



Critical Materials Institute
AN ENERGY INNOVATION HUB

DOE Critical Material R&D Programs

Thomas Lograsso

Oklahoma Geological Survey Critical Mineral Workshop

November 10, 2021

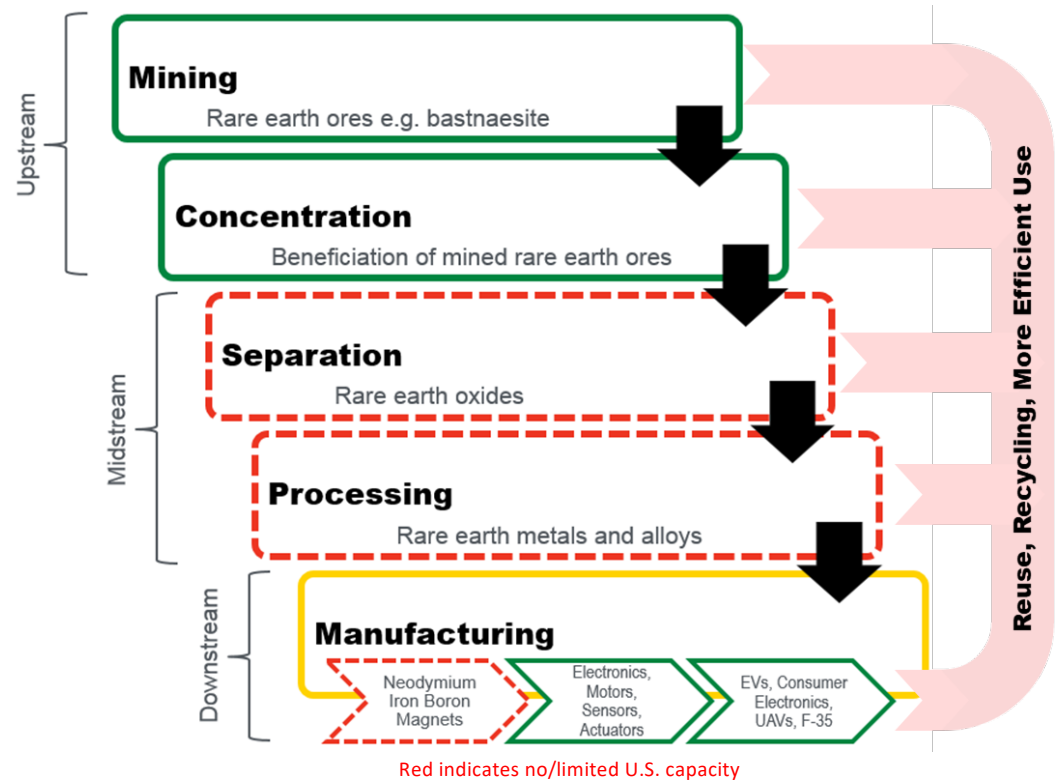


DOE Critical Materials Strategy

To address supply chain risks and build resilient, diverse and secure supply chains, DOE's strategy is based on 3 pillars

1. Diversifying Supply
2. Developing Substitutes
3. Reuse, Recycling & More Efficient Use, including Balanced Coproduction

– all in a safe, sustainable, and environmentally just way

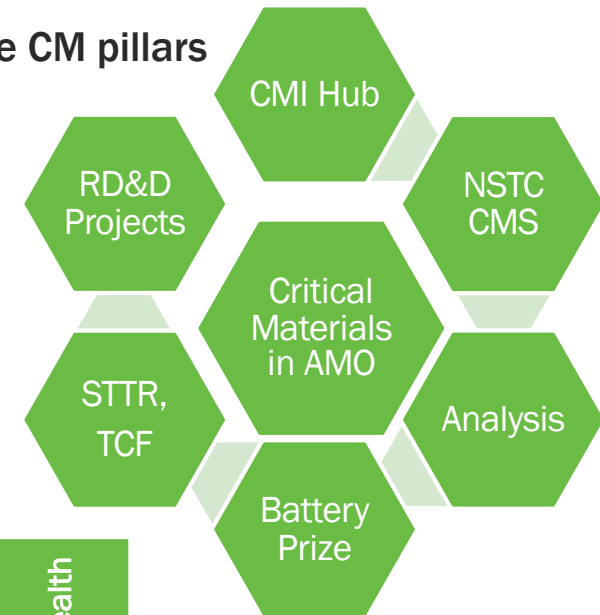


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Advanced Manufacturing Office: Critical Materials RD&D

