Project ECO_2S: Geologic Characterization and Preliminary Storage Capacity Estimates

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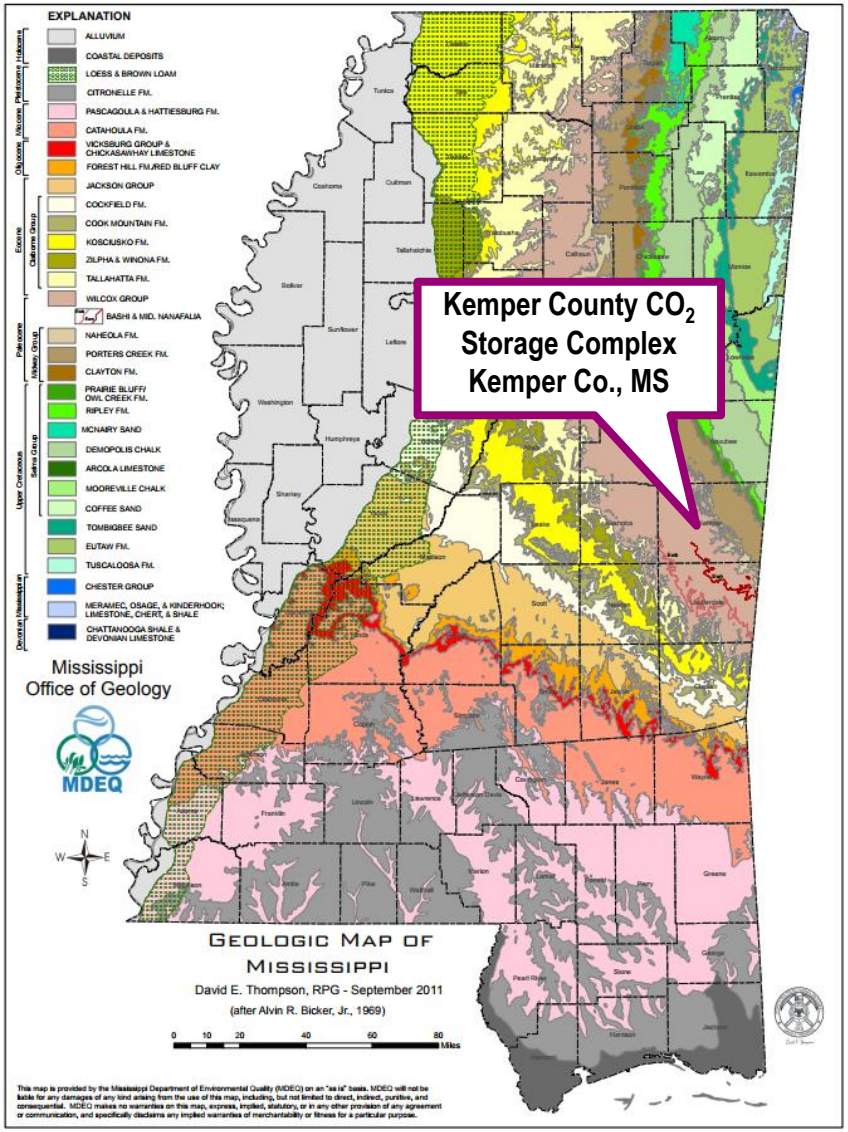
Presentation Outline



