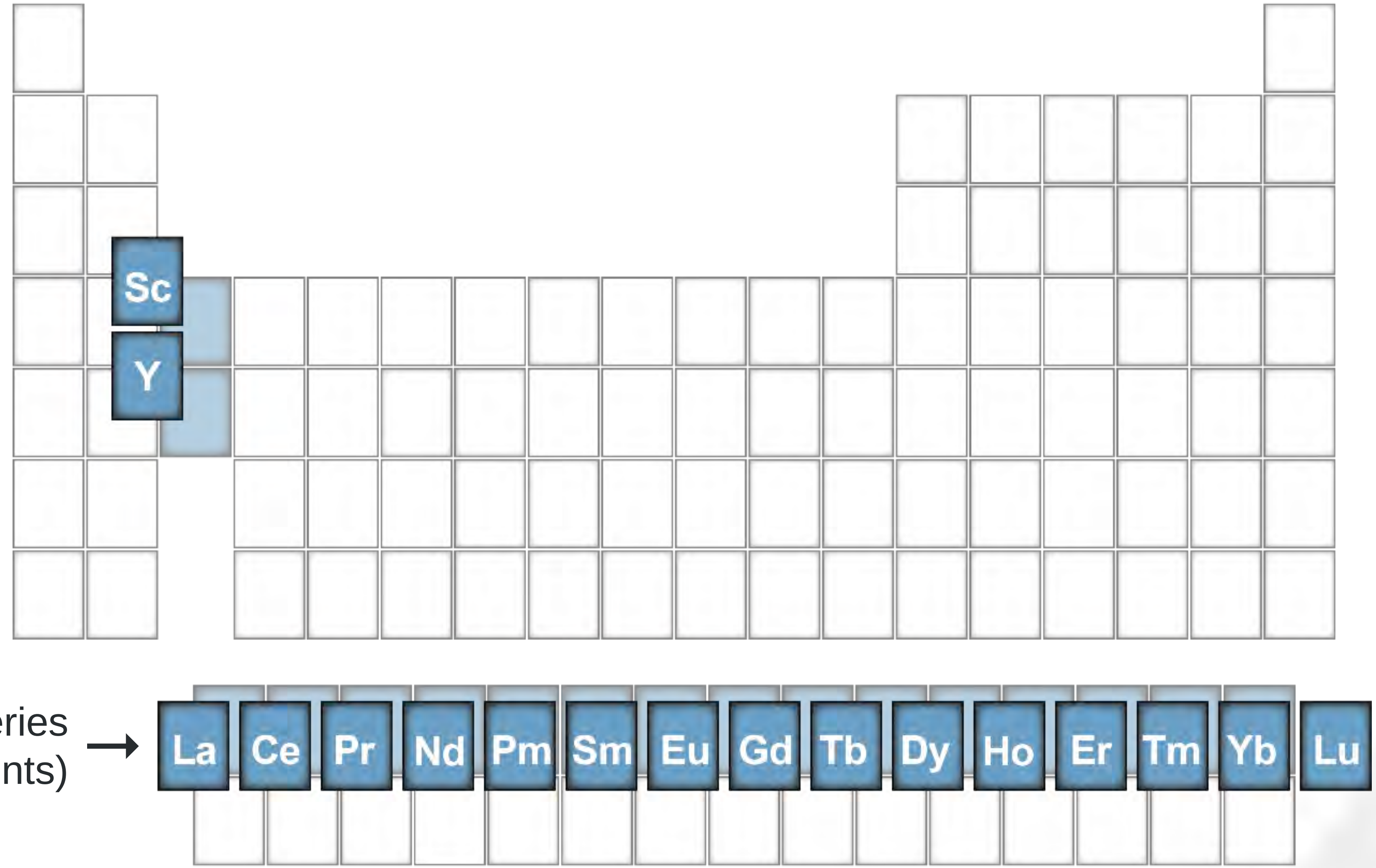


Elements with Greatest Potential to Contribute to the Williston Basin Market



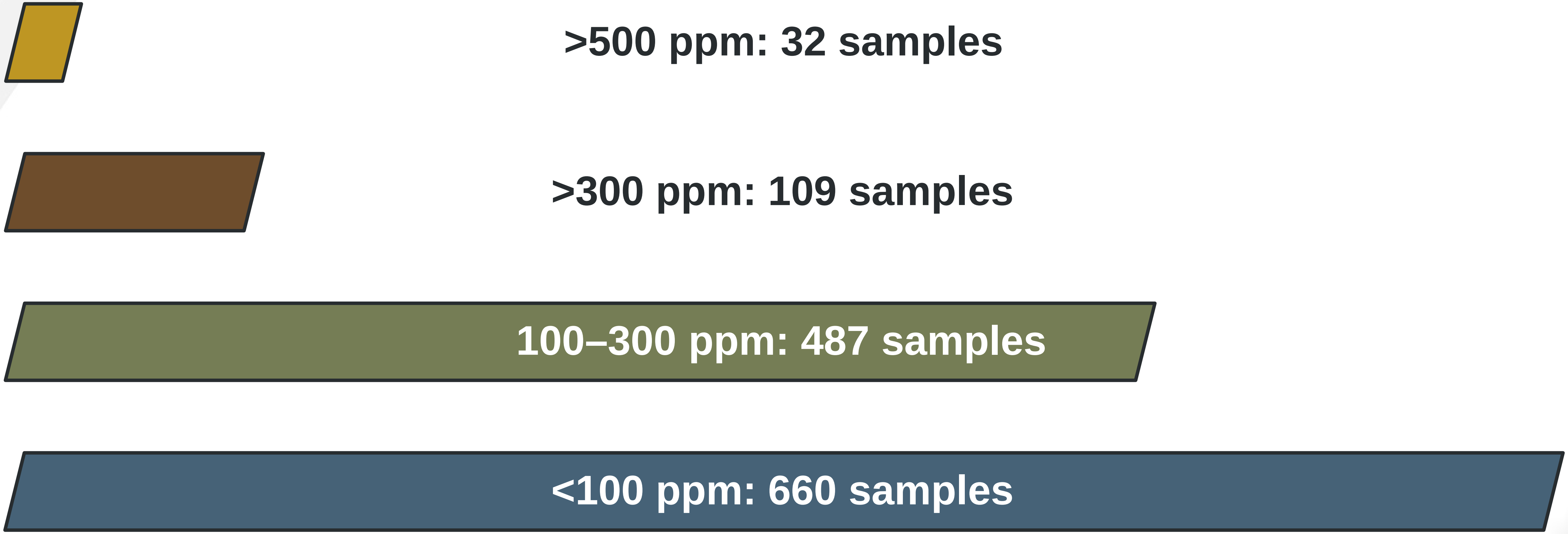
REE Concentrations: Total REE

Reported as the sum of:
- All rare earths
- Scandium (Sc)
- Yttrium (Y)



Lanthanide Series
(rare-earth elements)

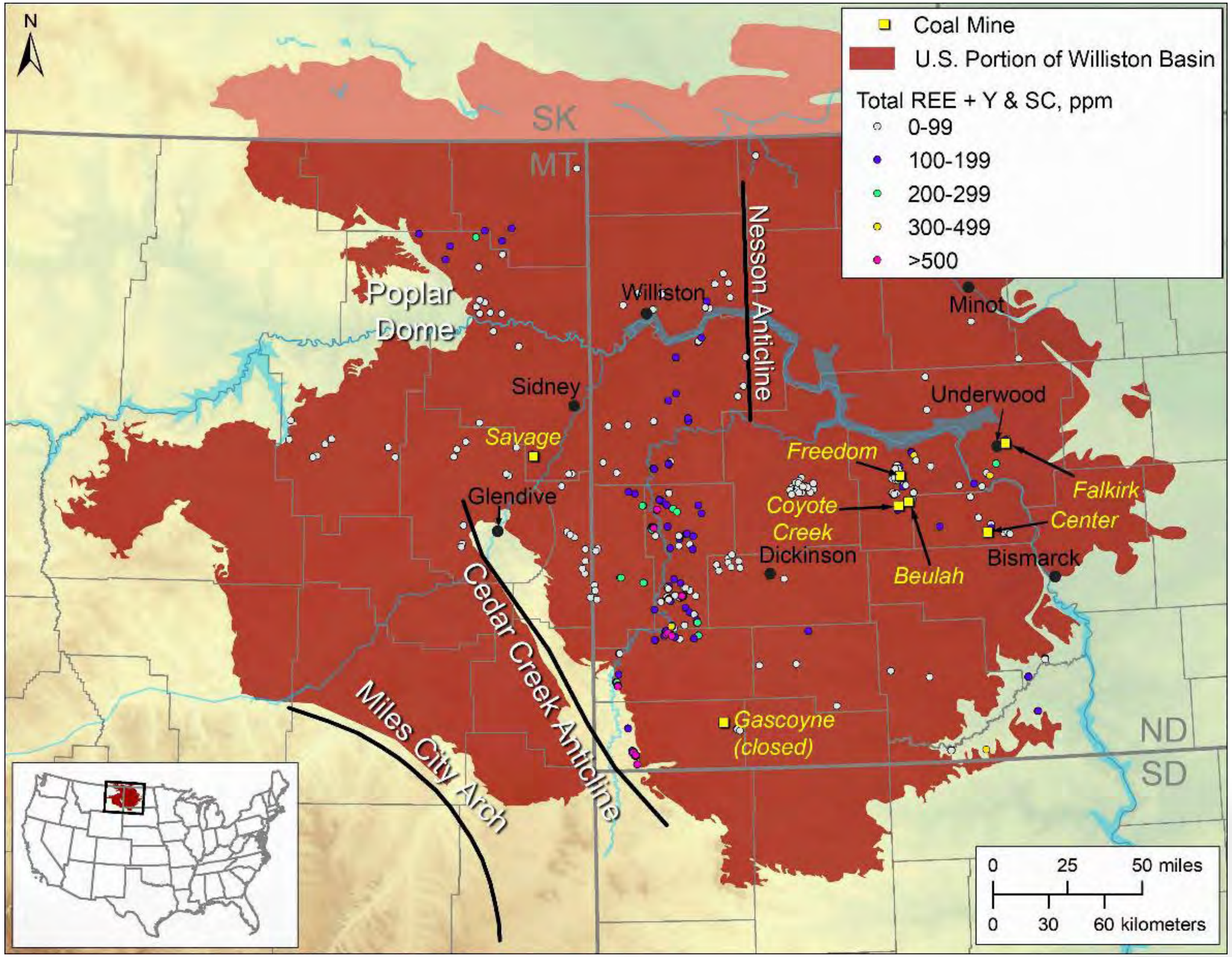
Total Rare-Earth Concentration Ranges for Lignite Coals in the Williston Basin



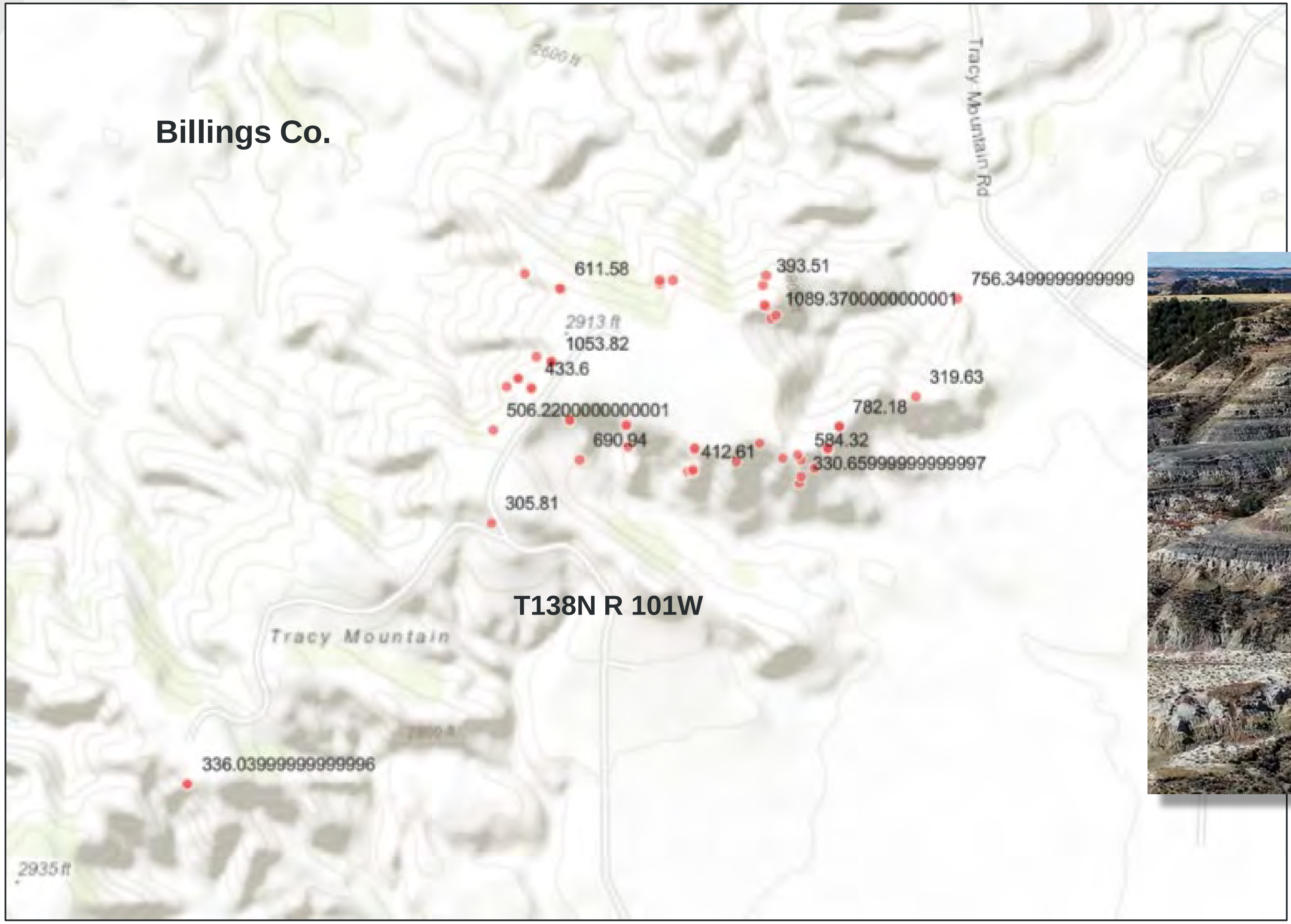
Rare-Earth Element Data Sample Locations

Sample locations are based on accessibility, not mining potential.

The H bed at sample site 68F, the site of the second highest rare-earth concentration in this study (638 ppm).



Tracy Mountain Coal Samples

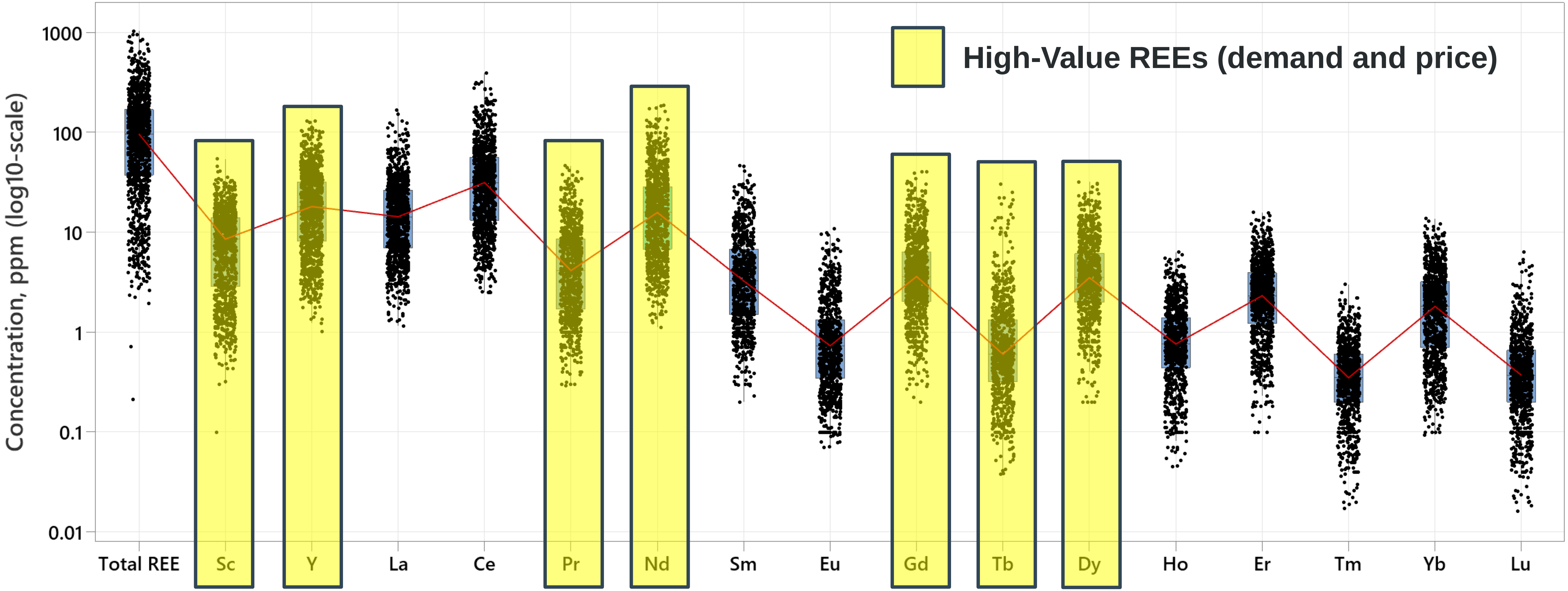


The highest REE sample collected in a coal was collected by the NDGS at Tracy Mountain: >1000 ppm in the **H bed Coal** on topographic high.

