

$C_M C_S C_F C_B$
*Critical Minerals in Coaly Strata
of the Cherokee-Forest City Basin*



U.S. DEPARTMENT OF
ENERGY FE0032056



Conservation and Survey Division

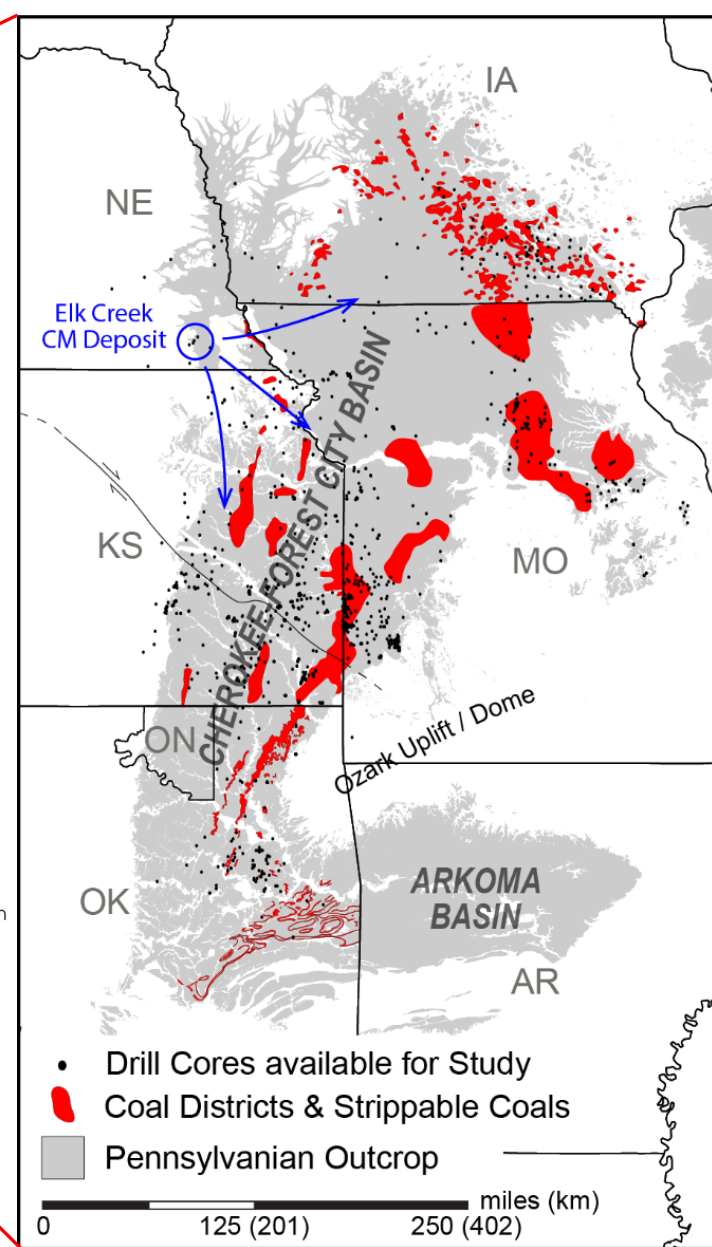
Studying Nebraska and
Serving Nebraskans for 128 years



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

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”



Blair
Schneider

Geochem Catch-up (1 of 3)



