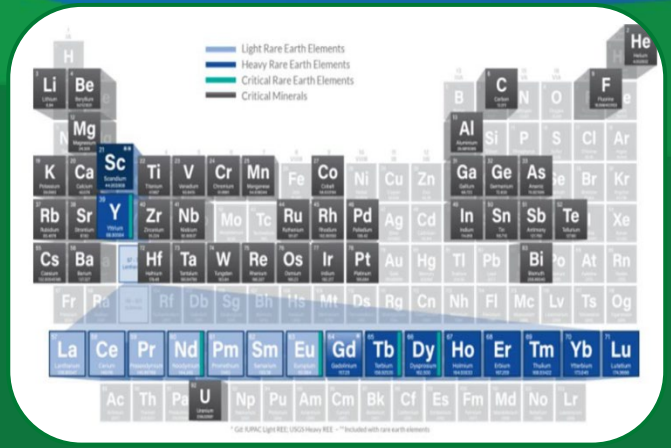
U.S. DEPARTMENT OF ENERGY

Fossil Energy and Carbon Management

Office of Resource Sustainability
Minerals Sustainability

David Alleman

April 2024



HQ Minerals Sustainability Team

DOE HQ

- Grant Bromhal
- Evan Granite
- Mary Anne Alvin
- Gabby Intihar
- Morgan Summers
- Julie Perez (ORISE)
- Layaa Amirthalingam (ORISE)

Minerals Sustainability Division Strategy

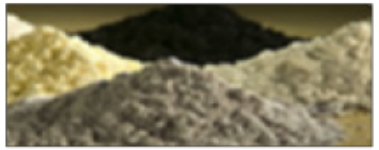
Resource Characterization Technologies

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

Critical Mineral Processing

Beneficiation

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



Processing

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

Carbon Ore Processing

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

Minerals Sustainability Division

Six main areas:

- Carbon Ore Processing
- Critical Minerals Processing
- Resource Assessment Technologies

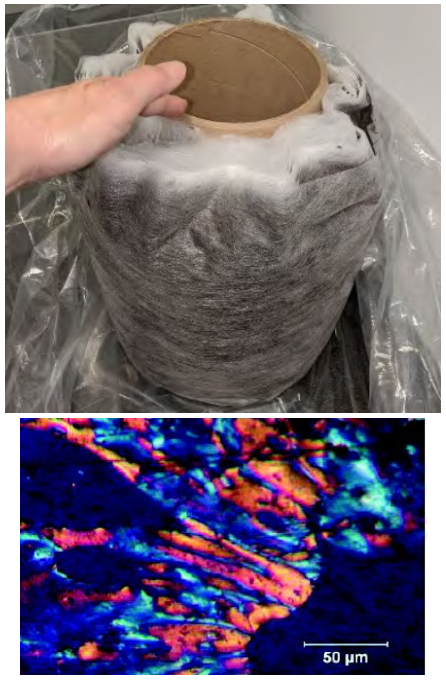
- International Standards
- Mine of the Future
- BIL funding

Carbon Ore Processing

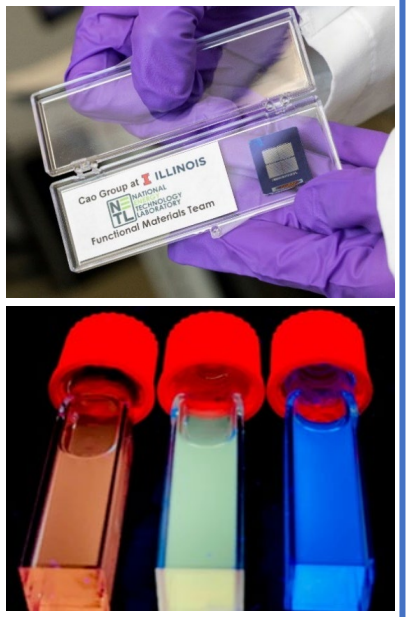
Advanced processing of carbon ore for the development of high value carbon products