I. Project ECO_2S Introduction

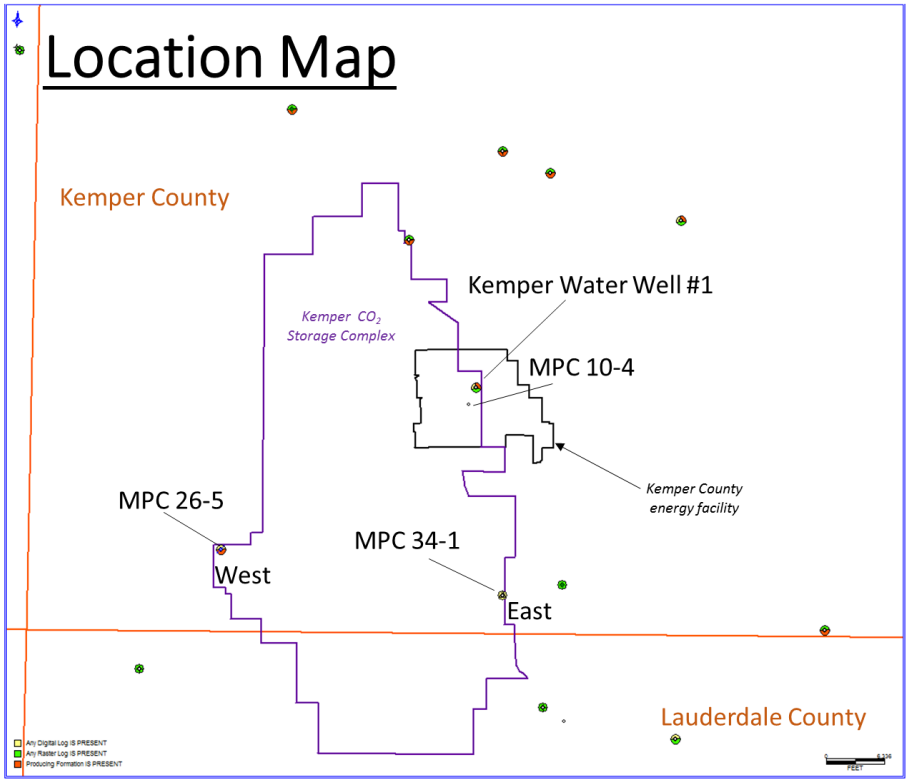
II. Geologic Characterization Plan

III. Results to Date

IV. Preliminary Storage Capacity

V. Conclusions

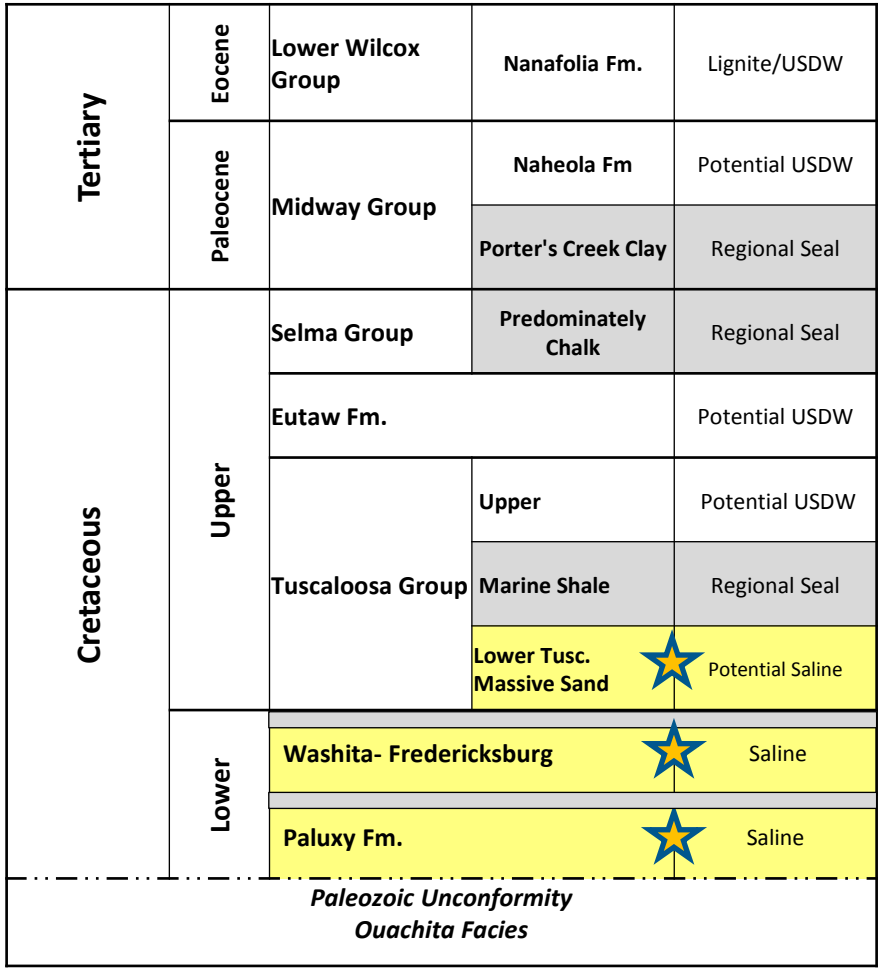
Project ECO_2S Introduction



MPC has established an area of interest exceeding 30,000 acres around the Kemper County energy facility and has begun acquisition of surface and mineral rights.

Project ECO_2S, a DOE-supported CarbonSAFE program, will pursue key advances in CO_2 storage knowledge and technology, including **optimizing CO_2 storage efficiency**, **modeling the fate of injected CO_2**, and **establishing residual CO_2 saturations**. In addition, Project ECO_2S will involve "real-life" experiences, issues, and challenges of **scaling-up from its regional, pre-feasibility assessment of CO_2 storage** to **establish a site-specific, commercial-scale CO_2 storage facility**, including **capturing the "lessons learned"** in making this transition.