June 2020

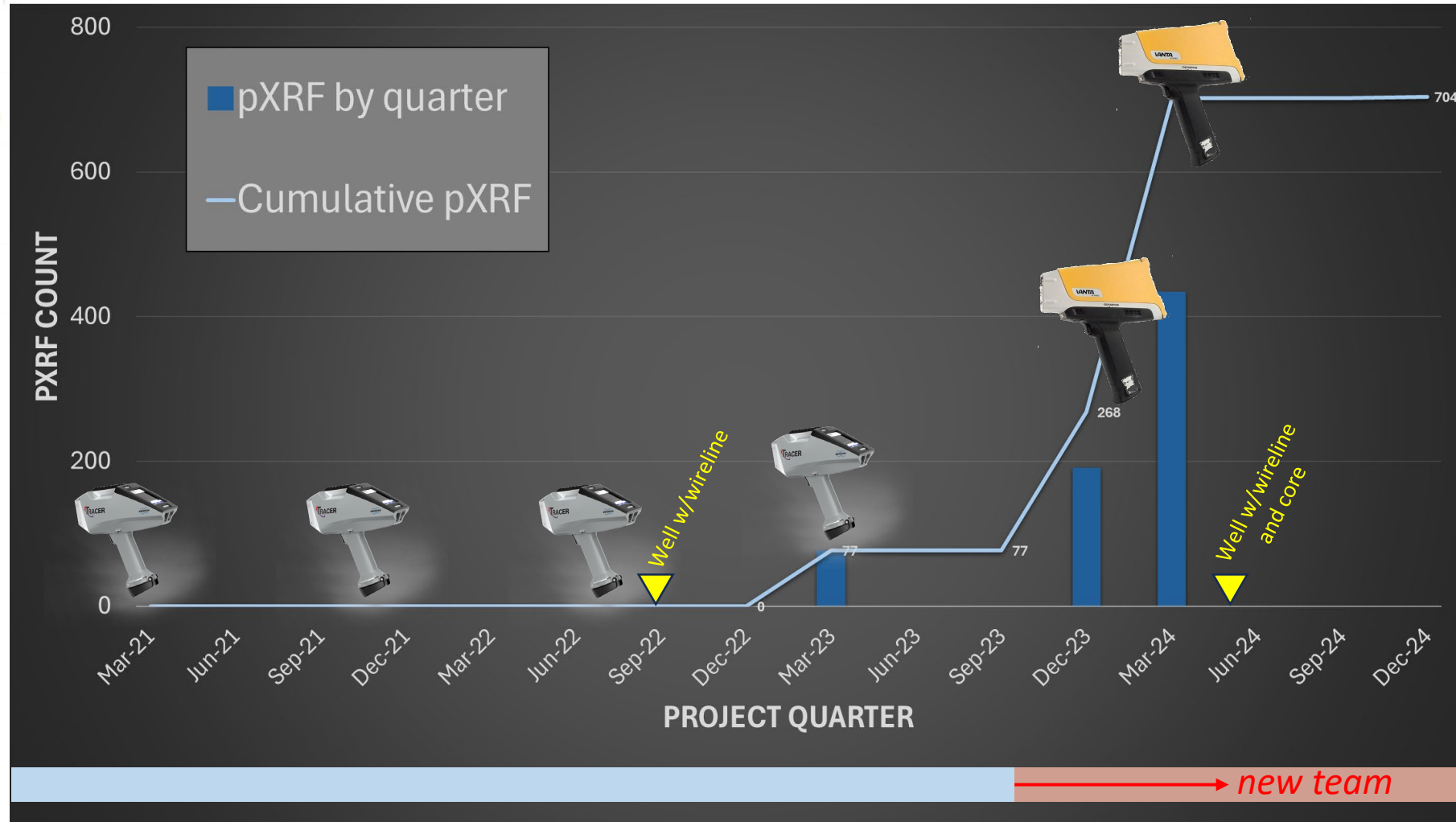


Nov 2023



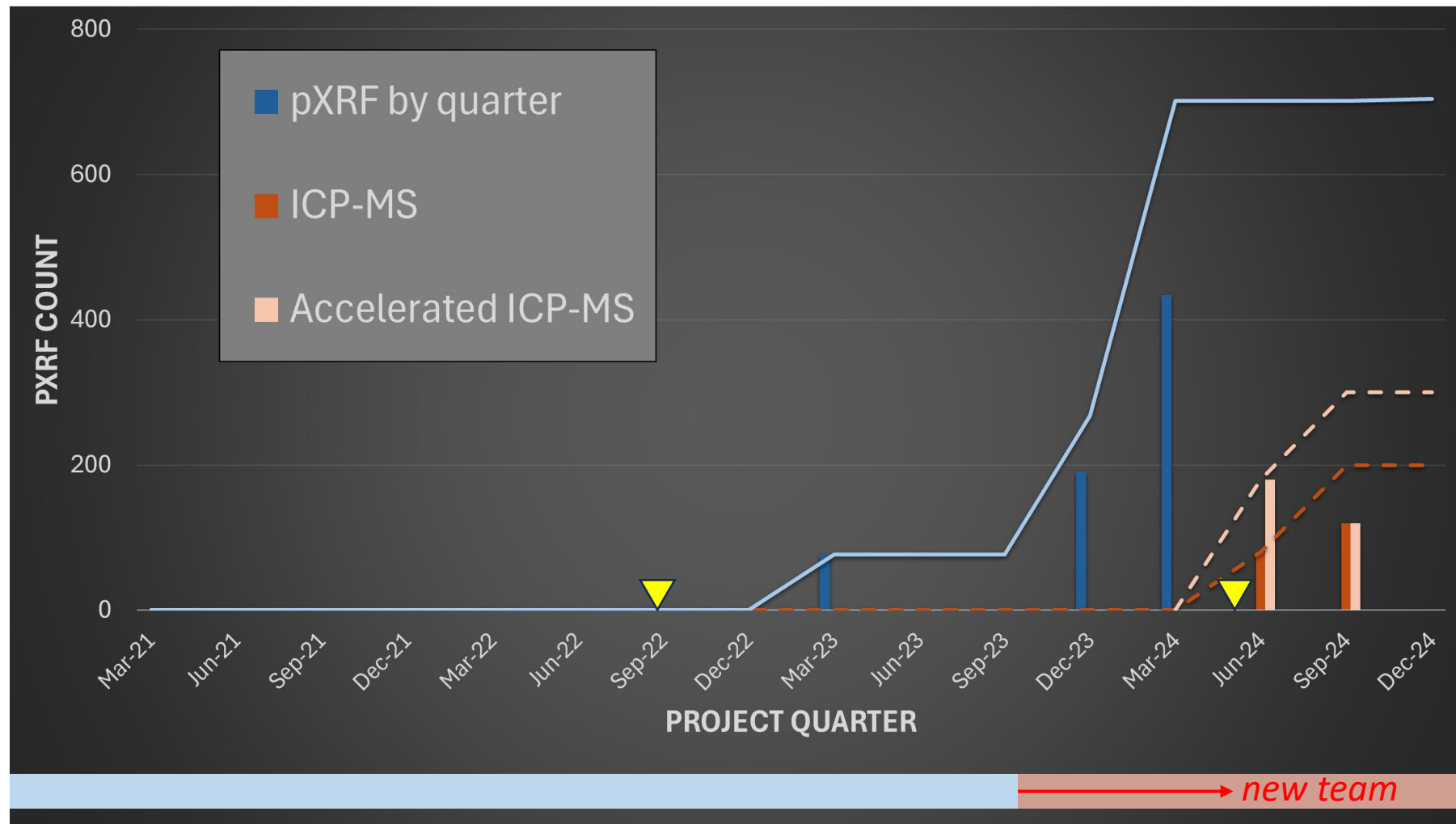
Kate Andrzejewski

2. Geochem Catchup



Geochem Catch-up (2 of 3)

University of Iowa ICP-MS



Dave Fowle

2. Geochem Catchup

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

Sample Reference # (# required to enable calculations)	Critical Minerals (ppm)																							Other Elements (ppm)																		
	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