Next-Gen Construction & Infrastructure Materials

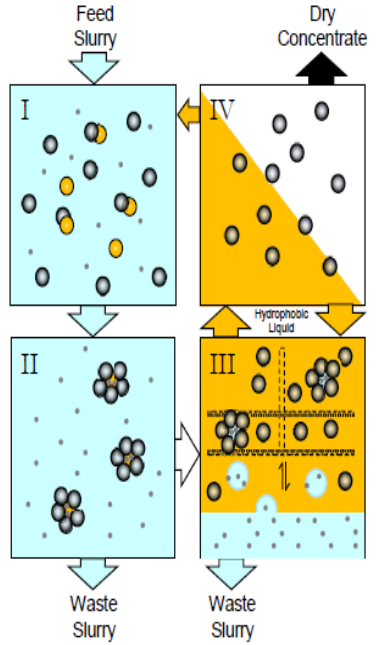
Carbon Fibers from Coal Tar Pitch



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

Critical Minerals Processing Development (2014-2023)

PROSPECTING

PROCESSING

PRODUCTION

Coal Refuse

AMD

Fly Ash

TRL 3-5

2016: FOA-1202
Conventional REE Separation & Recovery – 80-90% Purity

2016: RFP 9067 & 2017: RFP 10982
Field Prospecting

2017: FOA-1718
Transformational Separation

TRL 5-7

2019: 3 First-of-a-Kind Bench & Small Pilot-Scale REE Facilities

2020: FOA-2003
REE System Optimization & Efficiency Improvements – CM Production

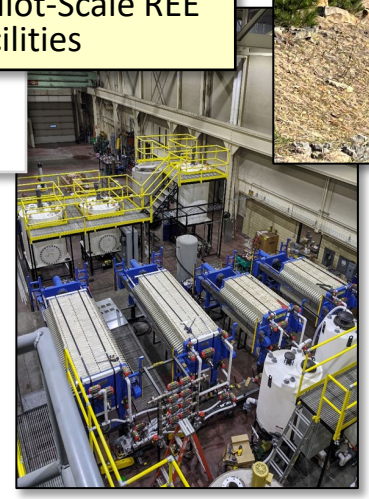
2020 & 2021: RFP
Concept & Feasibility Studies

2021: FOA-2346
CORE-CM Phase 1

2021: FOA-2404
Advanced Processing Phase 1

TRL 5-7

2021 & 2022: 2 Additional First-of-a-Kind Small Pilot-Scale REE & CM Facilities



Lignite

AMD

2023: FOA-2618
REE Demonstration Facility (Phase 1)

