Evolve CAPP

Evolve Central Appalachia

DE-FE0032055

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ACKNOWLEDGEMENT

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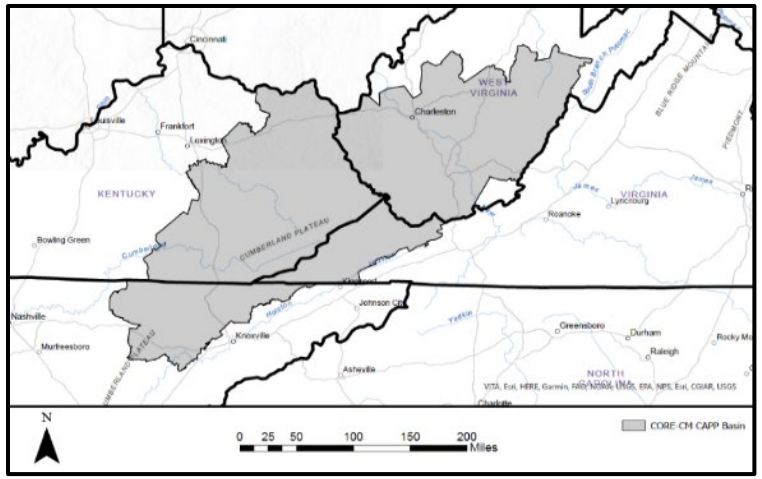
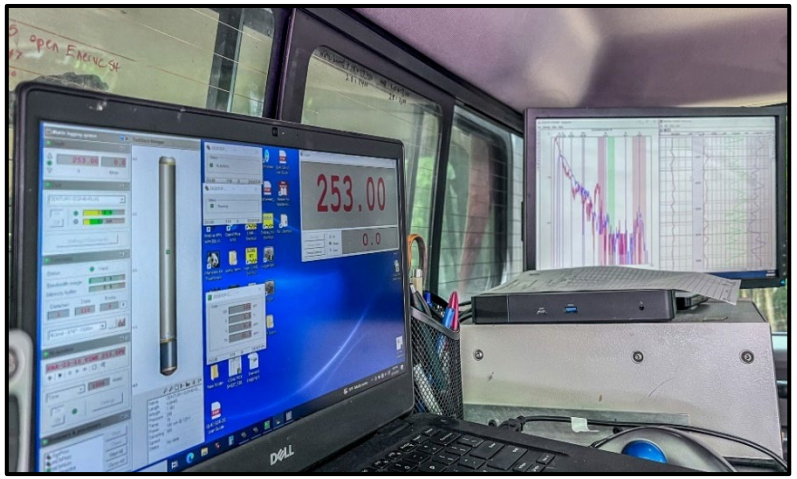
DISCLAIMER

EVOLVE CAPP IS PART OF AN INITIATIVE FOR U.S. COAL BASINS

- *Expanding & transforming the use of coal & coal-based resources to produce Rare Earth Elements (REE), Critical Minerals (CM) & novel high-value, nonfuel, Carbon-Based Products (CBP), as part of our next generation of domestic U.S. materials*
- *Enable the U.S. to reduce dependency on REE & CM imports & advance new industry*
- *Education & training for technicians, middle-skills workers & STEM professionals*





BACKGROUND – CRITICAL MINERALS

- USGS 2022 Critical Minerals Report includes 50 Mineral Commodities
- Classification based on share of import & countries of origin
- World Bank estimated that "energy critical minerals" (Lithium, Cobalt) **need to increase by 500% by 2050!**

https://www.worldbank.org/en/topic/extractiveindustries/brief/climate-smart-mining-minerals-for-climate-action

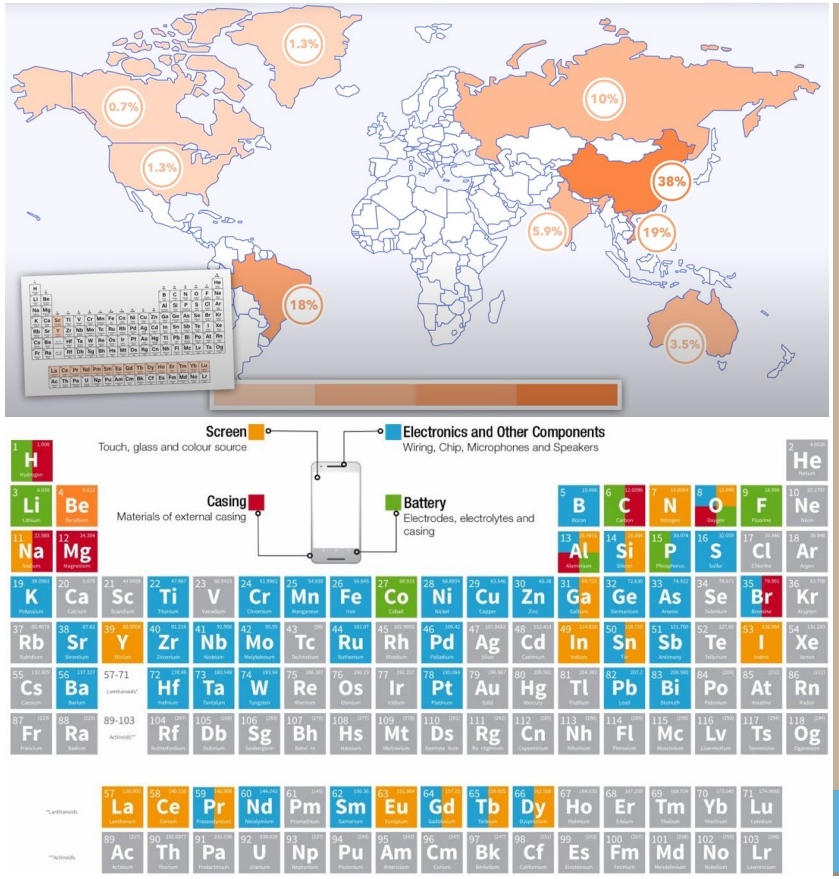
Criticality Usually Includes:

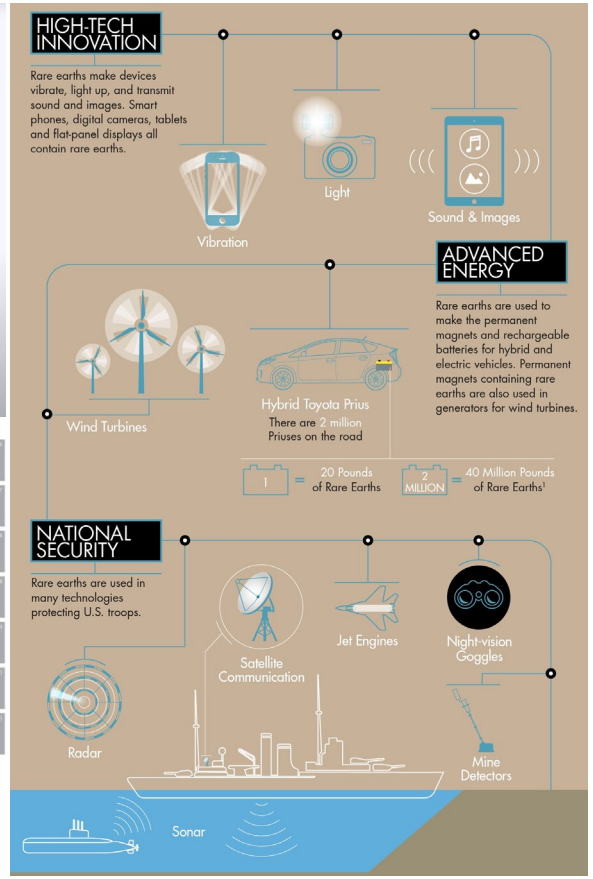
1. Dependence on Imports
2. Country Origin of Mineral Producer

