



Oklahoma Carbon Management

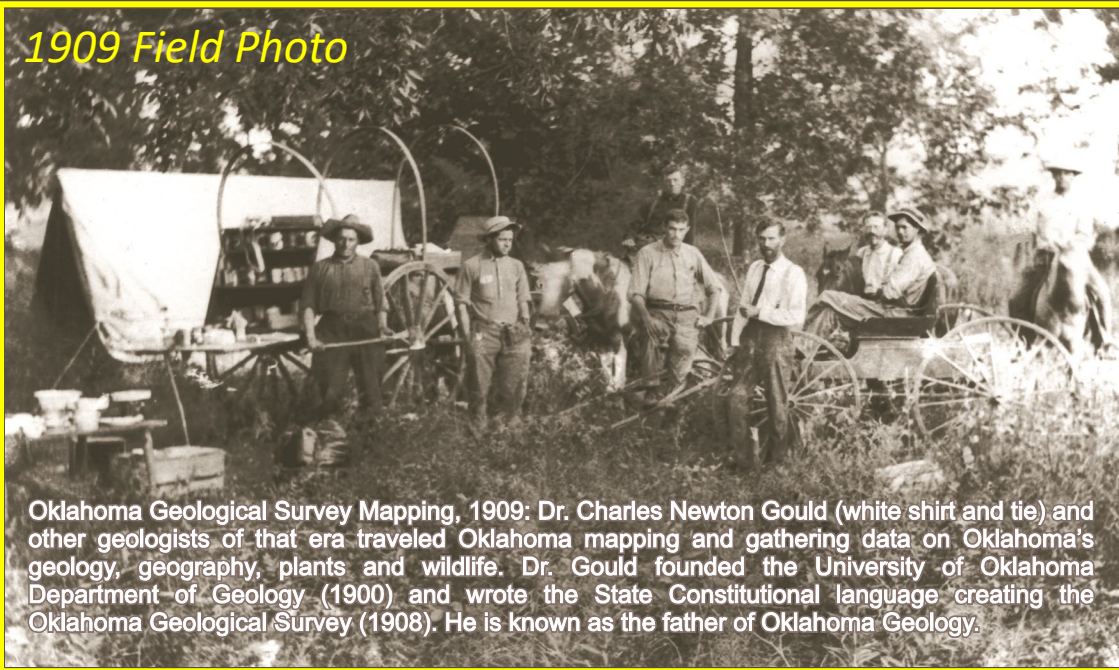
Nicholas W. Hayman
& the Oklahoma Geological Survey (OGS)
Contact: *hayman@ou.edu*

Summary

1. Comments about OGS & roles of Geological Surveys
 - Regulatory support (inc. Class-VI Primacy)
 - Education & Outreach (inc. Community Benefits Plan efforts)
 - Data Management & Technical Resources (inc. to other states & entities)
 - Geophysics Monitoring (e.g. Seismic Network)
2. Oklahoma CO2 Storage
 - Geological & Resource Setting
 - Arbuckle Formation: Where & Why?
 - Induced Seismicity & Flow
3. Thank You CUSP!



1909 Field Photo



Oklahoma Geological Survey Mapping, 1909: Dr. Charles Newton Gould (white shirt and tie) and other geologists of that era traveled Oklahoma mapping and gathering data on Oklahoma's geology, geography, plants and wildlife. Dr. Gould founded the University of Oklahoma Department of Geology (1900) and wrote the State Constitutional language creating the Oklahoma Geological Survey (1908). He is known as the father of Oklahoma Geology.



Currently 33 staff, 16 Ph.D.s.

~\$2.2-2.7M base budget, ~1:1
internal:external (and growing)

“One of the smaller big surveys”



Annual Report & other tools/data available at OGS.OU.EDU



Oklahoma Geological Survey
Nicholas W. Hayman, Director

BULLETIN 152

ISSN 0078-4389

**Woodford Shale (Upper Devonian to Lower Mississippian):
From Hydrocarbon Source Rock to Reservoir**

Brian J. Cardott and John B. Comer



The University of Oklahoma
Norman, Oklahoma

2021

OKLAHOMA GEOLOGICAL SURVEY

CRITICAL MINERALS WORKSHOP

SOUTHERN MIDCONTINENT

UP-AND-COMING OPPORTUNITIES

GEOSCIENTISTS, RESEARCHERS, STUDENTS,
POLICY MAKERS, GIS SPECIALISTS,
ACADEMICS, GEOSTATISTICIANS, ENGINEERS,
SOCIAL SCIENTISTS, ENVIRONMENTAL
SCIENTISTS



A VIRTUAL 3-DAY
3 HRS/DAY
WORKSHOP FULL OF
BRAINSTORMING,
DISCUSSIONS, AND
INFORMATION-SHARING
NOV 8-10 | 2021
FREE VIA ZOOM

INTERESTED?
VISIT OGS.OU.EDU OR EMAIL OGS@OU.EDU



GEOLOGIST OFFICE HOURS

METEORITE?
FOSSIL?
MYSTERY MINERAL?
STRANGE ROCK?


BRING IT IN AND
WE'LL TAKE A LOOK...

OPEN TO THE
PUBLIC

FRIDAY, DECEMBER 3, 2021
9:00AM - 12:00PM

**Sarkeys Energy Center,
100 E. Boyd Street, Norman, OK 73019**
Room P130 (basement)
free parking in the lot at
Boyd and Trout

QUESTIONS?
yunker@ou.edu
405-325-1211



Education & Outreach

The Oklahoma Geological Survey is a state agency for research and public service located on the Norman Campus of The University of Oklahoma and affiliated with the OU Mewbourne College of Earth and Energy. The Survey is chartered in the Oklahoma Constitution ([70 OK Stat § 70-3310 \(2014\) \(RTF\)](#)) and is charged with investigating the state's land, water, mineral, and energy resources, and **disseminating the results of those investigations to promote the wise use of Oklahoma's natural resources consistent with sound environmental practices.**

Oklahoma Petroleum Information Center (OPIC)



~4 football fields of core & well-log (paper) storage, layout rooms, & other facilities

