# CORE-CM in the Greater Green River and Wind River Basins: Transforming and Advancing a National Coal Asset


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Center for Economic Geology Research
School of Energy Resources
University of Wyoming


**CORE-CM Annual Forum - Greater Green River and Wind River Basins**
October 19-20, 2022
Western Wyoming Community College
Rock Springs, Wyoming

U.S. DEPARTMENT OF ENERGY

NATIONAL ENERGY TECHNOLOGY LABORATORY

UNIVERSITY OF WYOMING | School of Energy Resources

# Acknowledgement and Disclaimer

**Acknowledgment**: This material is based upon work supported by the Department of Energy under Award Number DE-FE0032047

# U.S. Department of Energy's CORE-CM Initiative

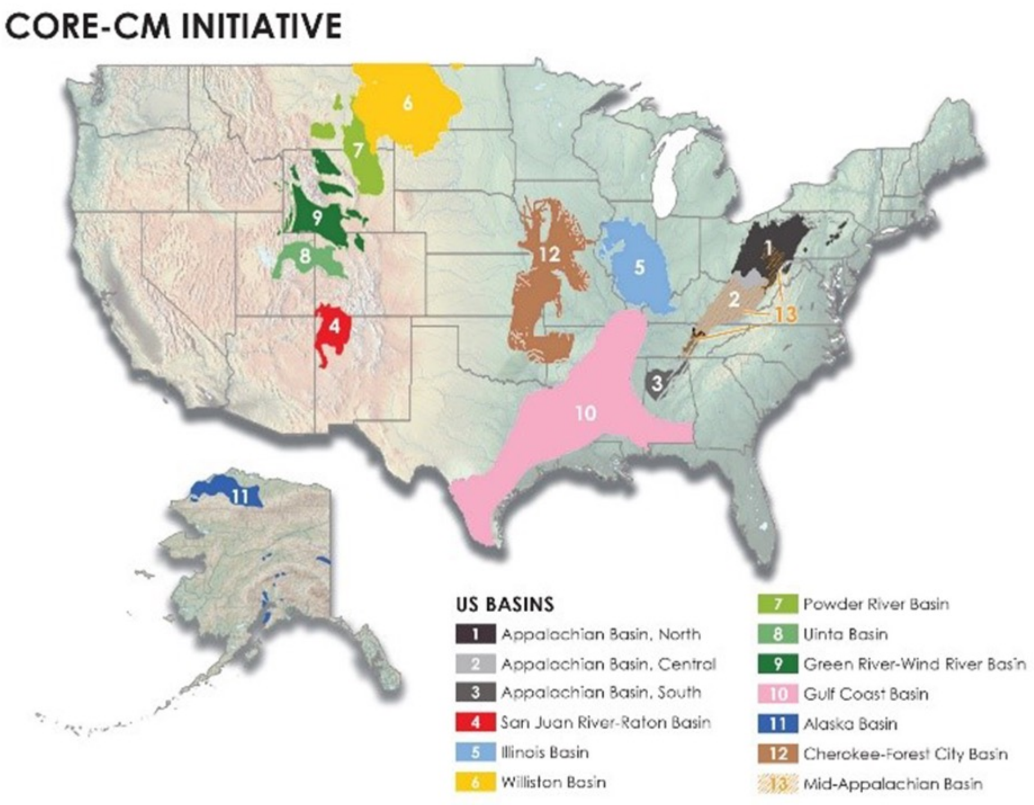
**Provide benefit to U.S. Coal Basins:**

Establish strategic plans to maximize the development of potential carbon ore, rare earth elements, and critical minerals (CORE-CM); within the creation of public-private partnerships.

Leverage highly trained workforces, existing and novel coal technologies, and energy infrastructure in development of CORE-CM supply chains.

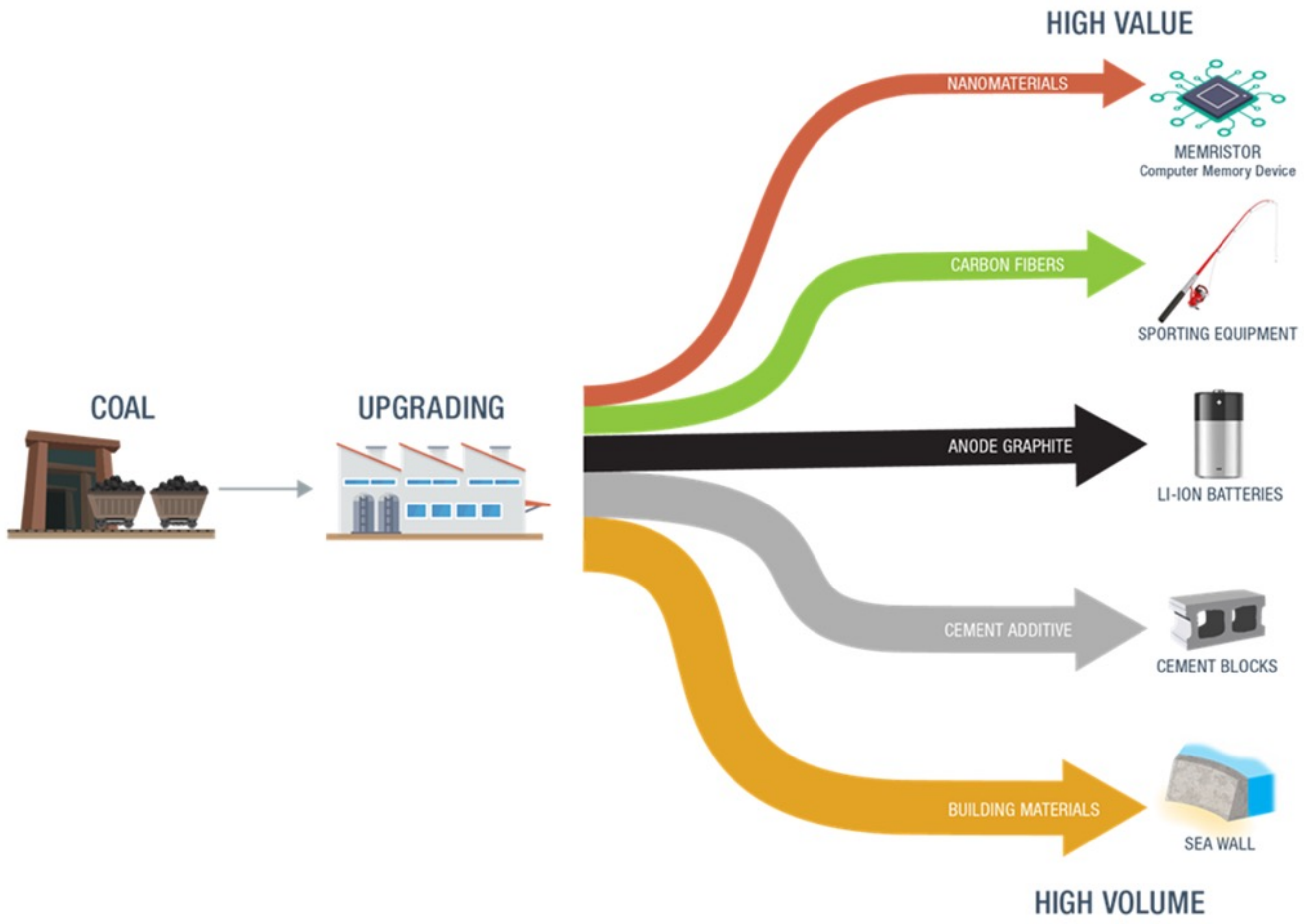
Complete detailed assessments, including State of The Art DATA (SOTA) acquisition of potential CORE-CM materials across U.S. coal basins.

Bring together a committed network of stakeholders, gaining acceptance of new energy technology within coal regions and across communities.




https://netl.doe.gov/node/11045

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

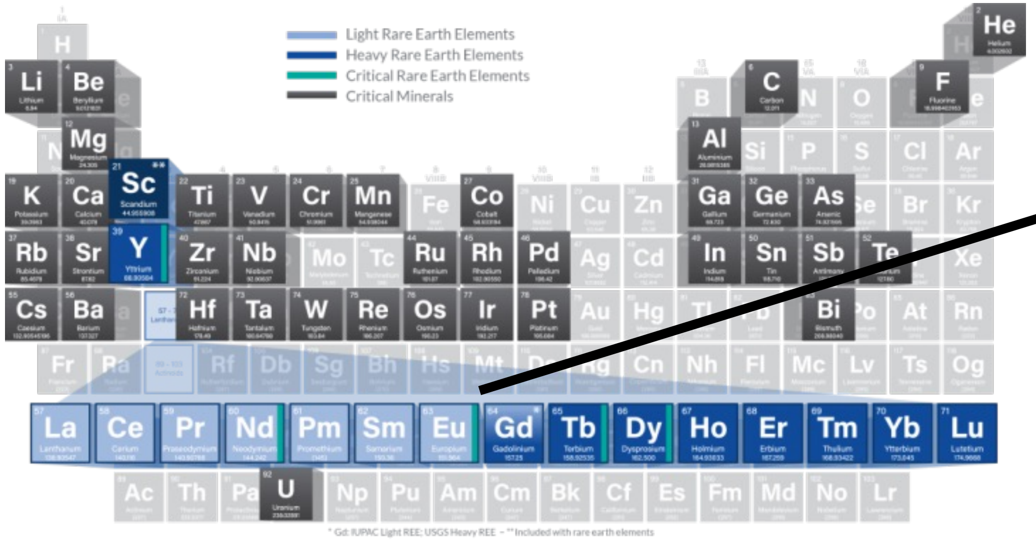


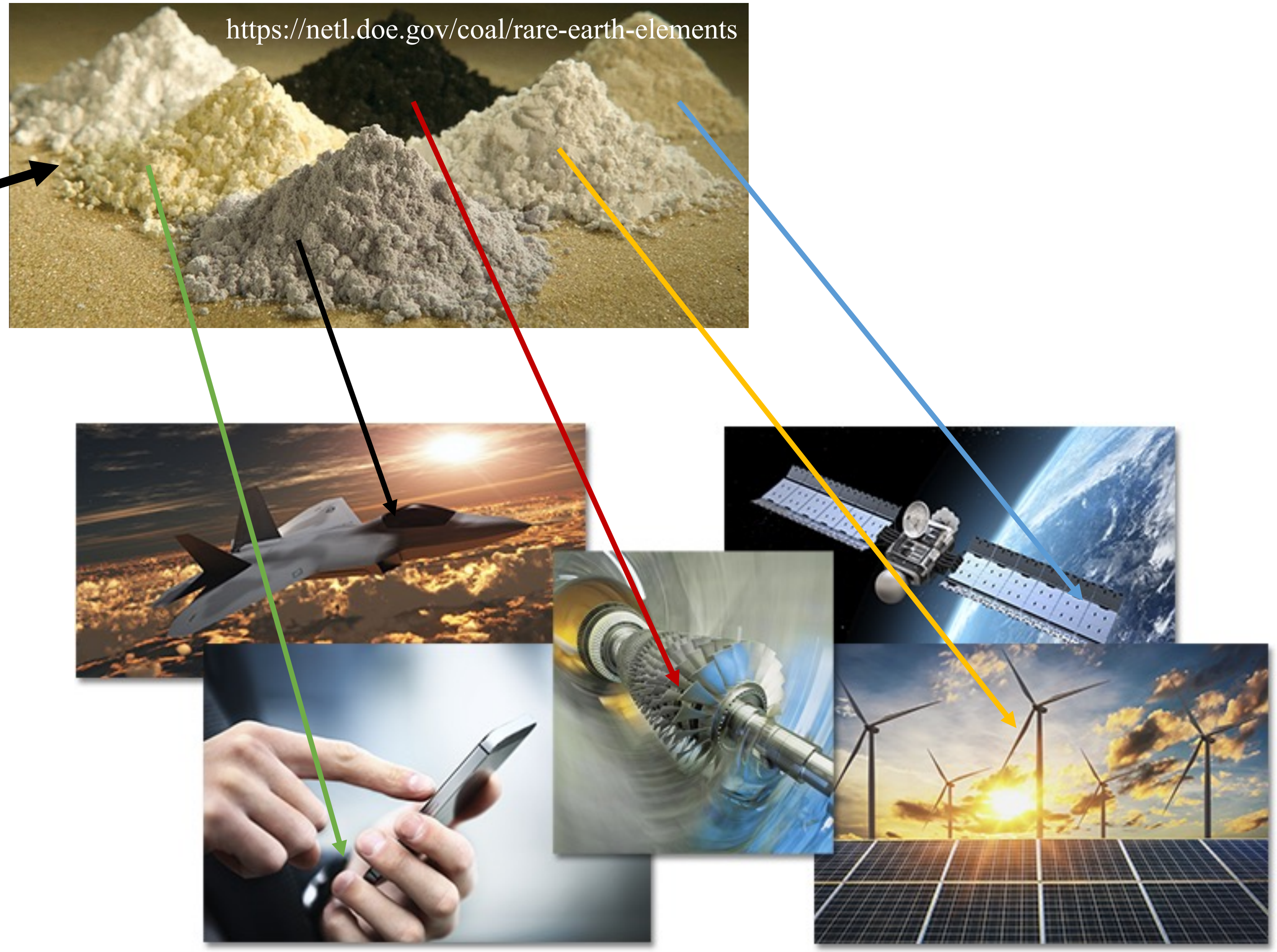

netl.doe.gov/Carbon-Ore-Processing


www.uwyo.edu/ser/research/centers-of-excellence/carbon-capture-conversion/

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

## Rare Earth Elements




- 15 elements (plus two related elements)
- Utilized in almost all modern technology

# CORE-CM in the Greater Green River and Wind River Basins

**Strategic Planning Objectives**

Develop planning for regional economic growth, job creation, and associated technology innovation around coal materials

Define regional economic growth potential around existing strengths, energy infrastructure, business and industry

Increase the supply of CORE-CM materials to manufacturers of non-fuel Carbon Based Products (CBP) and products reliant upon CM

Plan for regional supply chain integration to create a diverse CORE-CM emerging economy

Develop a coalition team to achieve these objectives

# Project Team

## University of Wyoming

School of Energy Resources
Center for Economic Geology Research

School of Energy Resources
Center for Energy Regulation & Policy Analysis

School of Energy Resources
Center for Carbon Capture and Conversion

College of Business
Center for Business and Economic Analysis

COLORADO SCHOOL OF MINES
EARTH • ENERGY • ENVIRONMENT

COLORADO GEOLOGICAL SURVEY

Los Alamos NATIONAL LABORATORY

WYOMING ENERGY AUTHORITY

Coalgeo, LLC

Colorado Northwestern Community College

WESTERN Wyoming Community College

BOSTON STRATEGIES INTERNATIONAL
Global growth. Guaranteed.

