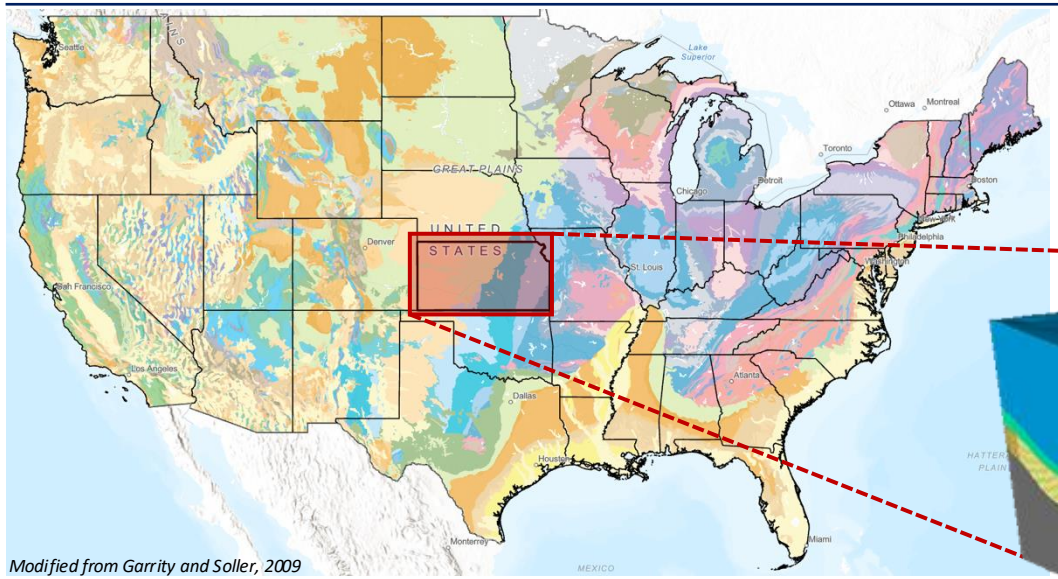
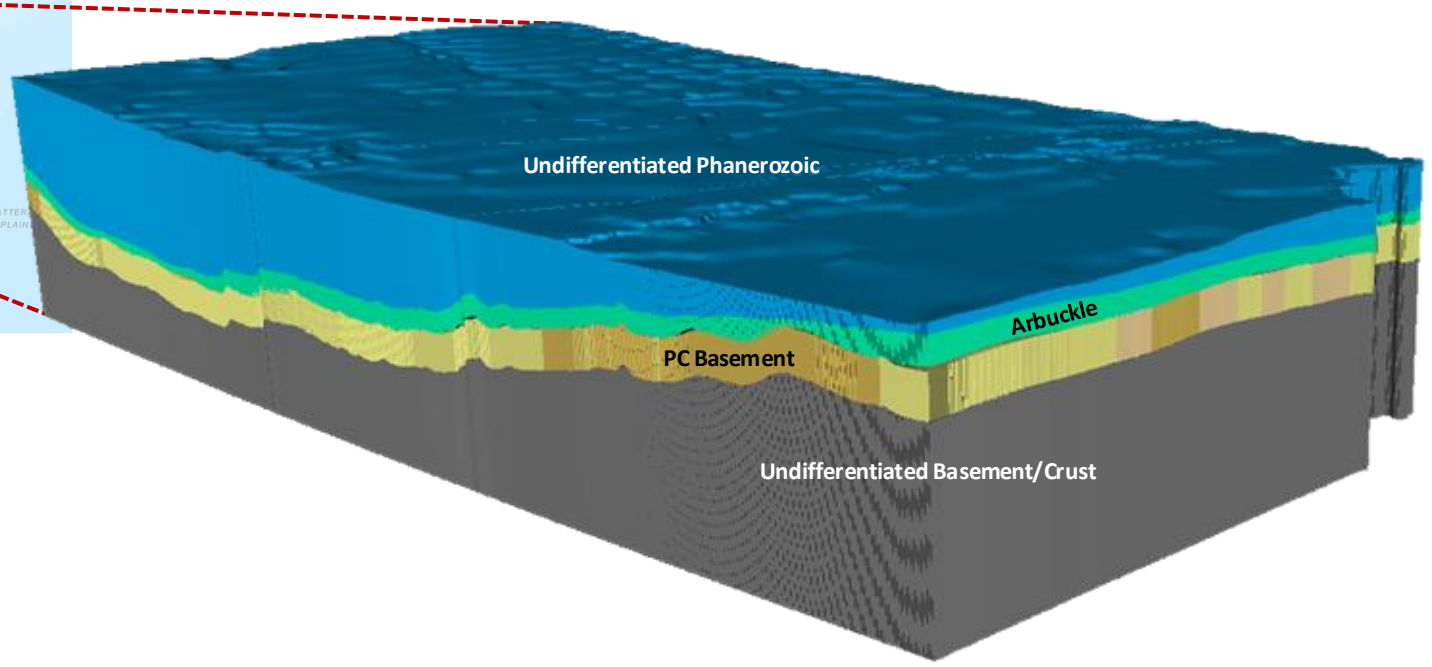
Regional Carbon Sequestration Screening in Kansas

Souvik Bhattacharjee, Ph.D.



Modified from Garrity and Soller, 2009



October 21-22, 2025, Wichita, KS
GEOLOGY & WELL TECHNOLOGY
SEMINAR & TECH FAIR

Arbuckle CCS play potential COA Map

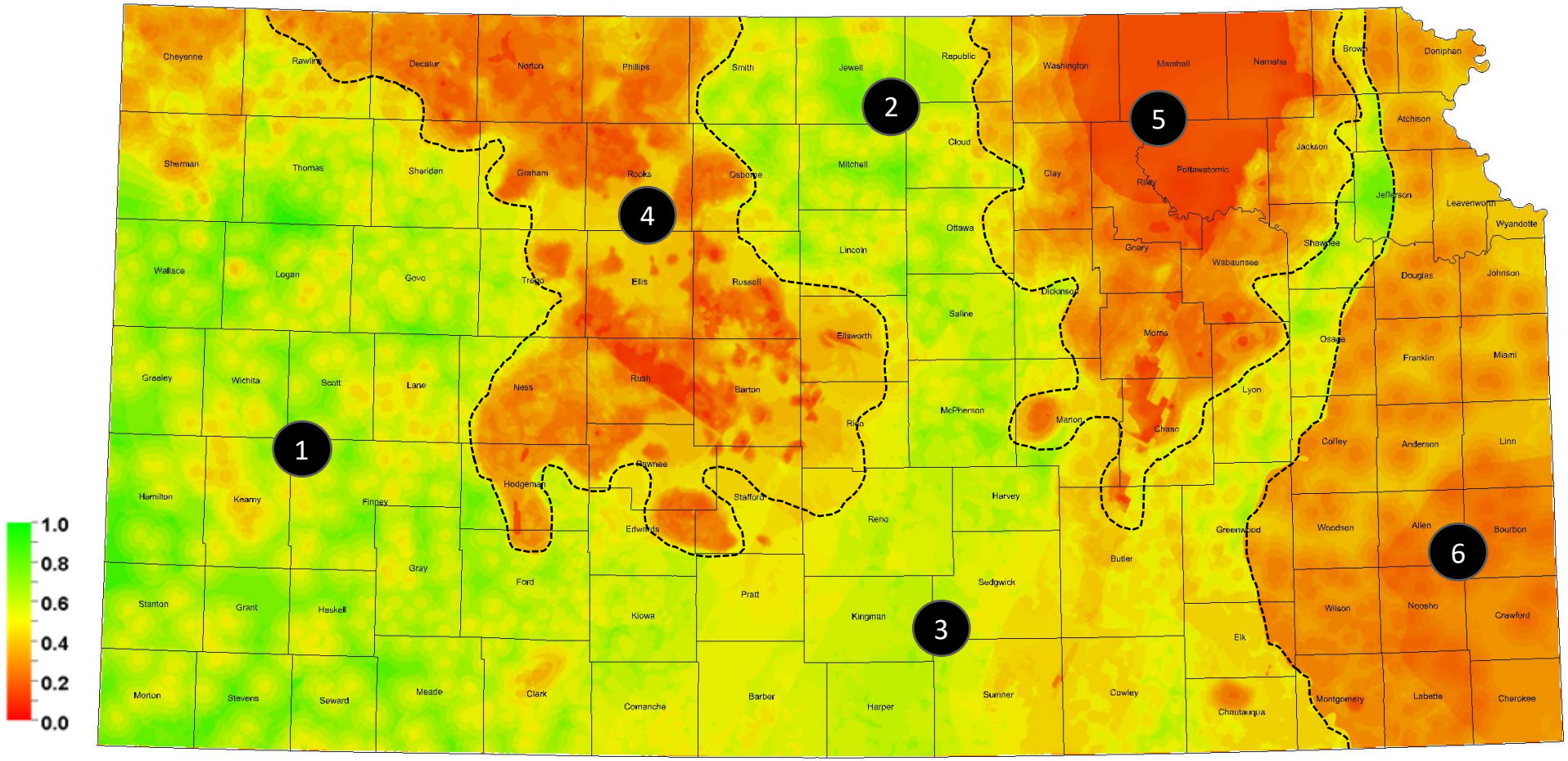
SDL KGS Subsurface Dynamics Laboratory

Favorable

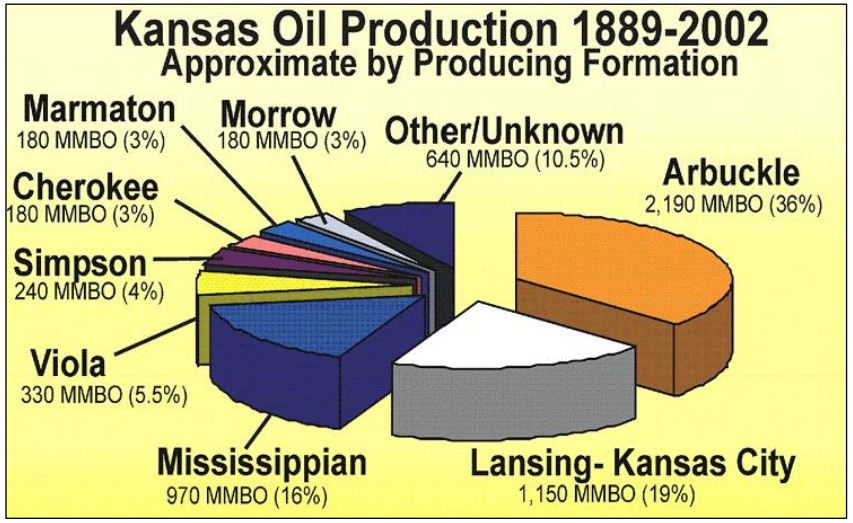
1. Hugoton Embayment
2. Salina Basin
3. Sedgwick Basin

Challenged

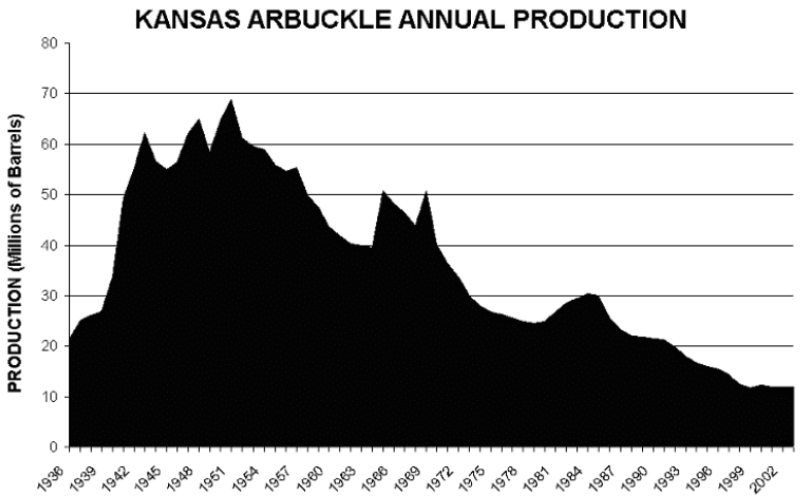
4. Central Kansas Uplift
5. Nemaha Ridge
6. Forest City Basin/Cherokee Platform



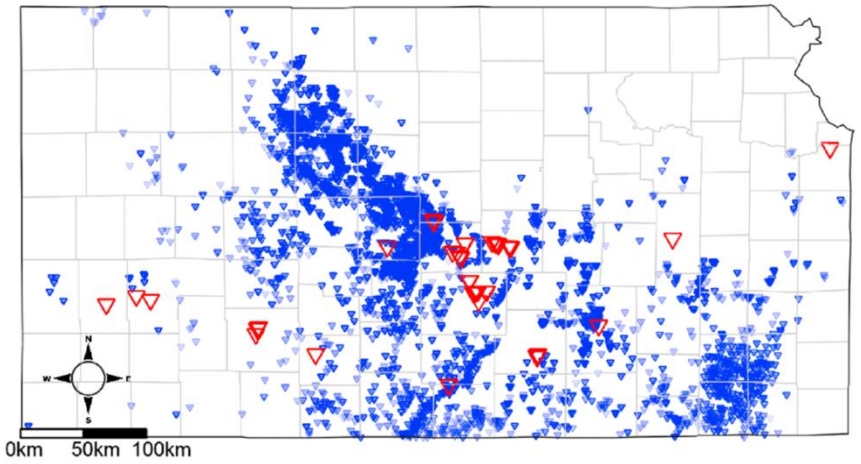
Why Arbuckle?