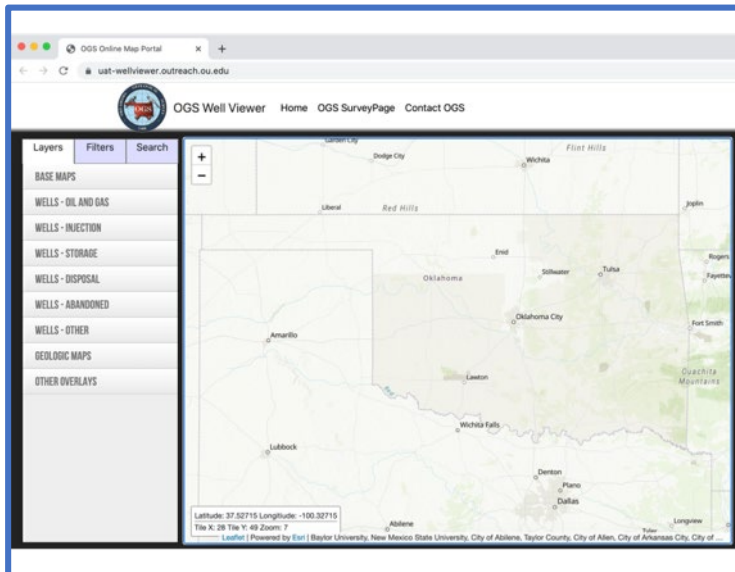
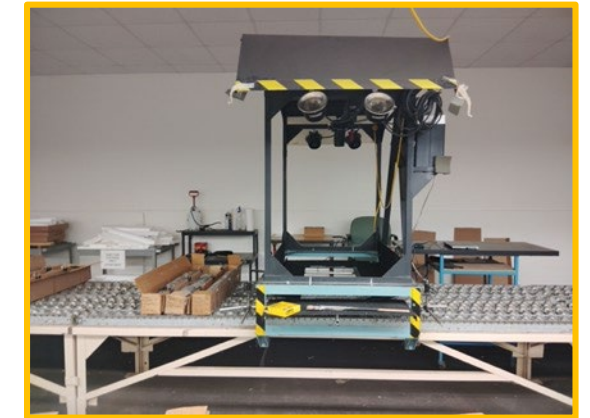
Digitizing much of the data into an on-line well-viewer:

<https://uat-wellviewer.dig.ou.edu/>

Before (SLR camera mount)



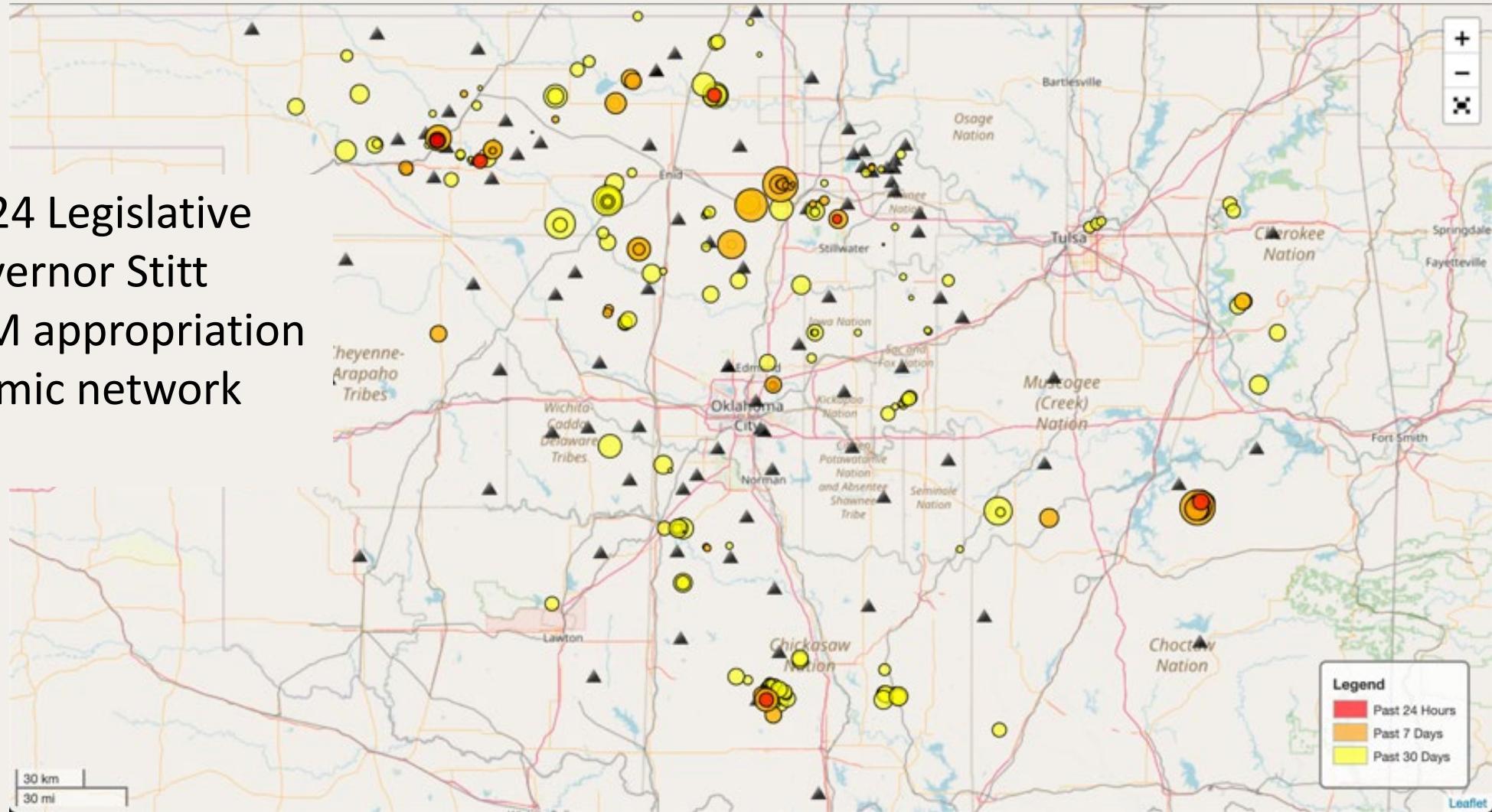
After (unique core scanning capabilities)



NEWS!!!
Baker-Hughes Core CT
lab coming to OPIC

OGS Earthquake Monitoring Network

NEWS!!! 2024 Legislative Session, Governor Stitt signed a \$4M appropriation for OGS seismic network upgrades!!!



