$C_M C_S C_F C_B$

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

U.S. DEPARTMENT OF ENERGY

FE0032056

IGS Iowa Geological Survey

Kansas Geological Survey, University of Kansas

Missouri Geological Survey 1853

Conservation and Survey Division

Studying Nebraska and Serving Nebraskans for 128 years

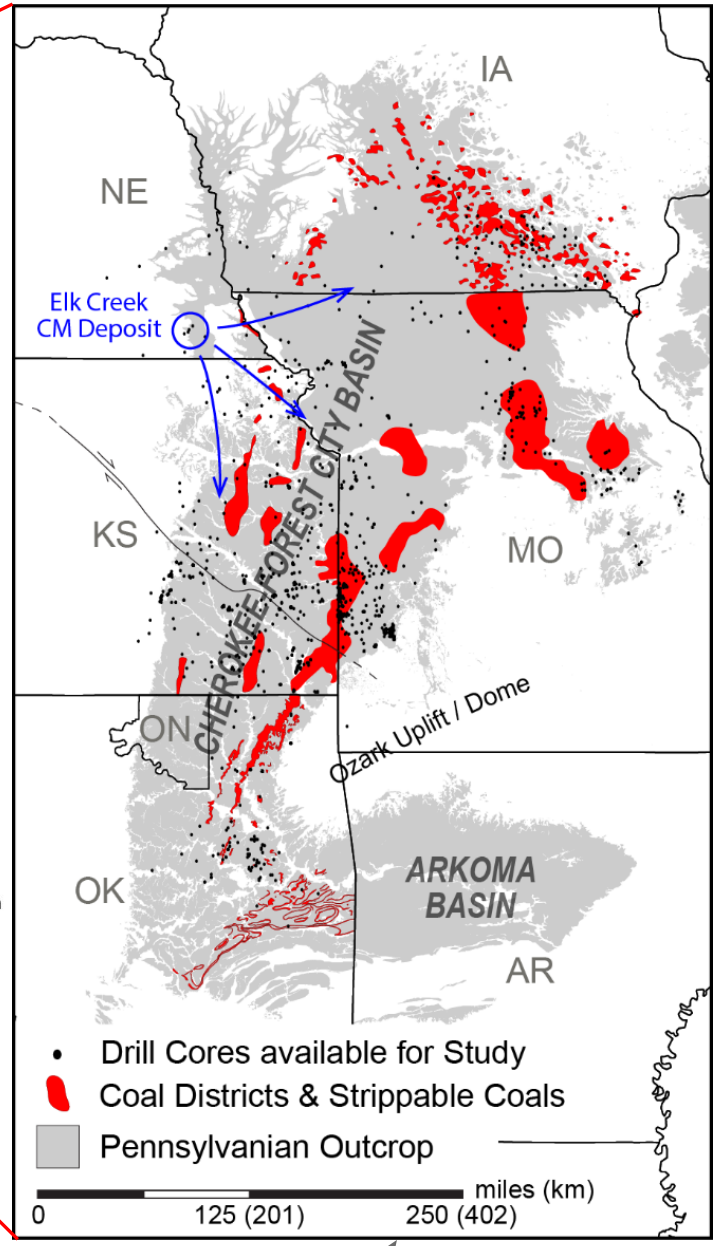
128 YRS CSD 1893-2021

Oklahoma Geological Survey OGS 1908

OSAGE Minerals Council

Outline

CoreCM - Kansas



1. Outreach
2. Geochem catch-up
3. Geochem Wireline Tool w/core
4. Data Management and Visualization
5. Numerical Modeling

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Engagement and Outreach

Advisory Council - quarterly

Industry engagement

- Survey/call plan by SCS Engineers (Carrie Ridley)
- Critical Materials Tech Hub CM2AE (T. Caruso – UMKC)
- Osage Nation Oil & Gas summit

Outreach & Community Engagement

- CM educational included in KGS outreach materials
  - Translation to Spanish and Osage underway
- KGS - Osage Nation educational event
- CM – KGS Public Informational Circular (working)

"smells like rotten eggs"

1. Outreach

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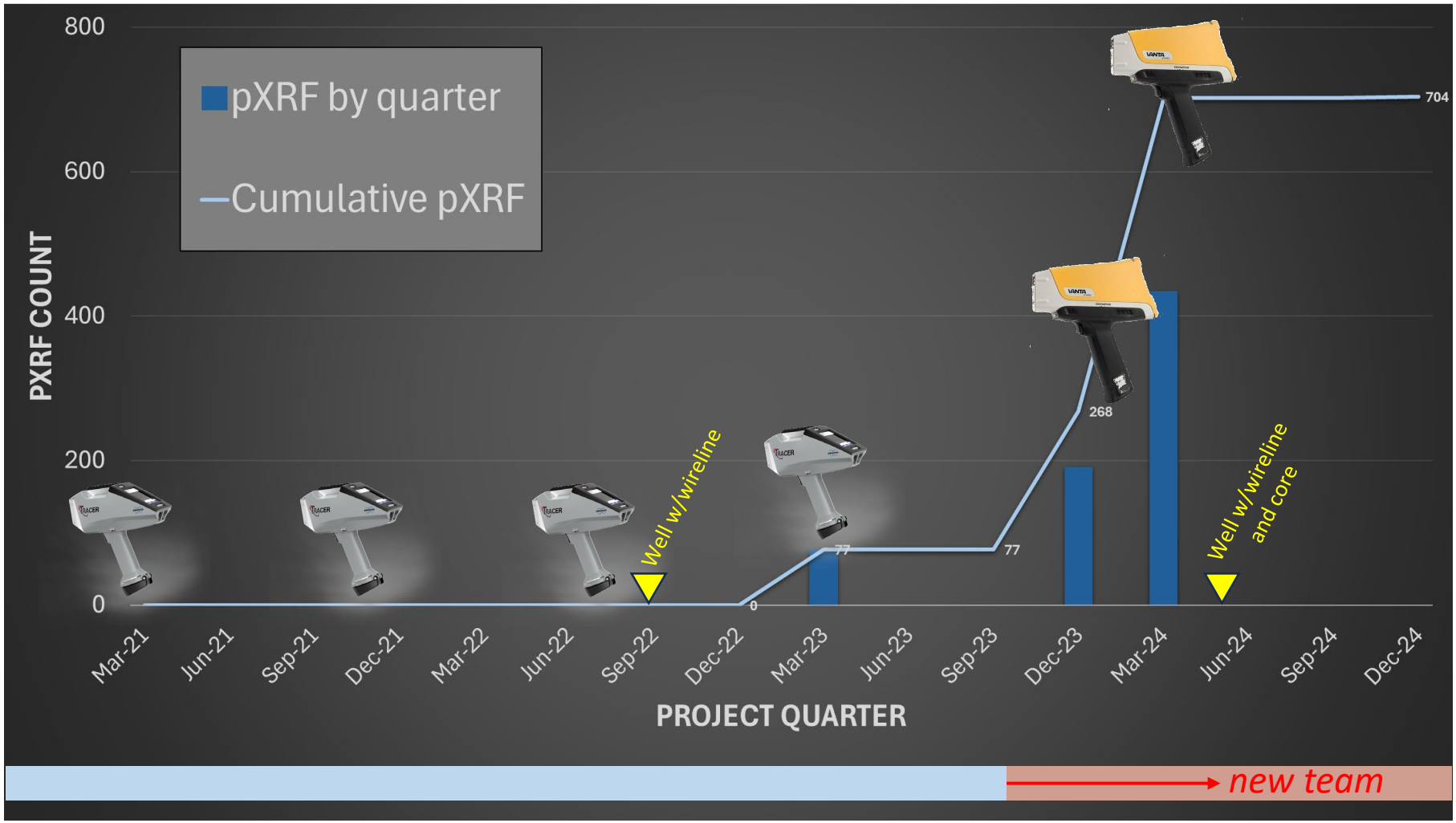
Geochem Catch-up (1 of 3)

