Project ECO$_2$S: Characterization of a World Class CO$_2$ Storage Complex

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NATIONAL ENERGY TECHNOLOGY LABORATORY

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Disclaimer

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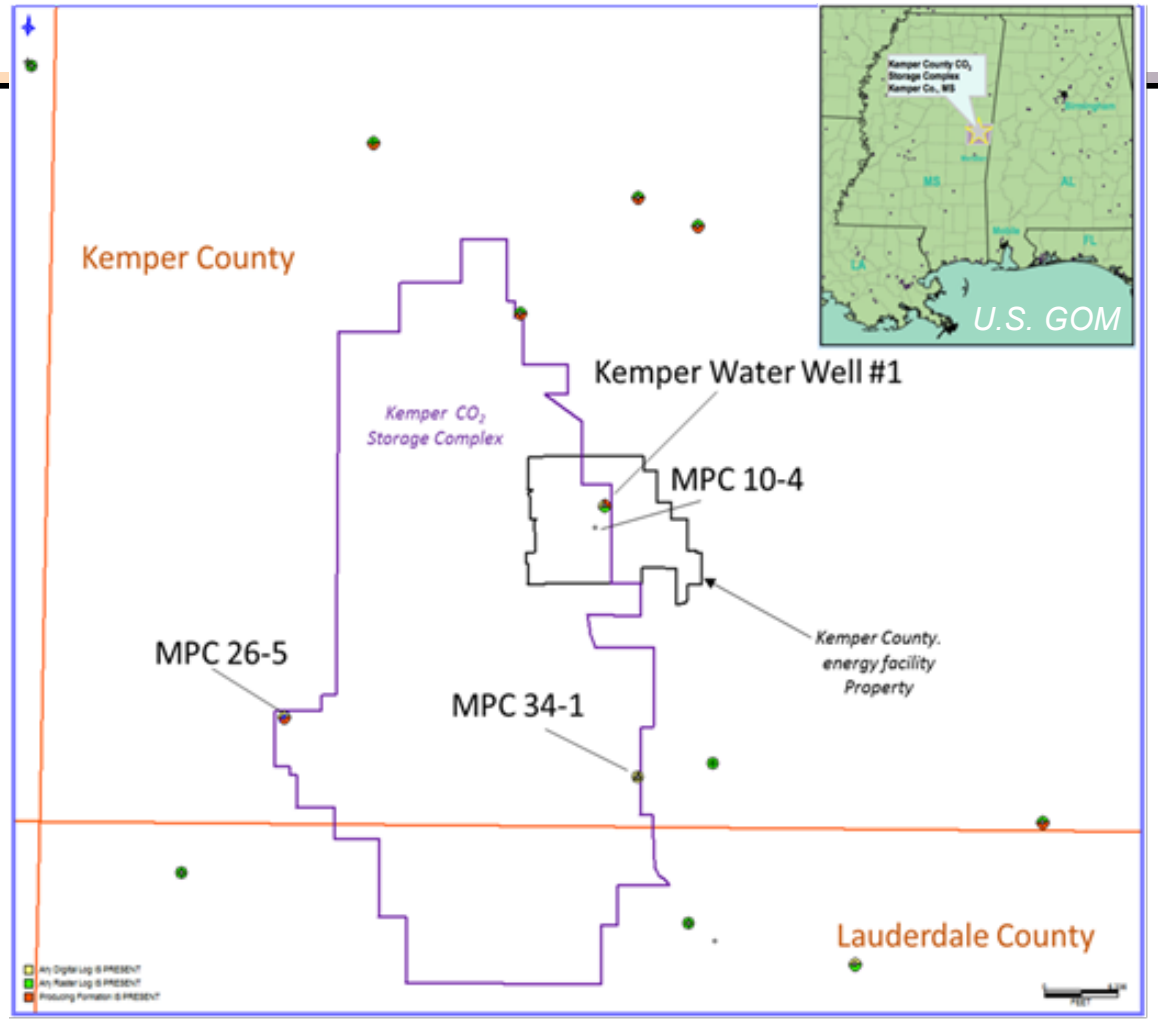
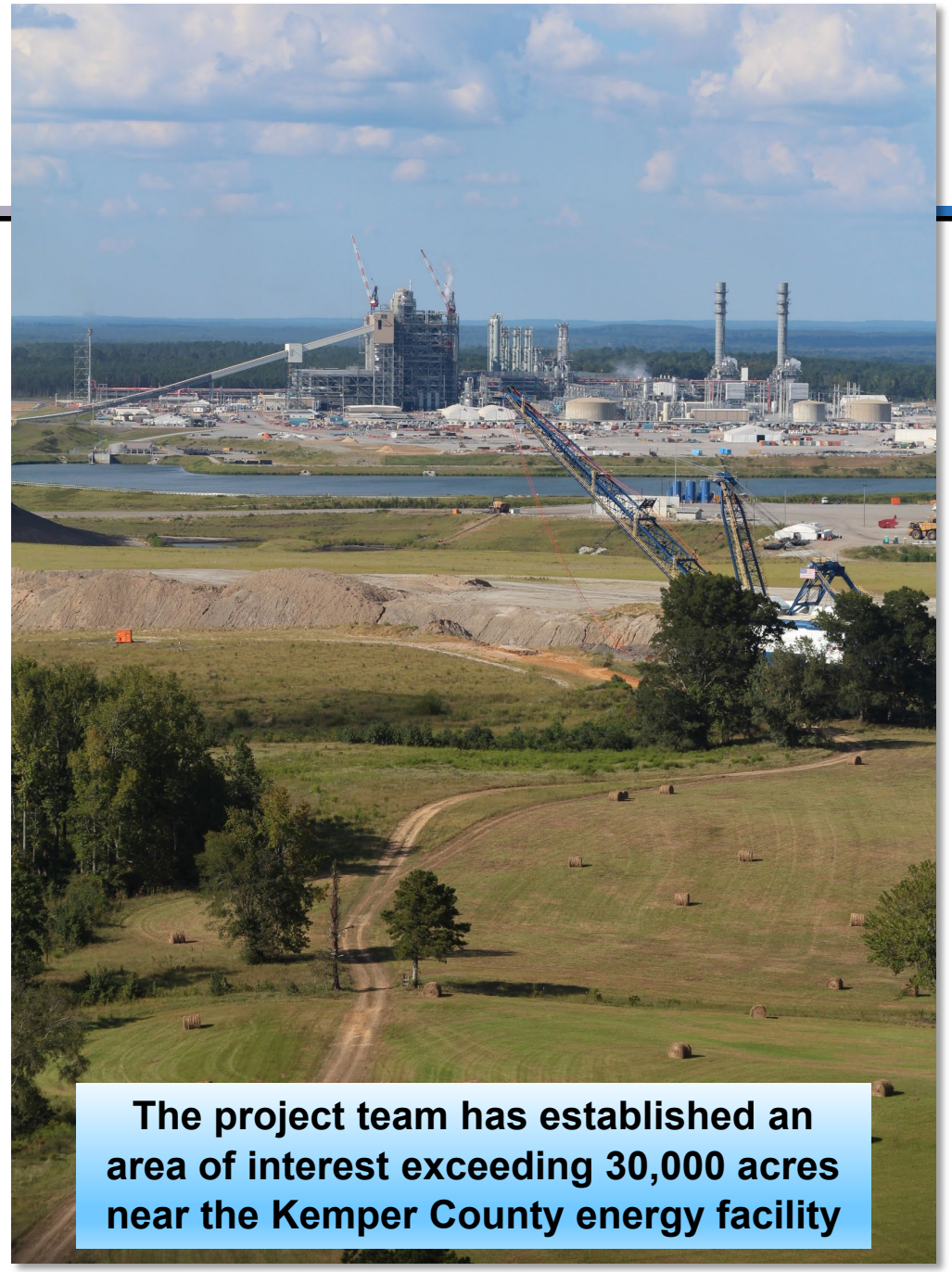
Why Kemper?