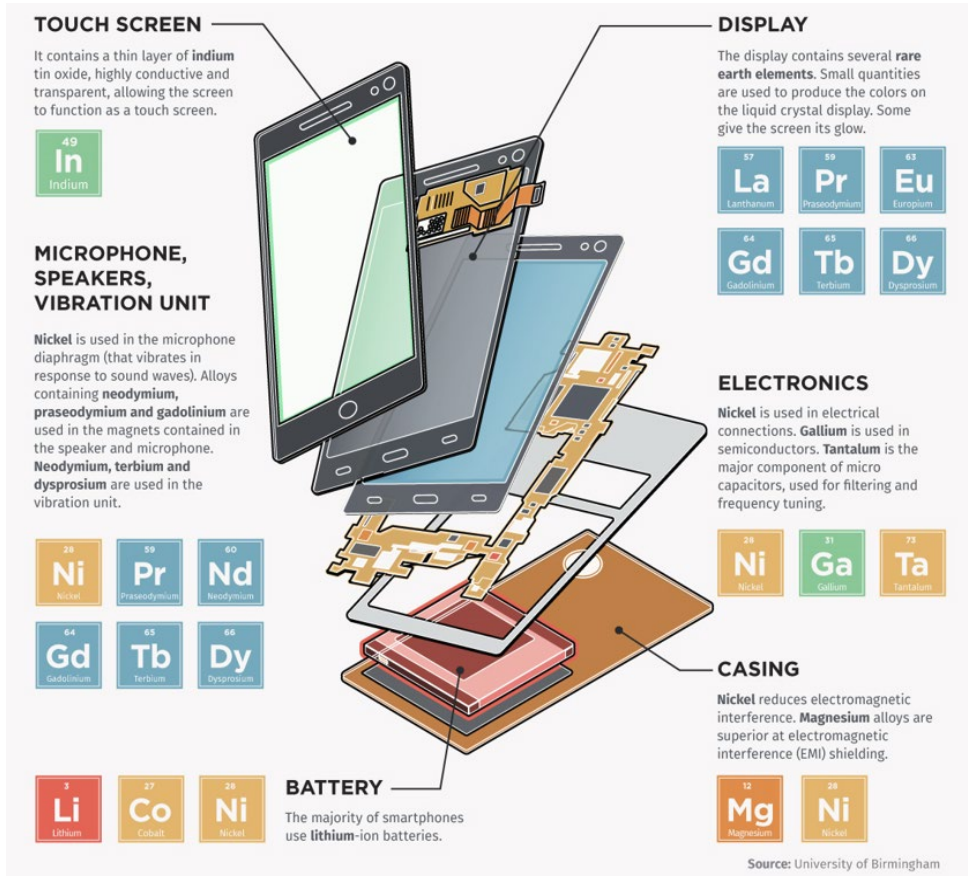
+ *Responsible Sourcing Practices*

Europium	100%	Phosphors, nuclear control rods
Fluorspar	100%	Manufacture of aluminum, cement, steel, gasoline
Gadolinium	100%	Medical imaging, steelmaking
Gallium	100%	Integrated circuits, LEDs
Graphite	100%	Lubricants, batteries
Holmium	100%	Permanent magnets, nuclear control rods
Indium	100%	Liquid crystal display screens
Lanthanum	100%	Catalysts, ceramics, glass, polishing compounds
Lutetium	100%	Scintillators for medical imaging, cancer therapies
Manganese	100%	Steelmaking, batteries
Neodymium	100%	Medical, industrial lasers
Niobium	100%	Steel, superalloys
Praseodymium	100%	Permanent magnets, batteries, aerospace alloys
Rubidium	100%	Research, development in electronics
Samarium	100%	Cancer treatment, absorber in nuclear reactors
Scandium	100%	Alloys, ceramics, fuel cells
Tantalum	100%	Electronic components, superalloys
Terbium	100%	Metal alloys, lasers
Thulium	100%	Metal alloys, lasers
Ytterbium	100%	Catalysts, scintillometers, lasers, metallurgy
Yttrium	100%	Ceramic, catalysts, lasers, metallurgy, phosphors
Iridium	?**	Coating of anodes for electrochemical processes
Rhodium	?**	Catalytic converters, electrical components
Ruthenium	?**	Electrical contacts, chip resistors in computers
Beryllium	11%	Alloying agent in aerospace, defense industries
Aluminum	13%	Power lines, construction, electronics
Zirconium	25%	High-temperature ceramics production
Palladium	40%	Catalytic converters
Germanium	50%	Fiber optics, night vision applications
Lithium	50%	EV rechargeable batteries
Magnesium	50%	Car seats, luggage, laptops
Nickel	50%	Stainless steel, rechargeable batteries
Tungsten	50%	Wear-resistant metals
Barite	75%	Hydrocarbon production
Chromium	75%	Stainless steel
Tin	75%	Coatings, alloys for steel
Cobalt	76%	Rechargeable batteries, superalloys
Platinum	79%	Catalytic converters
Antimony	81%	Lead-acid batteries, flame retardants
Zinc	83%	Metallurgy to produce galvanized steel
Titanium	88%	White pigment or metal alloys
Bismuth	94%	Medical, atomic research
Tellurium	95%	Solar cells, thermoelectric devices
Vanadium	96%	Alloying agent for iron, steel
Arsenic	100%	Semi-conductors, lumber preservatives, pesticides
Cerium	100%	Catalytic converters, ceramics, glass, metallurgy
Cesium	100%	Research, development
Dysprosium	100%	Data storage devices, lasers
Erbium	100%	Fiber optics, optical amplifiers, lasers

Energy / Technology / Defense: Raw Materials Dependency!

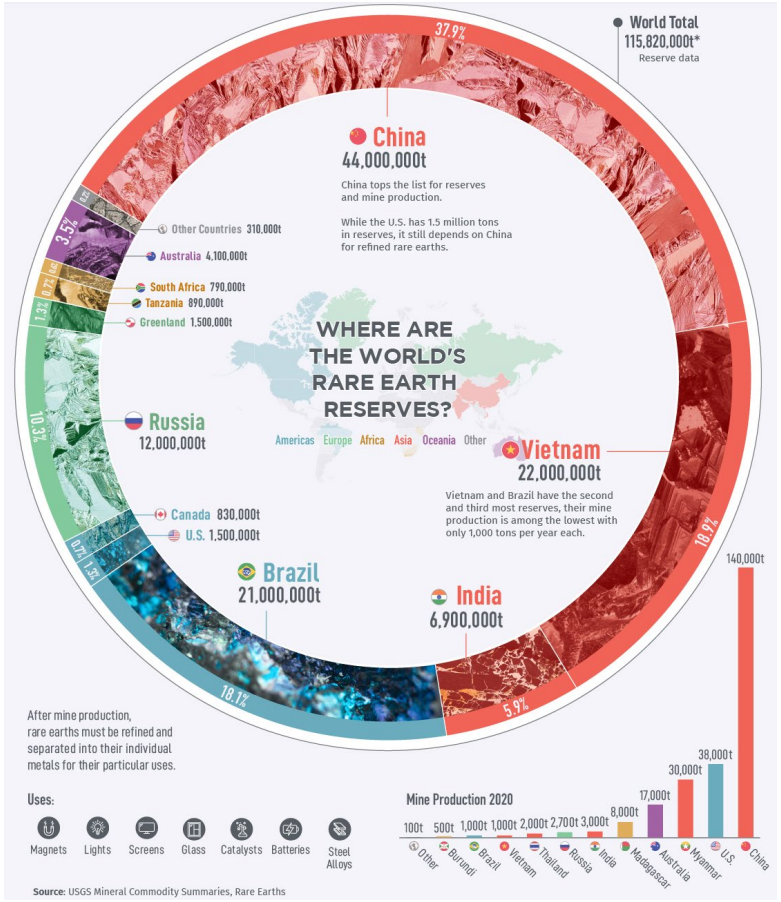






High Demand ⇒ Supply Shortages ⇒ Potential INTERRUPTIONS!

GEOPOLITICAL CATALYSTS



GLOBAL RARE EARTH OXIDE, METAL & MAGNET PRODUCERS

- Map of Global Rare Earth Oxide, Metal & Magnet producers
- **Only 5 non-China Western rare earth refineries** in operation, construction or recommissioning

Source: Goldman Sachs (July 2023)

Source: Goldman Sachs (July 2023)

RESEARCH TEAM

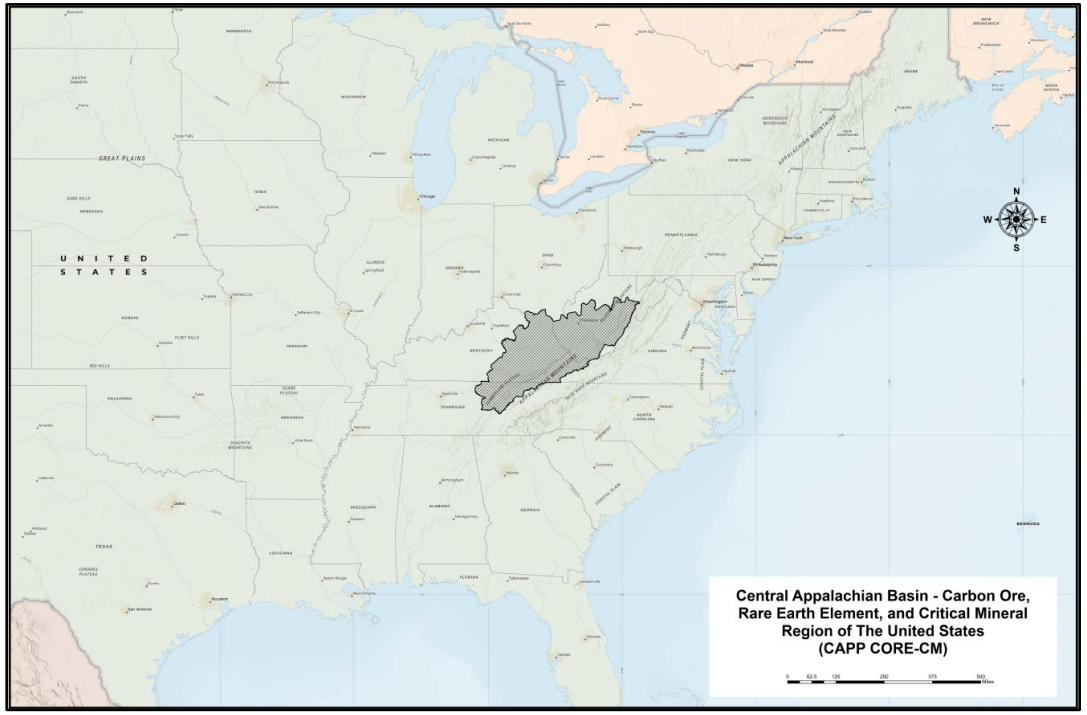
West Virginia University Mining Engineering	Virginia Tech VCCER & Mining Engineering	University of Kentucky Mining Engineering
Marshall Miller & Associates	Gray Energy Technologies	Oak Ridge National Laboratory
Advanced Resources Intl.	Chmura Economics	U. S. Geological Survey
Crescent Resource Innovation	Southern States Energy Board	Virginia Dept of Energy

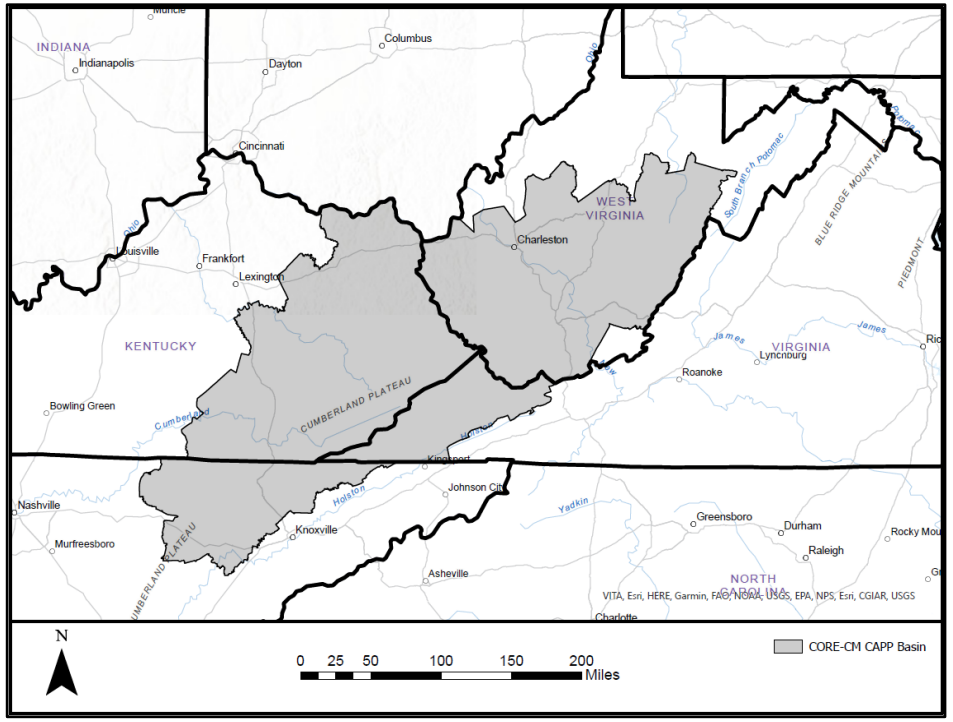
Mountain Empire Community College Coalition