June 2020 Nov 2023



Kate Andrzejewski

2. Geochem Catchup

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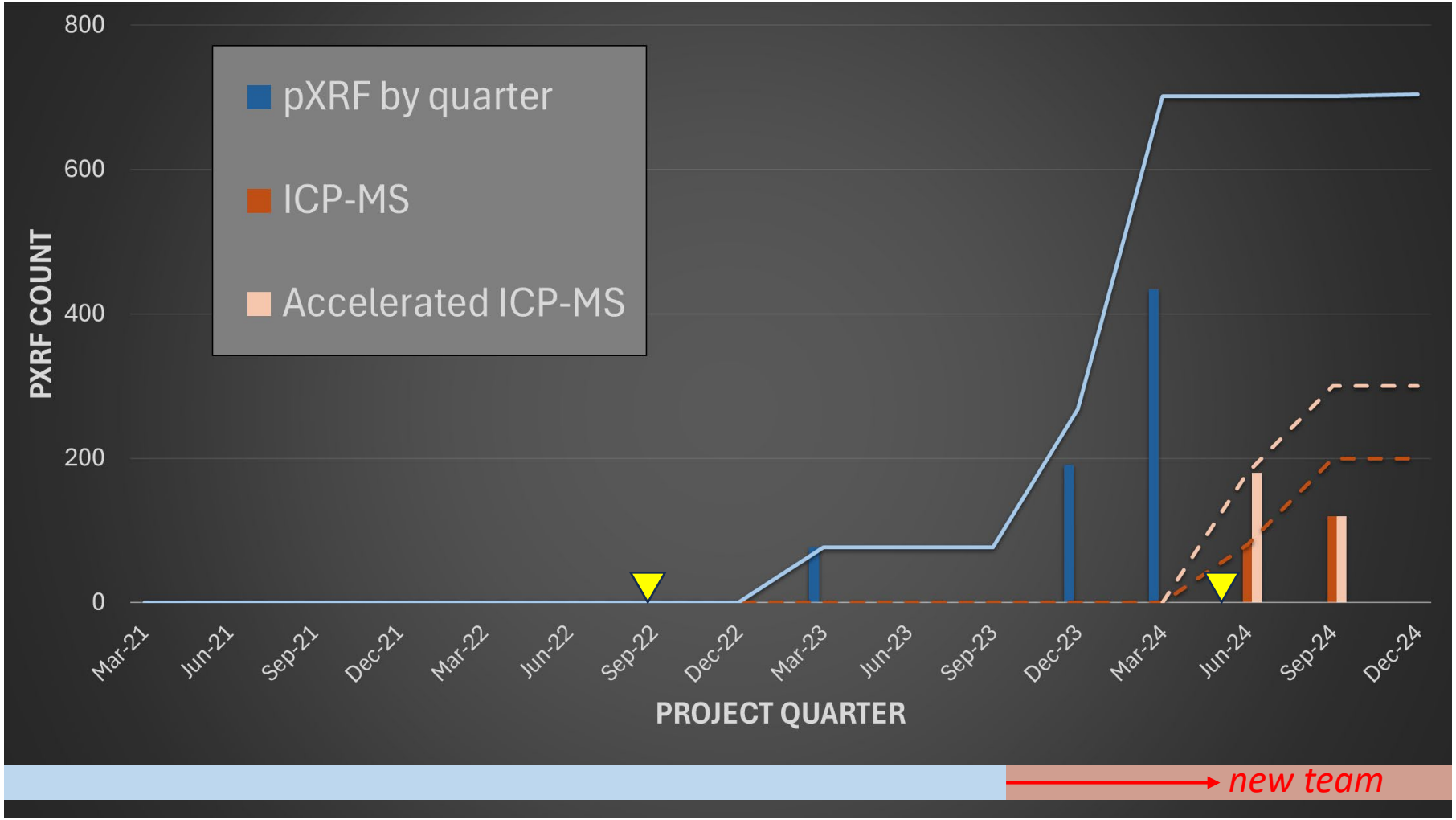
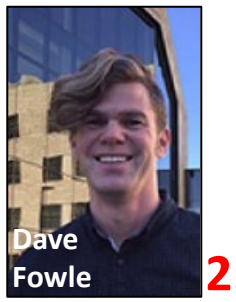
Geochem Catch-up (2 of 3)

University of Iowa ICP-MS





2. Geochem Catchup

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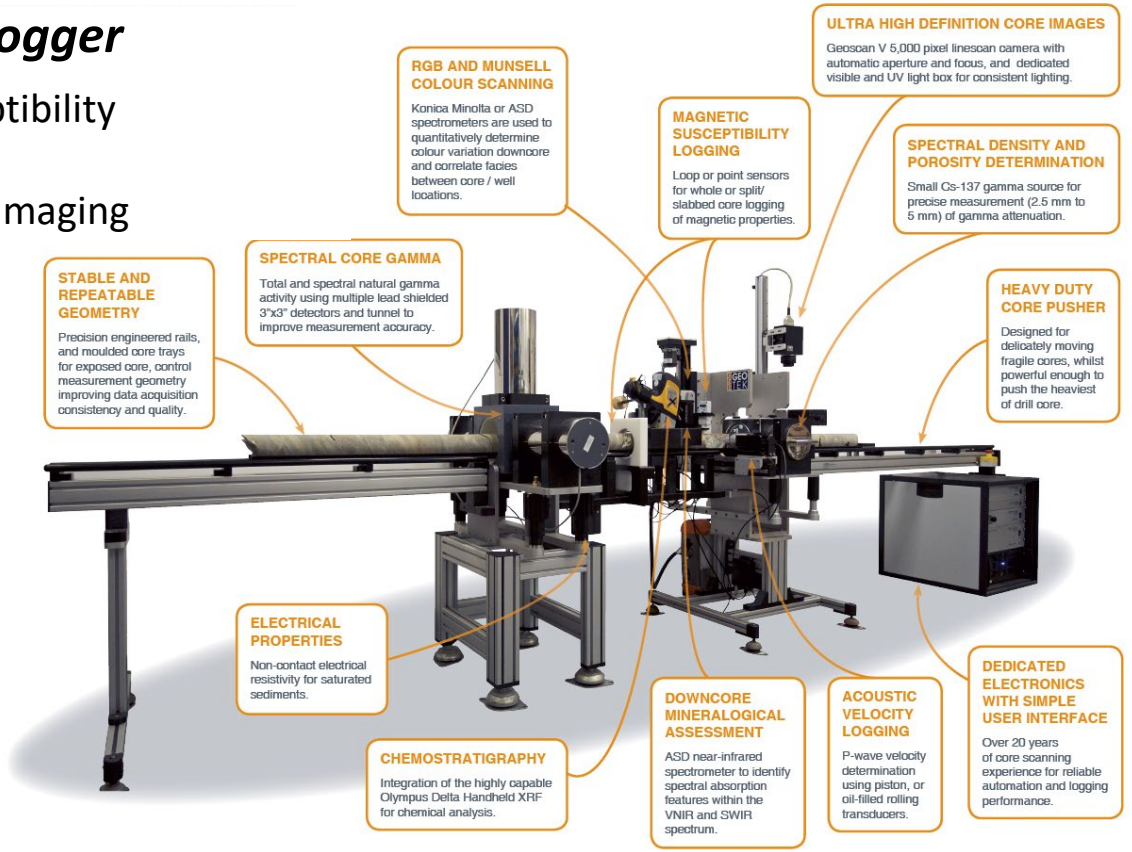
Geochem Catch-up (3 of 3)- MSCL Core Logger

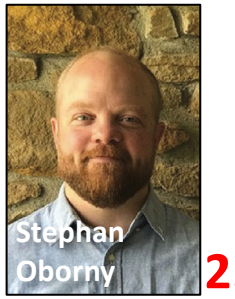
	Critical Minerals (ppm)																																					Other Elements (ppm)		
Sample Reference # (# required to enable calculations)	Al	Sb	As	$BaSO_4$	Be	Bi	Cs	Cr	Co	CaF_2	Ga	Ge	Graphite	Hf	He	In	Li	Mg	Mn	Nb	Ru	Rh	Pd	Os	Ir	Pt	Potash	Re	Rb	Sc	Sr	Ta	Te	Sn	Ti	W	U	V	Zr	Y	Other	Other	Other

Geotek Training - March 2024

MSCL Core Logger

Magnetic Susceptibility
Spectral GR
High-resolution Imaging
Density
Porosity
P-wave velocity
pXRF (1000's)