The goal is to demonstrate that the subsurface at Kemper CO_2 can <u>safely and permanently store commercial volumes of CO_2</u>



The project team has established an area of interest exceeding 30,000 acres near the Kemper County energy facility

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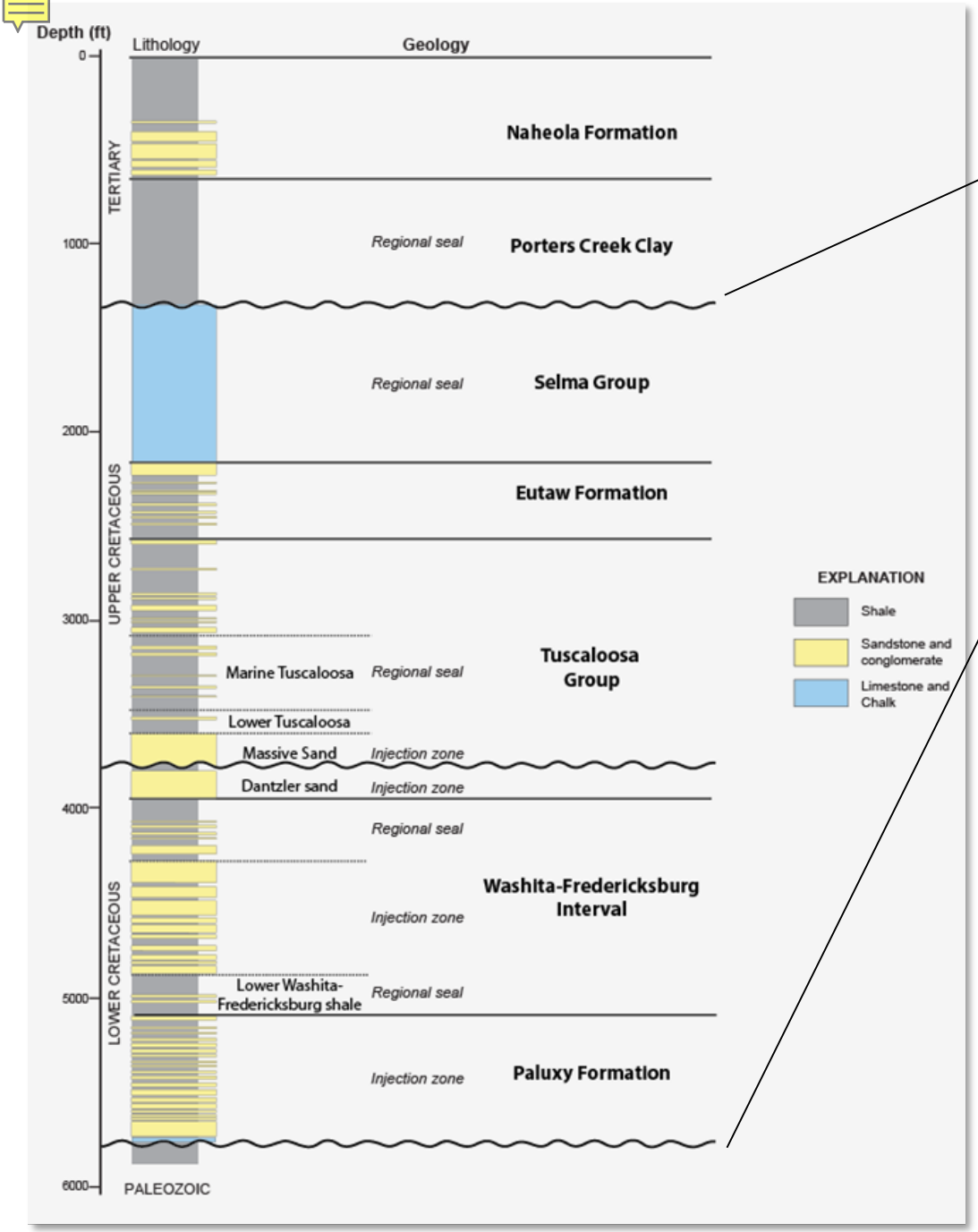
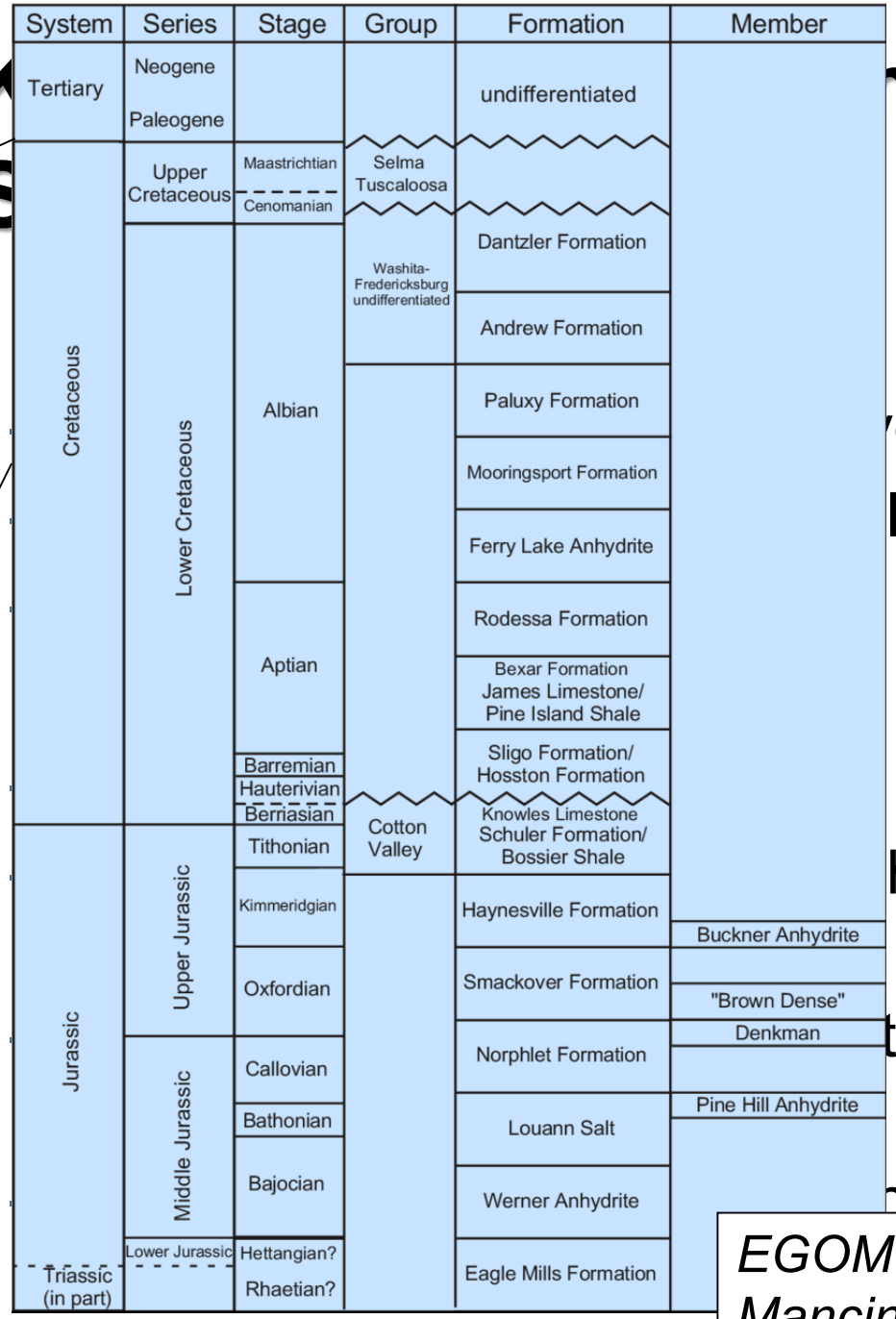
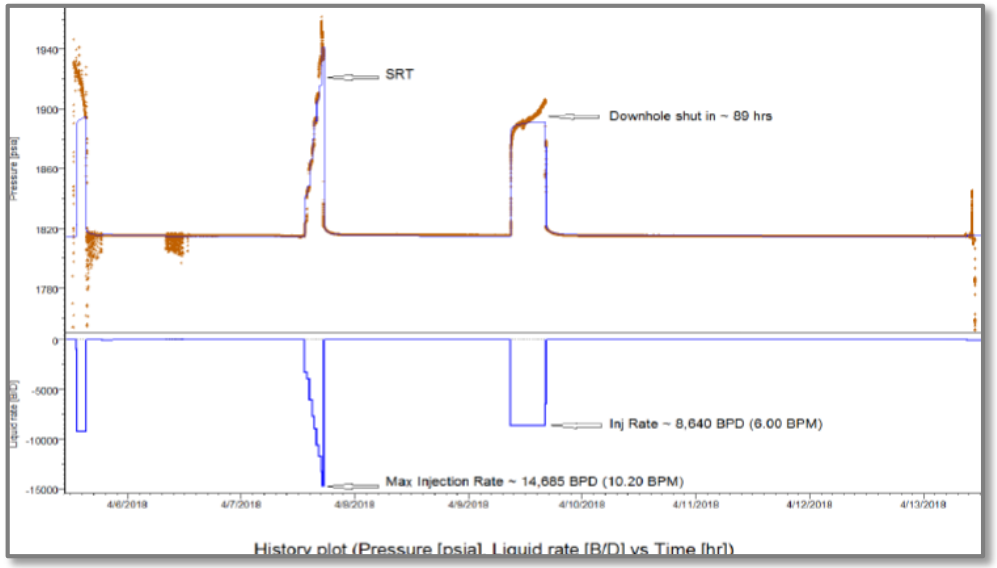




