Energy & Environmental Research Center (EERC)

Williston Basin CORE-CM Initiative

6-month Virtual Meeting
March 23, 2022

John P. Kay (PI)
Principal Engineer


CORE-CM
WILLISTON BASIN
Assessing Our Resources
Assessing the Markets
Looking Ahead
Q&A Time

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 rare-earth elements (REEs) and critical minerals (CMs).
  - Strengthen our national economy and security.

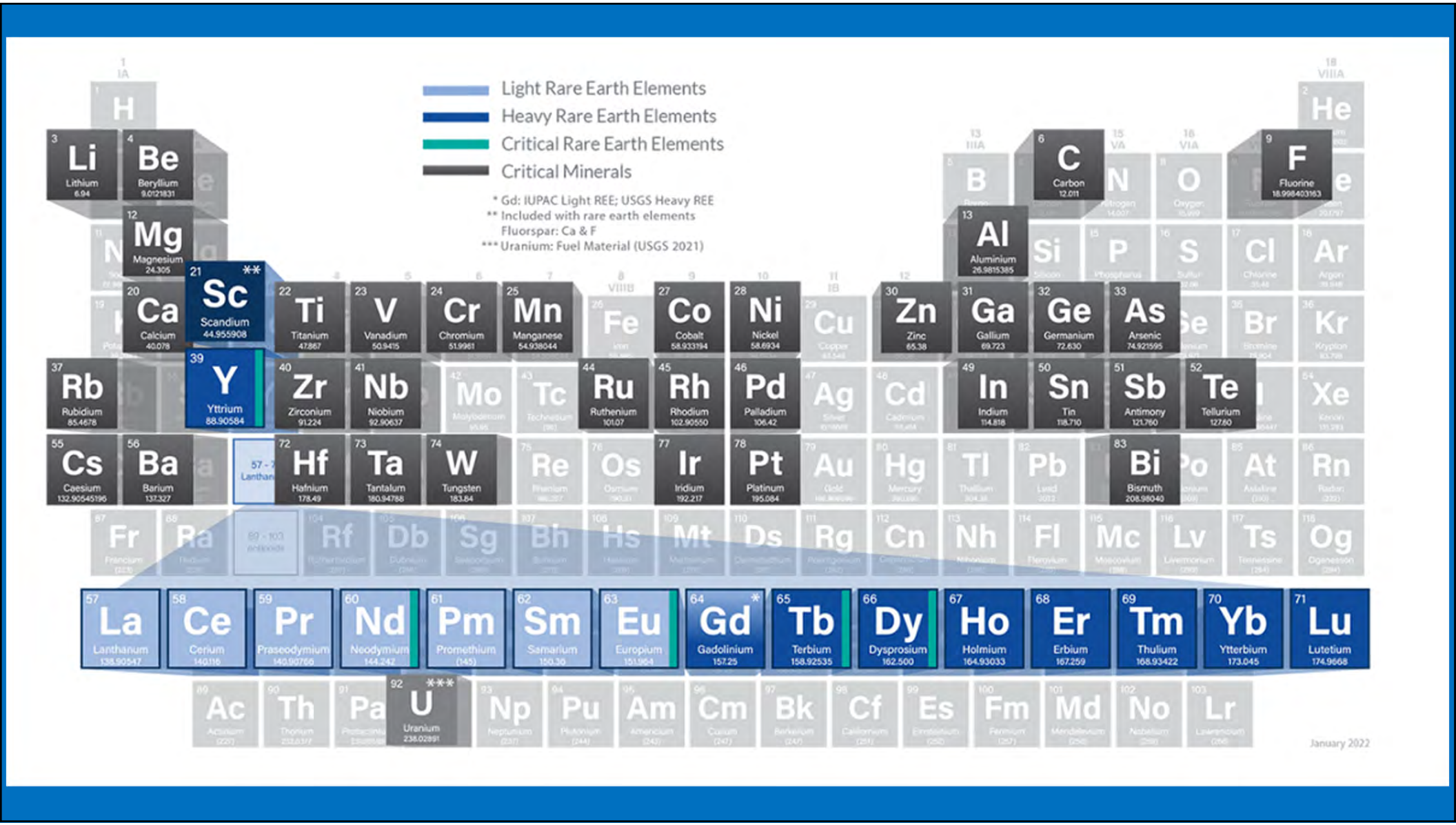
Uncertain Times – Susceptibility to Supply Disruptions

Developing domestic resources is as critical as ever.

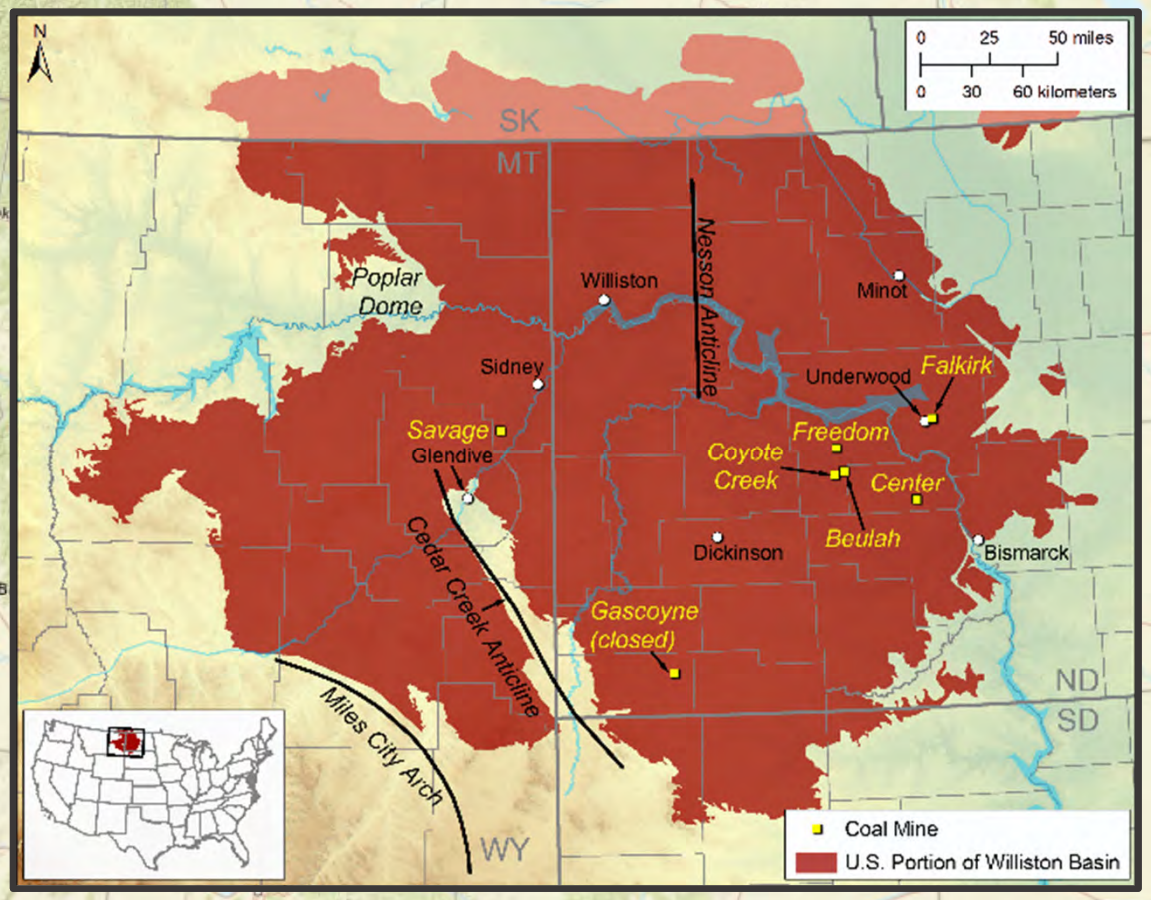
13 Coalition Teams – CORE-CM Initiative

Source: NETL

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


Light Rare Earth Elements
Heavy Rare Earth Elements
Critical Rare Earth Elements
Critical Minerals
* Gd: IUPAC Light REE; USGS Heavy REE
** Included with rare earth elements
Fluorspar: Ca & F
*** Uranium: Fuel Material (USGS 2021)
January 2022

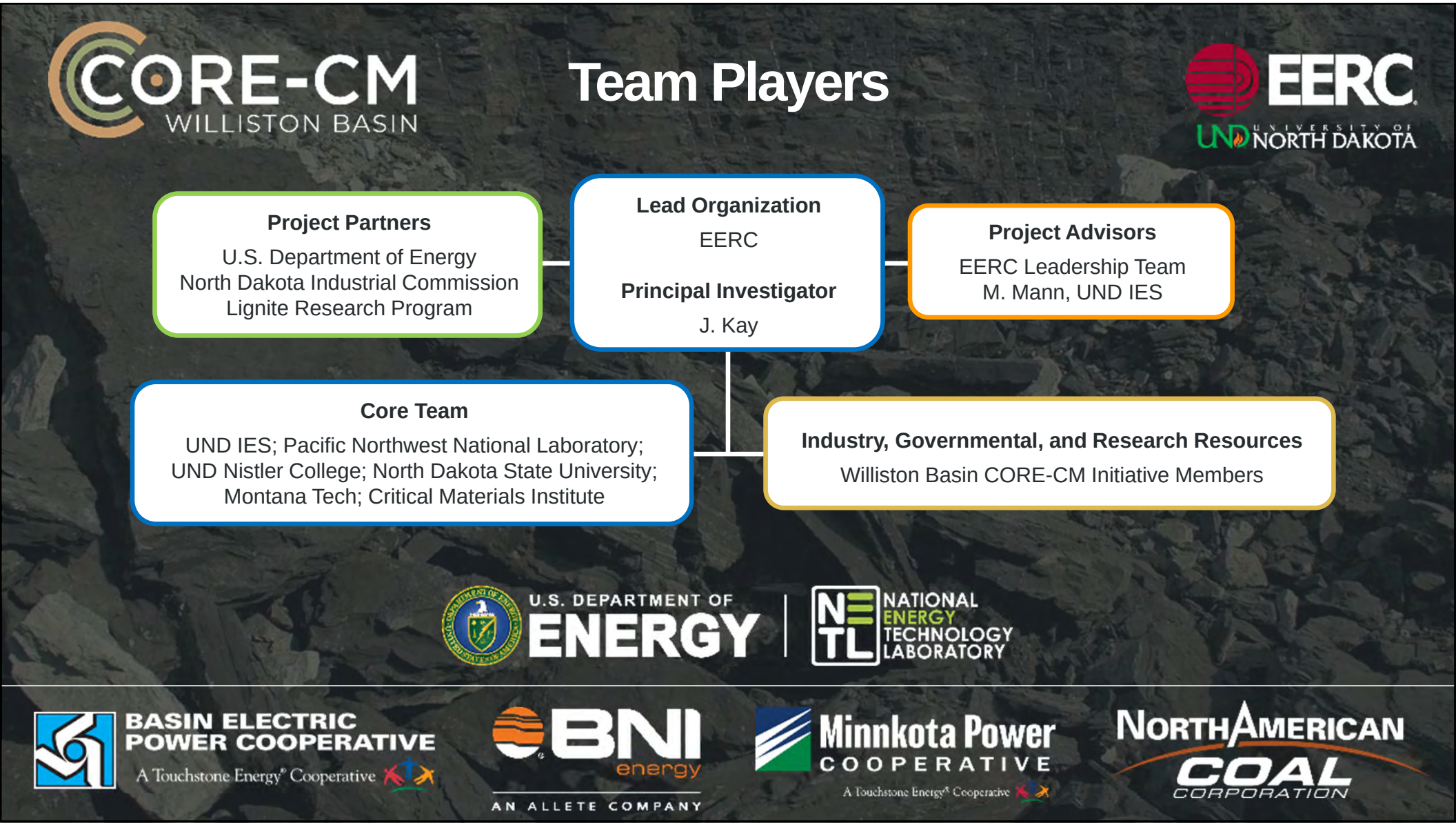
Williston Basin Has . . .



Resources

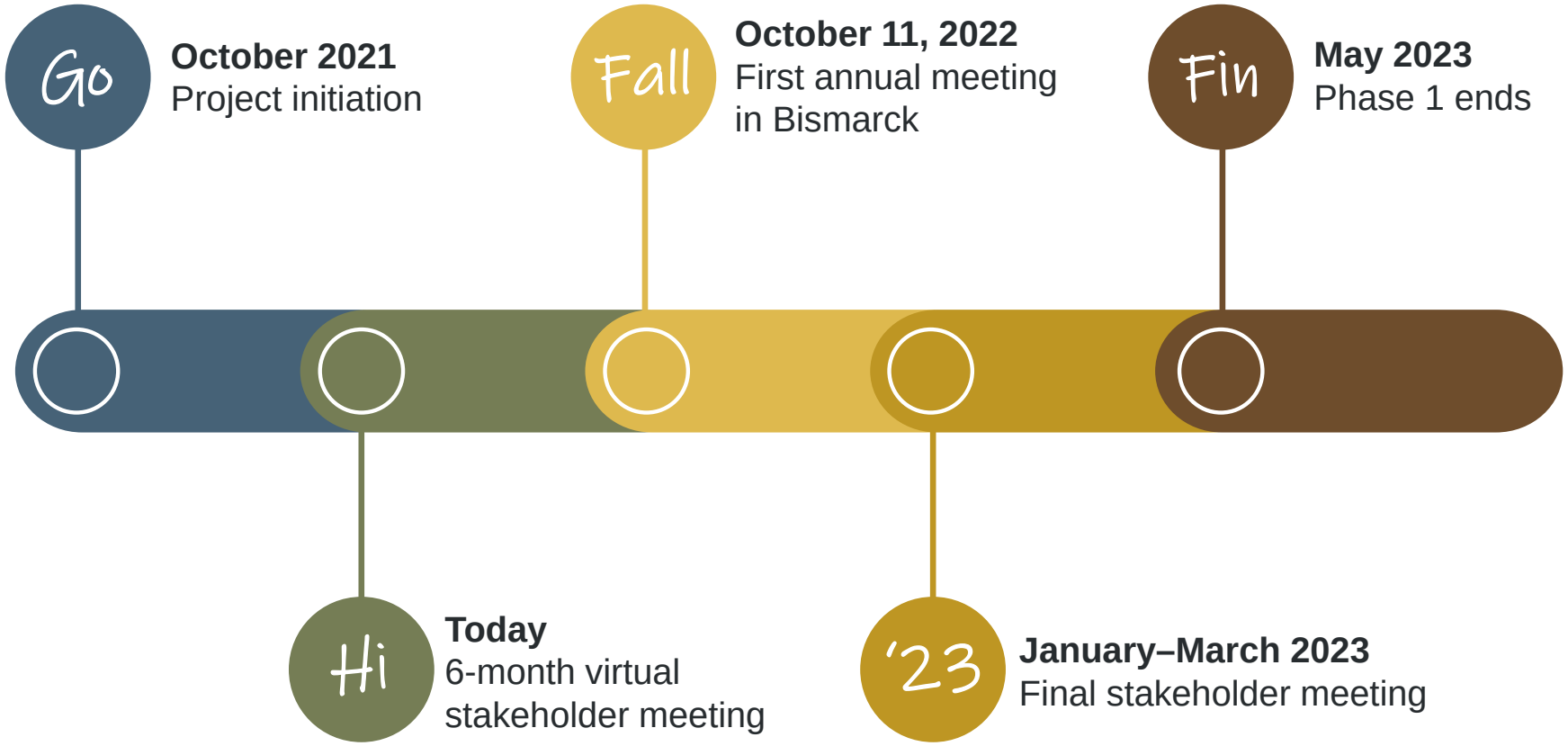
Infrastructure

Knowledge


CORE-CM
WILLISTON BASIN
Team Players
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
J. Kay
Project Advisors
EERC Leadership Team
M. Mann, 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
U.S. DEPARTMENT OF ENERGY
NETL NATIONAL ENERGY TECHNOLOGY LABORATORY
BASIN ELECTRIC POWER COOPERATIVE
A Touchstone Energy® Cooperative
BNI energy
AN ALLETE COMPANY
Minnkota Power COOPERATIVE
A Touchstone Energy® Cooperative
NORTHAMERICAN COAL CORPORATION