Tracy Mountain to Bullion Butte Looking Southwest

Moxness, L.D., Murphy, E.C., and Kruger, N.W., 2021, Rare earth and other critical element concentrations in the Sentinel Butte Formation, Tracy Mountain, North Dakota: Report of Investigation No.128, North Dakota Geological Survey.

REE Concentrations Found in Williston Basin Lignite

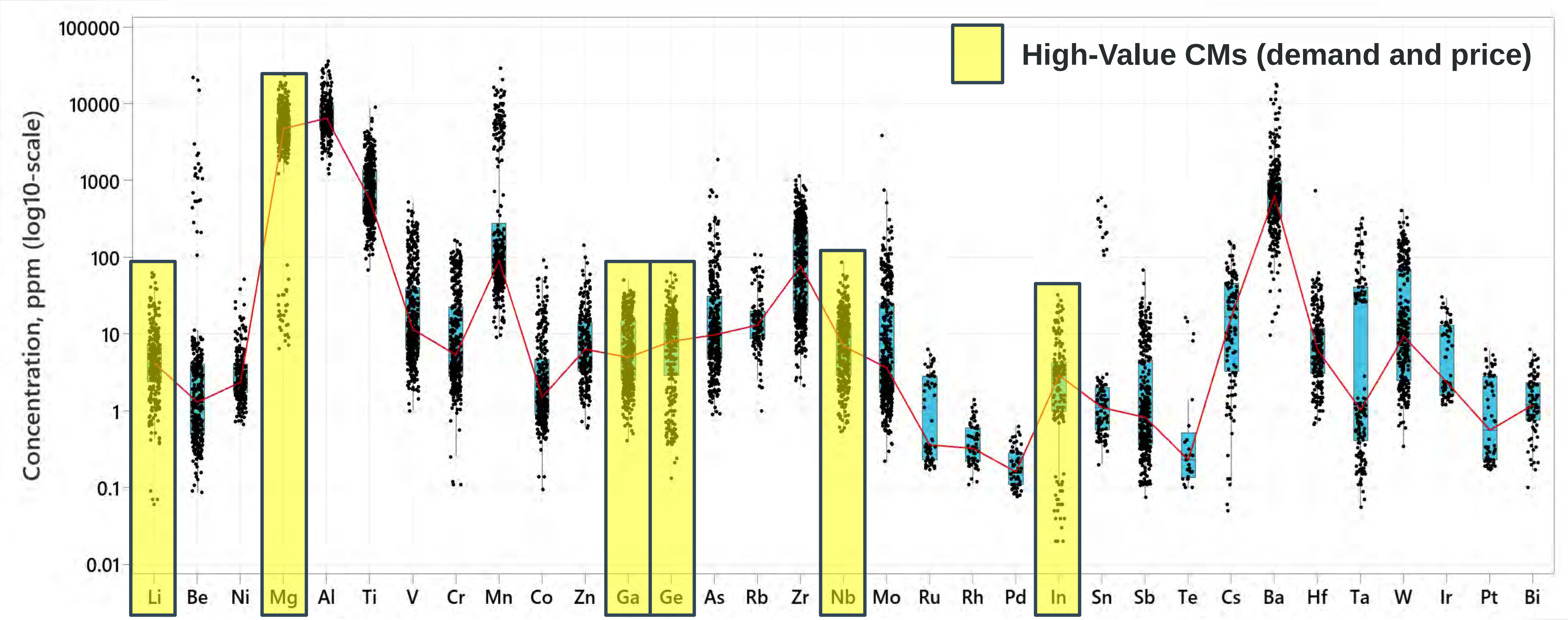


Sc – Scandium
Y – Yttrium

Pr – Praseodymium
Nd – Neodymium

Gd – Gadolinium
Tb – Terbium
Dy – Dysprosium

CM Concentrations Found in Williston Basin Lignite



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

Williston Basin REEs of Interest Abundance (upper continental crust)

Element	Symbol	Atomic No.	Crustal Abundance ppm* (Baseline)	ND Coal REE Avg ppm	ND Coal REE Max ppm	Price, $/lb
Scandium	Sc	21	22	9.42	54	997.73
Yttrium	Y	39	33	23.4	130	4.99
Praseodymium	Pr	59	9.2	6.45	46.04	56.1
Neodymium	Nd	60	41.5	22.71	184.41	56.1
Gadolinium	Gd	64	6.2	5.27	40	28.05
Terbium	Tb	65	1.2	1.35	30	915.4
Dysprosium	Dy	66	5.2	4.96	31.7	152.9

*Seredin, V.V., and Dai, S., 2012, Coal deposits as potential alternative sources for lanthanides and yttrium: International Journal of Coal Geology, v. 94, p. 67–93.

Where ***REE pricing*** *is now, it's probably* ***here for the long term****. As* ***for prices to drop, there'd have to be a fundamental change in either the supply or demand scenario, and I just can't see where all the supply of rare earths is going to come from to change that dynamic****.*

Tim Harrison, Managing Director of Ionic Rare Earths

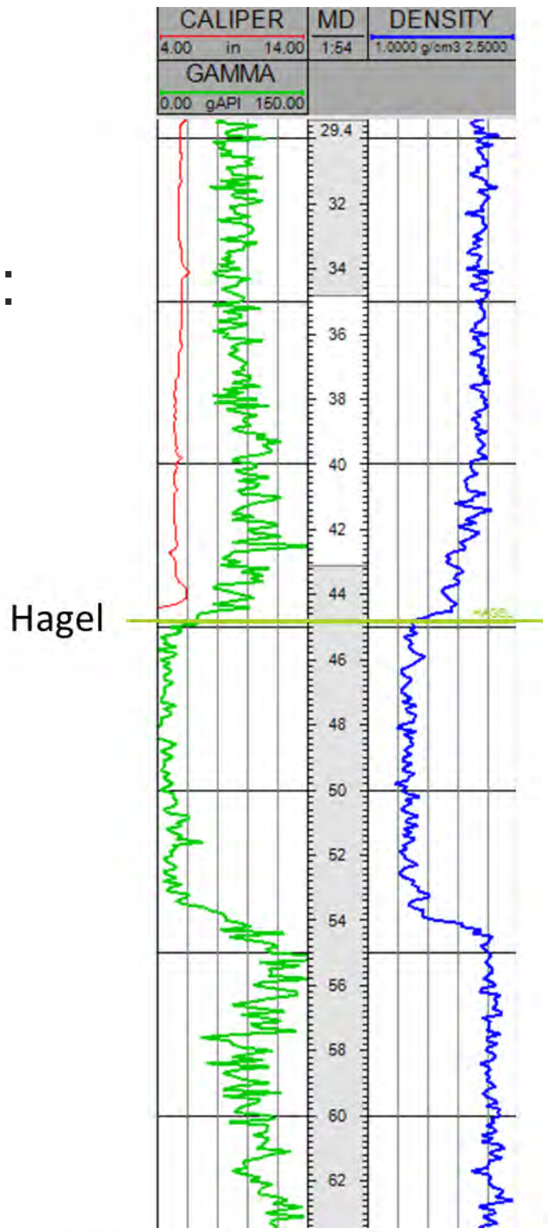
S&P Global Commodity Insights – May 2022

Geologic Model

- Data used in the creation of structural models comes from:
  - USGS and the National Coal Resources Data System (NCRDS)
  - NDGS
  - Wireline logs from the BNI Coal Mine

- 3D structural models of the seams
  - The focus of the structural models has been on coal seams near mines where wireline data were collected.

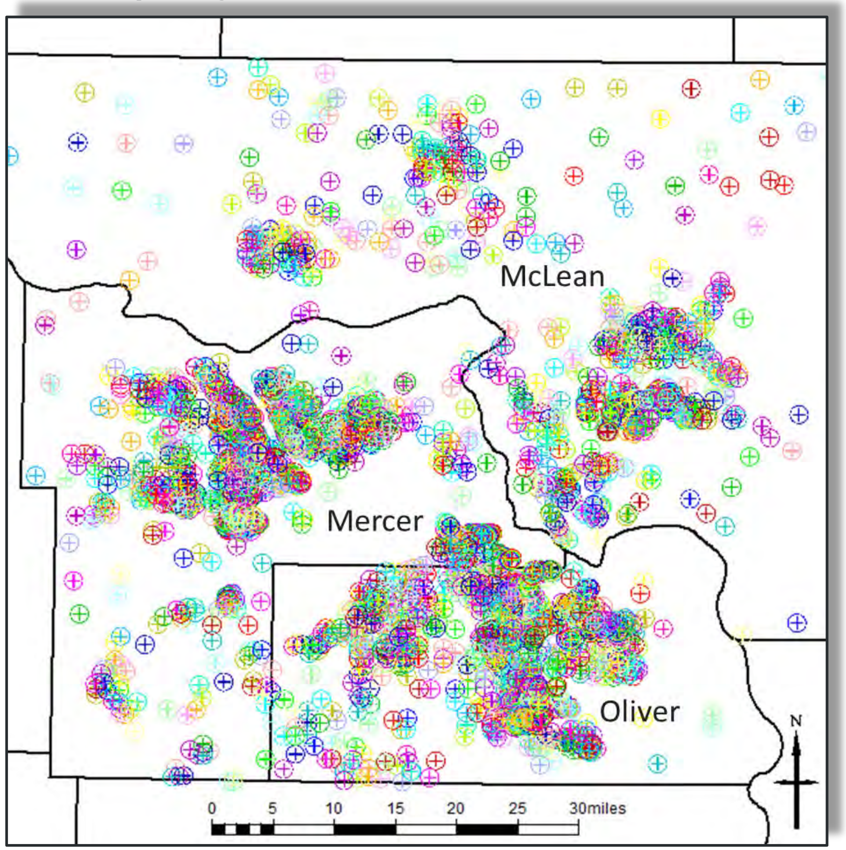
Wireline Log



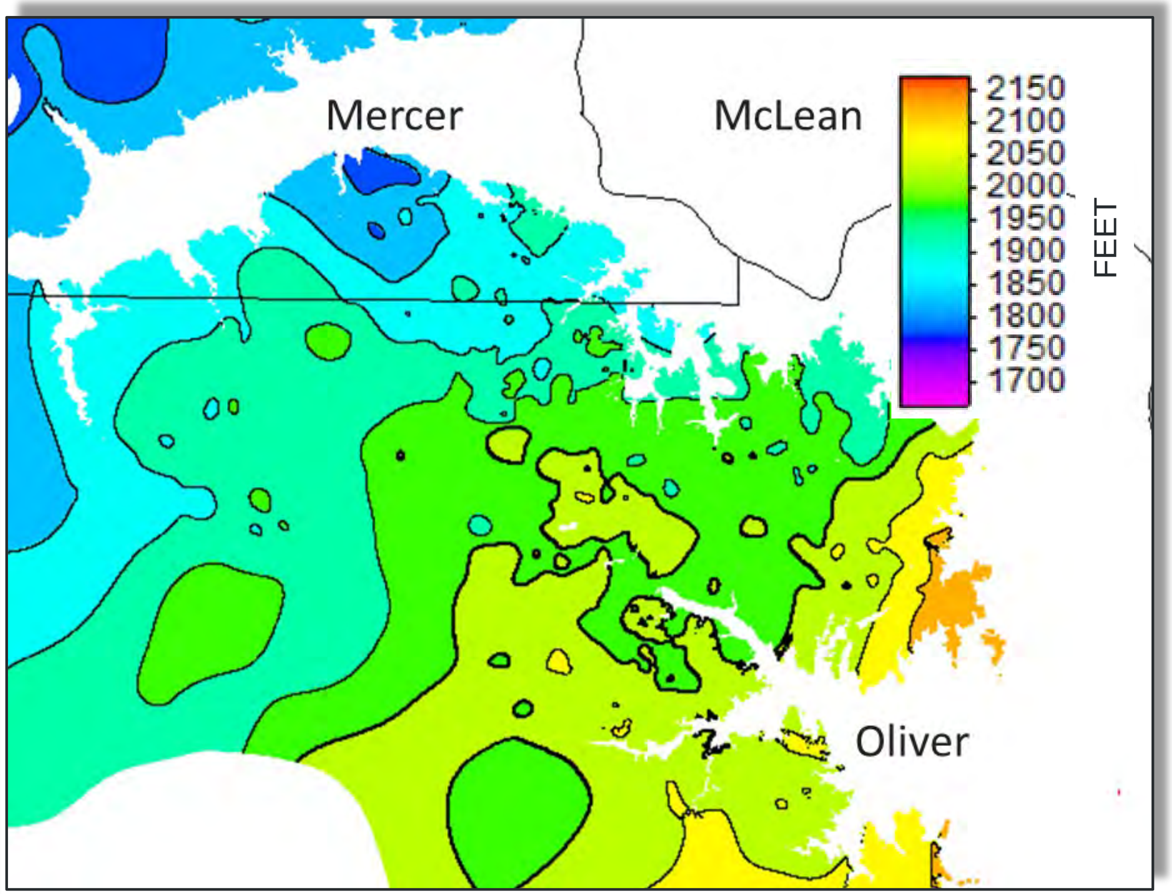
Geologic Model

Maps tie REE concentrations spatially to individual coal seams.

Sampling Points



Elevation of the Tops of Coal Seams



Models will be improved as more subsurface information becomes available.