2. Geochem Catchup

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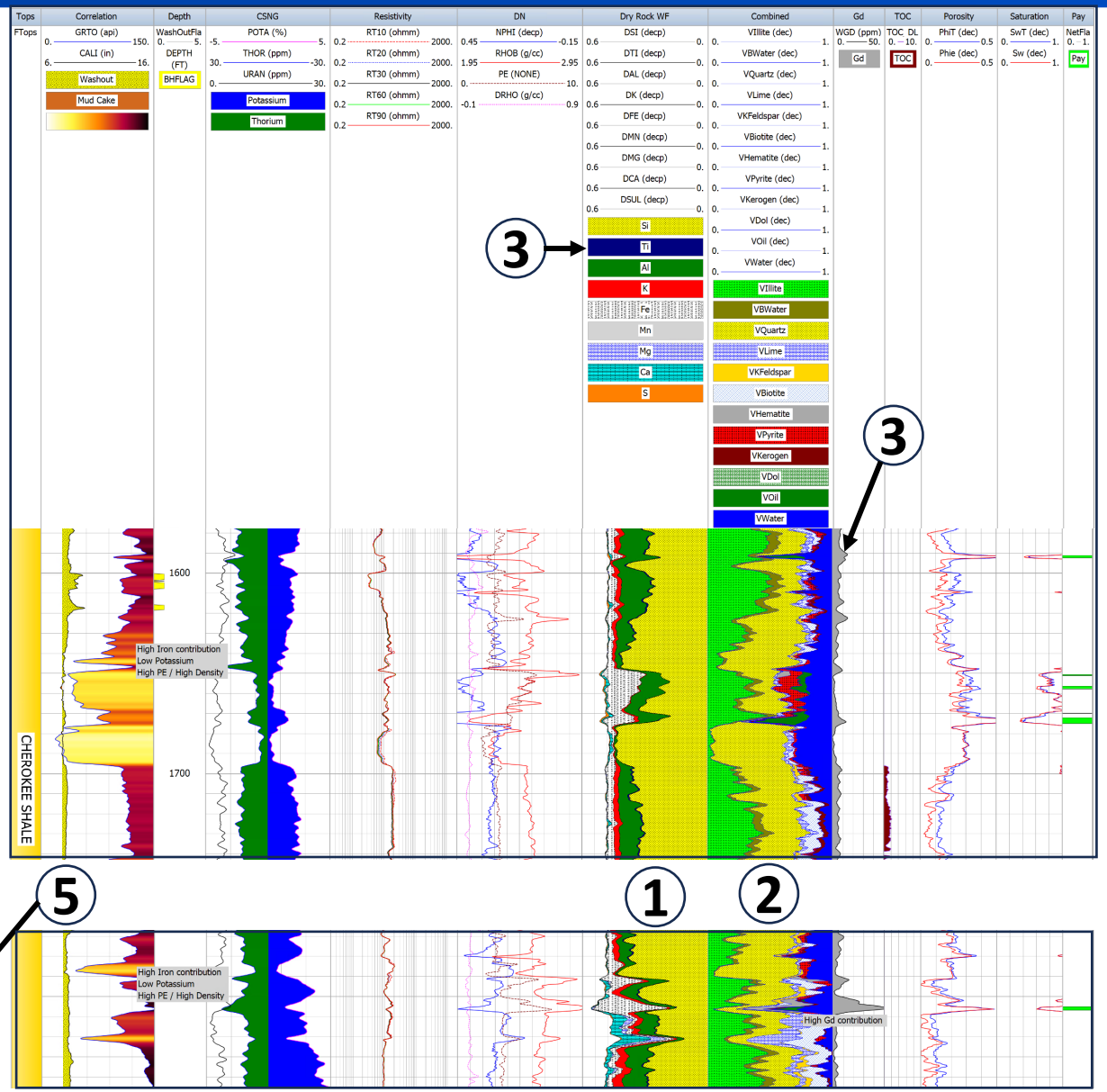
Geochem Wireline Tool with Core



3. Geochemical Wireline Tool with Core

Halliburton GEM Tool

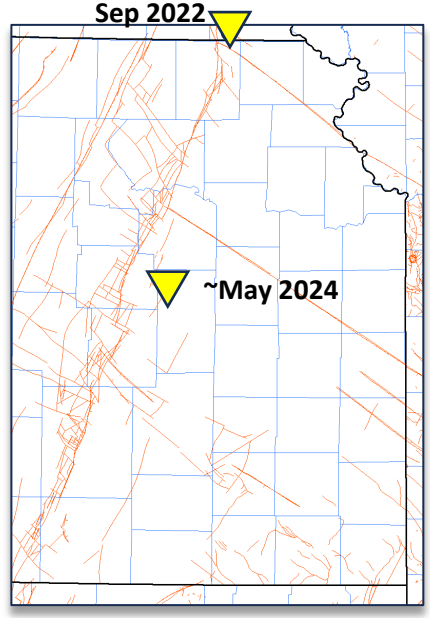
1. Nuclear Spectroscopy records near-continuous elemental concentration
   - Si, Fe, S, Ca, etc.
2. Closure and Petrophysical Model = Lithology
3. Gd, Mn, Ti concentrations from instrument
4. Core and regional high-quality bulk-rock chemistry
5. Geophysicist/Petrophysicist!!

jason.gumble@ku.edu

SAND - High Fe, High Density, Low K

SAND – Low GR, Low Fe, Low Density

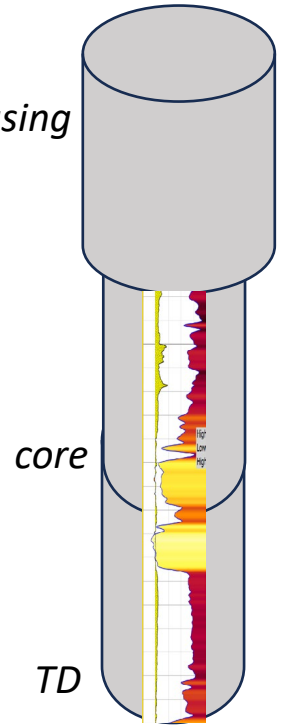
SHALE - High Gd shale (~2000-feet MD)