Geotek Training - March 2024

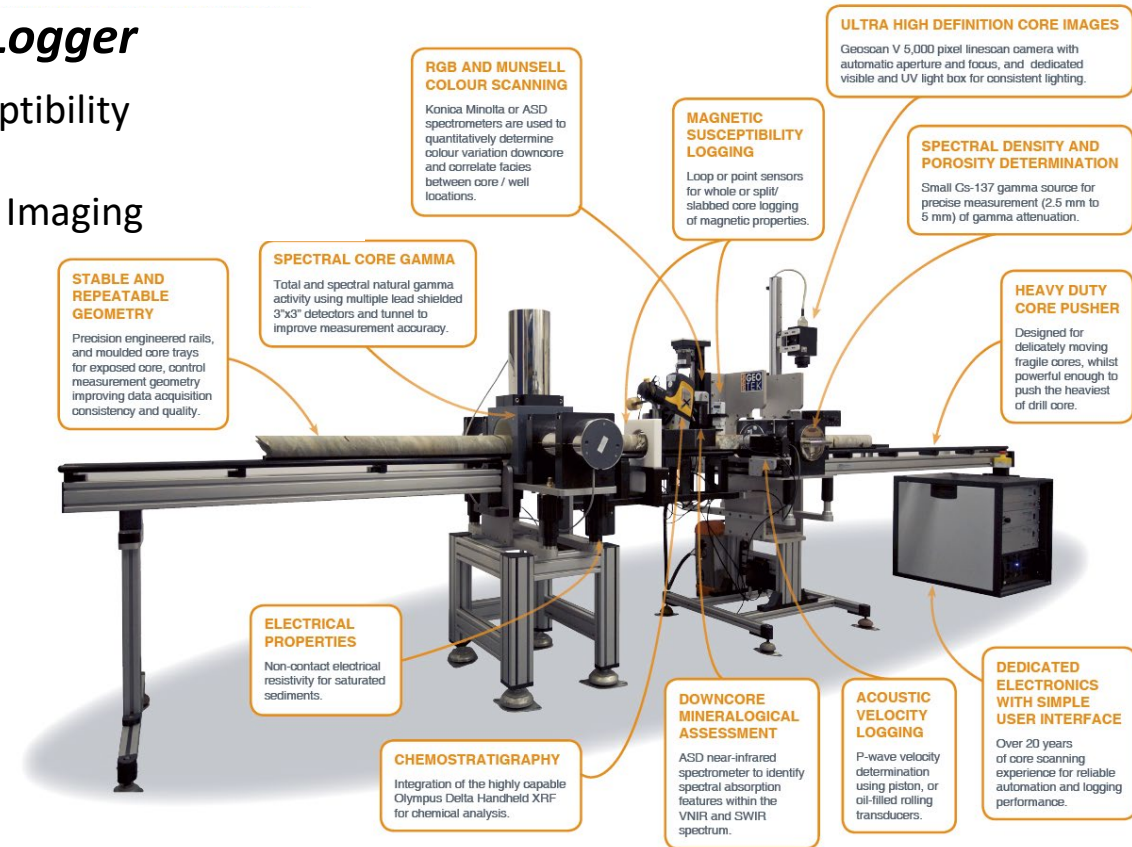


Stephan Oborny

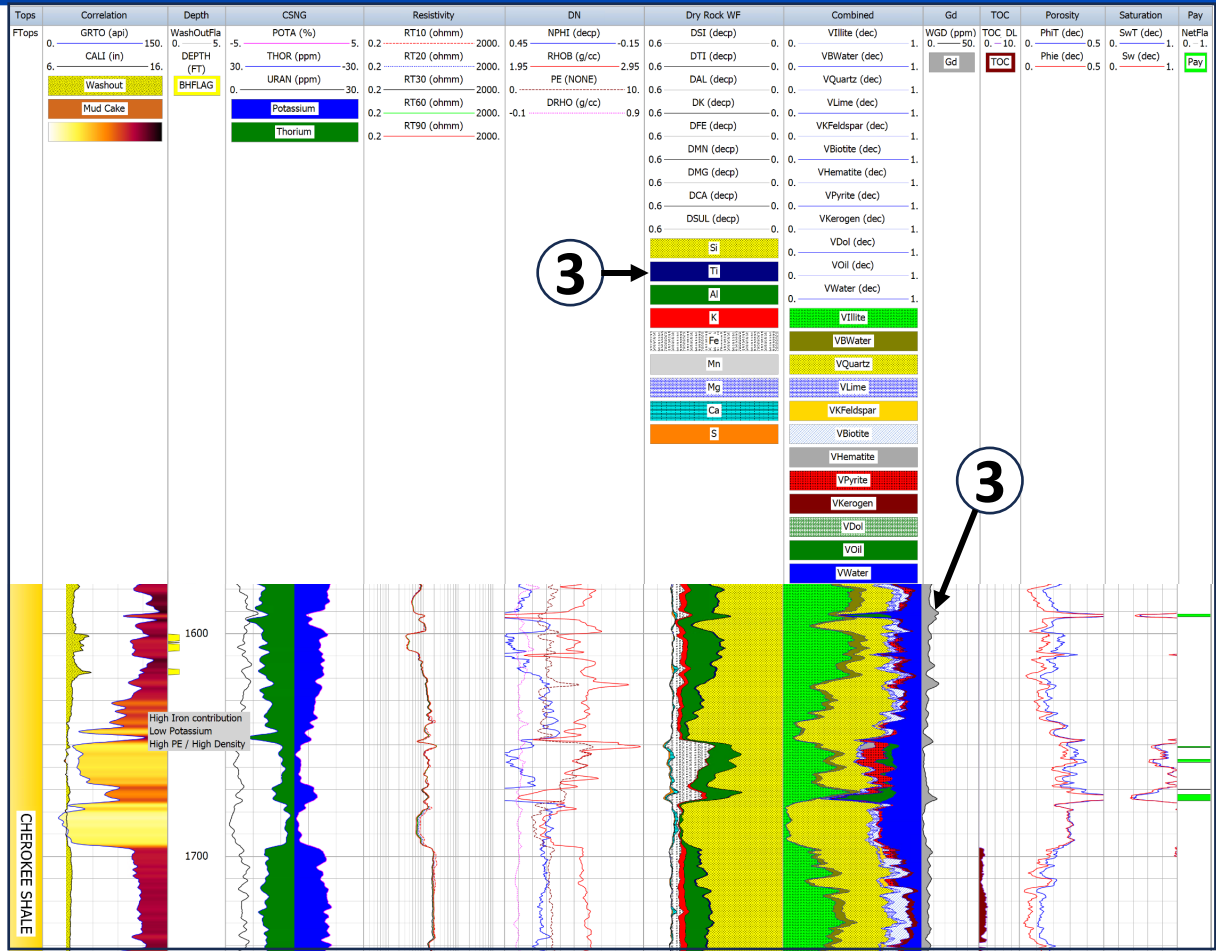
2. Geochem Catchup

MSCL Core Logger

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



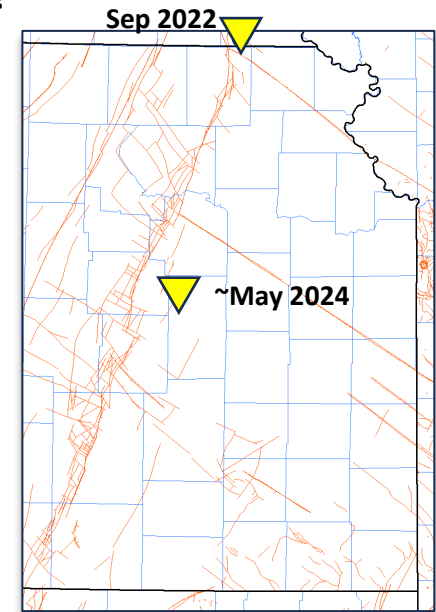
Geochem Wireline Tool with Core



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

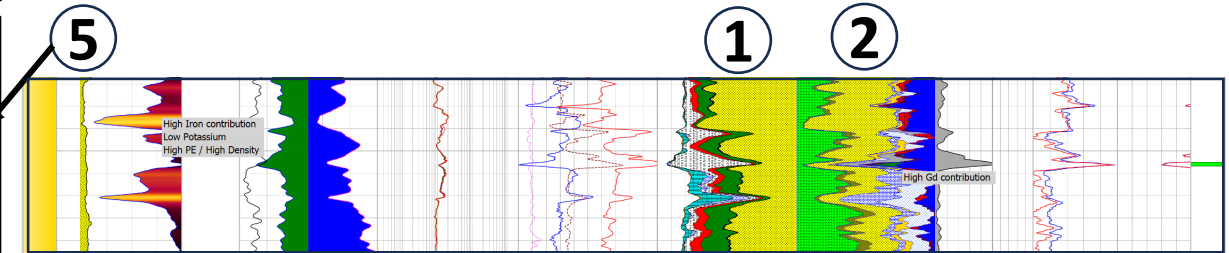
SHALE - High Gd shale (~2000-foot MD)



Doug Louis



Jason Gumble



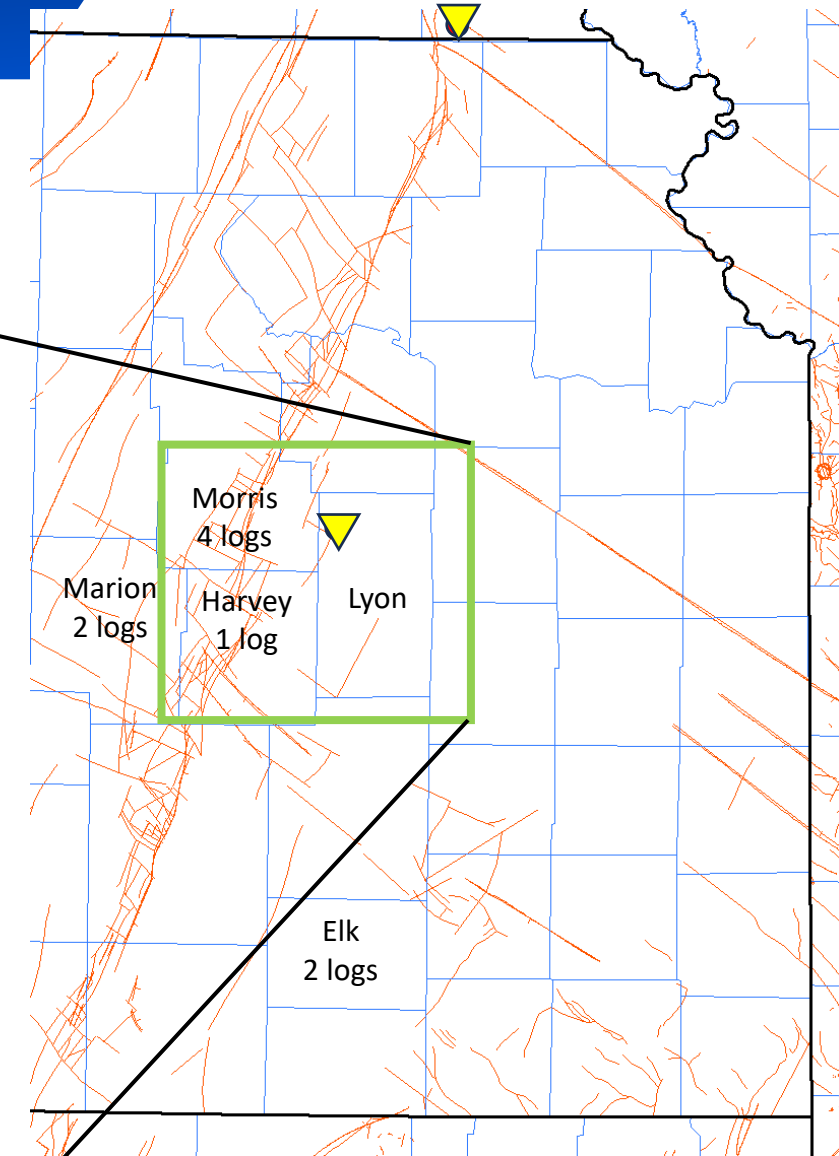
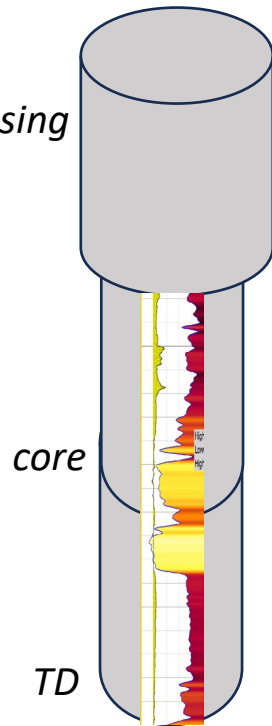
3. Geochemical Wireline Tool with Core