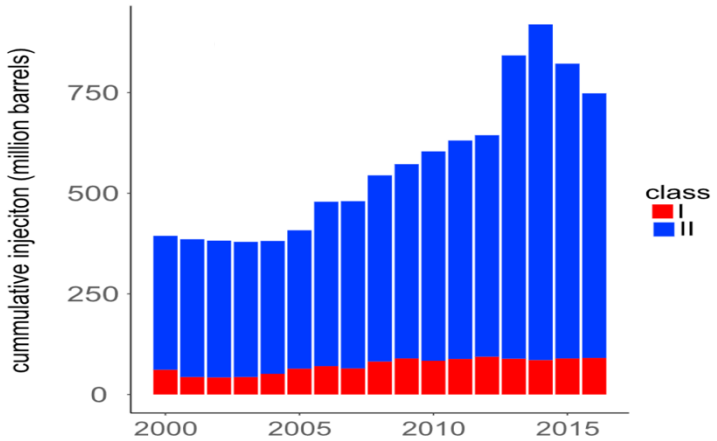
Arbuckle reservoir production data in million barrels, compared to total Kansas oil production. (Franseen et. al., 2004)



Annual Production from Kansas Arbuckle reservoirs. (Franseen et. al., 2004)

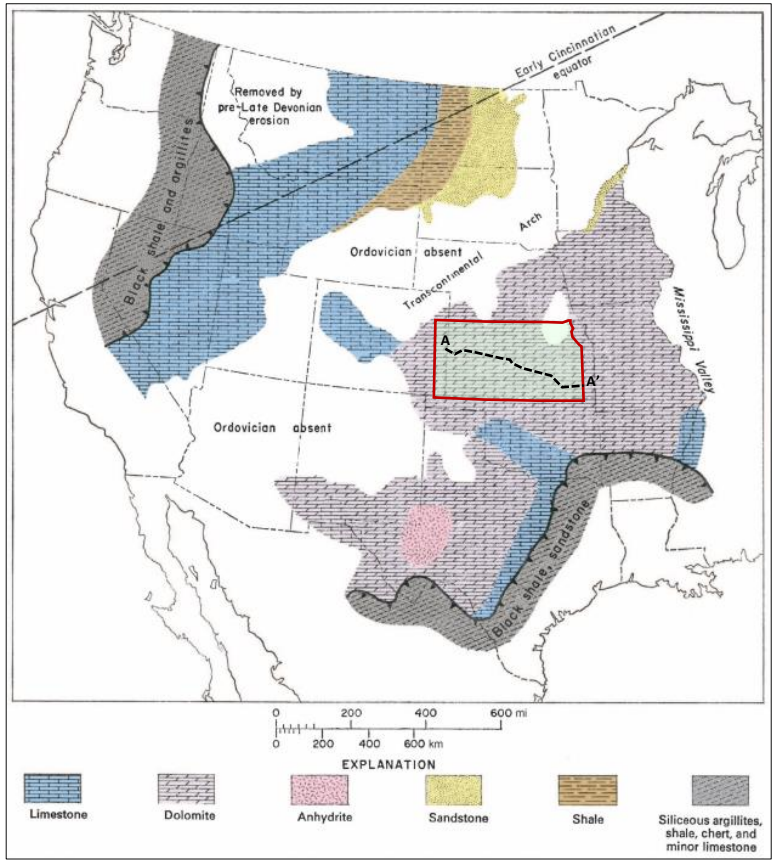


Locations of 49 Class I wells (red) and 2,381 Class II wells (blue) that dispose wastewater into the Arbuckle Group in Kansas. (Ansari et. al., 2019)

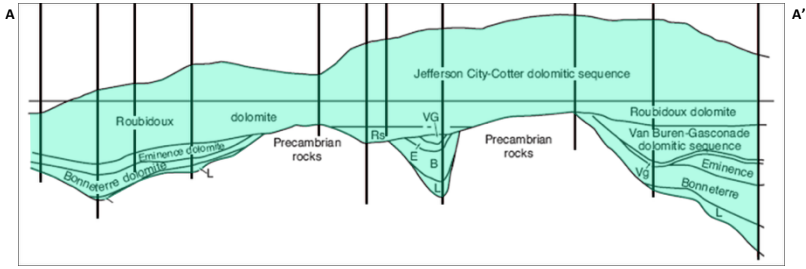


Yearly wastewater injection volumes from Class I (red) and Class II (blue) wells. (Ansari et. al., 2019)

Arbuckle: Regional Geology

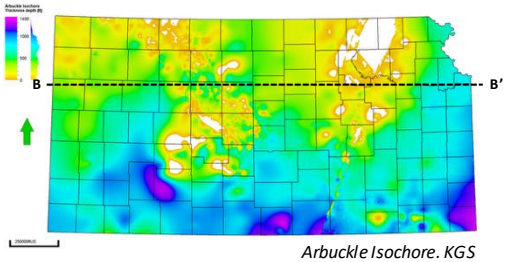


Distribution of Lower Ordovician lithofacies of western US (Arbuckle Fm in Kansas) (Fritz et. al., 2012)

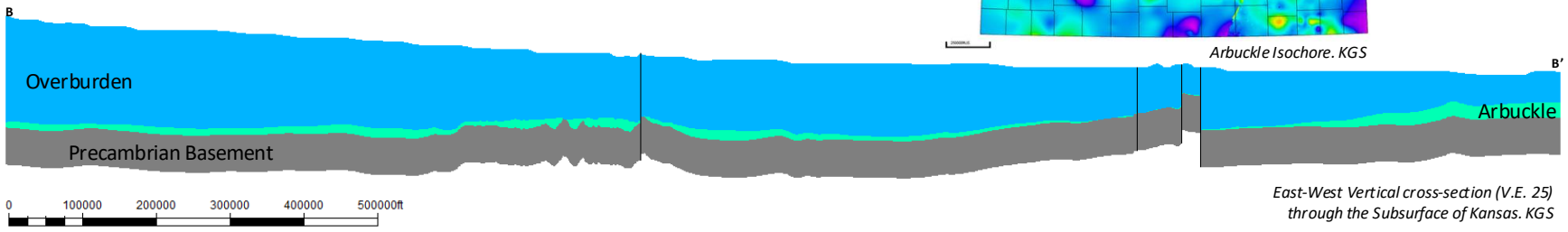


Diagrammatic cross-section of Arbuckle Group across Kansas. (Franseen et. al., 2004)

- **Arbuckle Group** – Cambro-Ordovician carbonate rocks (Reservoir, mostly dolomitized) resulting from Paleozoic transgressions as part of the Sauk Sequence
- Overlain regionally and locally by **Maquoketa**, **Chattanooga** and **Heebner** Shale (Seal: Ordovician, L. Miss-Dev, Pennsylvanian)
- Present in most of Kansas, except NW and NE Kansas due to post depositional uplift and erosion.



Arbuckle Isochore. KGS

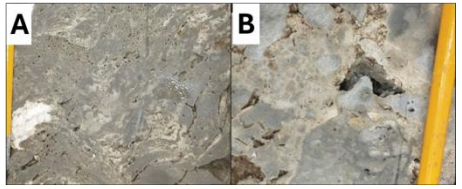


East-West Vertical cross-section (V.E. 25) through the Subsurface of Kansas. KGS

Chattanooga Shale →

MGPI Processing #1, Atchison, KS

Maquoketa Shale →

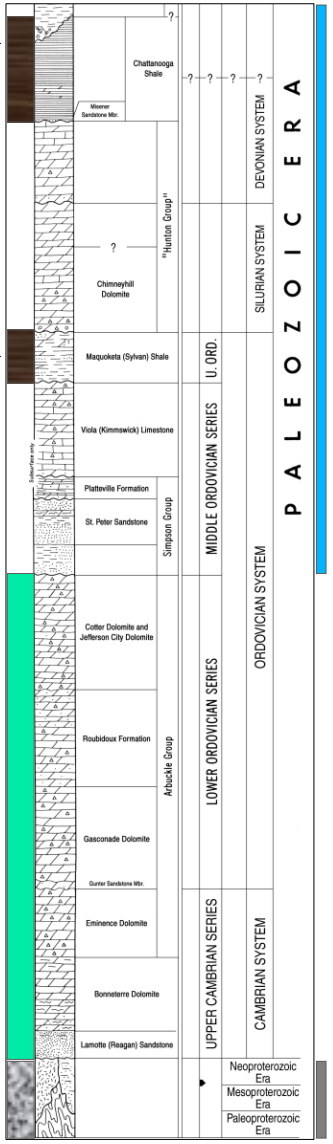


A,B- Core photographs of microbial carbonates with vuggy porosity. MGPI Processing #1, Atchison, KS

Arbuckle →

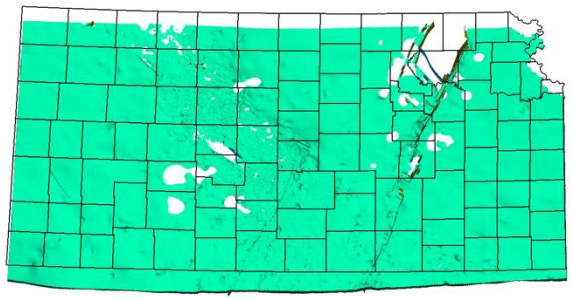
MGPI Processing #1, Atchison, KS

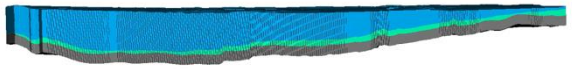
Precambrian Basement →

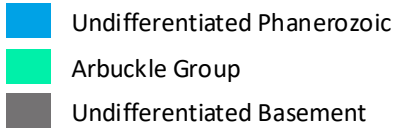


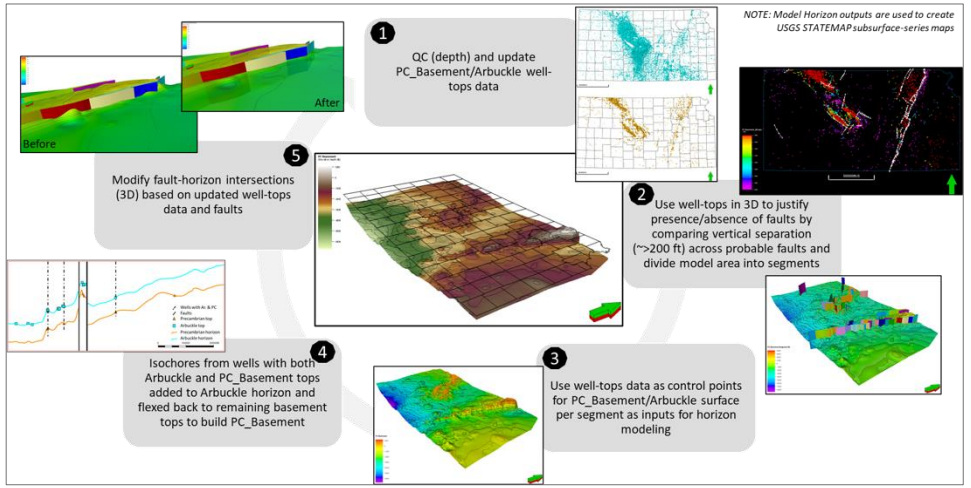
Strat section, KGS Bulletin, 189 Plate 1