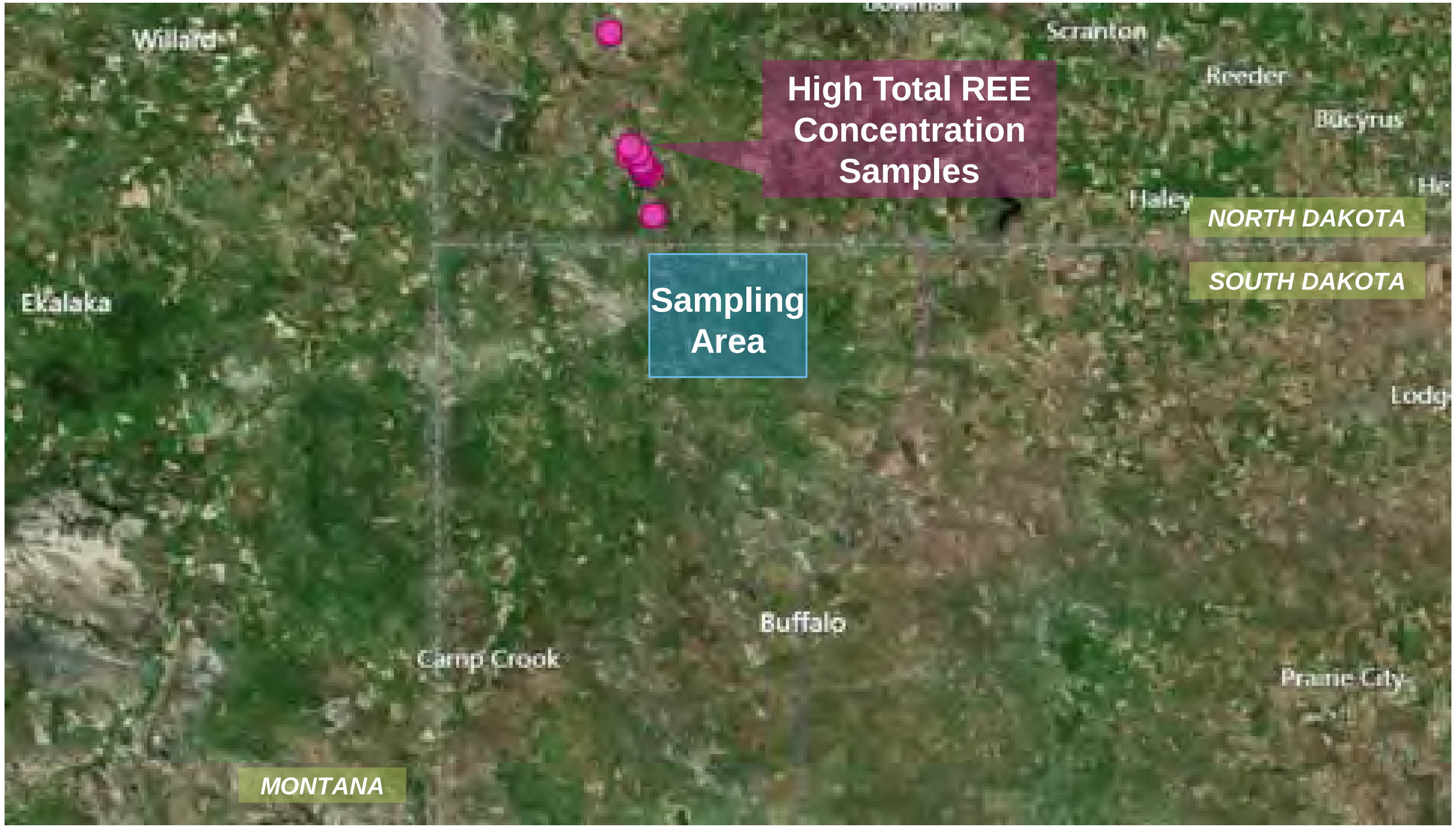

NEXT STEPS

Data Gaps

- Collect additional samples in neighboring states: South Dakota and Montana
- Look into possible coal sampling on Tribal lands
- Collect additional subsurface data
  - Lignite core
  - Wireline logs
  - Coal depth and thickness data

Coal Sampling in South Dakota

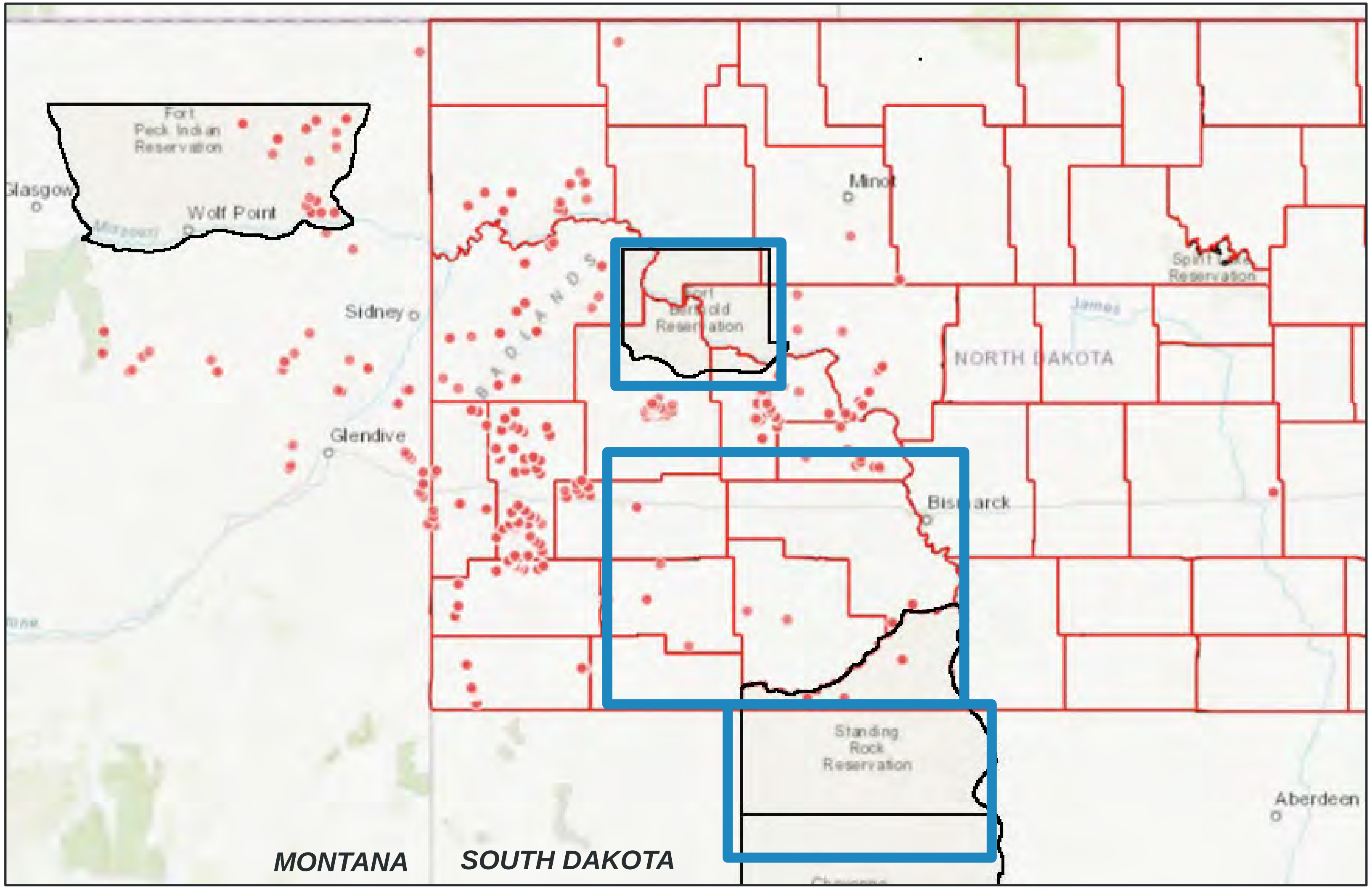
Sampling in South Dakota following high REE concentrations in North Dakota.



Future Potential Sampling Areas

= Potential Sampling

= Tribal Lands



Questions?

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CRITICAL MINERALS AND OTHER POTENTIAL MATERIALS IN RELATED RESOURCES

Bruce Folkedahl

Advisors

Shane Addleman – PNNL

Tom Lograsso – Critical Minerals Institute

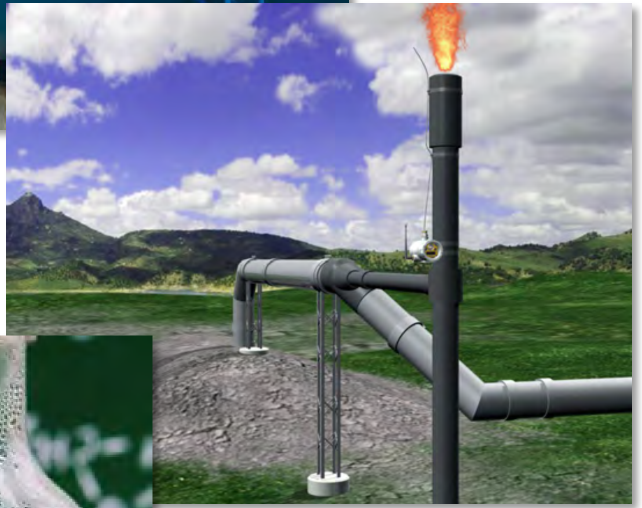
William Cohen – Current Lighting Solutions, LLC

What Are We Looking For?

Regional by-product streams that could become:

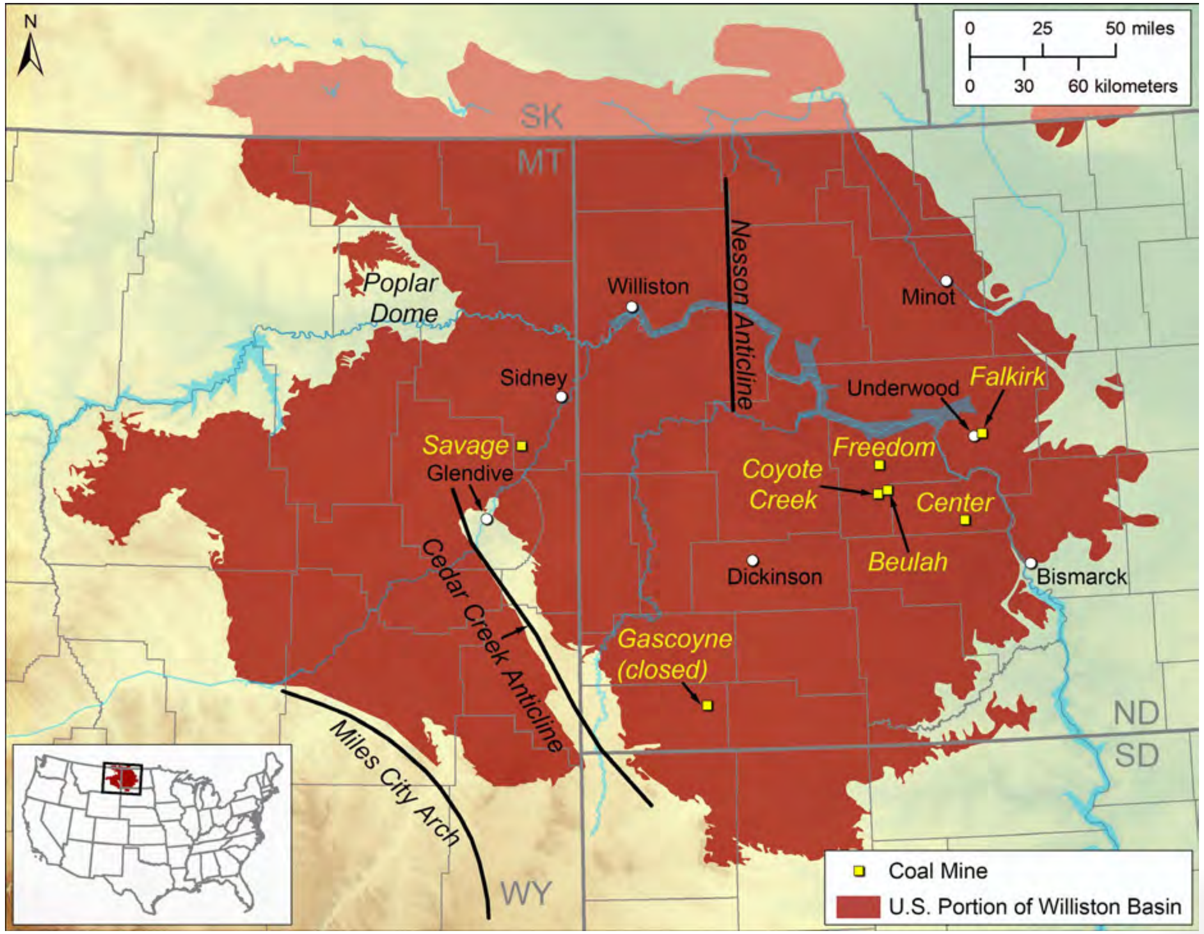
- Fuels
- Feedstocks
- Consumables

In production of rare-earth elements (REEs), critical minerals (CMs), or high-value, nonfuel, carbon-based products.



What's the Plan?

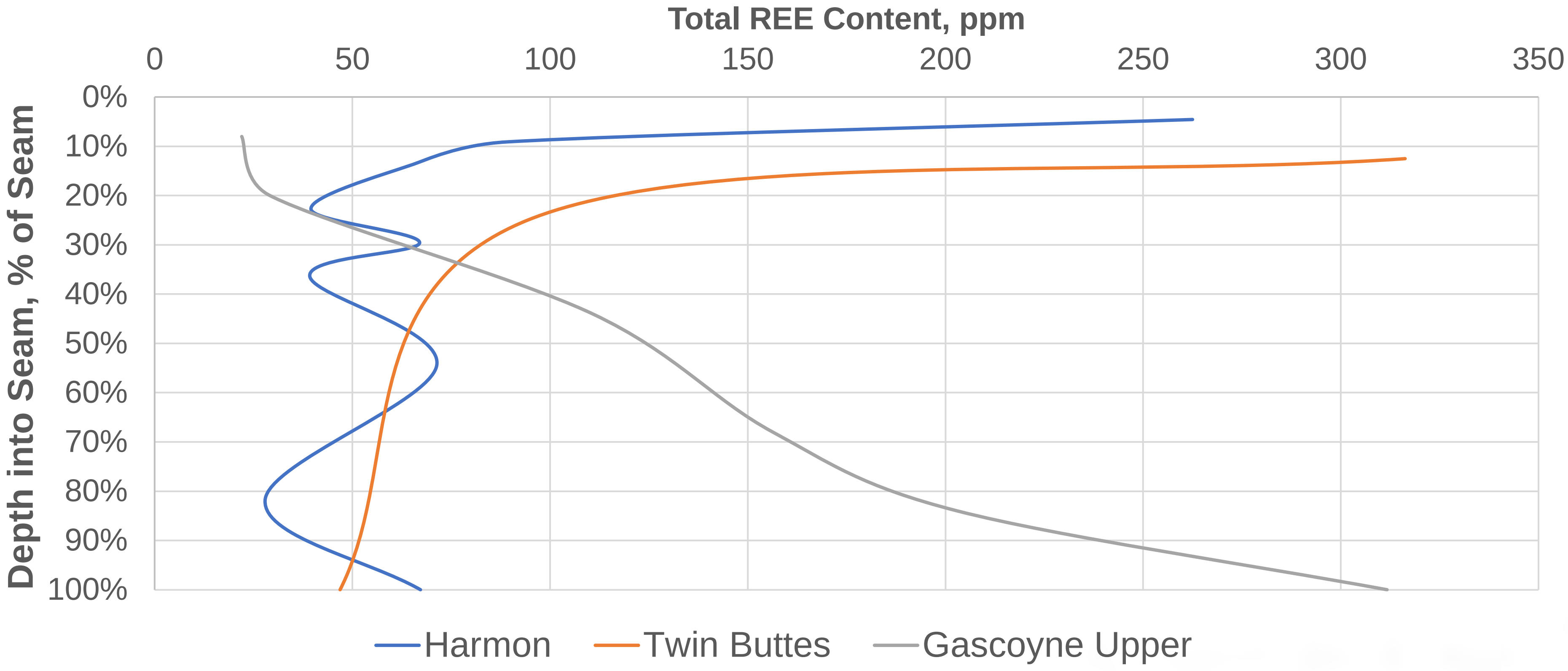
- **Compile a database of resources.**
  - Identify resources
    - ♦ Potential use
    - ♦ Volume of resources
    - ♦ Associated costs
    - ♦ Potential regulatory issues
    - ♦ Location
  - Any required enabling technologies
- **Integrate into the GIS-based model.**



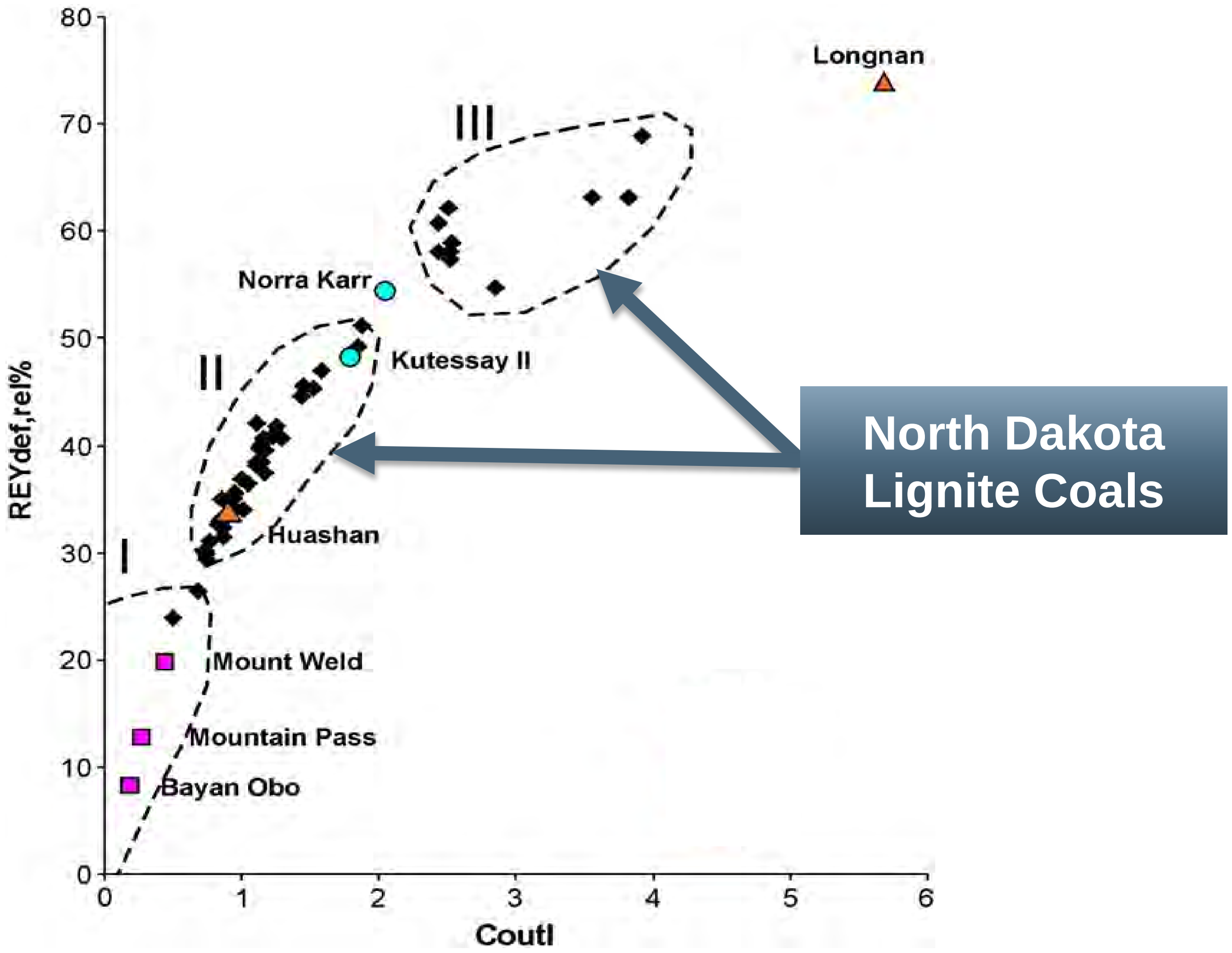
What Are Some of the Resources Identified So Far?