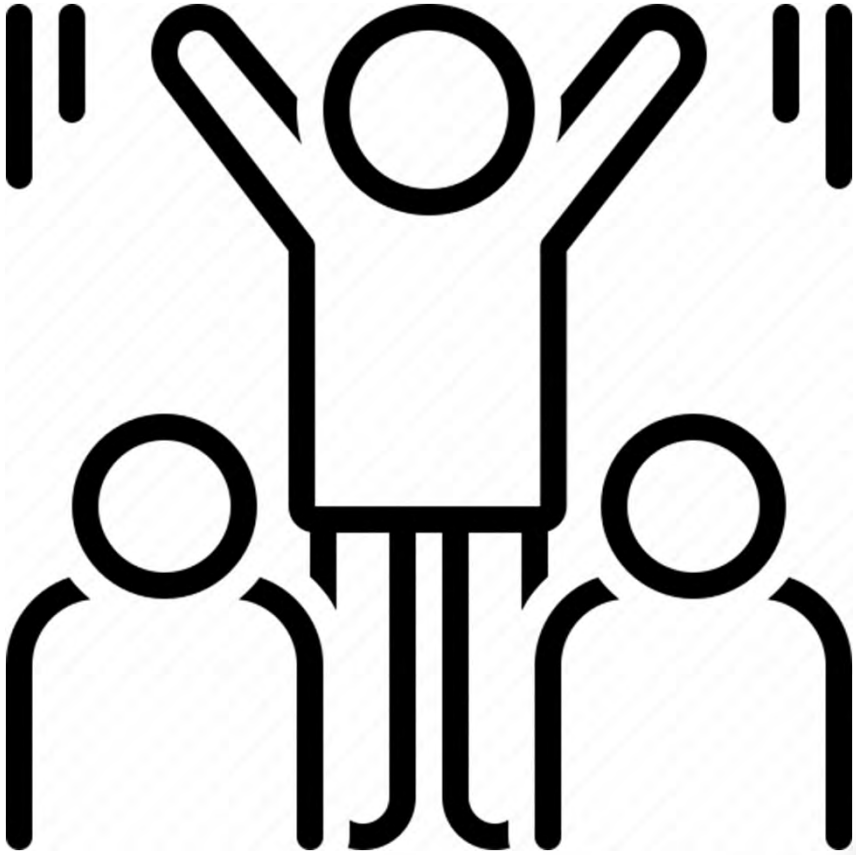

Assessment of Resources
Strategies for Infrastructure, Industries, and Business
Strategies for Waste Stream Reuse
Technology Innovation Centers
Technology Assessment, Development, and Field Testing
Stakeholder Education and Outreach

Stakeholder Meetings



Environmental Justice Considerations

Fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income, with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies.



Your input requested.

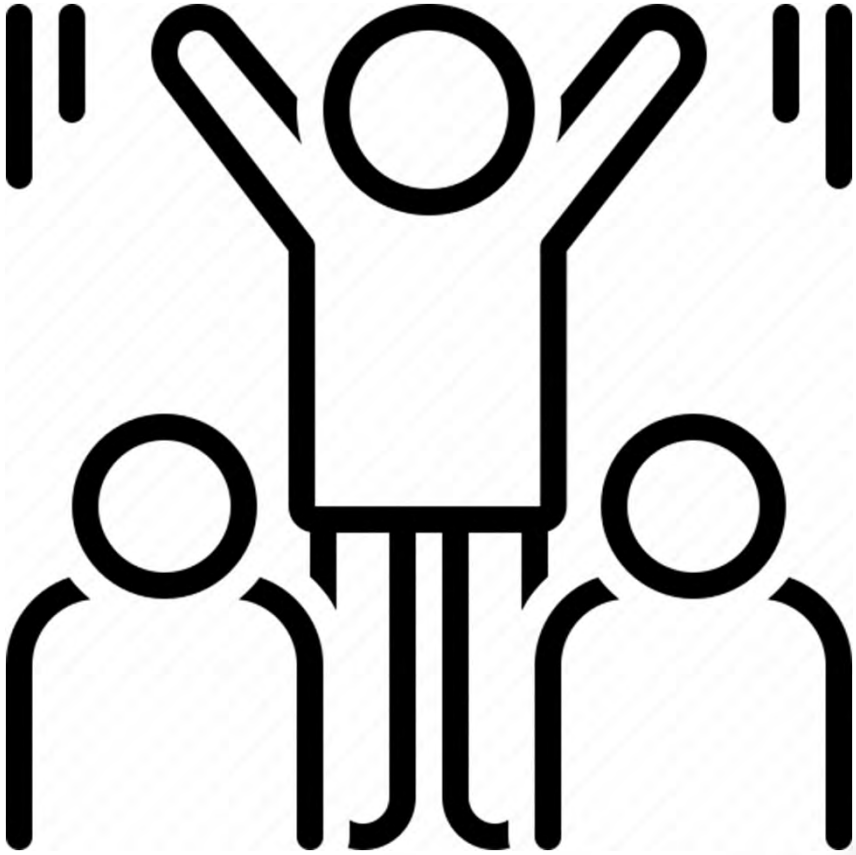
EERC UND NORTH DAKOTA | U.S. DEPARTMENT OF ENERGY | NETL NATIONAL ENERGY TECHNOLOGY LABORATORY | CORE-CM

Critical Challenges. Practical Solutions.

Environmental Justice Considerations

Your input requested.

Effective strategies
Pitfalls to avoid
People to connect with



Critical Challenges. Practical Solutions.

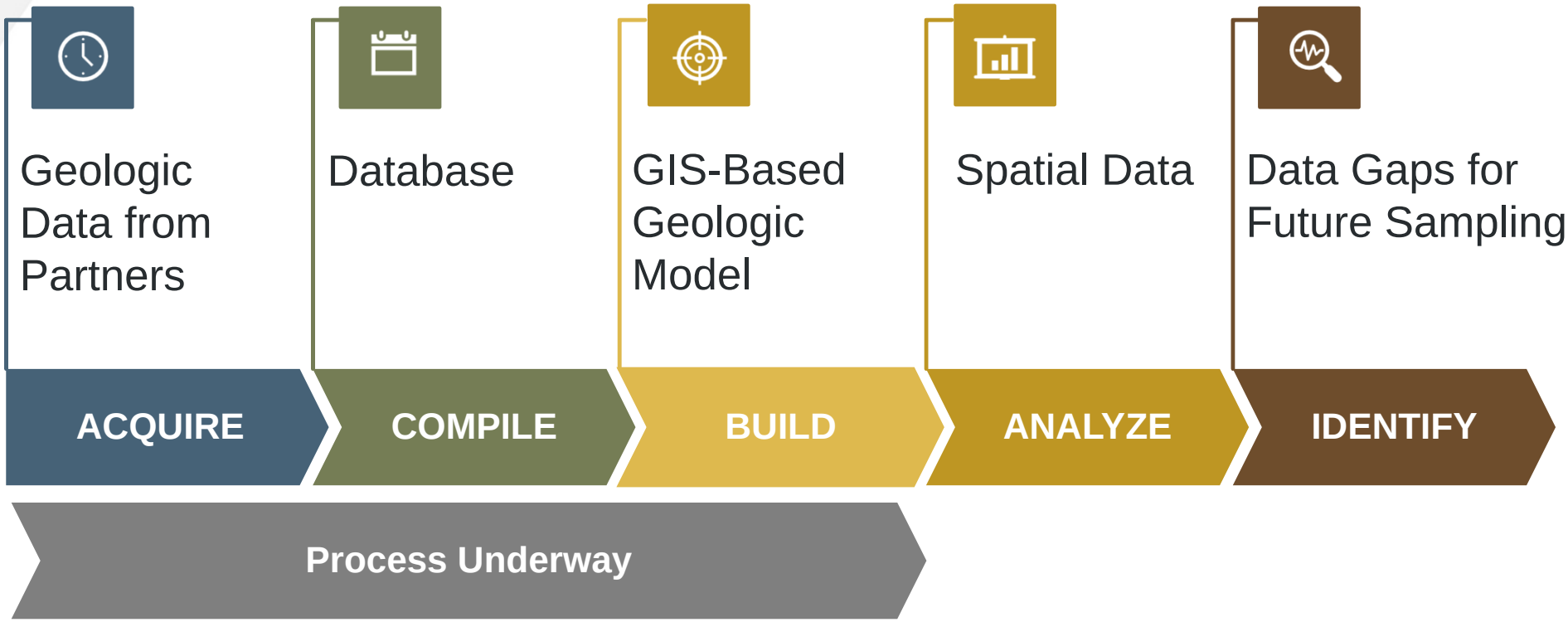

Thank you!

ASSESSING CORE-CM RESOURCES

Todd Brasel
Task Lead

Team
Ian Feole
Morgan Rach
Coby Kison

Basin Assessment Goals



Data Acquisition

- Partner-provided data
  - Rare-earth element (REE)
  - Critical mineral (CM)
  - Geologic data

Data Sources

REE and CM Sample Data		
New Data Sources	**Existing Data Sources**	**Data Requested**
North Dakota Geological Survey (NDGS)	Previously submitted data to the Energy Data eXchange (EDX)	NDGS
UND Institute for Energy Studies		

Coal Geology Data		
New Data Sources	**Existing Data Sources**	**Data Requested**
BNI Coal (well log data)	CoalQual Database U.S. Geologic Survey (USGS)	USGS
	National Coal Resources Data System (NCRDS) USGS	Freedom Mine
		Falkirk Mine

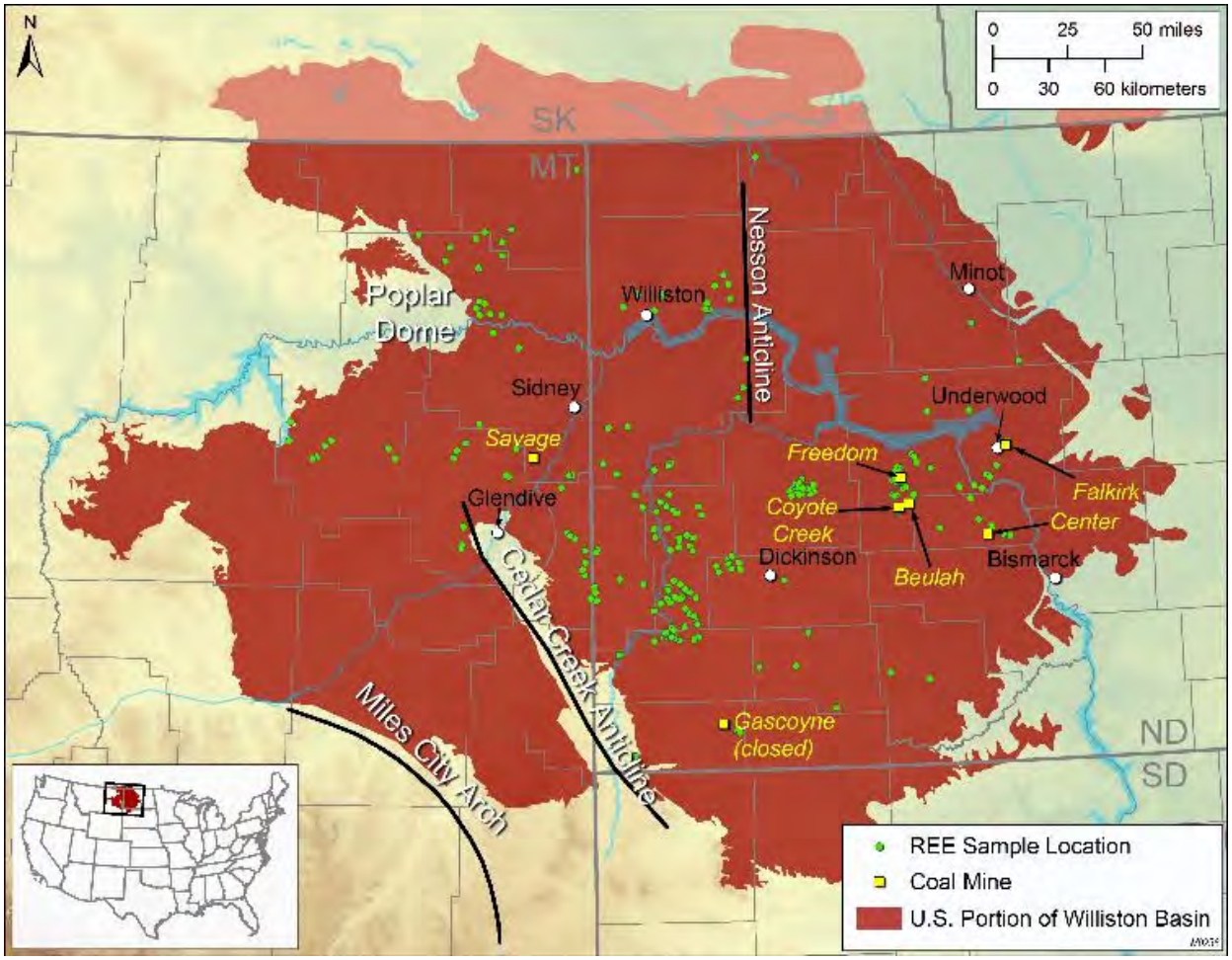
Data Compilation Status

- 1556 samples have been combined from multiple data sources.
  - REE concentrations
  - CM concentrations
  - Sampling information
  - Location information