Workflow









Faulted Framework Modeling Workflow

Products from 1+ year of work

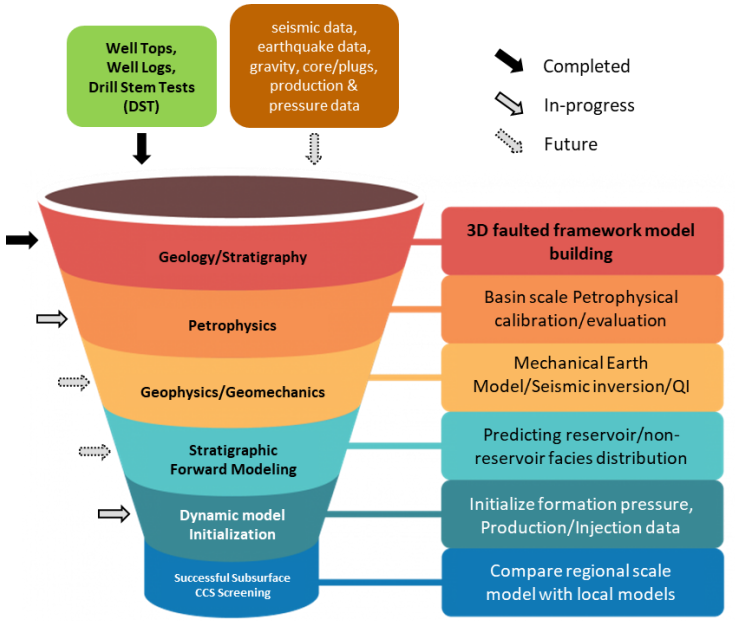
- Faulted framework model
- 2000*2000 ft cell size, 149 layers in Arbuckle with **~40 million cells**
- Subsurface Geologic Map of Precambrian basement and Arbuckle, Regional CCS potential map and considerations

Data used

- Well tops: ~5000 Precambrian Basement & ~60,000 Arbuckle
- Well logs: ~400 wells (~3-5 per county)
- DST data ~ 110 wells

Other data available

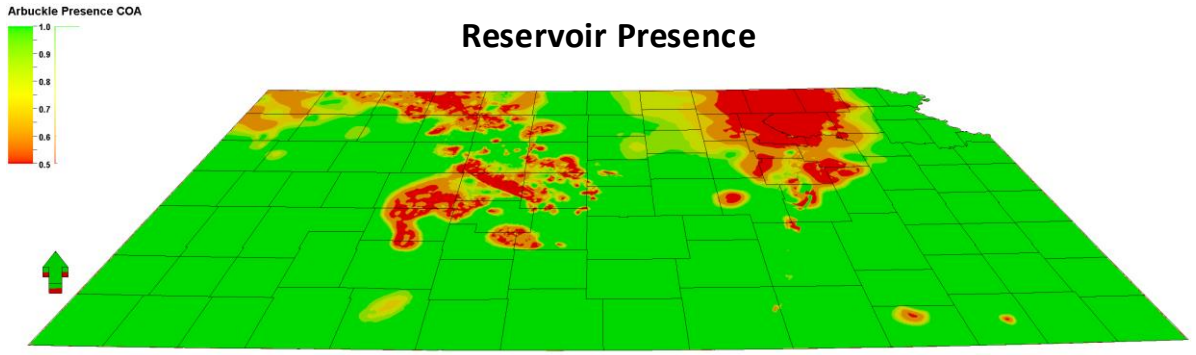
2D/3D seismic, Earthquake, Gravity, cores/cuttings



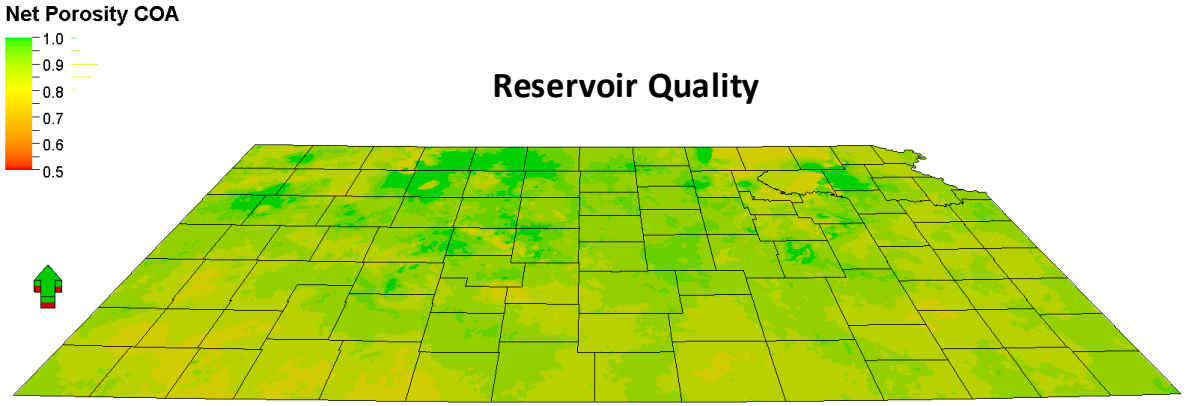
Regional Basin Scale Subsurface CCS Screening Workflow