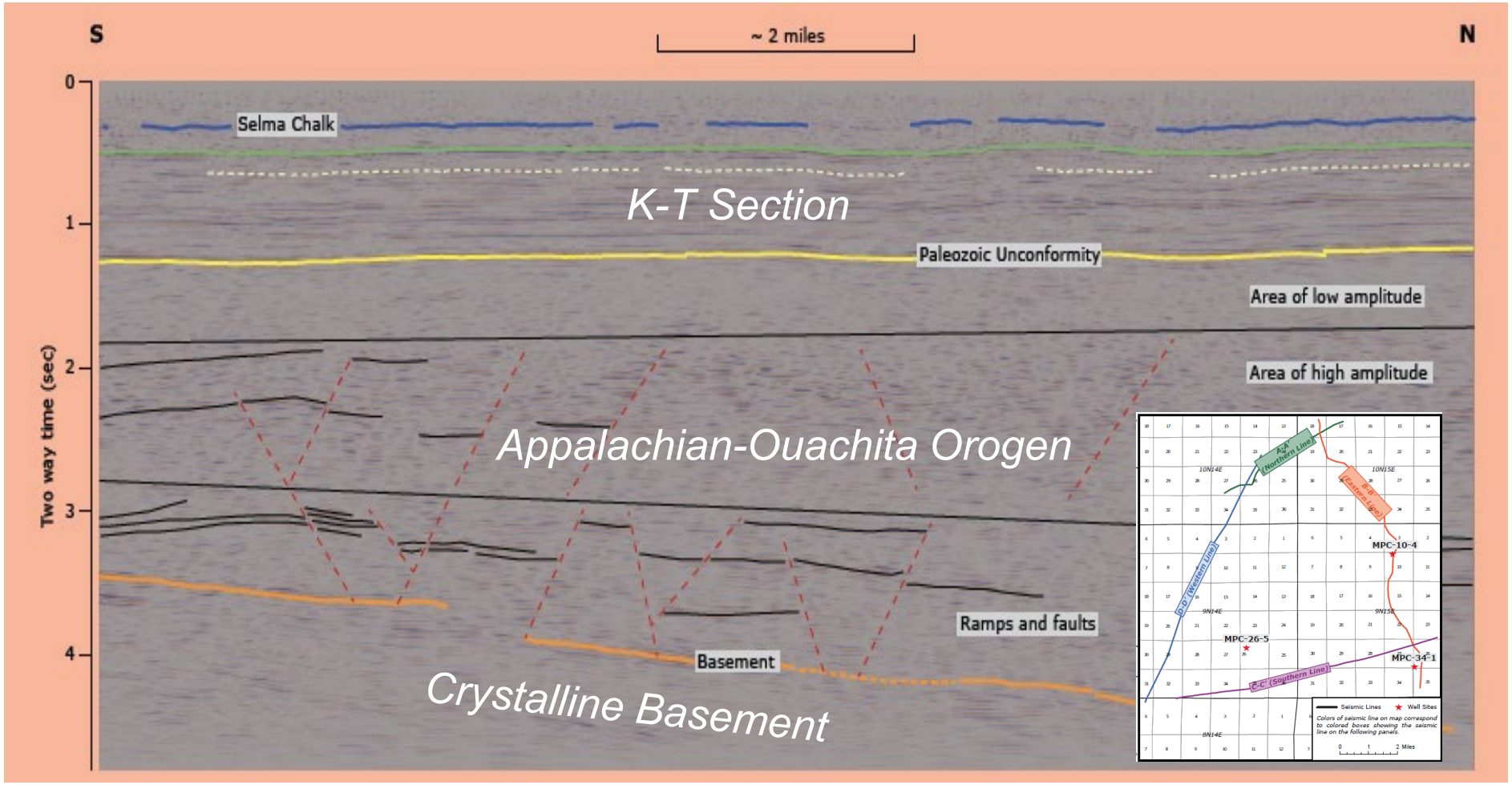
EGOM Strat Column
Mancini (2001)