Sources identified as feedstocks for REEs, CMs, and carbon products

- Lignite mining waste
  - Roof
  - Floor
  - Tonsteins
- Combustion by-products – ash



Why Lignite Ash?



Group I – Unpromising
Group II – Promising
Group III – Highly Promising

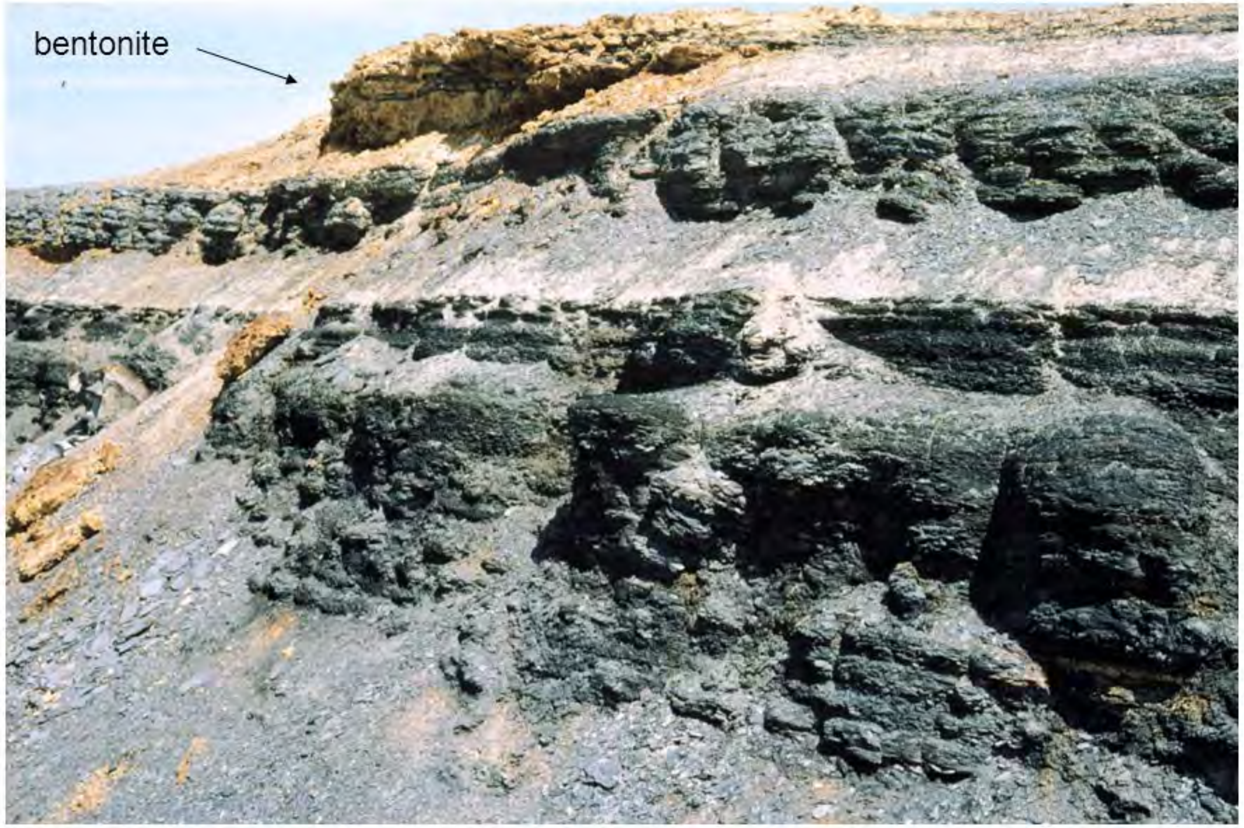
- REE-rich coal ashes
- Carbonatite ore deposits
- Hydrothermal ore deposits
- Weathered crust elution-deposited (ion-adsorbed) ore deposits

Seredin, V.V.; Dai, S. Coal Deposits as Potential Alternative Sources for Lanthanides and Yttrium. International Journal of Coal Geology 2012, 94, 67–93.

Other Resources – Shales

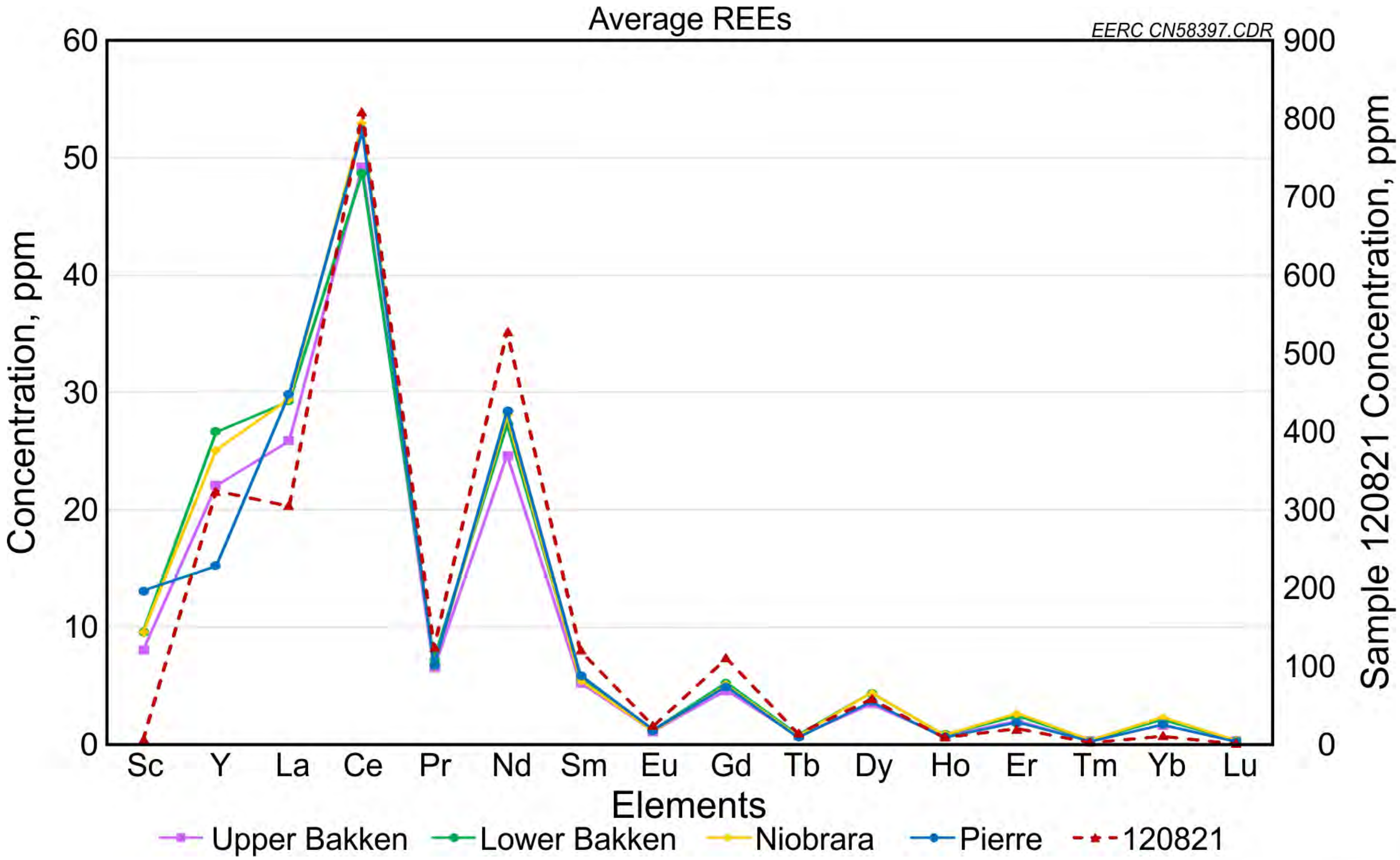
Of 43 Niobrara and Pierre samples, 9.3% had total REE levels greater than 300 ppm.

One location in the Bakken identified with REE levels over 2400 ppm.



Pierre shale with layers of bentonite.
Bentonite is weathered volcanic ash.

Average REE Levels in North Dakota Shales



Other Energy By-Product Resources?

Energy for Process

- Low-pressure/temperature steam from power generation
- Flare gas from oil production
- Methane from landfills
- Process heat from geothermal sources

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Other Chemical By-Product Resources?

- Chemical waste streams
  - Acidic materials
  - Basic materials
  - Organic materials

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Three Brands of Baking Soda by Willis Lam licensed under Creative Commons

Limes and Lemons by Michael Gabelmann is licensed under creative commons

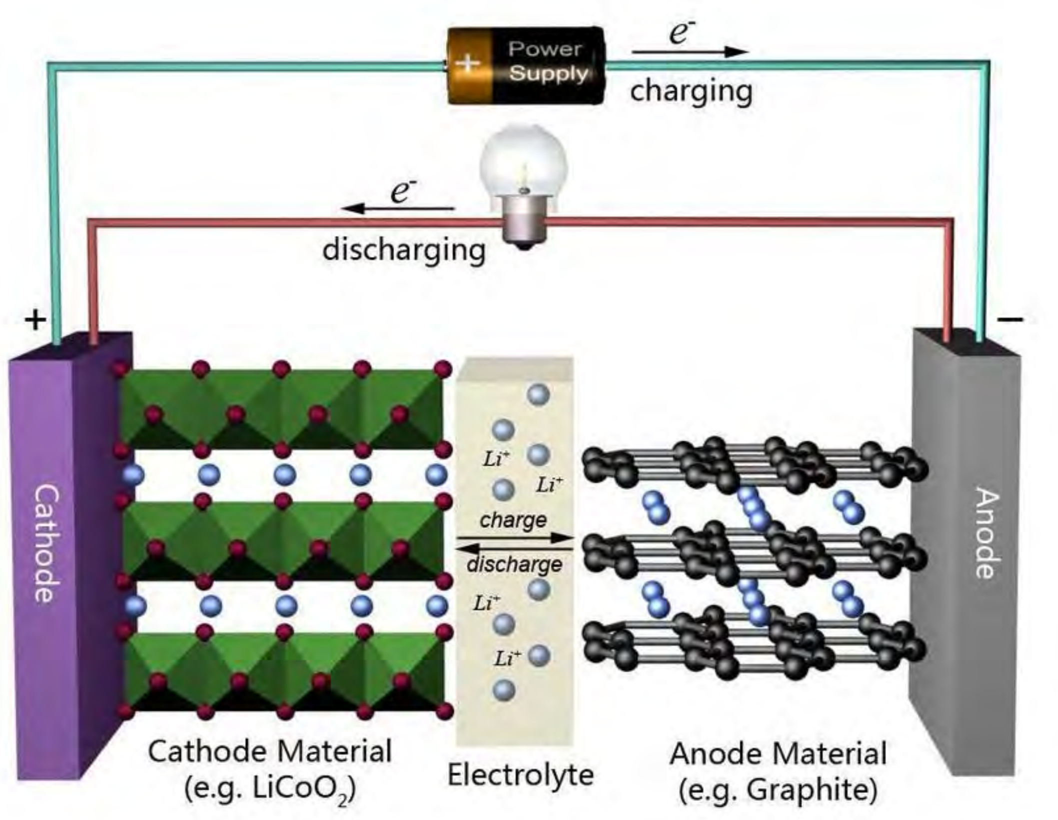
Sources for Process Chemicals

- Oil refinery waste streams
- Saline aquifers
- Produced water from oil production

Photo Credit EERC

Photo Credit EERC

Battery Materials: Lithium, Cobalt, Manganese, Nickel, Graphite



- Required for lithium-ion battery chemistries of all sizes, from hearing aids to grid scale.
- Heavy growth in all elements with EV industry and possible grid-scale energy storage.
- Doubling every 3–5 years.

Then What?

01

Identify Data Gaps

- What do we know?
- What do we need to learn?

02

Produce a Hierarchy of Best Potential Waste Streams

- Proximity to process sites
- Free or negative cost
- Improved environmental sustainability
- Regulatory considerations
- Transport

How You Can Help

- Resources and sites for future testing
  - Ores or waste streams for processing and testing
  - Piloting/testing/sites – Phase 2: 2024

- Technologies from partners to be evaluated
  - From any of the supply chain sectors
  - At any technology development level
  - Making a product needed or not currently made

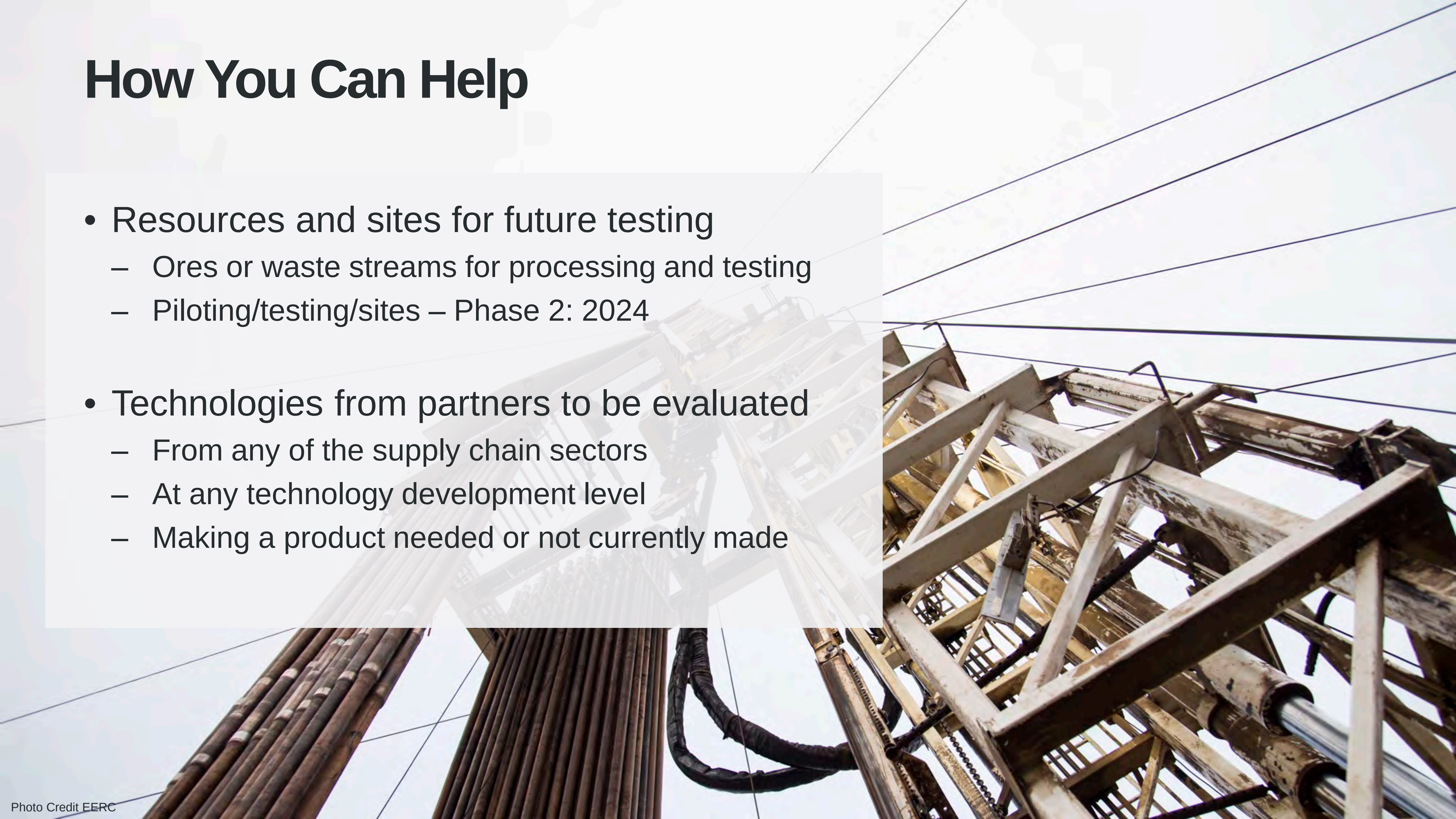


Photo Credit EERC


Thank You!
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THANK YOU

Critical Challenges. Practical Solutions.