# Current Support

**Wyoming Partners & Supporting Stakeholders:**
U.S. Congressional Delegation of Barrasso, Lummis, and Cheney; Wyoming Governors Office; Wyoming Mining Association; Wyoming Representive Donald Burkhart; Wyoming Representative Mike Greear; Wyoming County Commissioners Association; Wyoming Business Council; Wyoming Small Business Development Center; Impact 307; Wyoming Counties of Sweetwater, Sublette, Fremont, Carbon, and Uinta; Kemmerer Operations, LLC; Black Butte Coal; Bridger Coal Company; Sweetwater Economic Development Coalition; Southwest Wyoming Manufacturing Partnership; Central Wyoming College; City of Rock Springs; City of Green River

**Colorado Partners & Supporting Stakeholders:**
Colorado State Land Board; Colorado Division of Reclamation, Mining and Safety; Associated Governments of Northern Colorado; Routt County, CO Economic Development Office; Moffat County, CO; Trapper Coal Mine; Colowyo Coal Mine; Mango Materials; Ur-Energy Inc.

**Regional**
Tri-State; Peabody Energy; PacifiCorp; The University of Texas at Austin; Concurrent Technologies Corporation: Tetra Tech; Novex, LLC; Disa, LLC; NTEC

# Regional Strengths

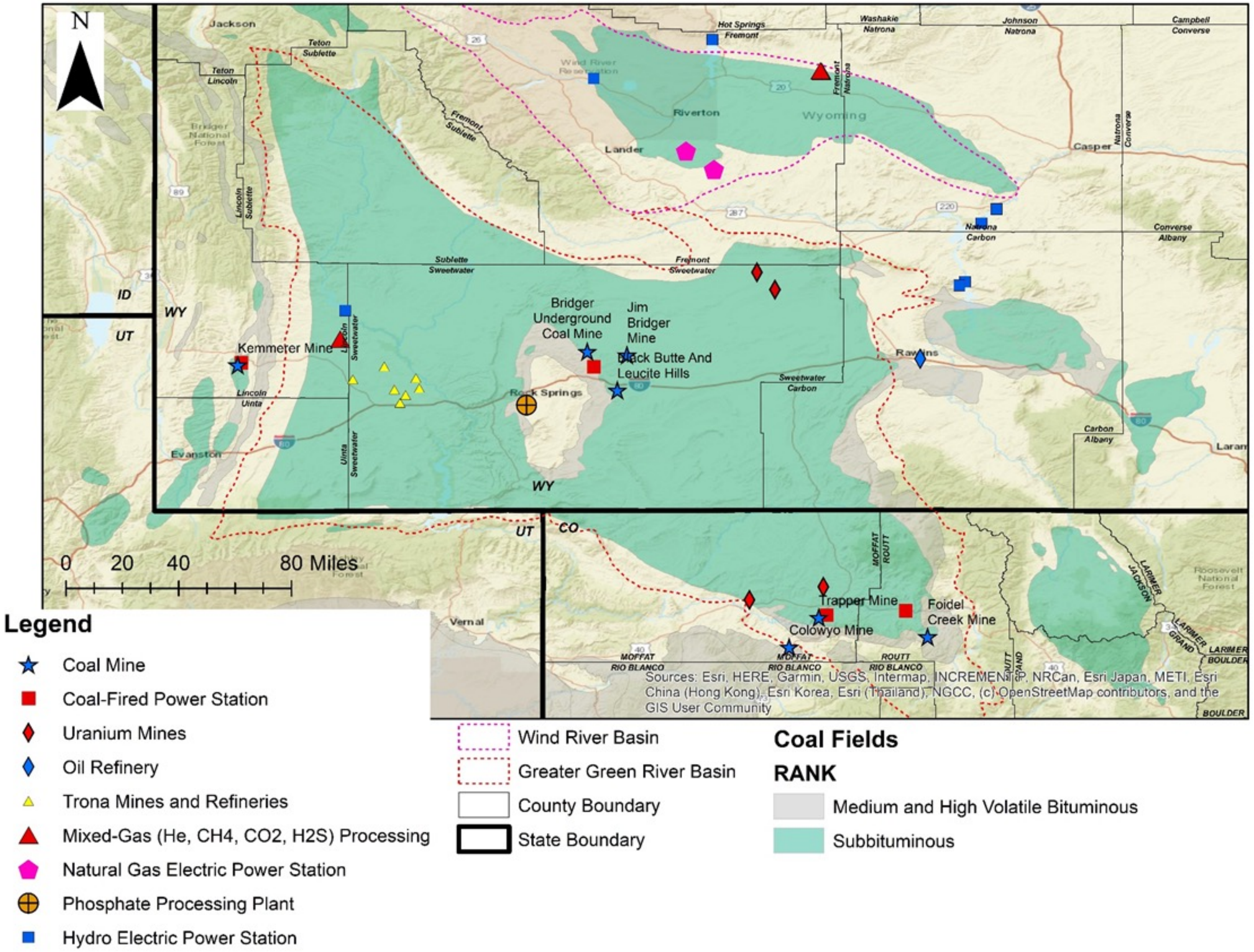
Home to a diversity of potential feedstocks and materials to benefit CORE-CM planning and development

- Major coal mines & extractive industries (e.g., uranium, trona, helium, oil, natural gas)
- Major industrial operations (e.g., power, soda-ash, gas-separation, phosphate) with

Advanced manufacturing and supply chain infrastructure relevant to CORE-CM is currently being initiated in the region

Economic downturn is well understood by regional stakeholders composed of a highly trained, adaptable & energy-savvy work-force

Workforce development, coalition team building & stakeholder involvement in public-private teams are all familiar to region partners



# CORE-CM Project Strategy

**Integrated Strategic Plan** for the Greater Green River and Wind River Basins

- Basinal Assessment of CORE-CM Resources
- Basinal Strategies for Reuse of Waste Streams
- Basinal Strategies for Infrastructure, Industries and Businesses
- Technology Assessment, Development and Field Testing
- Technology Innovation Centers
- Stakeholder Outreach and Education

Each results in a
**Strategic Plan** or **Assessment Summary**

- Summary of Environmental Justice Considerations
- Summary of Economic Revitalization and Job Creation Outcomes
- Environmental, Safety, and Health Analysis for Products Proposed to be Manufactured from CORE-CM Resources

# Basinal Assessment of CORE-CM Resources in the Greater Green River and Wind River Basins

University of Wyoming

School of Energy Resources
Center for Economic Geology Research

Colorado Geological Survey

Coalgeo, LLC

U.S. Department of Energy

National Energy Technology Laboratory

# Resource Assessment Team

**Task 2.0 - Basinal Assessment of CORE-CM Resources**

Lead: Davin Bagdonas, Research Scientist, Coal and Rare Earth Elements, UW Center for Economic Geology Research

Key Persons: Mike O'Keeffe, Mineral Resources and Geological Mapping, Colorado Geological Survey
Matthew Morgan, Deputy Director/Senior Research Geologist, Colorado Geological Survey
Alex Papp, Professional Geologist, Coalgeo, LLC
Matt Johnson, Research Scientist/Geomodeling, UW Center for Economic Geology Research
Erin Phillips, Research Scientist, UW Center for Economic Geology Research

- Wyoming State Geological Survey (advisory)

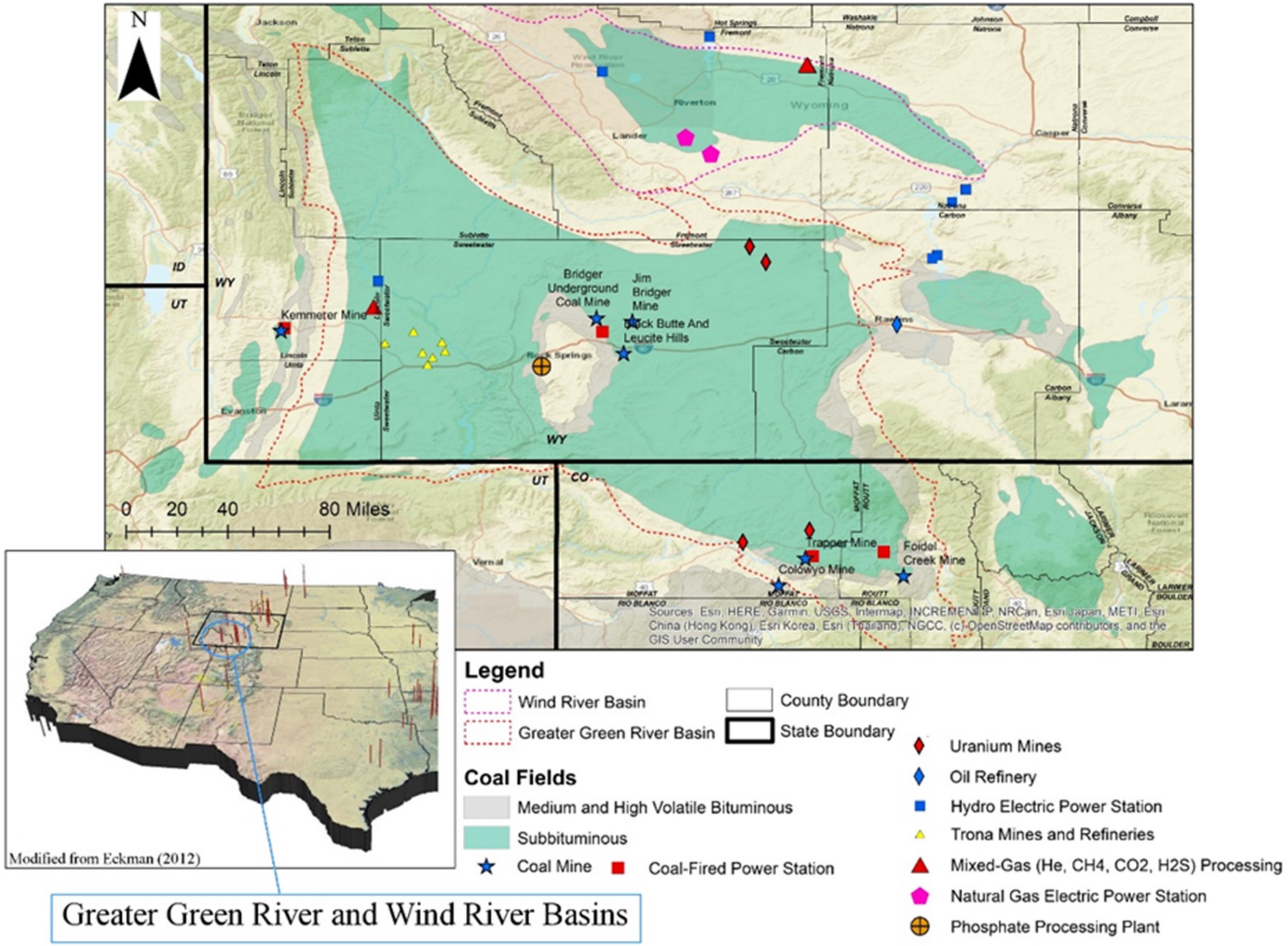
University of Wyoming | School of Energy Resources Center for Economic Geology Research

Colorado Geological Survey

# Task Objectives

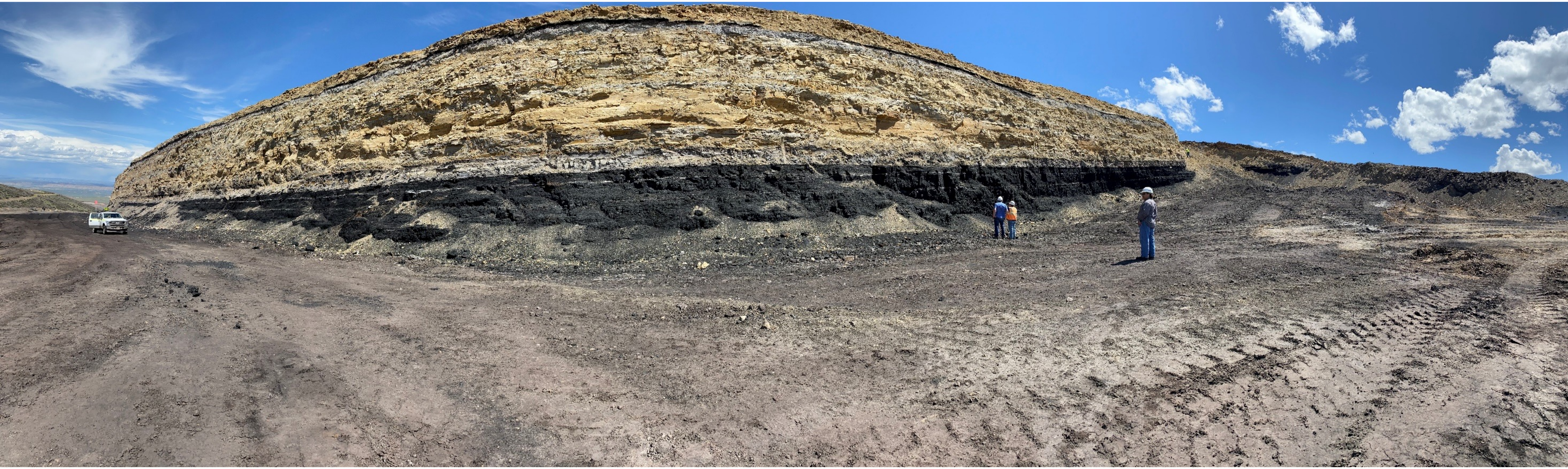
"This task will evaluate available historic and current state-of-the-art (SOTA) Carbon Ore, REE, and CM data collected from within the Greater Green River and Wind River Basins, including coal related sediments, coal ash, refuse, acid mine drainage, and other resources Then build an initial geologic model, propose future modeling, study trends, and identify what information should be learned in later project phases."

