Critical Minerals in the Cherokee-Forest City Basin

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Project Overview

- Funding (DOE and Cost Share)
 - \$1.9M
- Overall Project Performance Dates
 - Sep 2021 to Aug 2023
- Project Participants
- Overall Project Objectives
 - Develop basin-wide estimates of CM resources
 - Build basin-wide CM Community













Critical Minerals in Coaly Strata of the Cherokee-Forest City Basin

- Geology
 - Build a new stratigraphic & structural model of the basin
 - Foreland basin, Elk Creek CM Deposit
 - Assay critical mineral potential in coals, associated strata, and waste streams
 - Including: Rare Earth Elements, Aluminum, Lithium, Platinum Group Elements, Helium
- Business Development
 - Identify businesses that can use critical minerals and if any barriers exist for them
- Project Team
 - Geological surveys of Kansas, Missouri, Oklahoma, Nebraska, Iowa, Osage Nation
 - Advisory committee including NioCorp, Phoenix Coal, Martin Marietta, Kansas DOT, Iowa DOT, various emeritus scientists/professors



Technology Background

Energy Transition Has Four Key Technologies

Carbon Capture			Energy		Hydrogen		Critical				
	& Storage		Storage		Economy	Minerals					
•	Gets CO ₂ out of the atmosphere	•	Manages variable production of power from	•	Can be burned with natural gas	•	Required for high tech manufacturing				
•	Prolongs investments in current power		renewables and fossil generators	•	Transport fuel Industrial uses		(e.g., solar panels, wind turbines, electronics,				
	plants	•	Network benefits				screens)				



Complex to refine



KGS Critical Minerals Program

DOE CoreCM	NSF EPSCoR	USGS EarthMRI	USGS Strat Nomenclature
2021-2023	2021-2025	2022-2024	2021-2022
\$1.9M	\$1.9M	\$1.0M	\$250k
Penn Strat correlation; geochemical analysis of coal, underclay, black shale and waste; geochemical well logging; environmental and economic studies	Research Infrastructure improvement (Core scanner, XRF, ICP- MS)	Penn black shale pXRF	Harmonize Pennsylvanian stratigraphic nomenclature



Technical Approach

Paleo-Geography at 315 Million Years



Hypotheses for CMs in our basin



Additional hypothesis: enrichment via basement fluid flow

Prospect Maturation Process



Geological Modeling

- New and aggregated data will be integrated to develop new depositional models for Pennsylvanian-aged strata in the basin by testing new hypotheses about the structural setting and sediment accumulation
- Identify sweet-spots and fairways of CM accumulation and serve as a hypothesis to test with additional samples collection in Phase II



Resource Assessment

- Correlation of strata basin-wide
 - Well logs
 - Outcrop descriptions
- Legacy Geochemical Data
- Novel Geochemical Data
 - Portable XRF analysis at IA, KS, and MO for major elements (wt% to ppm)
 - ICP-MS at University of Iowa for trace elements (ppm to ppb)
 - Electron Microprobe (EMPA) at OGS to identify host mineral phases for CMs
 - Geochemical Well Logging at select wells
 - Core Scanner





Geochemical Well Logging

- Tools designed to derive elemental contributions contained within the total measured gamma-ray energy spectrum
- Can work in both openand case-hole environments
- Quantitative measurements of: Si, Al, Ca, Fe, Mg, S, Na, C, Mn, Ti, Gd
- Elemental concentrations can be applied to establish stratigraphic correlations
- Calibrations of downhole logs with pXRF, ICP-MS, and EMP geochemical analysis



Individual spectral yields from neutron capture are converted to elemental weight fractions



Interpretation of weight fractions determines mineralogy and matrix properties

NSF EPSCOR Project (\$1.9 million)

 Improve research infrastructure for Critical Minerals evaluation

- Core scanner
- Laboratory XRF



Waste Stream Mapping

- coal-fired power plants
- lead-zinc tailing piles
- cement plants
- refineries
- computer/electronics recycling centers



Other CM Resource: Produced Water

- 49 Class I and 2381 Class II Arbuckle wells across Kansas
- Injection volume 500 million barrels in 2015
- Separating critical minerals from produced water would be win-win
 - Get CMs
 - Get
 freshwater



Sources: Kansas Department of Health and Environment, ESRI, USGS, Kansas Corporation Commission, Kansas Geological Survey

Progress and Current Status of Project

Tasks

- 1. Environmental/Social Justice Assessments, Job Outcome Assessment
- 2. Geological Modeling of Basin Resources
- 3. Waste Stream Reuse Plan
- 4. Infrastructure, Industries, and Business Assessment
- 5. Technology Assessment, Development and Field-Testing Plan
- 6. Stakeholder Outreach and Education Plan
- 7. Technology Innovation Center



Leveraging All Data

- Strip Logs
- Raster Logs
- LAS Logs
- Drill Cores
- Cuttings
- Tops

NE

Kansas.