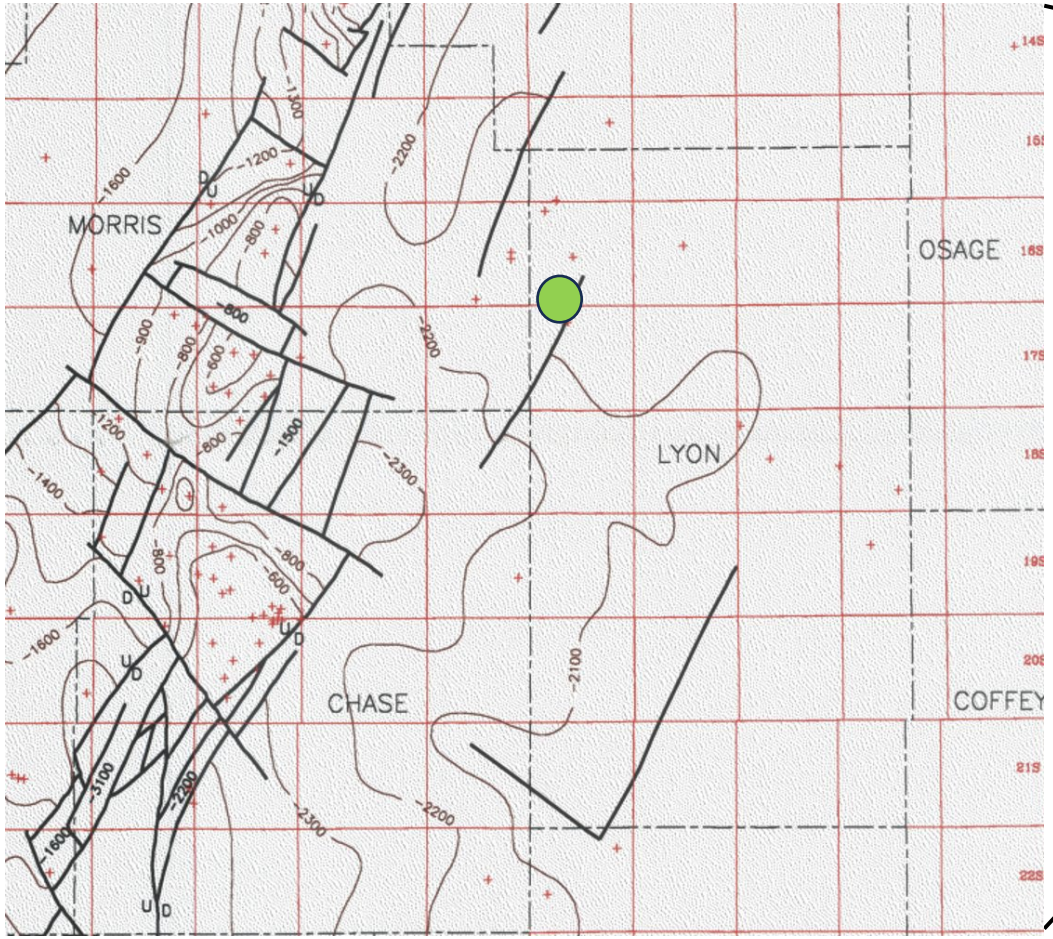


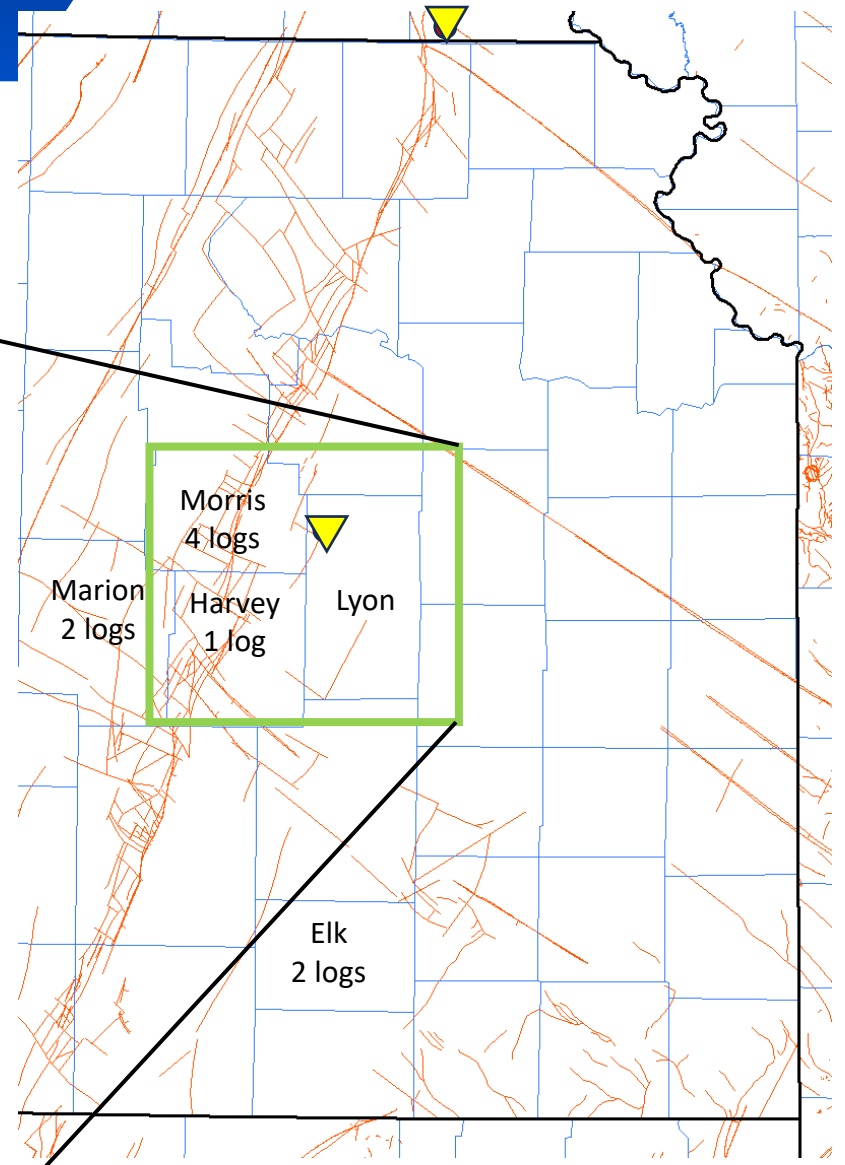
CoreCM Drilling Operations (2 of 2)

May 2024 Well Plan with KS O&G operator

- Drill 7 7/8” to 3,000-feet (measured depth)
- Shallow 4” core through Lower Pennsylvanian (~2,350-feet MD)
- Targeting 120-feet of continuous core







3. Geochemical Wireline Tool with Core

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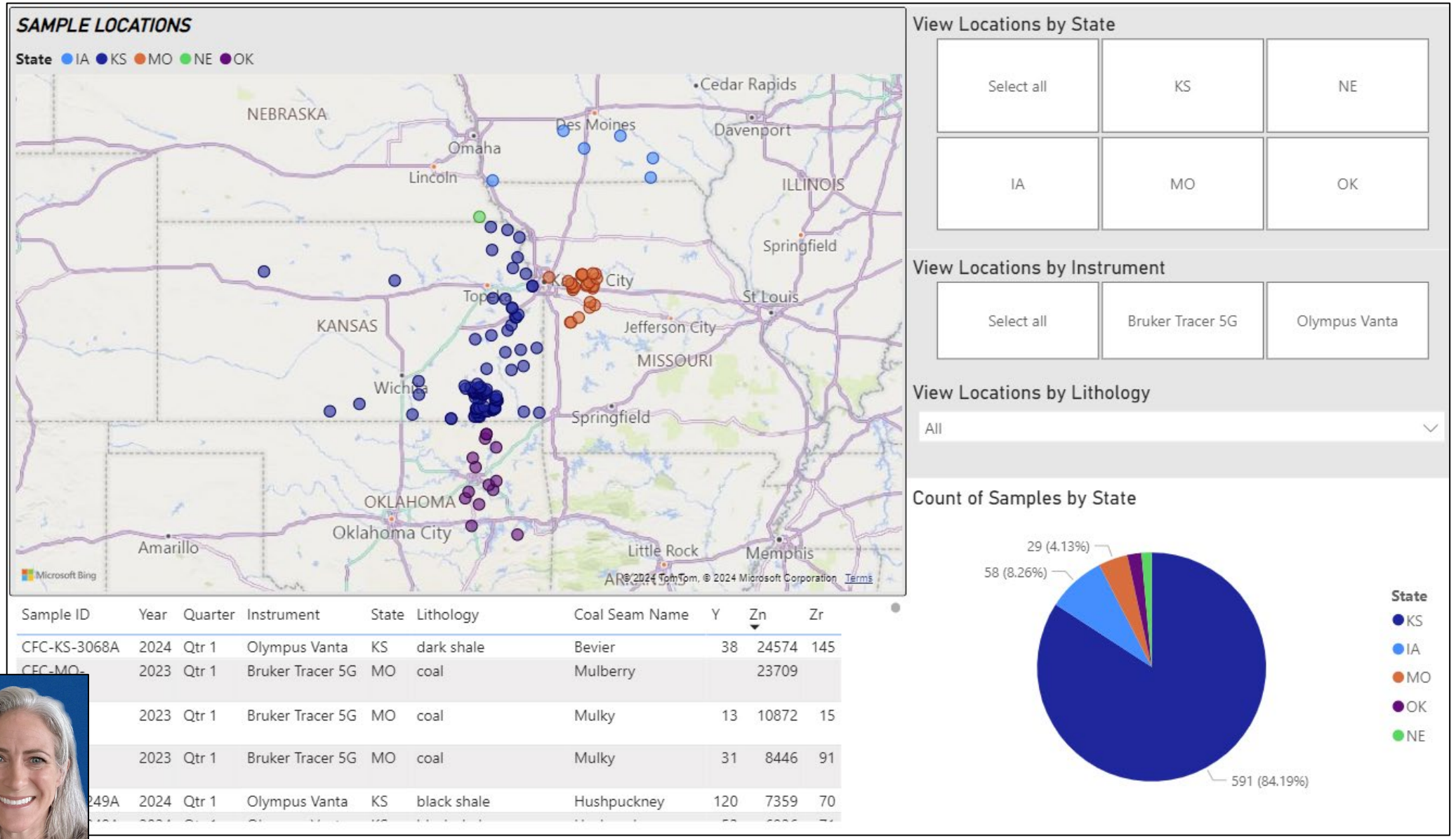
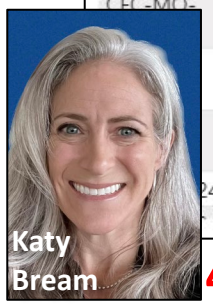
Data Management & Visualization (1 of 3)



Sample ID	Year	Quarter	Instrument	State	Lithology	Coal Seam Name	Y	Zn	Zr
CFC-KS-3068A	2024	Qtr 1	Olympus Vanta	KS	dark shale	Bevier	38	24574	145
CFC-MO-	2023	Qtr 1	Bruker Tracer 5G	MO	coal	Mulberry		23709	
	2023	Qtr 1	Bruker Tracer 5G	MO	coal	Mulky	13	10872	15
	2023	Qtr 1	Bruker Tracer 5G	MO	coal	Mulky	31	8446	91
249A	2024	Qtr 1	Olympus Vanta	KS	black shale	Hushpuckney	120	7359	70

PowerBI (for now)

ArcGIS Online option



4. Data Management and Visualization

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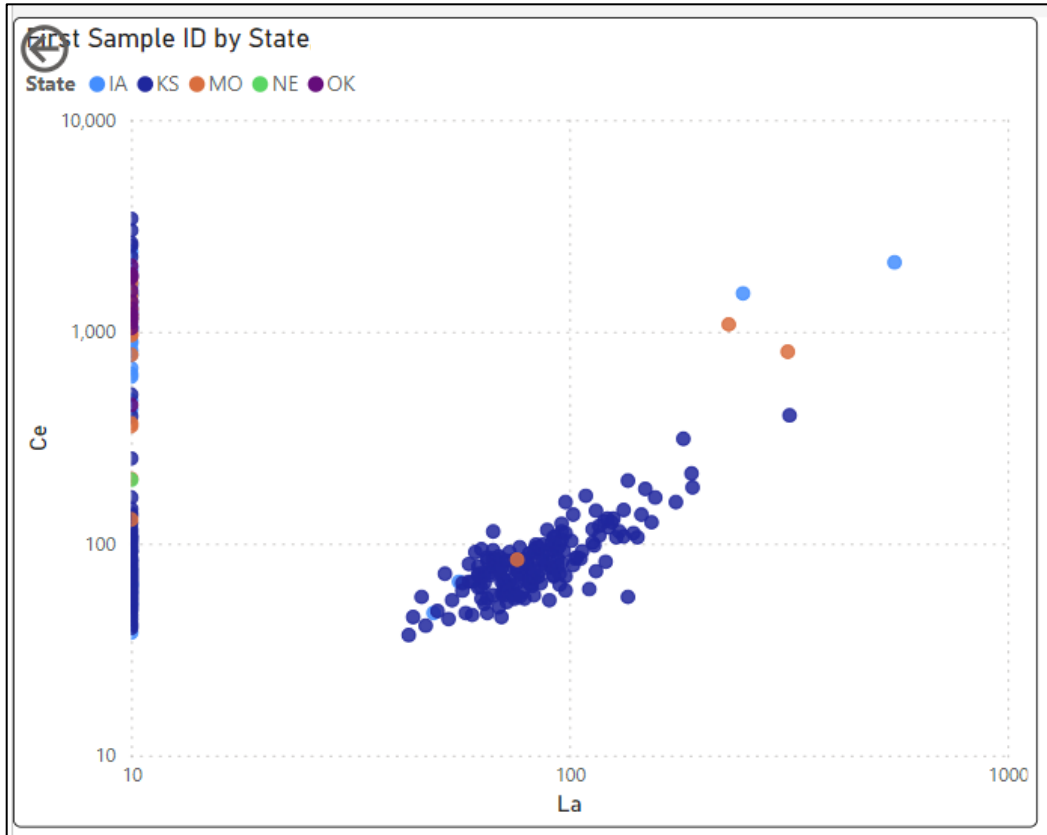
Data Management & Visualization (2 of 3)