Data Challenges

- Incomplete data
- Data-sampling clusters
- Unpublished data

REE and CM Sample Data Locations

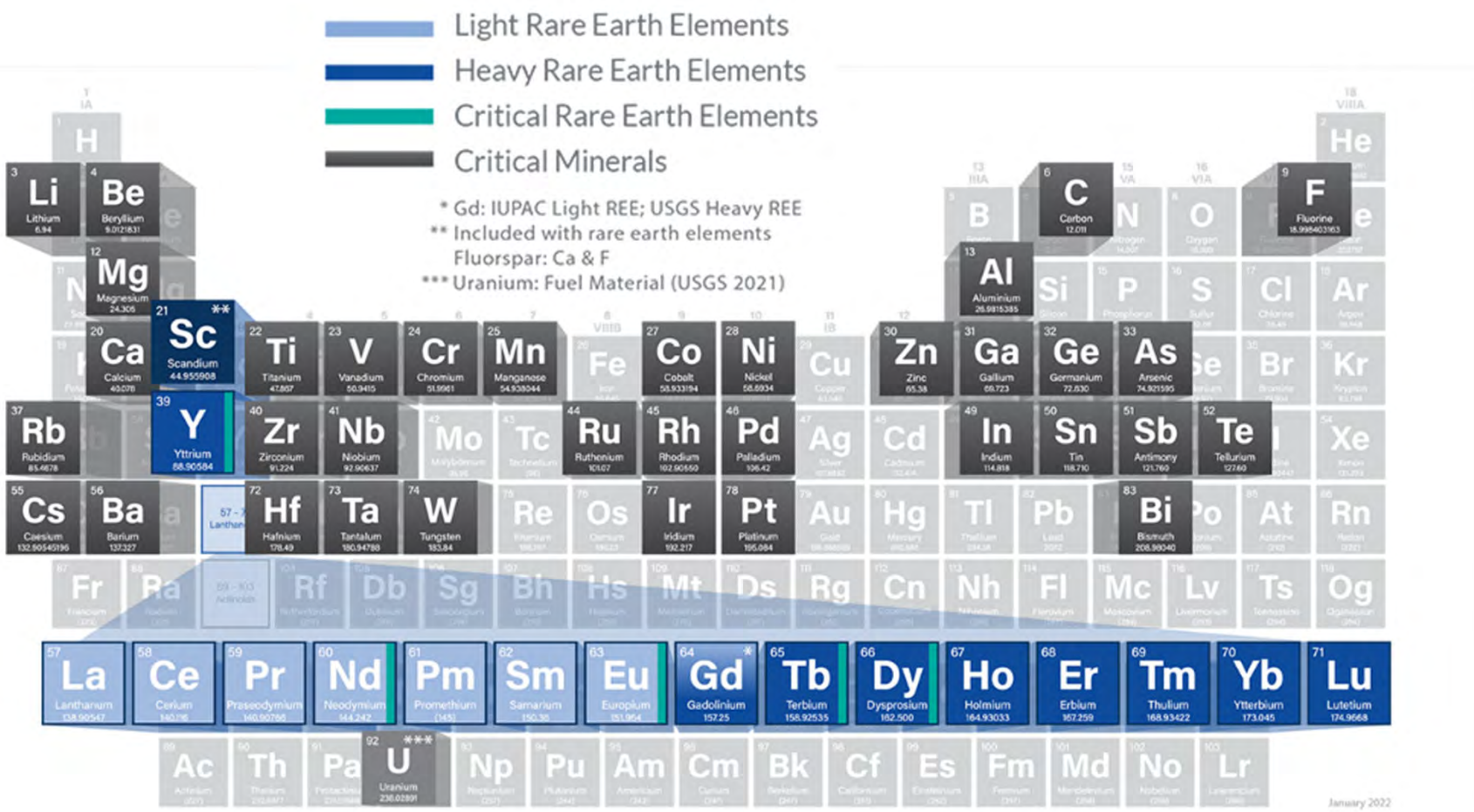


Work in Progress – Data Template

Add Missing Data Fields

Add New Data

REEs and CMs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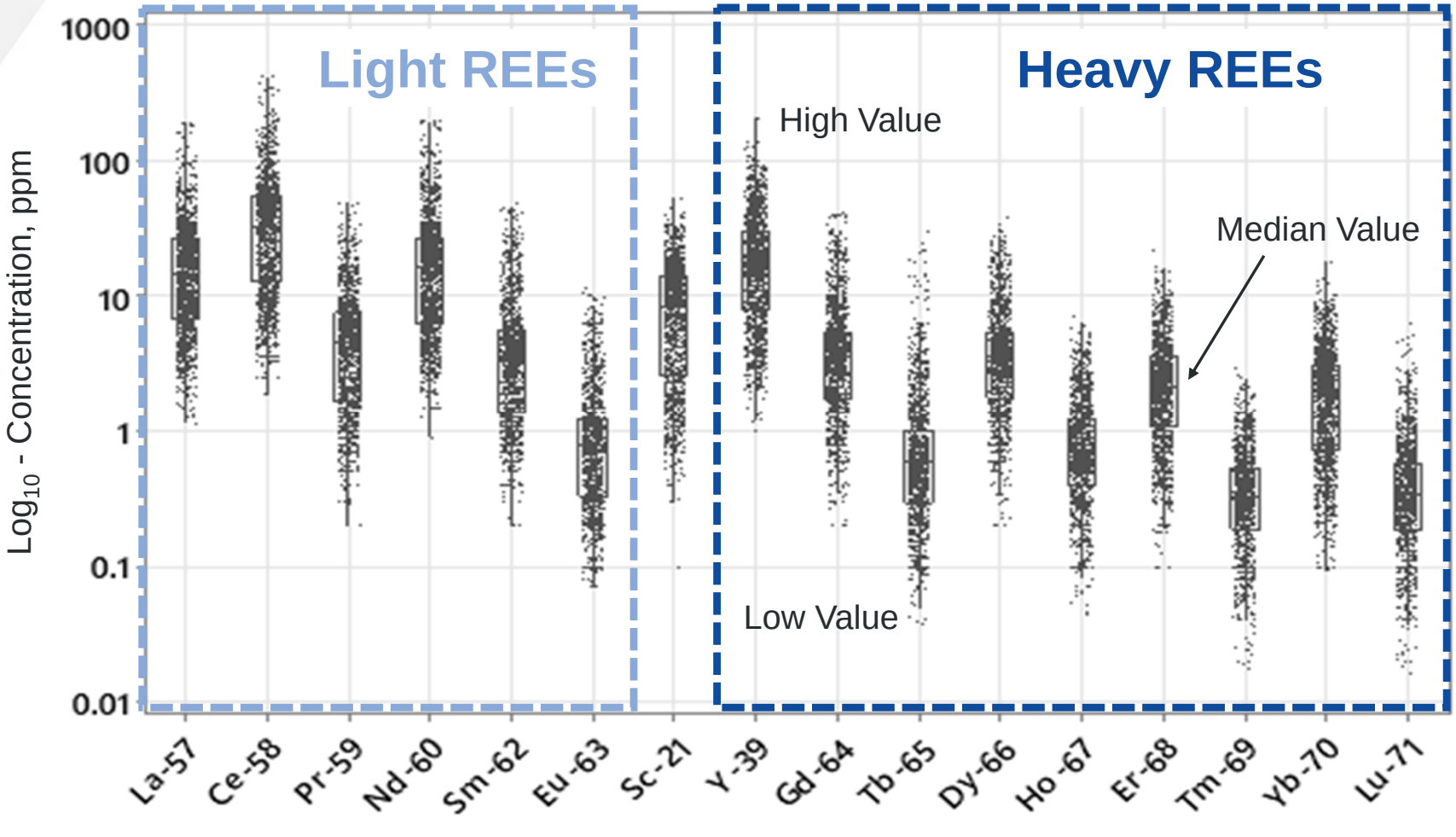
REE Concentration Data

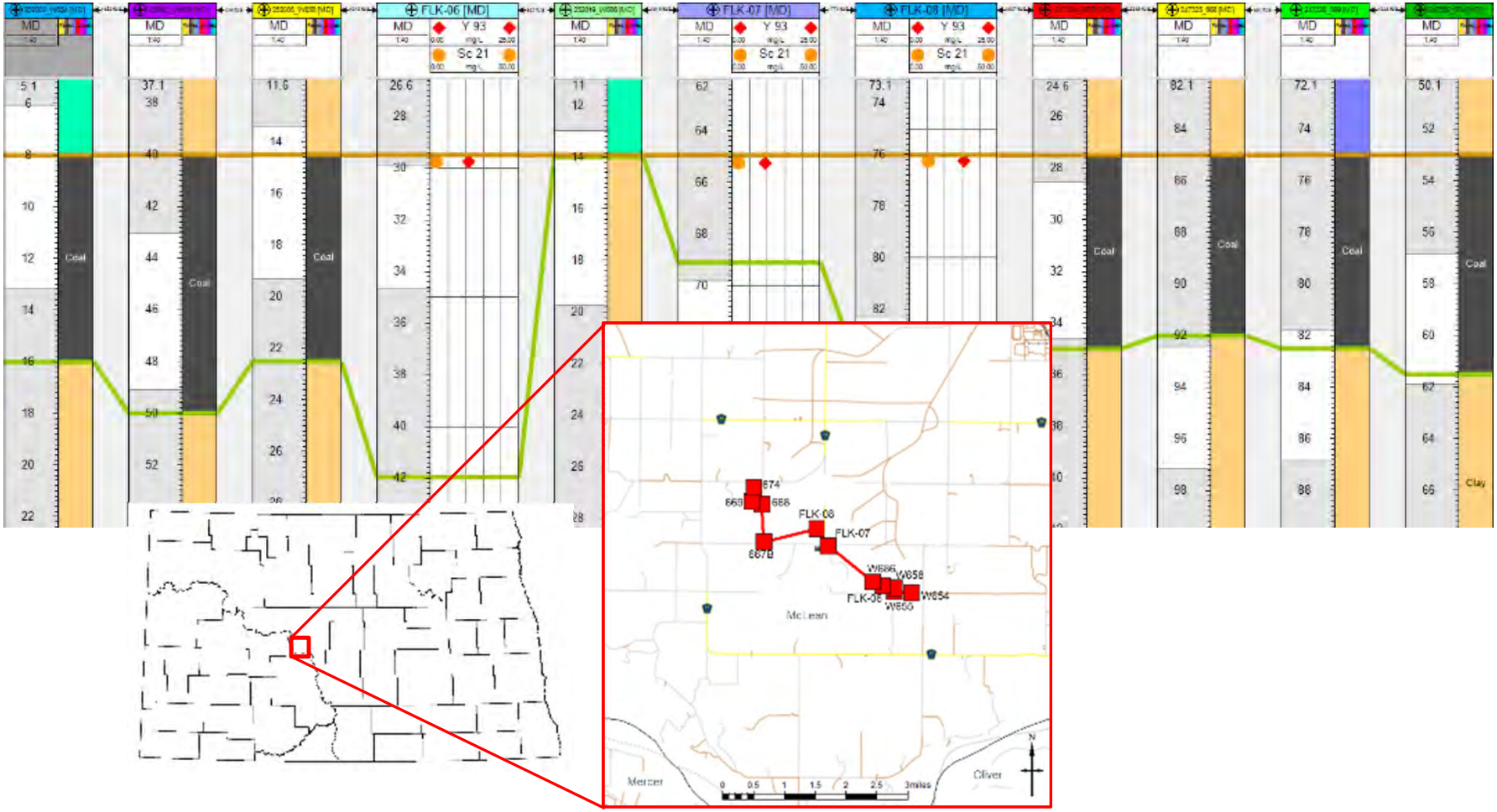


Geologic Model

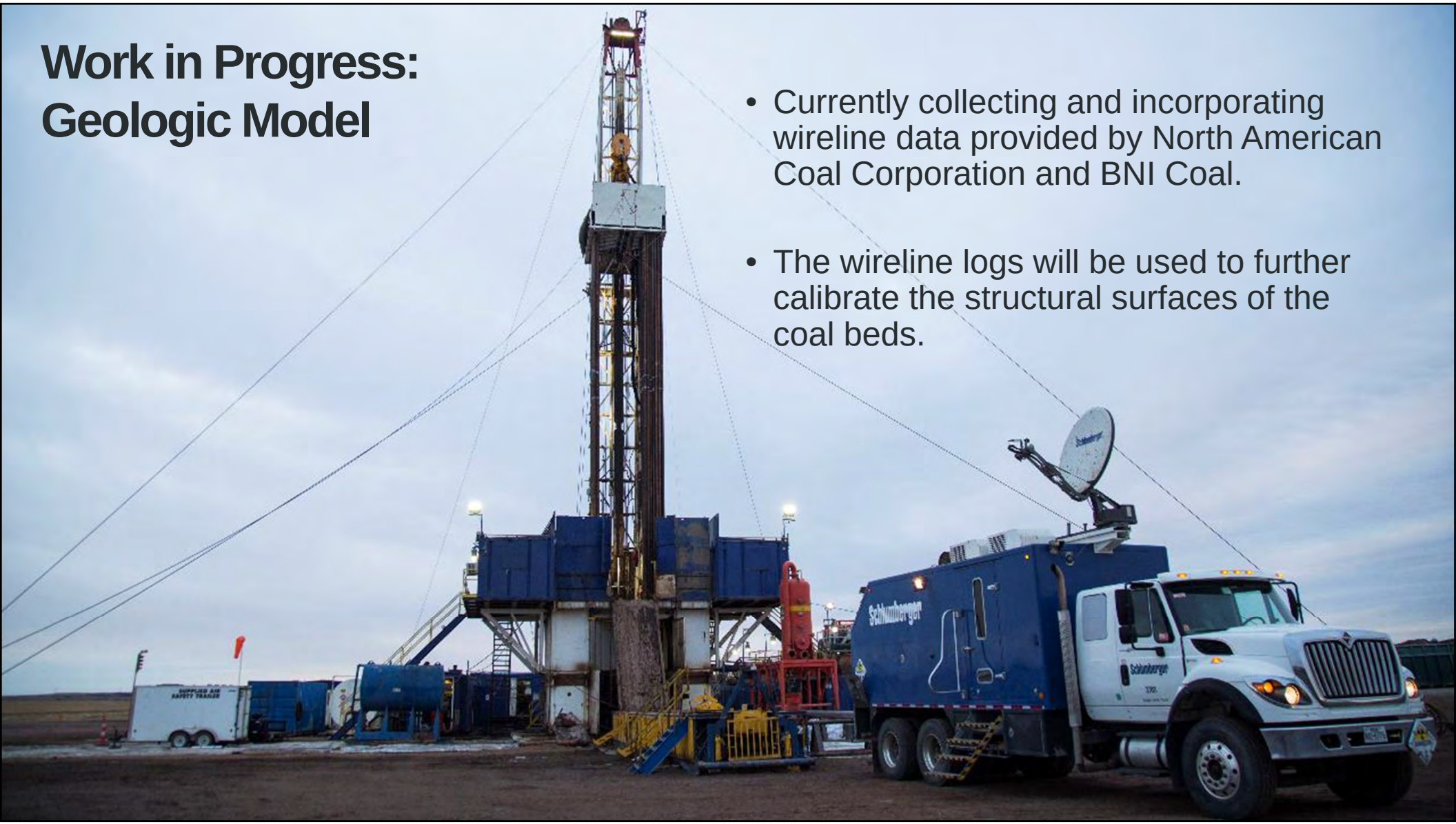
- Well spatial locations throughout the Williston Basin from the NCRDS
- Lithology descriptions – rock type
- Coal seam thickness
- Coal seam depth

Harmon Coal exposed along East River Road, Slope Co.