- **Resource Assessment of Coal Sediments**
- **Resource Assessment of Coal Ash, Refuse, AMD, and Other basin materials**
- **Geologic Model Development for Coal Sediments**
- **Resource Gap Analysis and Future Characterization Plan**



# Resource Assessment of Coal Sediments

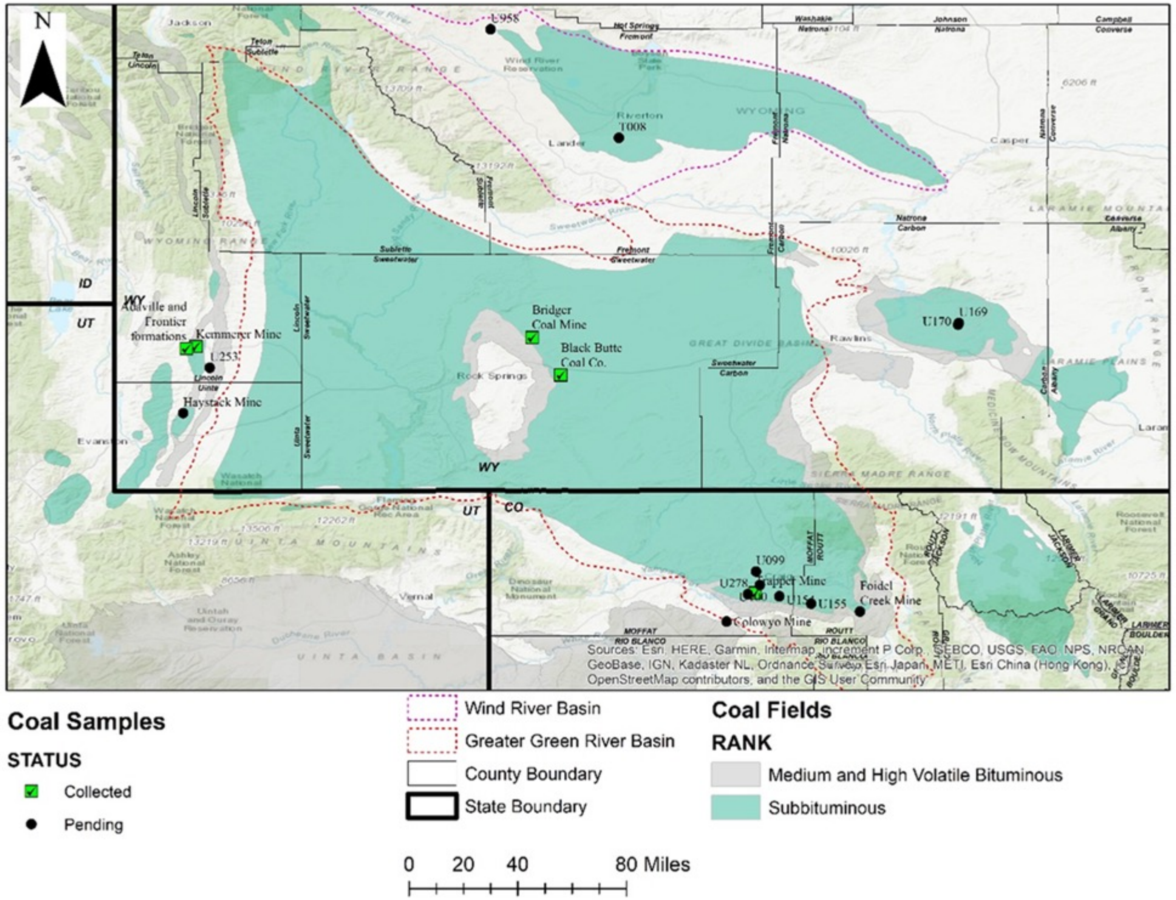
- **Resource Assessment of Coal Sediments**
  - Review existing & construct new SOTA CORE-CM data and archived samples of coal sediments
  - Identify and evaluate carbon-ore then build a list of locations and provide DOE a Site Access Agreement(s) for each target
  - Estimate quantities, and character of each resource
  - Provide input to COAL DATA initiative and NETL REE Sedimentary Resource Assessment Method (REE-SED)



# Resource Assessment of Coal Sediments

A diversity of potential coal feedstocks are being evaluated across numerous coal sub-regions:

- Wind River Basin CBM and exploratory sites
- Western Wyoming (Kemmerer Mine & Haystack Mine)
- Central Green River Basin (Black Butte & Bridger Mines)
- Hannah Coal Field (retired)
- Yampa Coal Field (Colowyo, Trapper & Twenty Mile Mines)

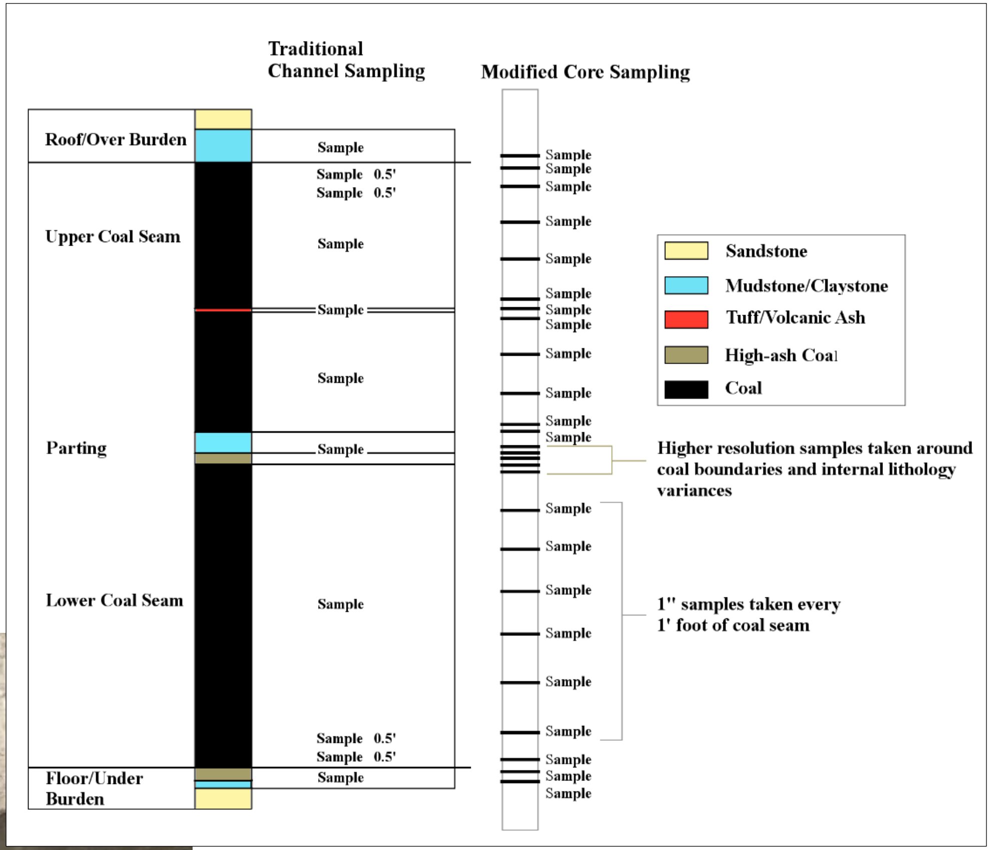


# Resource Assessment of Coal Sediments

Currently 300+ samples in utilized within the assessment strategy

Preliminary work identifies:

- Potential CORE-CM resources located on federal lands and tribal lands
- REE & CM behavior in coals in predictable geologic behaviors
- Initial confirmation of Assessment methods



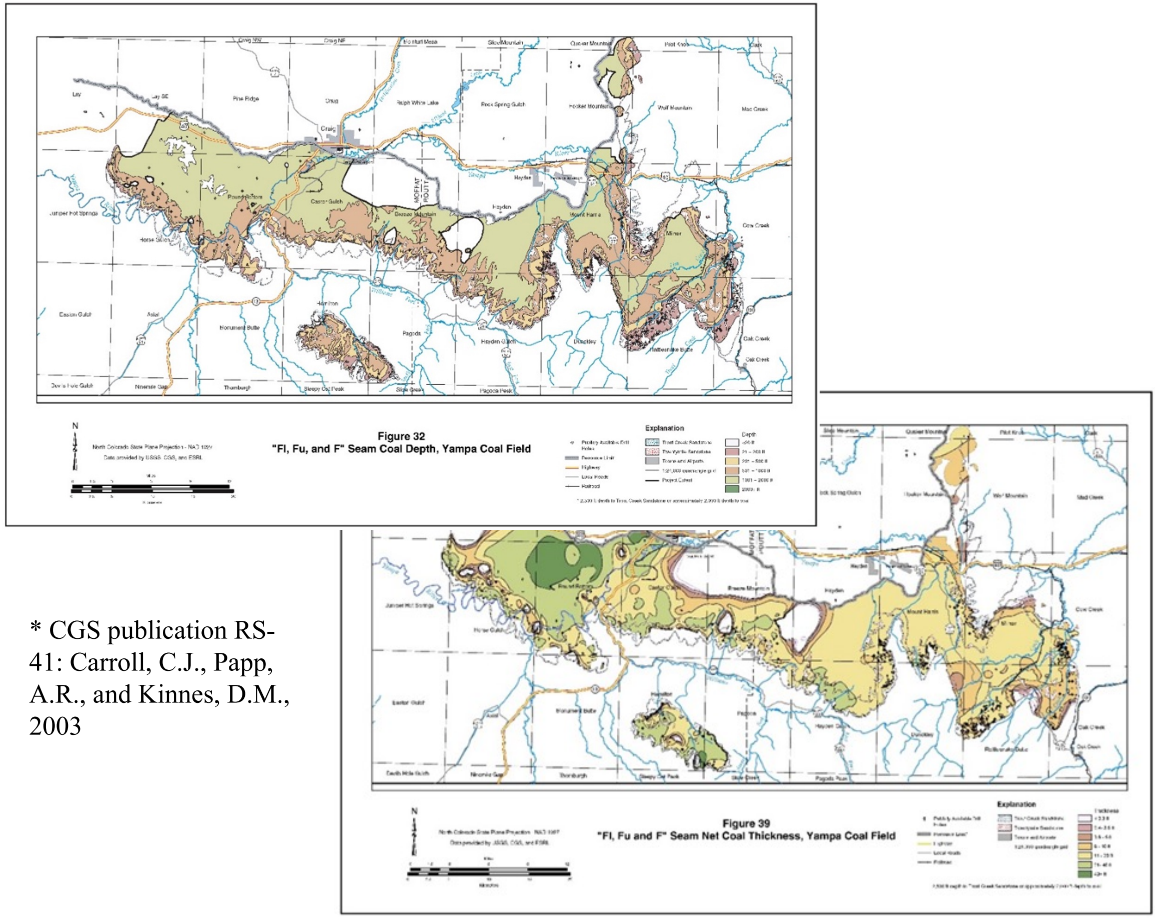

Montross, S.N.; Bagdonas, D.; Paronish, T.; Bean, A.; Gordon, A.; Creason, C.G.; Thomas, B.; Phillips, E.; Britton, J.; Quillian, S.; Rose, K. On a Unified Core Characterization Methodology to Support the Systematic Assessment of Rare Earth Elements and Critical Minerals Bearing Unconventional Carbon Ores and Sedimentary Strata. Minerals 2022, 12, 1159. https://doi.org/10.3390/min12091159

# Resource Assessment of Coal Ash, Refuse, AMD, and Other basin materials

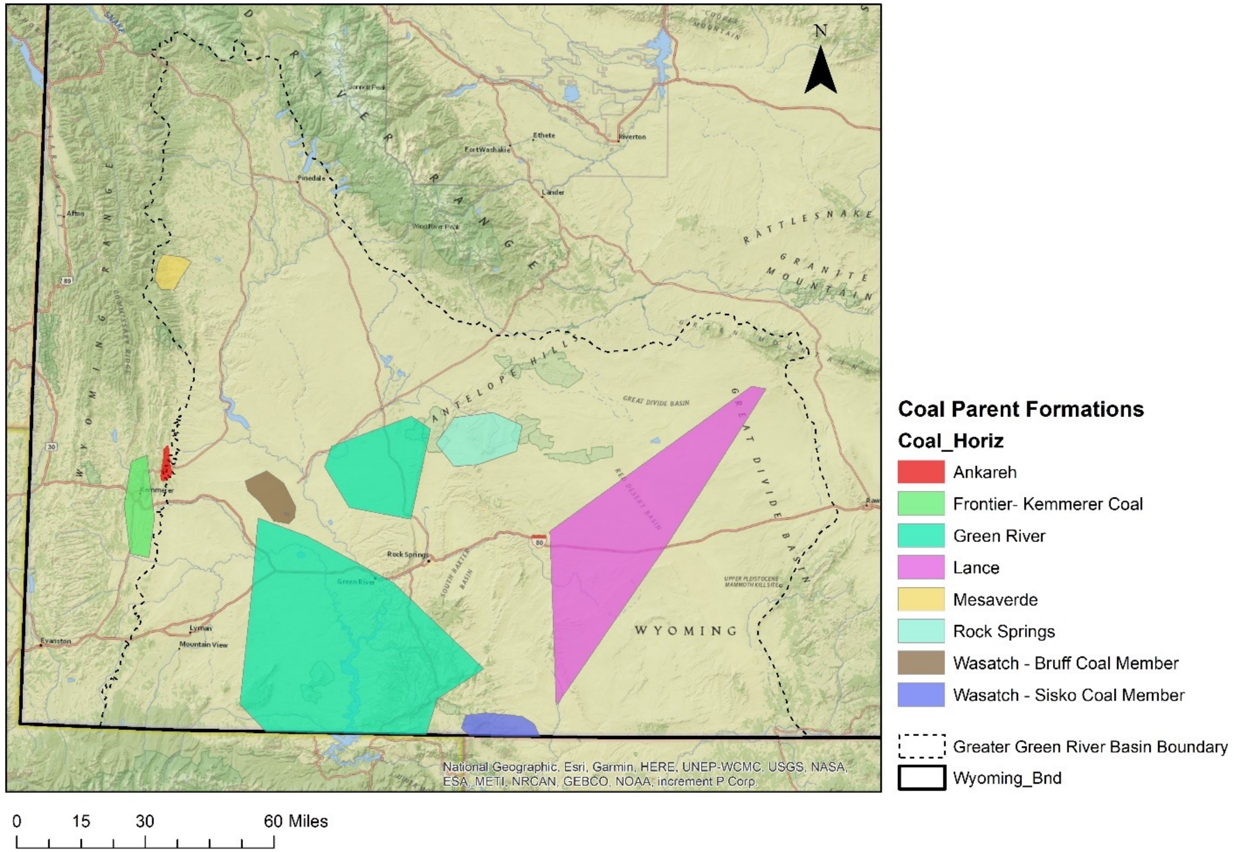
- **Resource Assessment of Coal Ash, Refuse, AMD, and Other basin materials**
  - Review SOTA feedstock CORE-CM data produced from existing GGRB-WRB industries such as coal, trona, phosphorus, uranium, helium, sulfur, vanadium, titanium, iron, zirconium, oil, gas, etc
  - Identify and evaluate coal-mining by-products and other extractive industry related resources, then build a list of locations, estimated quantities, and character of each resource
  - Provide DOE a Site Access Agreement(s) for each target