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

Surface Casing
>200-feet



3. Geochemical Wireline Tool with Core

Data Management & Visualization (1 of 3)

SAMPLE LOCATIONS

State ● IA ● KS ● MO ● NE ● OK

View Locations by State

Select all | KS | NE | IA | MO | OK

View Locations by Instrument

Select all | Bruker Tracer 5G | Olympus Vanta

View Locations by Lithology

All

Count of Samples by State

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



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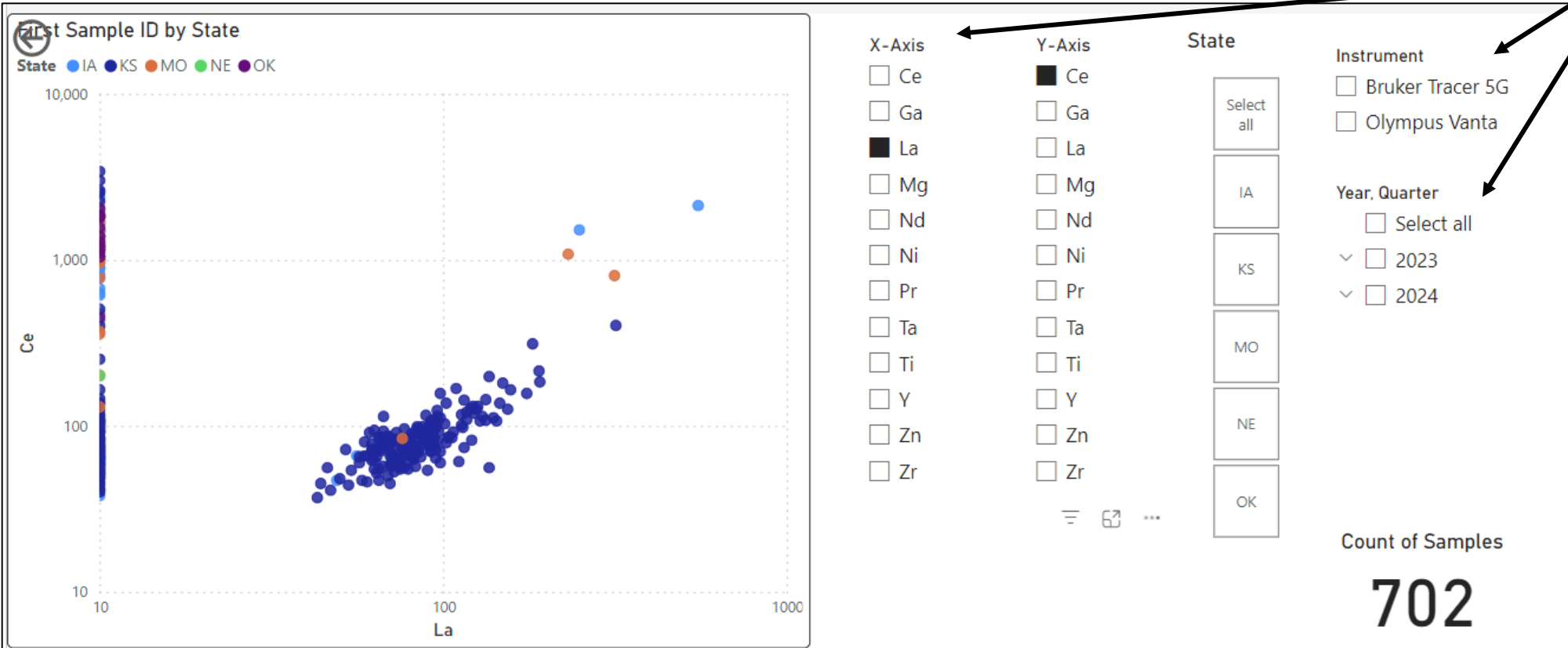
4. Data Management and Visualization

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

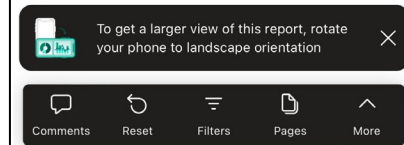
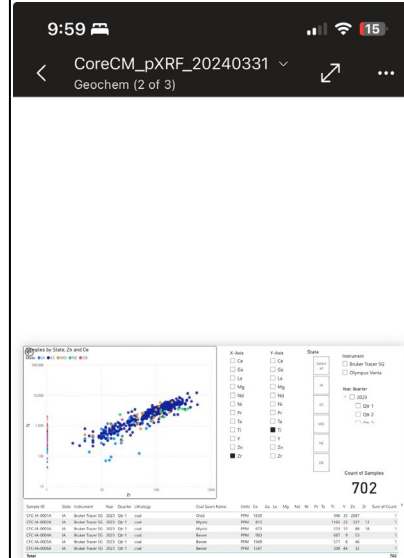
Year, Quarter

- 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
CFC-IA-0003A	IA	Bruker Tracer 5G	2023	Qtr 1	coal	Mystic	PPM	673								253	12	88	18	1
CFC-IA-0004A	IA	Bruker Tracer 5G	2023	Qtr 1	coal	Bevier	PPM	903								687	9	53		1
CFC-IA-0005A	IA	Bruker Tracer 5G	2023	Qtr 1	coal	Bevier	PPM	1949								571	8	46		1
CFC-IA-0006A	IA	Bruker Tracer 5G	2023	Qtr 1	coal	Bevier	PPM	1247								208	44	32		1
CFC-IA-0007A	IA	Bruker Tracer 5G	2023	Qtr 1	coal	Bevier	PPM	1226								177	22	26		1