Geologic Model – Cross Section



Work in Progress: Geologic Model



- Currently collecting and incorporating wireline data provided by North American Coal Corporation and BNI Coal.
- The wireline logs will be used to further calibrate the structural surfaces of the coal beds.

Future Work

Complete Incorporation of Wireline Logs into Geologic Model

Spatially Tie Geologic Model to REE and CM Sample Data

Identify Sampling Data Gaps – Where might we find areas to sample that look promising for high concentration of REEs?

How You Can Help

Suggest or share data sources

- REE concentration data
- CM concentration data
- Geologic information
  - Well logs
  - Coal thickness and depths
  - Lithology descriptions

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ASSESSING WASTE STREAM REUSE

Bruce Folkedahl

Advisors
Shane Addleman – PNNL
Tom Lograsso – Critical Minerals Institute
William Cohen – Current Lighting Solutions LLC

What Are We Looking For?

Waste streams that could become:

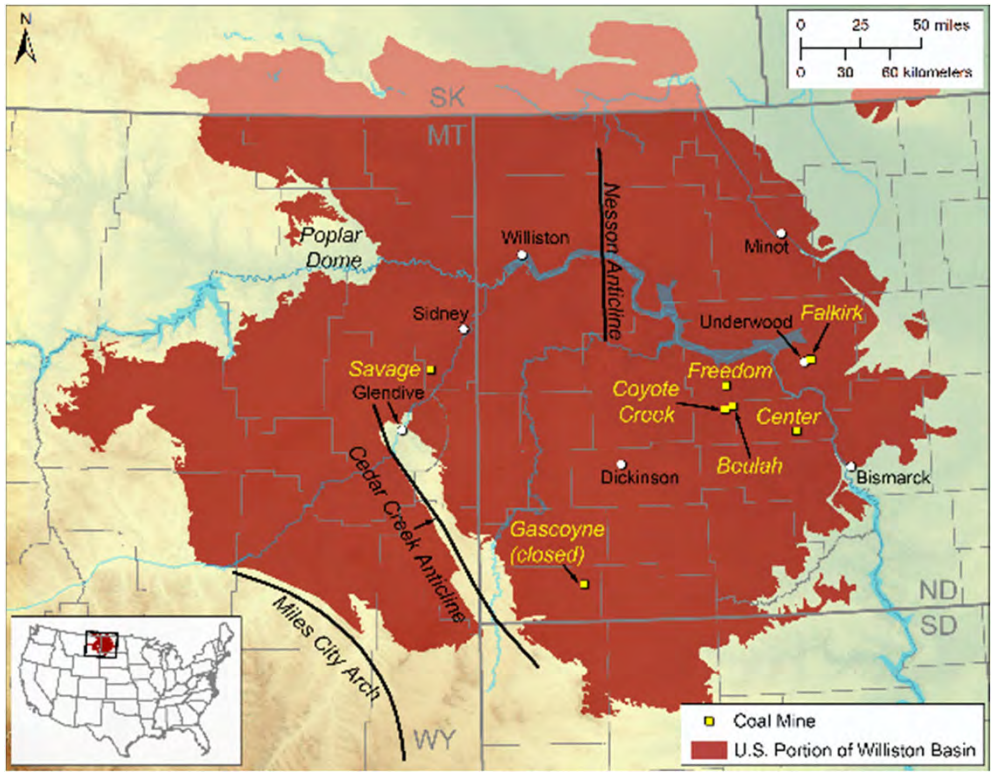
- Fuels
- Feedstocks
- Consumables

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

Water treatment image from: whatsnewinprocessing.co.za

What's the Plan?

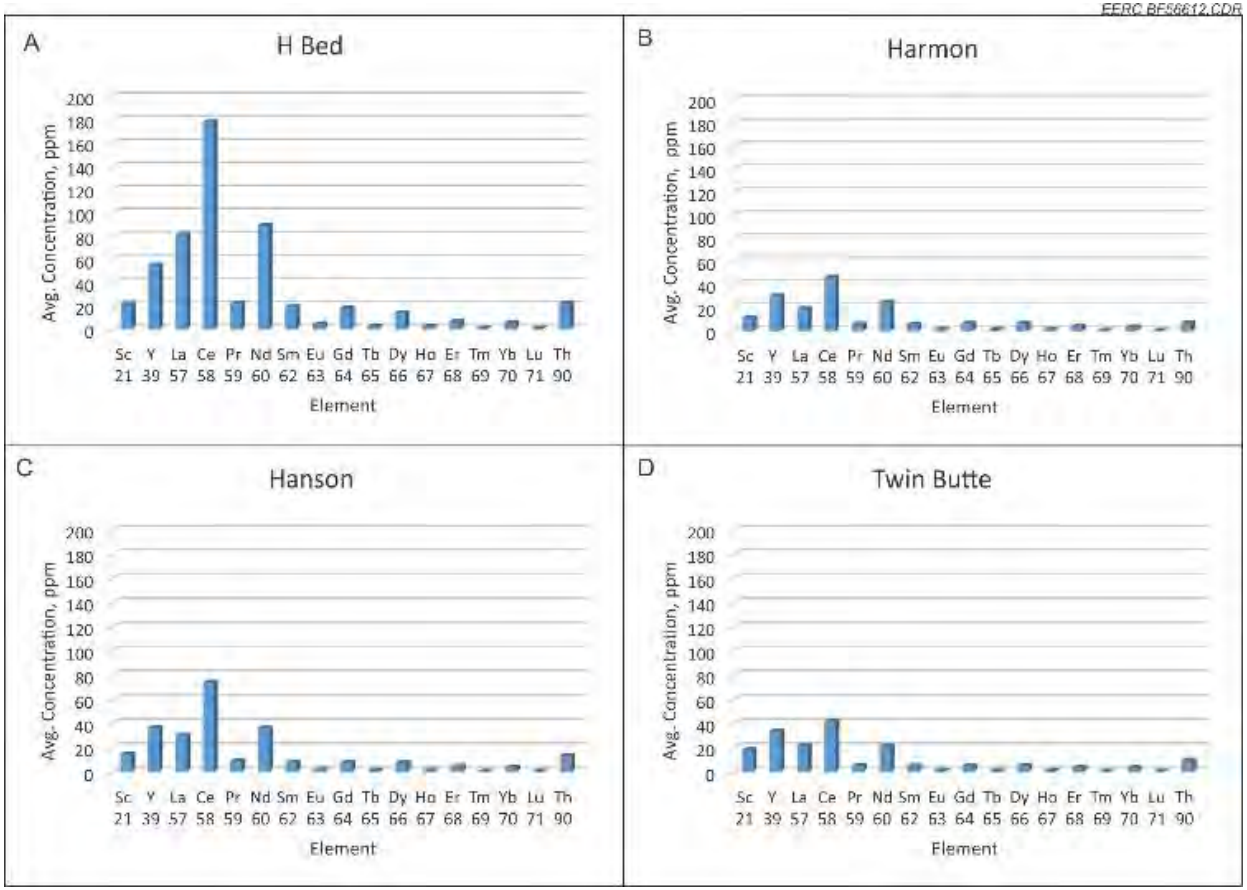
- **Compile a database of waste resources.**
  - Identify resources
    - ♦ Potential use
    - ♦ Volume of resources
    - ♦ Associated costs
    - ♦ Potential regulatory issues
    - ♦ Location
  - Any required enabling technologies
- **Integrate into the GIS-based model.**



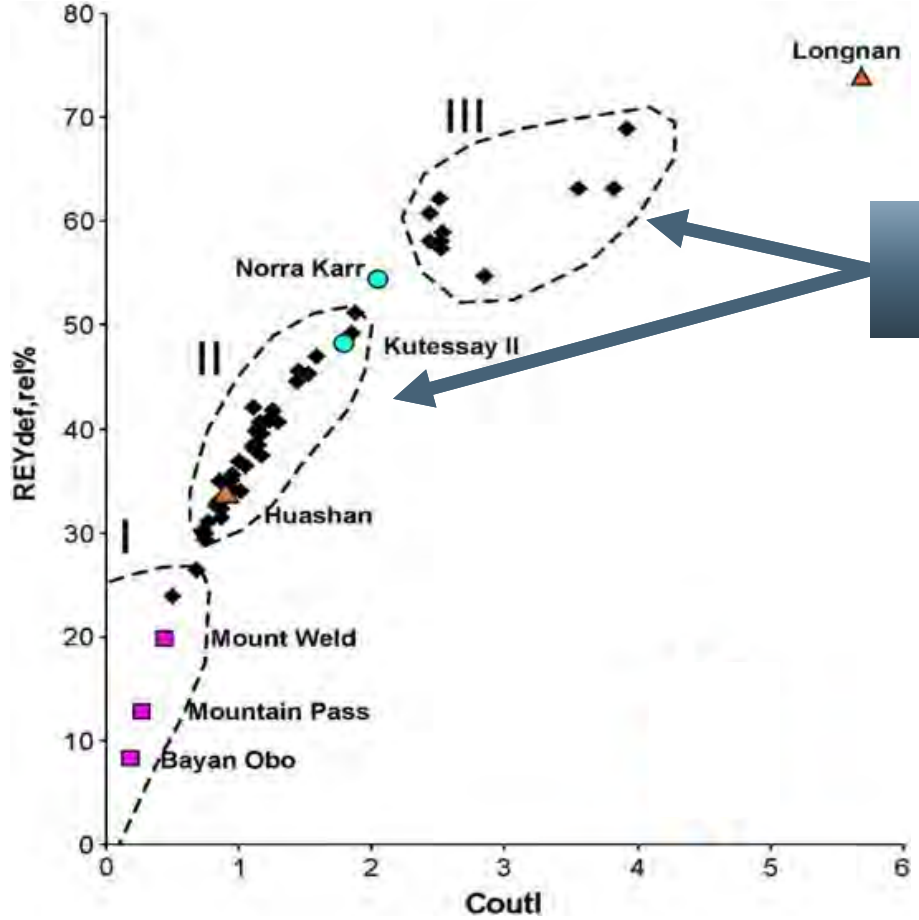
What Are Some of the Resources Identified So Far?

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

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



Why Lignite Ash?



North Dakota Lignite Coals

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 Waste Sources – Shales

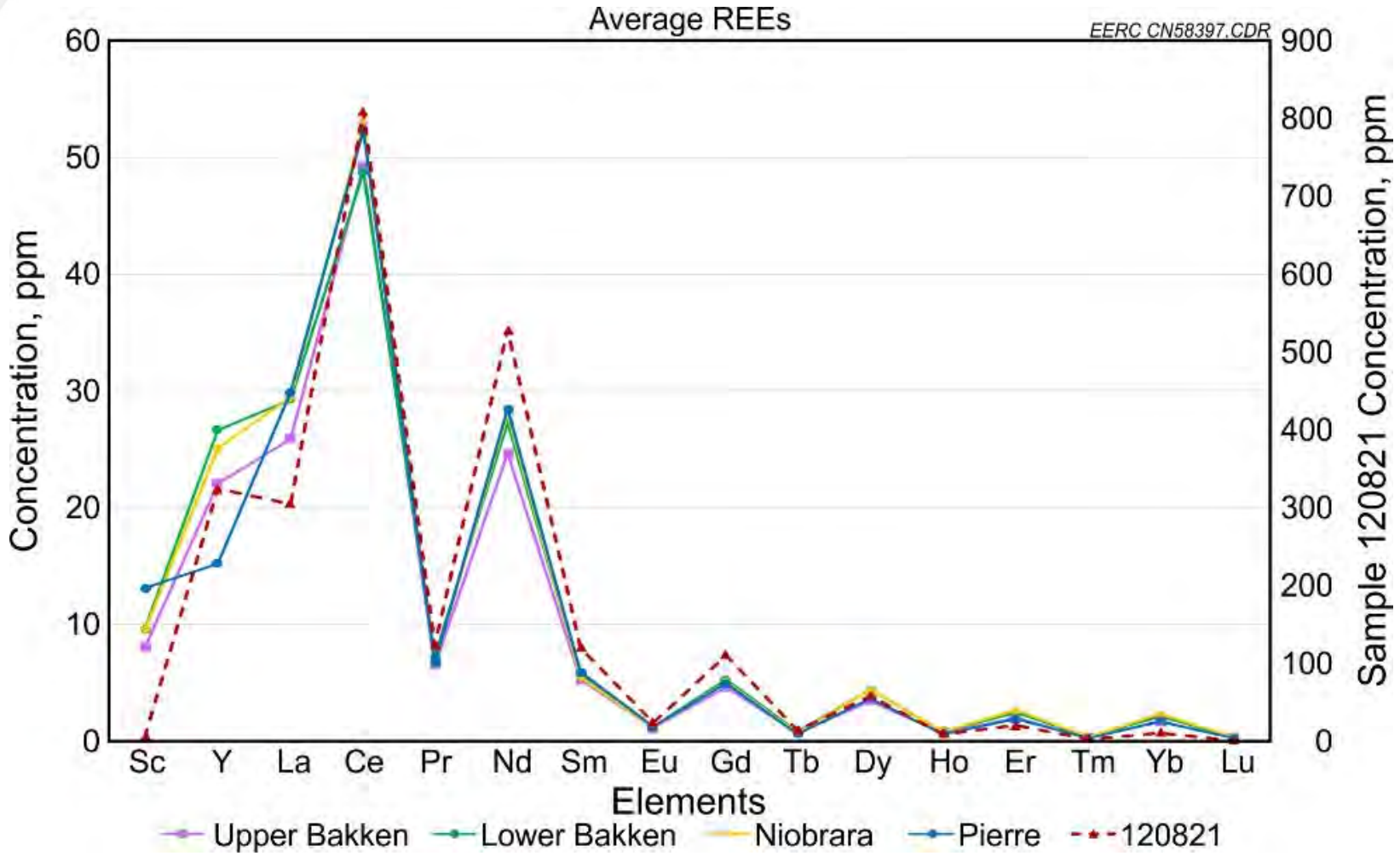
Of 43 Niobrara and Pierre samples, 9.3% had total REE levels greater than 300 ppm.