- Mountain Empire Community College (MECC), VA
- Roane State Community College (RSCC), TN
- Southeast Kentucky Community & Tech. College (SKCTC)
- Southern West Virginia Comm. & Tech. College (SWVCTC)

PROJECT OVERVIEW

- *Investigating the Rare Earth & Critical Minerals potential of the Central Appalachian (CAPP) basin*
- *Original Project Dates: October 1, 2021 – March 31, 2024; Funding: $1,584,999*
- *Extension: October 1, 2023 – September 30, 2024; Funding: $500,000*
- *Total: $2,084,999 DOE + $623,868 cost share*





PROJECT SCOPE

The general Evolve CAPP project scope is to:

1) *Assess existing knowledge*
2) *Perform a gap analysis*
3) *Fill identified gaps with future projects*
4) *Provide educational & public outreach*

PROJECT TIMELINE

EVOLVE CAPP

Task #	Task Name	2021			2022												2023												2024		
		10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
1.0	**Project Management & Planning**	A	B											D												H					
1.1	Summary of Environmental Justice Considerations																														
1.2	Summary of Economic Revitalization & Job Creation Outcomes																														
1.3	EHS Analysis for Products ... from CORE-CM Resources					C																									
1.4	Working Group Participation																														
2.0	**Basinal Assessment of CORE-CM Resources**									E																					
2.1	Preliminary Basinal Resource Assessment																														
2.2	Basinal Resource Gap Analysis																														
2.3	Characterization & Data Acquisition Plan																														
3.0	**Basinal Strategies for Reuse of Waste Streams**																														
3.1	Assessment of Mining Refuse & CCR Waste Streams																														
3.2	Assessment of Other Waste Streams																														
3.3	Waste Stream Gap Analysis																														
3.4	Waste Stream Utilization Roadmap																														
4.0	**Basinal Strategies for Infrastructure, Industries & Business**																														
4.1	Regional Infrastructure, Industry & Business Assessment																														
4.2	Strategies to Spur Economic Growth																														
4.3	Infrastructure Needs, Economic Challenges & Supply Chain Gaps																														
5.0	**Technology Assessment, Development & Field Testing**																														
5.1	Technology Assessment - Mining																														
5.2	Technology Assessment - Separation Processes																														
5.3	Technology Assessment - Carbon Products																														
5.4	Technology Assessment & Testing																														
5.5	Technology Gap Analysis & Field Testing																														
6.0	**Technology Innovation Centers (TIC)**																														
6.1	TIC Location																														
6.2	Commercial Acceleration																														
7.0	**Stakeholder Outreach & Education**																														
7.1	Initial Stakeholder Outreach & Education Plan									F																					
7.2	Stakeholders Advisory Committee					G																									
7.3	Workforce Readiness & Development																														
7.4	Public Outreach, Education & Engagement																														

Milestones:

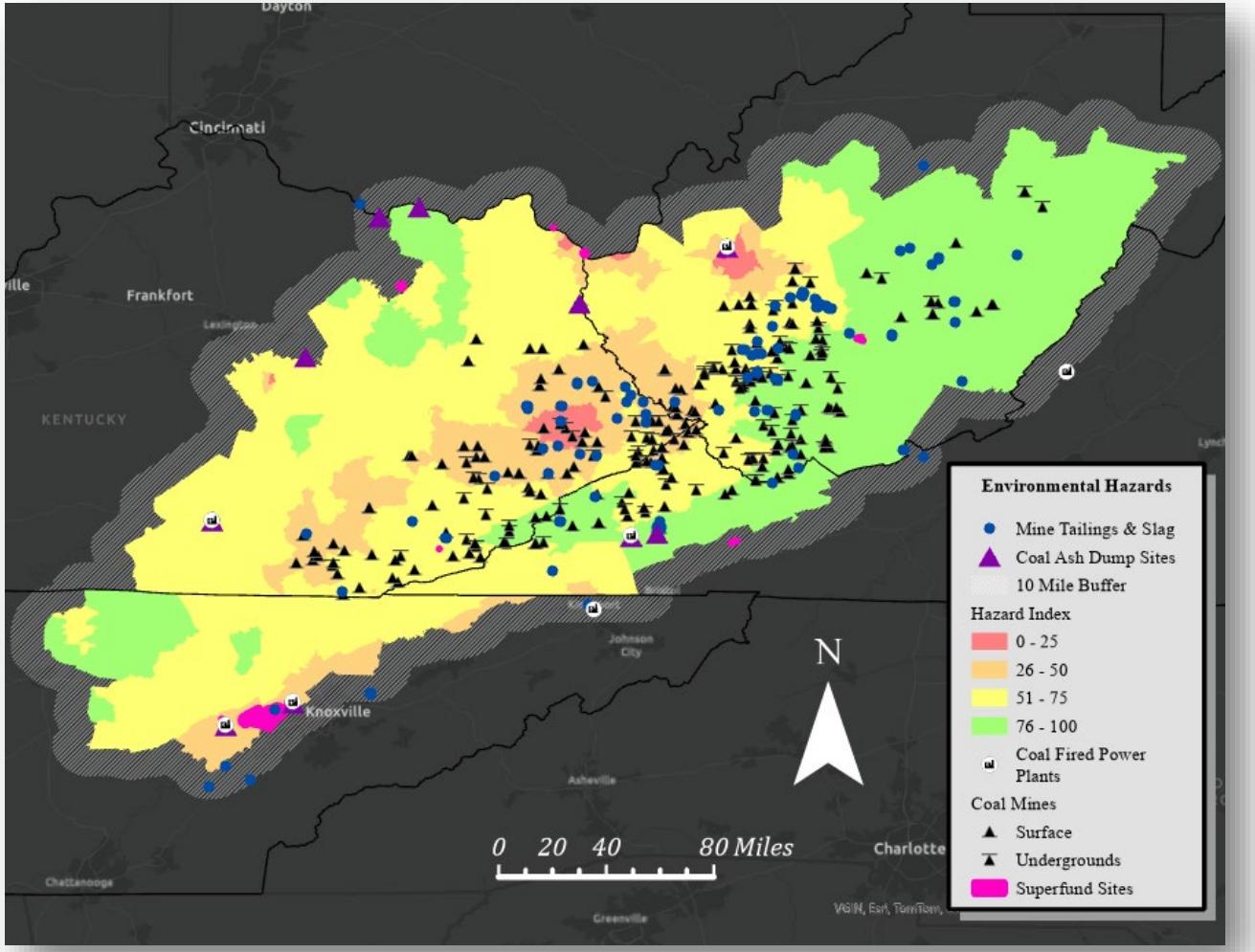
- ✓ (A) Project Kick-off Meeting
- ✓ (B) Project Management Plan
- ✓ (C) EH&S Workshop
- ✓ (D) Interim Report #1
- ✓ (E) Preliminary Sampling Plan
- ✓ (F) Initial Outreach & Education Plan
- ✓ (G) Stakeholder Advisory Committee
- ✓ (H) Interim Report #2
- ❑ (I) Final Report


ENVIRONMENTAL
JUSTICE

ENVIRONMENTAL HAZARDS IN THE CAPP REGION

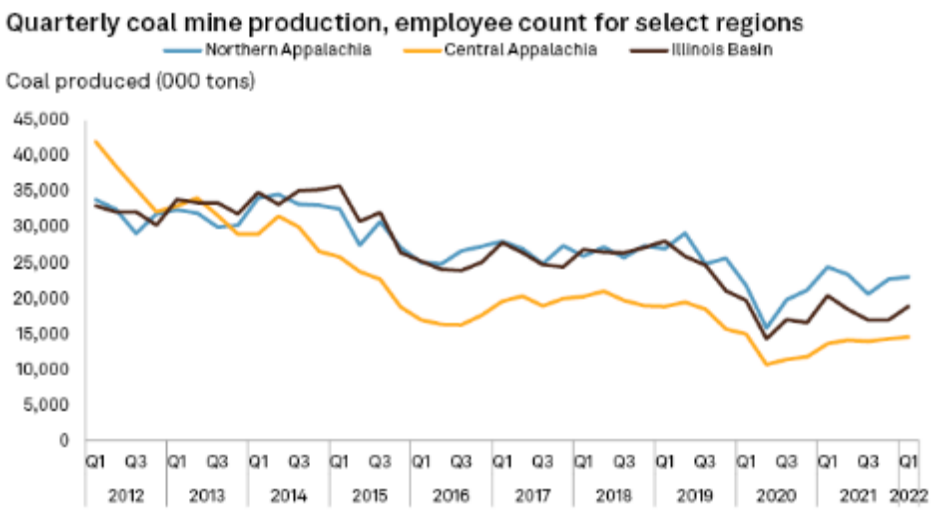
Methods of Analysis:
ArcGIS, EJScreen, CORD, CEJST, & other publicly available data