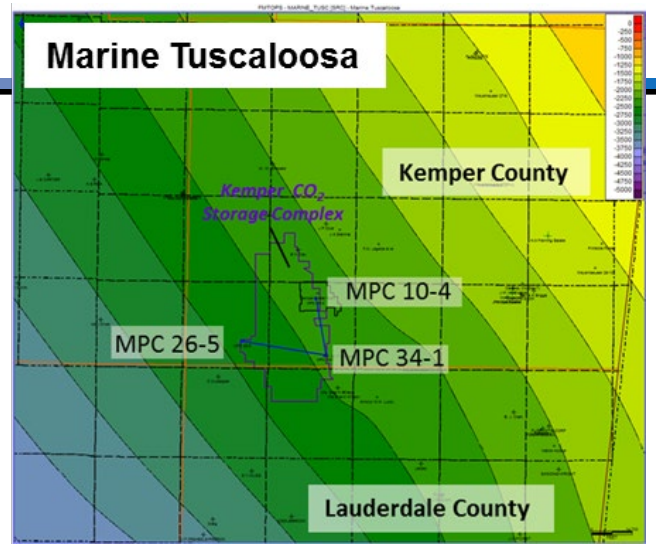
Data Collection

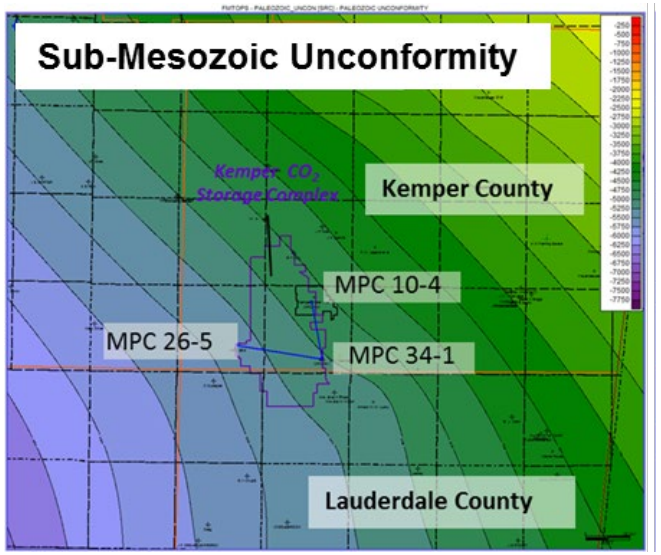
- Three characterization/monitoring wells were drilled in 2017 to test and characterize geologic properties
- Whole core was taken from the Paluxy and Washita-Fredericksburg reservoirs and the Marine Tuscaloosa shale confining unit
- Reservoir fluid sampling
- Injection test



Kemper Storage Complex Geologic Structure







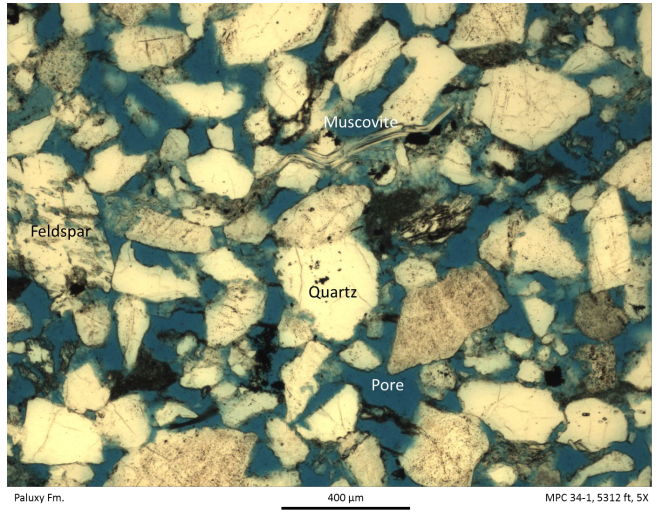
Storage Zone Properties

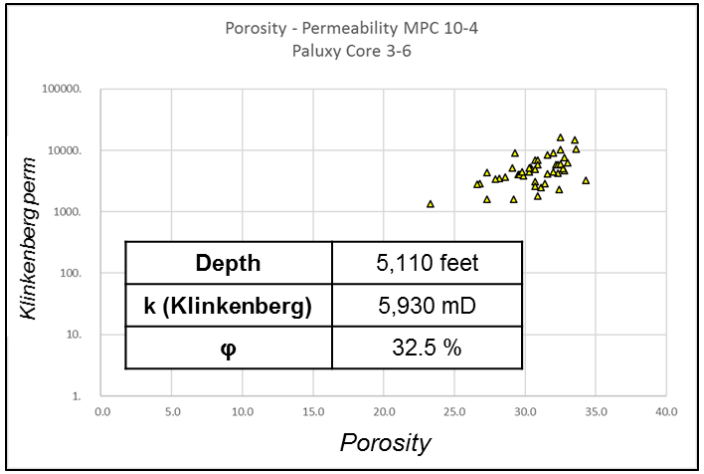
- Abundant stacked saline sandstone bodies in Paluxy, Wash-Fred, and lower Tuscaloosa.
- 350 meters of net sand. Logs and core show sandstone average porosity of 30%(!!)
- Routine core analysis indicates all sandstone water-saturated
- Darcy-class permeability common (up to 16 Darcies)

Paluxy sandstone

Interpretation: sandy braided stream deposit

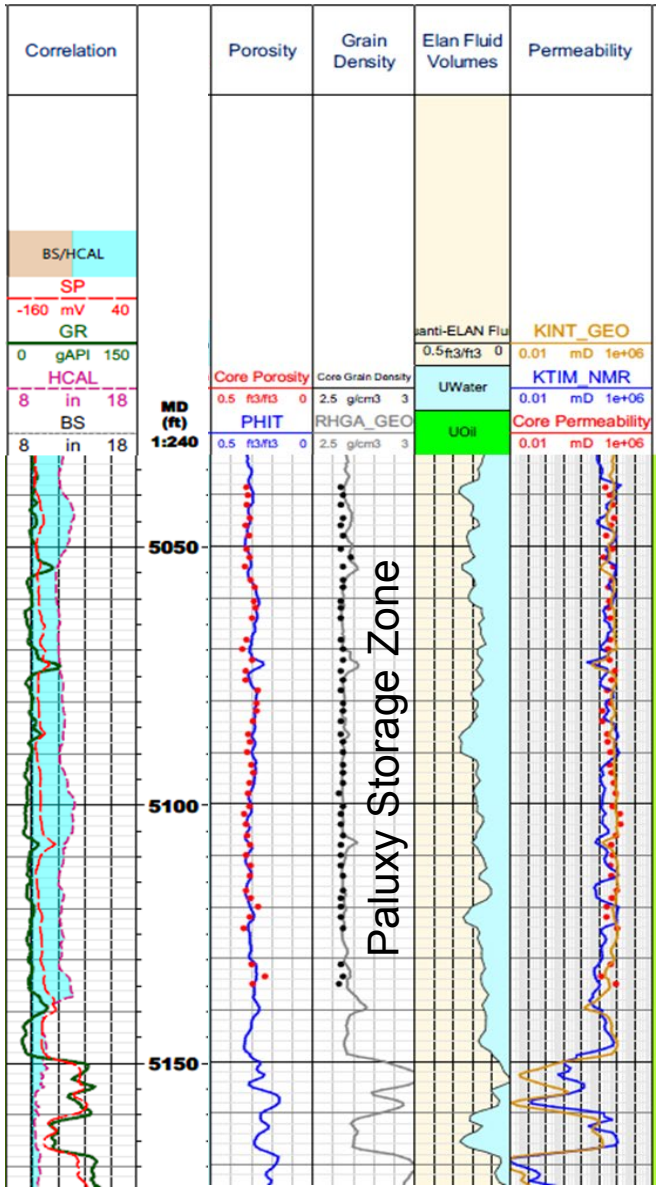
High-porosity sandstone in Paluxy Formation