702

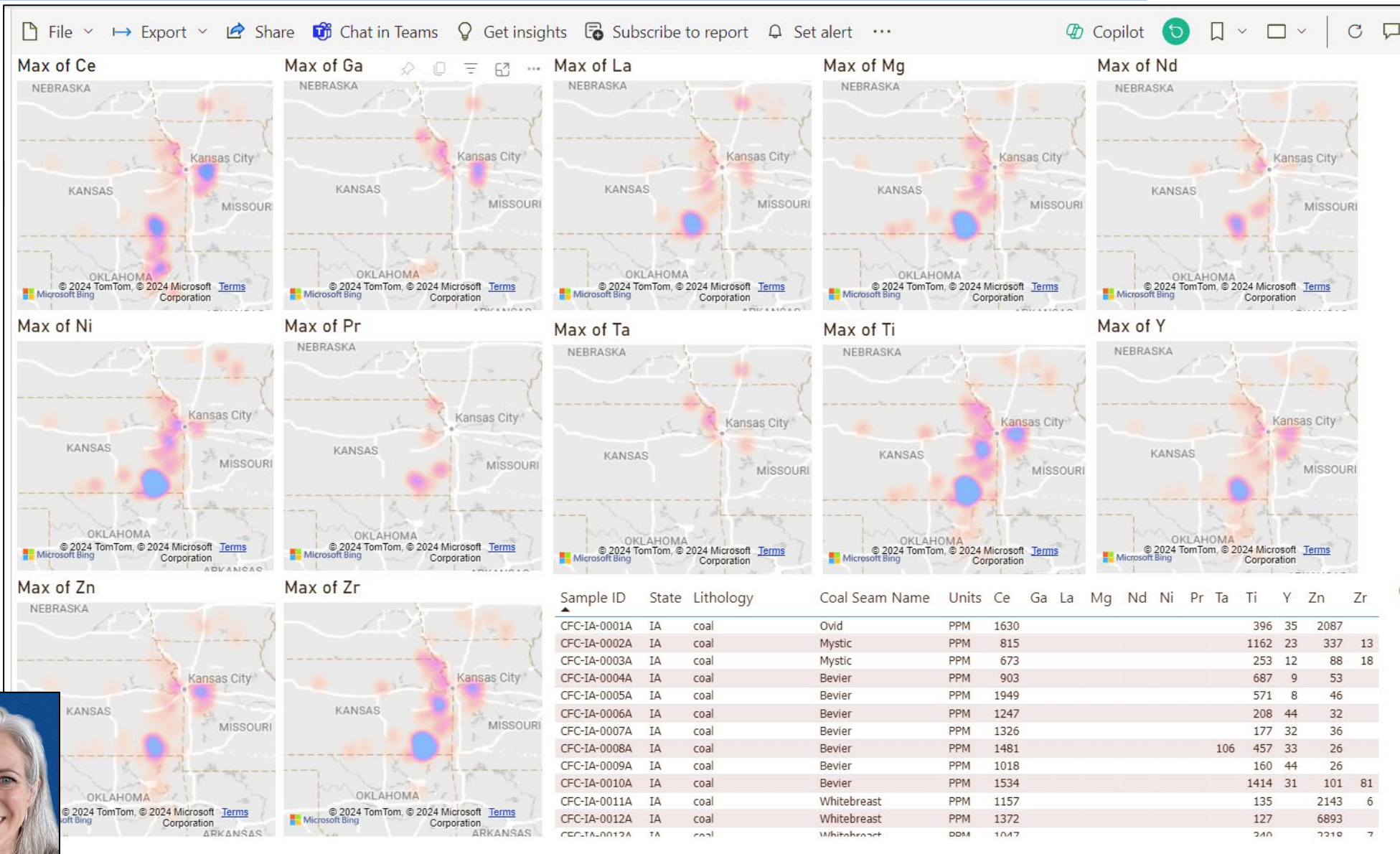


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4. Data Management and Visualization

Data Management & Visualization (3 of 3)

Scale intentionally not provided



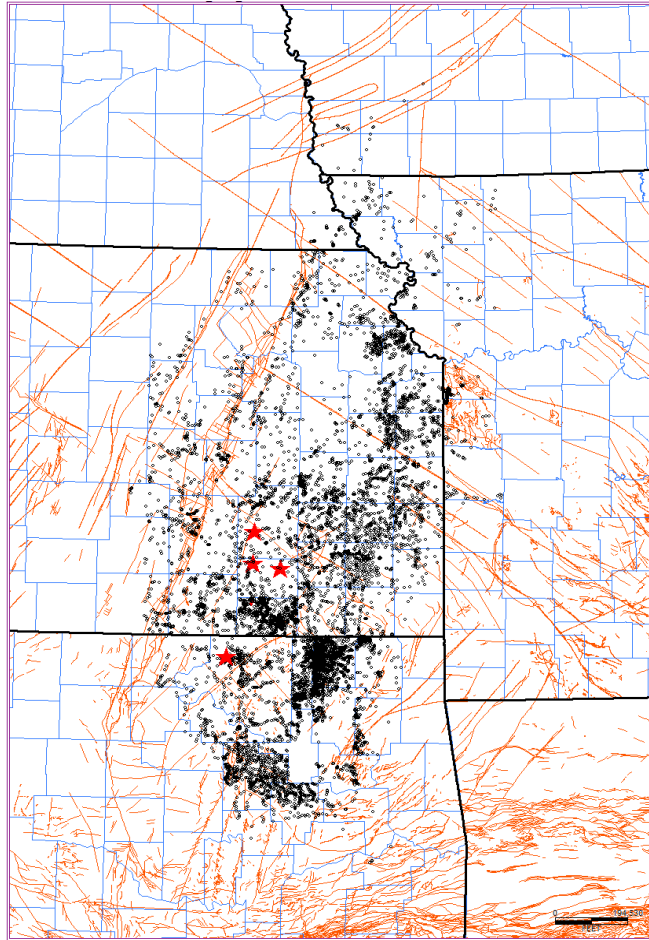
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4. Data Management and Visualization

Numerical Modeling (1 of 4) "Container"

Stratigraphic Framework

- Wireline Well Log Correlation of >10,000 wells



Kansas (In use by KGS)
Zeller (1968) (2018)

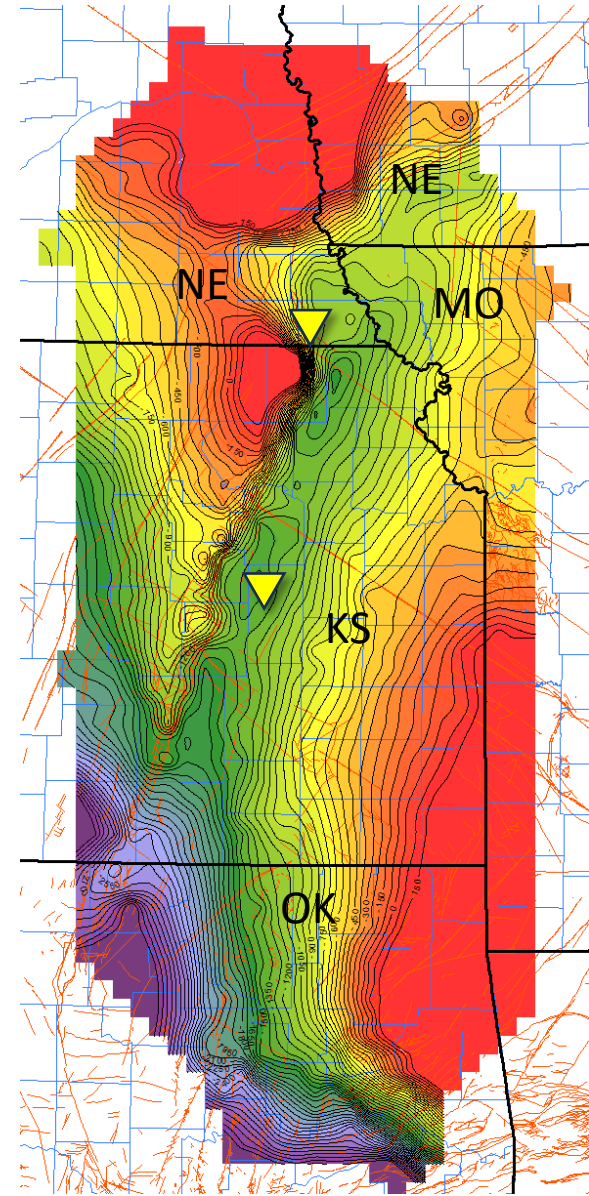
Missourian Stage	Kansas City Group	Bronson Subgroup	Galesburg Sh.	Dodds Creek Ss
			Swope Limestone	Bethany Falls Limestone Hutchpuckney Sh. Middle Creek Ls.
Pleasanton Group			Ladore Shale	Sniabar Limestone Mound City Shale
			Hertha Limestone	Critzer Limestone "Borbon Flag" (Jewett et al., 1965)
			Tackett Formation	
			Checkerboard Limestone	South Mound Sh. Heppler Sandstone
Marmaton Group			Holdenville Shale	
			Lenap Limestone	Idenbro Ls. Perry Farm Shale Norfleet Ls.
			Nowata Shale	Walter John. Ss.
			Altamont Limestone	Worland Ls. Lake Neosho Sh. Amoret Ls.
			Bandera Shale	Bandera Quarry Ss. Farrington Ls.
			Pawnee Limestone	Laberdie Ls. Mine Creek Sh. Myrick Station Ls. Anna Shale
Desmoinesian Stage			Labette Shale	Englevale Ss.
			Higginsville Ls.	
			Fort Scott Limestone	Little Osage Shale Blackjack Creek Limestone Excello Shale
Cherokee Group				Beezy Hill Ls. Bever coal Wedgits Ls. Mbr. Crawburg coal Flaming coal
				Atoka coal Canaan coal Ochale Ss. Mbr. Tawiah ls. bed Tebro coal Wap. Pebbly coal Seville (?) Ls. Mbr. Blujacket Ss. Mbr. Drywood coal Rowe coal Herald coal Warner Ss. Mbr.
undifferentiated				
Morrowan and Atokan Stages				
Mississippian Subsystem				

Kansas (Used by This Study)
modified from Oborny et al. (in prep.)
USGS - Interstate Nomenclatural Reconciliation