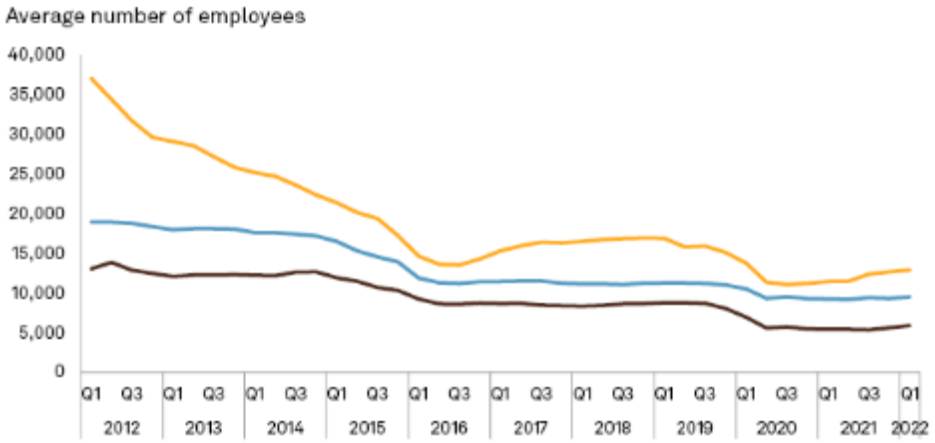
- 284 Active UG/OP Coal Mines
- 80M CY of Coal Waste in SW VA
- >15% area in RED or ORANGE

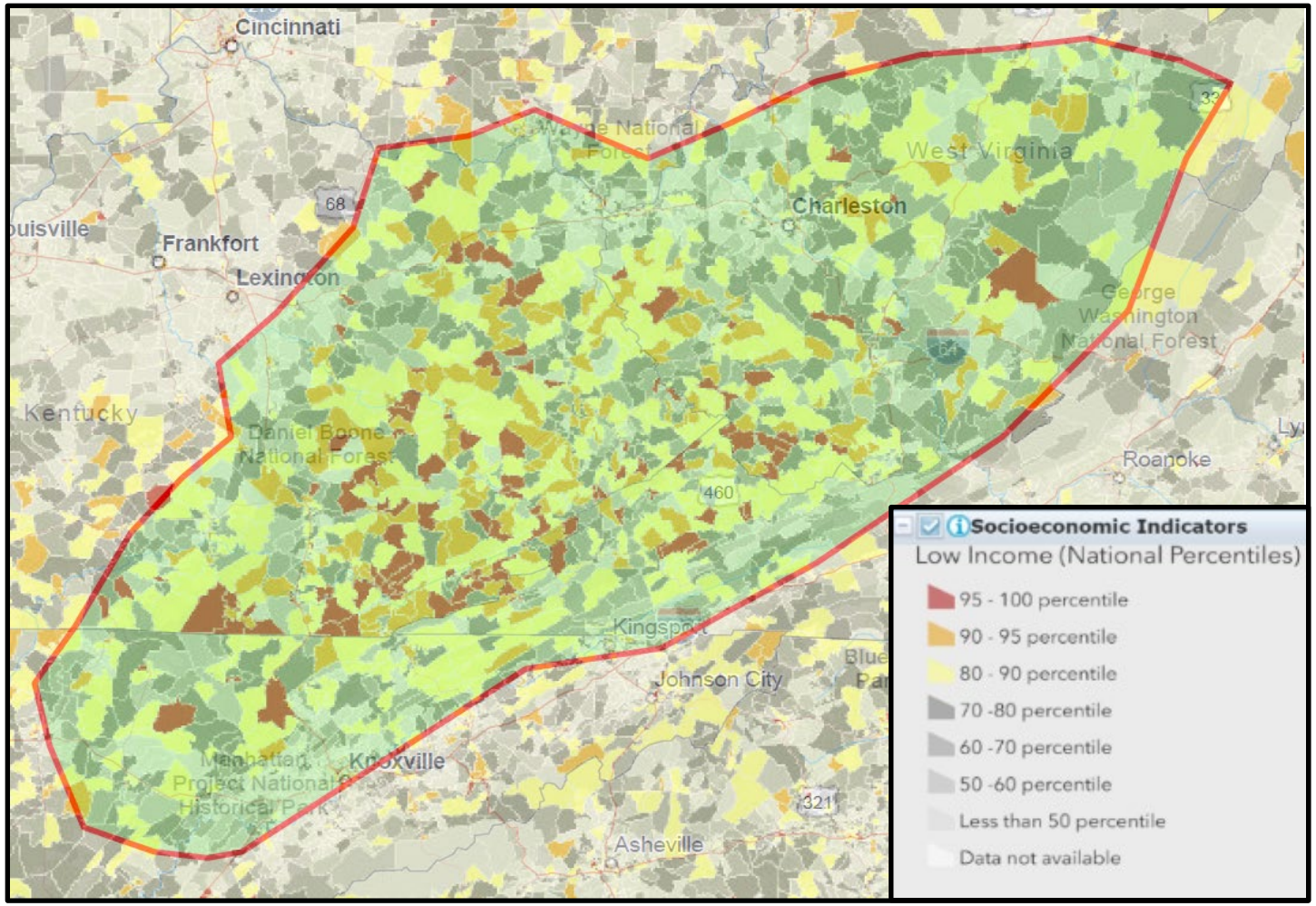


Sources: EPA, USGS, EIA, VADOE

CAPP EMPLOYMENT TRENDS & SOCIOECONOMIC INDICATORS







Source: S&P Global Market Intelligence (May 2022)

EVOLVE CAPP PRIORITIES & PRINCIPLES

Evolve CAPP Priorities:

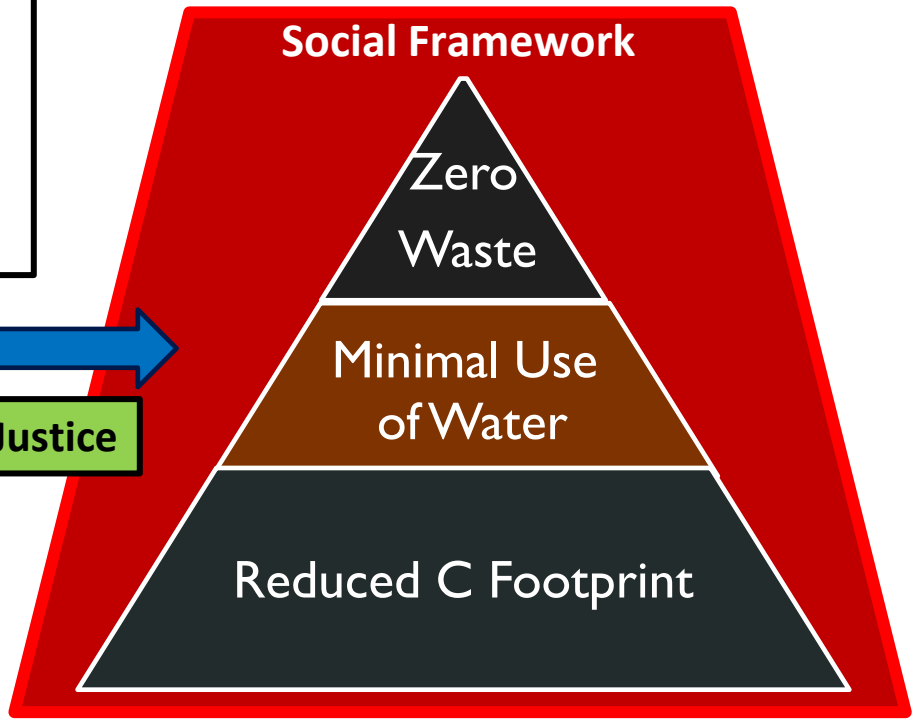
- ✓ Establish a CORE-CM Stakeholder **Community**
- ✓ Develop Vibrant CORE-CM Domestic Industries
- ✓ Supply Green & Digital Economy & Contribute to National Security
- ✓ Avoid Mineral Supply Risk, Potential Interruptions
- ✓ Create Downstream Value-Added Industries & Chains
- ✓ Stimulate Economic Growth in CAPP Region
- ✓ Foster New Job Creation & Upskilling of Local Workforce

Evolve CAPP Principles:

- Develop/Adopt Technologies, Processes & Best Practices that aim for "Zero Impacts" & can earn Social Acceptance
- **Sustainable/Responsible Sourcing**