- AMO's RD&D effort span the entire supply chain and incorporate all three CM pillars
- Critical Materials Institute (CMI Hub), to conduct crosscutting R&D spanning multiple supply chains
- Demonstration of improved industrial technologies to address supply chain gaps and SBIR projects to advance REE recycling
- R&D to advance next-generation technologies, in coordination with the CMI Hub
- Scale-up of lab-proven technologies through STTR, Technology commercialization Fund (TCF)



	Resource Assessment	Mapping	Mining & Concentration	Extraction & Separation	Processing	Refining & Alloying	System Integration	EOL/Waste Management	Analysis	Safety/Health
AMO	X		X	X	X	X	X	X	X	X



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Research, development, and demonstration projects (RD&D)

\$50 million
awarded

15 projects selected

FOUR PROJECTS

to validate and demonstrate
extraction, separation, and
processing technologies (\$44.7M)

ELEVEN PROJECTS

for next-generation extraction,
separation, and processing
technologies (\$5.3M)

Coordination with the Critical Materials Institute

- AMO projects will be expected to coordinate with CMI
- 7 projects partnered with CMI team members: Colorado School of Mines, Ames Lab, LLNL, ORNL
- 3 projects led by or partnered with CMI affiliates

Lithium R&D Virtual Center

- To meet FY20 congressional direction, lithium projects will be expected to meet every six months



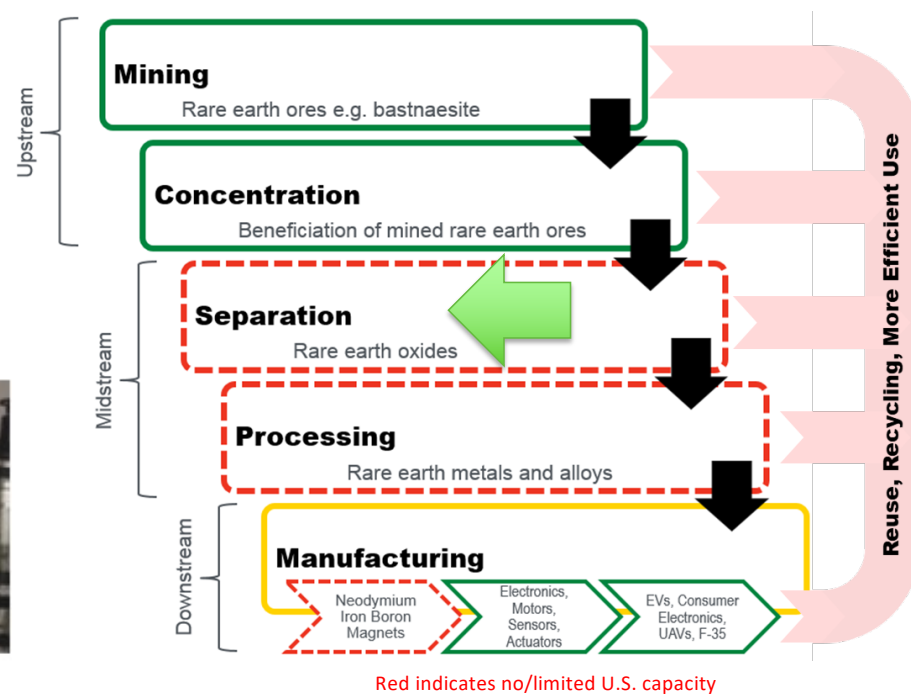
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Demonstration & Pilot Projects

Rare Earth Elements Separation & Processing Demonstration Project

- Demonstration of rare earth oxide separation for magnet manufacturing using novel technology
- Up to 15 tons of >99.5 pure neodymium-praseodymium oxide will be produced