# Geologic Model Development for Coal Sediments

- **Geologic Model Development for Coal Sediments**
  - Develop a CORE-CM specific geologic model to show the basin's large-scale stratigraphy

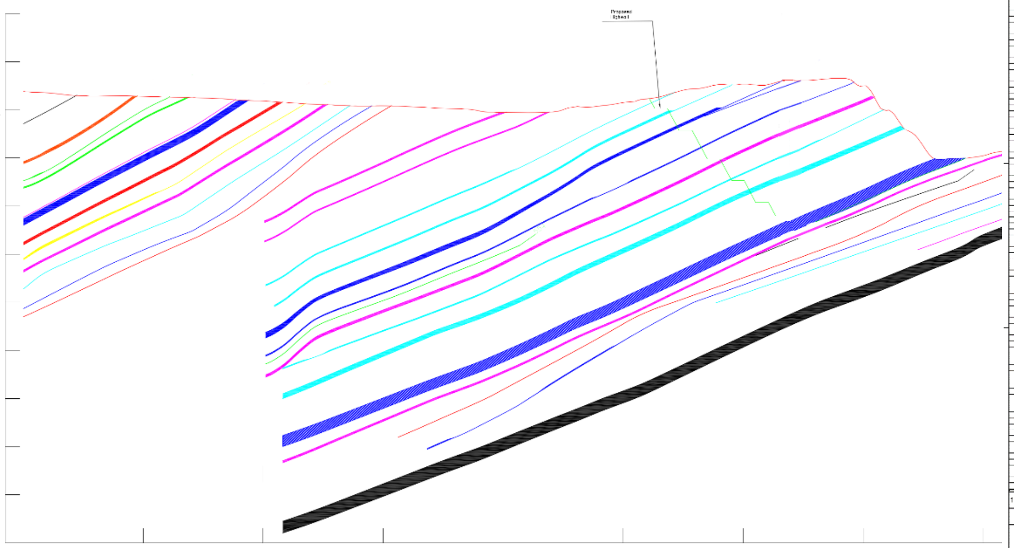


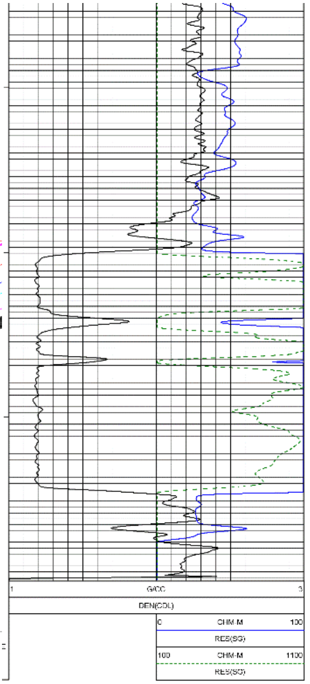

* CGS publication RS-41: Carroll, C.J., Papp, A.R., and Kinnes, D.M., 2003

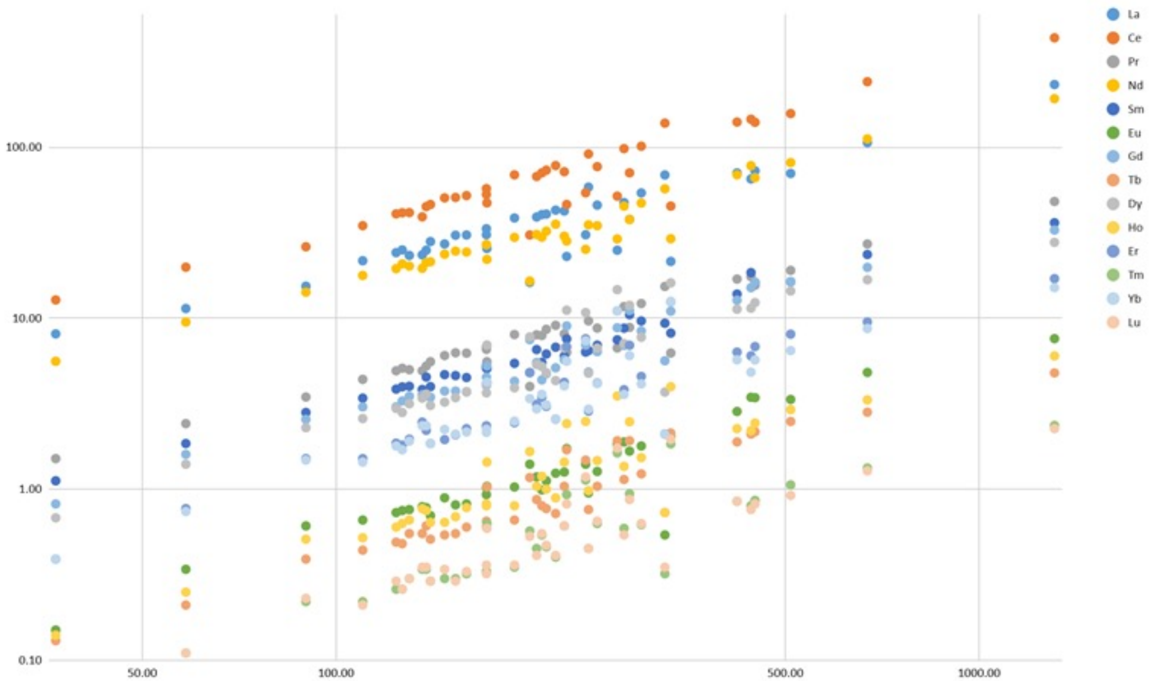


# Geologic Model Development for Coal Sediments

- **Geologic Model Development for Coal Sediments Continued**
  - Develop planning for smaller ore-body-type high-resolution model(s) at specific coal mines set within the basinal model extent
  - Investigate comparisons to REE-SED and future model implementation using SOTA data







# Resource Gap Analysis and Future Characterization Plan

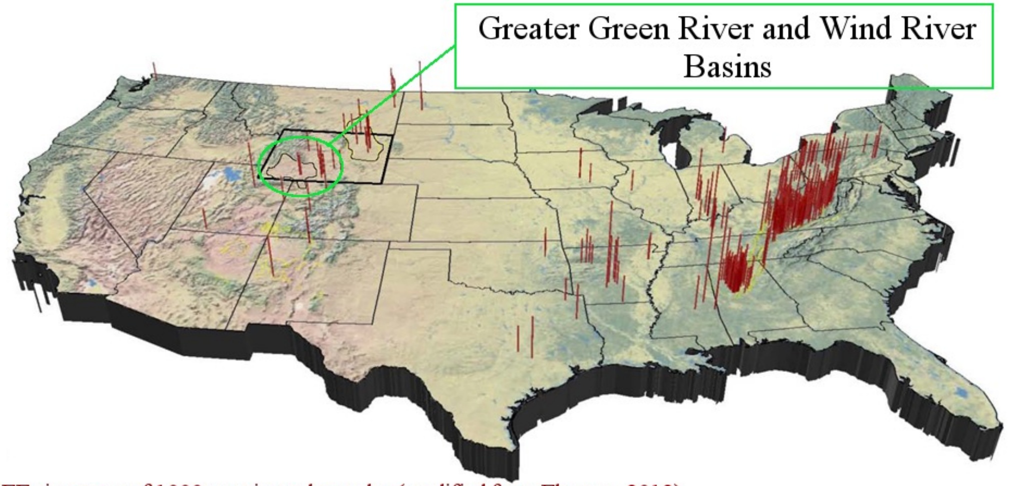
- **Resource Gap Analysis and Future Characterization Plan**

And how does the resource guide future development?

- **Potential technologies**
- **Leverage resource strengths of the basin**
- **Competitive advantage & techno-economically sound**

- **Addresses local Environmental & Social concerns**

- **Produce local economic development and job creation**




REEs in excess of 1000 ppm in coal samples (modified from Ekmann, 2012)

# Thank You

Additional Project Details & Information

Davin Bagdonas
abags@uwyo.edu

To be added to stakeholder updates

Christine Reed
Christine.Reed@uwyo.edu

# CORE-CM GGRB & WRB: Waste stream Reuse

- This work does two things:
  - When CORE-CM processes coal materials, there will be some waste products. We need to find a new use for these products in the GGRB & WRB.
  - The GGRB & WRB have many great industries which generate products currently treated as waste. CORE-CM's extraction process might need some of these as inputs.
- "Closing the loop" does three good things:
  - It reduces the disposal burden of CORE-CM and existing industries.
  - It reduces the cost of buying new/fresh reagents.
  - It spreads risk wider and gives all basinal industries more options to absorb market and supply chain shocks

*Using Waste Streams to boost economics*

Waste Streams from CORE-CM extraction used elsewhere

Waste Streams from elsewhere used for CORE-CM extraction

# New wastes CORE-CM might make: Who can use these?

- When CORE-CM processes coal materials, there will be some waste products. We need to find a new use for these products in the GGRB & WRB.

| Name | Location | Description | Use |
|---|---|---|---|
| Brine water | Ash/Coal dissolution | Neutral pH, some Na & S | If Sulfur allows, de-icing. Treatment for H-production. |
| Solvent | Solvent Extraction | Polar/non-polar solvents mixed together | Cleaning/treating/etching a surface, further non solvent-extraction processes |
| Electrolyte | ElectroChem cell | Metal salts, hydroxides | Abrasives, metal recycling/smelting, Al-Si aggregate |
| New-mining | Coal/REE/Meta l | AMD, pyrite, reduced fluid | Extraction acid, Metal precipitates |

# New wastes CORE-CM might make: Who can use these?

Burning, Synthesis, Gasifying, Pyrolyzing, Flotation, Solvent Extraction, Electrochemical, Bio-leaching

- When CORE-CM processes coal materials, there will be some waste products. We need to find a new use for these products in the GGRB & WRB.

| Name | Location | Description | Use |
|---|---|---|---|
| Diesel | Existing large open spaces | Biodiesel for existing fleets | |
| Coal to Liquids | | | |
| Hydrogen | | Ammonia production | |
| | | | |
| | | | |

# Existing wastes in the GGRB&WRB: May we take these off your hands?

- The GGRB & WRB have many great industries which generate products currently treated as waste. CORE-CM's extraction process might need some of these as inputs.

| Name | Location | Description | Use |
|---|---|---|---|
| Gas processing plants | Lost Cabin/Shute Creek | Natural Gas purification rejects | Sulfur, Propane/Ethane fuel, and inert gasses |
| Lower-grade Iron ore | Iron Mountain Mine | Tailings of $FeO_x$ | Aggregate, Ore |
| Sand Dunes | Kilpecker Sand Dunes | Aeolian (rounded) sand | Cracked to be angular aggregate, texture |
| Trona Rejectate | Trona Mines and Refineries | Oxidizing Brines and oily shale | ISR of Uranium or Vanadium, feedstock for |

# Existing wastes in the GGRB&WRB: May we take these off your hands?

- The GGRB & WRB have many great industries which generate products currently treated as waste. CORE-CM's extraction process might need some of these as inputs.

| Name | Location | Description | Use |
| --- | --- | --- | --- |
| Gypsum | Phosphate | | Building materials |
| Flared/Waste heat | Gas processing plants | | Waste/heat recovery<br>$CO_2$ source,<br>electrical generation |
| | | | |
| | | | |
| | | | |

# Last thought: Regulation is a factor in “closing the loop”

- Regulation is an essential part of setting standards for clean recycling.
- However, sometimes specifying the manner in which a waste product is remanufactured or recycled can exclude better options or raise barriers to entry for novel approaches:
    - Waste oil from transport operations contains metal filings, impure combustion byproducts, partially-broken-down oil, and the original oil.
    - This waste can be remanufactured into motor oil by floating/sinking metal and impurities like water or soot, doing some further filtering, and maybe other separations.
    - Only an authorized remanufacturer is allowed to accept used oil and treat it in this way. The metal filings are thrown away. (Burning the residual oil attached to them is forbidden)
    - If the resource were significant, a new company could be made to burn the residual oil in a safe way, and add further heat to melt the metal filings into new metal material. (The scale is not there currently so this is a well-considered regulation, but the point is it limits options.)