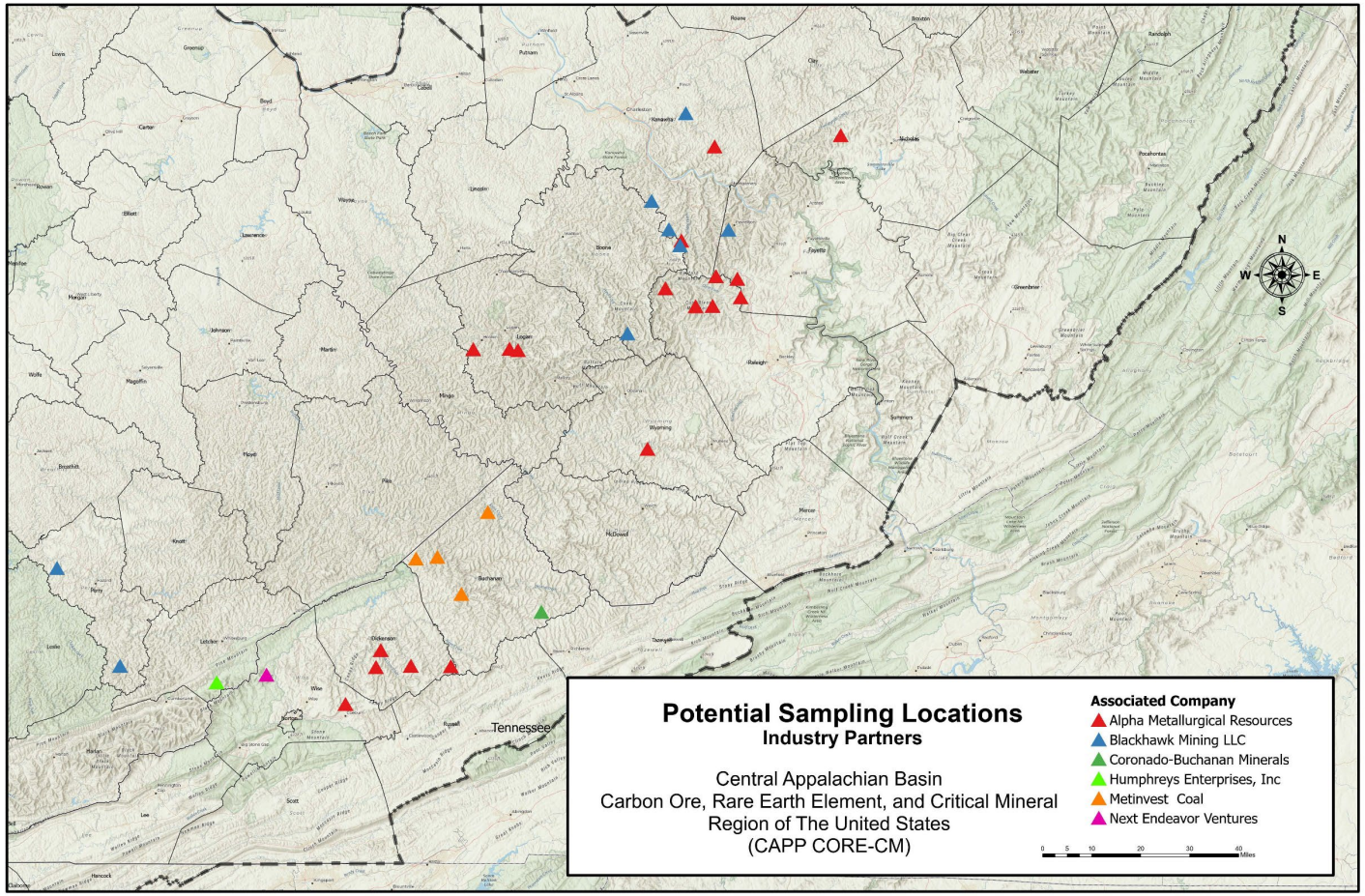
Equity & Social Justice

Positive Environmental & Social Outcomes



POTENTIAL SAMPLING LOCATIONS WITH INDUSTRY PARTNERS

- Targeting resource gaps
- Confirming historical sampling
- Leveraging industry partnerships



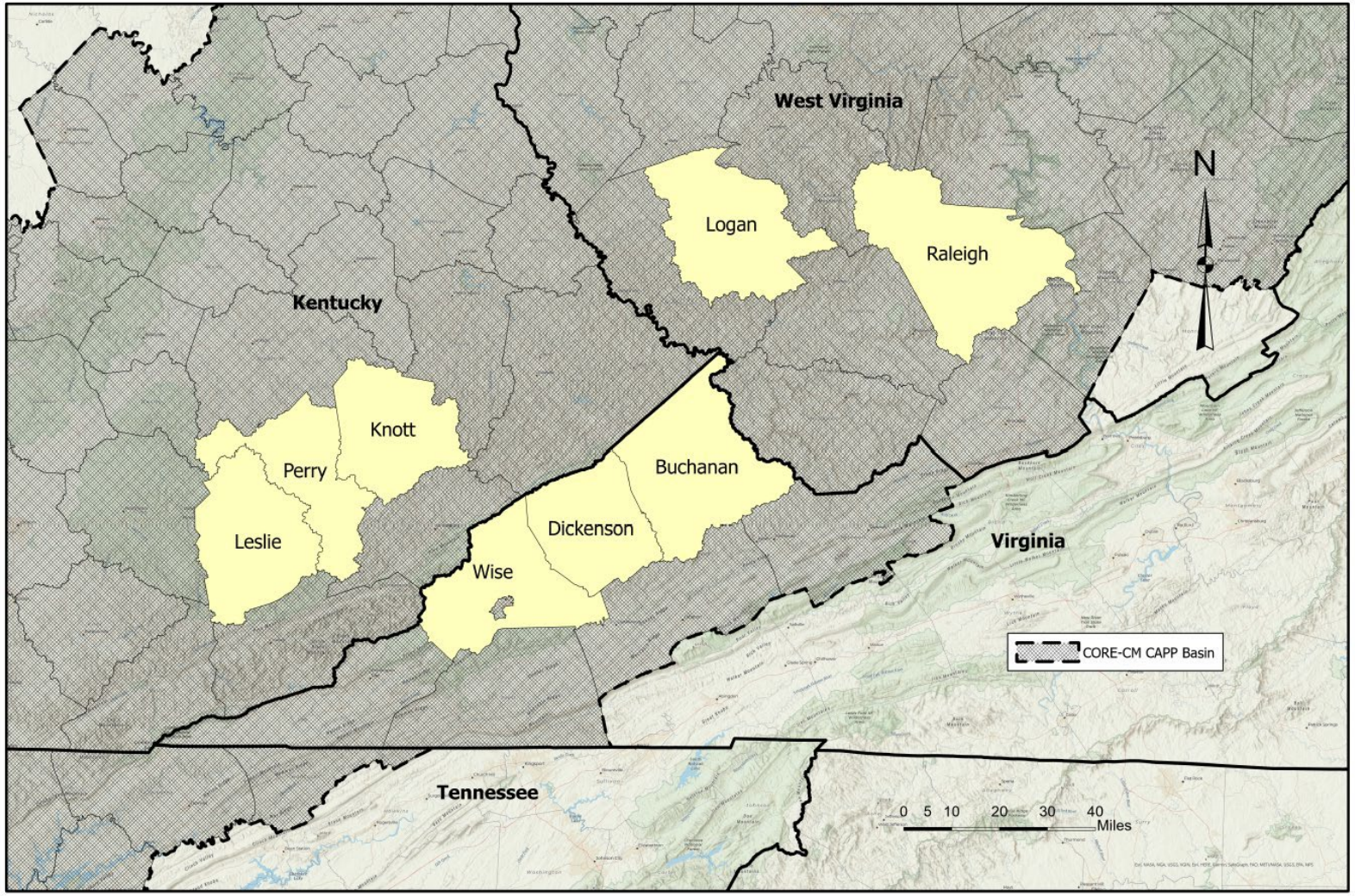
PROJECT EXTENSION - FOCUSED ON SAMPLE COLLECTION

- VCCER planned & implemented a sample collection & analysis plan
- The activities included:
  - Identifying specific sampling opportunities w/ industry partners
  - Field sampling and laboratory analyses including:
    - Rock core collection
    - Channel Sampling – surface & underground mines
    - Fly Ash Sample Collection
    - Acid Mine Drainage (AMD) Sample Collection
    - Oil & Gas Well Produced Water Sample Collection
  - Field screening including:
    - Geologic Logging
    - X-Ray Fluorescence (XRF)
    - Downhole Geophysical Logging – Spectral Gamma

ASSESSMENT OF CORE-CM RESOURCES

- **Sampling:**
  - *CCR sampling commenced* ***September 2022 (25 samples)***
  - *Initial drill core samples* ***September 2022 (19 samples)***
  - *Produced water sampling commenced* ***December 2022 (30 samples)***
  - *Mine sampling commenced* ***July 2023 (30 samples)***
  - *Additional samples collected since* ***August 2023 (>760 samples)***

CAPP REGION COUNTIES WHERE SAMPLES WERE COLLECTED

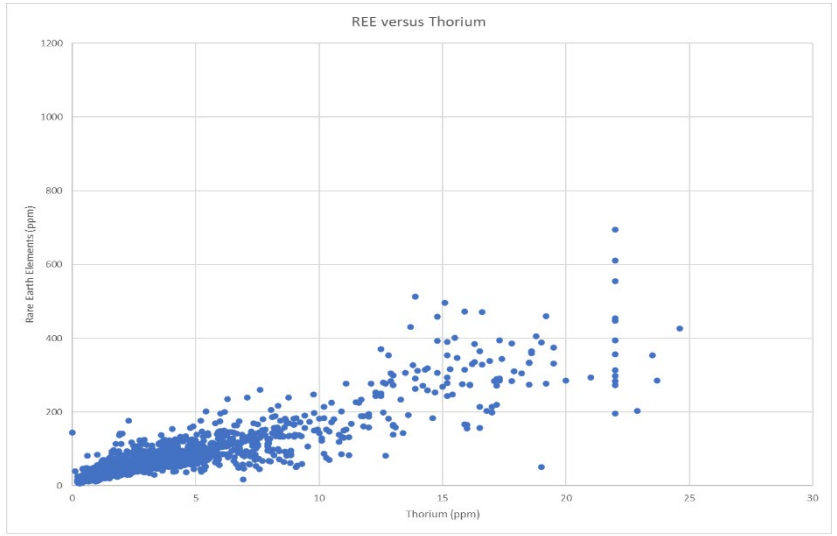


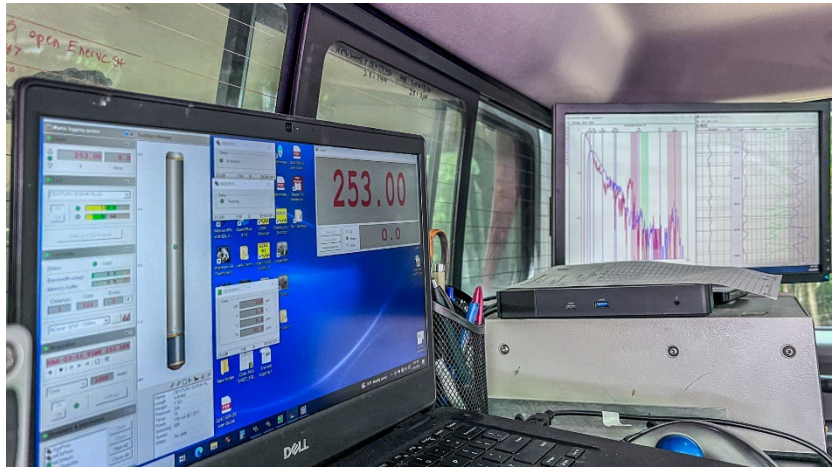
Virginia Counties to date:

- Buchanan
- Dickenson
- Wise


PRE-SCREENING TOOLS

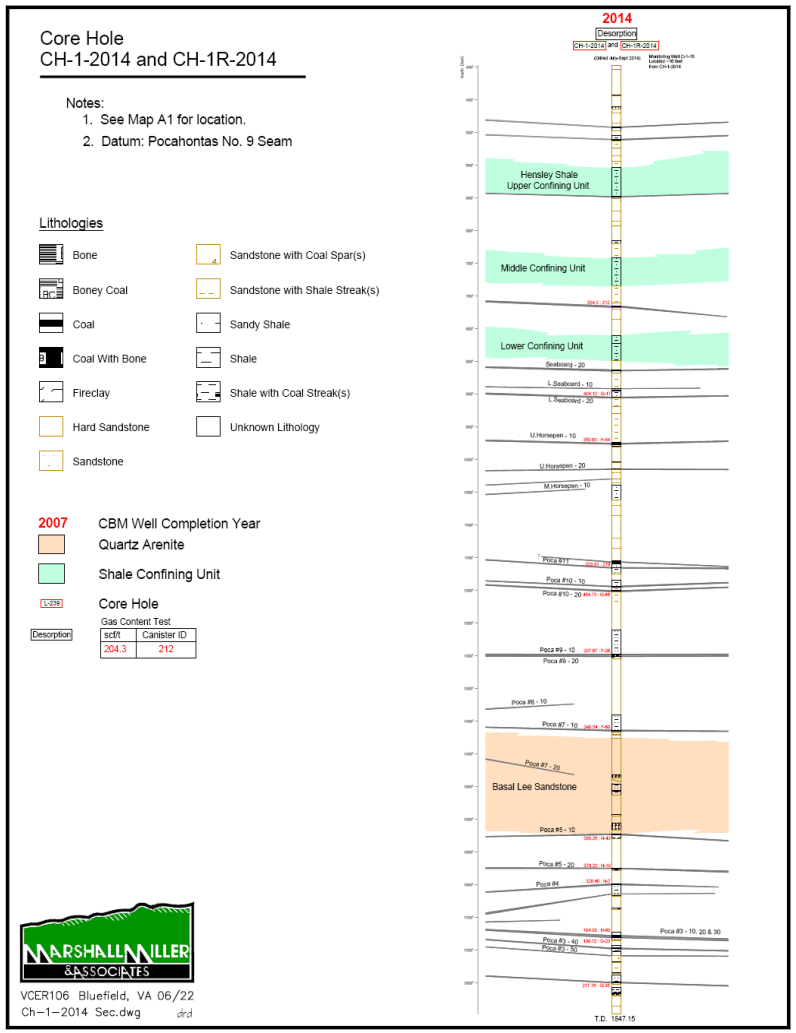
DOWNHOLE SPECTRAL GAMMA

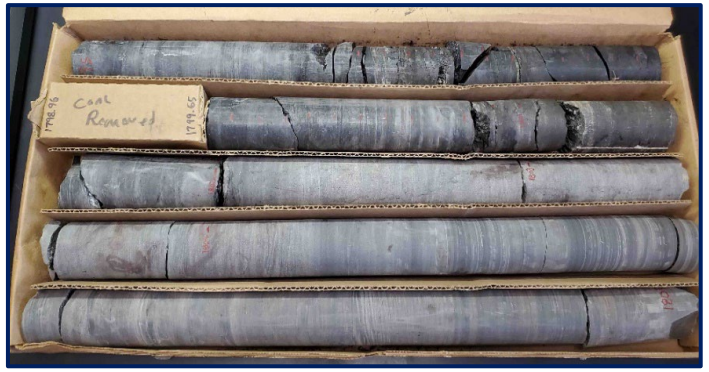




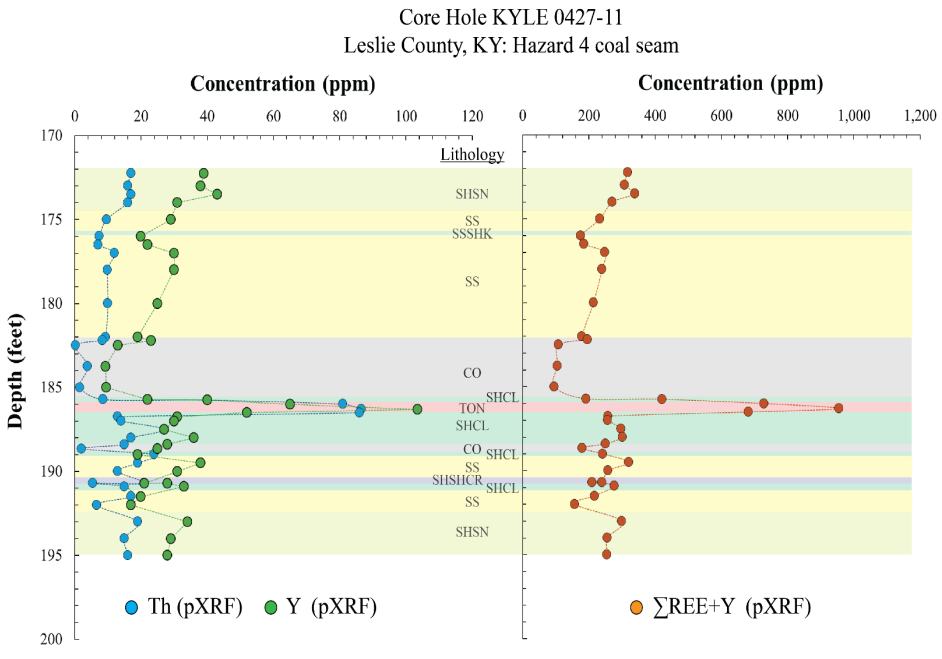
- REEs vs Thorium correlation, detectable w/ Spectral Gamma
- Gamma measured by converting gamma rays to measured & counted electronic pulses

P-XRF SCREENING



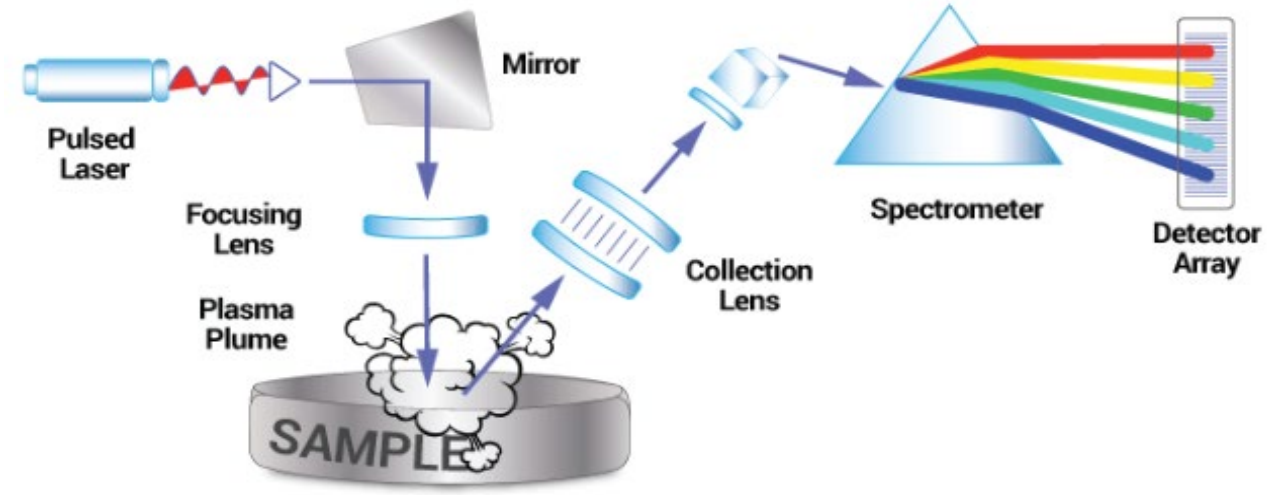


- Analyzing Core for REE-CMs
- 764 XRF scans collected



LIBS SCREENING

- **L**aser **I**nduced **B**reakdown **S**pectroscopy
- Used >30 years as a lab technique capable of analyzing any element in periodic table, now available handheld
- Pulsed laser fired at sample creates a plasma
- Plasma cools, atoms combine with electrons & emit UV, Optical & IR light compared with known wavelengths



KYLE 0427-11, BOX 3: 185.72’ – 195.72’

SHCL (ash-mottled claystone):

pXRF: ∑REE+Y = **421 ppm**

TON (tonstein):

pXRF: Y = 104 ppm, Th = 87 ppm

∑REE+Y = **955 ppm**

VA-C-1 Box #125: 1797’ – 1807’

includes P2 coal (Buchanan County, VA)

pXRF: Y = **32 ppm**, Th = **15 ppm**

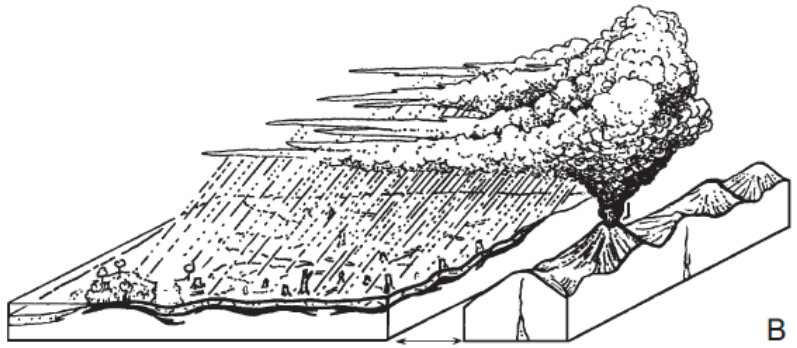
∑REE+Y	**269 ppm**
∑LREE	**215 ppm**
∑ HREE	**23 ppm**

BUILDING A DEPOSITIONAL MODEL

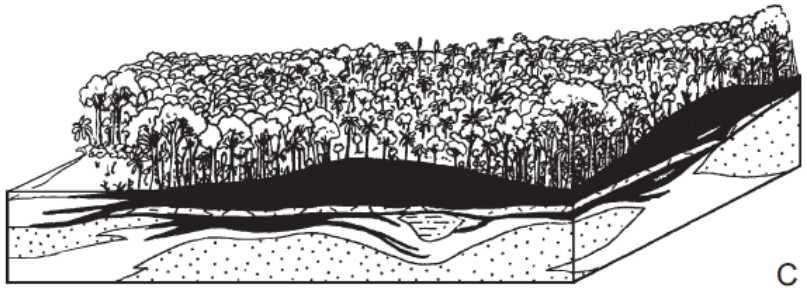
- Basic model for flint clay deposition in sedimentary depositional environment