Interactive Filters

Web Dashboard

Mobile App



X-Axis
- Ce
- Ga
- La
- Mg
- Nd
- Ni
- Pr
- Ta
- Ti
- Y
- Zn
- Zr

Y-Axis
- Ce
- Ga
- La
- Mg
- Nd
- Ni
- Pr
- Ta
- Ti
- Y
- Zn
- Zr

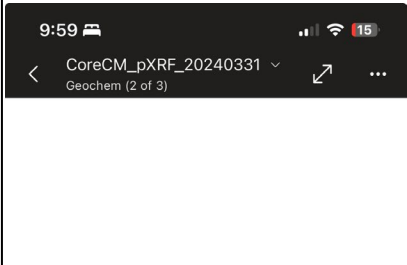
State
- Select all
- IA
- KS
- MO
- NE
- OK

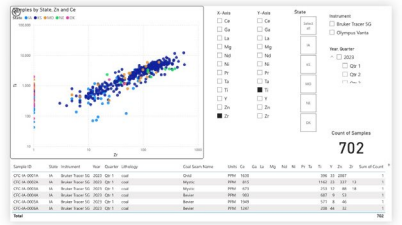
Instrument
- Bruker Tracer 5G
- Olympus Vanta

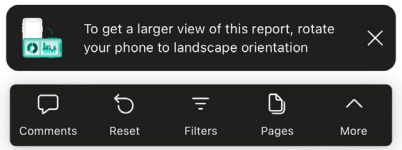
Year, Quarter
- Select all
- 2023
- 2024

Count of Samples
702

Sample ID	State	Instrument	Year	Quarter	Lithology	Coal Seam Name	Units	Ce	Ga	La	Mg	Nd	Ni	Pr	Ta	Ti	Y	Zn	Zr	Sum of Count
CFC-IA-0001A	IA	Bruker Tracer 5G	2023	Qtr 1	coal	Ovid	PPM	1630								396	35	2087		1
CFC-IA-0002A	IA	Bruker Tracer 5G	2023	Qtr 1	coal	Mystic	PPM	815								1162	23	337	13	1
-0003A	IA	Bruker Tracer 5G	2023	Qtr 1	coal	Mystic	PPM	673								253	12	88	18	1
-0004A	IA	Bruker Tracer 5G	2023	Qtr 1	coal	Bevier	PPM	903								687	9	53		1
-0005A	IA	Bruker Tracer 5G	2023	Qtr 1	coal	Bevier	PPM	1949								571	8	46		1
-0006A	IA	Bruker Tracer 5G	2023	Qtr 1	coal	Bevier	PPM	1247								208	44	32		1
																				702







4. Data Management and Visualization

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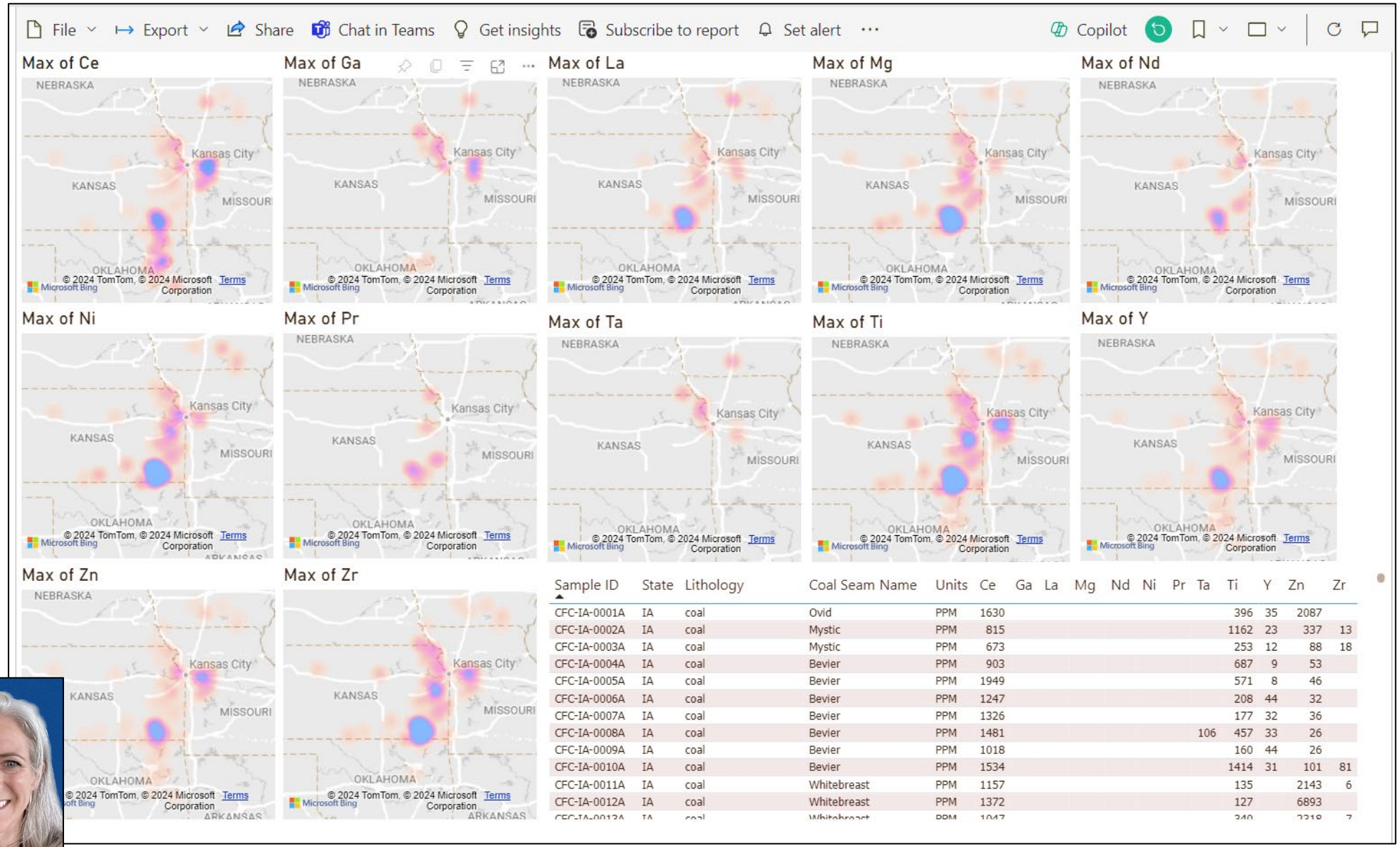
Data Management & Visualization (3 of 3)

Scale intentionally not provided



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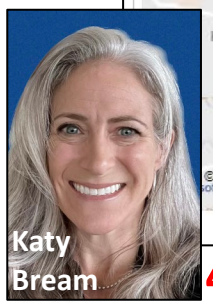
CFC-IA-0001A	IA	coal	Ovid	PPM	1630								396	35	2087	
CFC-IA-0002A	IA	coal	Mystic	PPM	815								1162	23	337	13
CFC-IA-0003A	IA	coal	Mystic	PPM	673								253	12	88	18
CFC-IA-0004A	IA	coal	Bevier	PPM	903								687	9	53	
CFC-IA-0005A	IA	coal	Bevier	PPM	1949								571	8	46	
CFC-IA-0006A	IA	coal	Bevier	PPM	1247								208	44	32	
CFC-IA-0007A	IA	coal	Bevier	PPM	1326								177	32	36	
CFC-IA-0008A	IA	coal	Bevier	PPM	1481							106	457	33	26	
CFC-IA-0009A	IA	coal	Bevier	PPM	1018								160	44	26	
CFC-IA-0010A	IA	coal	Bevier	PPM	1534								1414	31	101	81
CFC-IA-0011A	IA	coal	Whitebreast	PPM	1157								135		2143	6
CFC-IA-0012A	IA	coal	Whitebreast	PPM	1372								127		6893	