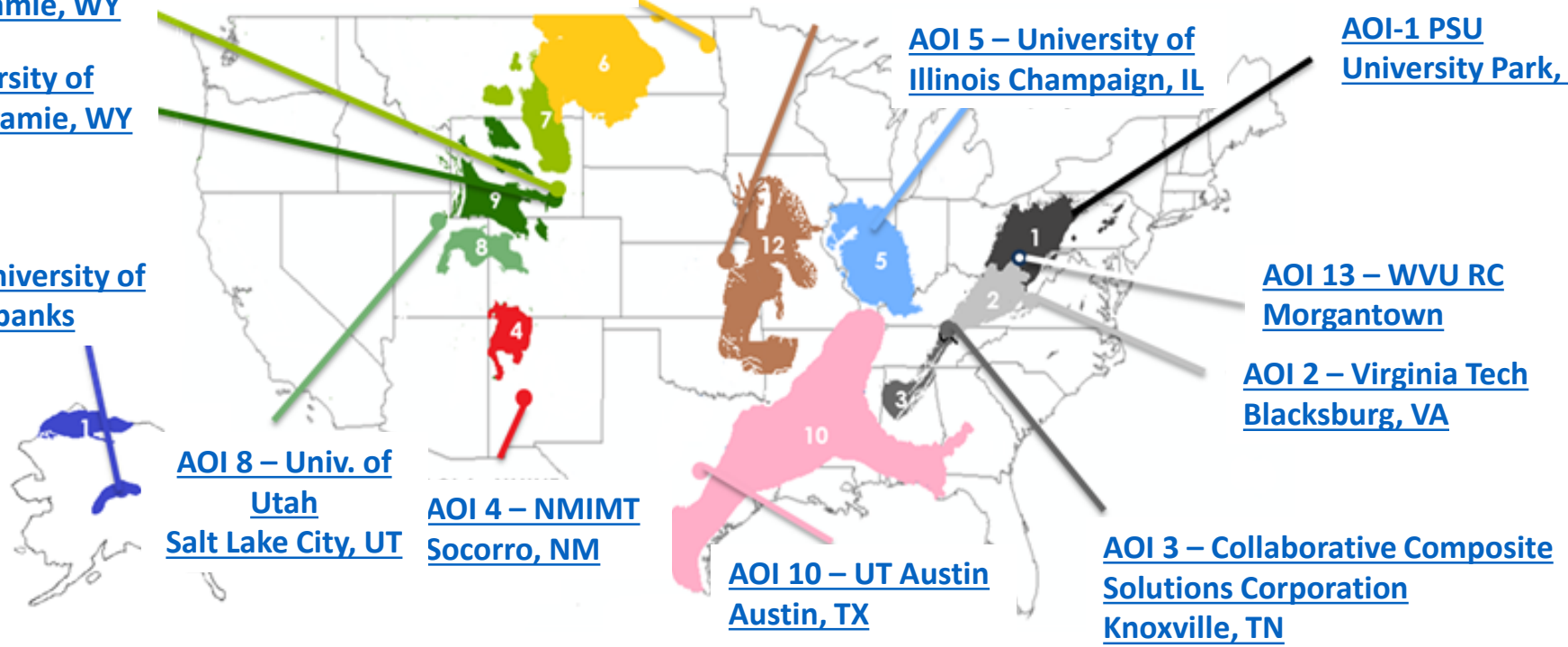
TRL 7-8

2027-2028: First-of-a-Kind REE Demonstration Facility

1,000 tonnes MREO/yr & CMM through Metals Refining

2015 2020 2025

CORE-CM: Developing National Prospectus by Assessing Regional Opportunities



- Build broad-based regional coalition teams, including Tribal Nations, local communities
- Investigate regional resources (materials, facilities, infrastructure, workforce), opportunities, and challenges
- Catalyze regional economic growth and job creation, while addressing legacy waste and environmental justice
- Enable production of REE, CM and high-value, nonfuel, carbon-based products

International Engagement and Standards Development

Responsible stewardship of critical materials is a domestic and international issue requiring high environmental standards across the entire supply chain

DOE engages in ISO efforts to improve sustainability in global critical material supply chains

- ISO TC 298 Rare Earth Elements
  - U.S. proposed developing a sustainability standards for rare earth mining, separation and processing to include environmental, economical and societal impacts
  - Working Group 5 has been established specifically for sustainability, and will be beginning work soon