Play elements - COA

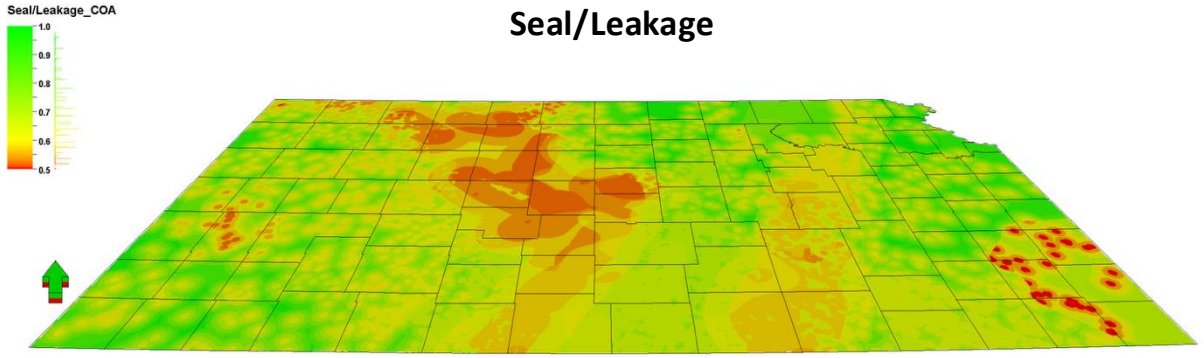
Reservoir Presence



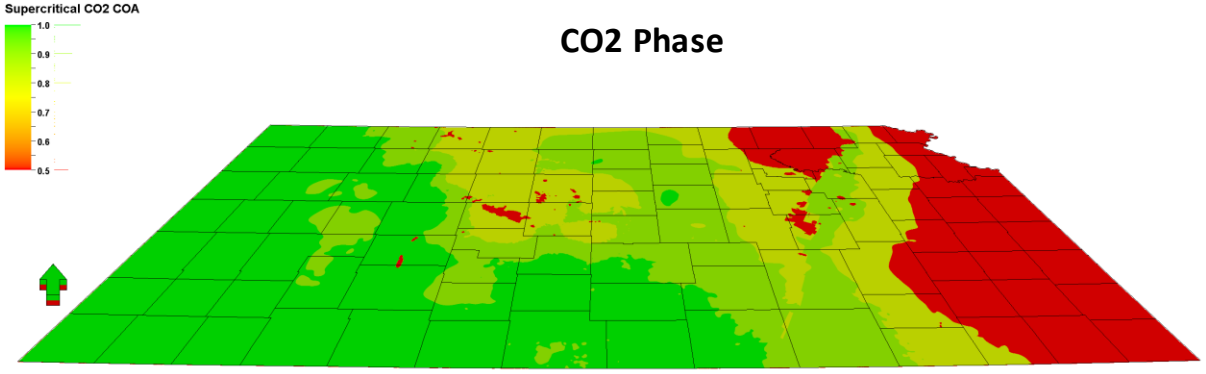
Reservoir Quality



Seal/Leakage



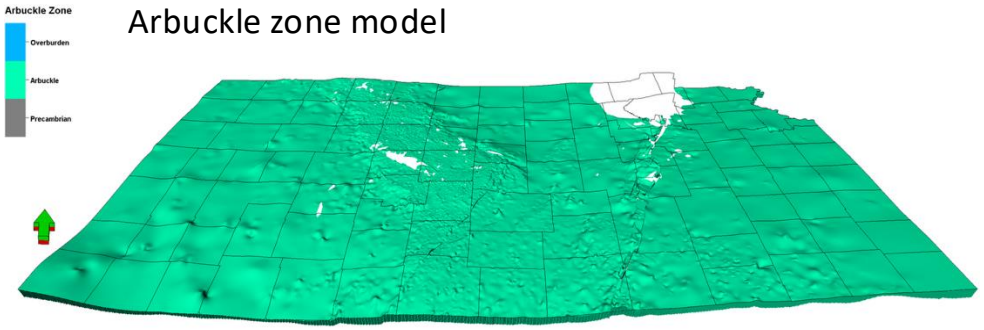
CO2 Phase



1. Reservoir Presence

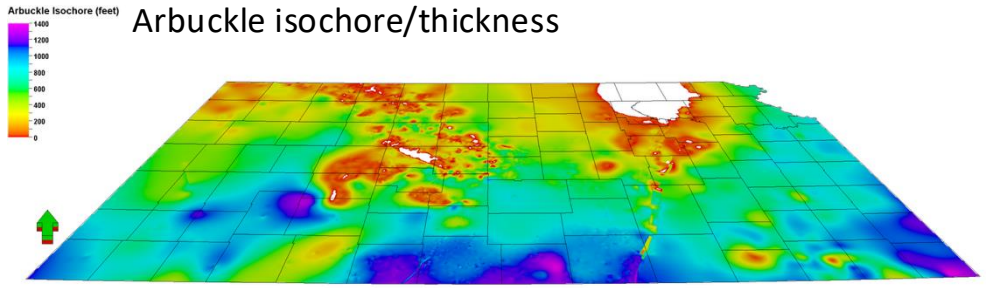
*COA – Chance of Adequacy

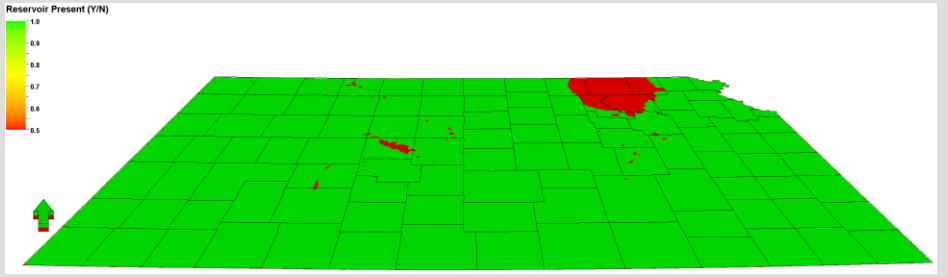
Arbuckle zone model



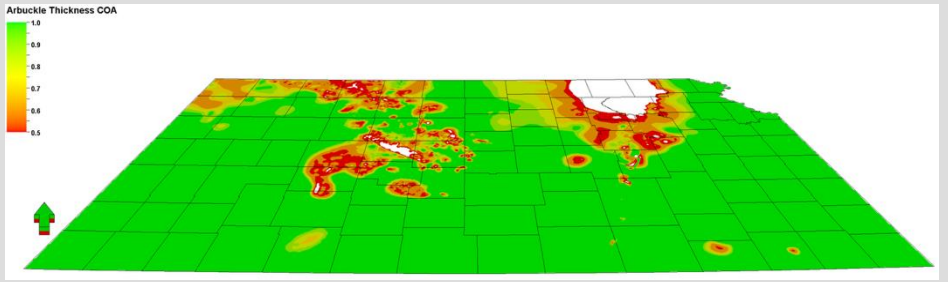
Arbuckle isochore/thickness

thicker

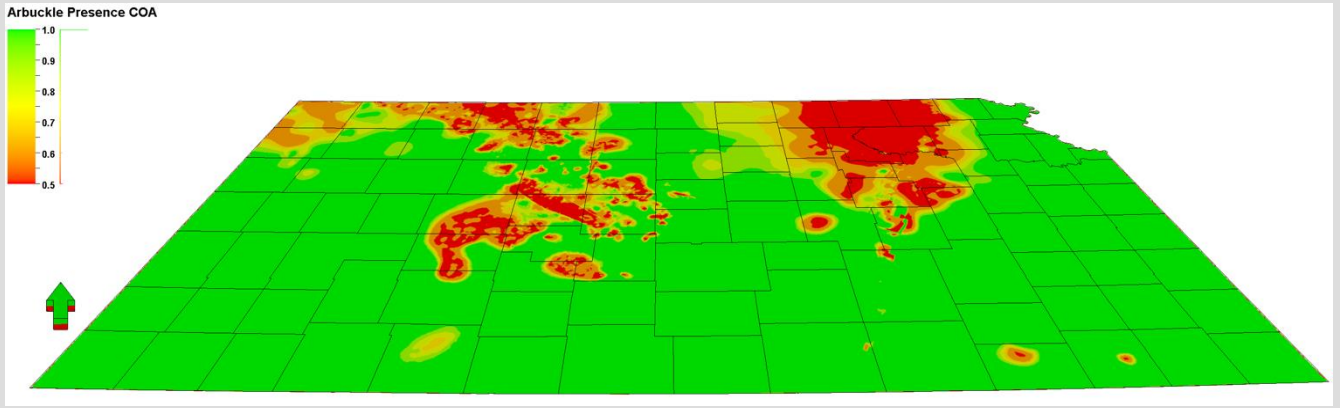




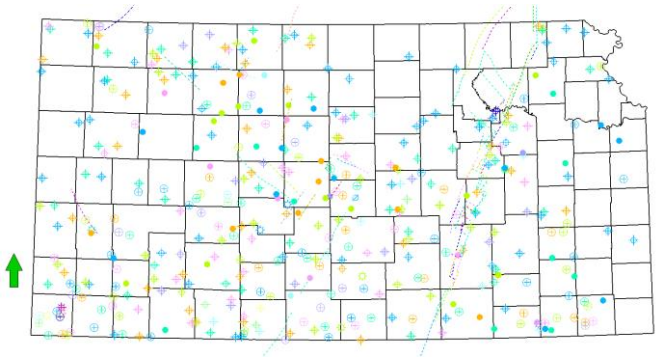
X



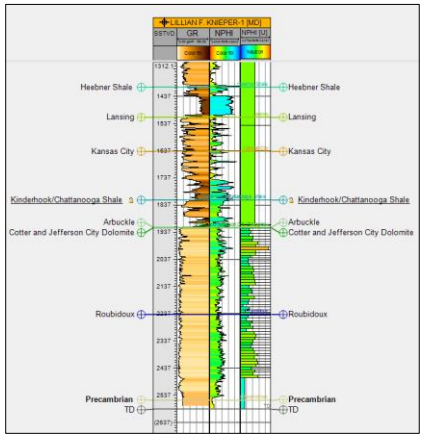
=



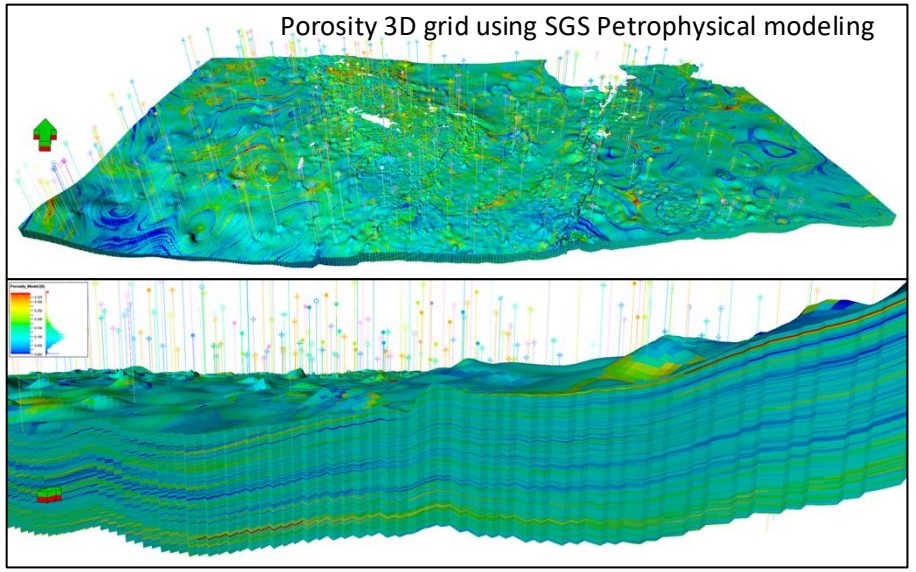
2. Reservoir Quality- Porosity



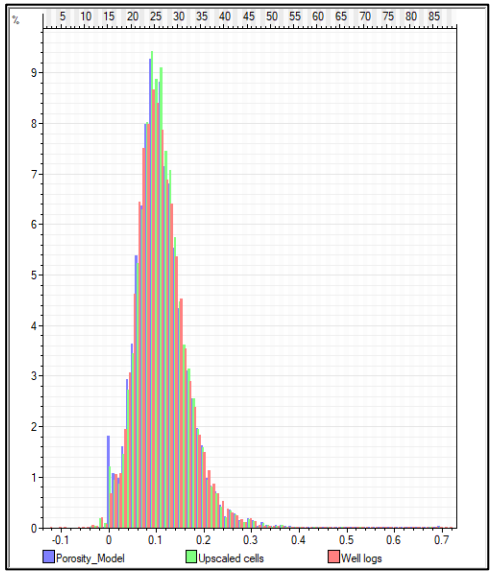
~400 wells



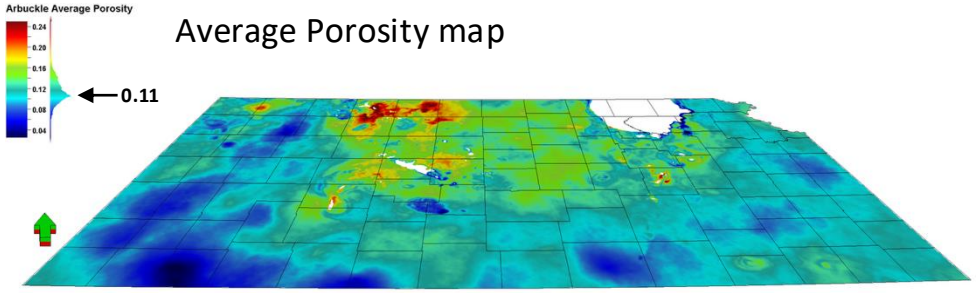
Well log vs Upscaled Porosity (NPhi – Neutron Porosity)



X-section view of Porosity 3D grid

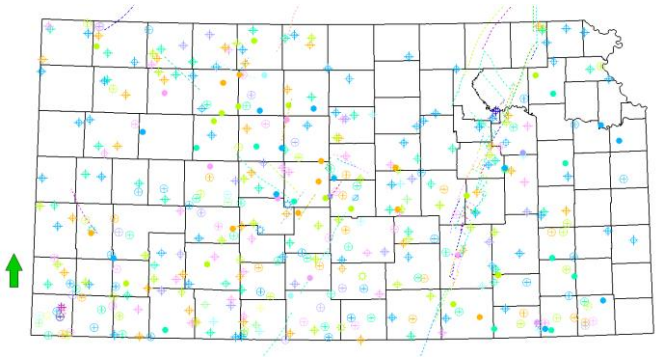


Well log vs Upscaled vs 3D grid Por

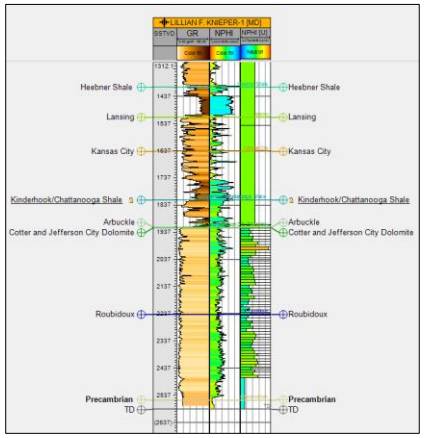


Average Porosity map

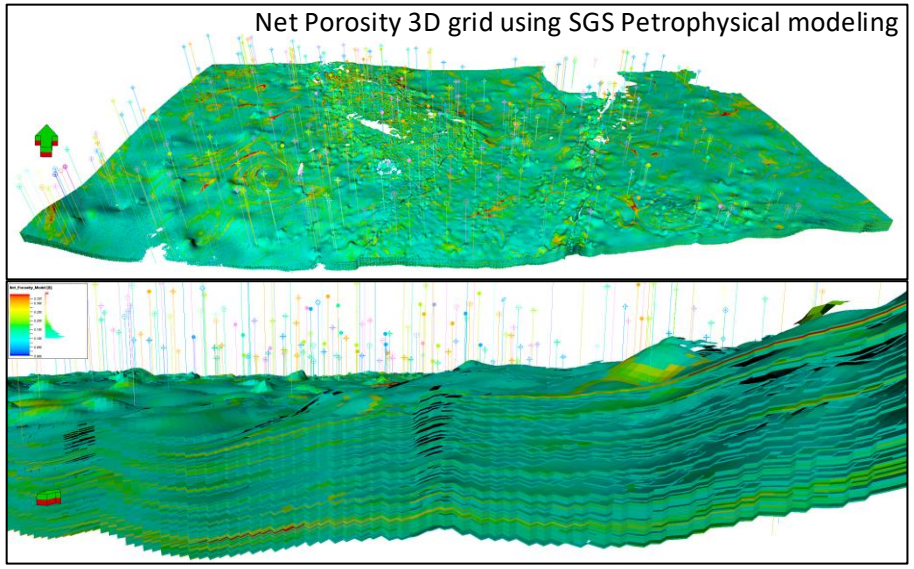
2. Reservoir Quality- Porosity



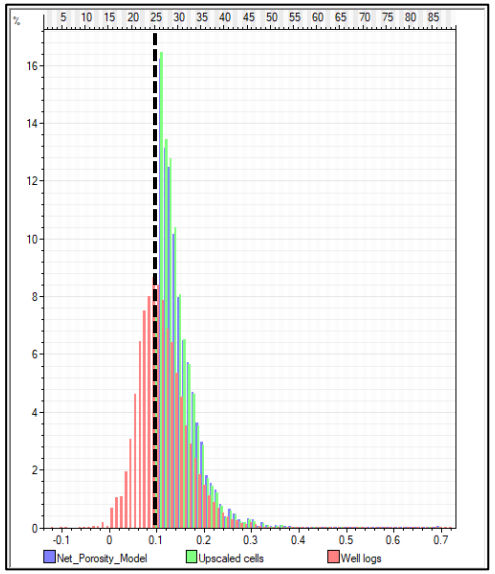
~400 wells



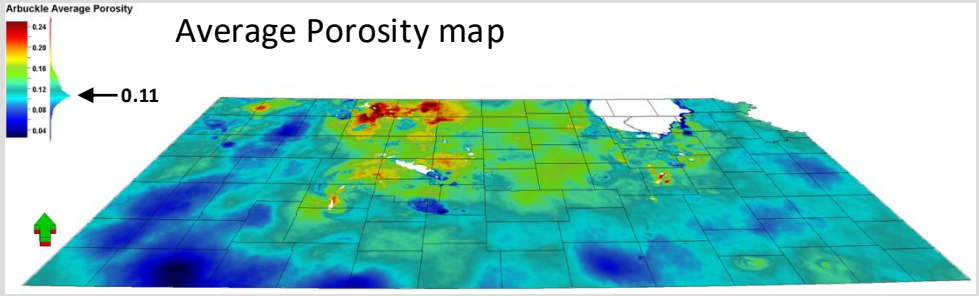
Well log vs Upscaled Porosity (NPhi – Neutron Porosity)