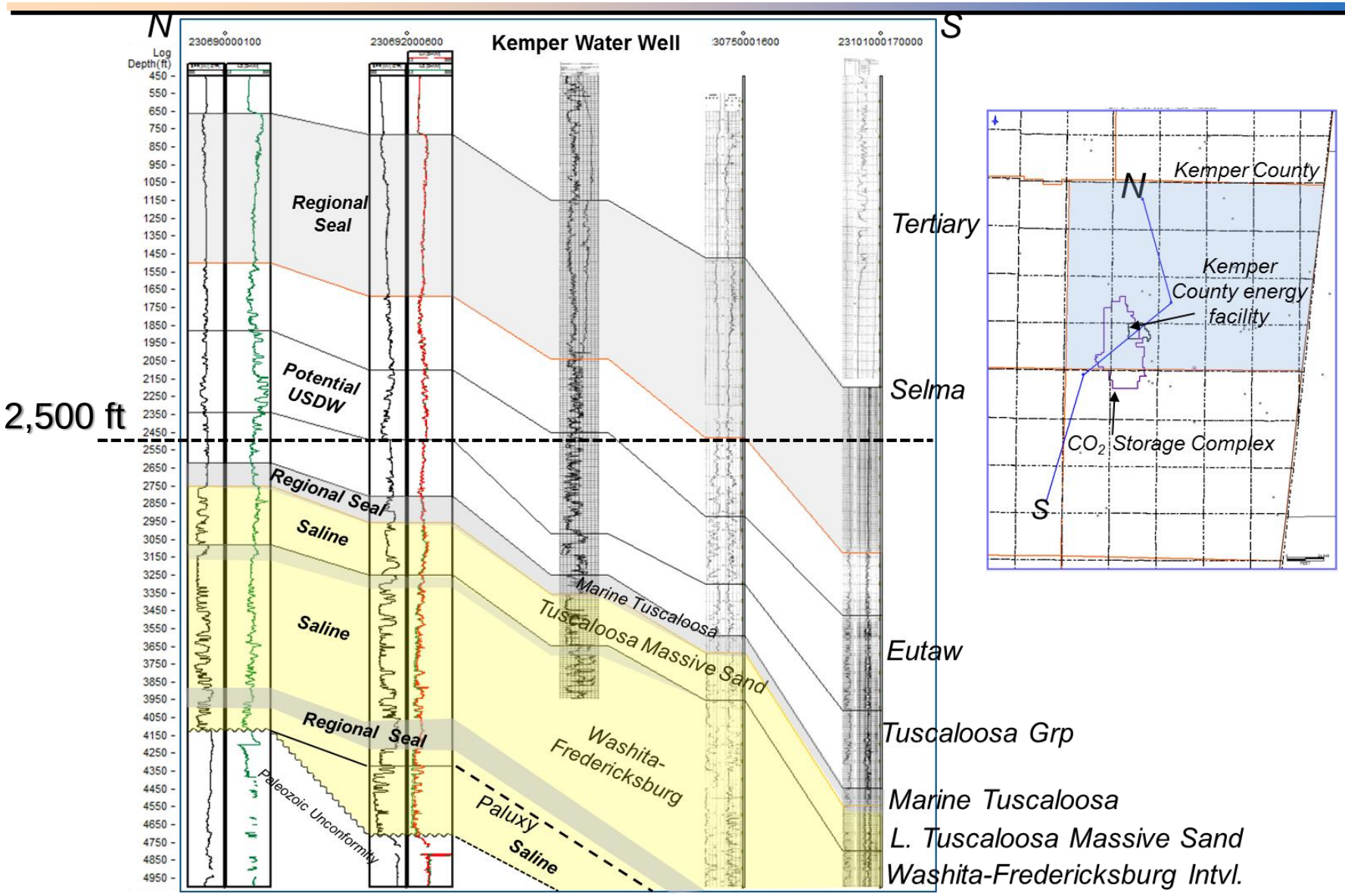
Kemper Storage Complex Stratigraphy



- Three Cretaceous storage clastic units with high porosity:
  - Lower Tuscaloosa Grp (massive sand)
  - Washita-Fredericksburg interval
  - Paluxy formation
- Three prominent caprocks (reservoir seals):
  - Tuscaloosa marine shale
  - Shale interval at top of the Washita-Fredericksburg
  - Shale interval at base of Washita-Fredericksburg
- Shallow seals in the Selma and Midway Groups

Source: Pashin, J.C., D.J. Hills, D. C. Kopaska-Merkel, M.R. McIntyre, Geological Evaluation of the Potential for CO_2 Sequestration in Kemper County, Mississippi, Final Report, prepared for Southern Company Research and Environmental Affairs, June 1, 2008.