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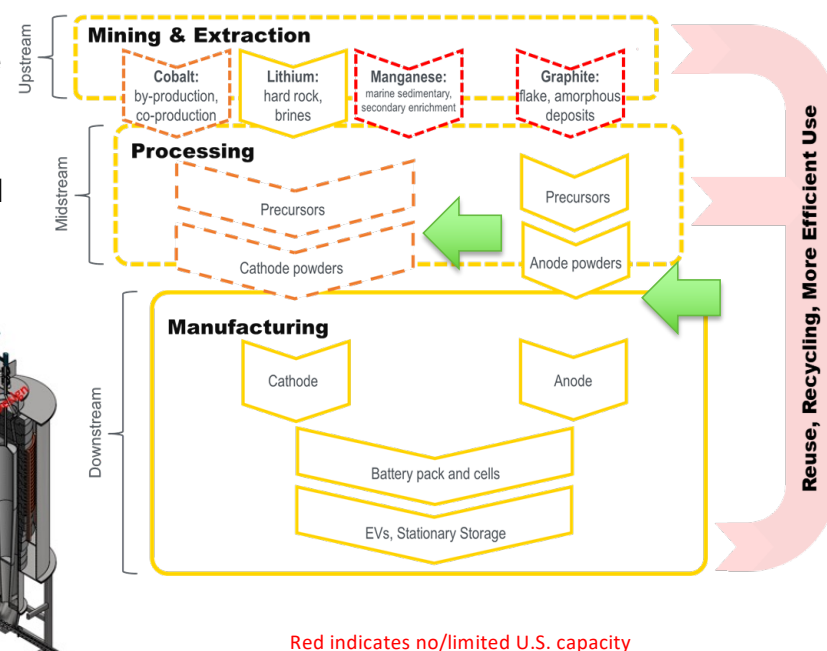
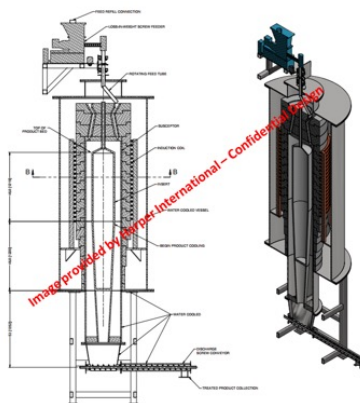
Demonstration & Pilot Projects

Lithium

- **Field Demonstration of Selective Leaching, Targeted Purification, and Electro-Chemical Production of Battery Grade Lithium Hydroxide Precursor from Domestic Claystone Resources**
 - Field validation of first-of-kind integrated set of processing technologies to produce lithium hydroxide from claystone
 - Throughput of ~5 metric tonnes of ore per day
- **Electrolytic Production of Battery-Grade Lithium Hydroxide from Geothermal Brine**
 - Demonstration of battery-grade lithium hydroxide converted from geothermal brines solutions via electrolysis
 - ~25 kg/hr of 99.5% pure lithium hydroxide for EV batteries

Graphite

- **High Efficiency Continuous Graphitization Furnace Technology for Lithium-Ion Battery Synthetic Graphite Material**
 - Pilot validation of first-in-the-world powder continuous induction-based graphitization furnace
 - Up to 200 kg/hr high throughput production of synthetic graphite



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Minerals Sustainability Division



Pillar 1



Resource Characterization & Technology Development

- Characterization for opportunities
- Resource assessment and predictive capabilities
- Web-based platform for integrated database system with AI/ML

Pillar 2



Sustainable Resource Extraction Technology Development

- Transformation, conventional and unconventional extraction technologies
- Integration of industrial beneficiation/concentration methods and technologies
- Remediation of existing sites and abandoned mine residuals

Pillar 3a



Processing, Refining, & Alloying Technology Development

Critical Materials

- Advanced extraction, purification, and reduction technologies through refining and alloying materials
- Enable commercial production through innovations
- First mover and second-generation large-scale pilot projects

Pillar 3b



Processing and Manufacturing Technology Development

Carbon Ore

- Housing and infrastructure development
- Advanced carbon material (carbon fiber, graphene, and nanomaterial) production
- Reinvest in critical (graphite and silicon) supply chains

International Engagements, Standards and Supply Chain Development

Ni, CO, Cr for Superalloys

- Identify co-production sources to meet increased demand in these metals
- Application of innovative processing, refining, and alloying technologies to increase purity from the waste materials