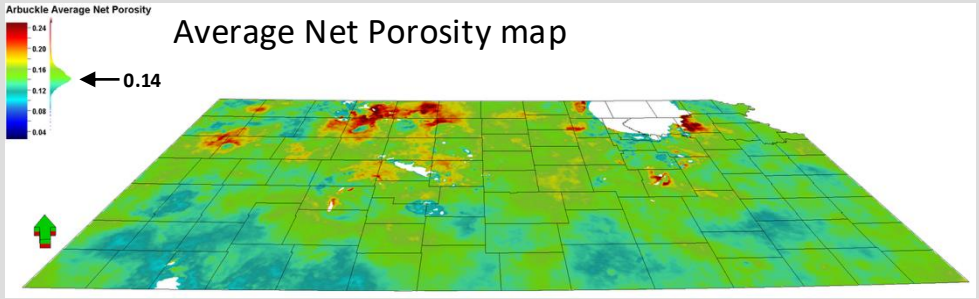


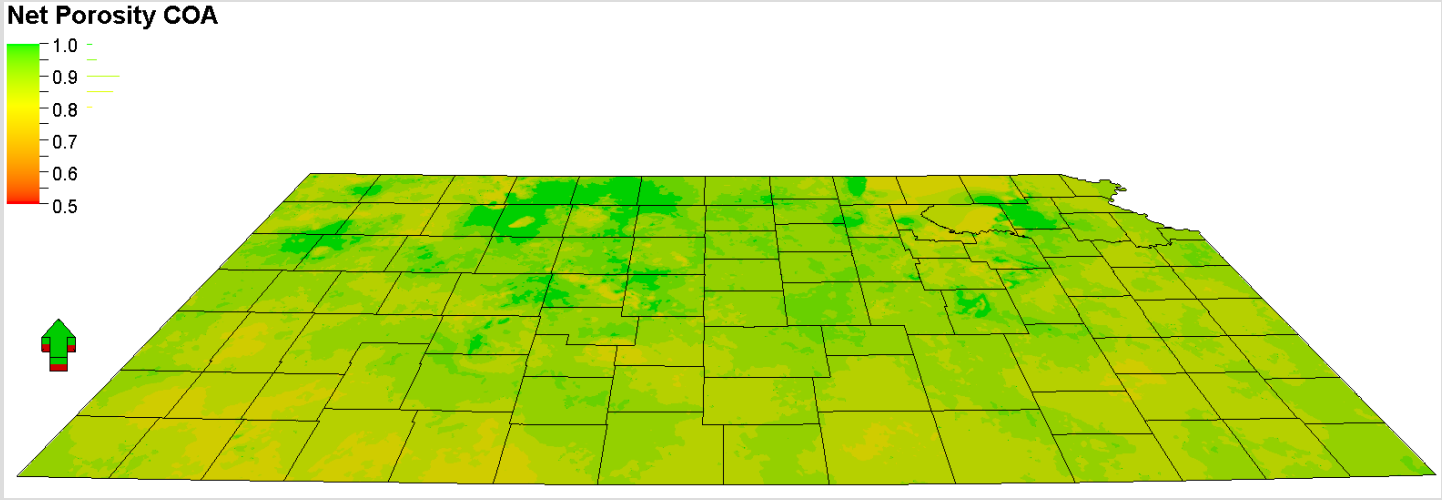
X-section view of Net Porosity 3D grid (~46% reduction in volume)



Well log vs Upscaled vs 3D grid Por

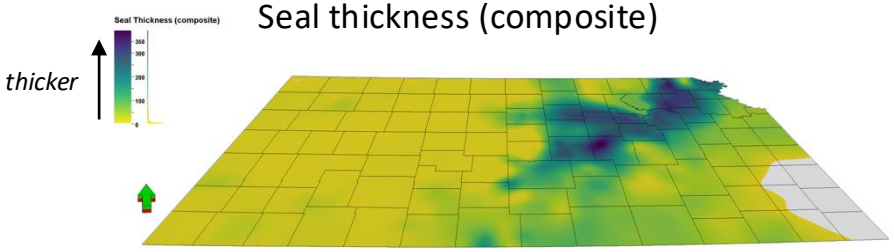






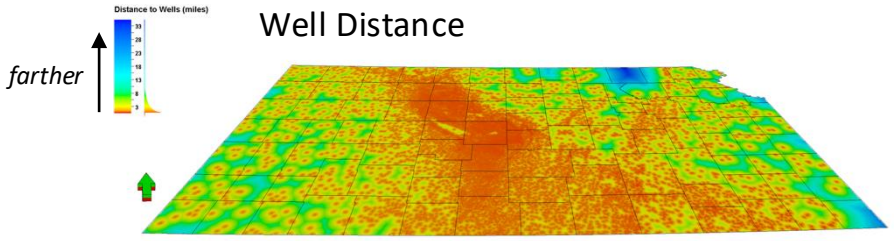
3. Seal (*leakage*)

Seal thickness (composite)

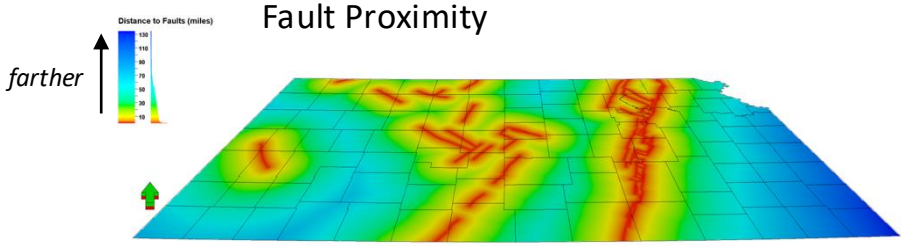


**combination of Chattanooga, Maquoketa & Heebner shales (regional distribution)*

Well Distance

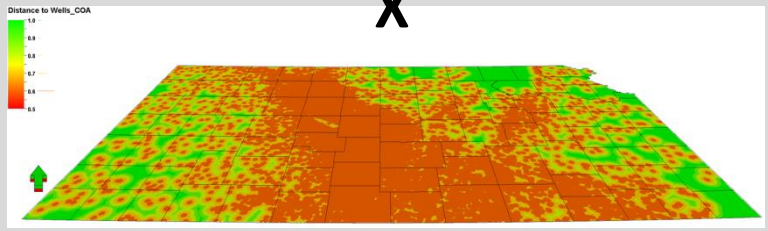


Fault Proximity

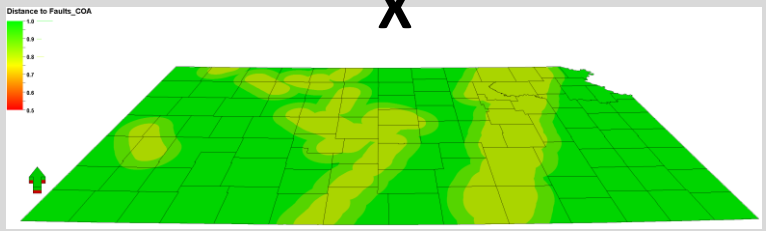


**Pseudo Faults at the boundary/edge of the model not considered for the COA map*

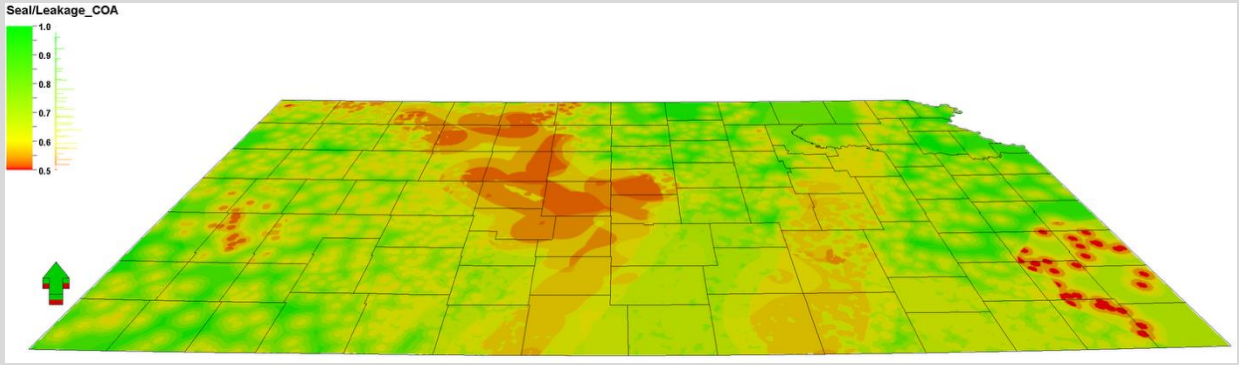
X



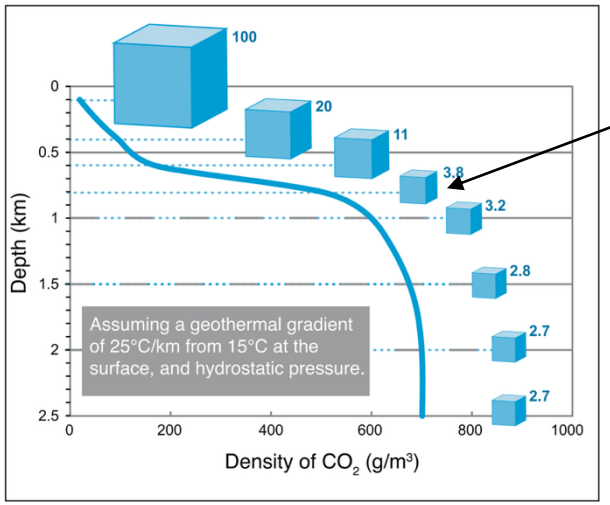
X



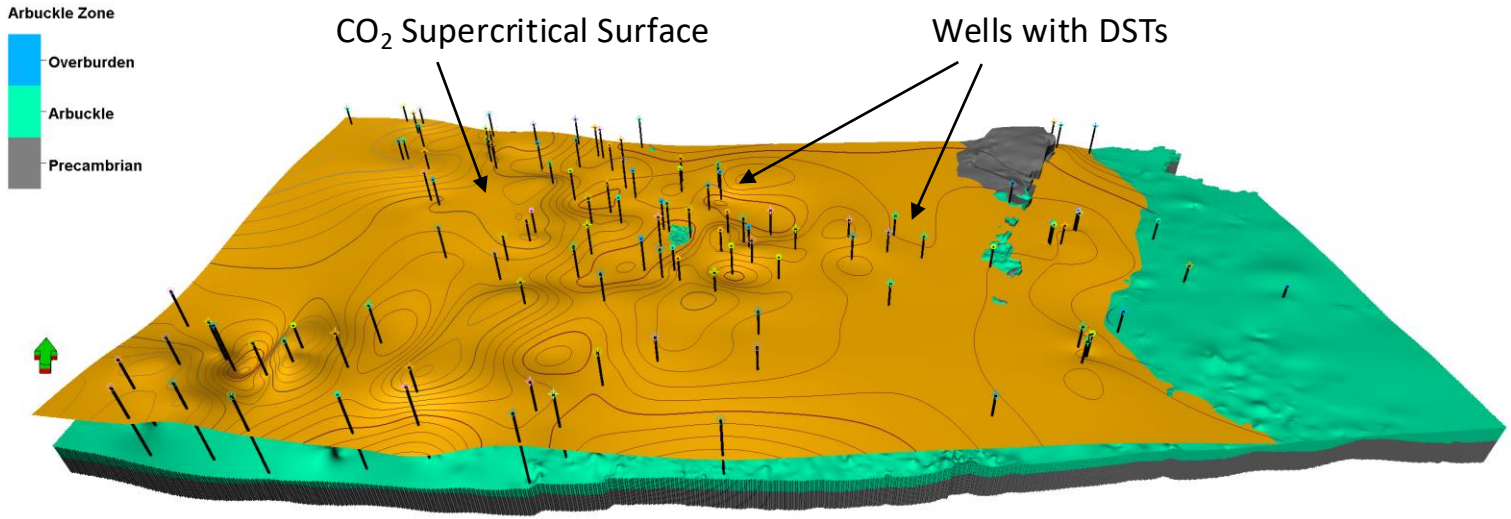
=



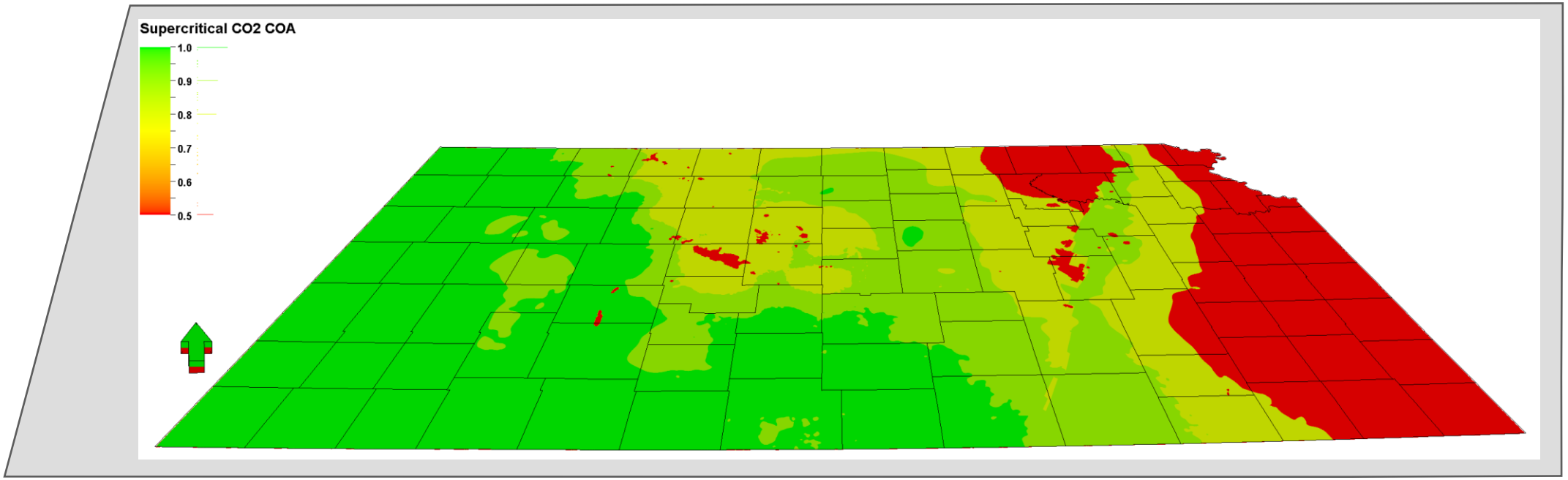
4. CO_2 Phase (supercritical vs subcritical)