Initial Geologic Assessment



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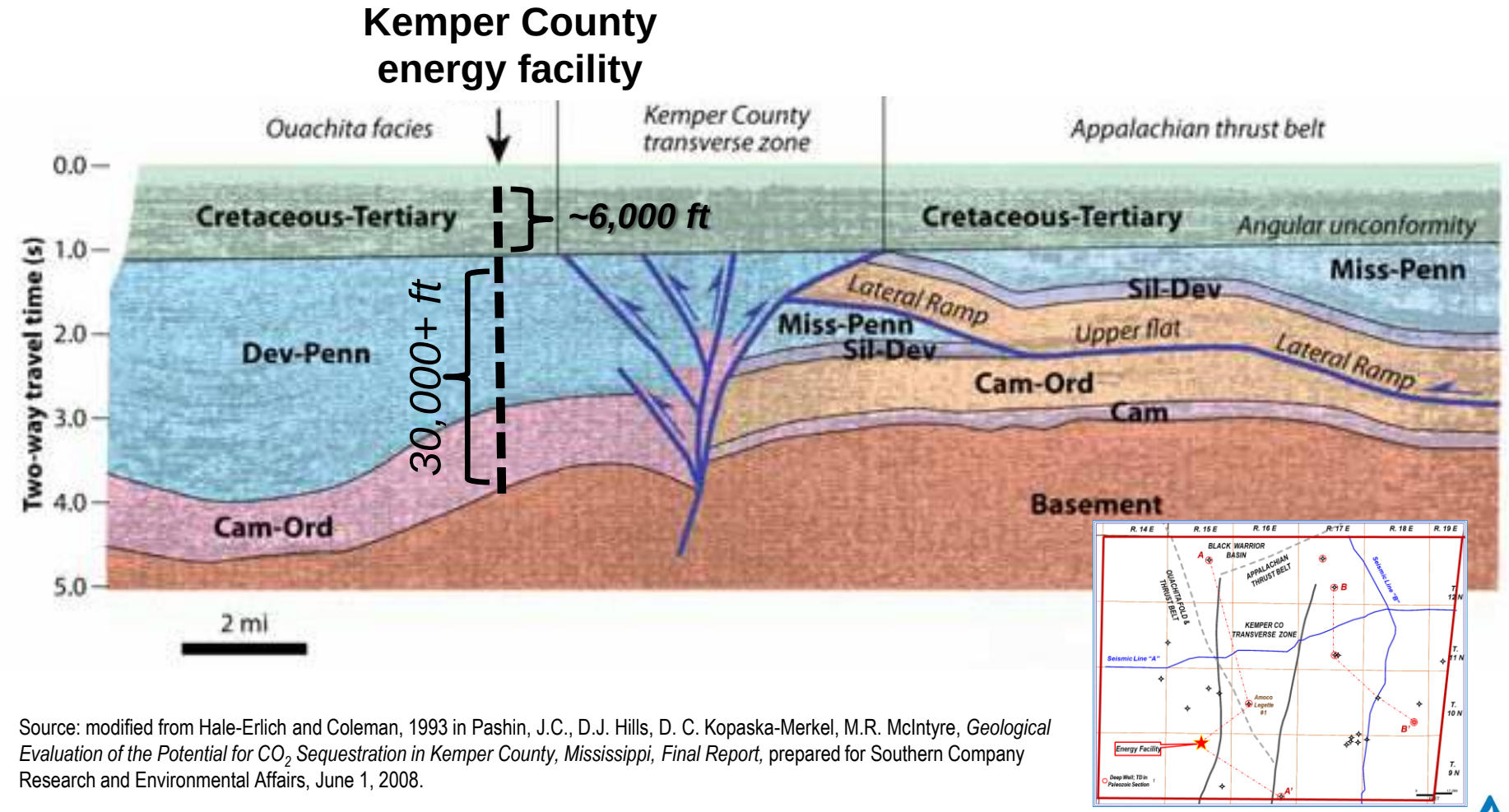
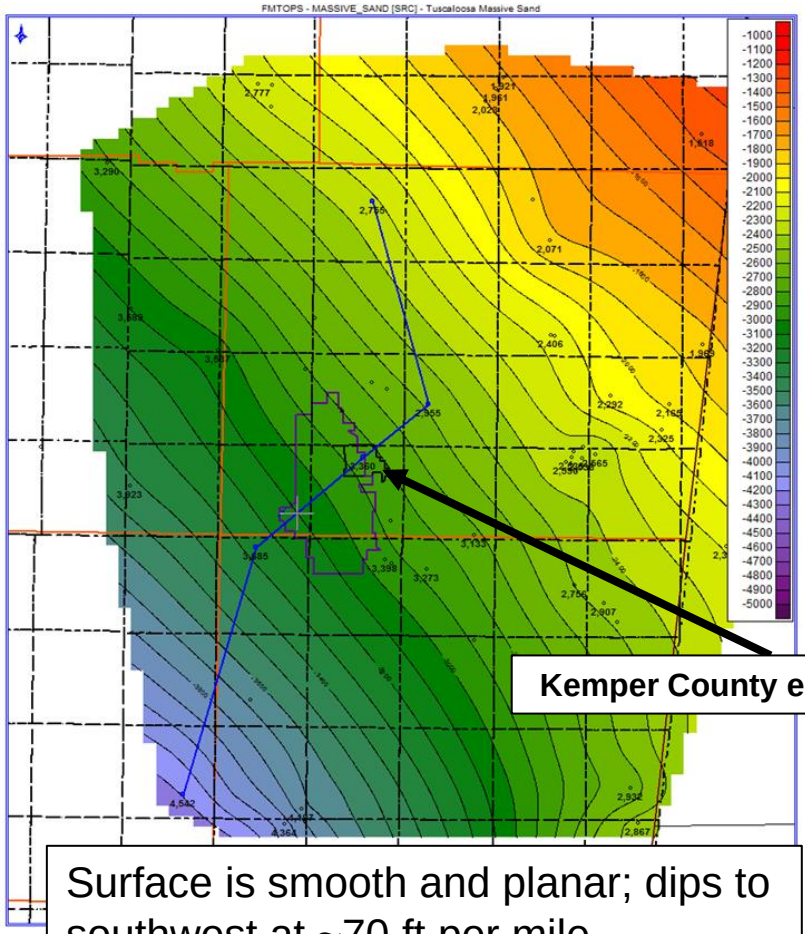
Kemper Storage Complex Deep Structure