EVALUATING TECHNOLGIES

Co-PI: Nolan Theaker
Co-PI: Bruce Folkedahl

Advisors
Shane Addleman - PNNL

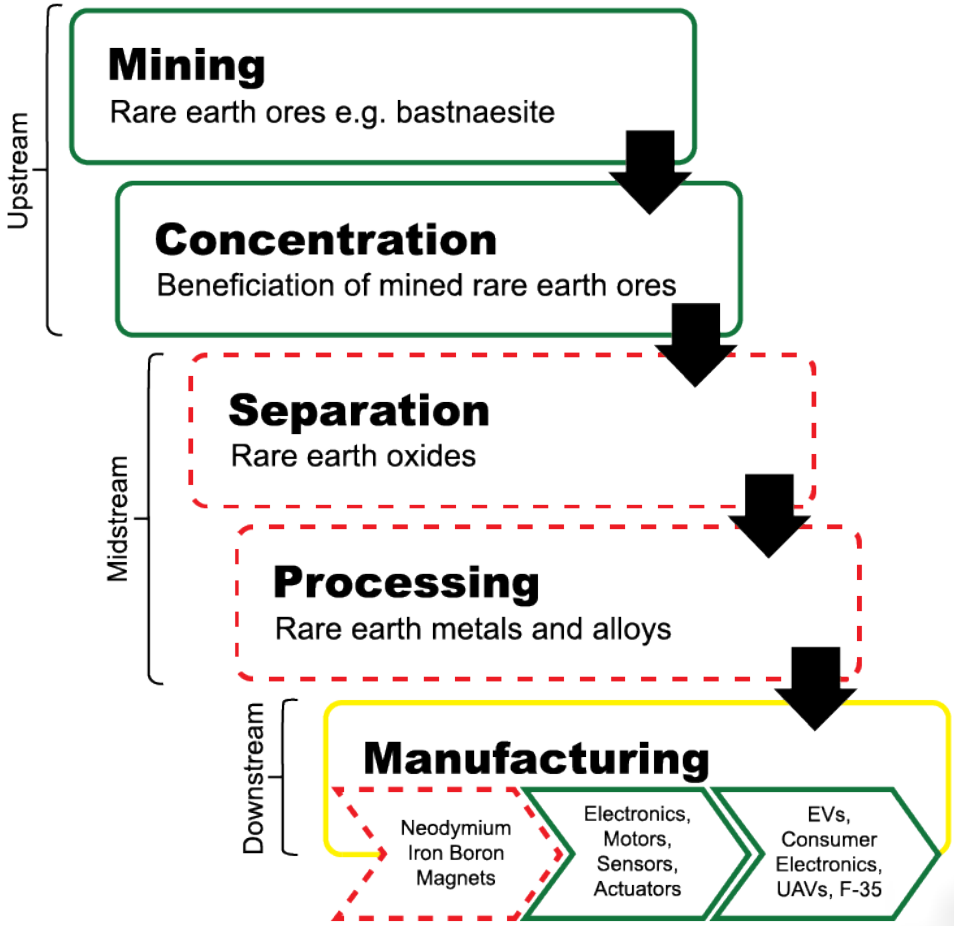
Overview

- Goals and scope of the study
- Elements of interest in the study
- Case study – rare earths
- Assessment plans

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

Scope of the Study

- Focusing on the sub-set of elements deemed market-relevant in the basin
  - REEs plus 7 other CMs
    - ♦ Determined from analysis and preliminary market research
  - Exclusions for absence in wastes/coals, or in nonprocessable form

- Evaluate technologies to the first “generally marketable” product
  - Product that can be significantly marketed outside of a linear supply chain

Mining Technologies

Process of getting high-value ore to surface including:

- Exploration technologies
- Ore extraction technologies/methods
- On-line/belt analysis/sorting technologies

Image Credit: Energy Technologies Inc.

Image Credit: Lignite Energy Council – Falkirk Mine

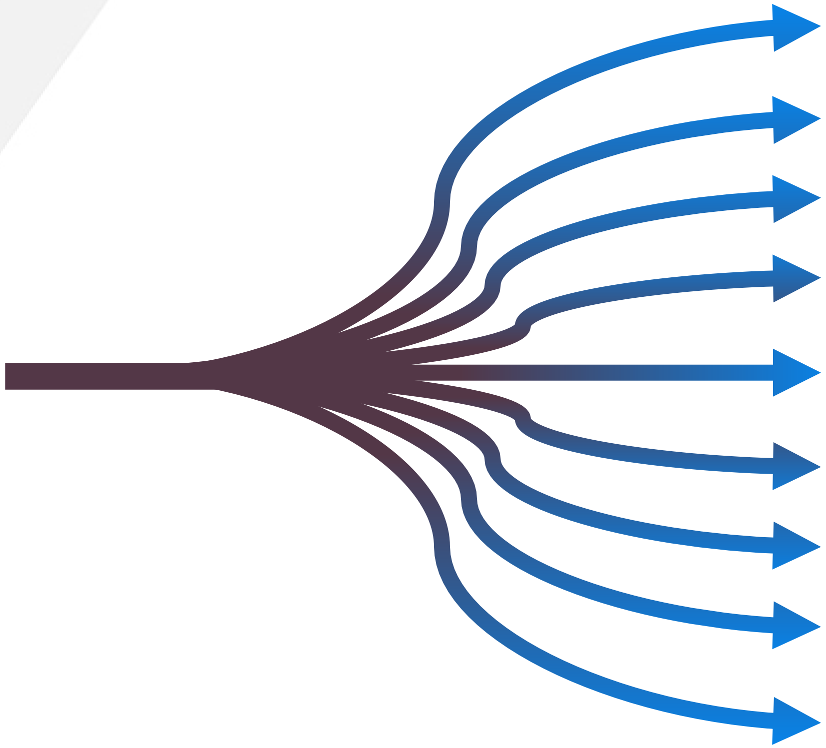
Ore Concentration

- Making a valuable component in a dilute ore more pure
  - Product not purity or form of final product
  - <5% ore to >90% concentrate
  - Removing impurities that are challenging to refine

- Physical and chemical means of ore concentration
  - Commonly both methods combined for a single processing method
  - Process designed for the feedstock

Image Credit: Mineral Technologies

Separation



- Separating - Generating a high-purity material (may not be in the right form)
  - Example: separating mixed REEs into individually pure forms
    - Many separation approaches exist

- Ore feedstock only somewhat affects the processing technology
  - Certain impurities not amenable with certain technologies

Processing

- Processing – Converting the high-purity material into a usable form
  - Example: Making metals from oxides or salts, or carbon fibers from pitch
  - Typically does not involve substantive purification
- Typically ore-feedstock-agnostic
  - Purity set by downstream, met by upstream

Image credit: Atlantic Copper/Mining Journal

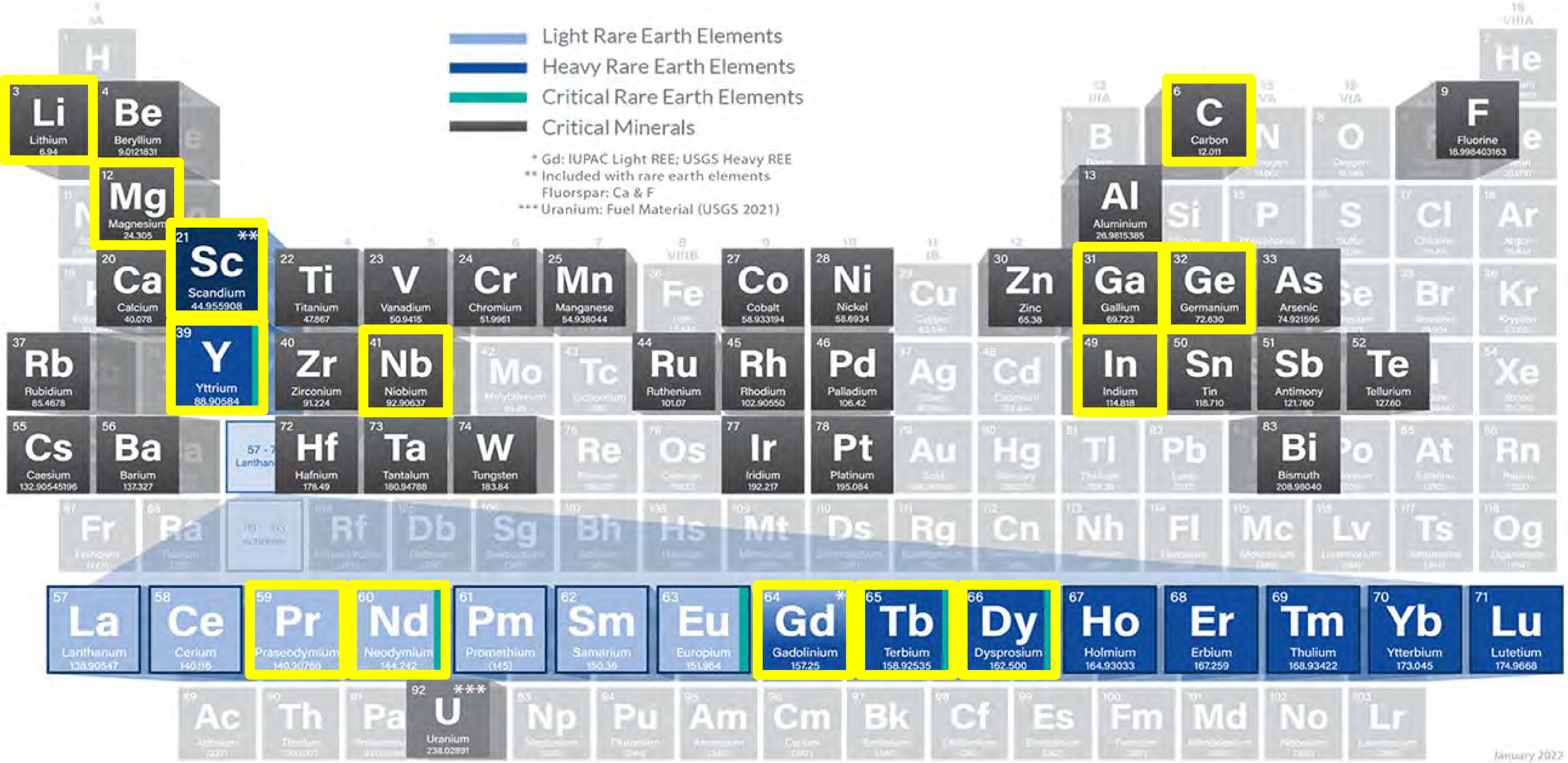
Manufacturing

Making the products that we use and need

- Generally marketable products
  - Products that are salable in many industries/final products
  - Magnets and electrical components
  - Graphite, carbon fibers, etc.
- Process may become feedstock-conscious again
  - Non-technical but for business
  - Buy American, ESG

Image Credit: NETL – REE/CM Website

Elements of Interest

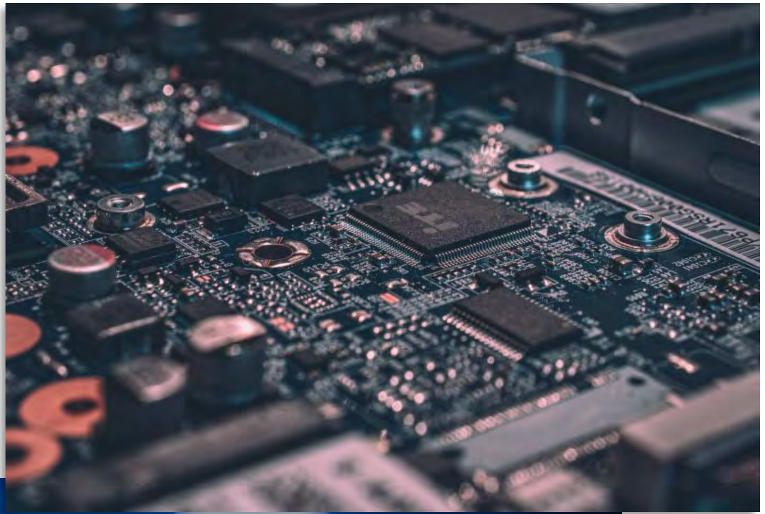


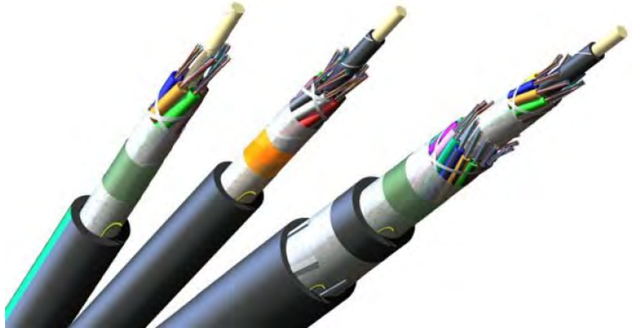
Rare-Earth Elements

- Many products possible from REEs, although magnets largely dictate production
  - Ores contain all 16 elements, despite only 4-5 high-value elements
    - ♦ Concentration/separation focused on high-value elements
- Production in U.S. focused on mining only
  - Mountain Pass, California
    - ♦ Refining and processing conducted non-domestic

Semiconductor Metals

- Encompasses Germanium and Gallium
  - Needs <u>very</u> high purity for marketability
    - 99.9999%+ usually as base
  - Very limited production, only recycling
    - More than 90% import reliant
    - Identified as a key weakness by DOD suppliers
- Commercial production from lignite/low-rank-coals done globally
  - Fly ash recycling and processing