A. Peat accumulation in mire subject to clastic influx; will become lower bench of coal seam

B. Volcanic ash deposited; will become flint clay parting



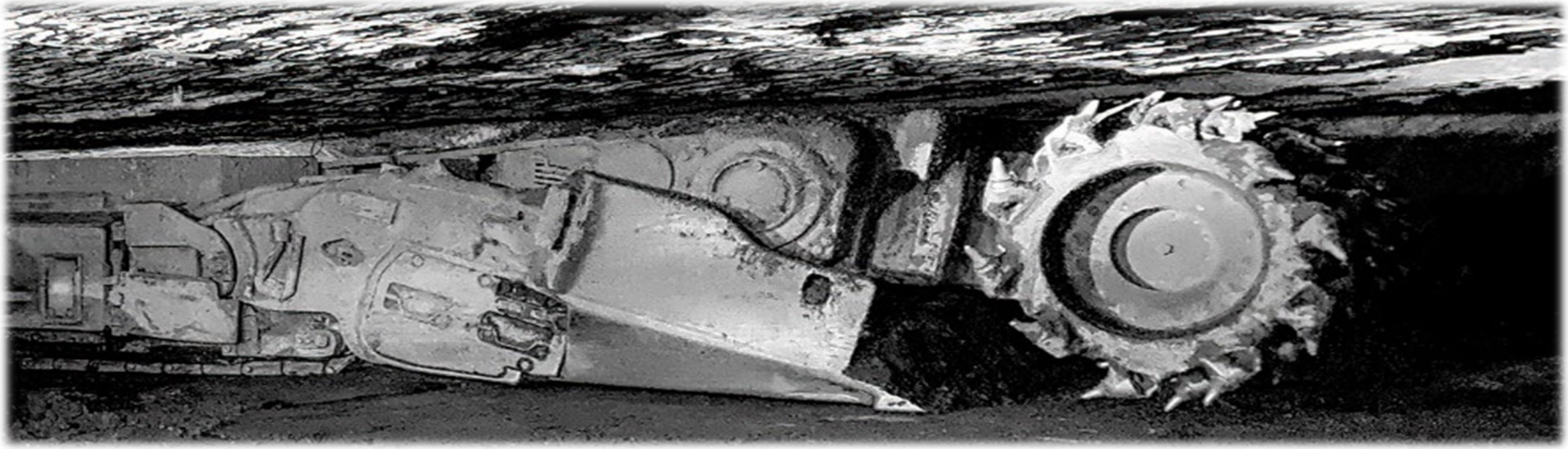
C. Peat accumulates after the ash fall; will become upper bench of coal seam



Eble, CF, Hower, JC, and Andrews, WM, 1999, Compositional Variations in the Fire Clay Coal Bed of Eastern Kentucky: Geochemistry, Petrography, Palynology, and Paleoecology, Report of Investigations 14, Series XI, Kentucky Geological Survey, University of Kentucky, Lexington, KY

TECHNOLOGY ASSESSMENT, DEVELOPMENT & FIELD TESTING

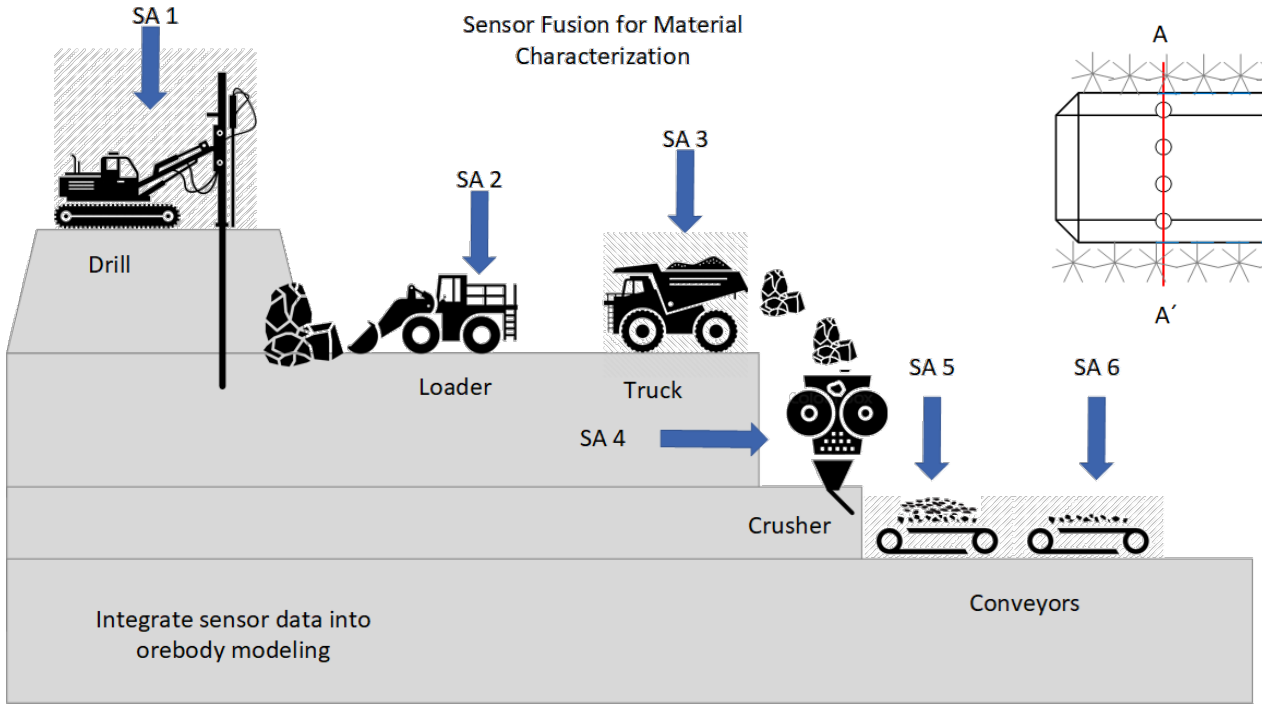
- Mining (primary, co-products, re-mining)
- Separation Processes
- Carbon Products
- Technology Assessment
- Field-Testing
- Gap Analysis

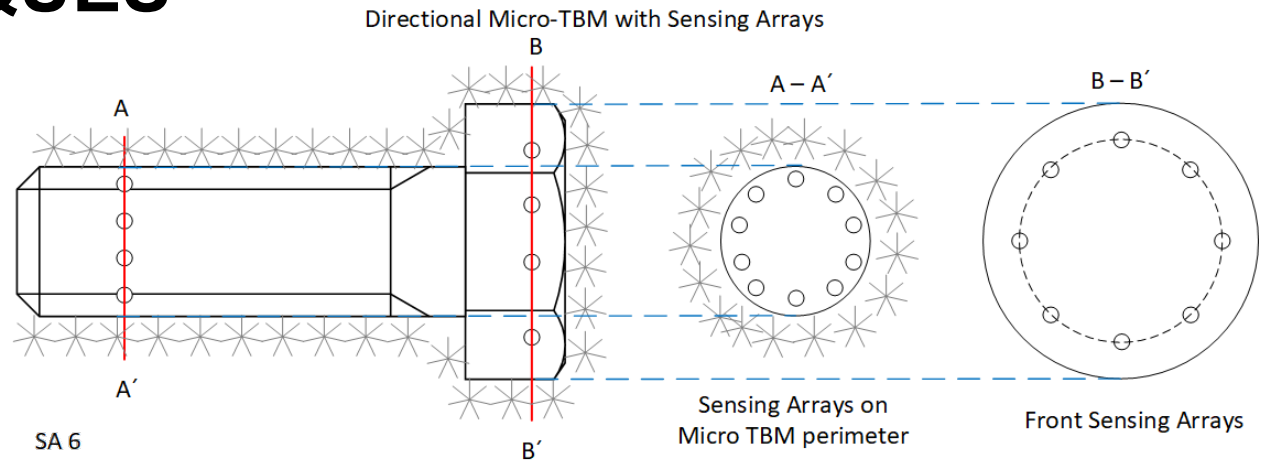


MINING TECHNOLOGY & OPERATIONS

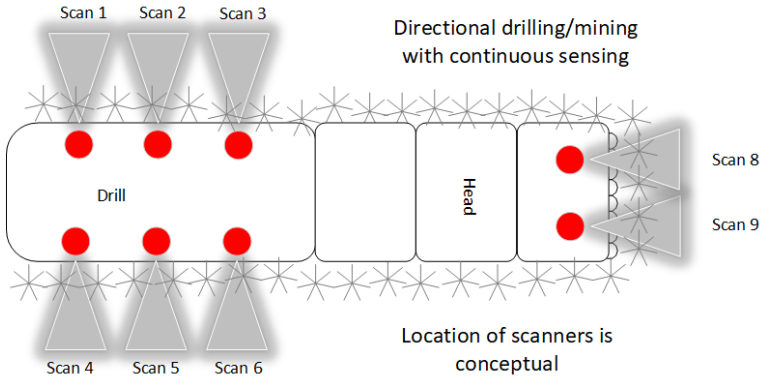
- **Material Handling**
  - Movement of ore from working face to processing operation
- **Surface Operations**
  - Out-of-Seam material placed in storage or replaced to get site back to approx. original contour
  - Material in storage may be available for re-mining operations to recover REE, but volume of material & mixing of material a challenge
  - Selective mining possible for out-of-seam material (flexibility in truck & shovel operations)
- **Underground Operations**
  - Selective material handling & selective mining are a challenge
  - Out-of-seam material is separated in processing plant & stored separately
  - Re-mining options available