# Task 5.0 – Technology Assessment, Development, and Field Testing (CSM, Taylor, Bentele, LANL, Goehring)

**Task Summary: This task is investigating existing and new technologies for extraction of CORE-CM from coal and waste streams, purification of extracted CORE-CM, incorporation of purified CORE-CM into high-value products, and repurposing of coal and waste stream materials in value-added products.**

# Patrick Taylor – Colorado School of Mines

**Expertise: 45 years experience in Teaching, Research and Consulting in: Mineral Processing, Extractive Metallurgy, Recycling and Waste Minimization. PI on numerous CM research projects**


## Current and Recent Related Research

Ga, Ge and In recovery from Zinc Plant Residues – CMI

Plasma Enhanced Reduction of Rare Earth Oxides – DOE

Technical and Economic Analysis of Commercial and New Rare Earth Reduction Processes - DOE

Improved Molten Fluoride Electro-Reduction of Rare Earth Oxides - CMI

**Major Activities:**

- **Literature and patent search summary of potential technology have been updated by CSM.**
- **Technologies that may be close to State of the Art were identified from this list.**
- **LANL is performing a literature review and a technology assessment with a special emphasis on LANL separation and processing technologies developed for actinide/lanthanide separation that could be adapted to REE extraction from coal and coal derived products.**
- **Initial samples have been received by CSM and LANL. These are being characterized through automated mineralogy, X Ray diffraction and chemical analysis.**

- **Assessment tasks include identifying additional sampling and exploration requirements, applications of conventional and unconventional mining/processing, and beneficiation, separation, purification as well as metal recovery processes utilizing these regional resources.**

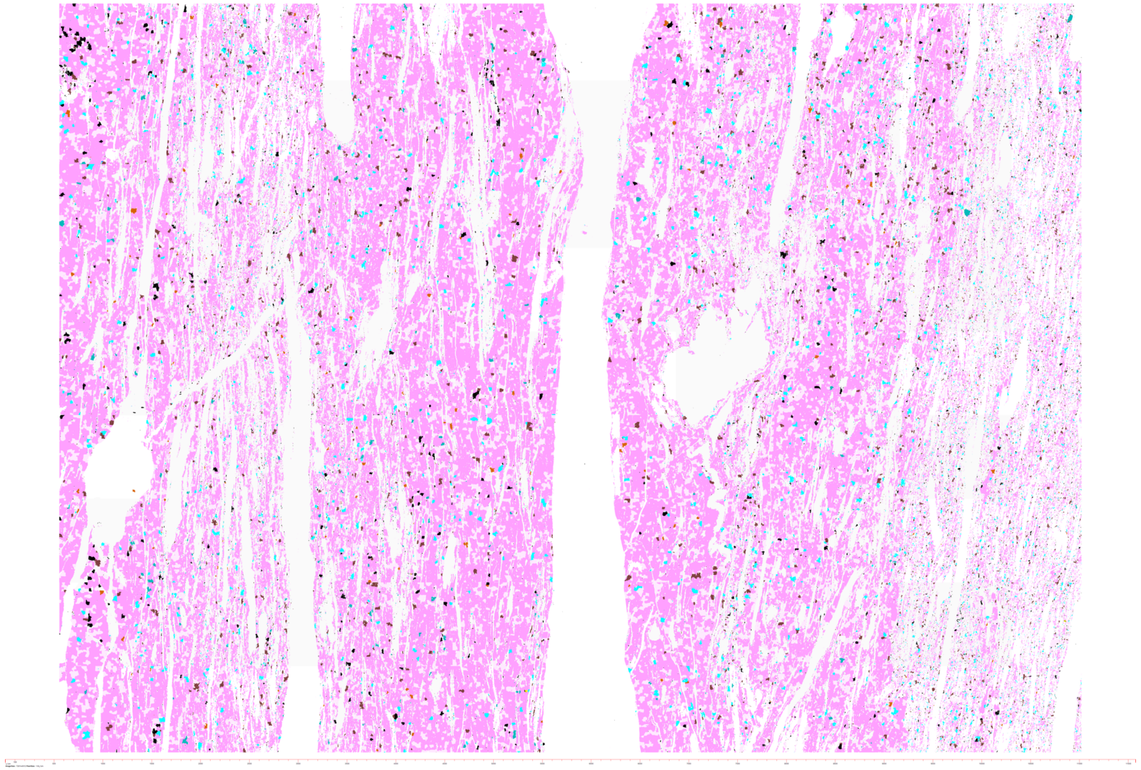
- **Additionally, existing technologies for the production of non-fuel, value-added products from coal (e.g., chemicals, polymers, carbon fiber, and activated charcoal), phosphate deposits (e.g., fertilizers), and trona waste (e.g., chemicals) will be assessed.**

- **Contact information was provided for a trona operation and a phosphate operation to Task 3.0 for data review.**

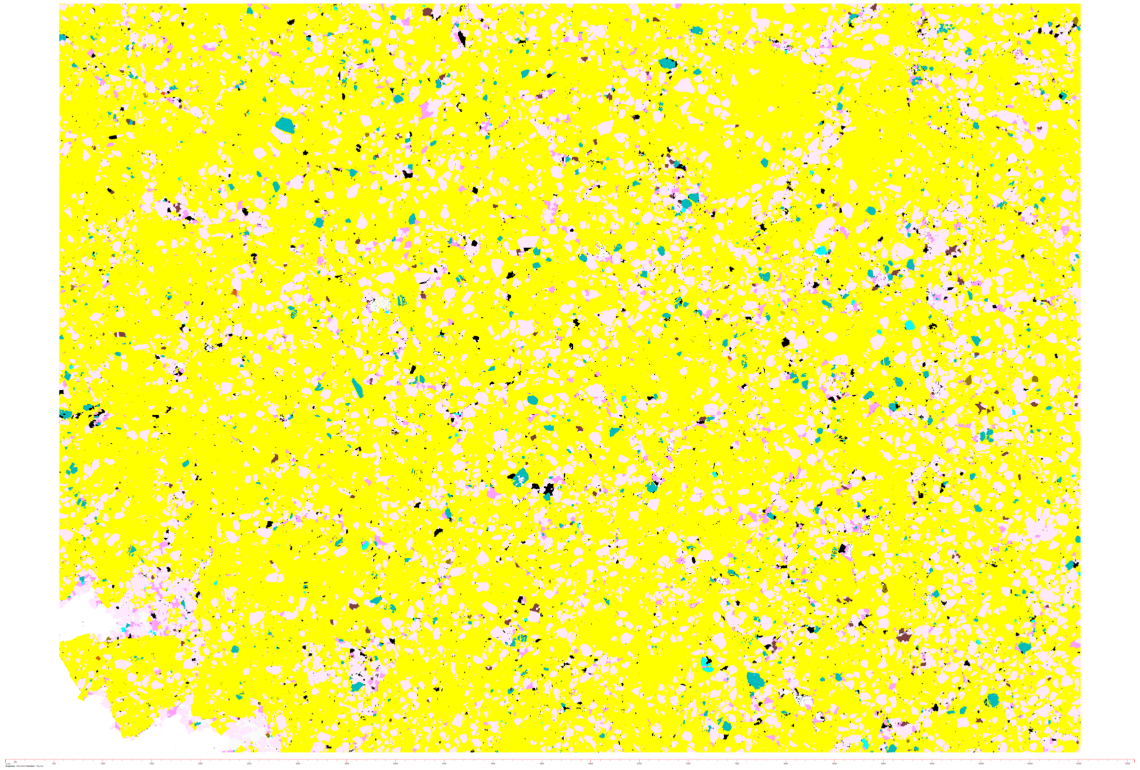
- **Results from previous work at CSM on characterizing the residue from trona leaching was provided.**

**Initial mineralogy results show the presence of small amounts of the rare earth containing minerals apatite, monazite, and zircon in coal basin rock. X-ray diffraction has confirmed the major mineral components.**

**Predominantly quartz and illite/muscovite/kaolinite**



**Predominantly pyrite, quartz, and feldspar**



**Mineralogy performed by Dr. Pfaff, Mineral and Materials Characterization Facility at Mines**

**Novel technology integration in GGRB-WRB resource chains**

- **Potential new/novel technologies will be identified and related to the basinal CORE-CM and waste stream material (e.g. fly ash) characterizations.**
- **This may include novel mining techniques, unconventional resource recovery methods, etc.**
- **Novel technologies will be assessed as cost effective and environmentally friendly alternatives to conventional approaches that may be useful to economic development in the basin.**
- **New and unconventional uses of coal and waste streams (e.g. carbon nano-tubes, carbon films) will be identified and assessed for the commercialization of GGRB-WRB resources.**
- **Initial resource categories have been identified to guide technology groupings similar to those in subtask 5.1. This effort is pending results from Task 2.0 and 3.0.**

**Some near SOTA highlights**

**Pyrolysis**

**Microwave assisted pyrolysis**

**Gasification**

1. **Specialized carbon capture in coordination with gasification**
2. **In situ bio-gasification**

**Solvent Extractions and carbon refinement**

1. **Crystalline carbon made with high temperature treatment and solvent extraction for electrode or nanomaterial carbon**
2. **Microwave assisted amorphous to graphitic carbon conversion**
3. **Carbon-carbon composites**
4. **Carbon fiber derived from coal pitch**
5. **Polymer-coal composites**

**Concentration and separation**

1. **REE recovery from coal ash, coal, coal basin rock, and oil shale**
2. **Bioleaching of coal ore**
3. **Advanced sortation for preliminary separations**

**Infrastructure repurposing**

1. **Retrofitting coal plants for thermal energy storage**
2. **Retrofitting coal plants for small scale nuclear energy reactors**

# Selective hydrothermal extraction of lanthanides

Brent Marshal Goehring, LANL

October 20, 2022

LA-UR-20-21659

# Technical Goals

- Aim for new technology:

1. Avoid investing in extraction of cheap **LREE**, extract **M/HREE** only
   **→increase the value of the intermediate/final product**
2. Exclude extraction and concentration of **U** and **Th** **→ avoid investment in rad remediation**
3. Maximize **environmental friendliness** of the technology

# Method

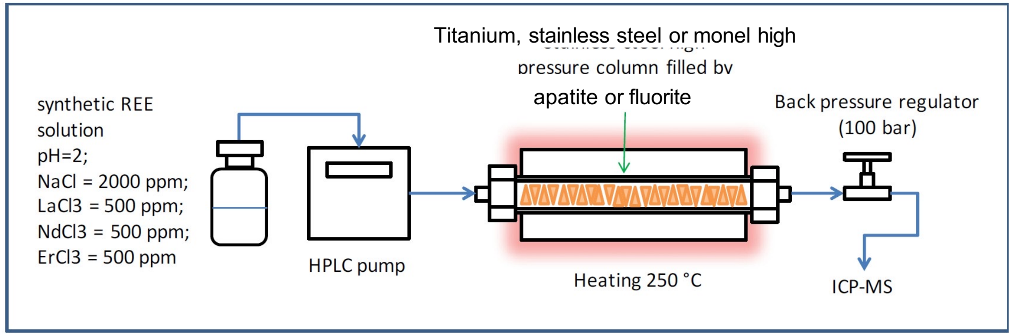
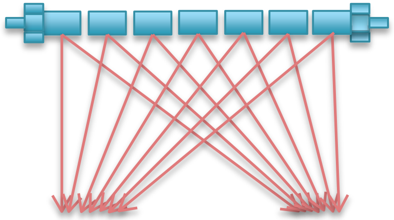


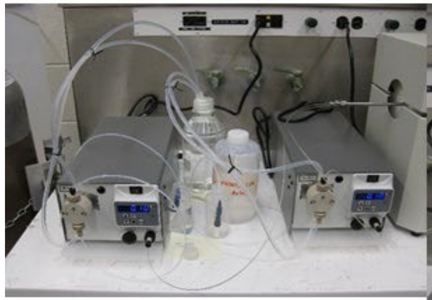

**Figure 2.** Design of the proof-of-concept experiments mimicking extraction and separation mechanisms illustrated in Figure 1.

Post-experiment treatment



XRD; SEM (mineral composition)

XRF (chemical composition)

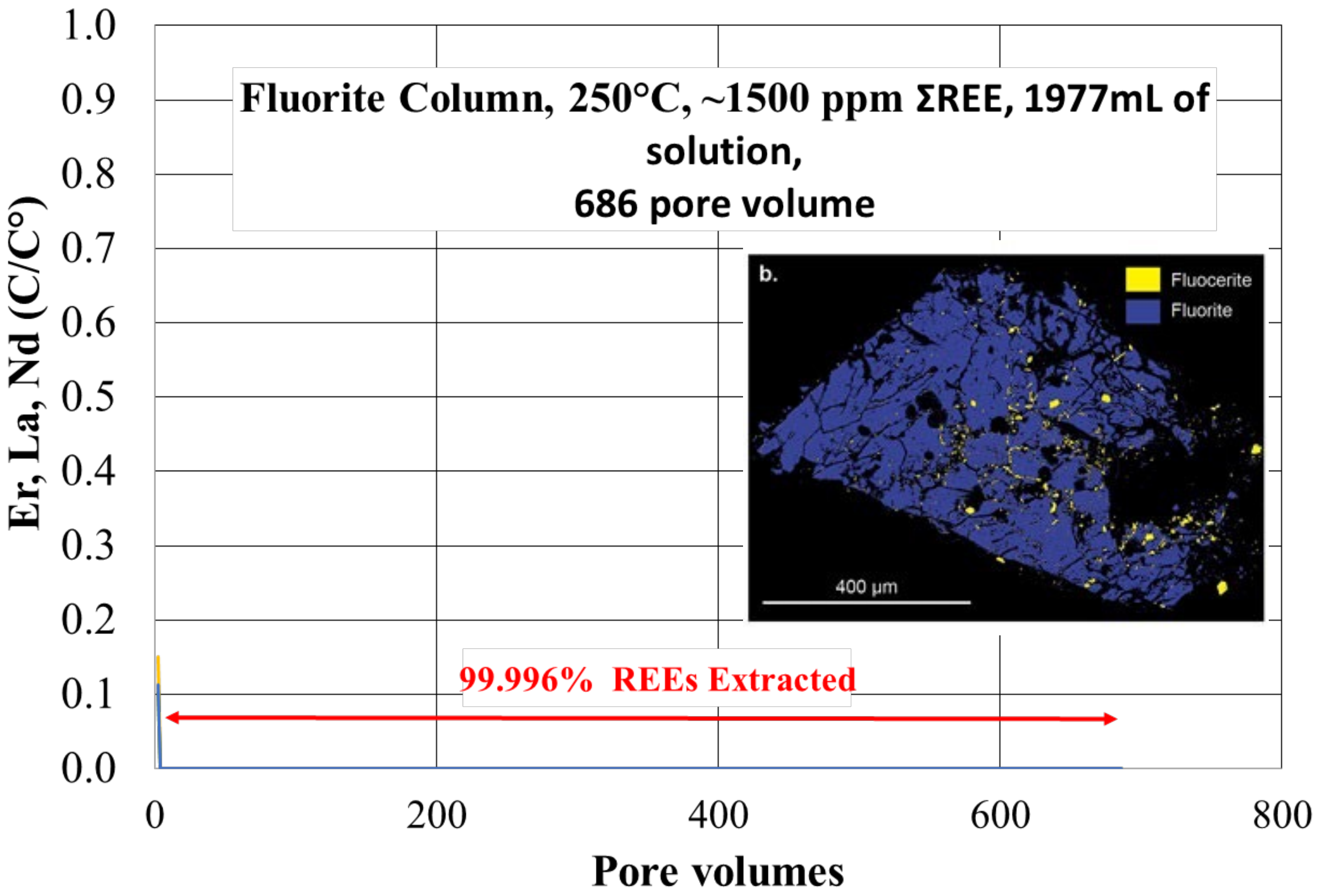


High Pressure Pumps


Oven

Fraction collector

# Fluorite ($CaF_2$) - filled columns



# Conclusions

- Hydrothermal-based technology (with fluorite) extracts from aqueous feedstock M/HREE selectively
- Hydrothermal approach permits to avoid extracting and concentrating U and Th
- The technology is patented (U.S. provisional patent application No. 62/859,428)
- Manuscript published: *Nature Geoscience*
  - Strzelecki, A. C. *et al*. Fluocerite as a precursor to rare earth element fractionation in ore-forming systems. *Nat Geosci* **15**, 327–333 (2022).