Depth	5,110 feet
k (Klinkenberg)	5,930 mD
φ	32.5 %

Elemental Log Analysis (ELAN) interpretation*



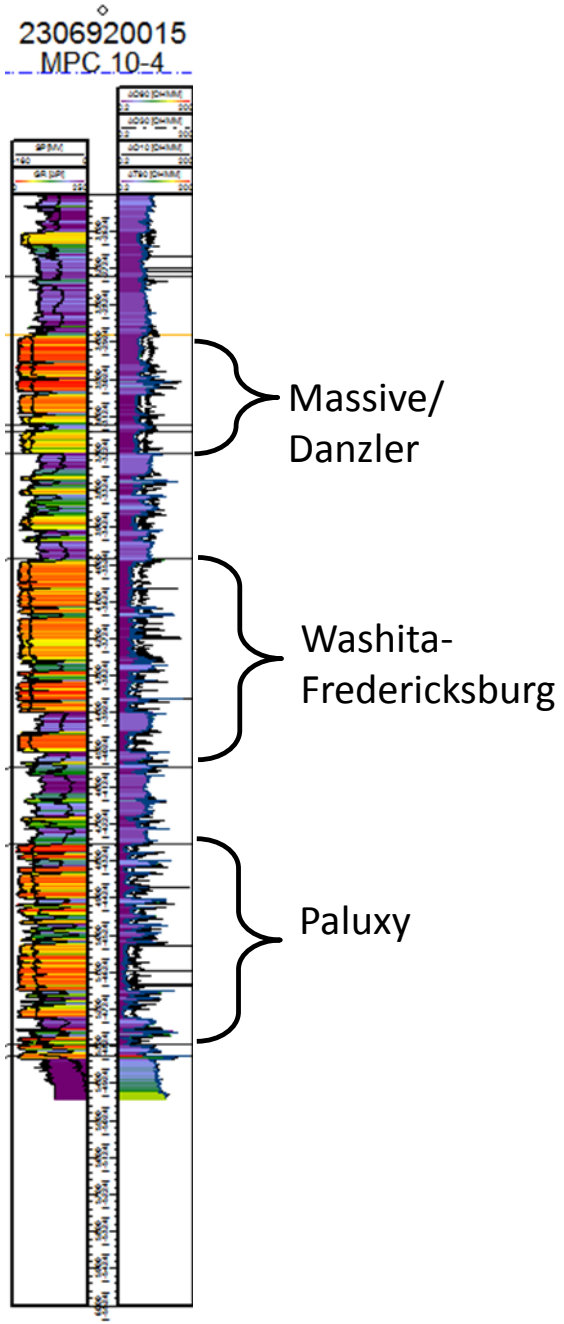
**ELAN is a mark of Schlumberger*

Storage Complex Capacity

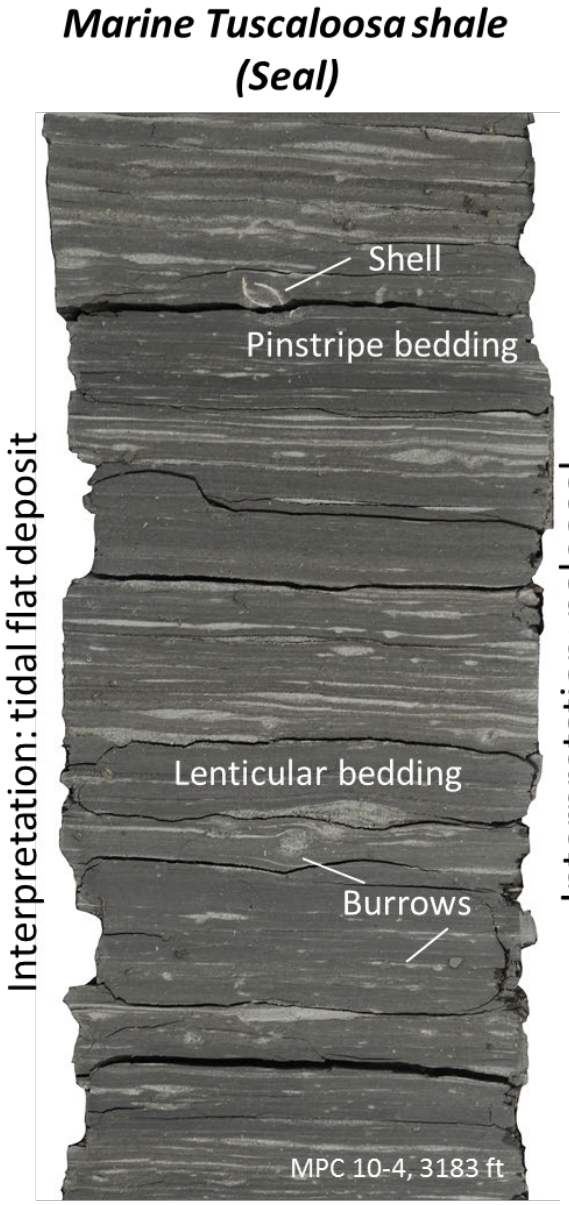
- Each of the three potential storage zones have commercial capacity
- Together the three storage zones result in a gigatonne capacity storage complex that has the potential to act as a regional hub