<https://wichita.ogs.ou.edu/staff/earthquake/events.html>

Class-VI Primacy

By 2022 Oklahoma Secretary of Energy (OSEE) Ken McQueen had worked with OGS, DEQ (Env. Quality), and OCC (Class-II regulator) to have the Governor submit a letter of intent for Class-VI to EPA

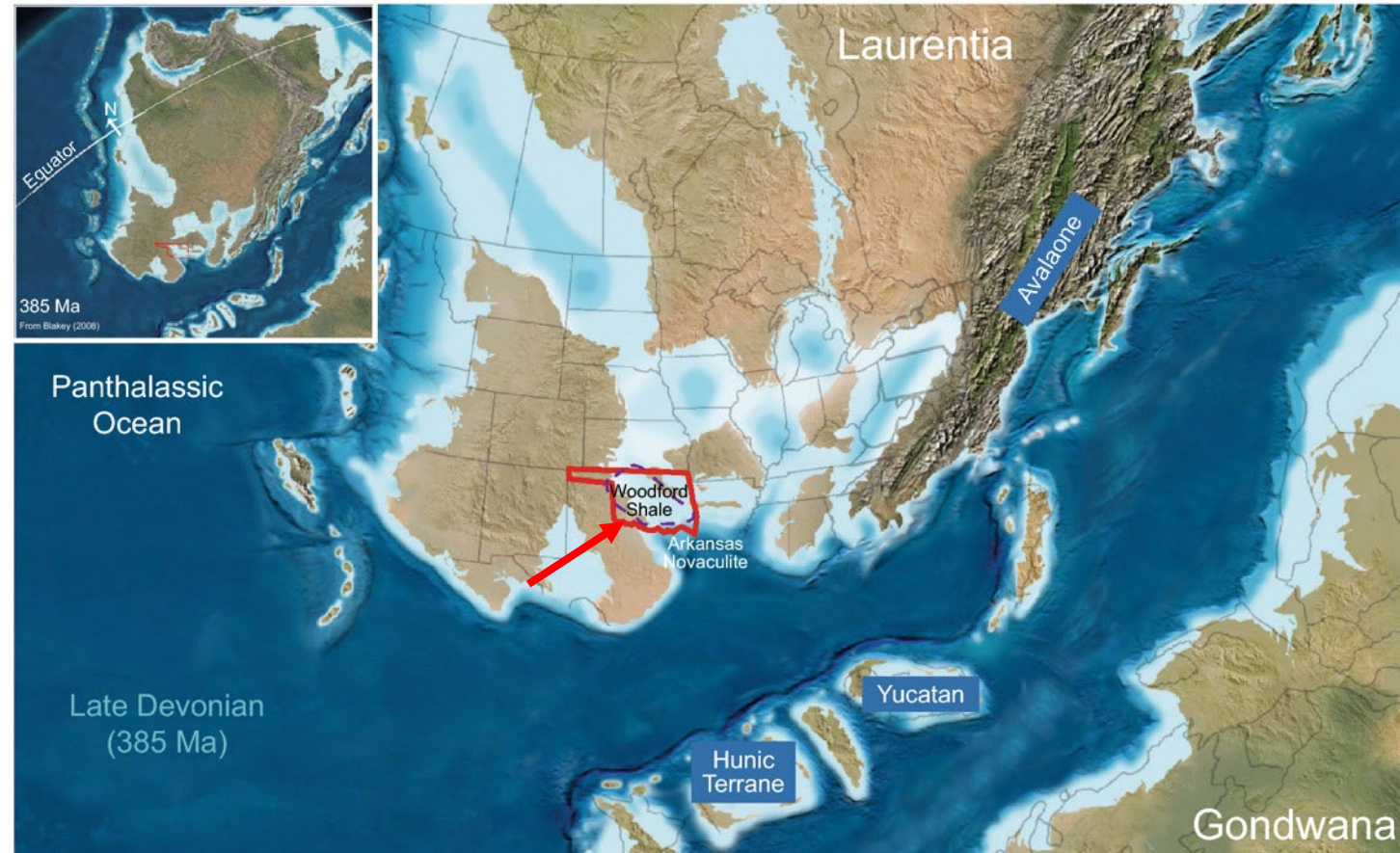
By Spring of 2024 draft legislation required to proceed to primacy, but not brought to floor

Why not?: Issues surrounding unitization between Ag and O&G; different POVs within O&G community on wide range of issues

Assuming legislation & permit application gets ironed out, there remains a challenge about Arbuckle Storage & Induced Seismicity



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385 Million Years Ago

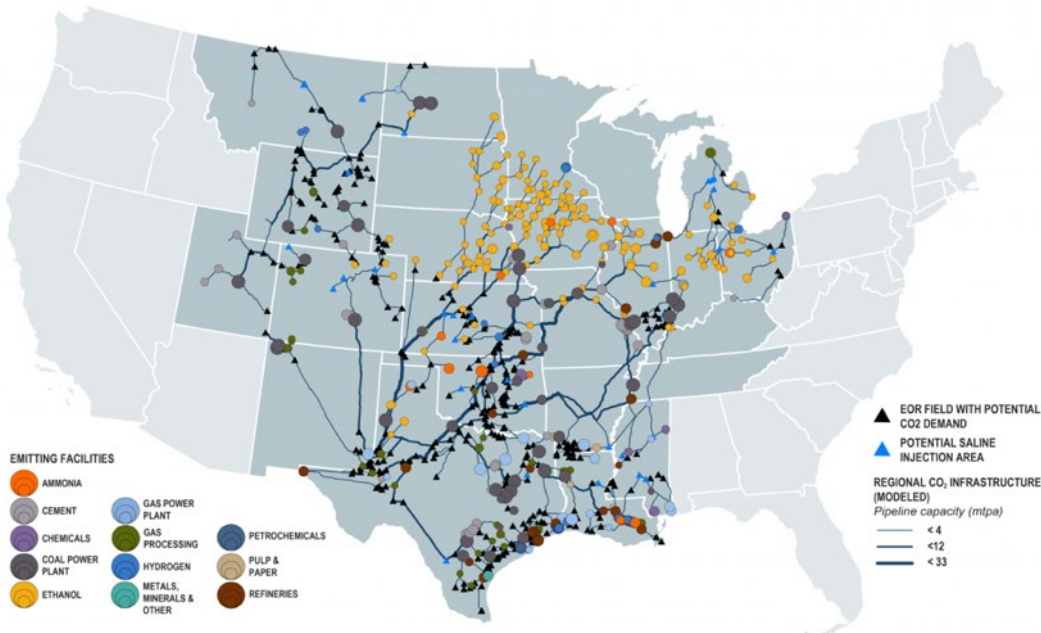
Blakely, 2013 Plate Reconstruction, from Wang & David, 2019



CUSP, Sept. 11, 2024

Oklahoma at the crossroads of the Net Zero economy

- Pipeline infrastructure from Kansas Fertilizers to OK EOR fields
- NS Enid pipeline for CO₂ to Ardmore Basin EOR
- Planned H₂ pipelines
- Anadarko Basin & other areas with storage resource but low infrastructure density