Carbon Ore to Products

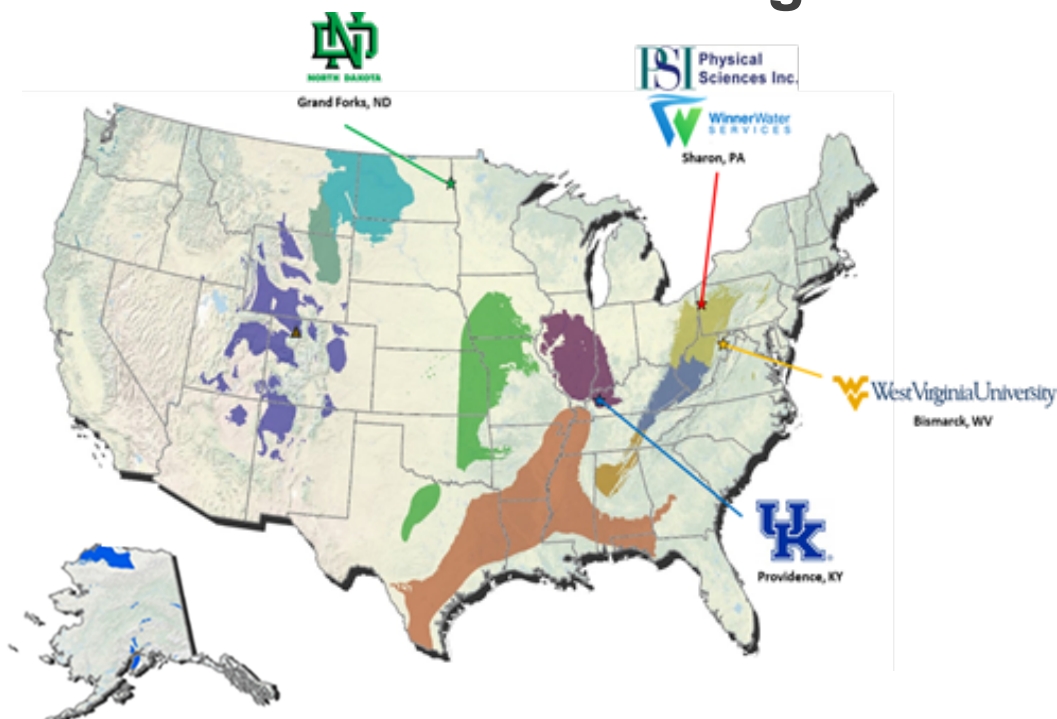
- Assessment and characterization of coal and waste materials
- Environmentally responsible extraction and beneficiation
- Co-production of high purity carbon and critical material products



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Small Scale Pilots: Proving Technical Feasibility



Projects increased purity of MREOs being produced up to 99%

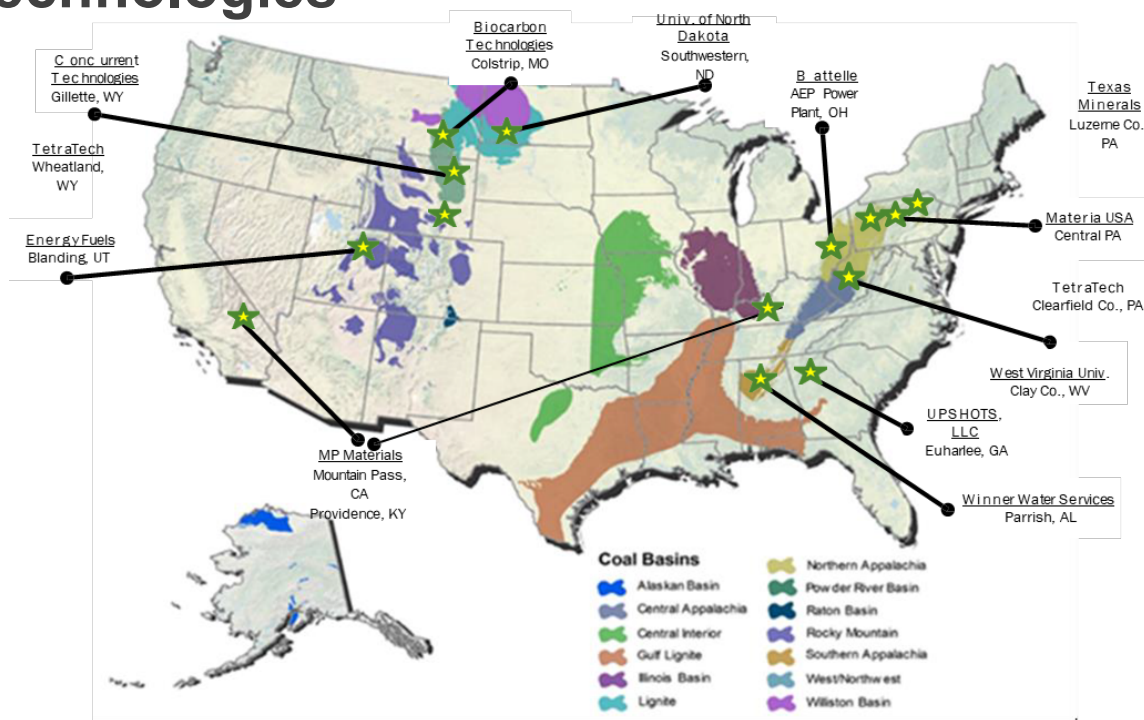
Quantity MREO Produced Annually				
	2018	2019	2020	2021
UKY (Refuse)	0.6 kg	1.5 kg	0.5 kg	Processing Begins in Fall
	80% purity	>90% purity	~98% purity	
WVU (AMD)	44 g		Field Pilot Construction (Facility Start Up January 2022)	
	95 – 99% purity			
PSI (ASH)	0.01 kg MRES	0.149 kg MRES	1.06 kg MRES	1.76 kg MRES
	≤10% purity	≤14% purity	≤67% purity	≤91% purity
	0.004 kg MREO equivalent	0.057 kg MREO equivalent	0.41 kg MREO equivalent	0.67 kg MREO equivalent
UND (Lignite)	5-10 g	500 g	Pilot Construction (Facility Start – Up October 2021)	
		30 -85% purity		
	5 – 15% purity	4000 g		
		4 – 9 % purity		