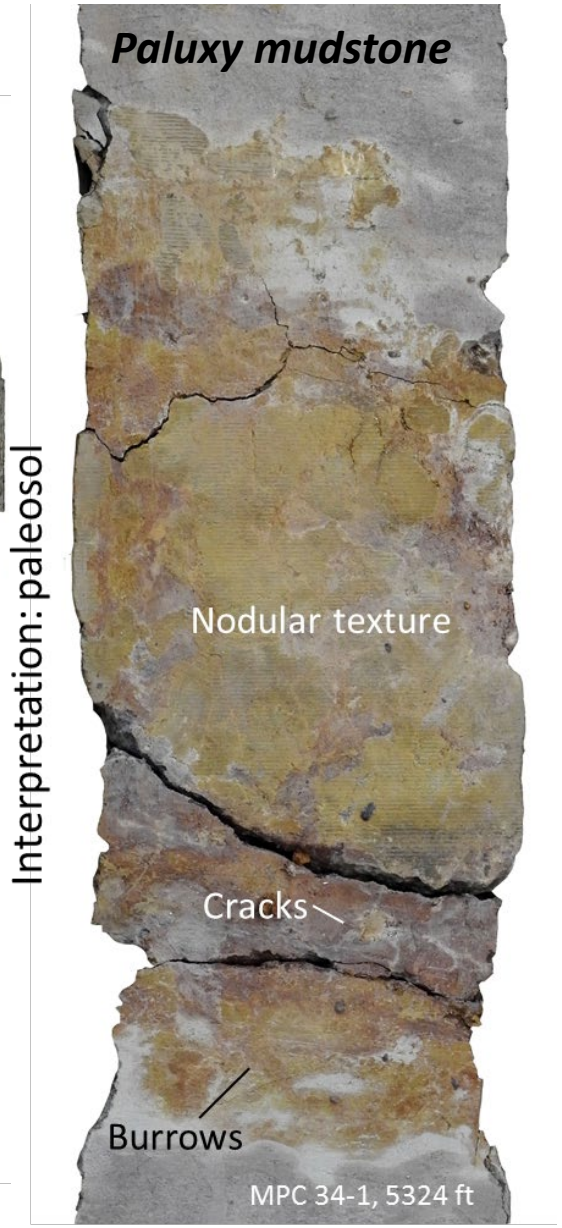
CO_2 Storage Reservoir	P_{10} Capacity (MMmt)	P_{50} Capacity (MMmt)	P_{90} Capacity (MMmt)
Massive/Dantzler	60	120	200
Wash.-Fred.	280	540	920
Paluxy	160	310	530

DOE methodology for site-specific saline storage efficiency calculation based on fluid displacement factors for clastic reservoirs where net pay, net thickness and net porosity are known of 7.4% (P_{10}), 14% (P_{50}) and 24% (P_{90}) (Goodman et al., 2011)



Caprock Studies





- Tuscaloosa Grp mudrocks - marginal marine to offshore; Upper K mudrocks - continental
- Smectititic clay in all units with large amounts of bound water
- High water saturation in the mudstone units helps keep capillary entry pressure high, and *mudrock permeability is on the order of 1 nanodarcy*.
- Geomechanically, the shale is soft and pliable and thus very difficult to fracture
- Mudrock units are likely effective seals; slow permeation of the mudrock pore systems makes significant migration of injected CO_2 out of the storage complex unlikely.

Univ. Wyoming's High Bay Research Facility

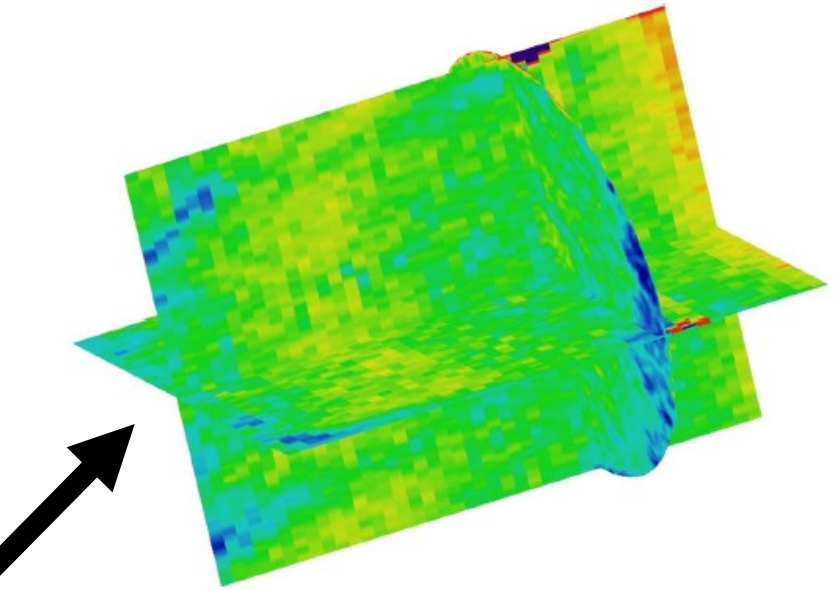
Macro- and Micro-Scale Flow Experiments

- Investigate CO_2 capillary trapping in reservoirs
- Study end-point relative perms for a supercritical CO_2 /brine system
- Study draining-imbibition relative perm curves for a supercritical CO_2 /brine system
- Microfluidics model to test saturation and sweep efficiencies