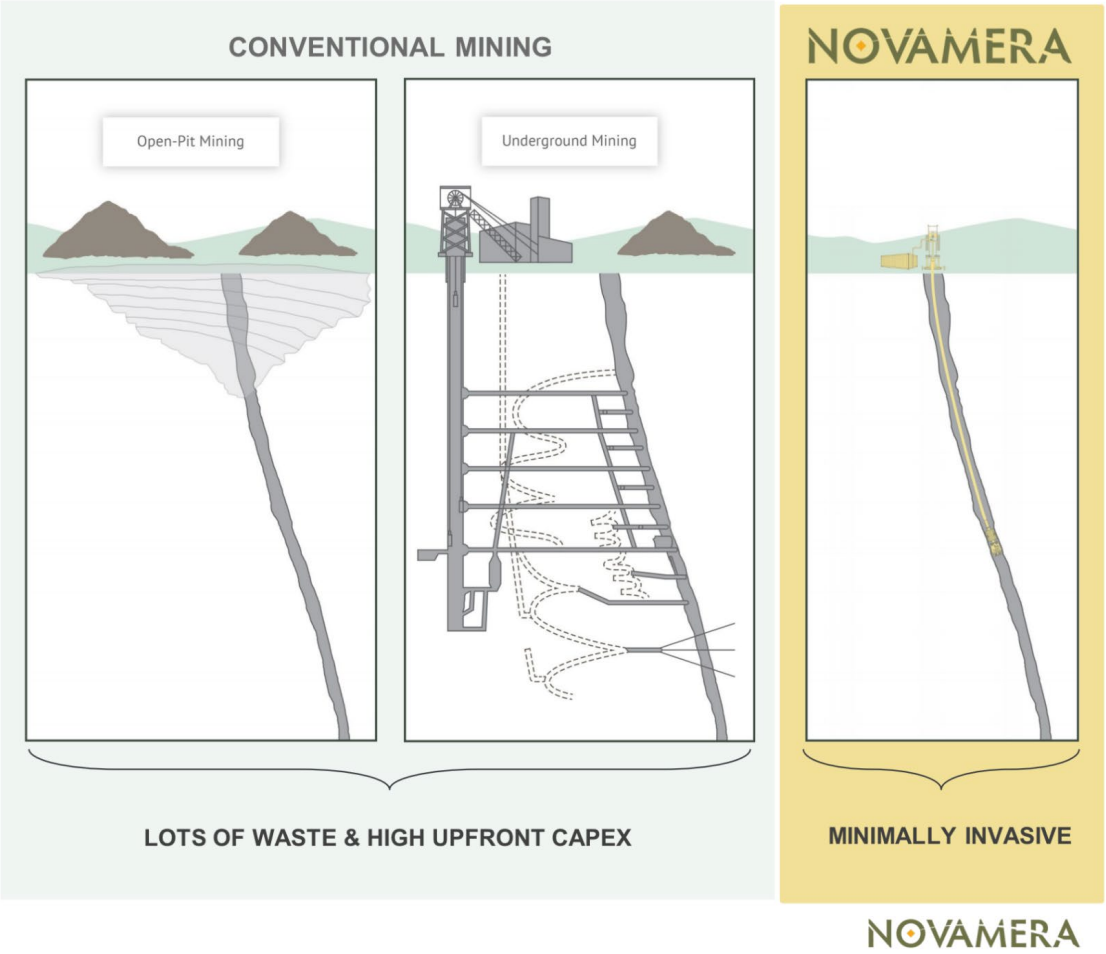
- ISO TC 333 Lithium
  - New technical committee that is still developing strategic business plan, but is meant to include the full supply chain, excluding LIB as end products
  - Sustainability proposal put forth by the U.S. and is currently posted for a 12-week ballot

OSTP NSTC CMS, International Bilaterals/Trilateral interactions are opportunities to coordinate responsible development of supply chains

Advanced Critical Material Recovery

Opportunity to capitalize on recent efforts to revolutionize mining technology

- Take a “laparoscopic” approach
  - No removal of overburden
  - No big hole to be filled
  - No workers underground
  - Minimized impact on water (aquifers, rivers, streams)



MSD-Related BIL provisions

FECM-responsible, Critical Material-related (~$1B)

- 40205 (c) – REE Demonstration Facility
- 41003 (b) – Rare Earth Minerals Security
- 41003 (c) – Critical Material Innovation, Efficiency, and Alternatives
- 41003 (d) – Critical Material Supply Chain Research Facility

Mining-specific (unfunded so far)

- 40210 – Critical Minerals Mining and Recycling Research (nominally $400M)