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Pre-FEED Studies: Toward Transformational Technologies



Initial Potential Byproducts or Coproducts

Alumina, Aluminum hydroxide, Cobalt Oxide, Carbon, Cement Substitute, Ferric Chloride, Gallium, Gasifier slag products, Germanium, Hafnium, Iridium, Iron Oxide, Lithium, Magnetite, Niobium, Pig iron, Quartz, Titanium Oxide, Upgraded Lignite, Uranium, Zirconium, and Zeolite

Option Projects

Contractor	Feedstock	Region of Feedstock
West Virginia University	Acid Mine Drainage	Northern/Central Appalachian Coal and Montana Copper Mine
MP Materials	Refuse Heap Leaching	Kentucky Coarse Mine Refuse and AMD sludge
Energy Fuels	Coal Measures Sediments (Existing mine)	New Mexico
University of North Dakota	Lignite (Existing mine)	North Dakota
Winner Water Services	PCC Fly Ash	Georgia (Plant Gorgas)
Tetra Tech - PA	Appalachian Underclays	Pennsylvania
Texas Minerals	Appalachian (anthracite) Underclays	Pennsylvania (Luzerne County) Jeddo Coal Eckley North
Materia USA	Appalachian Underclays	Pennsylvania (Clearfield County)



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Carbon Ore Processing

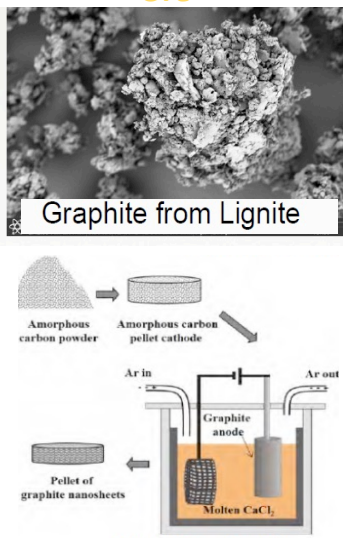


Opportunities toward a clean energy transition -- Advanced processing of carbon ore and associated by-products for the development of everyday and high value carbon products

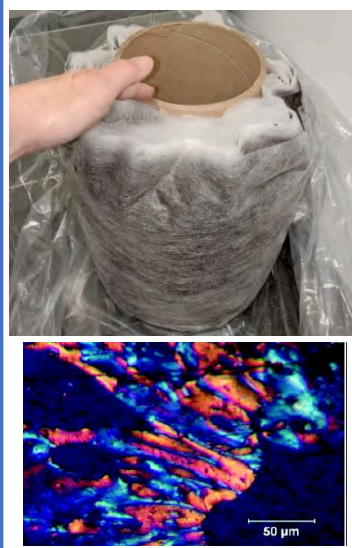
Next-Gen Construction & Infrastructure Materials