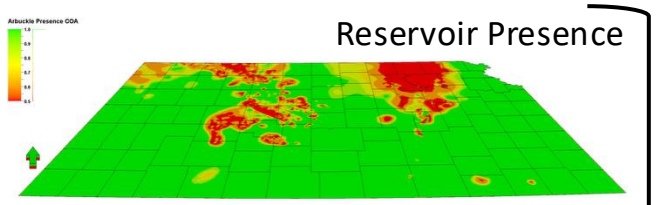
Variation of CO2 density with depth. CO2 density increases rapidly at approximately 800 m depth, when the CO2 reaches a supercritical state. Cubes represent the relative volume occupied by the CO2 and down to 800 m, this volume can be seen to dramatically decrease with depth (IPCC Special Report on Carbon Dioxide Capture and Storage, 2005)



Special thanks to Mark White for CO2 phase interpretation from DST using STOMP.
Each DST served to initialize a vertical grid for STOMP-CO2. (n=~110 wells; ~350 DSTs)

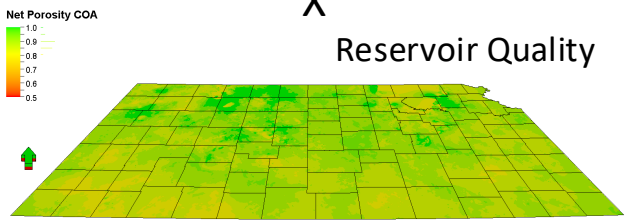


Regional COA



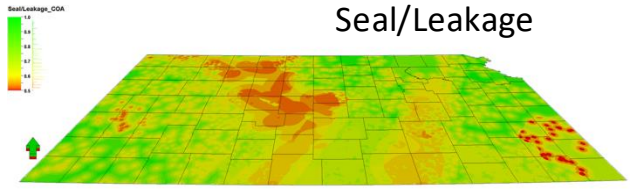
Reservoir Presence

X



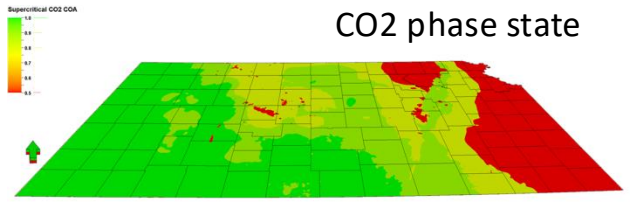
Reservoir Quality

X



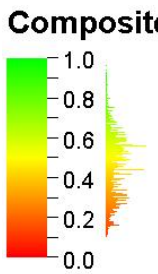
Seal/Leakage

X



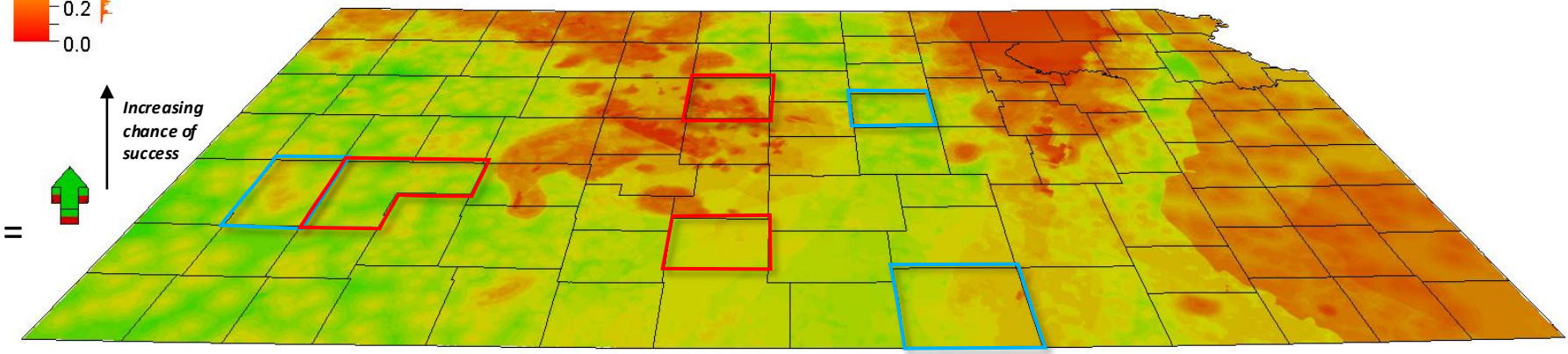
CO2 phase state

=



Increasing chance of success

Aggregate CCS COA Map

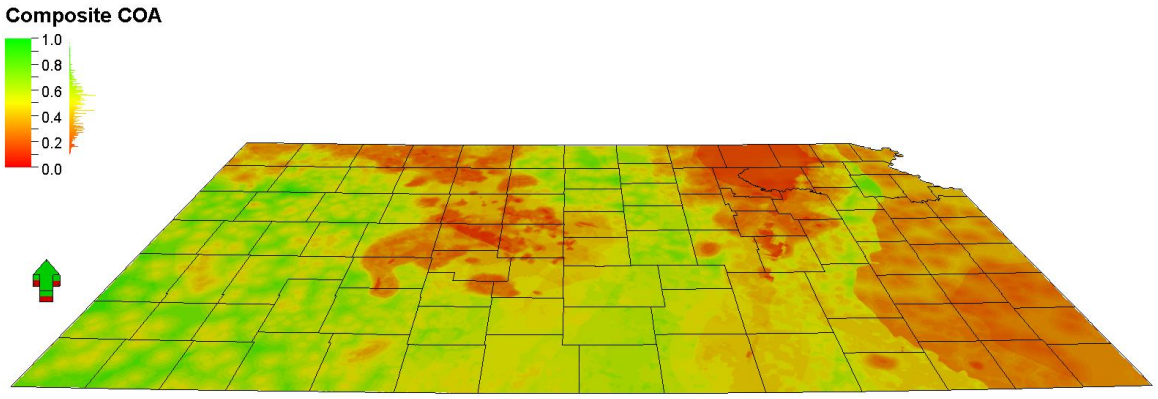


DOE Funded CCS evaluations

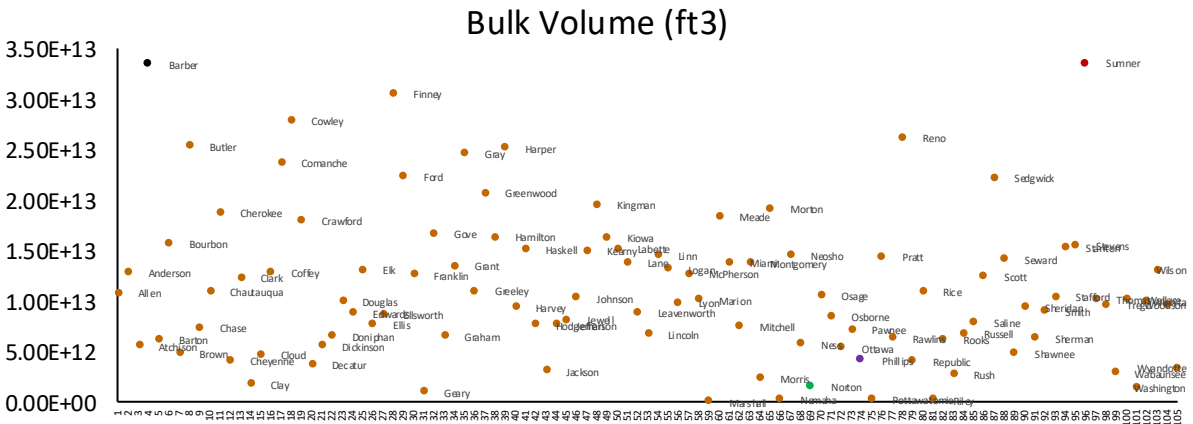
Class VI Applications

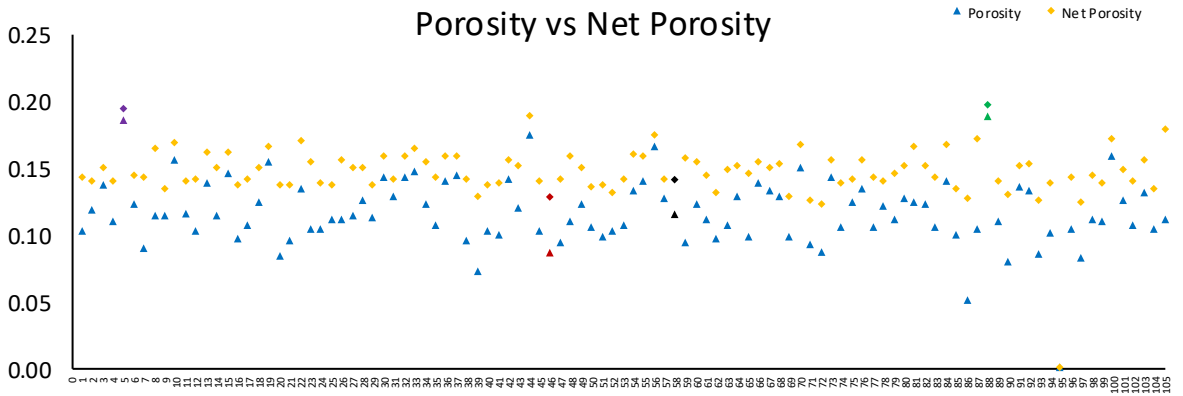
NOTE: Challenged play elements don't preclude a successful CCS project/prospect
Favorable play elements don't guarantee a successful CCS project/prospect