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 Waste Resources?

Energy for Process

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

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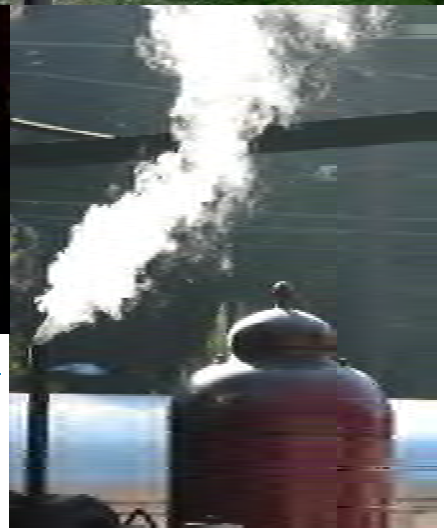

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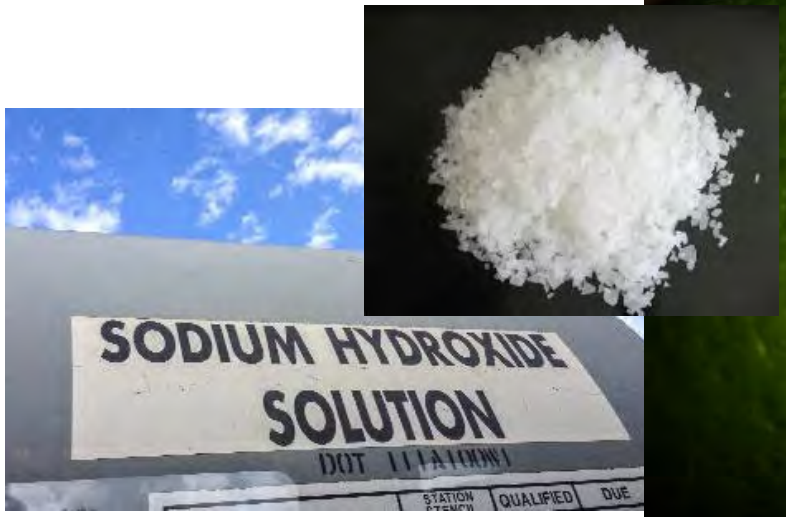
Other Waste Resources?

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

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



Sodium Hydroxide by Tony Webster is licensed under creative commons

Limes and Lemons by Michael Gabelmann is licensed under creative commons

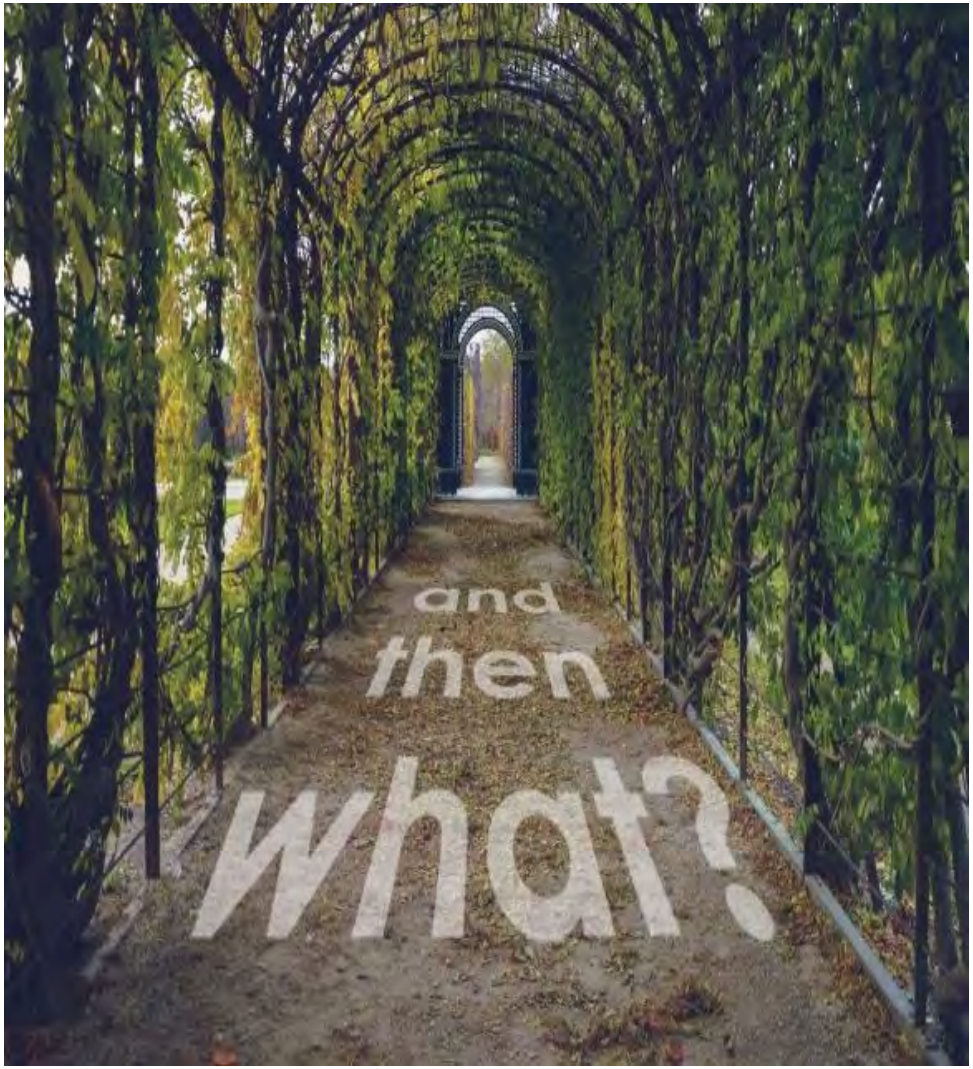
Sources for Waste Chemicals

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

Photo Credit EERC

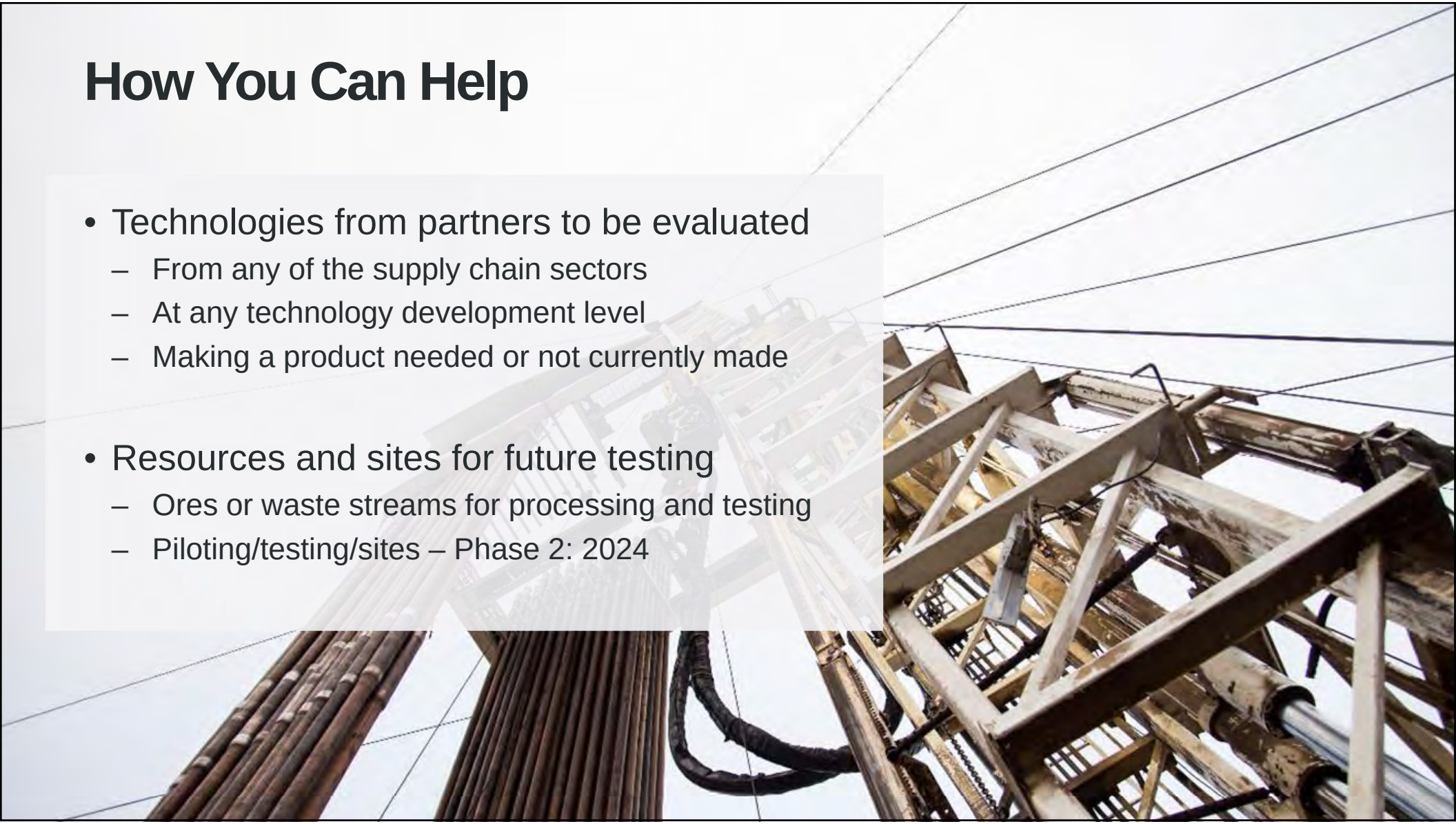
Then What?

- Identify data gaps
  - What do we know?
  - What do we need to learn?
- 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

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



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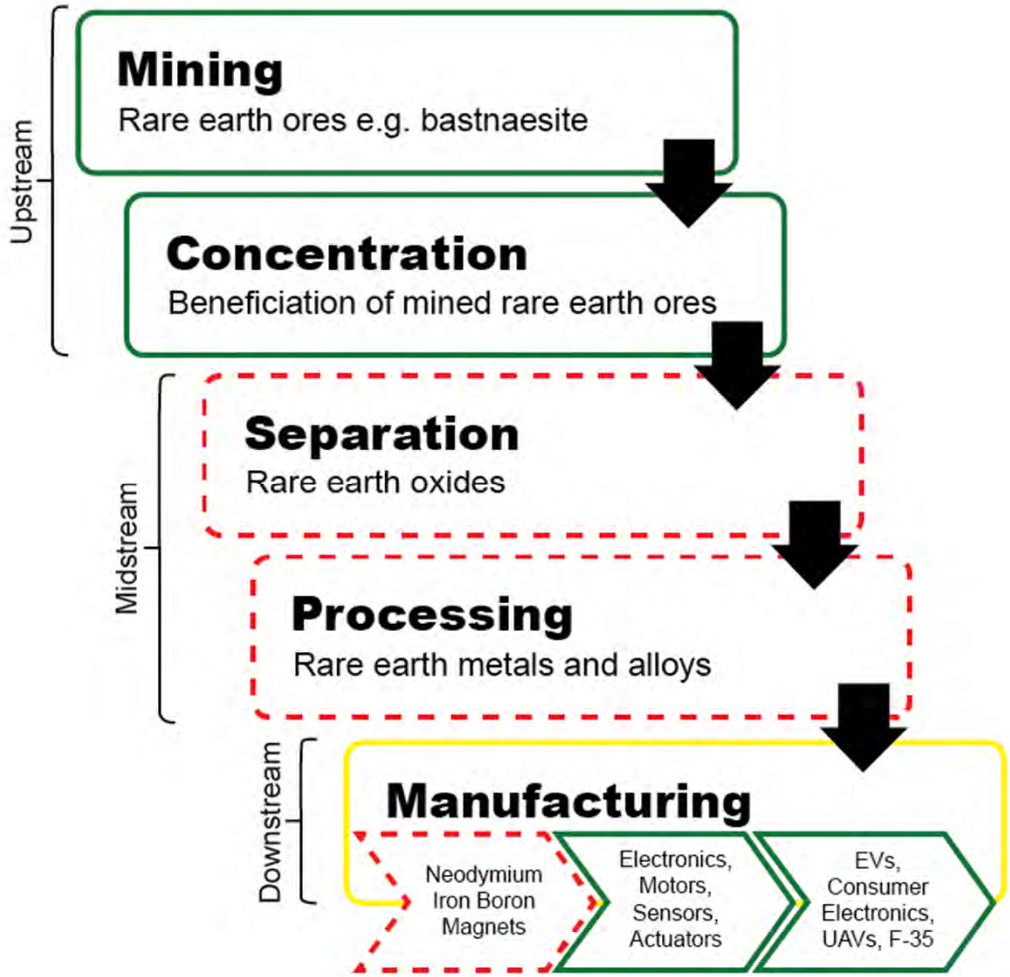
TECHNOLOGY ASSESSMENT, DEVELOPMENT, AND FIELD TESTING

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

Advisors
Shane Addleman – PNNL

What Are We Trying to Achieve?

- Identify technologies across supply chain.
- How do we fill these gaps?