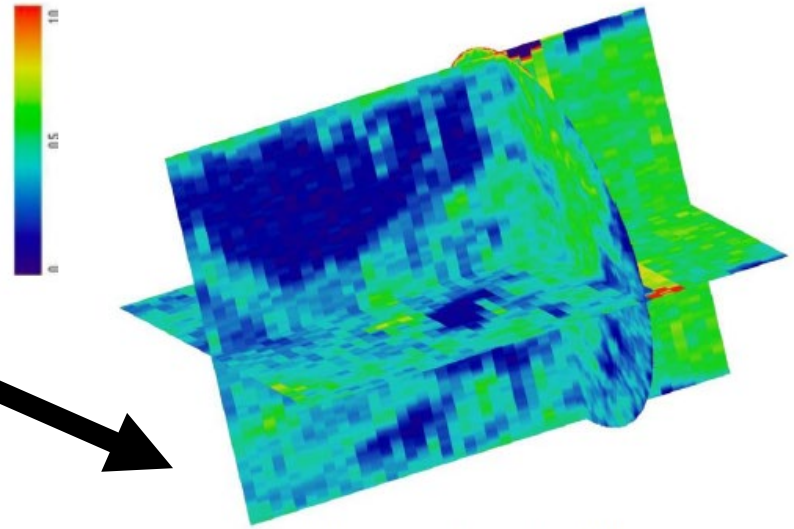
Three-dimensional visualizations of fluids distributions along the length of core sample

a) at the end of CO_2 injection

b) subsequent brine injection



(a) S_{CO2i} = 0.59 (outlet – inlet)



(b) S_{CO2r} = 0.39 (outlet – inlet)

PIRI TECHNOLOGIES, LLC

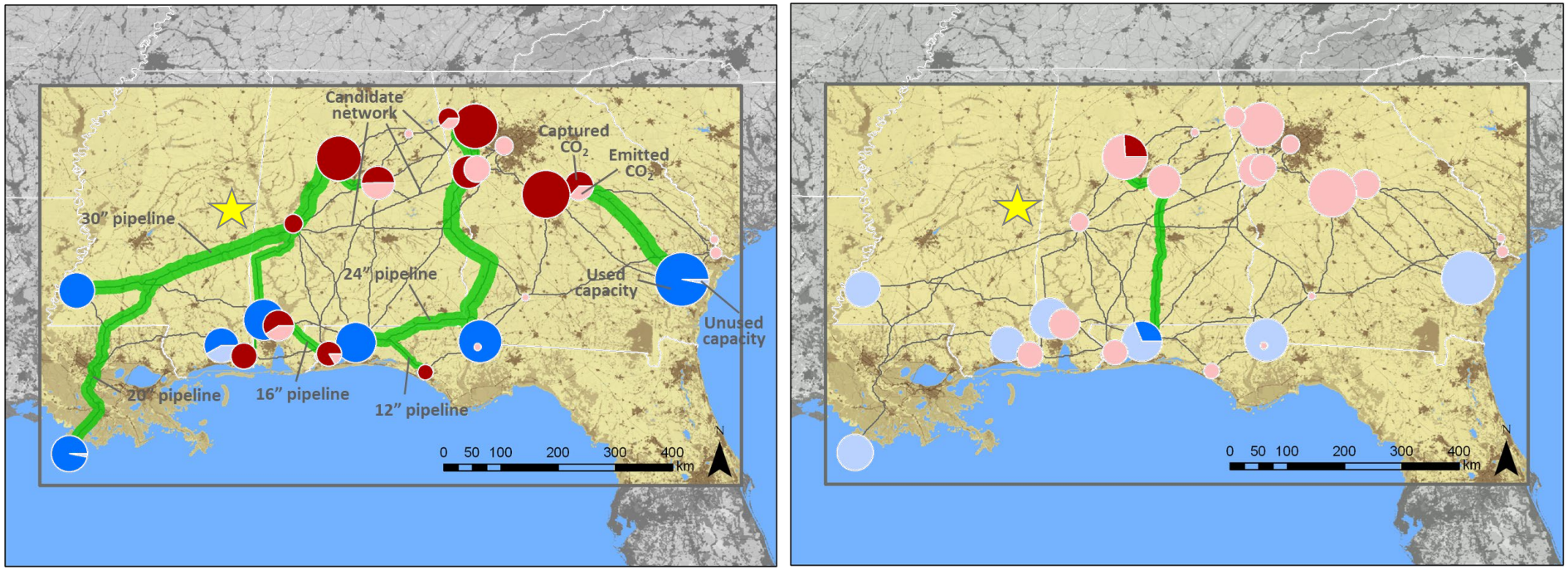
SimCCS: Integrated CCS Decision Making

SimCCS (Scalable infrastructure model for CCS)

- Economic-engineering model for optimizing CCS infrastructure design.

SimCCS$^{2.0}$ †

- Ground-up redesign—enabled by CarbonSAFE—into a Java-based package with HPC.
- Open-source: can be utilized by any DOE project (and beyond).



†Middleton *et al.* (2018). An open-source tool for optimizing CO_2 capture, transport, and storage infrastructure, *Environmental Modelling and Software*, In Review

Impact of Storage Costs

- Low-cost storage options occur beneath the energy facility
  - $2.00 - $4.00 USD per metric ton depending on the volume of CO_2 captured (*after DOE investment*)
- This drives the value proposition where existing infrastructure could be utilized for CO_2 capture, compression, transportation and storage
- Given the expanded U.S. 45Q tax credit for CO_2 storage, having geologic storage data and cost estimates drives ongoing:
  - Refining cost and performance data with technology vendors
  - Applying data to internal resource planning and modeling
  - Improving internal transportation, storage and monitoring cost information
- The project has reduced commercial-scale development risks associated with large storage capital expenses such as well drilling and injection facilities

So what have we learned about the Kemper Storage Complex?

A world class, low risk CO_2 storage prospect

- Storage zones have exceptional capacity
- Caprocks are laterally continuous, confining properties are encouraging
- No structural "show stoppers"

Low storage costs drive commercial storage potential

Next steps: reservoir simulation, monitoring strategies, commercialization plan, ISO geological storage standard

<u>Kemper's storage geology looks similar to that of the eastern GOM</u>

Southern Company

Mississippi Power

Advanced Resources International, Inc.