From: Great Plains Institute

- Basins determined by Ancestral Rockies (Pennsylvanian Age)
- Many Gt storage in Sedimentary sections, but also mafic units (CCS mineralization)

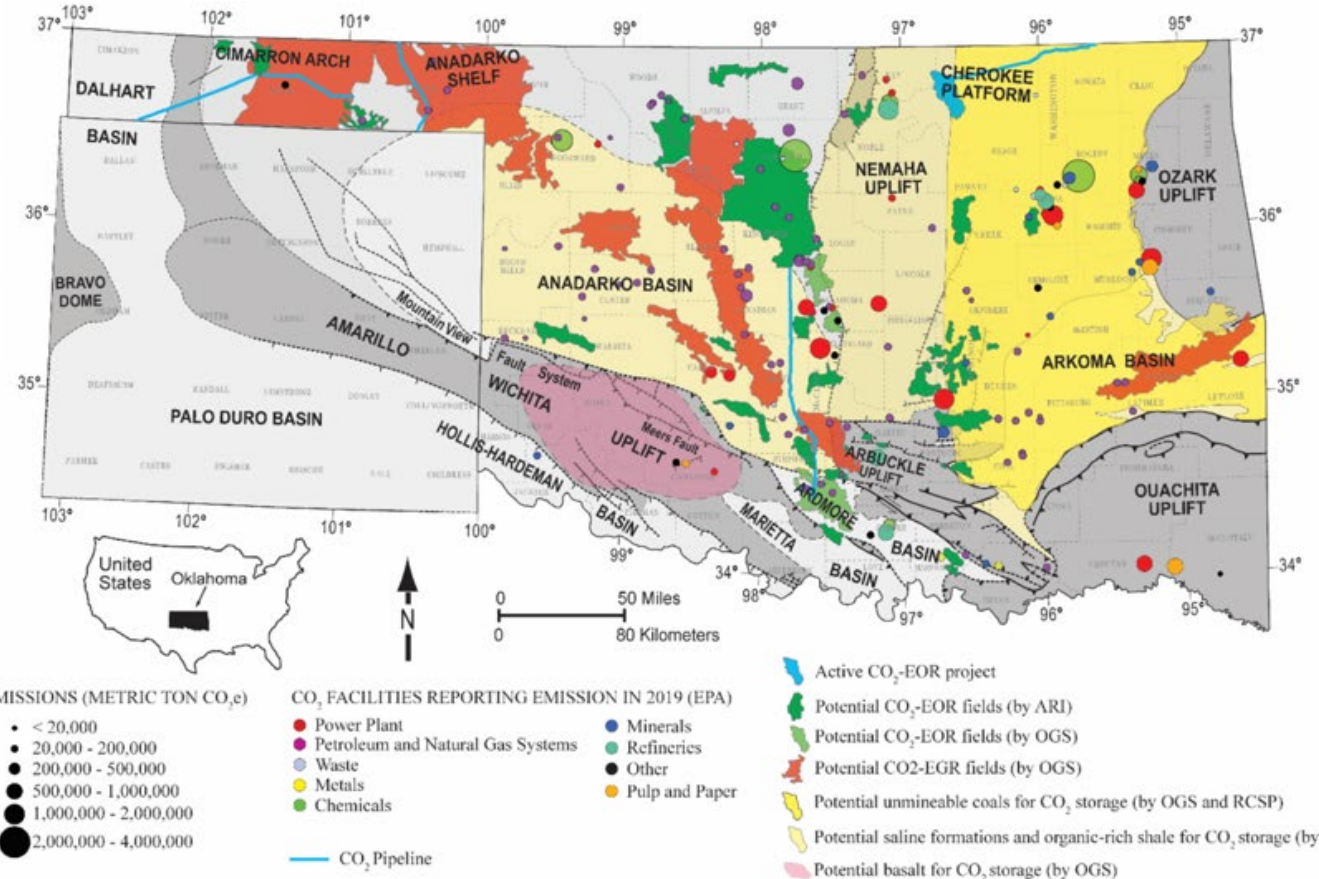
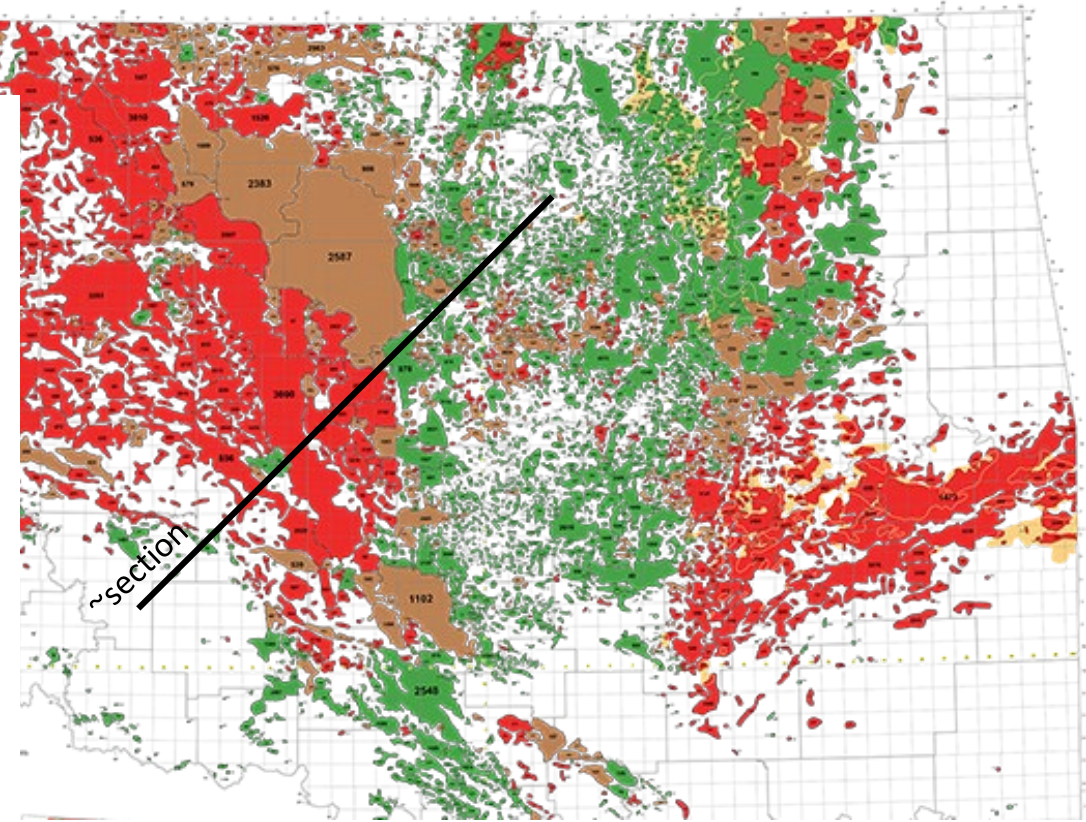
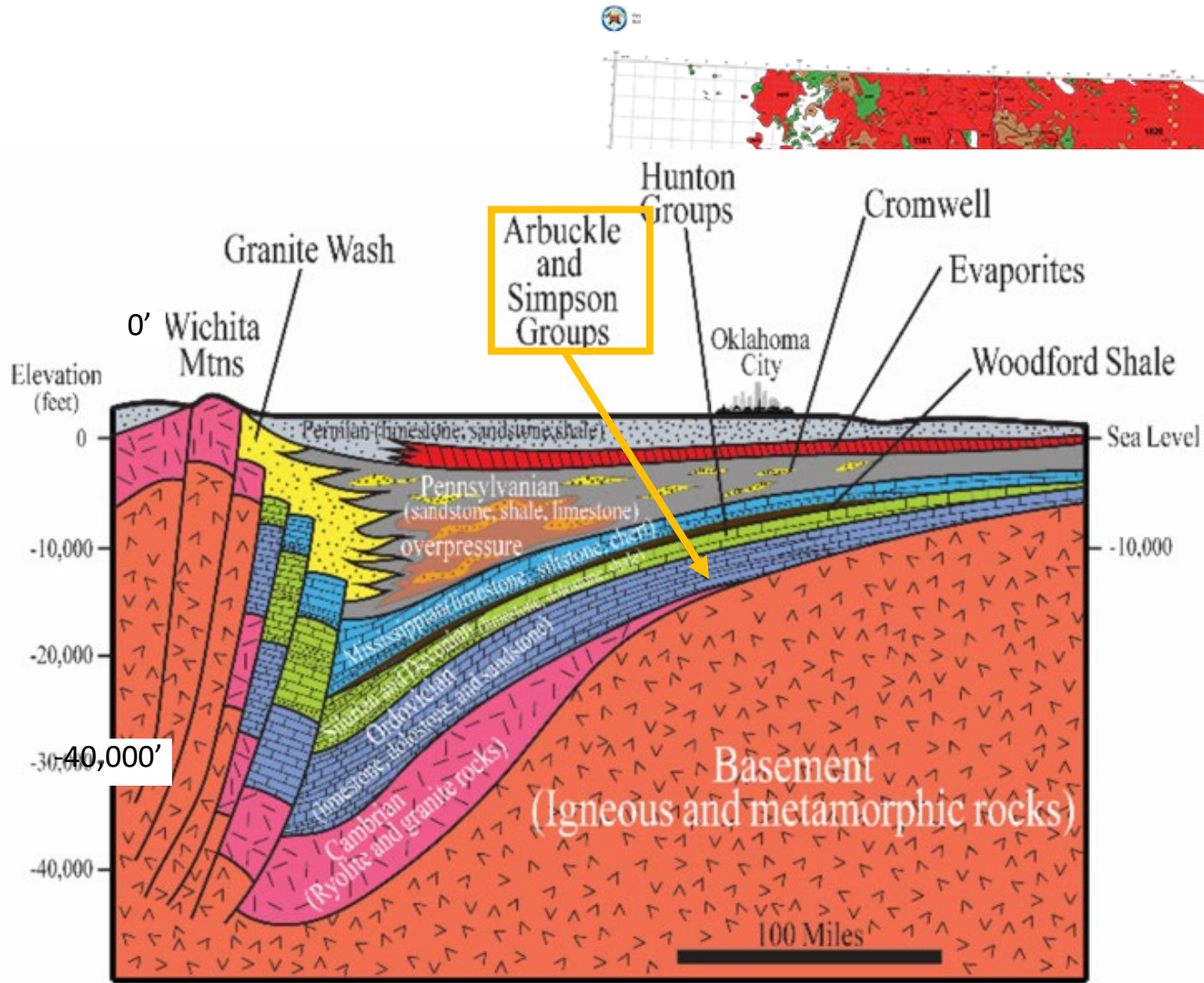