Mining Technologies

- Mining methods
  - High-value ore
  - Thin seams or sections (<2 foot)

Image Credit: Wirtgen – 4200SM

- Ore exploration and tracking
  - New technologies
  - Rapid, in-the-field analysis

Image Credit: NETL REE/CM LANL LIBS Team

Ore Concentration

- Physical methods
  - Density separation
  - Wettability
  - Magnetics

Image Credit: Mineral Technologies

Ore Concentration

- Chemical methods
  - Acid–base leaching
  - Solvent extraction

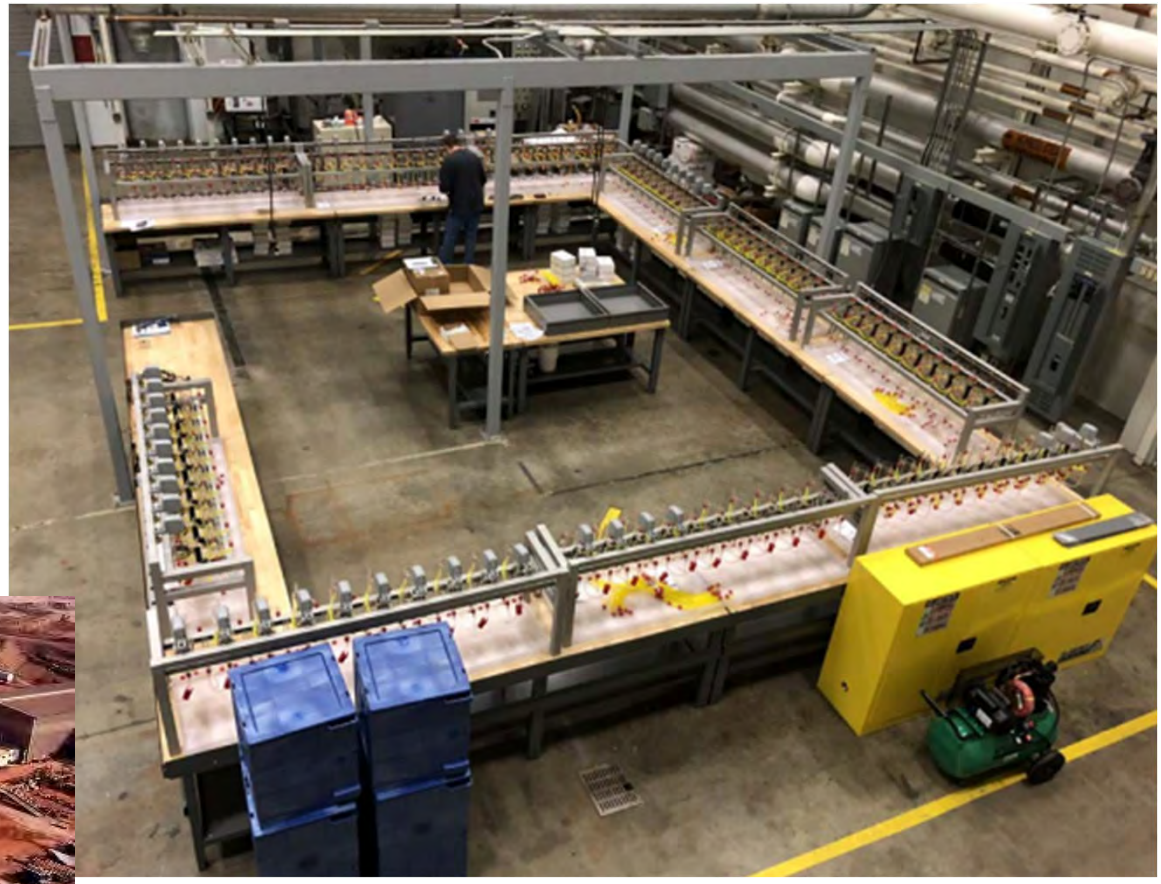


Image Credit: West Virginia University

Image Credit: BTL Liners

Separation and Processing

- Separating – generating a high-purity material
- Processing – converting the high-purity material into a usable form

Image Credit: Harvard – Separated Rare Earth Oxides

Image Credit: Less Common Metals

Manufacturing – Making the Products We Need

Identify:

- Intermediate products
- Final products

Image Credit: NETL – REE/CM Website

Assessment – Williston Basin Coal and Hard Rock

- How will technologies perform with Williston Basin lignite?
- What concentration/form of ore is needed?

Image Credit: Lignite Energy Council – Center Mine

Assessment – Williston Basin Non-Rock Resources

- What else might contain REEs and CMs?
- What technologies are needed to process these?

Assessment – Technology Readiness

- Time to market
  - Scale of the technology tested
  - Risks with scale-up
  - Does this work for Williston Basin resources?

Image Credit: NETL – REE/CM Website

Image Credit: UND Institute for Energy Studies

How You Can Help

- Technologies from partners to be evaluated (June 30, 2022)
  - From any of the supply chain sectors
  - At any technology development level
  - Making a product needed or not currently made
- Resources and sites for future testing (Phase 2)
  - Ores or waste streams for processing and testing
  - Locations to place pilot demonstrations

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STRATEGIES FOR INFRASTRUCTURE, INDUSTRIES, AND BUSINESS

Jason Laumb
Task Lead

Task Assistants
Dean Bangsund – NDSU
David Flynn – UND Nistler School
Mike Ryder – Graduate Student
Kirk Williams – EERC


CORE-CM Business Boundary
Williston Basin
Saskatoon
Regina
Moose Jaw
Medicine Hat
Lethbridge
Brandon
Winnipeg
Kenora
Red Lake
Ontario
Nipigon
Thunder Bay
Wawa
Lake Superior
Spokane
Montana
Helena
Billings
Dakota
Fargo
Minnesota
Minneapolis
St Paul
Wisconsin
Idaho
Boise
Idaho Falls
Wyoming
South Dakota
Pierre
Sioux Falls
Madison
Milwaukee
Lake Michigan
Chicago
Iowa
Des Moines
Nebraska
Cheyenne
Lincoln
Illinois
Springfield
Denver
Kansas City
UNITED STATES
0 100 200 miles
0 100 200 kms

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?

Strategy – Know Your Customer

Raw REEs/CM?

Final Products?

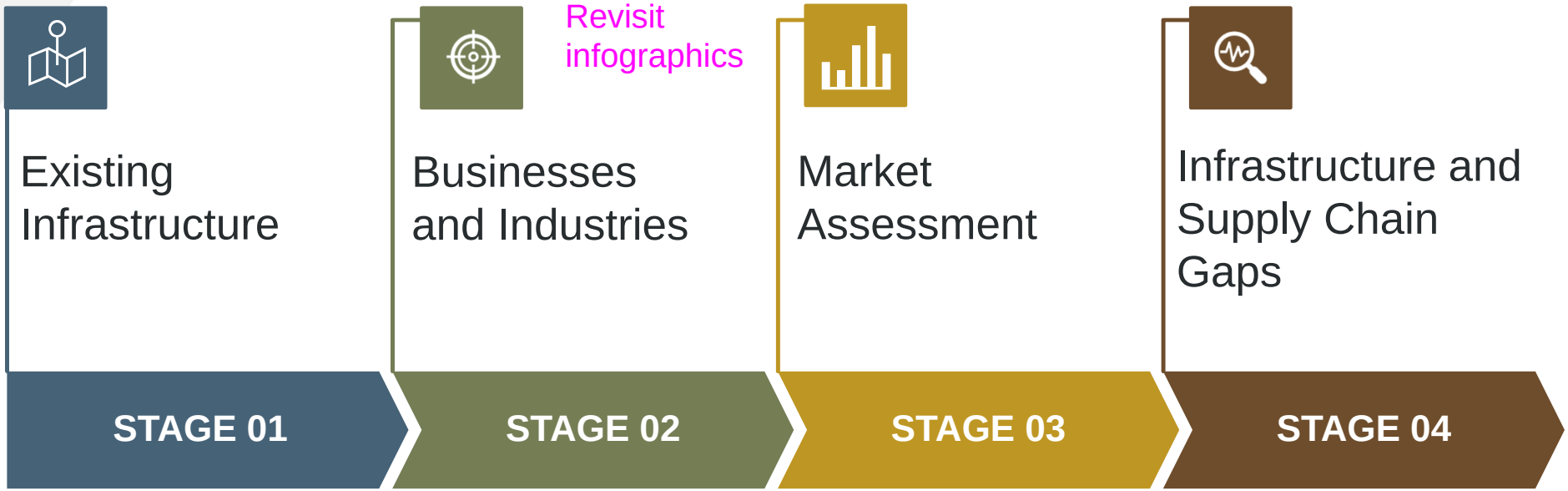
- Magnets
- Aggregate
- Computer components
- Graphite/graphene

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

Business Boundary Timeline and Team



Jason Laumb
Angie Morgan and others

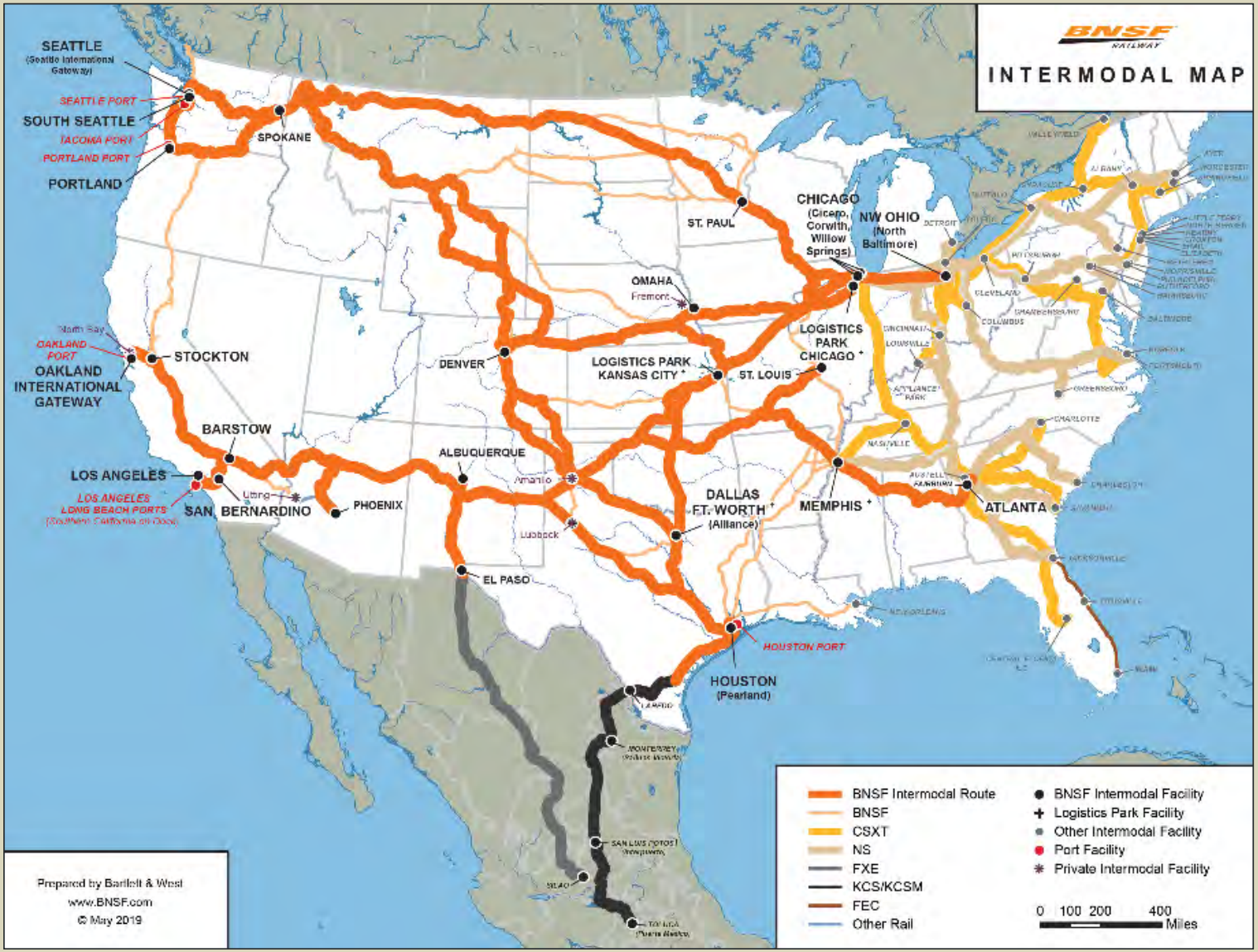
EERC

David Flynn
UND Nistler School

UND

Dean Bangsund
Ag Economics

NDSU



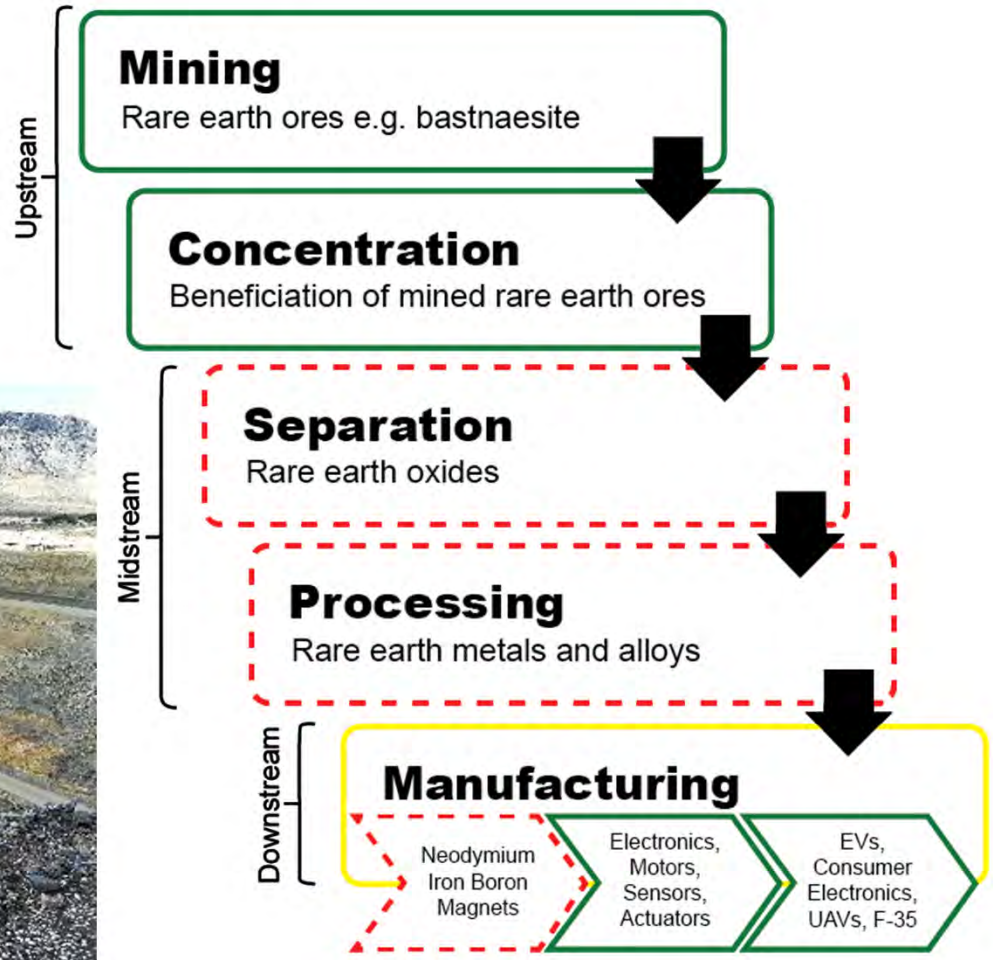
Advantageous Transportation Infrastructure

- Rail
- Truck
- Port in Duluth

Key Findings, cont.