# *Mining is a big part of our heritage*

# ***Thank you !!!***


**Conqueror Coal Mine - Missouri 1903**

**My Great Grandpa James Taylor**

**Different is *not always* better, but better is *always* different*.**

***Copied from the Henderson mill blackboard, 2006**

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# Questions?

**GGRB & WRB CORE-CM Annual Forum**
**October 20th , 200**
**Rock Springs, WY**

# Task 6: Technology Innovation Centers

University of Wyoming | School of Energy Resources

# CORE-CM: Carbon Ore, Rare Earth and Critical Minerals Initiative
## Task 6. Technology Innovation Centers

### Overall Goals

- **Primary**: to recover REE's and Critical Materials of specific interest determined by:
  - Supply, Demand & Economic attractiveness.
  - Countering anticipated supply shortages (scarcity)
  - Reducing foreign dependence
- **Secondary**: Manage feedstock residual carbon, in case of carbon-ore.
- **Tertiary**: manage & use remaining mineral matter.

Challenge is where is the value and is it extractable economically!

Targeted Rare Earths*

Cerium
Dysprosium
Erbium
Europium
Gadolinium
Holmium
Lanthanum
Lutetium
Neodymium
Praseodymium
Samarium
Scandium
Terbium
Thulium
Ytterbium
Yttrium

Other Critical Minerals**

aluminum (bauxite)
antimony
arsenic
barite
beryllium
bismuth
cesium
chromium
cobalt
fluorspar
gallium
germanium
graphite (natural)
hafnium
helium
indium
lithium
magnesium
manganese
niobium
platinum group metals
potash
rhenium
rubidium
scandium
strontium
tantalum
tellurium
tin
titanium
tungsten
uranium
vanadium
zirconium

* Per DOE-NETL's Feasibility of Recovering Rare Earth Elements Program
** Additional critical minerals identified in Executive Order 138172

UW School of Energy Resources

# Technology Innovation Centers (TIC"s)
## Guiding Principles & Selection Criteria

### GUIDING PRINCIPLES

- Technology selection offers sustainable advantages.
- Should leverage geographic, geological & resource strengths of the basin.
- Has potential to deliver competitive advantage.
- Addresses (& considers) local water availability & management concerns
- Must have material prospects for growing /diversifying local economic development & job creation.
- Are associated with a degree of novelty & newness.
- Are outwardly techno-economically sound & has positive & deliberate market impact

### SELECTION CRITERIA

- Counters anticipated shortages & reduces foreign dependence for supply.
- Preferentially addressing scarcity challenges that cannot be fulfilled from other sources.
- Reduced carbon emissions & 'waste' compared to the current situation.
- Feedstock availability in sufficient quantity within the PRB to address long term US. projected demand.
- Potential to co-process different source feedstocks.
- Economic viability, job creation prospects together with business & Investors interests.
- Leveraging existing resources, asset capabilities & competencies available within the PRB

# CORE-CM: Carbon Ore, Rare Earth and Critical Minerals Initiative
# Task 6. Technology Innovation Centers

## Different Extraction & Process Options Considered

- Burning
- Synthesis
- Gasifying
- Pyrolyzing
- Flotation
- Solvent Extraction
- Electrochemical
- Bio-leaching
- $H_2$ Production
- etc.

**Preliminary Assessment Of Extraction And Process Options**

1. Clarity and Physical Feasibility → 2. Fit for Purpose → 3. Economic Potential

**1. Clarity and Physical Feasibility**

**1. Burning with CCS (baseline)**
**2. Burning without CCS**
**3. Coal Ash Synthesis**
~~4. Coal Bed Methane~~
~~5. Coal Fires (Geothermal Heat)~~[1]
~~6. "Coal-to-Dirt~~
~~7. "Coal-to-Liquids~~
~~8. "Coal-to-Solids"~~
**9. Fly Ash Synthesis**
**10. Gasification**
**11. H2 Production**
**12. Metals Production**
**13. Pyrolysis**
**14. Solvent Extraction**

**2. Fit for Purpose**

**1. Burning with CCS (baseline)**
~~2. Burning without CCS~~
**3. Coal Ash Synthesis (renamed to Concentration and Separation of Rare Earths from Coal Ash)**
~~4. Coal Bed Methane~~
**5. Fly Ash Synthesis (renamed to Concentration and Separation of Rare Earths from Metal Ore)**
**6. Gasification with H2 Production**
~~7. Gasification for Power without CCS~~[7]
~~8. Metals Production~~
**9. Pyrolysis**
**10. Solvent Extraction**

**3. Economic Potential**

1. **Burning with CCS (baseline)**
2. **Pyrolysis**
3. **Gasification with CCS**[9]
4. **Solvent Extraction + Pyrolysis of Raffinate**
5. **Concentration and Separation of Rare Earths from Coal Ash**
6. **Concentration and Separation of Rare Earths from Metal Ore**

**Down select Justification**

**1st Cut**
- 2. Clarity, overlap
- 4. Emissions, unrepresented low value feedstock
- 5. Clarity, overlap
- 6. Environmental
- 7. Environmental/water
- 8. Insufficient H2 content, economically unattractive

**2nd Cut**
- 2. Out of Scope/not sustainable
- 7. Out of Scope / not sustainable
- 8. Does not address full scope

**3rd Cut**
- 3. High Cost, altitude challenge /relevance.

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# CORE-CM: Carbon Ore, Rare Earth and Critical Minerals Initiative
# Task 6. Technology Innovation Centers

## Preliminary Analysis Has Yielded 5 Pathways for Economic Evaluation

1. Burning with CCS (baseline)
2. Pyrolyzing
3. Solvent Extraction
4. Concentration & Separation from metal ores, including bio-leaching
5. Concentration & Separation from coal ash, including bio-leaching

### Fit for Purpose "Down-Filtering" per Criteria Consistent with CORE-CM Guiding Principles

| | Criterion → | Reducing Foreign Dependency (per EO 13817) | Feed Available | Feed Quality (fit for purpose) | CO2 Emission without CCS | Other Undesirable Waste Products | Fit-for-Purpose Decision |
|---|---|---|---|---|---|---|---|
| | Scale→ | 1=None | 1=None | 1=Unusable | 1=CO2 | 1=Multiple | Yes |
| | Process Name ↓ | 10=Many | 10=Plentiful | 10=Rich | 10=No CO2 | 10=No Wastes | No |
| **Burn** | **Burning without CCS** | 1 | 10 | 5 | 0 | 8 | No |
| | **Burning + CCS** | 3 | 10 | 5 | 5 | 8 | Yes |
| **Use the Coal to Produce Carbonaceous Products** | **Coal Bed Methane** | 2 | 3 | 3 | 2 | 8 | No |
| | **Pyrolysis** | 3 | 10 | 9[i] | 5 | 8[ii] | Yes |
| | **Gasification without CCS** | 5 | 10 | 9 | 2 | 8 | No |
| | **Gasification with CCS** | 5[iii] | 5 | 9[iv] | 4 | 8[v] | Yes |
| | **Solvent Extraction + Pyrolysis of Graphene Oxide, Activated Carbon, Char Bricks and Soil Conditioner from Mined Coal** | 6 | 10 | 9[vi] | 7 | 5[vii] | Yes |
| **Extract the Rare Earths from Ores & Waste Streams** | **Concentration and Separation of Rare Earth from Metal Ores** | 10 | 6[viii] | 4[ix] | 8[x] | 4.5[xi] | Yes |
| | **Concentration and Separation of Rare Earths From Coal Ash** | 10 | 10[xii] | 4[xiii] | 8[xiv] | 6[xv] | Yes |

Source: Boston Strategies International

NOTES:
[i]Quality varies by type (bituminous, etc.) and some may have oxygen in it while others don't.
[ii] Coke
[iii] One of the gasification routes could be used to produce hydrogen.
[iv] Quality varies by type (bituminous, etc.) and some may have oxygen in it while others don't.
[v] Produces an ash residual.
[vi] Quality varies by type (bituminous, etc.) and some may have oxygen in it while others don't.
[vii] Can vary from 1-10. Asphalt concentration is a very good use of the concentrate. Depends whether you further process the raffinate or not, and what residual there is.
[viii] Ores are scattered and at various concentrations.
[ix] Starting with a target of rare earths one would normally target a richer mineral resource than coal.
[x] Involves furnaces and burning.
[xi] Could be 2-7 depending on potential for bioleaching. You still have the residual from the ore. See The Future of More Sustainable Rare Earth Mining and other journal articles.
[xii] 100 years of ash is already there and coal ash ponds need to be treated anyway for environmental reasons.
[xiii] Starting with a target of rare earths one would normally target a richer mineral resource than coal.
[xiv] Involves furnaces and burning.
[xv] Could be 5-7 depending on bioleaching. Still left with coal ash, even after processing.

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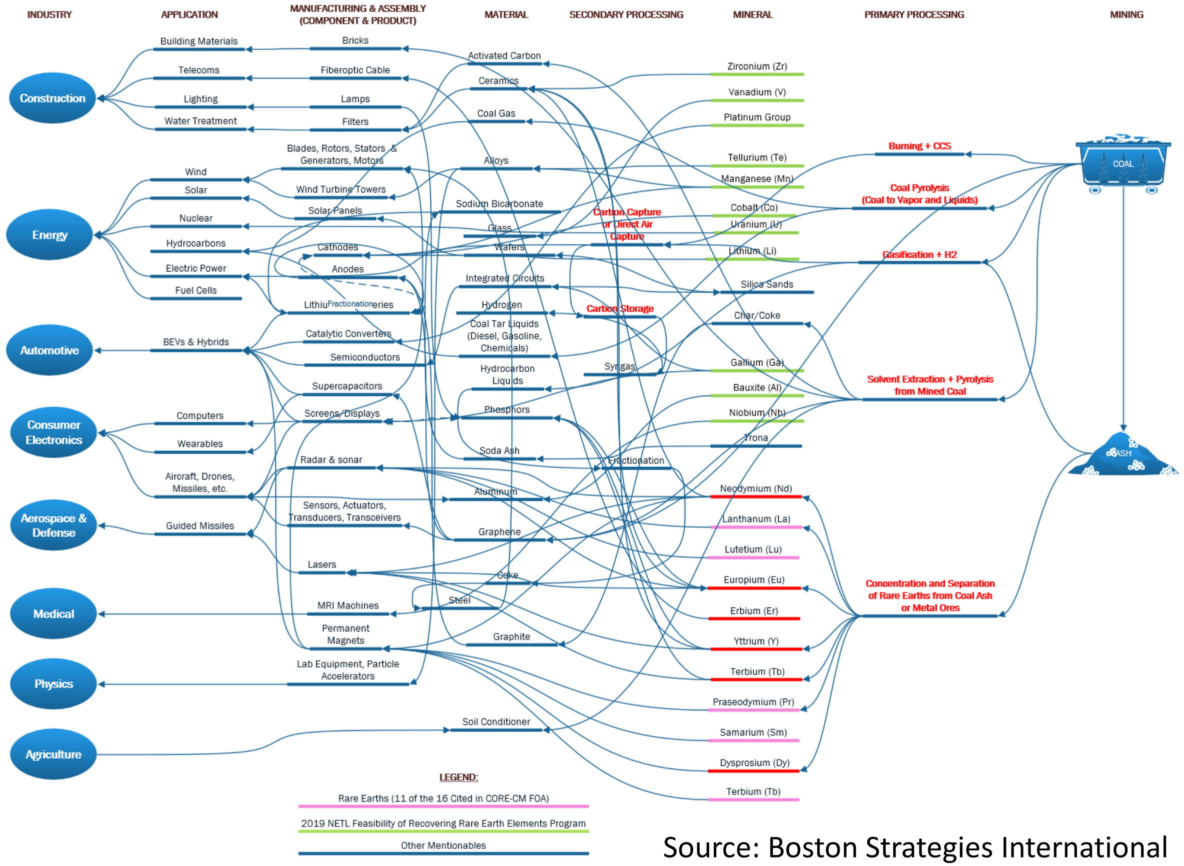
# CORE-CM: Carbon Ore, Rare Earth and Critical Minerals Initiative
# Task 6. Technology Innovation Centers

## Potential Supply Chain Pathways to Be Analyzed Versus Project Goals

### Preliminary Economic Evaluation (work in Progress)

- **End-market Size** (societal and economic impact)
- **Local Capital Expenditure** (near-term job creation & local spending)
- **Labor Intensity** (long-term job creation)
- **Local Operating Expenditure** (business growth potential & tax revenues)
- **$CO_2$ Footprint** (environment & health impact)
- **Sales Per-head** (knowledge intensity)