Figure 2. Geological provinces and prominent carbon emissions and facilities^{12,22-27}. Major CO₂ emissions are illustrated for the year 2019 along with known CO₂ pipelines, geological provinces, and some major oil and gas fields.

The subsurface is a massive region of potential resources both for production & storage



CUSP, Sept. 11, 2024

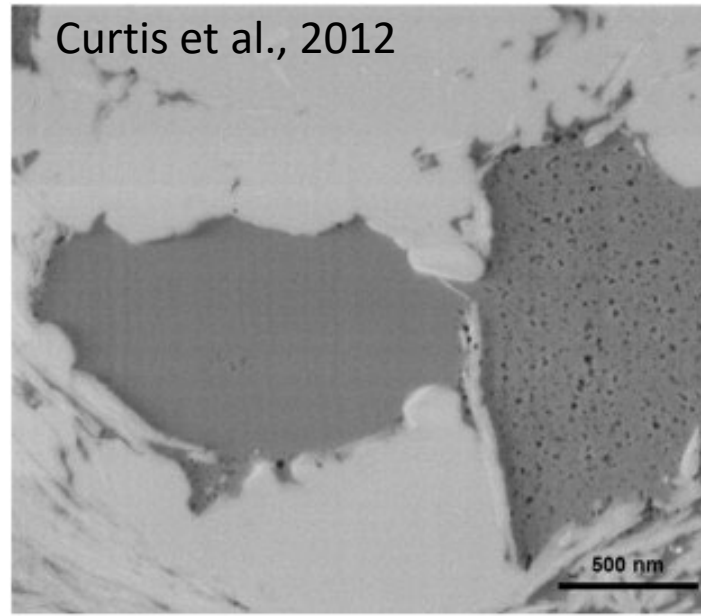
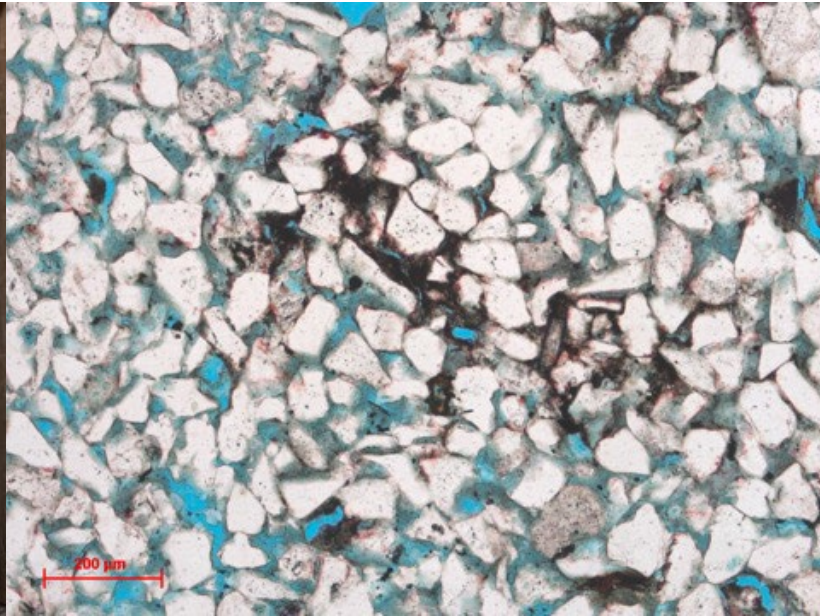
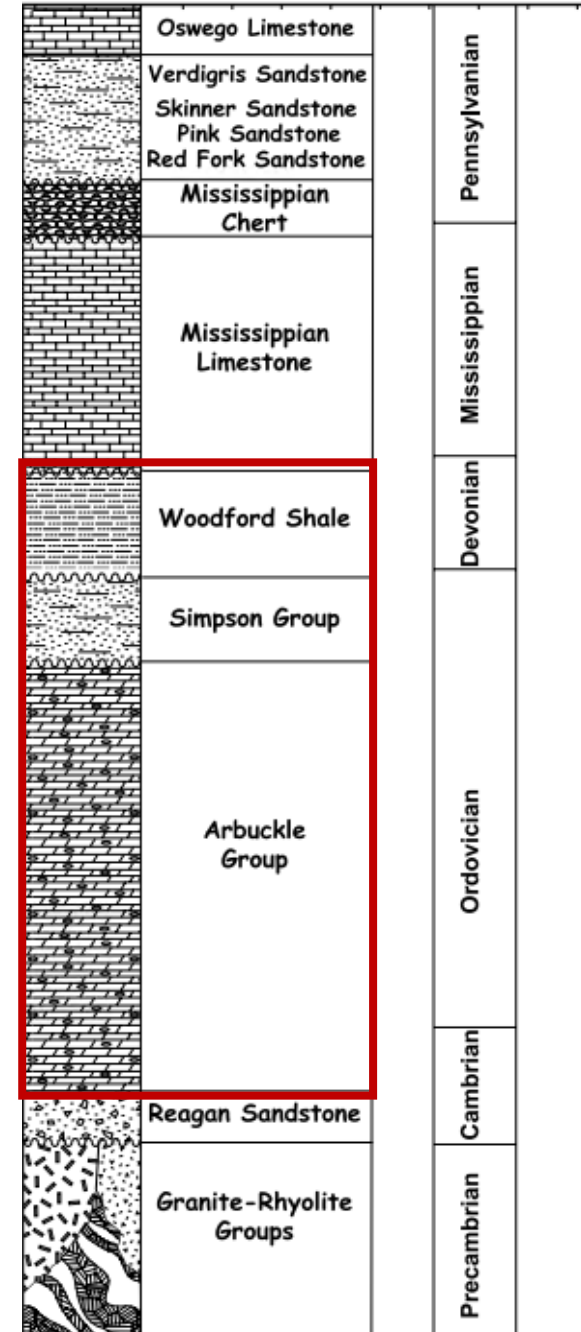
Green = Oil
 Red = Gas
 Beige = Oil & Gas
 (SCOOP/STACK)

Arbuckle-Simpson-Woodford

Reservoirs (Arbuckle Carbonate)

Reservoirs (Simpson Sandstone)

Seals (e.g. Woodford Shale)



Curtis et al., 2012

Penny for scale

200 micron scalebar

500 nanometer scalebar



CUSP, Sept. 11, 2024

CUSP Focus on Arbuckle & Simpson

OGS effort: Contribution to SCO₂T database

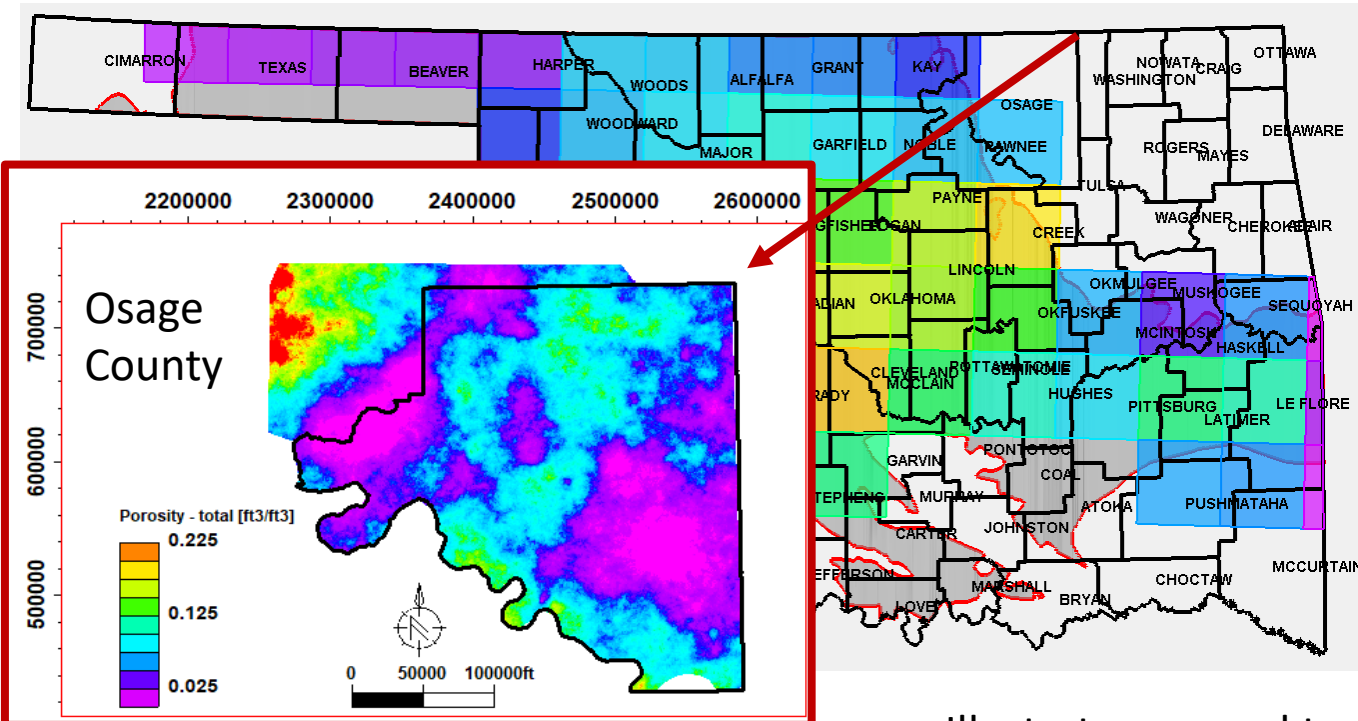
Osage effort: resulting in CarbonSAFE proposal in review