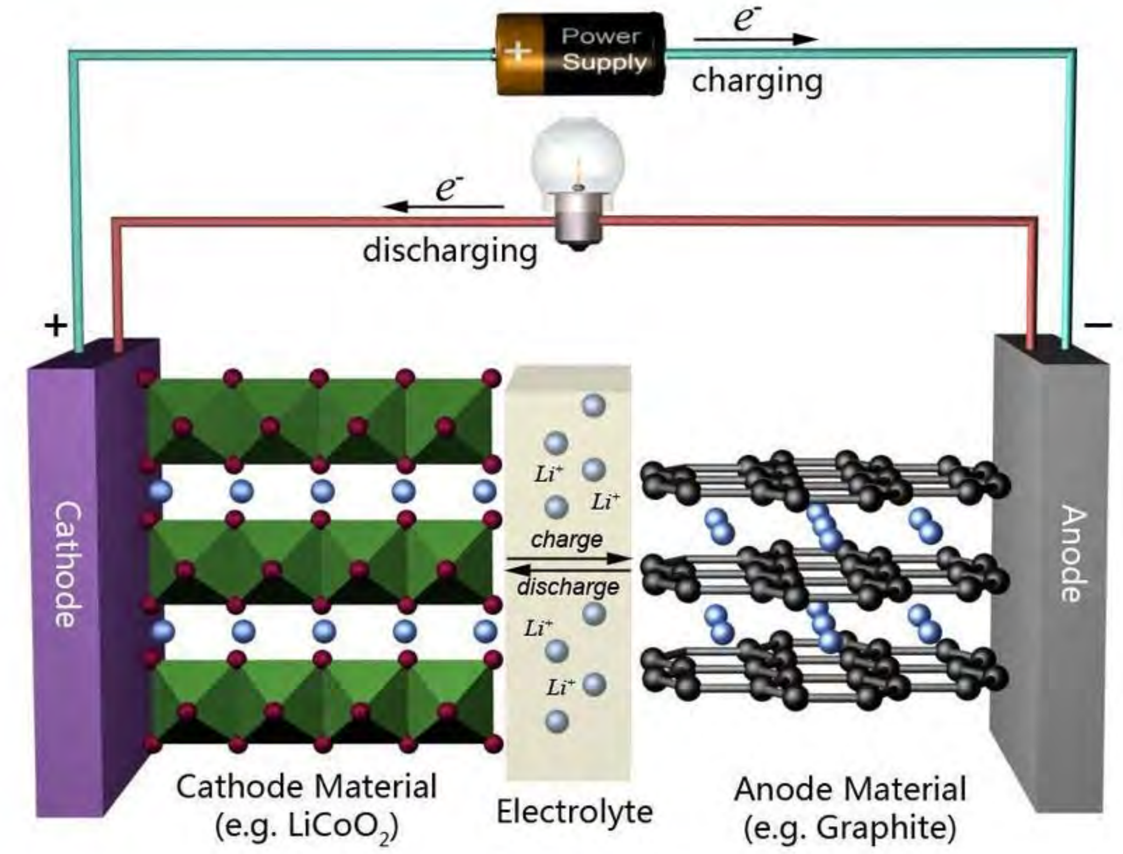




Lithium

- Predominantly used in lithium-ion batteries
  - Commonly sold as battery-grade lithium carbonate

- Technologies for processing revolve around resource type
  - Brine vs mineral
    - ♦ This study will focus on brines
  - Both technology areas are commercial



Carbon

- Graphite identified as critical mineral
  - Heavy battery application use

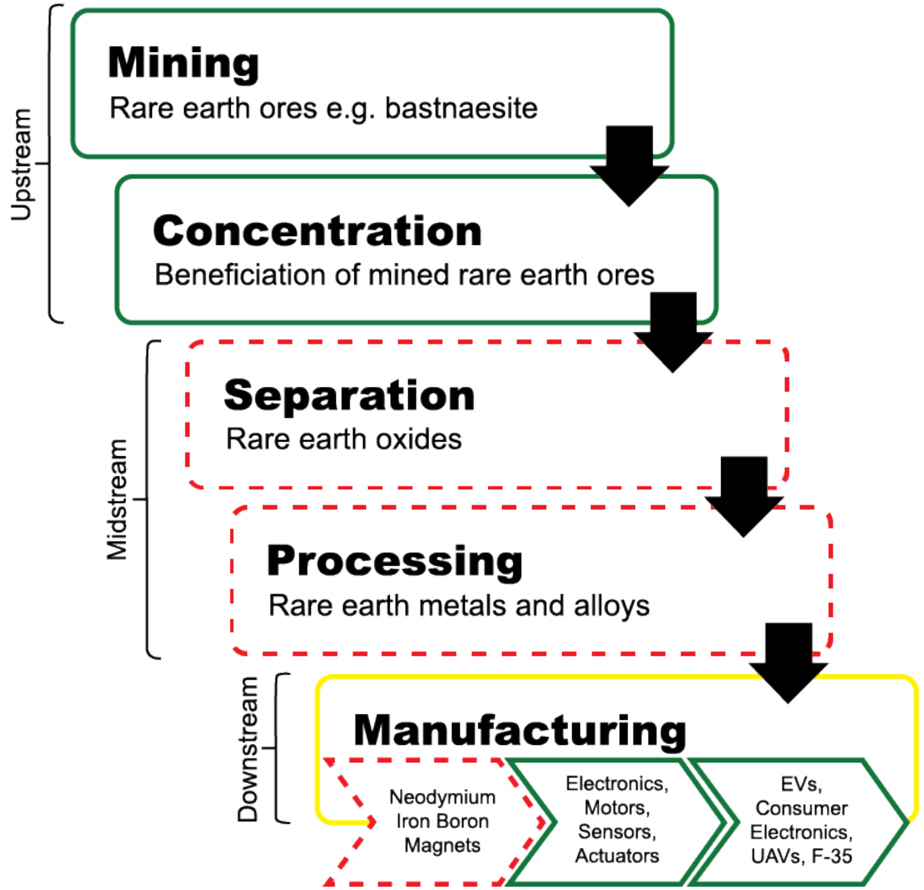
- Many other carbon products in high or emerging demand
  - Graphene
  - Carbon fibers
  - Activated carbon
  - Many more

Image credit, phone: Tyler Lastovich, Pexels
Image credit, graphene pattern: Graphen by AlexanderAIUS is licensed under CC BY 3.0

Case Study – Rare Earths Supply Chain Evaluation

Evaluation criteria and span of technology inclusion

- Identify current US scale of technology use
- Identify feedstock criteria



Mining – Rare Earths

- Two main resources within *coal* basin
  - Lignite deposits
  - Fly ash
- Commercial "mining" of both conducted
  - Getting high-value ore to the surface
- Focus for REEs
  - Analysis and sorting of material
    - ♦ Not commercial yet for REEs
  - Selective mining of high-REE seams
    - ♦ Mining of sub-seams commercial to 3-6″ accuracy
    - ♦ REEs abundant at margins of seams

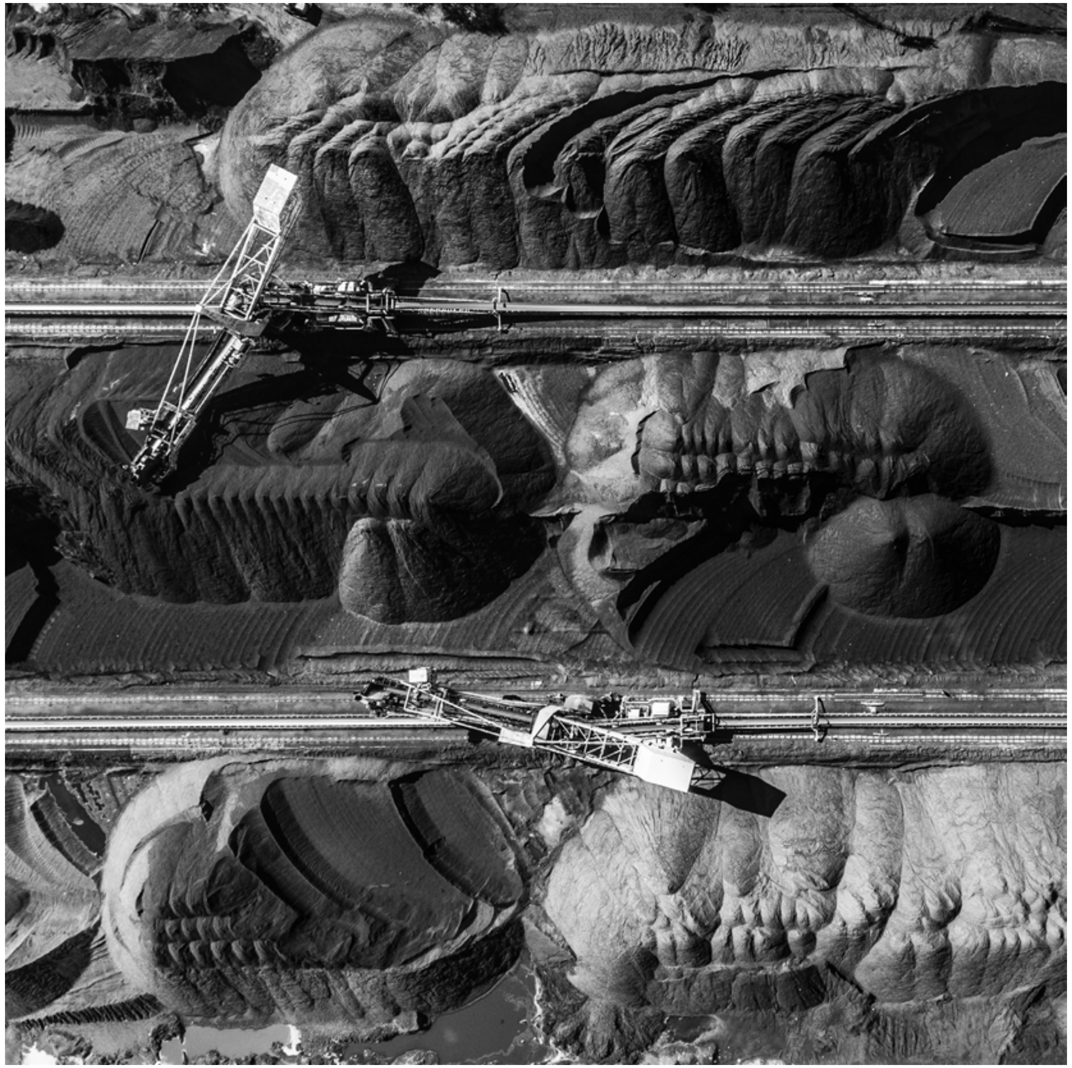


Image credit: Curioso Photography, Pexels

Ore Concentration – Rare Earths

- Goal: Mixed rare-earth oxide (MREO) concentrate
  - Typically chemical processing/ore digestion
  - From lignite – testing at pilot scale this year
  - From fly ash, technologies at/near bench-scale

- MREO is standard form of product for downstream

Image Credit UND Institute for Energy Studies

Separation – Rare Earths

- Goal – Individually separated REOs (ISREO)
  - Many separation pathways possible
  - US capacity limited to combined ~200 tons/year
    - US demand >6,000 tons/year direct
  - Pilot to near-pilot technologies exist
  - Largely REE-ore agnostic
  - Purity >99%

Image Credit: NETL – Resource Sustainability Website

Processing – Rare Earths

- Goal – Rare-earth metals (REMs) and alloys
  - Not a purification process – incoming must match outgoing needs
    - ♦ Completely feedstock agnostic
  - Common alloys: Nd/Pr, Sc/Al
  - Domestic production <10 tons per year
    - ♦ Commercial tech, but non-US
    - ♦ Pilot tech in US

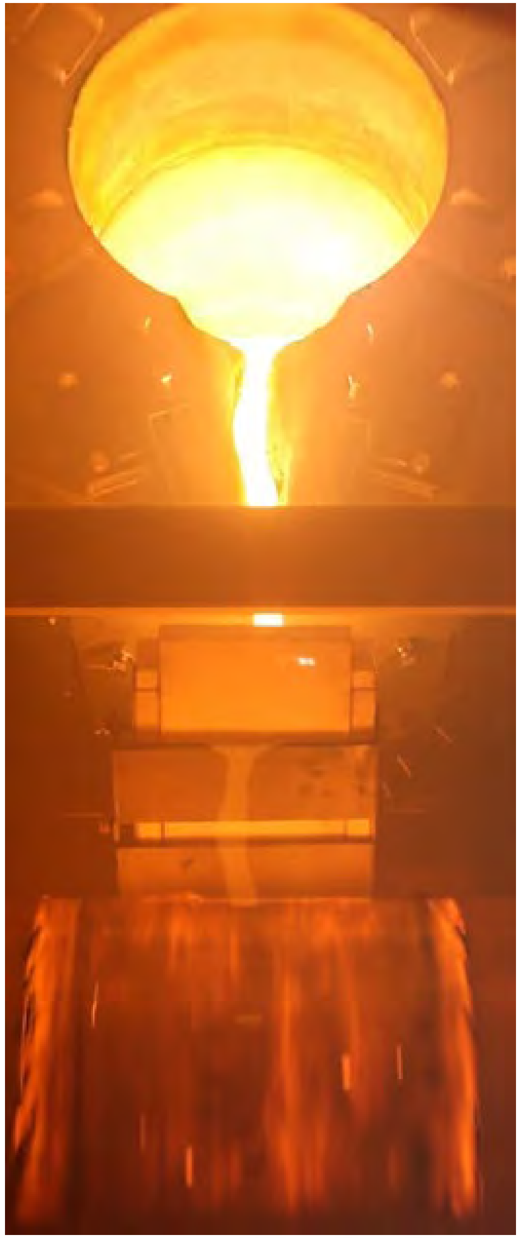


Image Credit: Less Common Metals

Manufacturing – Rare Earths

- Goal: Rare-Earth Magnets
  - Blending of REMs, Fe, B for specific magnet formulation
    - Many formulations exist – application-focused
  - Coating of surface (to avoid oxidation)
  - US capacity <0.01 tons per year
    - Essentially lab-scale
  - Heavily patented field – entrance into market challenging

Image Credit: Stanford Magnets

Assessment – Williston Basin Resources

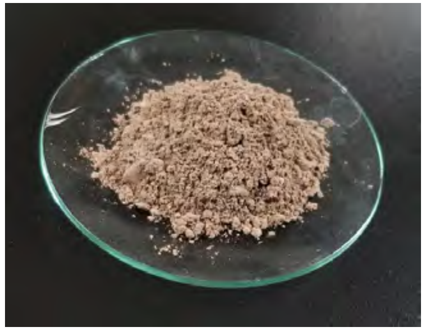
- Coal and hard rock resources
  - Can these technologies use the W.B. low-rank coals?
    - ♦ What change is needed for them to?
  - What concentration/form of ore is needed?

Image Credit: Lignite Energy Council – Falkirk Mine

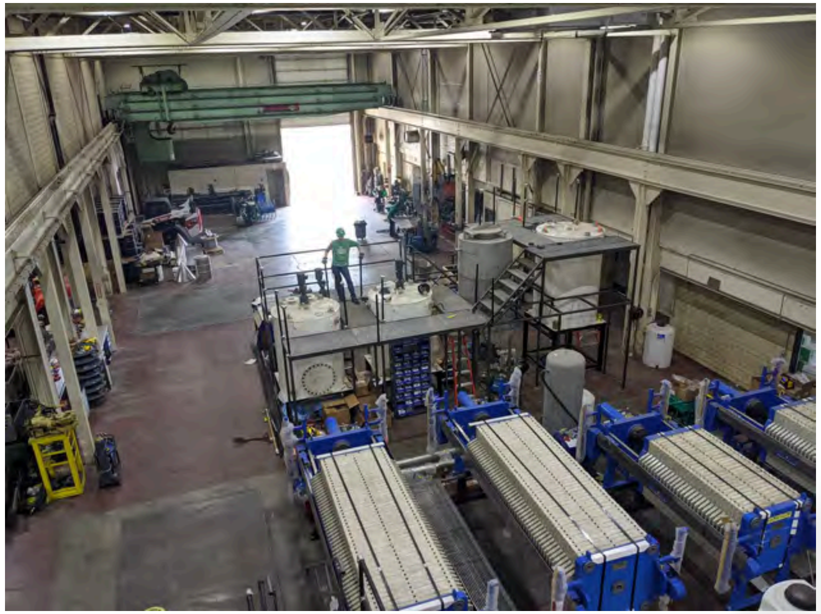
- Non-rock resources
  - Are there REEs/CMs within non-mineral resources within the region?
    - ♦ Can technologies account for the impurities/non-valuable effects of these?

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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University of North Dakota

College of Engineering & Mines
University of North Dakota

BUSINESS OPPORTUNITIES IN THE WILLISTON BASIN

Jason Laumb
Task Lead

Task Assistants
Dean Bangsund – NDSU
David Flynn – UND Nistler School
Kirk Williams – EERC

Strategy – What Do We Have?

- Identify basin infrastructure, businesses/industries, and economic challenges.
- Identify markets, barriers to market penetration, size, distribution, and needs.
  - Competitive environment
    - ♦ What is the competition?
    - ♦ How is this product superior?
      - Lower CO_2 footprint?
      - Cheaper?
      - Available?