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

Mountain Pass REE Mine, California

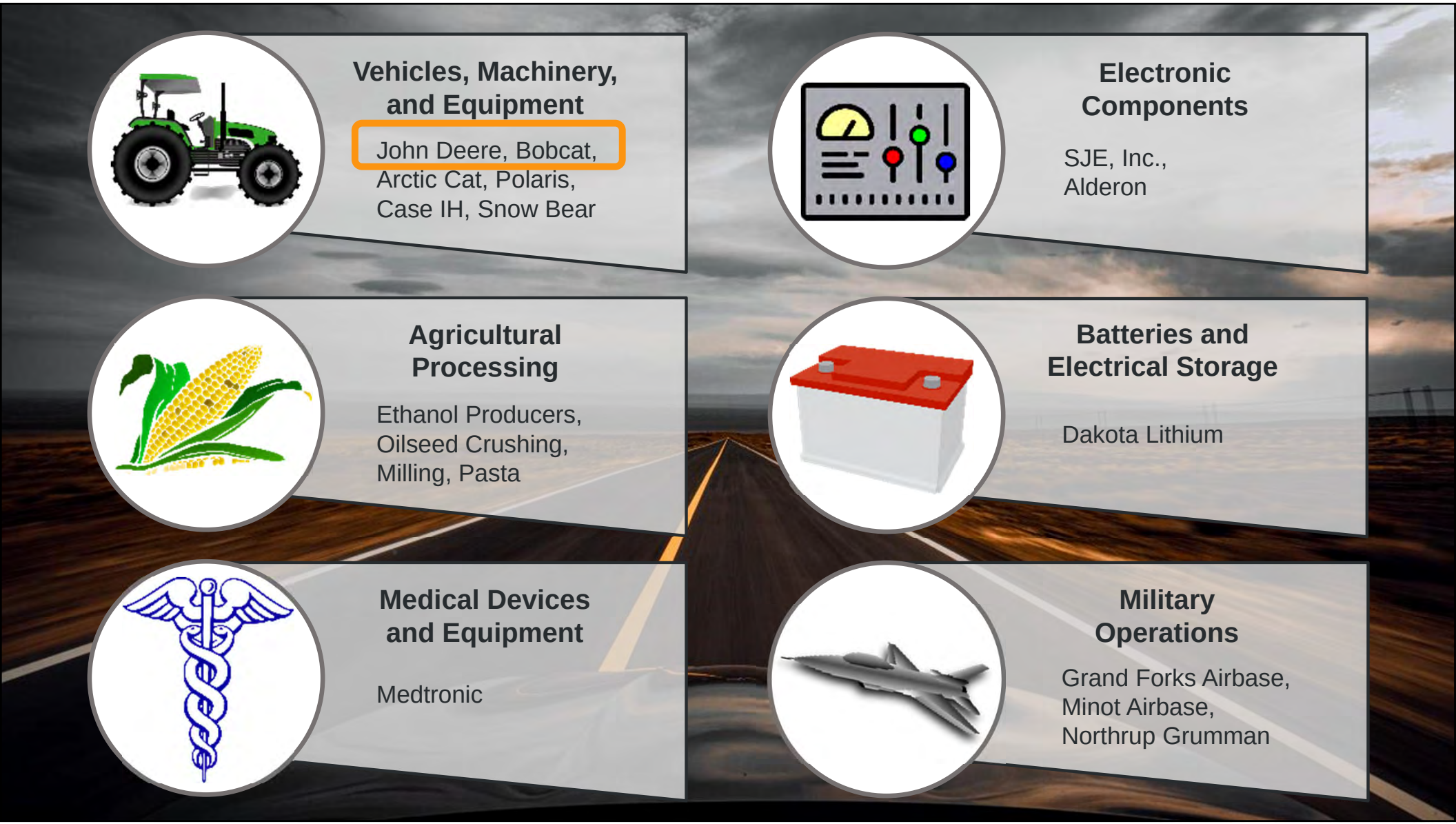


Extraction to Concentrate – Hub and Spoke

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

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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TECHNOLOGY INNOVATION CENTERS

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Advisors
Shane Addleman – PNNL
Tom Lograsso – Critical Minerals Institute
William Cohen – Current Lighting Solutions LLC

Technology Innovation Centers – Pushing the State of the Art

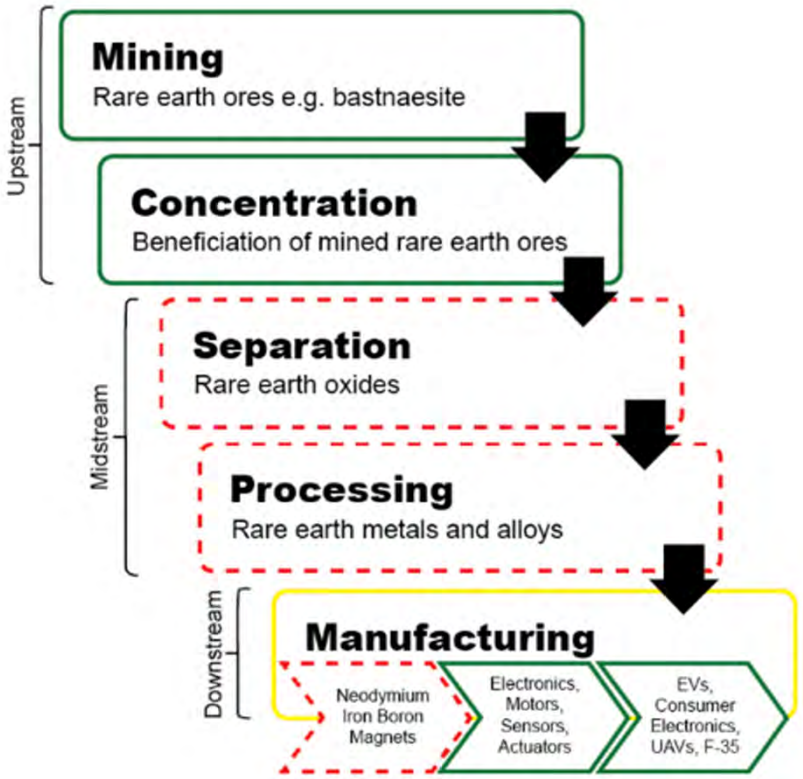
Working with Project Partners to Formulate Plans

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

Photo by Cytonn Photography from Pexels

What's the Plan?

- **Accelerate research** that will enable commercial deployment of advanced processing and production of rare-earth elements (REEs), critical minerals (CMs), and high-value, nonfuel coal products.
- **Support engagement** of public–private partnerships and basinal industries to advance new and innovative technology development.
- **Advance opportunities** for the education and training of the next generation of technicians, skilled workers, and STEM professionals.



Creation of TIC Plans

Create the Public–Private Partnership

- Led by the EERC
- Support from a core group of advisors
  - Organizational structure
  - Governance
  - Prospective participants

TIC Plan

Integration of the basin's natural resources, infrastructure, industrial needs, and waste stream reuse opportunities

Photo by Chokniti Khongchum 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

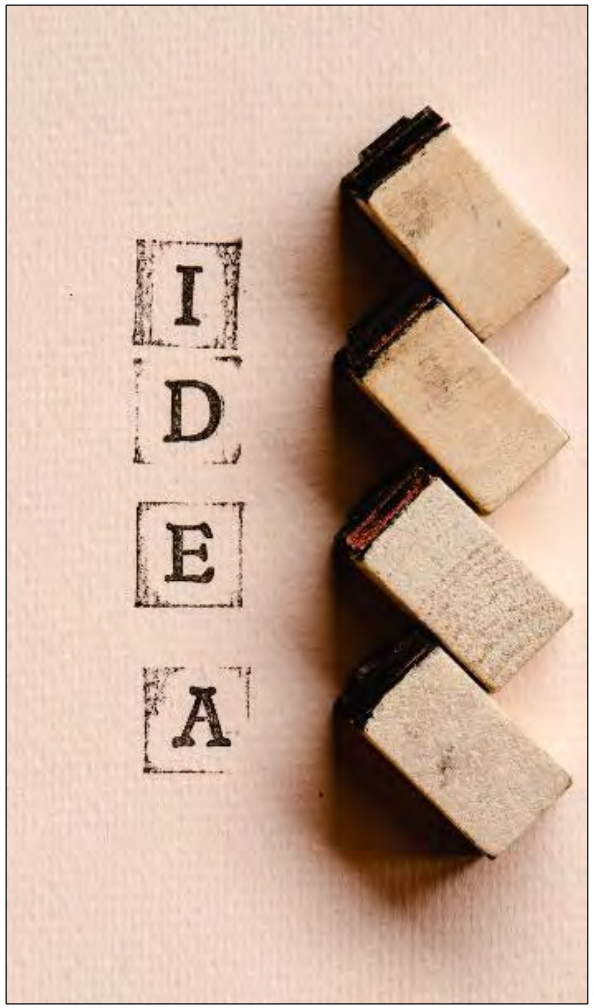
How You Can Help

Public and Private Partners

- Suggestions for board members by June 2022

Resources and Sites for Future TIC

- Evaluating site, structure, and governance
- Implementation – Phase 2: 2024



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ENGAGING STAKEHOLDERS

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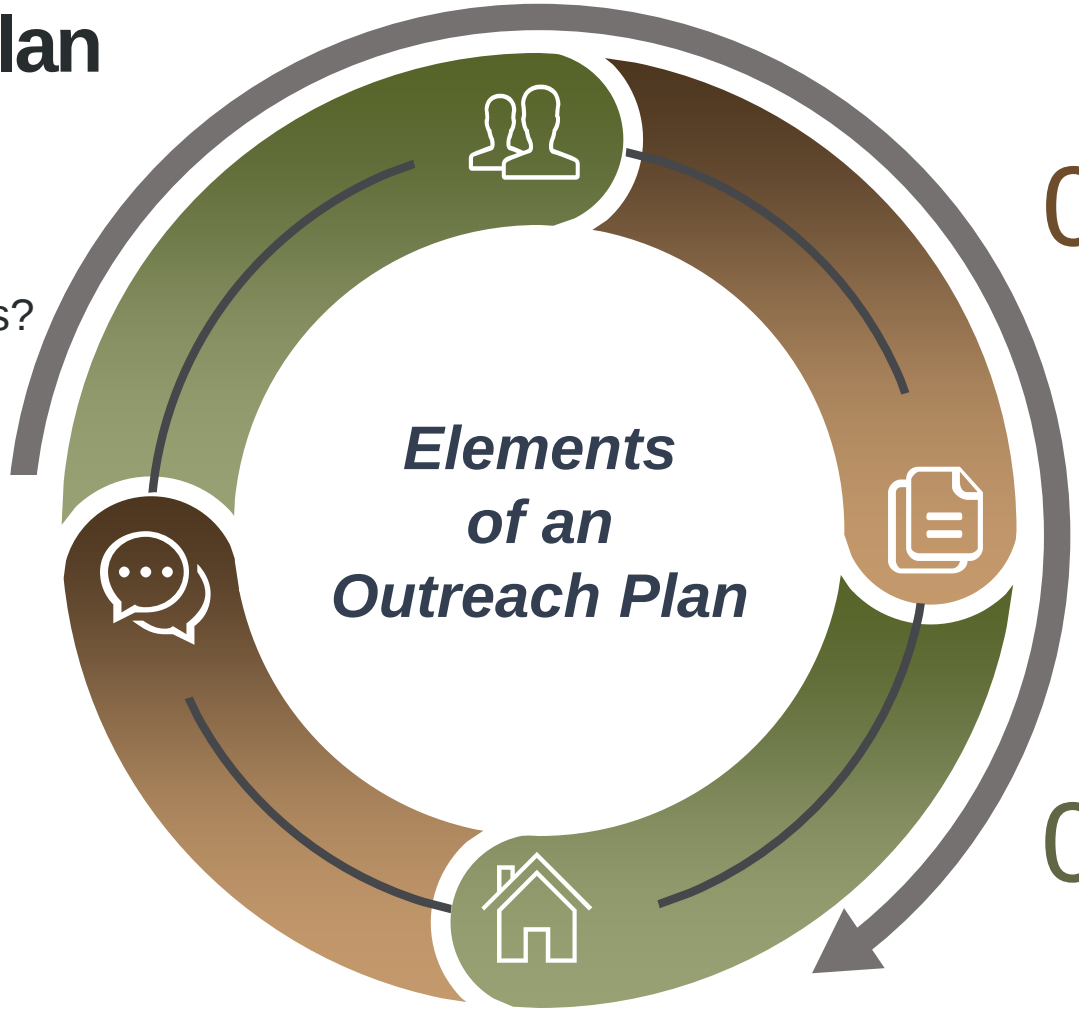
Outreach Plan



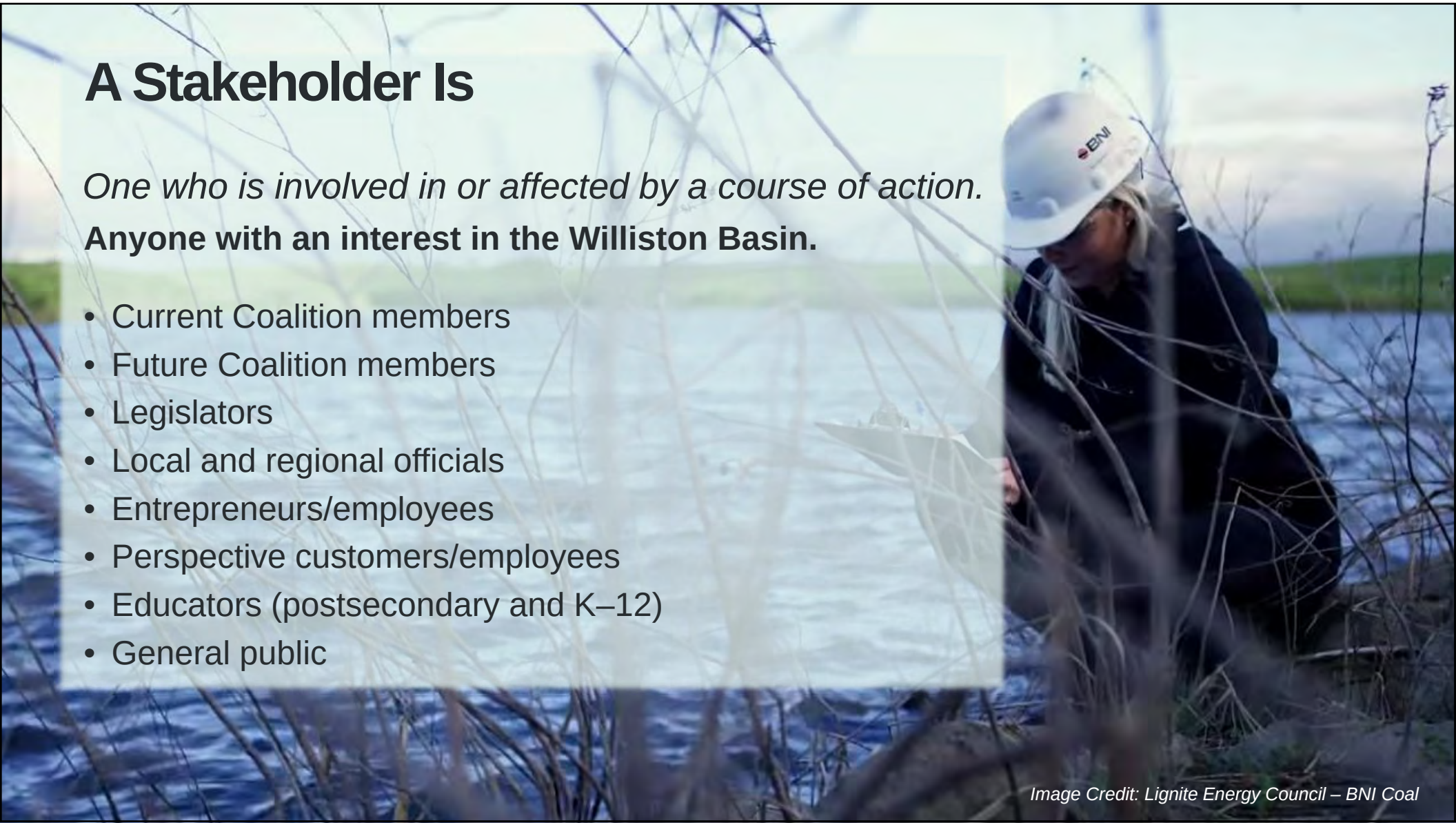
01 ***Who*** are the audiences?