Source: modified from Hale-Erlich and Coleman, 1993 in Pashin, J.C., D.J. Hills, D. C. Kopaska-Merkel, M.R. McIntyre, *Geological Evaluation of the Potential for CO_2 Sequestration in Kemper County, Mississippi, Final Report,* prepared for Southern Company Research and Environmental Affairs, June 1, 2008.

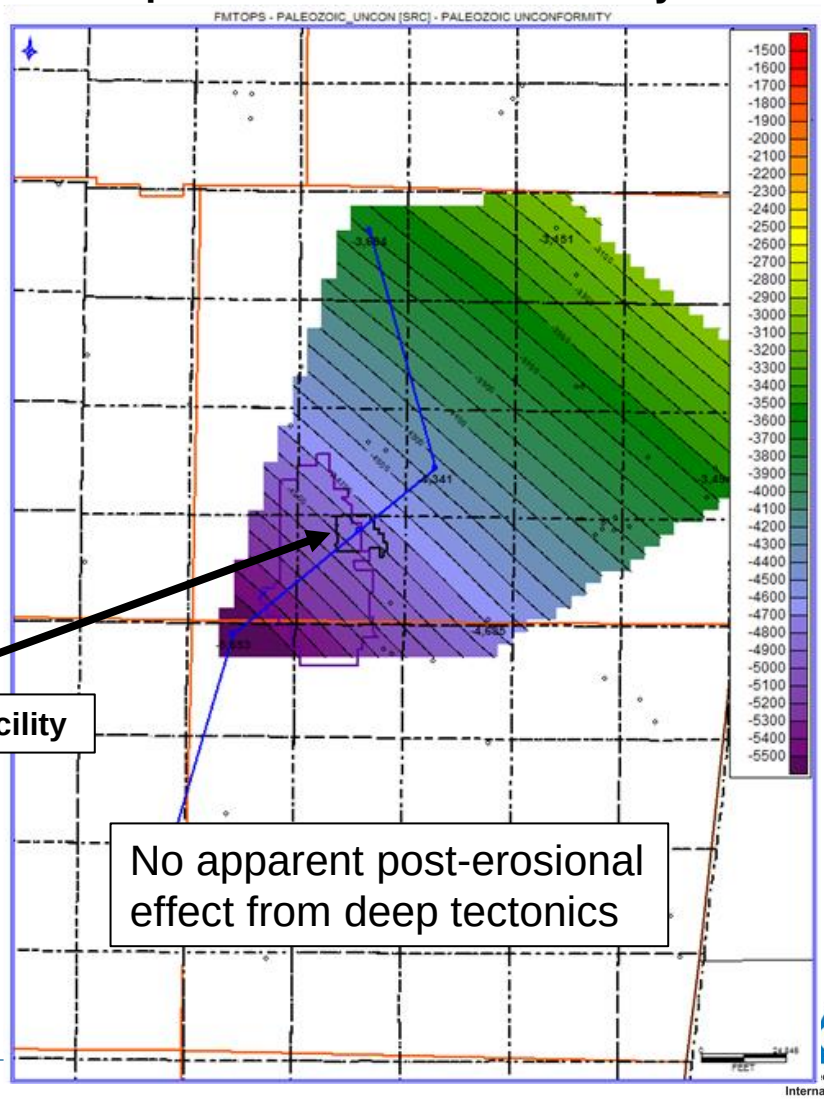