Missourian Stage	Kansas City Group	Bronson Subgroup	Galesburg Formation	
			Swope Formation	Bethany Falls Ls. Hutchpuckney Sh. Middle Creek Ls. Elm Branch Formation
Pleasanton Group			Hertha Formation	Sniabar Ls. Mound City Sh. Critzer Ls.
Marmaton Group	Holdenville Subgroup			Shale Hill Shale "Borbon Flag" (Jewett et al., 1965)
				Glenpool Ls. Lost Branch Sh. Nowata Creek Sh. Sni Mills Ls.
Marmaton Group	Appanoose Subgroup			Lenap Fm. Idenbro Ls. Nowata Formation Walter Johnson Ss. unnamed limestone
				Altamont Formation Worland Ls. Lake Neosho Sh. Amoret Ls.
				Bandera Formation Bandera Quarry Ss. Farrington Ls. Coal City Ls.
Desmoinesian Stage	Fort Scott Subgroup			Pawnee Formation Mine Creek Sh. Myrick Station Ls. Anna Shale Childers School Ls.
				Labette Formation Englevale Ss. Labette ls. Ss.
				Higginsville Ls. Blackjack Creek Limestone Excello Shale unnamed limestone
Cherokee Group	Cabaniss Subgroup			Upper Cabaniss from base of Hux Limestone Beezy Hill Ls. Bever coal Wedgits Ls. Mbr. Mecca Quarry Shale Crawburg coal Flaming coal
				Lower Cabaniss from base of Hux shale Atoka coal Canaan coal Ochale Ss. Mbr. Tawiah ls. bed Tebro Shale Wap. Pebbly coal Seville (?) Ls. Mbr. Inoki Ls. Mbr. Blujacket Ss. Mbr. Drywood Formation Rowe coal Herald coal Warner Ss. Mbr.
undifferentiated				
Morrowan and Atokan Stages				
Mississippian Subsystem				

Missouri
Bridges et al. (2019)
USGS - Interstate Nomenclatural Reconciliation

Missourian Stage	Kansas City Group	Bronson Subgroup	Galesburg Formation	
			Swope Formation	Bethany Falls Ls. Hutchpuckney Sh. Middle Creek Ls. Elm Branch Formation
Pleasanton Group			Hertha Formation	Sniabar Ls. Mound City Sh. Critzer Ls.
Marmaton Group	Holdenville Subgroup			Shale Hill Shale "Borbon Flag" (Jewett et al., 1965)
				Blue Mound Sh. Locust Ck. coal Knobtown Ls. Waldron River Ss. Manthey Sh. Eoline Ls.
Marmaton Group	Appanoose Subgroup			Lenap Fm. Idenbro Ls. Nowata Formation Walter Johnson Ss. unnamed limestone
				Altamont Formation Worland Ls. Lake Neosho Sh. Amoret Ls.
				Bandera Formation Bandera Quarry Ss. Farrington Ls. Coal City Ls.
Desmoinesian Stage	Fort Scott Subgroup			Labette Formation Englevale Ss. Labette ls. Ss.
				Higginsville Ls. Blackjack Creek Limestone Excello Shale unnamed limestone
Cherokee Group	Cabaniss Subgroup			Mulky Formation Beezy Hill Ls. Lagonda Formation Bever Formation Whosley Mbr. Verdigris Ls. Mbr. Mecca Quarry Shale Crawburg coal Flaming coal Robinson Branch Fm. Mineral Formation Cammon Formation Cheneau Ls. Mbr. Tawiah Ls. Mbr. Tebro Formation Tebro Shale Weir Formation Hachberry Branch Ls. Mbr. Welbom Formation Blujacket Sandstone Drywood Formation Rowe Formation Warner Sandstone Hartshome (?) Formation
				Atoka coal Canaan coal Ochale Ss. Mbr. Tawiah ls. bed Tebro coal Wap. Pebbly coal Seville (?) Ls. Mbr. Inoki Ls. Mbr. Blujacket Ss. Mbr. Drywood Formation Rowe coal Herald coal Warner Ss. Mbr.
undifferentiated				
Morrowan and Atokan Stages				
Mississippian Subsystem				



v. 3.27.2024



Stephan Oborny

5. Numerical Modeling

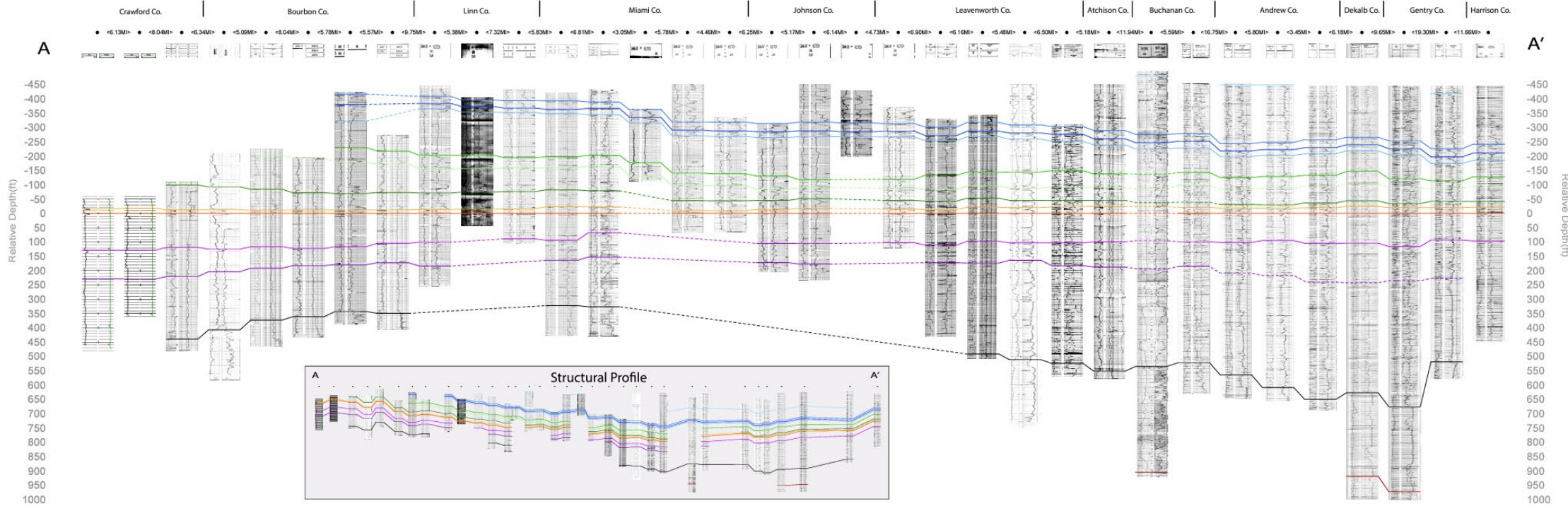
Numerical Modeling (2 of 4) "Container"

Cross section NS - 7 Crawford Co., KS to Harrison Co., MO

Horizontal Scale = 12808.7
Vertical Scale = 50.0
Vertical Exaggeration = 259.2x

TOPS AND MARKERS

- Top Eureka Shale Member
- Top Stark Shale Member
- Top Huskyhooker Shale Member
- Top Mound City Shale Member
- Base Nayaka Creek Shale Member
- Top Lake Neosho Shale Member
- Top Anna Shale Member
- Top Binkley Shale Member
- Top Excelsior Shale Member
- Top Mecca Quarry Shale Member
- Base Tebo Shale Member
- Top Mississippian Lime Member
- Top Chattanooga Shale Member