### Value Chains for Economic Analysis (Jobs, etc.)




Source: Boston Strategies International

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# CORE-CM: Carbon Ore, Rare Earth and Critical Minerals Initiative
## Value Chain Analysis Architecture

- 42 unique potential value chains based on permutations of process routes & end-markets
- Considering extension to include hybrid routes (secondary processing and by/co-products eg carbon products, mineral products)

| # | Primary Process | Primary Process Shorthand | Feed Mineral | Secondary Process | Product | Application | Process Route Description | End Use |
|---|---|---|---|---|---|---|---|---|
| 0 | Burning without CCS (Baseline) | Baseline | Coal | None | Coal | Electric Power | Baseline-Coal for Electric Power | Electric Power |
| 1 | Burning + CCS | Burn+CSS | Coal | CCS | Coal | Electric Power | Burn+CSS-Coal for Electric Power | Electric Power |
| 2 | Oxy Fuel Combustion + CCS | Oxy+CSS | Coal | CCS | Coal | Electric Power | Oxy+CSS-Coal for Electric Power | Electric Power |
| 3 | Pyrolysis | Pyrolysis | Coal | Fractionation | Coal-equivalent | Diesel | Pyrolysis-Coal for Diesel | Hydrocarbons |
| 4 | Pyrolysis | Pyrolysis | Coal | Fractionation | Coal-equivalent | Gasoline | Pyrolysis-Coal for Gasoline | Hydrocarbons |
| 5 | Gasification+CCS | Gasification | Coal | Fischer Tropsch | Coal-equivalent | Gasoline | Gasification-Coal for Gasoline | Hydrocarbons |
| 6 | Gasification+CCS | Gasification | Coal | Fischer Tropsch | Coal-equivalent | Jet Fuel | Gasification-Coal for Jet Fuel | Hydrocarbons |
| 7 | Gasification+CCS | Gasification | Coal | Fischer Tropsch | Coal-equivalent | Diesel | Gasification-Coal for Diesel | Hydrocarbons |
| 8 | Gasification+CCS | Gasification | Coal | Turbo generator | Coal-equivalent | Electric Power | Gasification-Coal for Electric Power | Power |
| 9 | Solvent Extraction & Pyrolysis of Raffinate | Solvent Extraction | Coal | Fractionation/Sepn | Coal-equivalent | Asphalt | Solvent Extraction-Coal for Asphalt | |
| 10 | Solvent Extraction & Pyrolysis of Raffinate | Solvent Extraction | Coal | Fractionation/Sepn | Coal-equivalent | Resin | Solvent Extraction-Coal for Resin | |
| 11 | Solvent Extraction & Pyrolysis of Raffinate | Solvent Extraction | Coal | Raff Pyrolisis | Coal-equivalent | Graphene Oxide | Solvent Extraction-Coal for Graphene Oxide | Sensors, Actuators, Transducers, Transceivers, Supercapacitors, Anodes |
| 12 | Solvent Extraction & Pyrolysis of Raffinate | Solvent Extraction | Coal | Raff Pyrolisis | Coal-equivalent | Activated Carbon | Solvent Extraction-Coal for Activated Carbon | Water Treatment |
| 13 | Solvent Extraction & Pyrolysis of Raffinate | Solvent Extraction | Coal | Raff Pyrolisis | Coal-equivalent | Char Bricks | Solvent Extraction-Coal for Char Bricks | Construction |
| 14 | Solvent Extraction & Pyrolysis of Raffinate | Solvent Extraction | Coal | Raff Pyrolisis | Coal-equivalent | Soil Conditioner | Solvent Extraction-Coal for Soil Conditioner | Fertilizer |
| 15 | REE from Coal Ash | RE from Ash | Coal Ash | Acid Digestion, Solvent Ex | REE from Coal Ash - All RE | All Applications | RE from Ash-Coal Ash for All Applications | |
| | RE Metal Processing from Rare Earth Ores | RE Processing | RE Ore | Individual Metal Sepn | REE from Ore - All REE | All Applications | RE Processing-RE Ore for All Applications | |
| 16 | RE Metal Processing from Rare Earth Ores | RE Processing | RE Ore | Individual Metal Sepn | Neodymium (Nd) | Permanent Magnets | Neodymium (Nd) for Permanent Magnets | Blades, Rotors, Stators & Generators, Motors, Computer Hard Drive, Microphones and Speakers, Magnetic Refrigeration |
| 17 | RE Metal Processing from Rare Earth Ores | RE Processing | RE Ore | Individual Metal Sepn | Neodymium (Nd) | Glass and Polishing, Ce | Neodymium (Nd) for Glass and Polishing, Ceramics | Polishing Compound, Pigment and Coating, UV Resistant Glass, X-Ray Imaging, Capacitors, Sensors, Colorants, Scintillator, Refractories |
| 18 | RE Metal Processing from Rare Earth Ores | RE Processing | RE Ore | Individual Metal Sepn | Neodymium (Nd) | Catalysts | Neodymium (Nd) for Catalysts | Petroleum Refining, Catalytic Converter, Fuel additive, Chemical Processing, Air Pollution Control |
| 19 | RE Metal Processing from Rare Earth Ores | RE Processing | RE Ore | Individual Metal Sepn | Neodymium (Nd) | Phosphors, Metal Alloy | Neodymium (Nd) for Phosphors, Metal Alloys | Radar & Sonar, Laser, X-Ray Imaging, Optical Sensors, Fibre Optics, NimH Batteries, Fuel Cells, Steel, Super Alloy, Aluminum/Magnesium |
| 20 | RE Metal Processing from Rare Earth Ores | RE Processing | RE Ore | Individual Metal Sepn | Cerium (Ce) | Glass and Polishing | Cerium (Ce) for Glass and Polishing | Polishing Compound, Pigment and Coating, UV Resistant Glass, X-Ray Imaging |
| 21 | RE Metal Processing from Rare Earth Ores | RE Processing | RE Ore | Individual Metal Sepn | Cerium (Ce) | Ceramics, Phosphors | Cerium (Ce) for Ceramics, Phosphors | Capacitors, Sensors, Colorants, Scintillator, Refractories, Radar & Sonar, Laser, X-Ray Imaging, Optical Sensors, Fibre Optics |
| 22 | RE Metal Processing from Rare Earth Ores | RE Processing | RE Ore | Individual Metal Sepn | Cerium (Ce) | Catalysts | Cerium (Ce) for Catalysts | Petroleum Refining, Catalytic Converter, Fuel additive, Chemical Processing, Air Pollution Control |
| 23 | RE Metal Processing from Rare Earth Ores | RE Processing | RE Ore | Individual Metal Sepn | Cerium (Ce) | Metal Alloys | Cerium (Ce) for Metal Alloys | NimH Batteries, Fuel Cells, Steel, Super Alloy, Aluminum/Magnesium |
| 24 | RE Metal Processing from Rare Earth Ores | RE Processing | RE Ore | Individual Metal Sepn | Lanthanum (La) | Glass and Polishing, Ce | Lanthanum (La) for Glass and Polishing, Ceramics | Polishing Compound, Pigment and Coating, UV Resistant Glass, X-Ray Imaging, Capacitors, Sensors, Colorants, Scintillator, Refractories |
| 25 | RE Metal Processing from Rare Earth Ores | RE Processing | RE Ore | Individual Metal Sepn | Lanthanum (La) | Catalysts | Lanthanum (La) for Catalysts | Petroleum Refining, Catalytic Converter, Fuel additive, Chemical Processing, Air Pollution Control |
| 26 | RE Metal Processing from Rare Earth Ores | RE Processing | RE Ore | Individual Metal Sepn | Lanthanum (La) | Metal Alloys | Lanthanum (La) for Metal Alloys | NimH Batteries, Fuel Cells, Steel, Super Alloy, Aluminum/Magnesium |
| 27 | RE Metal Processing from Rare Earth Ores | RE Processing | RE Ore | Individual Metal Sepn | Terbium (Tb) | Permanent Magnets | Terbium (Tb) for Permanent Magnets | Blades, Rotors, Stators & Generators, Motors, Computer Hard Drive, Microphones and Speakers, Magnetic Refrigeration |
| 28 | RE Metal Processing from Rare Earth Ores | RE Processing | RE Ore | Individual Metal Sepn | Terbium (Tb) | Phosphors | Terbium (Tb) for Phosphors | Radar & Sonar, Laser, X-Ray Imaging, Optical Sensors, Fibre Optics |
| 29 | RE Metal Processing from Rare Earth Ores | RE Processing | RE Ore | Individual Metal Sepn | Europium (Eu) | Ceramics | Europium (Eu) for Ceramics | Capacitors, Sensors, Colorants, Scintillator, Refractories |
| 30 | RE Metal Processing from Rare Earth Ores | RE Processing | RE Ore | Individual Metal Sepn | Europium (Eu) | Phosphors | Europium (Eu) for Phosphors | Radar & Sonar, Laser, X-Ray Imaging, Optical Sensors, Fibre Optics |
| 31 | RE Metal Processing from Rare Earth Ores | RE Processing | RE Ore | Individual Metal Sepn | Erbium (Er) | Glass and Polishing | Erbium (Er) for Glass and Polishing | Polishing Compound, Pigment and Coating, UV Resistant Glass, X-Ray Imaging |
| 32 | RE Metal Processing from Rare Earth Ores | RE Processing | RE Ore | Individual Metal Sepn | Erbium (Er) | Phosphors | Erbium (Er) for Phosphors | Radar & Sonar, Laser, X-Ray Imaging, Optical Sensors, Fibre Optics |
| 33 | RE Metal Processing from Rare Earth Ores | RE Processing | RE Ore | Individual Metal Sepn | Yttrium (Y) | Ceramics | Yttrium (Y) for Ceramics | Capacitors, Sensors, Colorants, Scintillator, Refractories |
| 34 | RE Metal Processing from Rare Earth Ores | RE Processing | RE Ore | Individual Metal Sepn | Yttrium (Y) | Phosphors | Yttrium (Y) for Phosphors | Radar & Sonar, Laser, X-Ray Imaging, Optical Sensors, Fibre Optics |
| 35 | RE Metal Processing from Rare Earth Ores | RE Processing | RE Ore | Individual Metal Sepn | Yttrium (Y) | Metal Alloys | Yttrium (Y) for Metal Alloys | NimH Batteries, Fuel Cells, Steel, Super Alloy, Aluminum/Magnesium |
| 36 | RE Metal Processing from Rare Earth Ores | RE Processing | RE Ore | Individual Metal Sepn | Praseodymium (Pr) | Permanent Magnets | Praseodymium (Pr) for Permanent Magnets | Blades, Rotors, Stators & Generators, Motors, Computer Hard Drive, Microphones and Speakers, Magnetic Refrigeration |
| 37 | RE Metal Processing from Rare Earth Ores | RE Processing | RE Ore | Individual Metal Sepn | Praseodymium (Pr) | Glass and Polishing, Ce | Praseodymium (Pr) for Glass and Polishing, Ceramics | Polishing Compound, Pigment and Coating, UV Resistant Glass, X-Ray Imaging, Capacitors, Sensors, Colorants, Scintillator, Refractories |
| 38 | RE Metal Processing from Rare Earth Ores | RE Processing | RE Ore | Individual Metal Sepn | Praseodymium (Pr) | Catalysts | Praseodymium (Pr) for Catalysts | Petroleum Refining, Catalytic Converter, Fuel additive, Chemical Processing, Air Pollution Control |
| 39 | RE Metal Processing from Rare Earth Ores | RE Processing | RE Ore | Individual Metal Sepn | Praseodymium (Pr) | Phosphors, Metal Alloy | Praseodymium (Pr) for Phosphors, Metal Alloys | Radar & Sonar, Laser, X-Ray Imaging, Optical Sensors, Fibre Optics, NimH Batteries, Fuel Cells, Steel, Super Alloy, Aluminum/Magnesium |
| 40 | RE Metal Processing from Rare Earth Ores | RE Processing | RE Ore | Individual Metal Sepn | Samarium (Sm) | Permanent Magnets | Samarium (Sm) for Permanent Magnets | Blades, Rotors, Stators & Generators, Motors, Computer Hard Drive, Microphones and Speakers, Magnetic Refrigeration |
| 41 | RE Metal Processing from Rare Earth Ores | RE Processing | RE Ore | Individual Metal Sepn | Dysprosium (Dy) | Permanent Magnets | Dysprosium (Dy) for Permanent Magnets | Blades, Rotors, Stators & Generators, Motors, Computer Hard Drive, Microphones and Speakers, Magnetic Refrigeration |
| 42 | RE Metal Processing from Rare Earth Ores | RE Processing | RE Ore | Individual Metal Sepn | Gadolinium (Gd) | Glass and Polishing, Ce | Gadolinium (Gd) for Glass and Polishing, Ceramics, Phosphors | Polishing Compound, Pigment and Coating, UV Resistant Glass, X-Ray Imaging |

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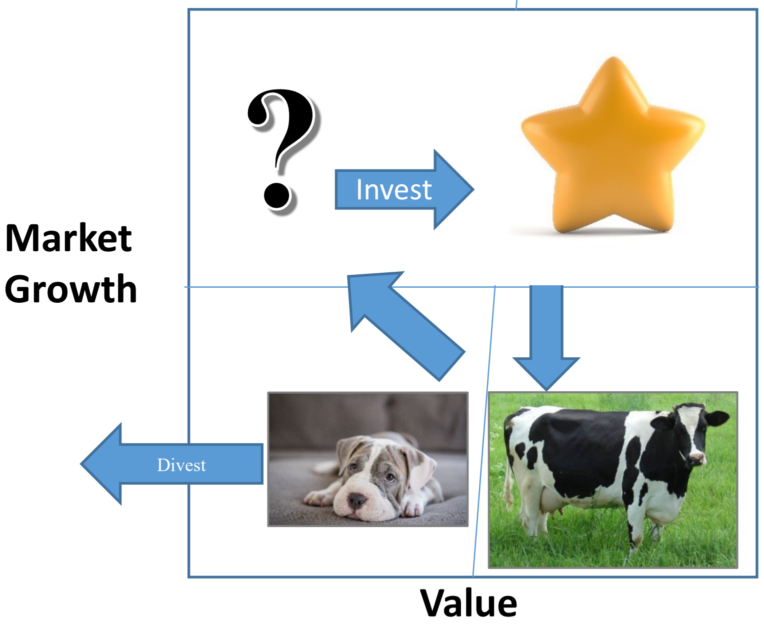
# Task 6. Technology Innovation Centers – Portfolio Management Approach

## Technologies That Best Fit Goals Will Be Prime Innovation Center Investments

**Technology Innovation Cycle**




*Source: Boston Strategies International, after BCG Growth-Share Matrix*

*Cow image from https://medium.com/@PapzitoSA/who-killed-my-fat-cow-e0b81e356da4*

**Likely Components of Technology Innovation Center Investments**

### Strategic Plan

**Research**
- High school curricula
- College programs
- Grad and post-grad offerings
- Research laboratories
- Grants
- Endowments

**Development**
- Patent filing activity
- Demonstration projects
- Education
- Training

**Commercialization**
- Public-private partnerships
- Technical assistance
- Stakeholder outreach
- Technology Transfer

*Source: Boston Strategies International*

**Strategic Priorities Guided by Independent Board**

Siting & location of Technology Innovation Center(s) to leverage existing research strengths & infrastructure.