(Pranter, OU, lead PI):

<https://doi.org/10.1016/j.fuel.2023.129323>

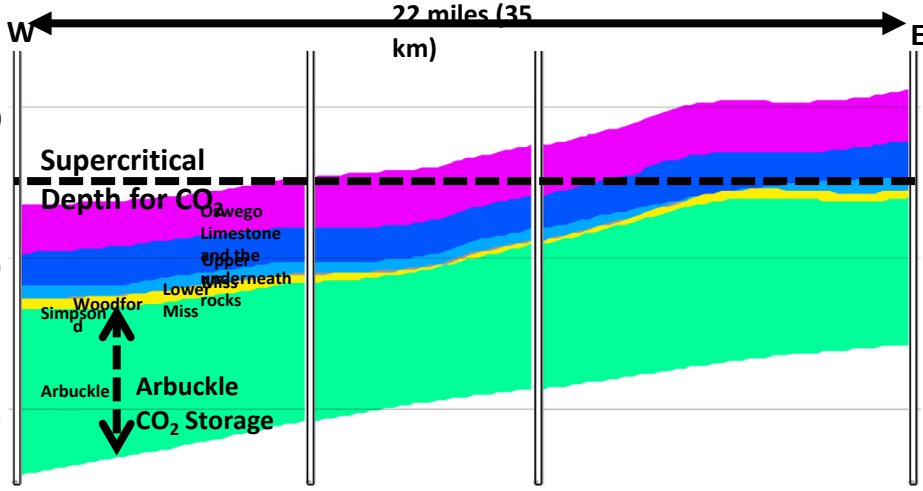
Carbon Solutions statewide effort: Miranda et

al.,2023, <https://doi.org/10.1002/ghg.2244>



Arbuckle Formation

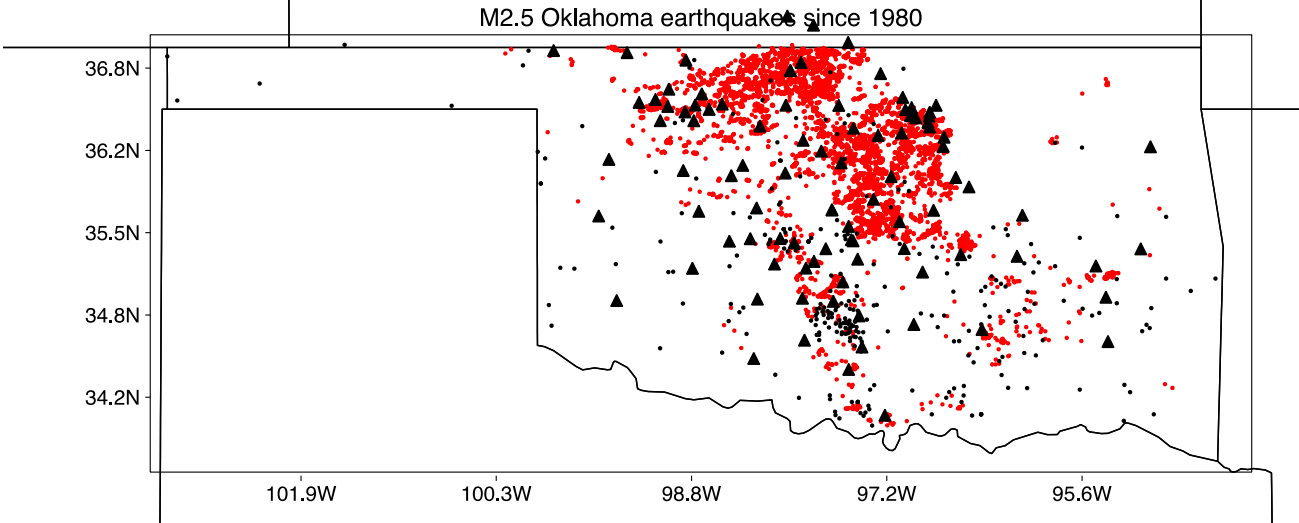
Simpson Formation



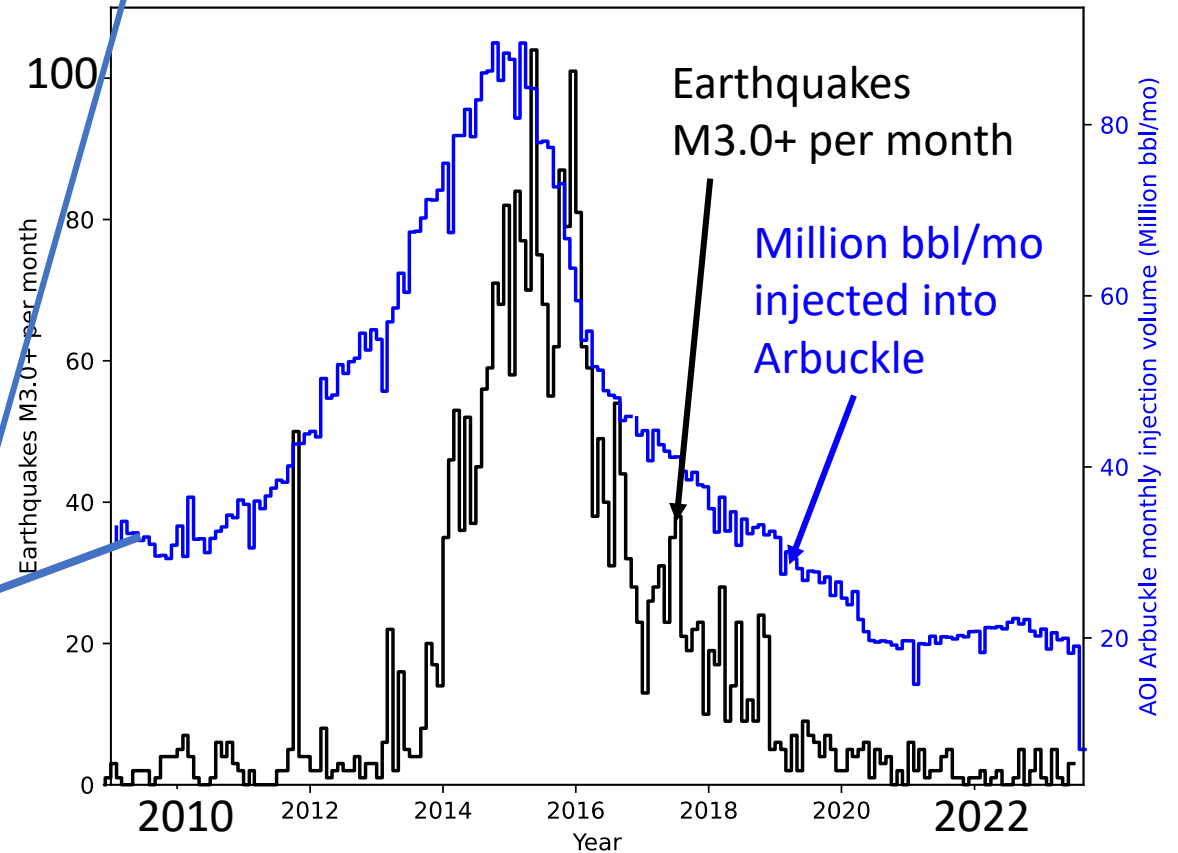
- Illustrates general trend from NE to SW for Arbuckle
- Belt of high storage capacity in central part of state
- “Flat earth” assessments to 100’s of GT CO₂