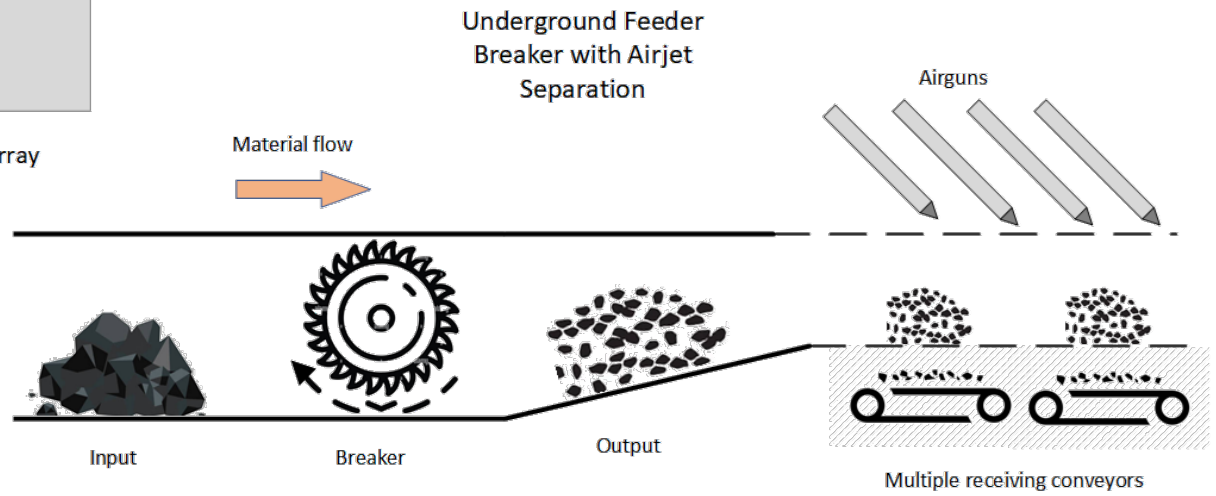
EXAMPLE MINING TECHNIQUES





SA = Sensor Array

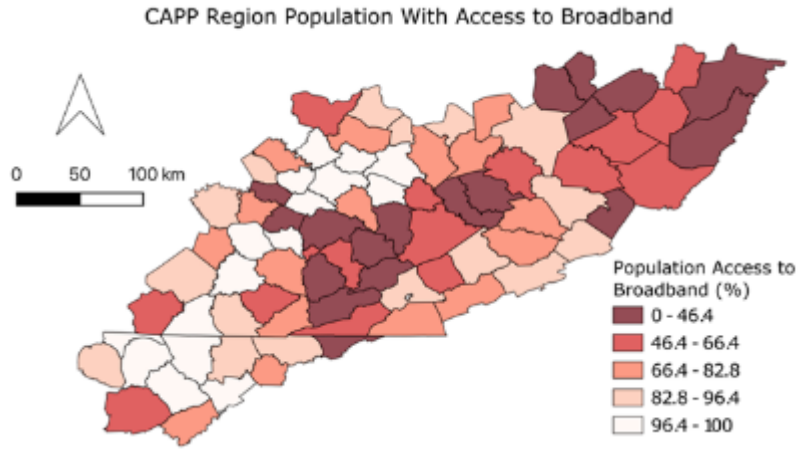


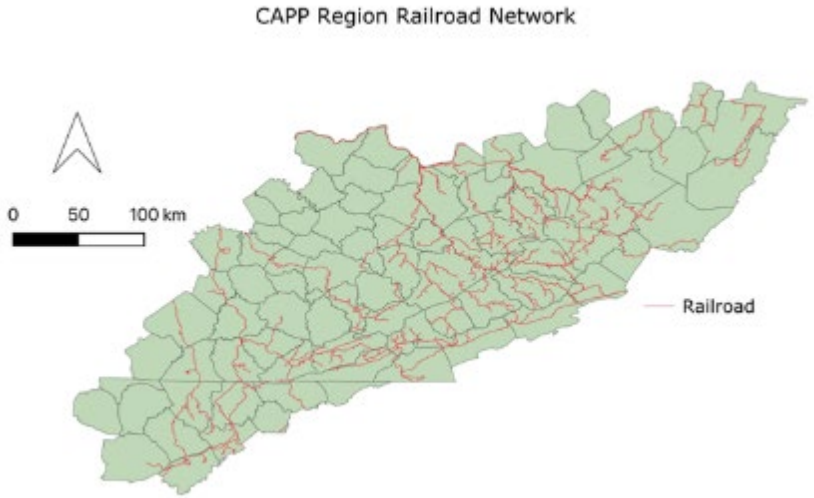


INITIAL INFRASTRUCTURE ASSESSMENT

Screening for various metrics, including:

- Cheapest source of electricity
- Primary & secondary roads
- Power generation
- Railroad networks
- Commercially navigable waterways
- Fly ash pond locations
- Population with access to broadband
- Educational opportunities





OUTREACH INTEGRATED WITH PROJECT MANAGEMENT

Project Management & Planning

- EJ Considerations
- Economic Revitalization & Job Creation Outcomes
- EH&S Analysis

Stakeholder Outreach & Education

Initial Stakeholder Outreach & Education Plan

- Stakeholder Advisory Committee
- Workforce Readiness & Development
- Public Outreach, Education & Engagement

WORKFORCE READINESS & DEVELOPMENT

- Workforce Readiness Plan
- Workshops & Forums
  - ✓ Engage stakeholders/entrepreneurs, public, future workforce personnel
  - ✓ Identify & assess skillsets & employment opportunities
  - • Offer programs, certifications & skills training to match needs of projects in basin

Workforce Readiness Plan

Step 1
Assess the Workforce

→

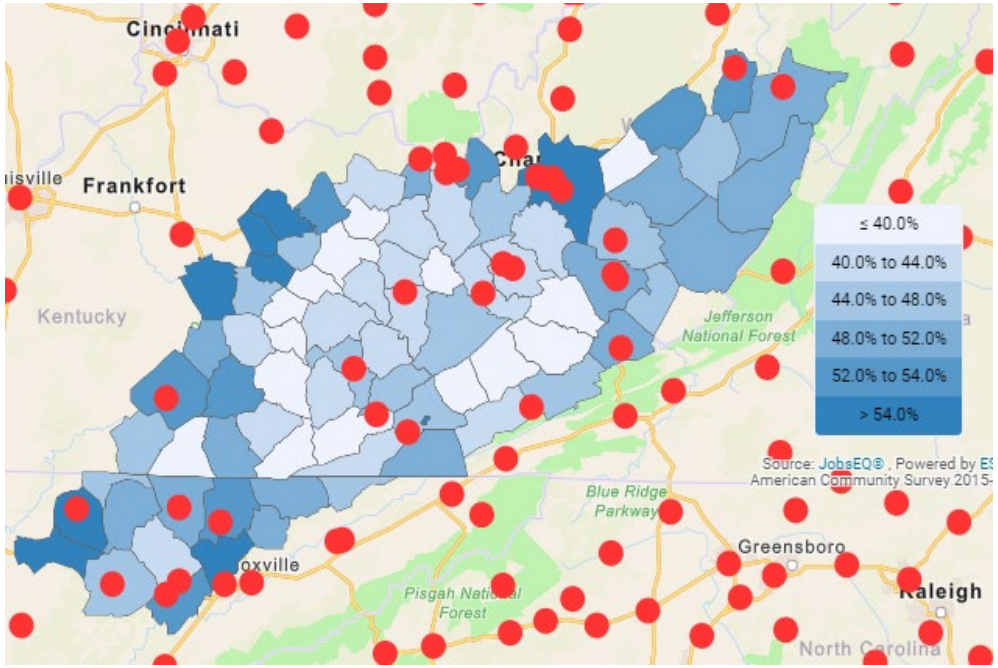
Step 2
Identify Supporting Organizations

→

Step 3
Develop the Workforce

Labor Force Participation Rate

w/ locations of Public 2-year or Less Training Facilities



EDUCATION & TRAINING – CAPP REGION

School	Commercial Vehicle	Construction/ Heavy Equp.	Diesel Mech. & Technician	Drafting & Design Tech.	Electrical & Electronic Tech.	Electrical & Electronic Comm.	Electrician	Industrial Mechanics	Information Technologies	Machine Shop Tech.	Welding
Academy of Careers and Technology	x		x	x			x				x
Ashland Community and Technical College	x		x	x			x	x	x	x	
Ben Franklin Career Center		x	x								x
Berea College									x		
Big Sandy Community and Technical College	x		x	x	x		x	x	x	x	x
Bluefield State College						x			x		
BridgeValley Community & Technical College			x	x		x					x
Cabell County Career Technology Center							x			x	x
Carver Career Center							x				
Eastern Kentucky University									x		
Fayette Institute of Technology							x				
Fortis Institute-Cookeville	x										
Fred W Eberle Technical Center	x		x				x				x
Hazard Community and Technical College	x	x	x	x			x		x		x
Marshall University									x		
Mercer County Technical Education Center							x				x
Morehead State University									x		
Mountain Empire Community College						x			x		x
Mountwest Community and Technical College						x				x	x
New River Community and Technical College			x								x
Somerset Community College	x		x		x		x	x	x	x	
Southeast Kentucky Community			x	x	x		x	x		x	x
Southern WV Community and Technical College						x	x				x
Southwest Virginia Community College						x			x		x
TN College of Applied Technology-Crossville	x		x					x			x
TN College of Applied Technology-Harriman			x					x			x
TN College of Applied Technology-Jacksboro							x				x
TN College of Applied Technology-Livingston			x					x			x
TN College of Applied Technology-Oneida-Huntsville											x
University of the Cumberlands									x		
University of Pikeville									x		
West Virginia University Institute of Technology					x				x		

STAKEHOLDER OUTREACH & EDUCATION - VIRGINIA

- *Open Public Session + Stakeholder Mtg: Abingdon, VA,* ***March 2022***
- *MCPA PE Seminar: Lebanon, VA,* ***October 2023***
- *VaDOE Electrical Retraining Seminar, Big Stone Gap, VA,* ***September 2023***
- *VEDP Rural Virginia Action Committee: Richmond, VA,* ***September 2023***
- *Critical Minerals Workshop, Blacksburg, VA,* ***March 2023***
- *Public Outreach, Education & Engagement:* ***40 presentations to date..***
  - ***USEA, SSEB, SME, SME-CAS, SME-FL, SPE, etc.***

DOE-FOA 3077 - CORE-CM PHASE II "REGIONS OF INTEREST"

- Phase II CORE-CM Program
- Potential $7.5M in funding per region
- Proposals submitted for Regions 1 & 2

EVOLVE CAPP

Evolve Central Appalachia

Scan QR code for more info:

https://energy.vt.edu/research/evolve-capp.html

For more information, please contact:

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