02 ***What*** should they know?

Process Underway

04 ***How*** will they respond?

03 ***Why*** should they care?



A Stakeholder Is

One who is involved in or affected by a course of action.

Anyone with an interest in the Williston Basin.

- Current Coalition members
- Future Coalition members
- Legislators
- Local and regional officials
- Entrepreneurs/employees
- Perspective customers/employees
- Educators (postsecondary and K–12)
- General public

Image Credit: Lignite Energy Council – BNI Coal

Williston Basin CORE-CM Messaging

Nine-second sound bite:

Williston Basin CORE-CM is investigating the use of lignite coal resources to produce a domestic supply of the chemical elements, minerals, and nonfuel carbon-based products essential to healthcare, technology, clean energy, and national security and to catalyze economic growth and job creation.

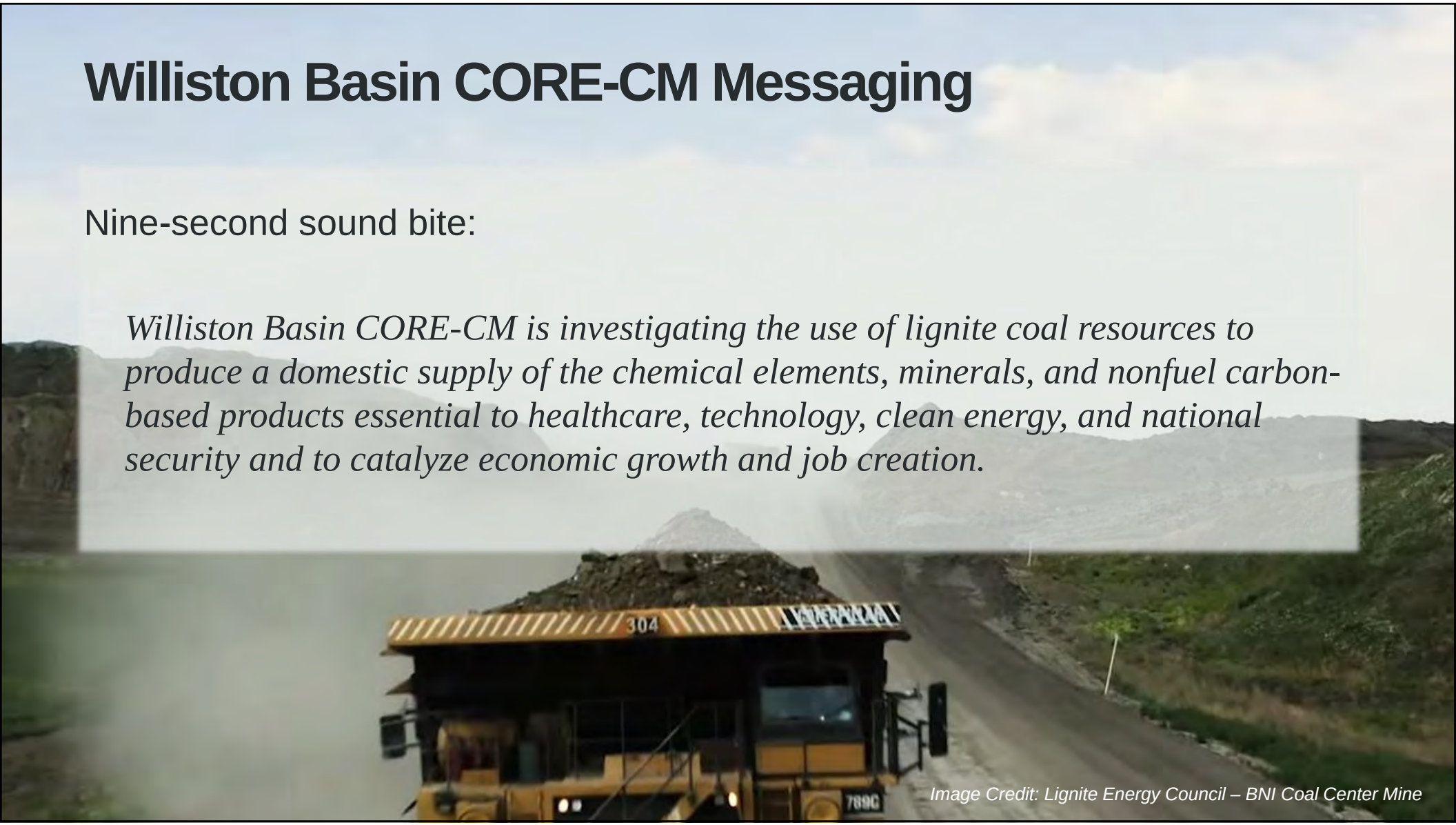
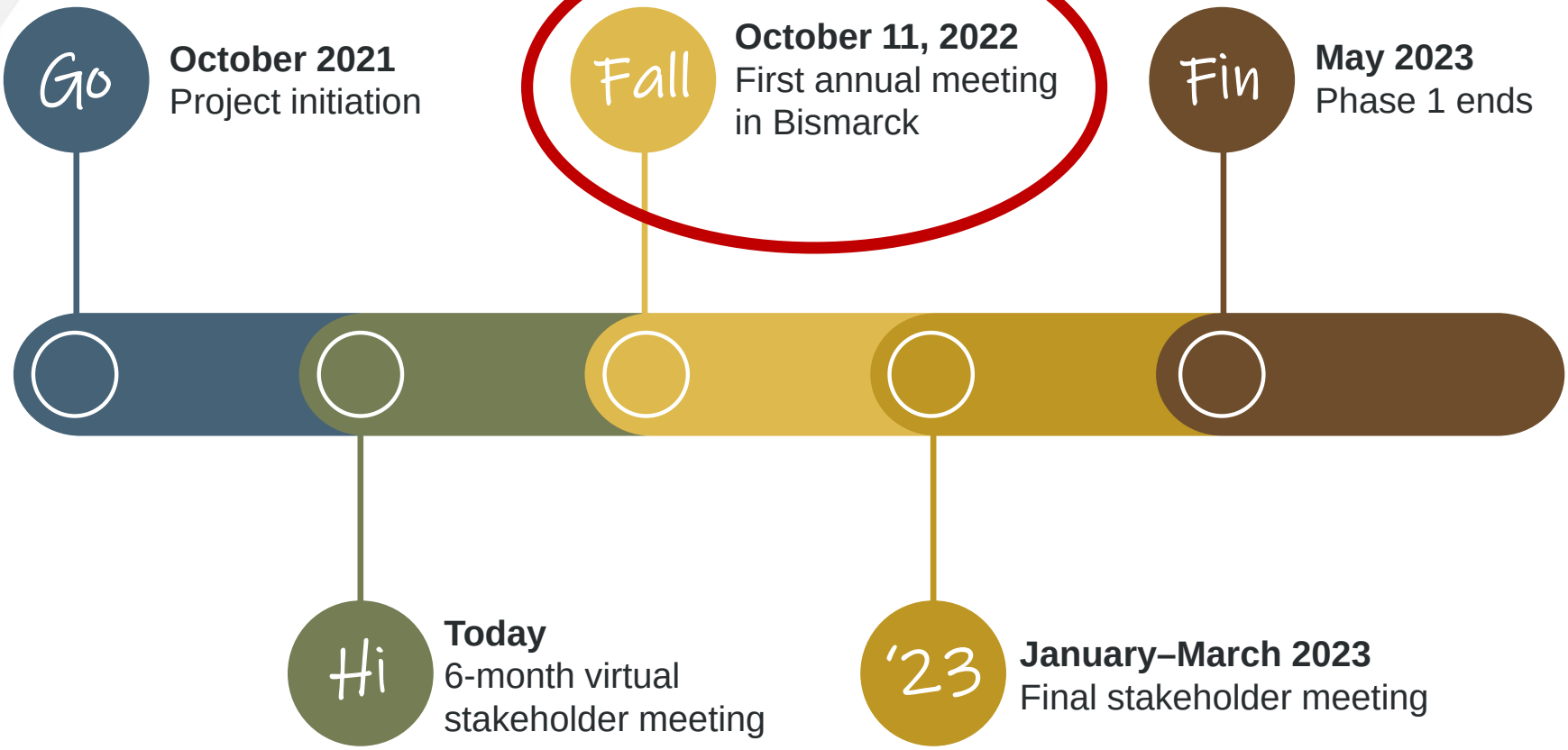


Image Credit: Lignite Energy Council – BNI Coal Center Mine

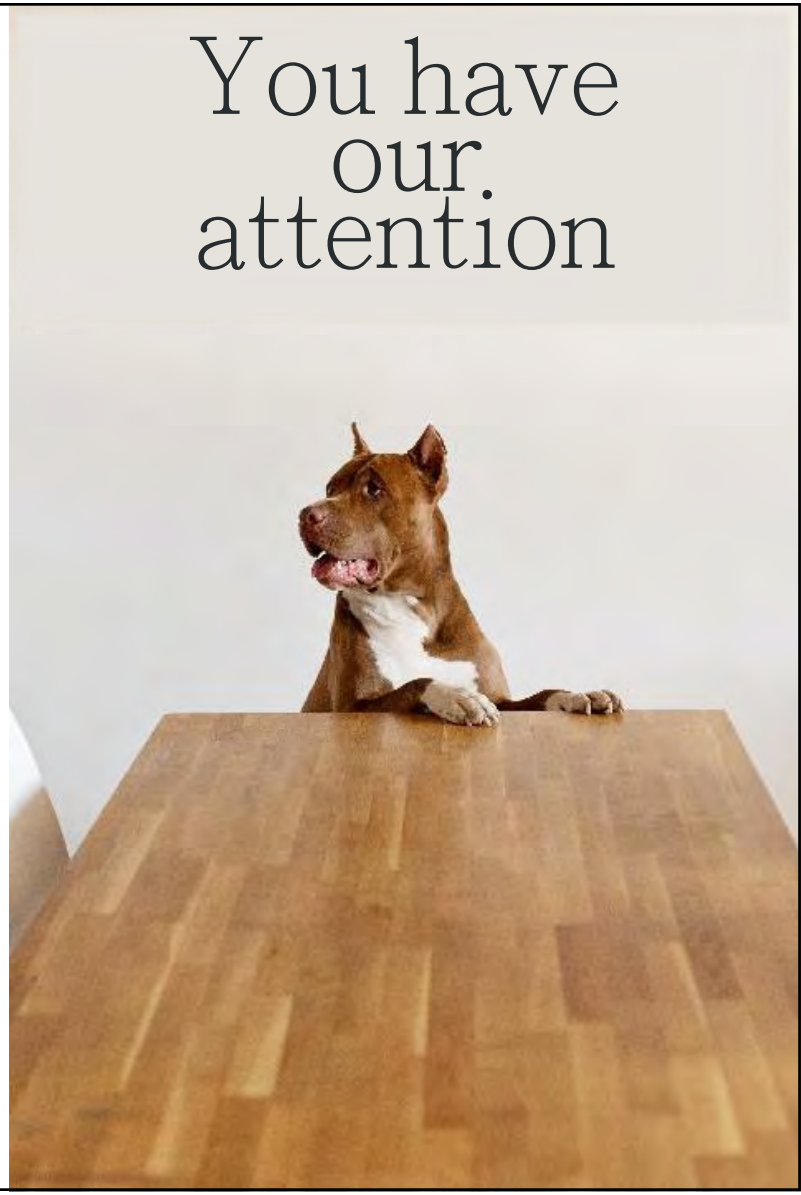
Why Should I Care about Critical Minerals?

Outreach – Stakeholder Meetings



What Do YOU Want to Know and HOW?

- Materials, delivery methods, audiences?
- Where do you network?
  - Forums
  - Conferences
  - Seminars/webinars



How You Can Help

Help us improve our messaging and outreach.

Respond to the survey coming in your e-mail.

- Critique today's meeting.
- What other information would you like?
- What materials would you find helpful?
- What conferences/meetings would be good venues for CORE-CM?

Image Credit: Energy & Environmental Research Center

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Q & A

How You Can Help

Data

- REE and CM concentration data
- Geologic information
  - Well logs
  - Coal thickness and depths
  - Lithology descriptions

How You Can Help

Technologies to Be Evaluated (June 30, 2022)

- From any of the supply chain sectors
- At any technology development level
- Making a product needed or not currently made

Resources and Sites for Future Testing (Phase 2)

- Ores or waste streams for processing and testing
- Locations to place pilot plant demonstrations

Photo by RODNAE Productions from Pexels

How You Can Help

Supply Chain and Business Matters

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

Photo by Fred from Pexels

How You Can Help

Public and Private Partners

- Suggestions for board members by June 2022

Resources and Sites for Future TIC

- Evaluating site, structure, and governance
- Implementation – Phase 2: 2024

Respond to the survey coming in your e-mail.

- Critique today's meeting
- What other information and materials would help?
- What conferences/meetings would be good venues for CORE-CM?

Photo by Oleg Magni from Pexels

Final Details

- Please reach out if you can partner with us.
- Watch your e-mail for a survey.
- Slides from this event will be online.
- Project website: undeerc.org/wb-corecm.

Photo by Glenn Carstens-Peters on Unsplash

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