4. Data Management and Visualization

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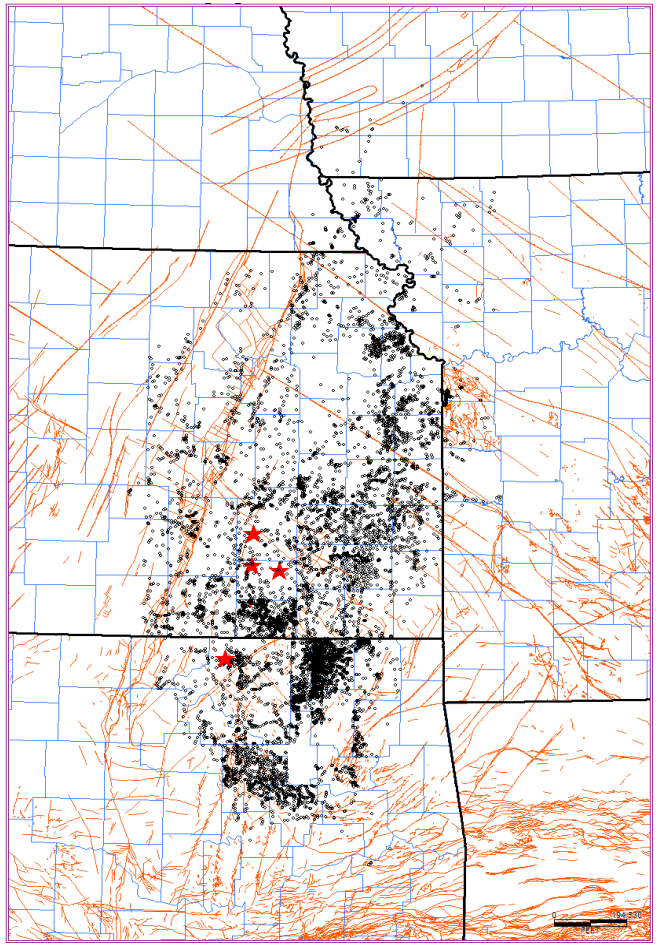
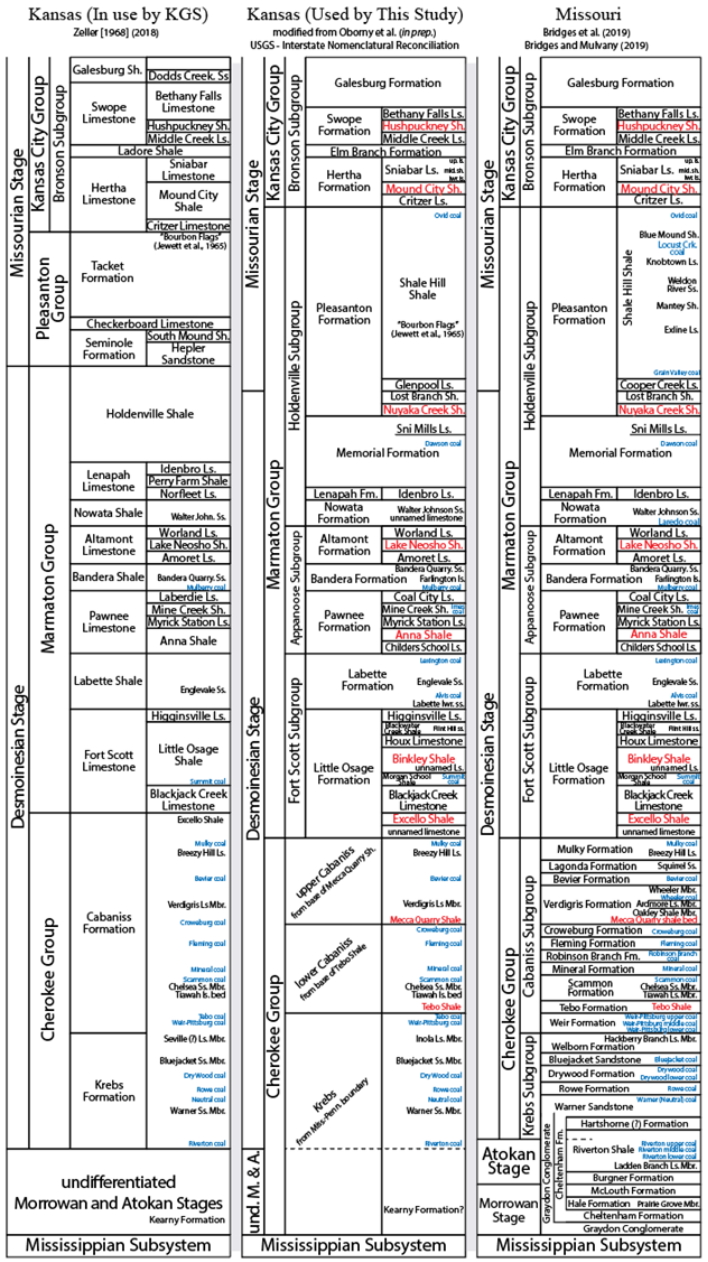
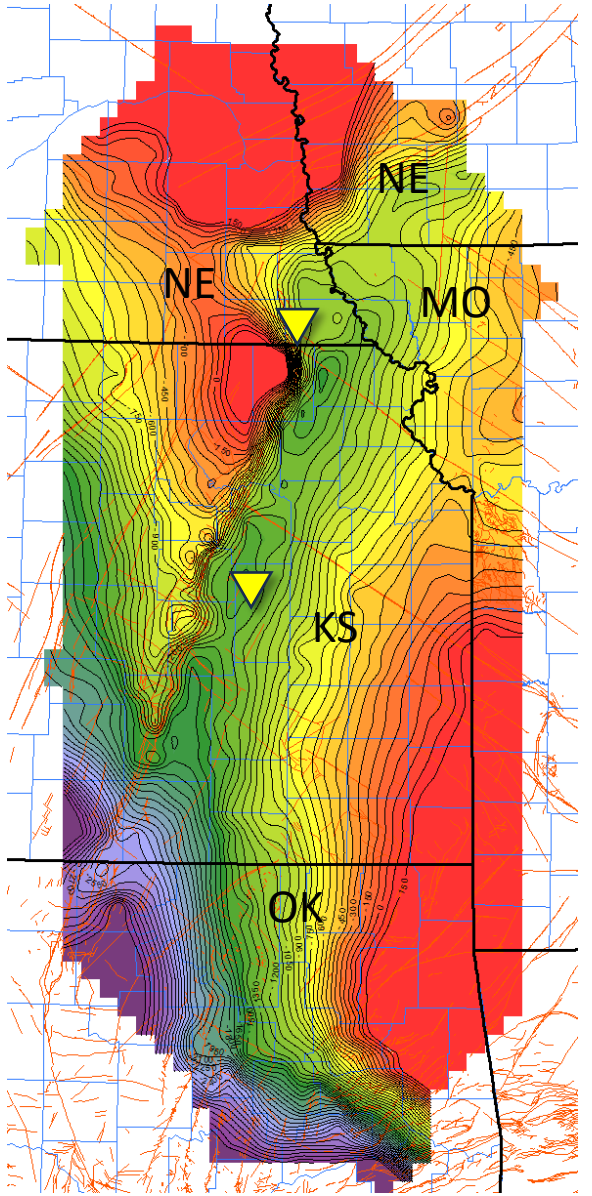
Numerical Modeling (1 of 4) “Container”

Stratigraphic Framework

- Wireline Well Log Correlation of >10,000 wells







v. 3.27.2024

5. Numerical Modeling

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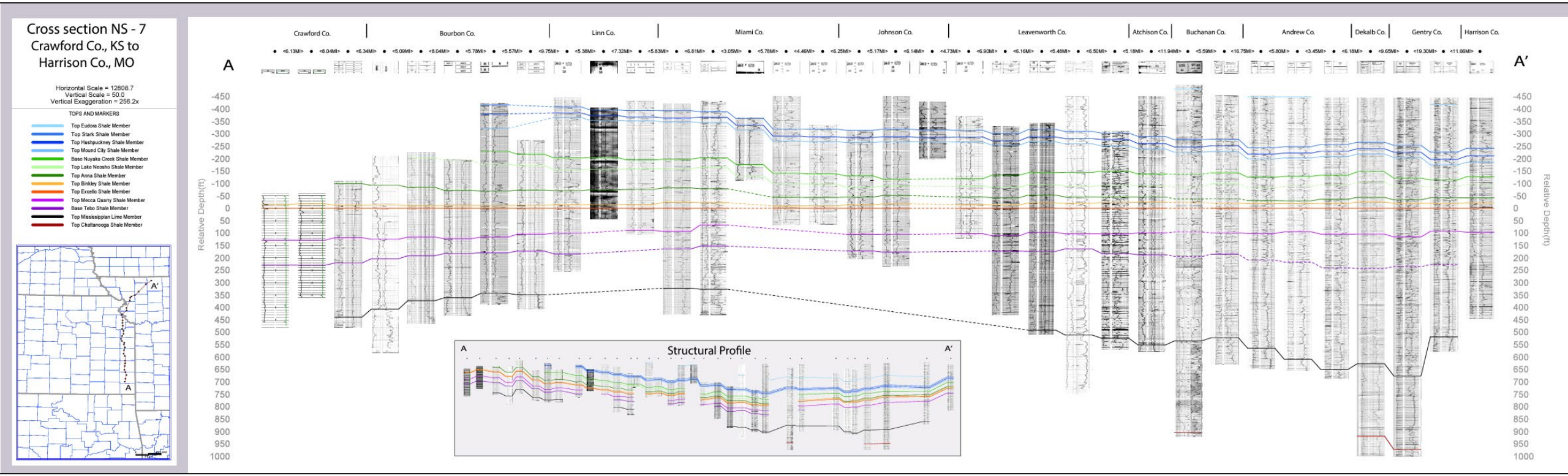
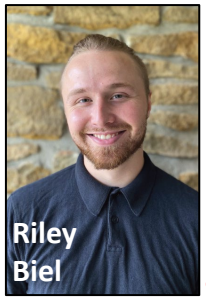
Numerical Modeling (2 of 4) “Container”