Business Boundary Timeline and Team

Existing Infrastructure

STAGE 01

Businesses and Industries

STAGE 02

Market Assessment

STAGE 03

Infrastructure and Supply Chain Gaps

STAGE 04

Jason Laumb,
Angie Morgan, and others

EERC

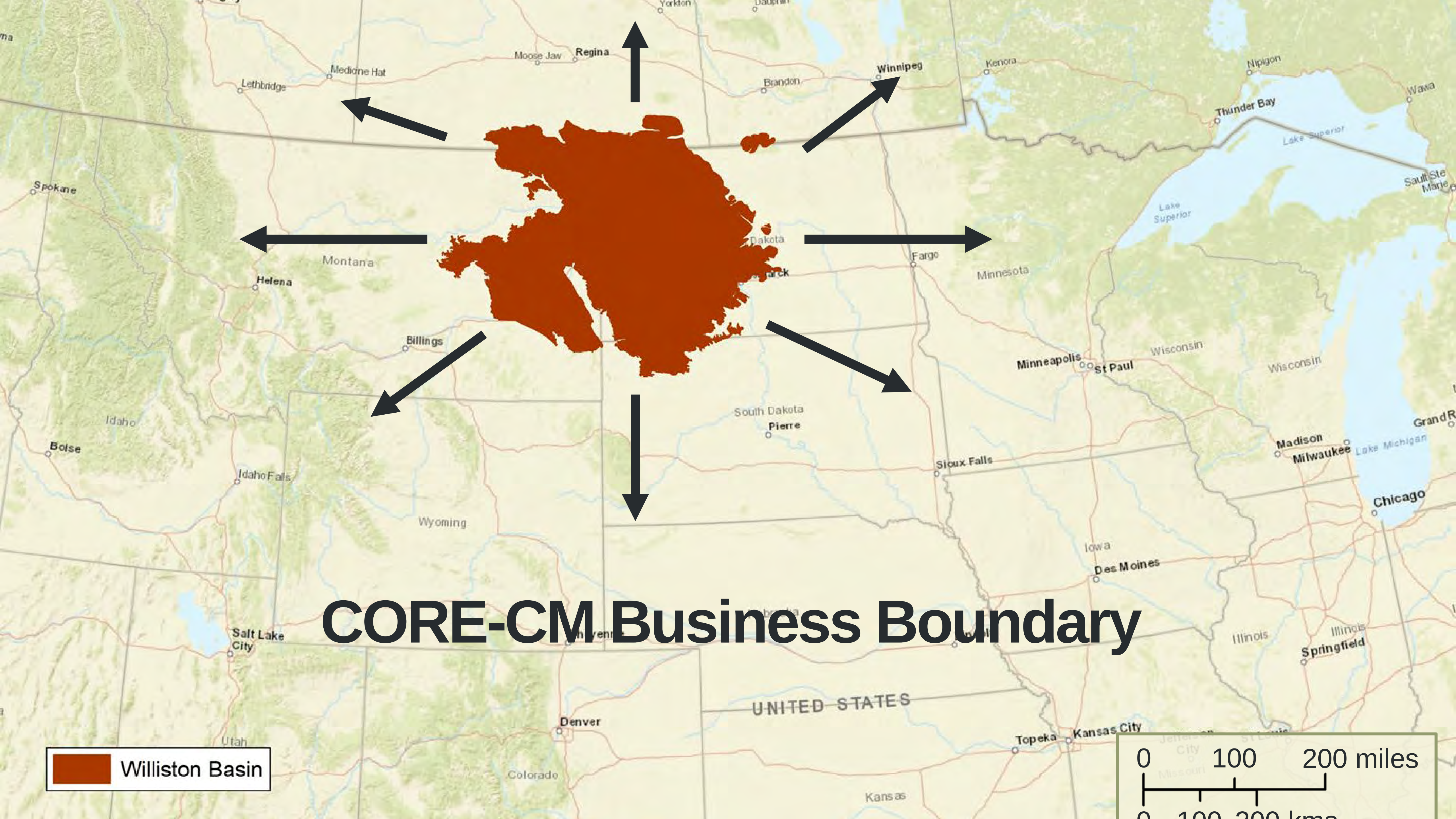
David Flynn
UND Nistler School

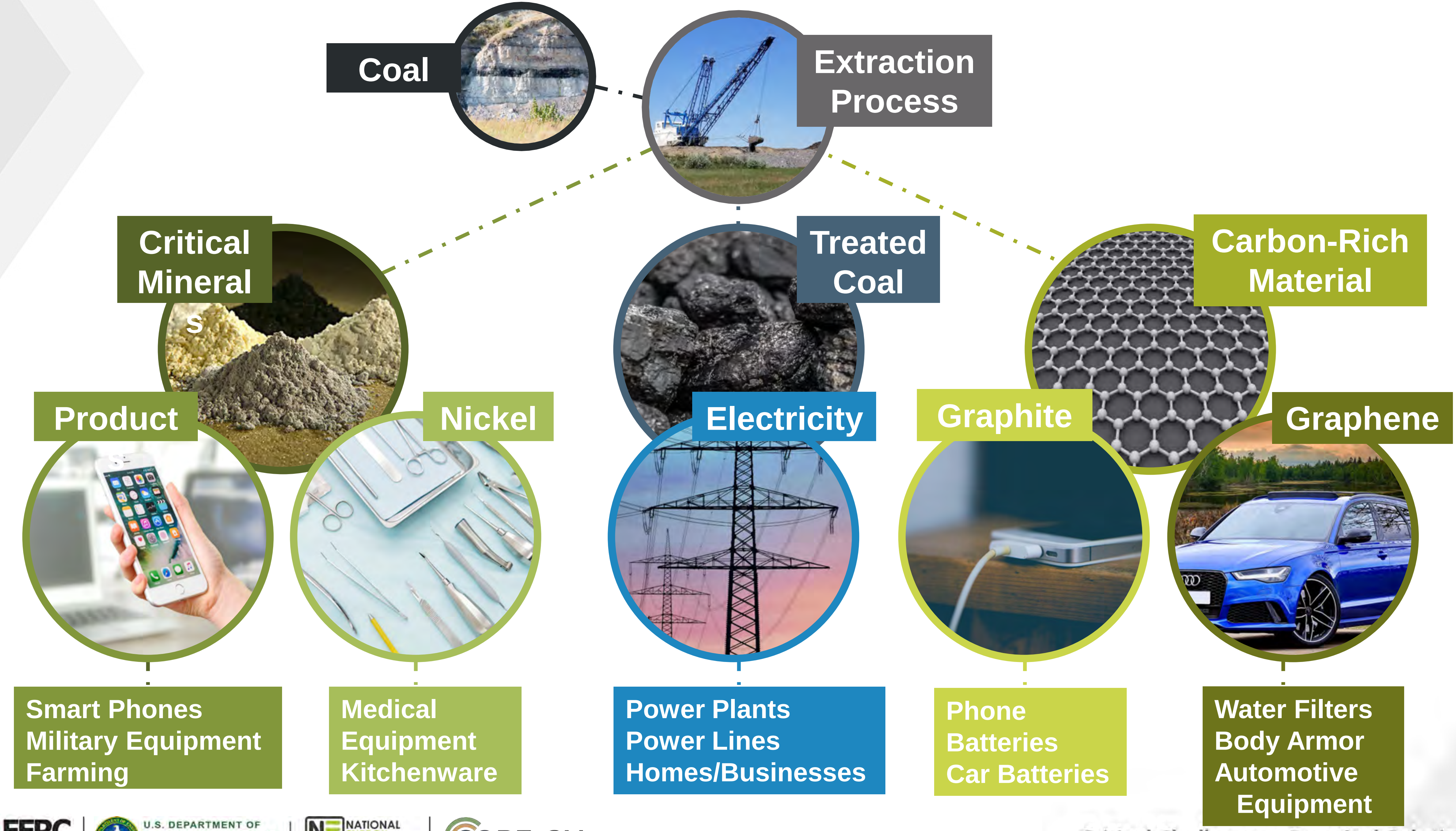
UND

Dean Bangsund
Ag Economics

NDSU

CORE-CM Business Boundary





Critical Challenges. Practical Solutions.

Strategy – Know Your Customer

Raw REEs/CM?

Final Products?

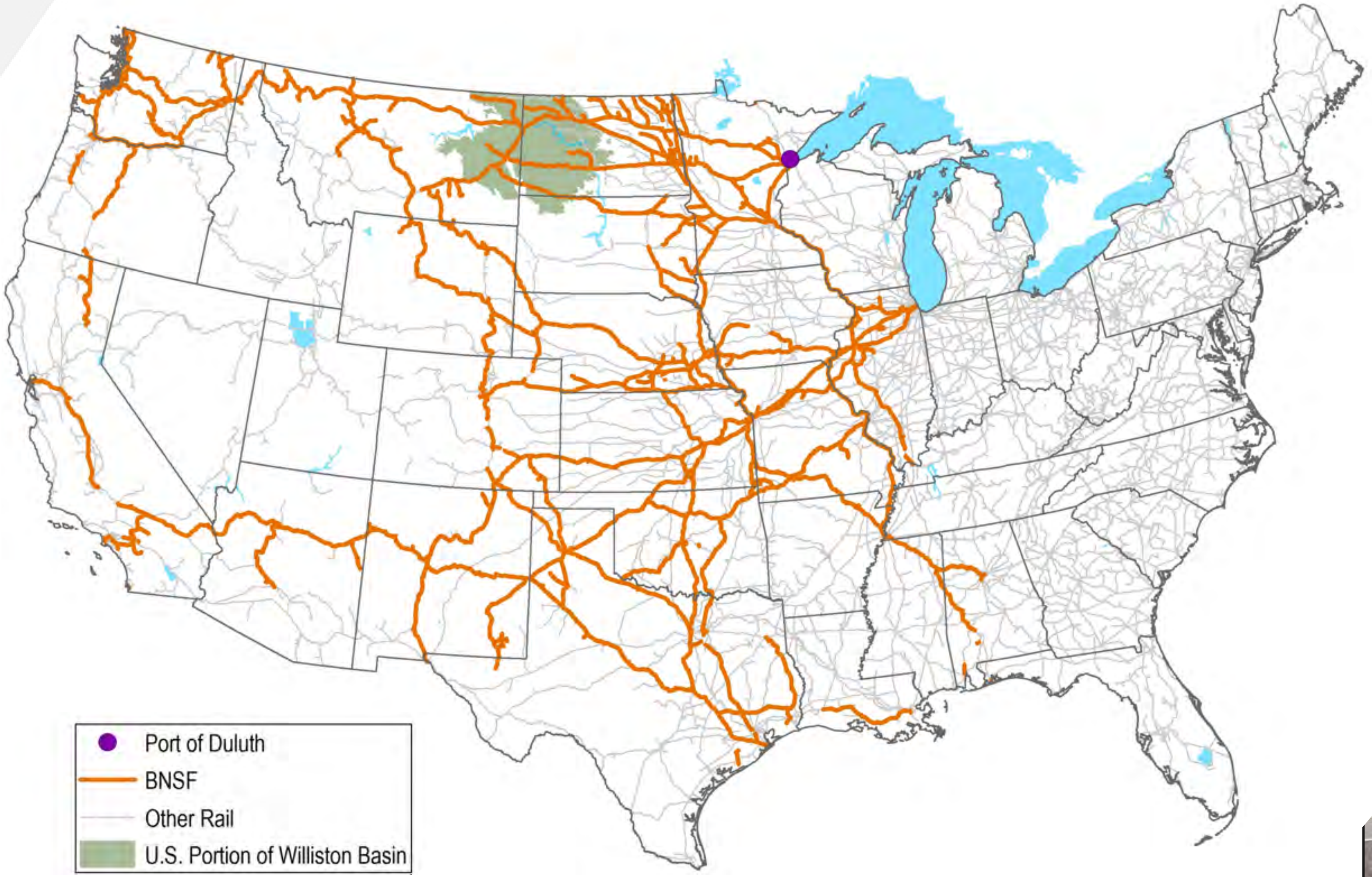
- Magnets
- Aggregate
- Computer components
- Graphite/graphene
- Batteries

Photo Credit: Tima Miroshnichenko from Pexels

Strategy – What Do We Need?

- **Additional infrastructure and resources**
- **Ideas to spur economic growth**
- **Logistical needs to fill supply chain gaps**