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# CORE-CM: Carbon Ore, Rare Earth and Critical Minerals Initiative
## Value Chain Evaluation Ranking Matrix

1. US Demand in 2040 (US)
2. Basinal Supply 2040 (US)
3. Capital Expenditure in 2022
4. Payback Period
5. Employment
6. Carbon Footprint
7. Scientific Complexity

### Economic Evaluation Criteria

| Goal | Criterion | Metric | Unit of Measure | Weight |
|---|---|---|---|---|
| Be a player in large and growing markets | US Demand (US) | Total US market sales of each Component used for each Application | Millions of Dollars | 0% |
| Long-run local economic benefit | Basinal Supply (US) | Maximum (capacity-constrained) potential sales of each Component for each Application | Millions of Dollars | 30% |
| Short-run local economic benefit | Capital Expenditure | Total Invested Capital (TIC) | Millions of Dollars | 30% |
| Return on investment | Payback Period | Time to pay back TIC | Years | 10% |
| Indicate local job creation potential | Employment | Jobs | Full-Time Equivalents | 12.5% |
| Minimal environmental externalities | Carbon Footprint | CO2, CH4, N2O | Tons of CO2 Equivalent | 12.5% |
| Intellectual capital growth | Scientific Complexity | 1-10, with 1 being the current coal mining industry and 10 is high-tech "clean room" manufacturing | 1-10 Scale | 5% |

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# Technology Innovation Centers
## Location Considerations

### FOCUS AREAS

- Selective Mining
- Extractive metallurgy
- Recovery Processes
- REE-CM Goods Production

### LEVERAGING EXISTING INFRASTRUCTURE& CAPABILITIES THAT EXIST ACROSS THE BASIN

| | |
|---|---|
| • Coal Mines, CO & WY | (Carbon-ore, Feedstock processing, handling & bulk transport) |
| • Power Plants, CO & WY | (Carbon-ore, utility service supply, energy production & export) |
| • Metals Recycling Cluster, CO | (Processing technologies, metals handing) |
| • Magnet Manufacturers, CO | (Product and Applications Development) |
| • Universities & Colleges, CO & WY | (Existing REE & CM research & development activity) |
| • Private Technical Centers, CO & WY | (REE & CM Technology development, Pilot plant, scale-up & engineering skills) |
| • Opto-photonics industry, CO | (REE & CM user industry with growth aspirations) |
| • Uranium Mines, WY | (Source of REE & CM, expertise in solution mining & above ground processing) |
| • Advanced Manufacturing e.g. biotech | (Seeding new ideas for technology innovation) |

# Technology Innovation Centers

## Some Example Technology Interest Areas Being Investigated.

### In-situ Rare Earth Element (REE) & Critical Minerals (CM's) Extraction

- Wyoming has significant expertise in solution mining uranium.
- Abundant rare earth element (REE) & critical minerals (CM's) are known to exist in shallow seems associated with coal overburden & under burden seams – similar depths to uranium presence.
- Some Key-Challenges to be addressed
  - Geotechnical viability (water aquifer availability & drainage)
  - Selecting solvent(s) to be deployed
  - Effective Implementation strategies e.g. injection & solvent recovery well designs
  - Top side extraction process e.g. thermal, electrochemical, membrane, ion-exchange etc etc

### Organic Acids & Oxidants as Opposed to use of Mineral Acids for REE_CM Recovery

- Evidence that alternative sustainable chemistries may offer more environmentally attractive solutions.
- Formic acid for example, can be produced in-situ from $CO_2$ using electrochemistry, which is provided from in-situ production of hydrogen peroxide.
- Some Key-Challenges to be Addressed
  - Developing strategies to effectively recover REE & CM's of interest (synergistic solvent type selection)
  - Solvent recycling & reuse
  - Potential to adopt bio-technological processes
  - Waste management & conversion into value added co-products (circular economy).

# Technology Innovation Centers

## Next Steps

- Complete value chain analysis of REE-CM resource opportunities and match to market forecasts.

- Continue to refine and develop propositions to guide technology investment based upon criteria and guiding principles.
  - New Proposed technology interest areas welcome!

- Prioritize technology interest areas based upon (to do)
  - Rationalizing the diversity of potential REE-CM containing feedstocks from wide ranging sources (carbon ore, trona, phosphoria, uranium, other mineral wealth) & prirotization of main source interest(s).
  - Actualize existing industries & infrastructure together with economic development impacts
  - Leverage local resource availability, existing capabilities, existing industry & stakeholder interests

- Diversify & grow existing industry clusters
  - Need to Appreciate CO opportunities

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# CORE-CM TASK 7 UPDATE

**Christine Reed**
Director of Outreach
UW School of Energy Resources

Prepared for GGRB-WRB Annual Forum
October 20, 2022

THE WORLD NEEDS MORE COWBOYS.

University of Wyoming | School of Energy Resources

# Task 7 Outreach and Engagement

**GREATER GREEN RIVER AND WIND RIVER BASINS**

WORKFORCE TRAINING & DEVELOPMENT
COMMUNITY ENGAGEMENT
OUTREACH AND  EDUCATION

UNIVERSITY OF WYOMING

School of
Energy Resources

Colorado Northwestern Community College

WESTERN
WYOMING COMMUNITY COLLEGE

# Task 7 Outreach and Engagement

## OBJECTIVES OF CORE-CM OUTREACH

- ✓ **Providing information on the project to the target communities within the identified basins**
- ✓ **Assess existing resources & infrastructure**
- ✓ **Identify gaps in communication and training**
- ✓ **Make recommendations**

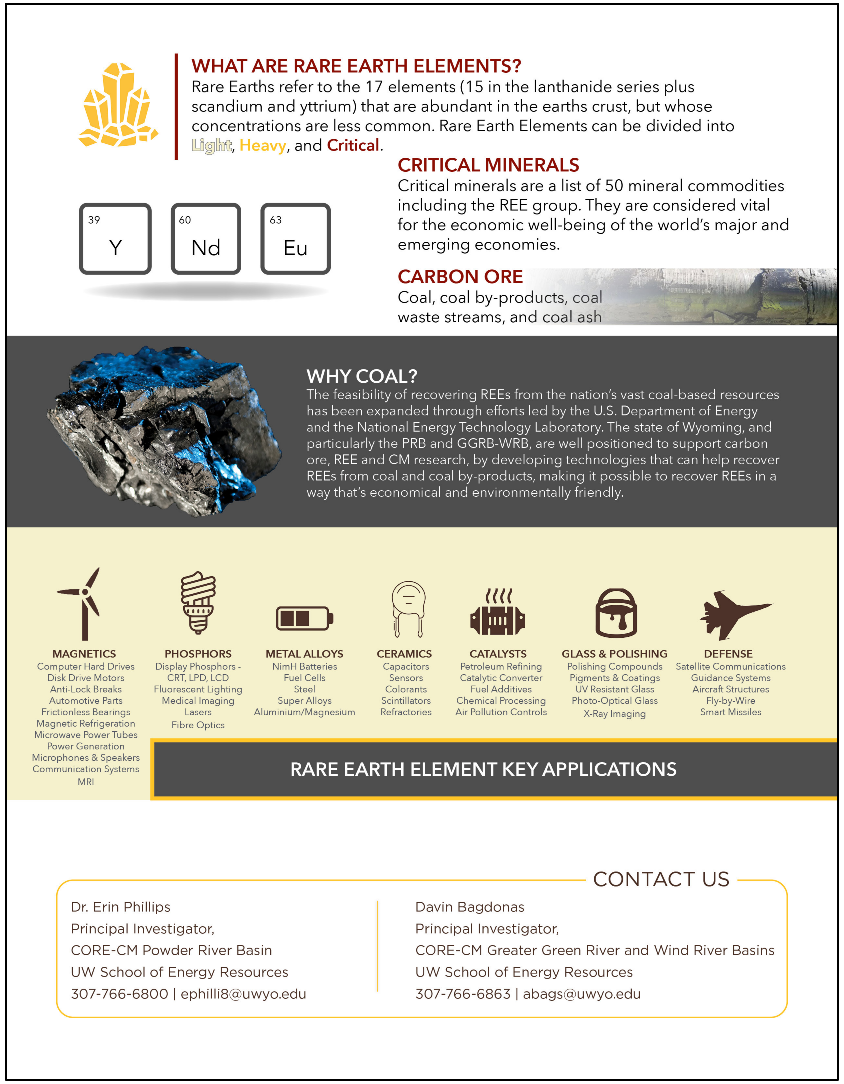
# Task 7 Outreach and Engagement

## ACCOMPLISHMENTS AND CURRENT EFFORTS

- **Website and High-Level Informational Resources**
- **Webinars**

  *The webinar series has covered varying topics related to REE and CM; the webinars are open to the wider community and designed to educate and bring in more stakeholders and interested community members.*
- **Annual Forum**

  *In-person event hosted on-site in the GGRB to provide updates on project task and allow industry partners and stakeholders to connect.*
- **Collaboration with other CORE-CM and DOE Projects**
- **Expanding Contact List**



# Task 7 Outreach and Engagement


- High Level Overview
- Try to bring in different perspectives
  - Federal
  - Academic
  - Policy/Legal
  - Industry
  - Community

# Task 7 Outreach and Engagement


- New topic at the forefront of all energy development

  *U.S. Department of Energy is actively working to implement the Biden administration's Justice40 Initiative, a goal that 40% of the overall benefits from federal investments in climate and clean energy flow to disadvantaged communities.*

- Key Takeaways
  - ✓ avoiding disproportionate impacts
  - ✓ ensuring the equitable distribution of the benefits of new industries
  - ✓ participation for communities in energy sector decision-making and development

- Other Takeaways
  - ✓ Still disagreement over 'who' qualifies as disadvantages populations
  - ✓ Sparked further research for clarity

# Task 7 Outreach and Engagement


- Extremely productive and informative!
- There are a lot of resources throughout the state and at the federal level for workforce training/retraining
  - Community Colleges
  - Funding Opportunities
  - State Organizations
- Other considerations within the community that need to be taken into account
  - Investment in communities and infrastructure outside of the industry matter!

KEY TAKEAWAY

The resources are there! Industry needs to be communicative of their needs so that these organizations can adjust accordingly!

# Task 7 Outreach and Engagement

## OTHER EFFORTS IN COMMUNITY EDUCATION & OUTREACH

**Collecting Data on K-12 Education:**
Compiling a list of resources of existing resources for K-12 education programs to identify gaps and opportunities.

**Tribal Outreach and Engagement:**
Task 7 has connected with Tribal Leadership on the Wind River Reservation to establish channels of communication and learn about their tribal governance system.

Next steps include connecting further with tribal business councils, energy and water committees, and expanding network to include the Crow Nation in the Powder River Basin.

# Task 7 Outreach and Engagement

## MAKERSPACE BADGE

*In a digital age, Task 7 researchers are working to develop a makerspace training badge on Rare Earth Elements. The Makerspace Wyrkshop is open for anyone to gain online credentials for enhanced employment opportunities. Task 7 will provide:*

- Rare Earth Element and Critical Mineral specific training badges
- Interface with employers to make recommendations for other makerspace badges useful in an REE industry
- Promote the platform to connect potential employers with future employees across the REE supply chain

# Task 7 Outreach and Education

## PROJECT NEEDS AT START

**Information:**
What questions are you being asked? What resources can we provide or where can direct attention?

**People:**
Who should we be talking to? How should we best be communicating?

**Infrastructure:**
What currently exists that is applicable?

## PROJECT NEEDS NOW

**Identified Gaps in Policy:**
We still have a lot of questions about what permitting might look like in an REE industry

**Manufacturing:**
With limited manufacturing happening in our region that utilizes REE and CM, an important voice is missing

**Tribal and Community:**
Still work to be done!

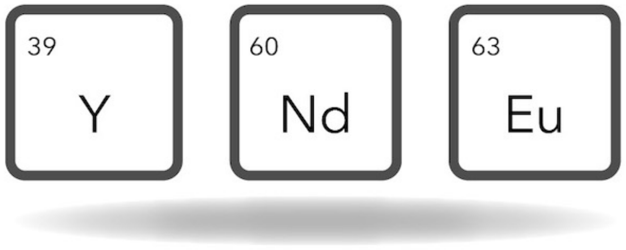
# Task 7 Outreach and Education

## NEXT STEPS

**Task Specific Outreach:**
As our other task leads are progressing in their directives,  how can outreach help?

**Shift Focus to Colorado Side of the Basin:**
Understandably, we have been very focused on Wyoming on the outreach side of things. We are going to start giving more attention to Colorado!

**Address Identified Gaps**
See what we can do to get more information on some of the gaps that have been identified, and make assessments from there.



# CORE-CM TASK 7 UPDATE

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THE WORLD NEEDS MORE COWBOYS.

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