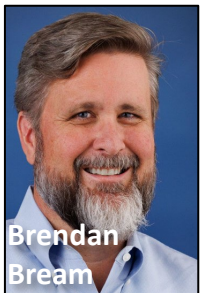
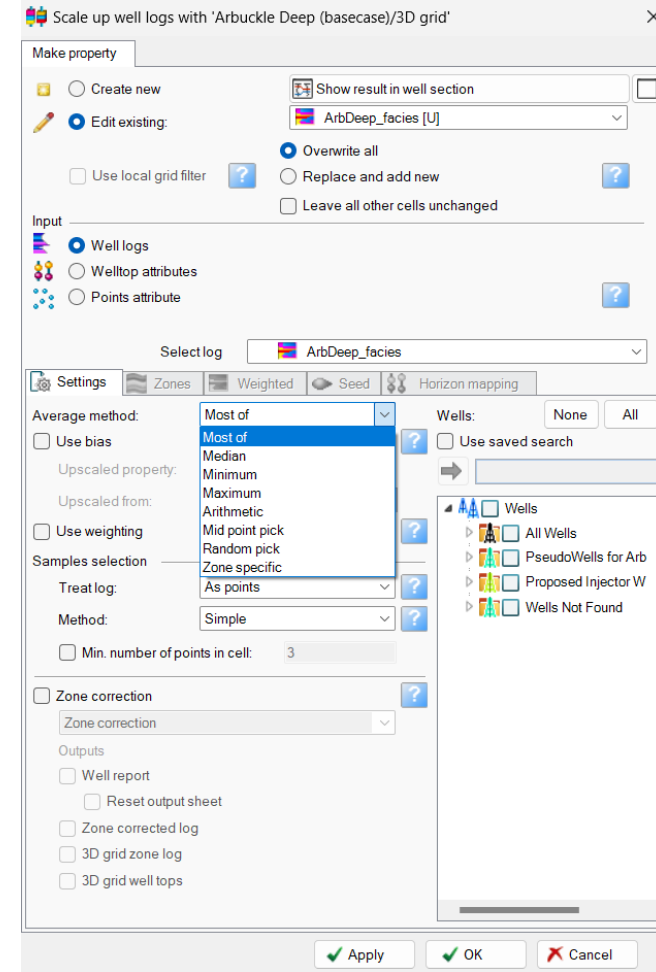
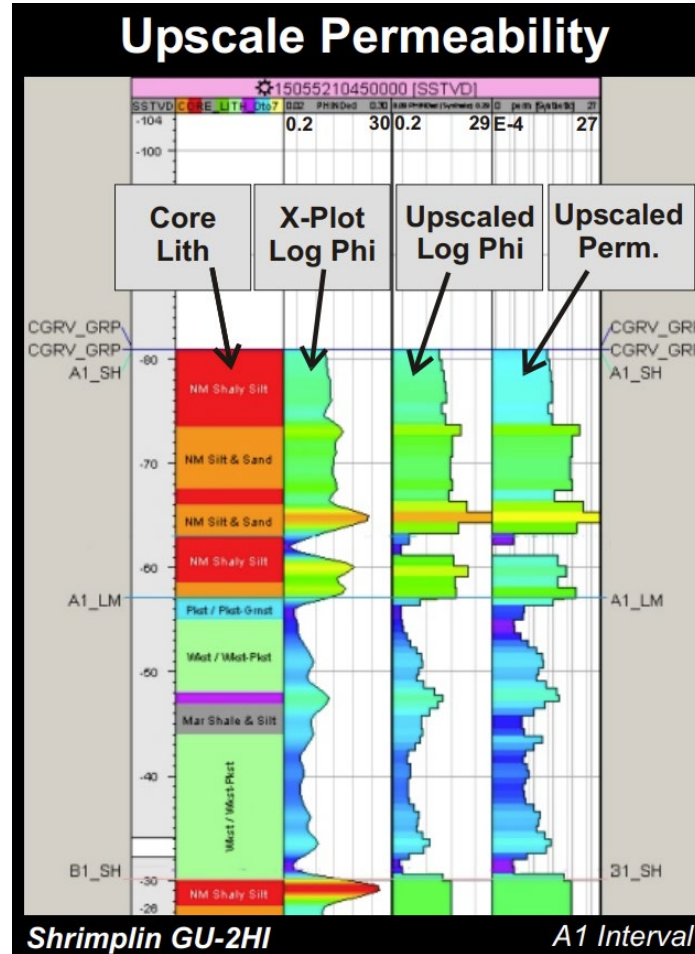
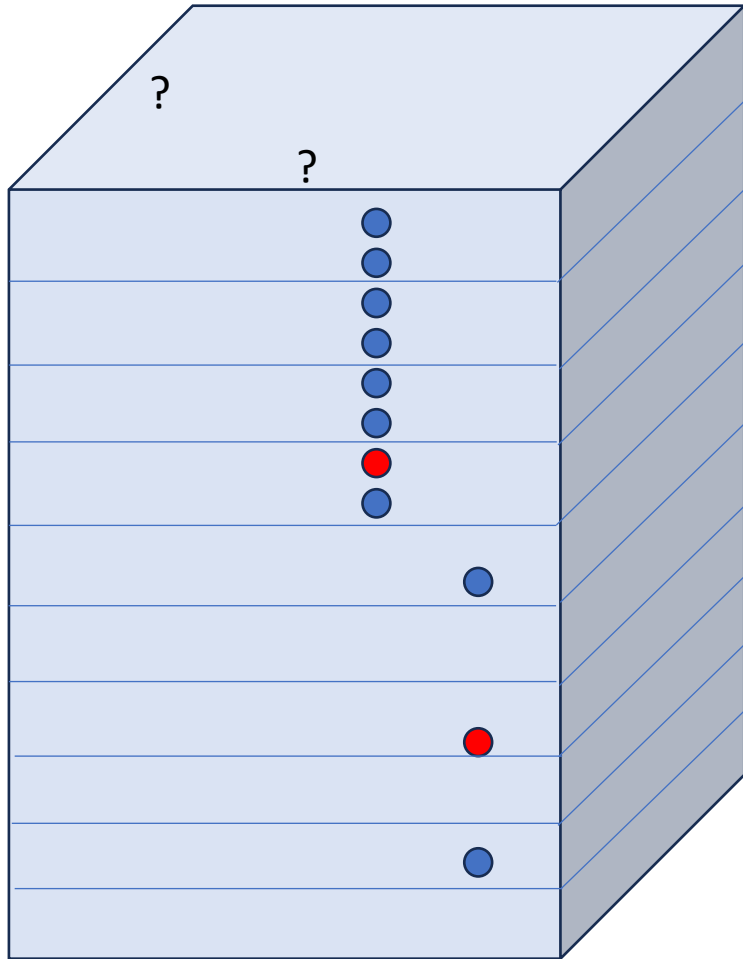
5. Numerical Modeling

Numerical Modeling (3 of 4) "Numbers"

Use High-resolution well log correlation surfaces as "containers"

Upscale geochemical data - (all? including pXRF?)