Produced water (PW), salt-water disposal (SWD), underground-injection-controls (UIC) & induced seismicity

At peak injection >80 million barrels (>5000 Olympic pools or just under 1 Lake Thunderbird) of SWD into the Arbuckle **every month**.



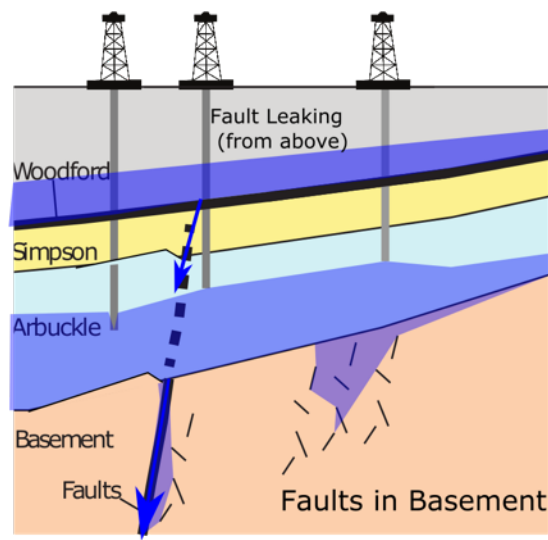
Earthquakes have been more concentrated within SCOOP/STACK where injection has been concentrated. Also geological controls.



Question: would injection of CO2 away from the seismic belt face a lower hazard?

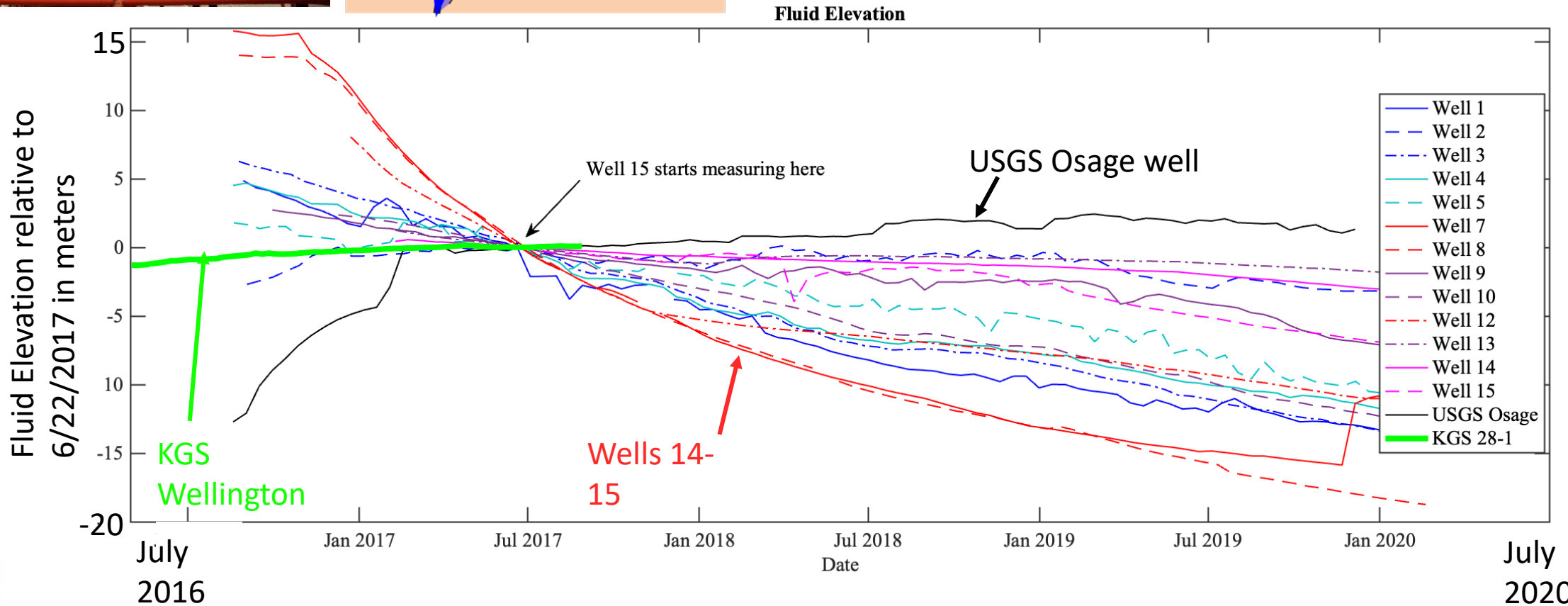
CUSP, Sept. 11, 2024





Allen et al., "Minor Revisions" at Journal of Geophysical Research:

- Pressure monitoring of Arbuckle wells found long term declines (and lots of short-term transients).
- Clearly flow, but note these are DENSE fluids and not a buoyant CO2 plume.



FINAL SLIDE

1. Comments about OGS & roles of Geological Surveys
 2. Oklahoma CO2 Storage
 3. Thank You CUSP!
- DOE -2799 award to State Surveys is helping us get up to capacity
 - Industry connections from CUSP are invaluable for our mission
 - CUSP projects w/ Utah and Kansas have inspired us in our technical strategies
 - Welcome future collaborations with CUSP members and beyond!