Preliminary County Statistics

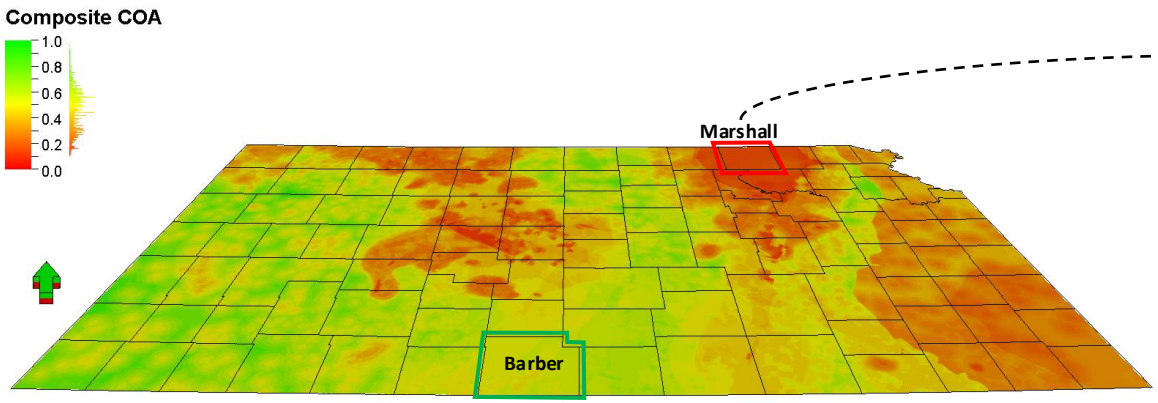


Arbuckle CCS play potential COA Map

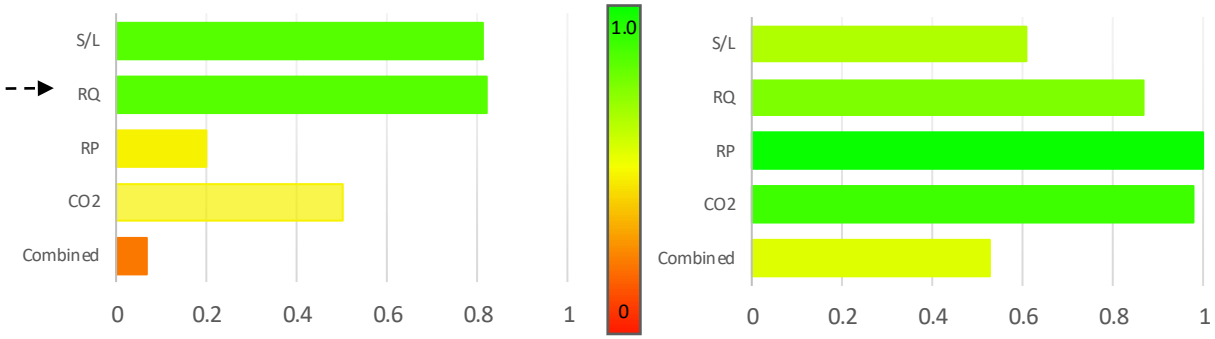


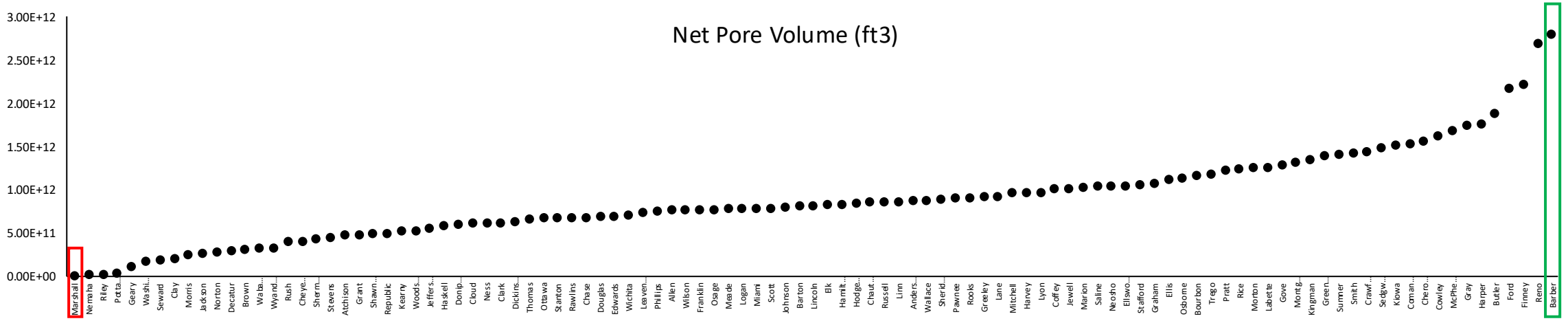


Preliminary County Statistics

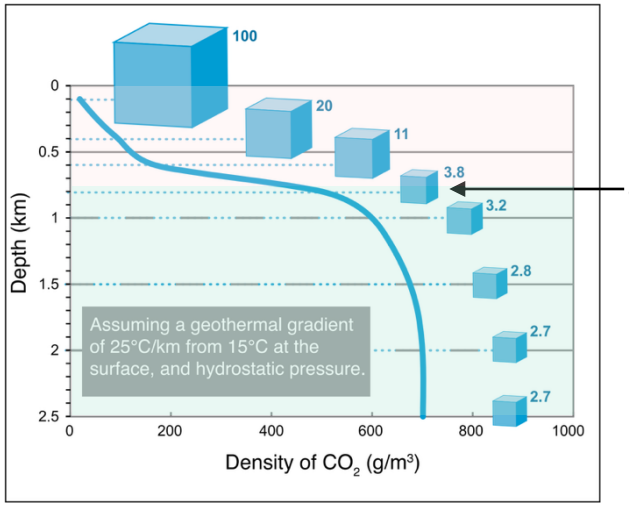


Arbuckle CCS play potential COA Map

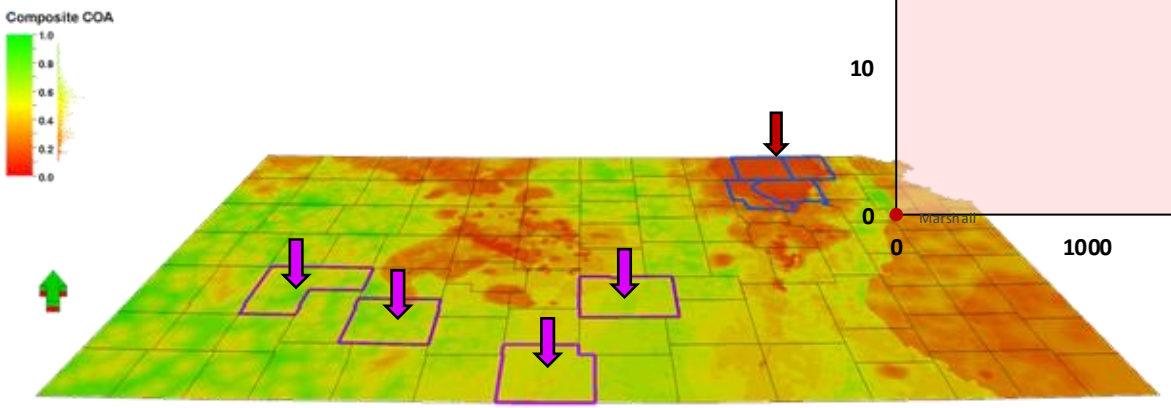


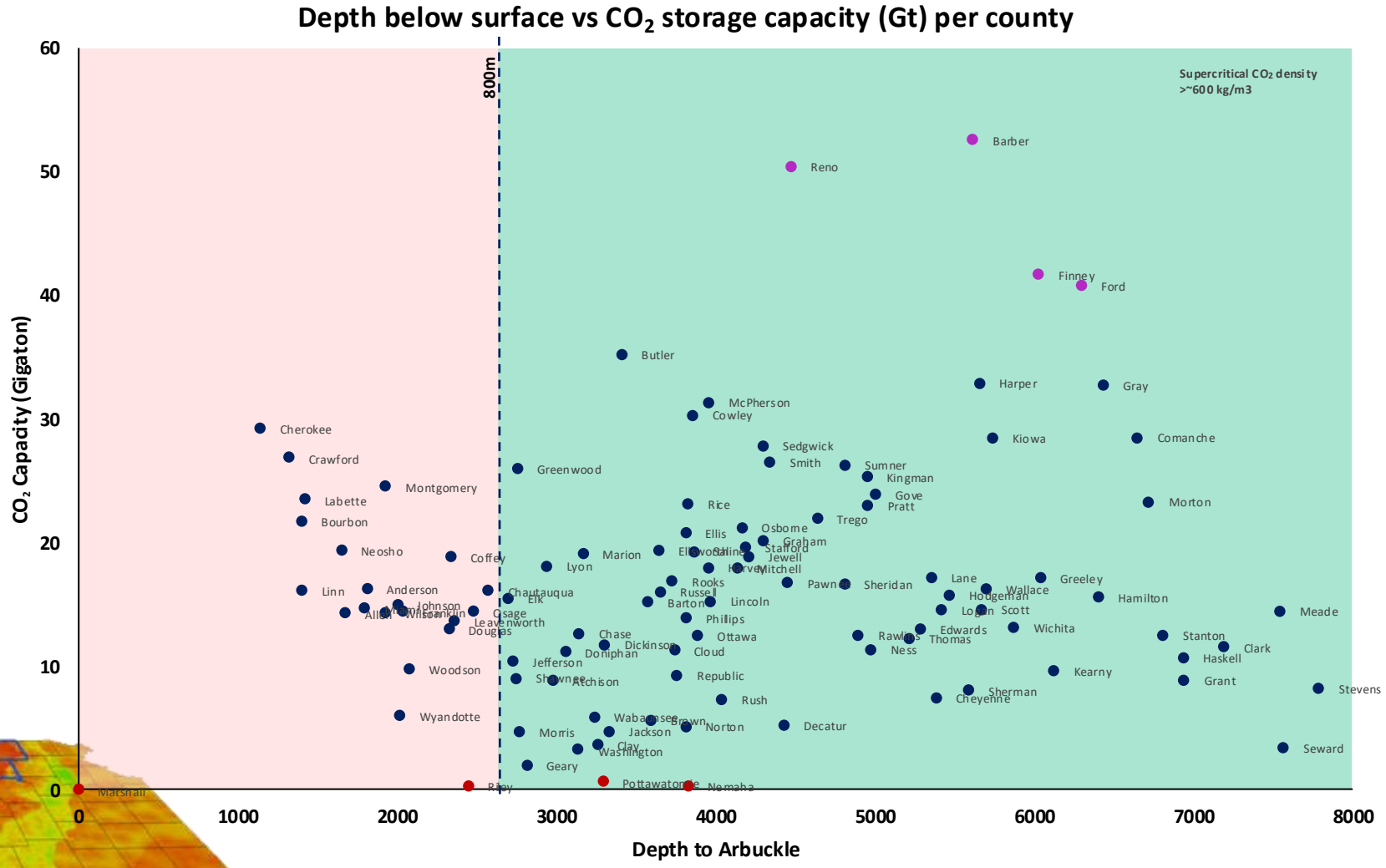


Preliminary CO_2 storage estimates (max)

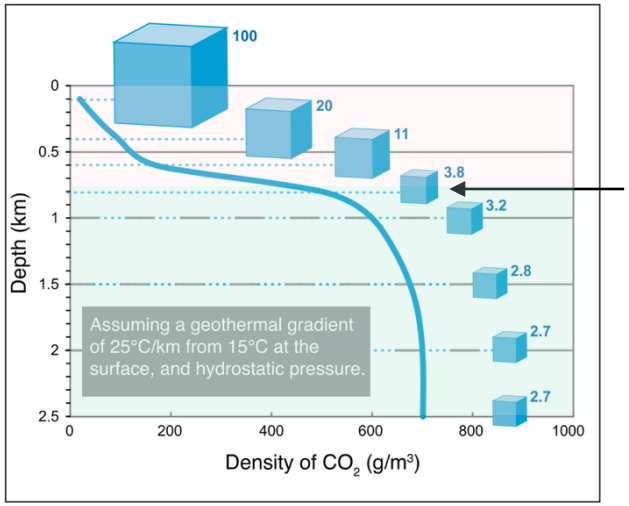


Variation of CO2 density with depth. CO2 density increases rapidly at approximately 800 m depth, when the CO2 reaches a supercritical state. Cubes represent the relative volume occupied by the CO2 and down to 800 m, this volume can be seen to dramatically decrease with depth (IPCC Special Report on Carbon Dioxide Capture and Storage, 2005)