Advantageous Transportation Infrastructure

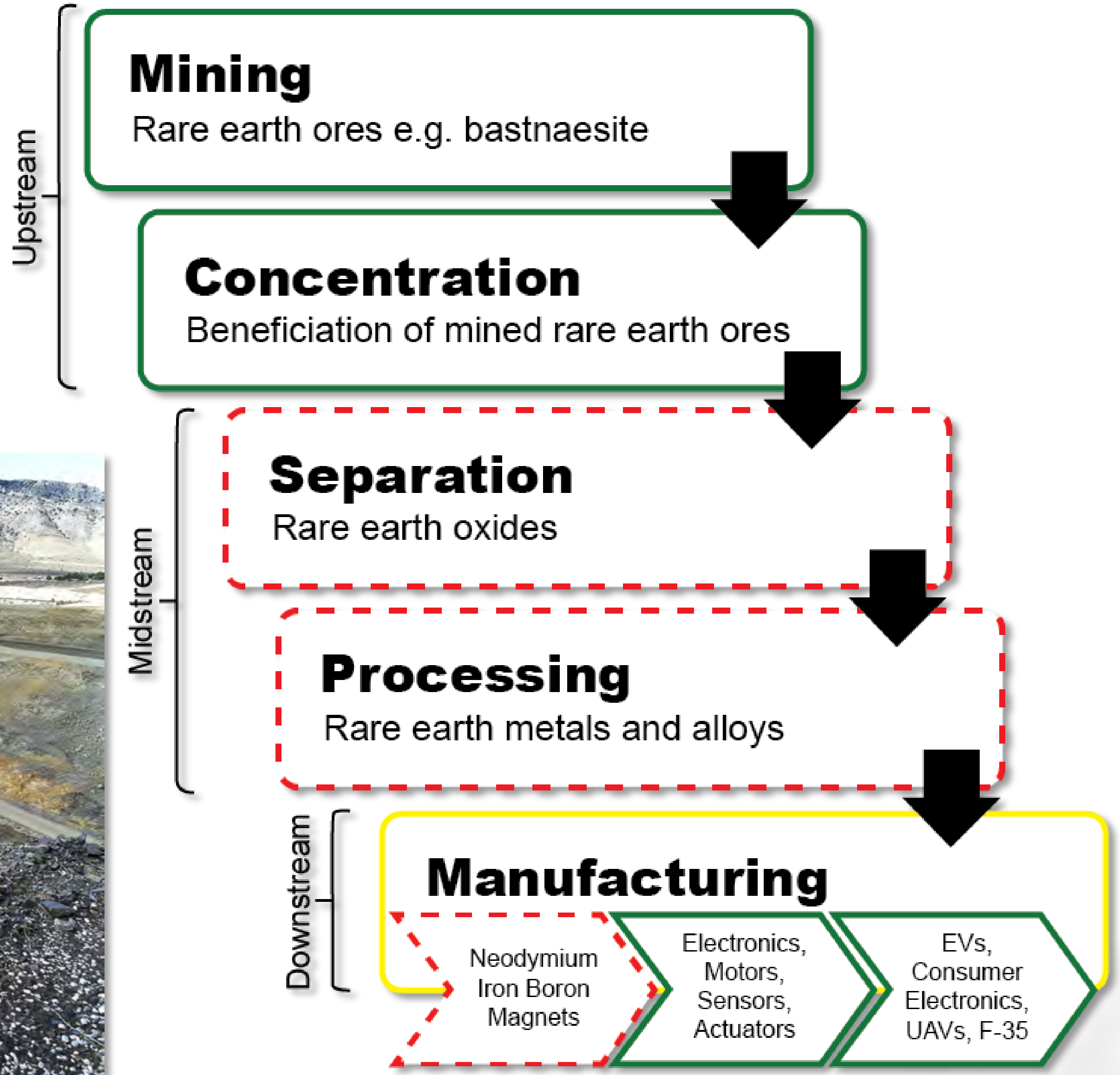


- Rail
- Truck
- Port in Duluth

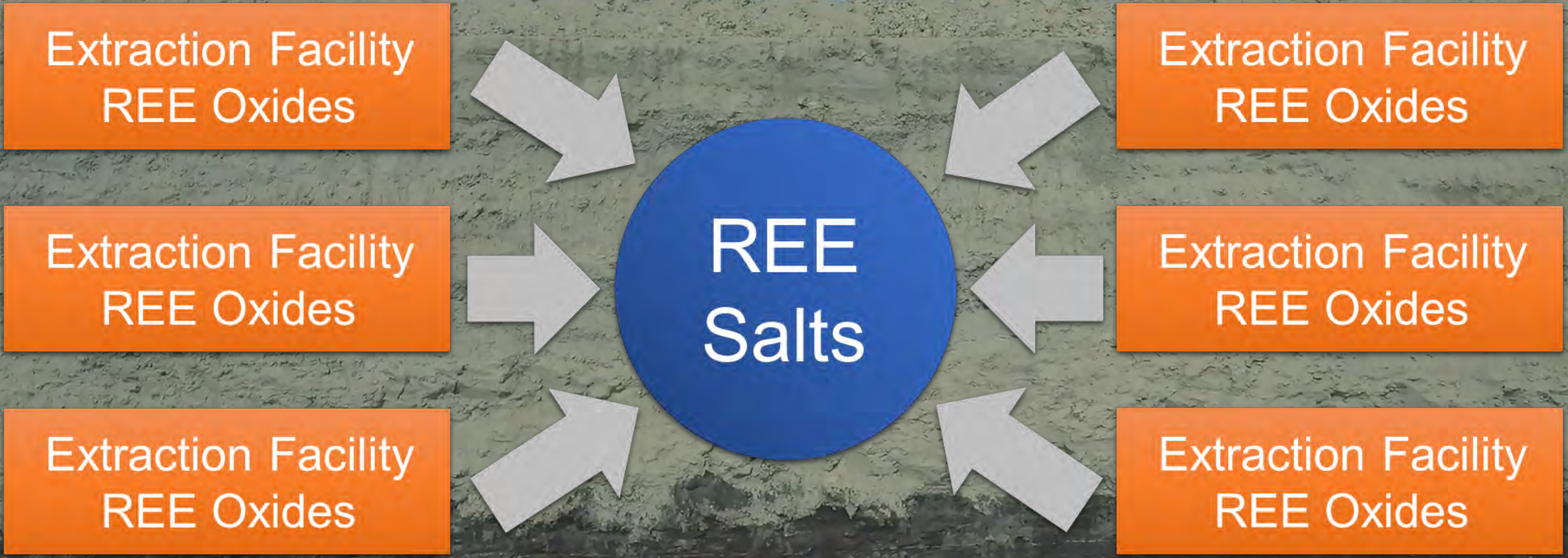
Key Findings

- Regional industries
  - End users of final products
  - Defining business model

Mountain Pass REE Mine, California



Extraction to Concentrate – Hub and Spoke



- Synthetic graphite: $22,000 per ton.
- Expected new market over 1 million tons per year by 2025.

Graphite Target Parameters

Property	CDG Quality/Performance Target	Commercial Battery-Grade (SLC1506T) Graphite
Carbon Purity, %	>99.90	≥99.90
Ash, %	<0.05	≤0.10
Moisture, %	0	≤0.10
Tap Density, g/cm^3	≥1.00	≥1.00
Performance Parameters		
First Cycle Specific Capacity, mAh/g	377	377.2
First Cycle Efficiency (FCE), %	~93	~93.3
Reversible Capacity, mAh/g	~340 – 355	~340 – 355
C/10 Retention after 22 Cycles, %	99.9	99.9

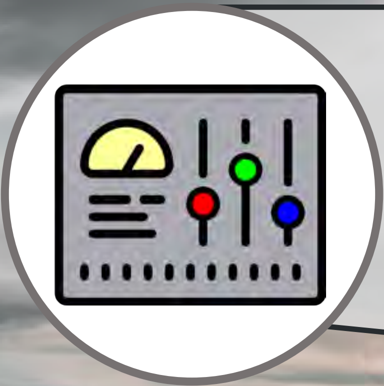
Barriers: Limited Market Penetration and Price Control

Market Assessment

- Key barrier – market penetration
  - Large purchase agreement
  - China controls the price!
- Use of CMs in our region?

Vehicles, Machinery, and Equipment

John Deere, Bobcat, Arctic Cat, Polaris, Case IH, Snow Bear



Electronic Components

SJE, Inc., Alderon

Agricultural Processing

Ethanol Producers, Oilseed Crushing, Milling, Pasta

Batteries and Electrical Storage

Dakota Lithium

Medical Devices and Equipment

Medtronic

Military Operations

Grand Forks Airbase, Minot Airbase, Northrup Grumman

Recycling

- Magnet elements are near-term target
  - Neodymium
  - Praseodymium
  - Dysprosium
  - Terbium
- Turbine motors
- MRI machines
- Hard drives

Image Credit: Mart Production/Pexels

Key Takeaways

1. Critical mineral users and markets are influenced globally.
2. Hub-and-spoke development.
3. Key market barrier is the buyer.

How You Can Help

- Additional critical materials that have come to light because of political unrest in Europe?
- Supply of critical materials that is impacting your business?
- Forecasted supply chain issues for components using critical materials?

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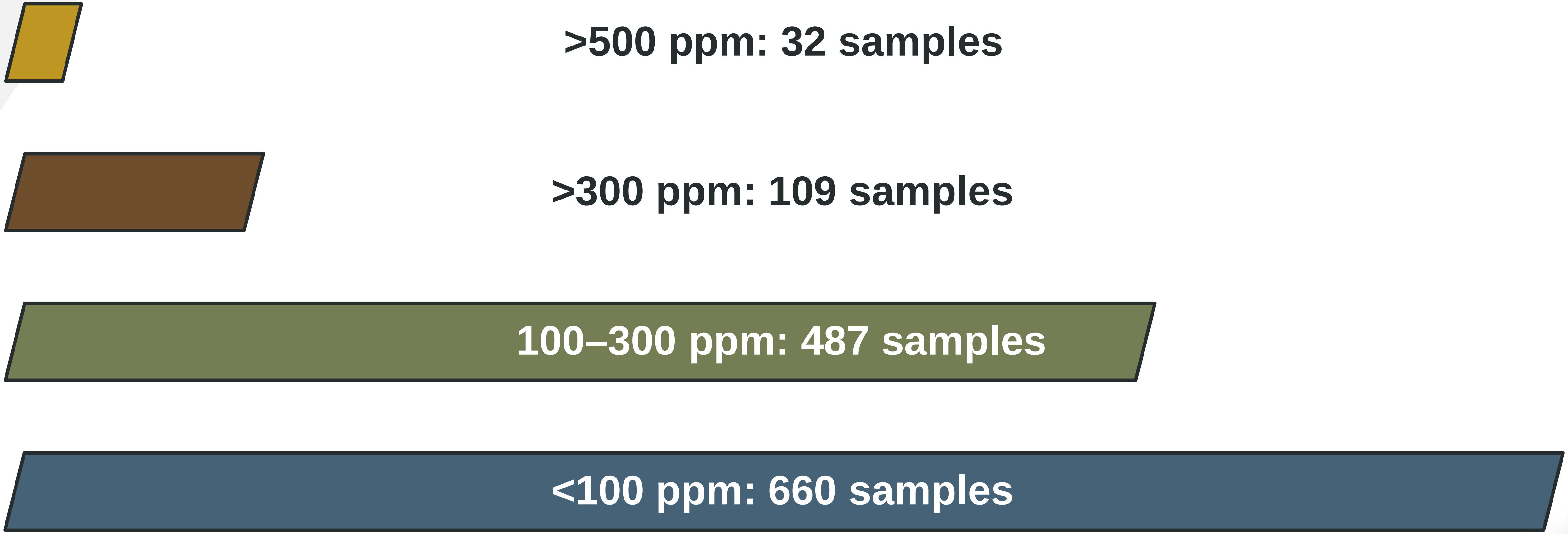
THANK YOU

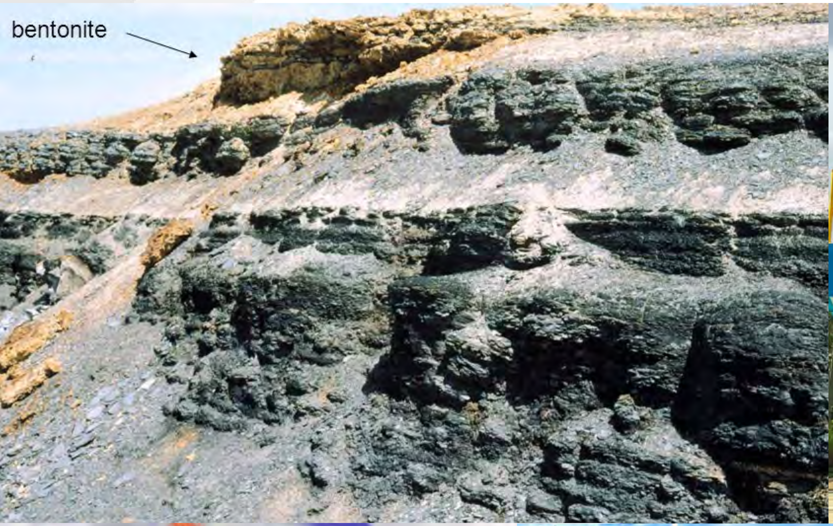
Critical Challenges. Practical Solutions.

THE ROAD AHEAD

Vast areas still need to be explored, and more detailed sampling must be done.



Related resources have been identified as having CM synergies.



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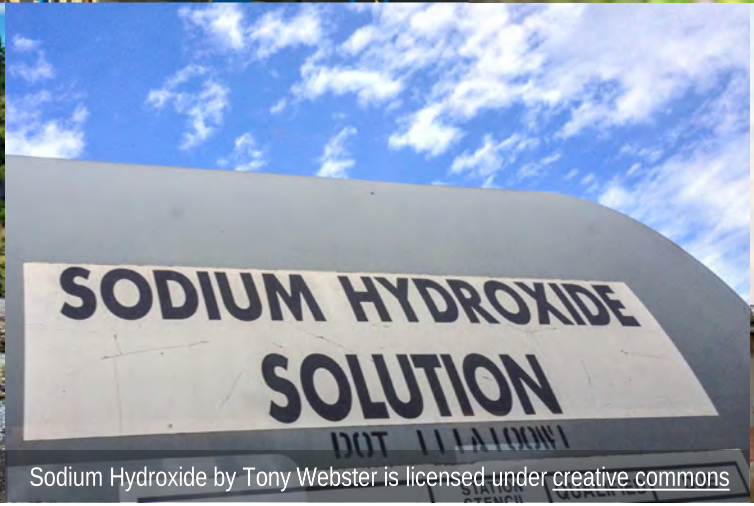

Sodium Hydroxide by Tony Webster is licensed under creative commons

Photo Credit: EERC

Several technologies are available for CM extraction and processing.
This phase is focused on identification; the next one is focused on demonstration.

Image Credit: Mineral Technologies

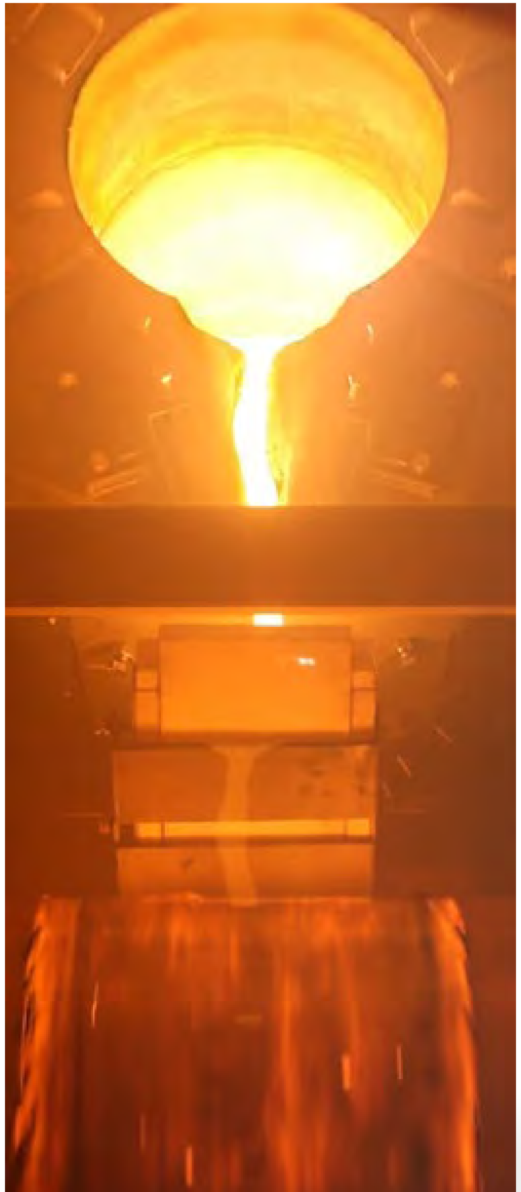

Image Credit: Less Common Metals

Image Credit: Energy Technologies Inc.

Image Credit UND Institute for Energy Studies

CM markets are highly influenced by global forces.

Technology Innovation Centers (TIC): Pushing the State of the Art

Working with Project Partners to Formulate Plans

- Basin-specific public–private partnerships
- Develop and validate CORE-CM technologies at laboratory scale

Photo by Cytonn Photography from Pexels

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

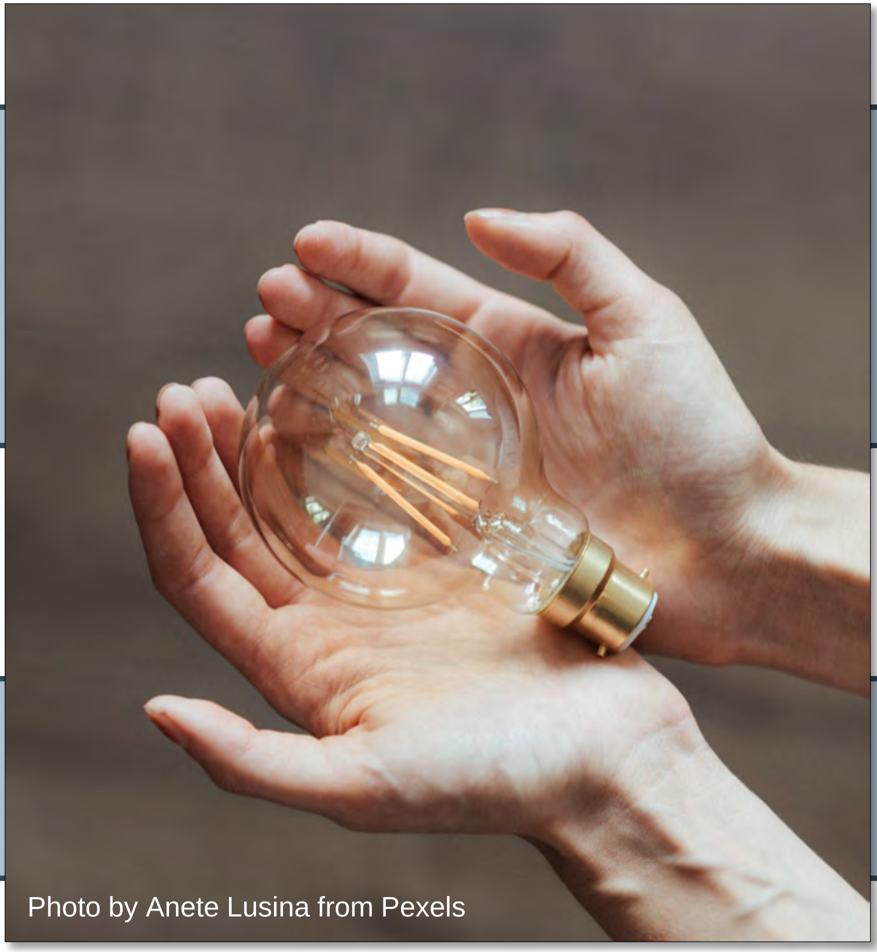

Photo by Anete Lusina from Pexels

Looking Ahead

Now
October 11, 2022
CREES-WB Symposium

Soon
November 30, 2022
Webinar:
CM Technologies

'23
January 11, 2023
Webinar:
Business in the Basin

TBA
March 2023
Webinar:
The Basin's CM Future

Fin
Spring 2023
Final Meeting
Phase I Ends

Next
The Future
Next Steps to
Be Determined

Phase I Next Steps: Now Through May 2023

- 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

Get Involved

The time is now.

Based on the next steps, prioritize work.

The wheels are in motion.

Collaborate.

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THANK YOU

Critical Challenges. Practical Solutions.