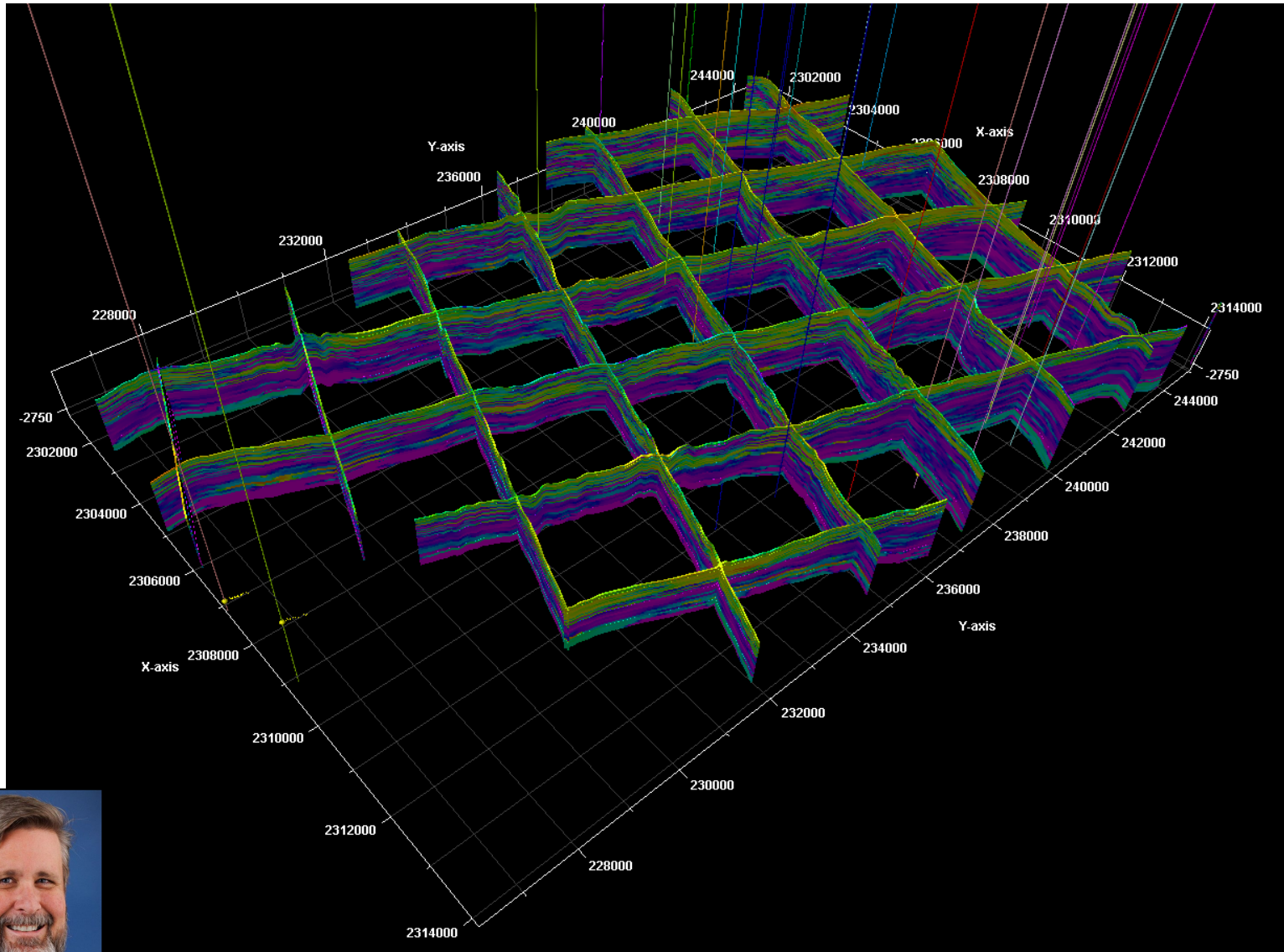
Populate between data points – (by facies?, within container subzones?)



Brendan Bream

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

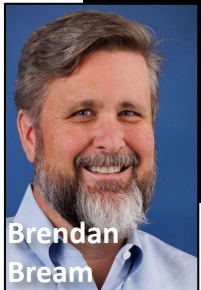
Test predictive ability

- New well?, New core?
- Larger model?

Volumetrics

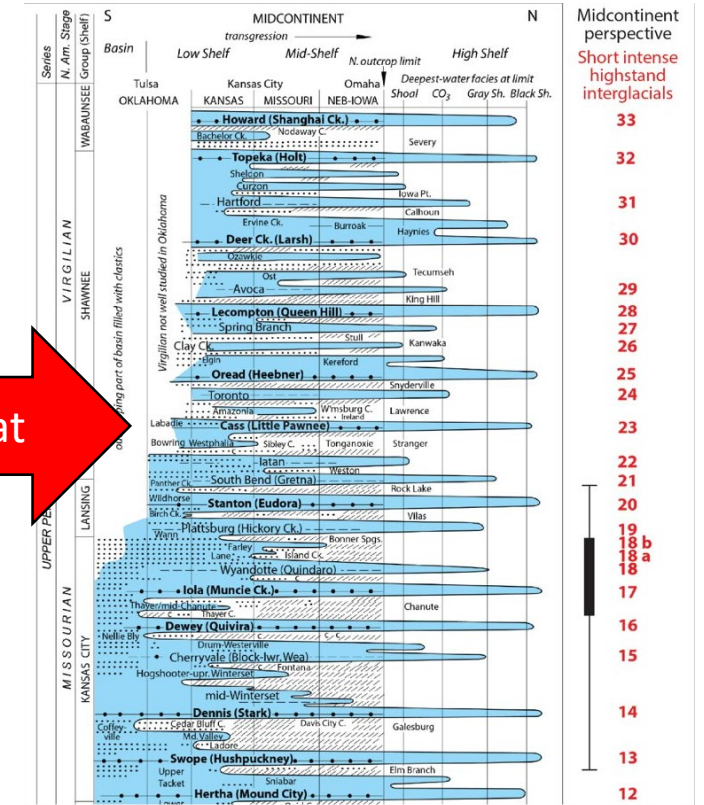
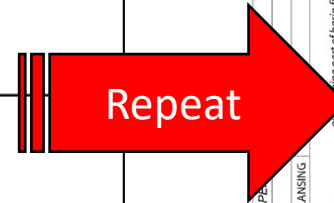
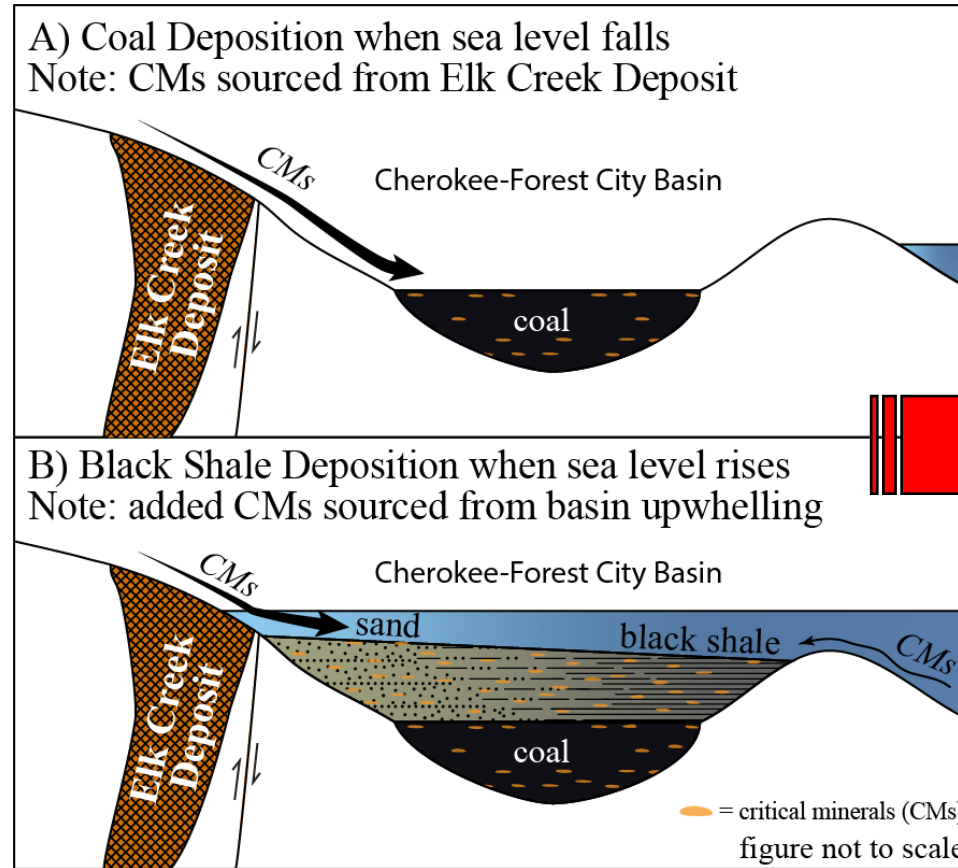
- Bulk rock volume
- Concentration-thickness

*Automate with workflows for iterating
Neural Network to connect dots?*



Brendan
Bream

Test the Hypotheses



Heckel, 2013; Oborny et al., 2017

Conclusions



U.S. DEPARTMENT OF
ENERGY



Conservation and Survey Division

Studying Nebraska and
Serving Nebraskans for 128 years



Project Execution

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