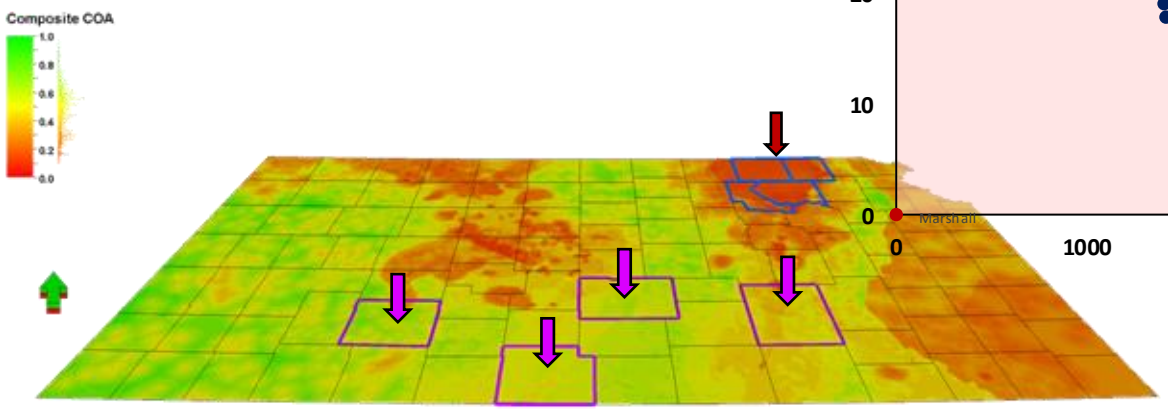


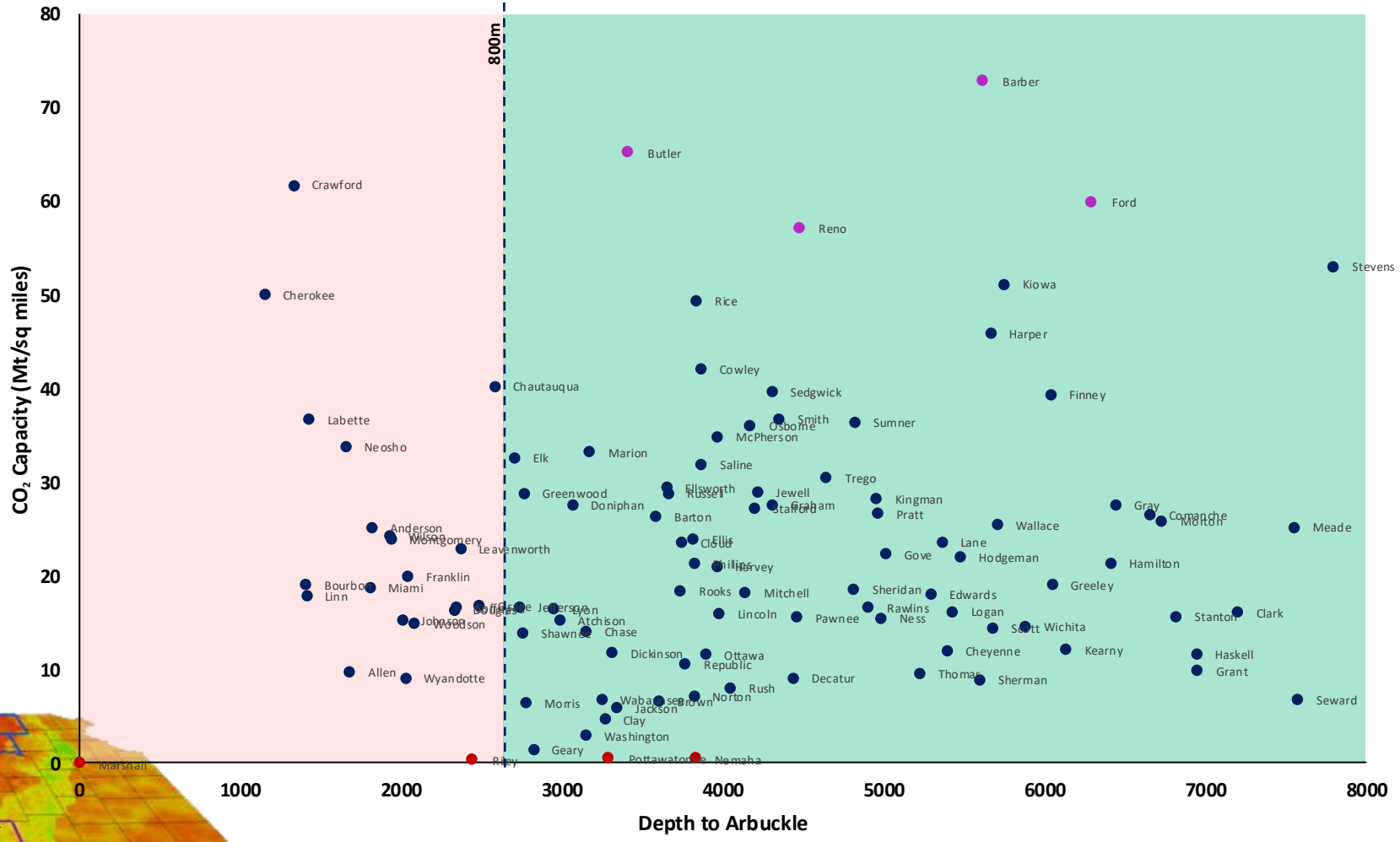


Preliminary CO_2 storage estimates (max)

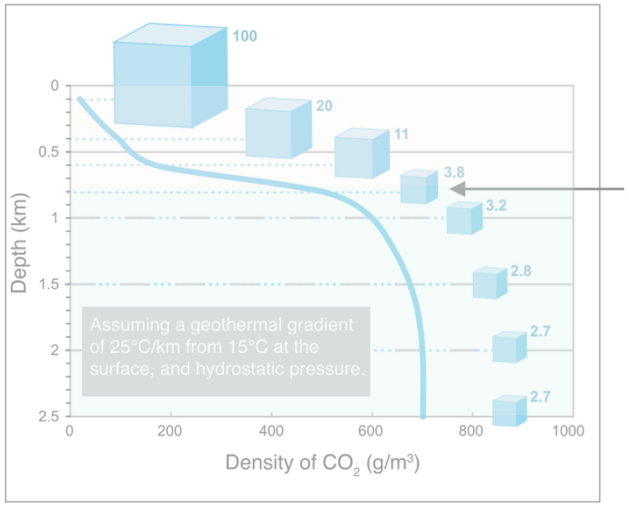


Variation of CO2 density with depth. CO2 density increases rapidly at approximately 800 m depth, when the CO2 reaches a supercritical state. Cubes represent the relative volume occupied by the CO2 and down to 800 m, this volume can be seen to dramatically decrease with depth (IPCC Special Report on Carbon Dioxide Capture and Storage, 2005)

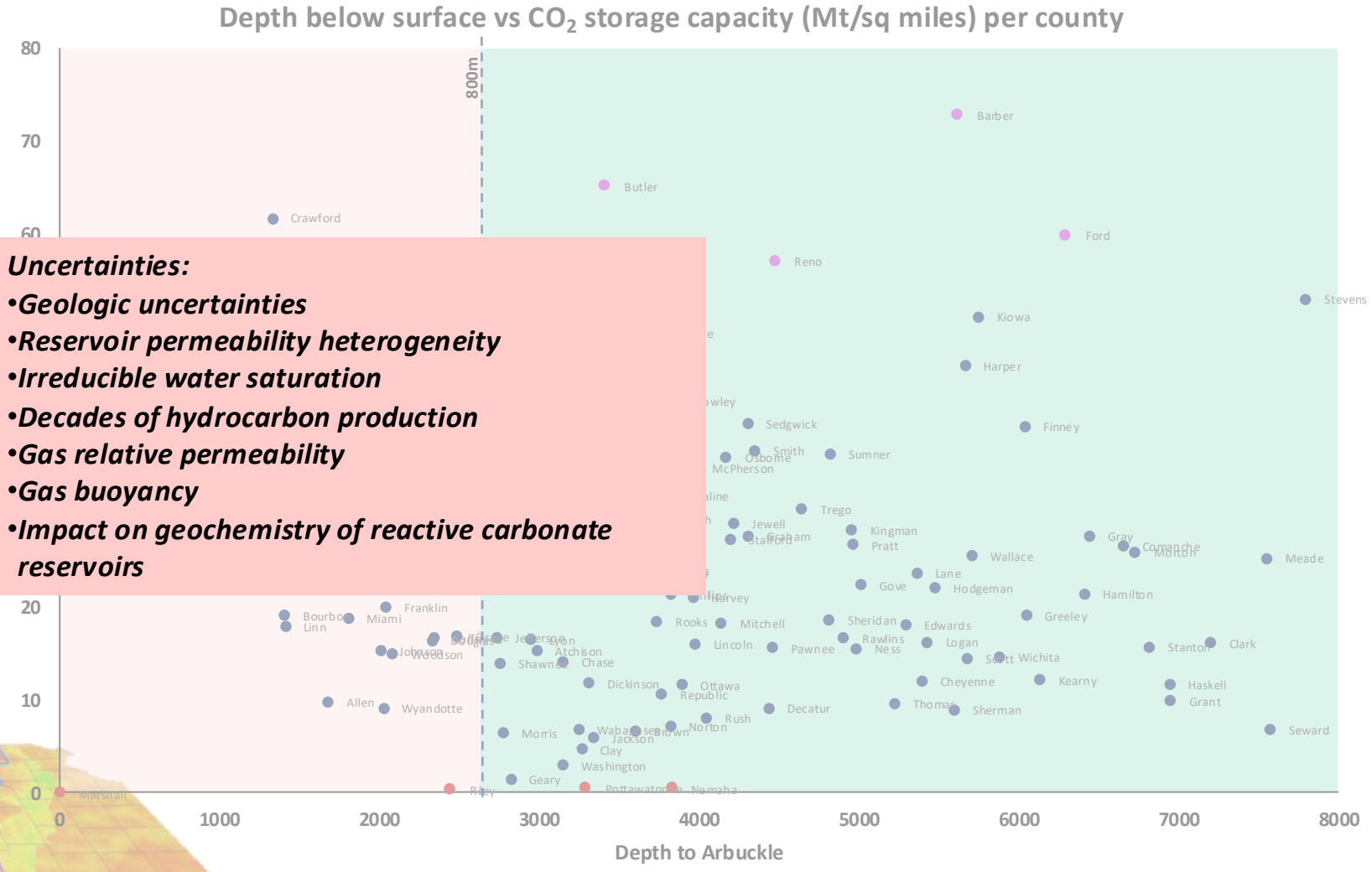




Preliminary CO_2 storage estimates (max)



Variation of CO2 density with depth. CO2 density increases rapidly at approximately 800 m depth, when the CO2 reaches a supercritical state. Cubes represent the relative volume occupied by the CO2 and down to 800 m, this volume can be seen to dramatically decrease with depth (IPCC Special Report on Carbon Dioxide Capture and Storage, 2005)

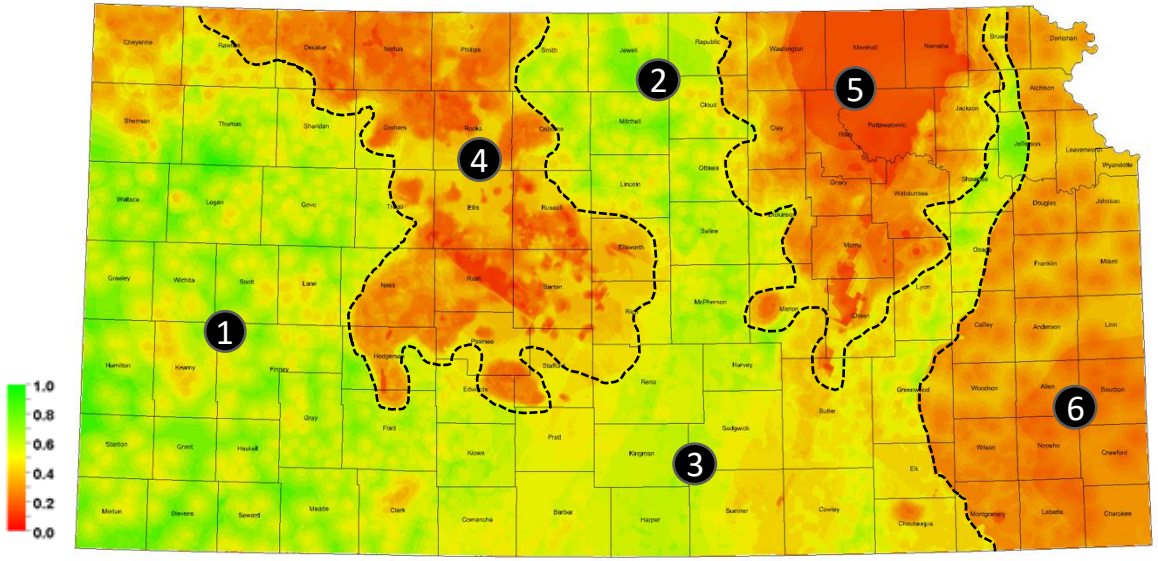


Uncertainties:

- ***Geologic uncertainties***
- ***Reservoir permeability heterogeneity***
- ***Irreducible water saturation***
- ***Decades of hydrocarbon production***
- ***Gas relative permeability***
- ***Gas buoyancy***
- ***Impact on geochemistry of reactive carbonate reservoirs***

Takeaways

- Valuable regional screening effort, utilizing the Arbuckle-Basement faulted framework model
- Identify “favorable” vs potentially “challenged” areas for geologic carbon sequestration



Scope for future work (near term):

1. Normalize petrophysical data and build robust property models
2. Revise CO_2 phase study with additional DST data
3. Compare regional study with focused studies

Big Picture:

A basis for basin-scale screening methodology of Carbon Sequestration

THANK YOU