Riley Biel

5. Numerical Modeling

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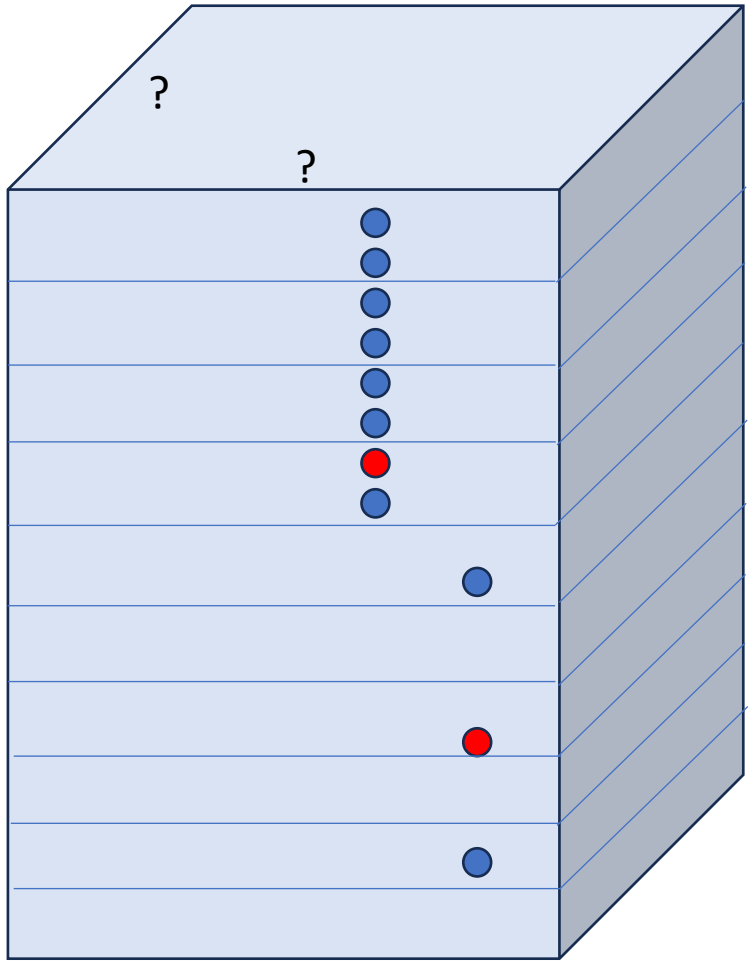
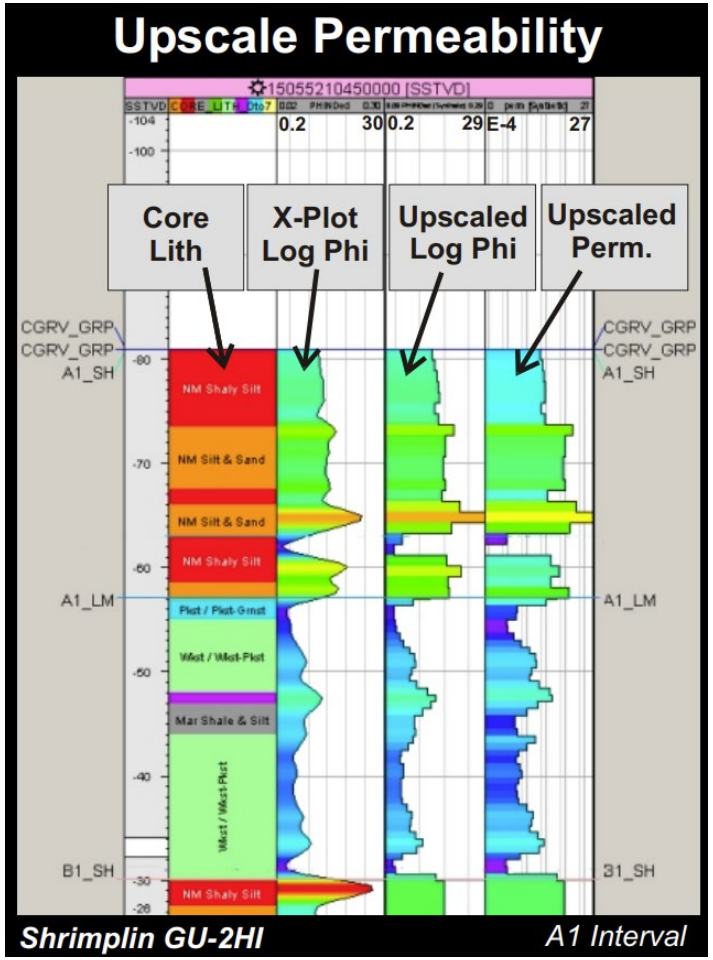
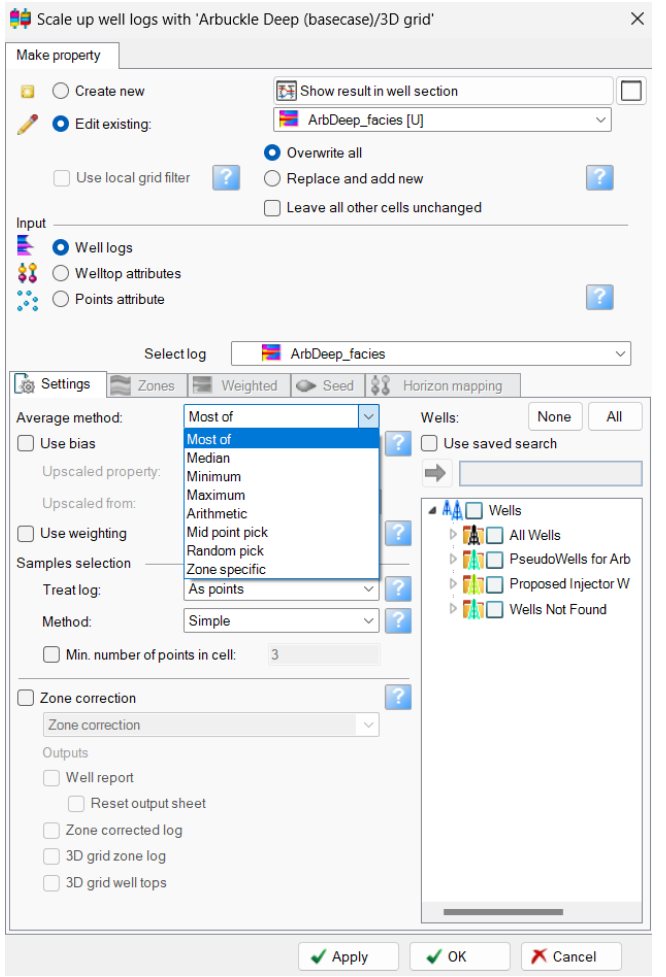
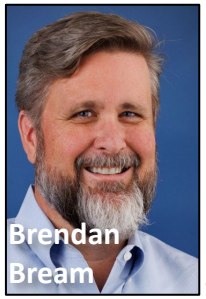
Numerical Modeling (3 of 4) "Numbers"

Use High-resolution well log correlation surfaces as “containers”
Upscale geochemical data - (all? including pXRF?)
Populate between data points – (by facies?, within container subzones?)