Stratigraphic and Structural Modeling

- Originally 243 wells in transects → 40,000+
- Goal
 - Correlate throughout region
 - Hang chemistry on stratigraphy
 - Make interval isopachs and geochemical maps
- Current Progress
 - Wells picked: 3,000+
 - Tops: 50,000+



Geochemical Well Logging

- Halverson #4A-2 well in SE Nebraska
- 40 mi from Elk Creek Carbonatite
- 2100 ft of elemental and spectral gamma logs
- Elemental tool directly measured
 - Al, Fe, Si, S, Ti, K, Ca, Mn, Mg, Gd
- Gd variable throughout section, with significant elevations in target interval
 - 10 ppm to over 50 ppm
- Opportunity for a core-log calibration in new NE Kansas well



Core Scanning



Identified Legacy Coal Samples



Challenges

- Huge geographic footprint
- Sharing data
- Volatility of price in the O&G industry has meant costs and timetables for drilling have been in flux
 - Logging costs rose significantly...10 logs became 2
 - Now with extra money, we can add calibration core
- Industry acceptance of sampling and reuse of waste
- Public wary of new mining due to legacy mining wastes still being remediated

Outreach

Presentations on CoreCM

- Critical Minerals Workshop, Oklahoma Geo Survey, Nov 2011
- AAPG Energy Minerals Division, Dec 2021
- KGS Advisory Committee, Dec 2021
- Kansas Geological Society, January 2022
- Wichita State University, January 2022
- Kansas Oil & Gas Association, April 2022
- Press Release (carried on Kansas Public Radio), June 2022
- The Energy Council (US + Canada), June 2022
- Kansas Legislative Field Conference, July 2022
- AAPG, August 2022
- Kansas CCR Workgroup, Sept 2022
- Eastern Kansas Oil & Gas Association, Oct 2022
- Public Utility Fortnightly with Brian Anderson, October 2022
- Sheraton Starbucks Barista, October 2022



Technical Advisory Board

- Scott Honan, NioCorp
- Clay Hartley, Phoenix Coal Company
- Rory Martin, Martin Marietta
- Bob Dawson, Iowa Dept of Transportation
- Bob Henthorne, Kyle Halverson, KDOT
- Erik Blume, KU Innovation Park
- Phil Heckel, PhD, Emeritus, Univ Iowa
- Dave Newell, PhD, Emeritus, KGS



IADOT



Native Lands in the Cherokee-Forest City Basin



- 36 individual tribes within the Cherokee-Forest City basin
- Three initial responses indicating interest in the First Nations Advisory Council
 - Quapaw
 - Prairie Band Potawatomie
 - Muscogee Creek
- Lack of capacity for participation in CoreCM activities
- Engage with future workers?
- Haskell University
 outreach

Environmental Justice Metrics



- EPA EJ Screen
 - Proximity to Superfund Sites
 - Proximity to Hazardous Waste
 - Socioeconomic Indicators
 - Air Toxics Cancer Risk
- Surface and Underground Mine Information
 - Availability varies state by state
- Proximity to Water Features
 - Surface Waters
 - Drinking Water Wells

Governmental Outreach

- Legislators
 - State level
 - Federal
- Executive Cabinet
 - Governors
 - Dept of Commerce
- Regulators
 - EPA Region 7
 - KCC, KDHE





Summary

Key findings

- Regional geological concept is holding up to avalanche of data
- Geochemical well log identified CM enrichment (Gd)
- Lessons learned
- Large regional projects are complex Future plans
 - Finish geological modeling by including chemical data

"Take-away" message: Well coordinated effort, expertise, and technology required to execute across broad areas



Appendix

Org Chart—Our CoreCM Team

Kansas

















lowa



Alyssa Bancroft



Suriamin

Oklahoma



Missouri







Nebraska



Matt Joeckel

Gantt Chart

				20)21		2022										2023									
Task	Task Name	Resource	8	0	Ν	D	J	F	Μ	Α	Μ	J	J	A	S	0	Ν	D	J	F	Μ	A	Μ	J	J	Α
1.0 Project Management and Planning																										
1.1	Project Management	KGS																								
2.0 Basinal Assessment of CM Resources			+																		-					
2.1	Data Aggregation	Team																								
2.2	Geological Modeling	KGS																								
2.3	Resource Assessment	Team																								
2.4	Data Acquisition Plan	Team																								
3.0 Basinal Strategy - Reuse & Waste					←												-	•								
3.1 Assessment Plan Team																										
4.0 Basinal Strategy – Infrastructure, Industries, and Business Assessment																										
4.1	Assessment Plan	KGS, IGS																								
5.0 Technology Assessment & Development							-															_				
5.1 Develop Plan KGS, IGS																										
6.0 Tec	hnology Innovation Cent	ter																				_				
6.1	Develop Plan	KGS																								
7.0 Outreach and Education																						\neg				
7.1	Develop Plan	KGS																								
8.0 Reporting											•												-			
8.1	Interim Phase 1 Report	KGS													Х											
8.2	NETL-EDX	KGS																								
8.3	Final Phase 1 Report	KGS																					Χ			
	Phase 2 Application																						Χ			