Graphite from Carbon Ore



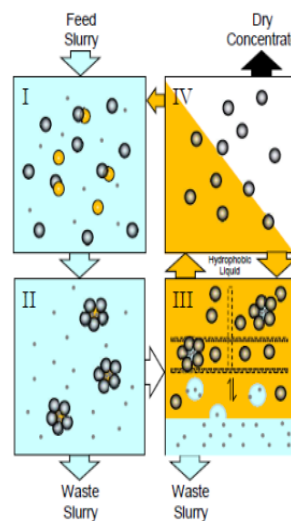
Carbon Fibers from Coal Tar Pitch



Nanomaterials



Waste Recovery



- Generated predominantly from *coal waste and refuse* – toward remediation
- Enable domestic manufacturing of strategic materials to encourage job creation
- Ensure the health and safety of the environment and people around the use and disposal of carbon-based products



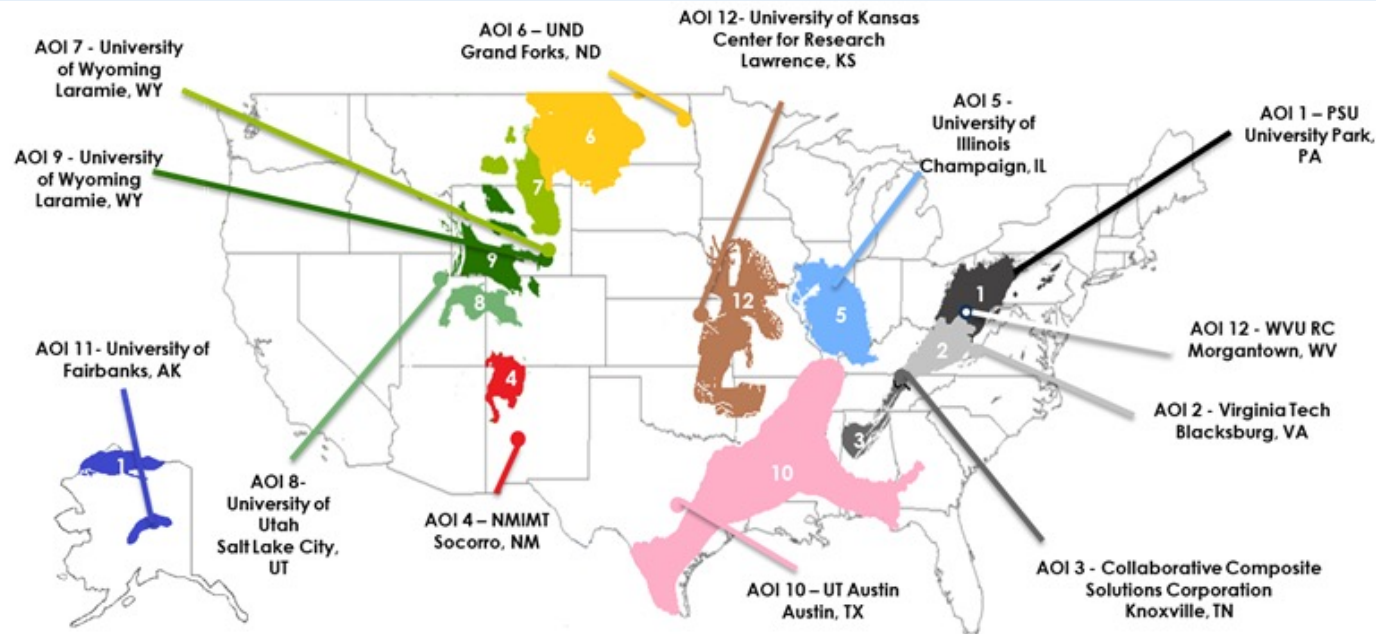
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CORE-CM Regional Challenges



Building coalitions to develop and implement strategies that accelerate and realize the full economic potential of carbon ore and critical minerals across the U.S.



- Address the upstream and midstream CM supply chain and downstream manufacturing of high-value, nonfuel, carbon-based products, ores and critical minerals
- Co-located with economically stressed communities in need of clean energy jobs and will provide the foundation for educating next generation technicians, skilled workers, and STEM professionals.



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Questions!

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Fossil Energy and Carbon Management

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