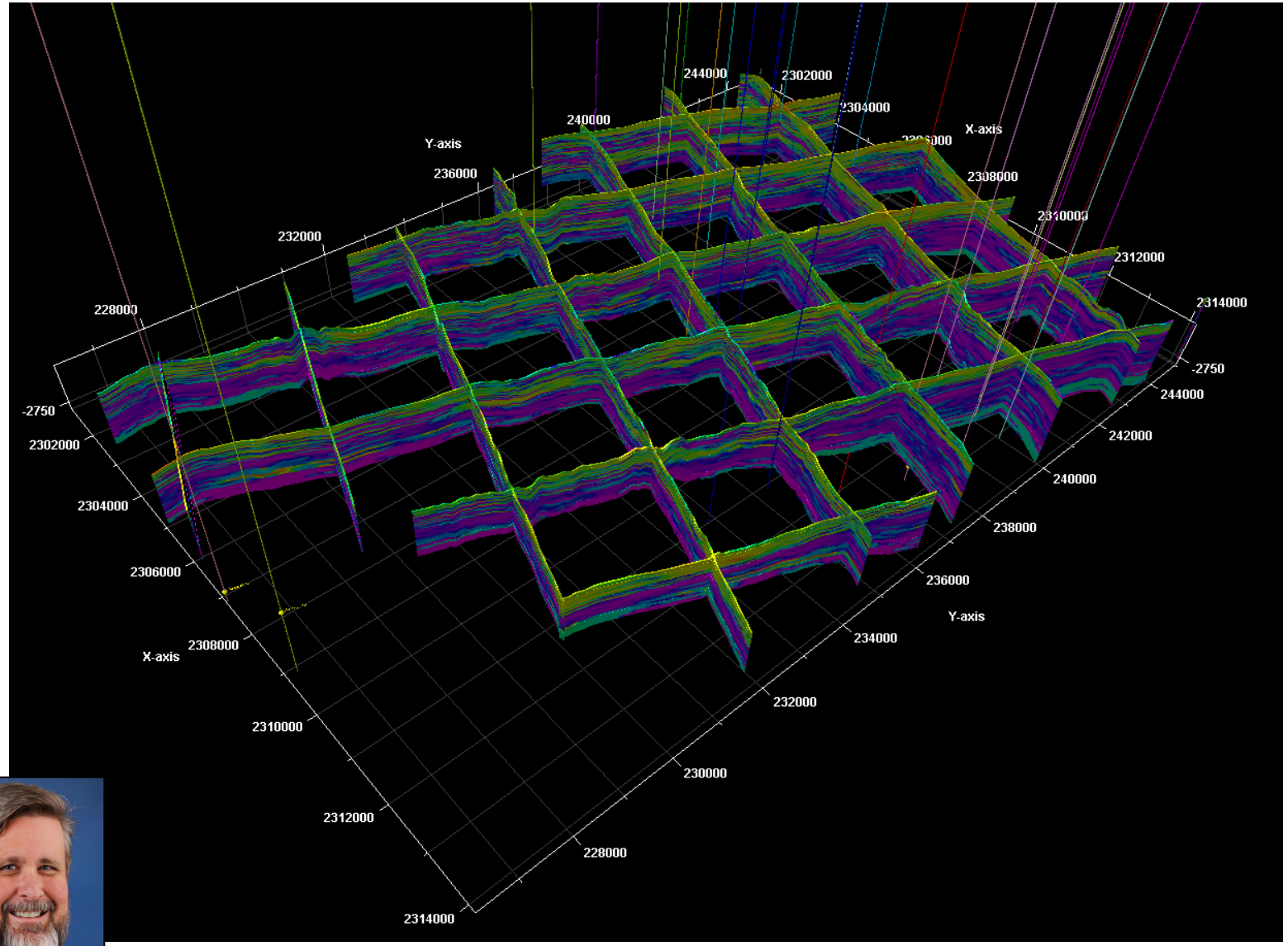






5. Numerical Modeling

Numerical Modeling (4 of 4) "Numbers"



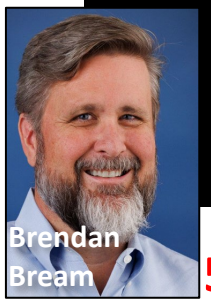
Multiple elemental abundance distributions

Geometric properties for cells
- Depth below surface
- Distance to [TBD facility]
- Distance to nearest control
- Depth to max concentration

Test predictive ability
- New well?, New core?
- Larger model?

Volumetrics
- Bulk rock volume
- Concentration-thickness

Automate with workflows for iterating Neural Network to connect dots?



5. Numerical Modeling

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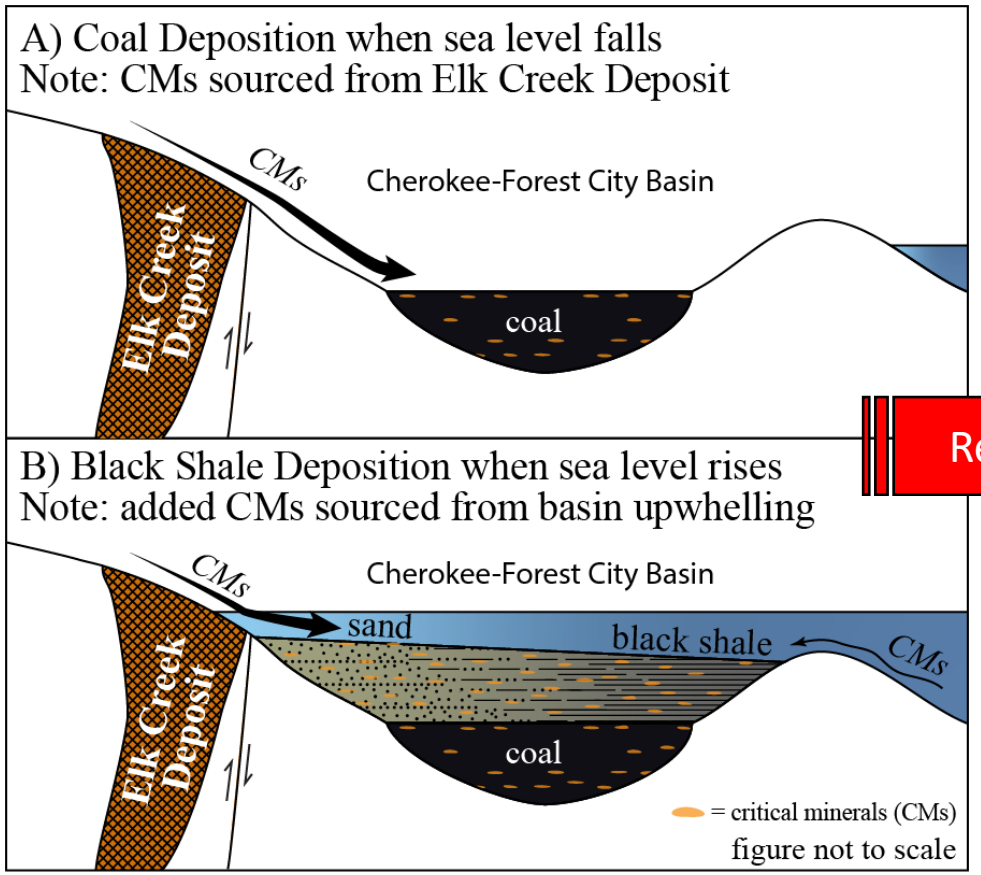
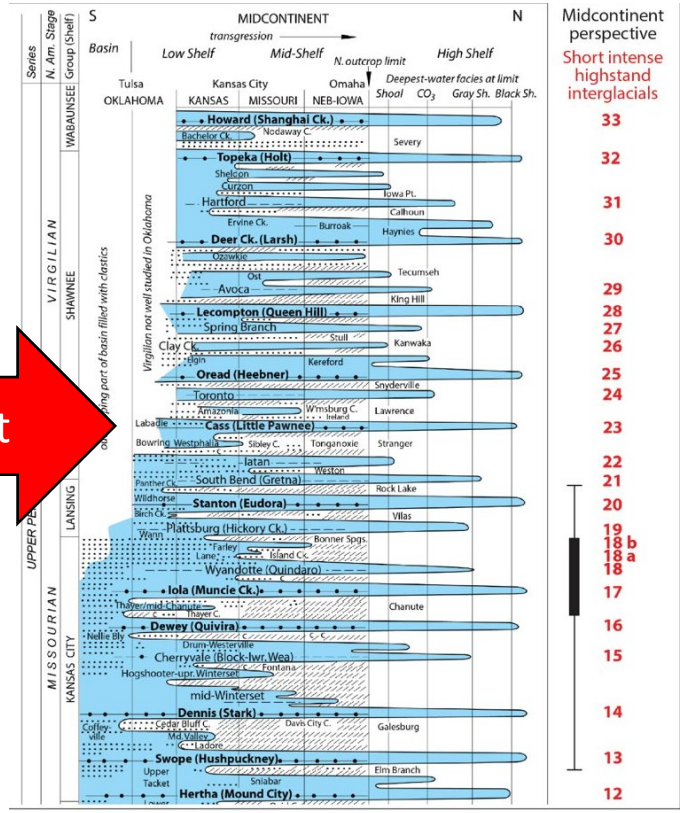
Test the Hypotheses



Repeat



Heckel, 2013; Oborny et al., 2017

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Conclusions

U.S. DEPARTMENT OF ENERGY

Conservation and Survey Division

Studying Nebraska and Serving Nebraskans for 128 years

128 YRS CSD 1893-2021

IGS Iowa Geological Survey

OSAGE Minerals Council

Oklahoma Geological Survey OGS 1908

Missouri Geological Survey 1853

Kansas Geological Survey University of Kansas

Project Execution

- Right Team!
- Right Plan!
- *Right Time?*

KU Kansas Geological Survey The University of Kansas