Initial Geologic Assessment

Structural Contour Map, Top of Lower Tuscaloosa



Surface is smooth and planar; dips to southwest at ~70 ft per mile

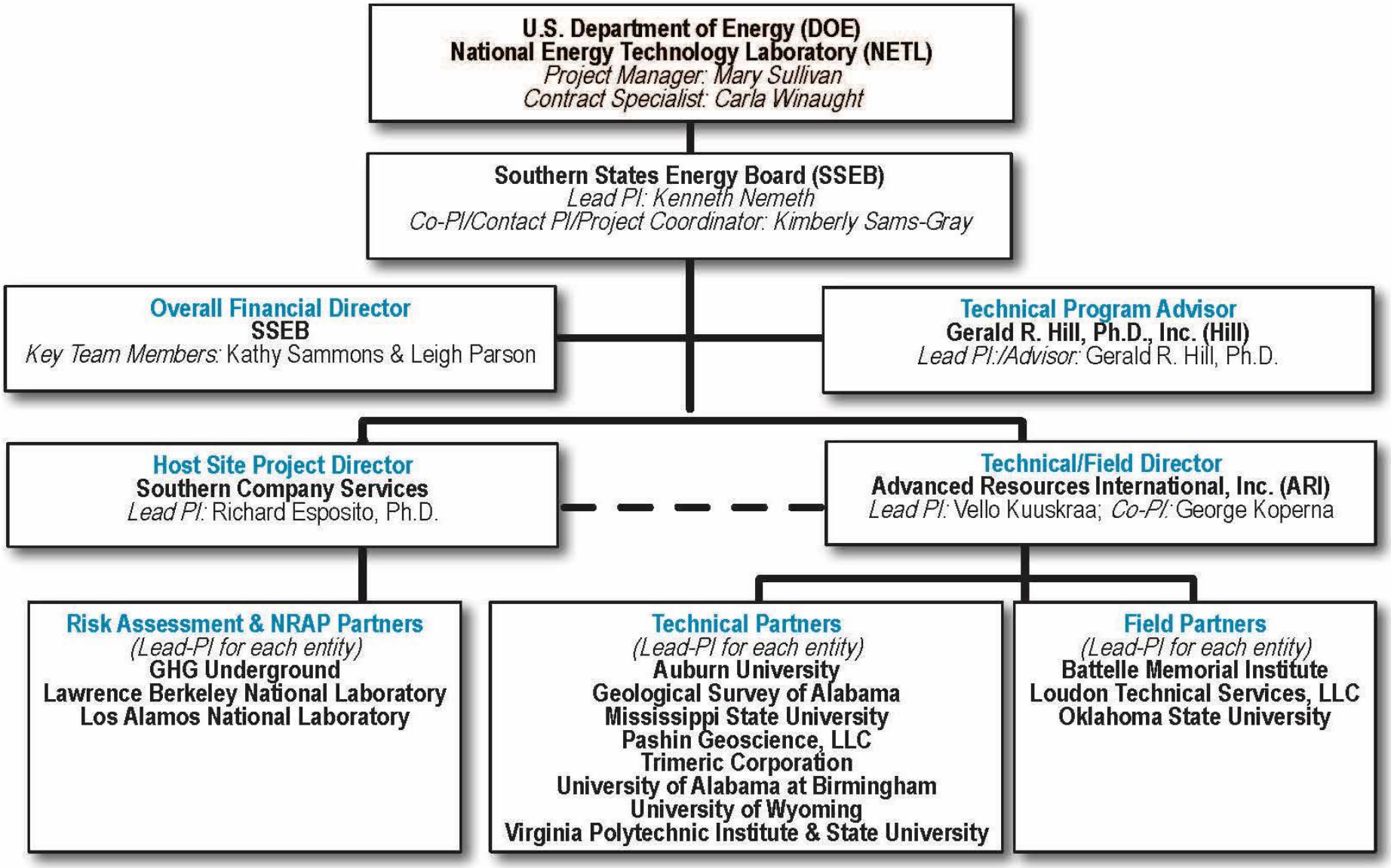
Structural Contour Map, Top of Paleozoic Unconformity



Kemper County energy facility

No apparent post-erosional effect from deep tectonics

Project ECO_2S Organization Chart

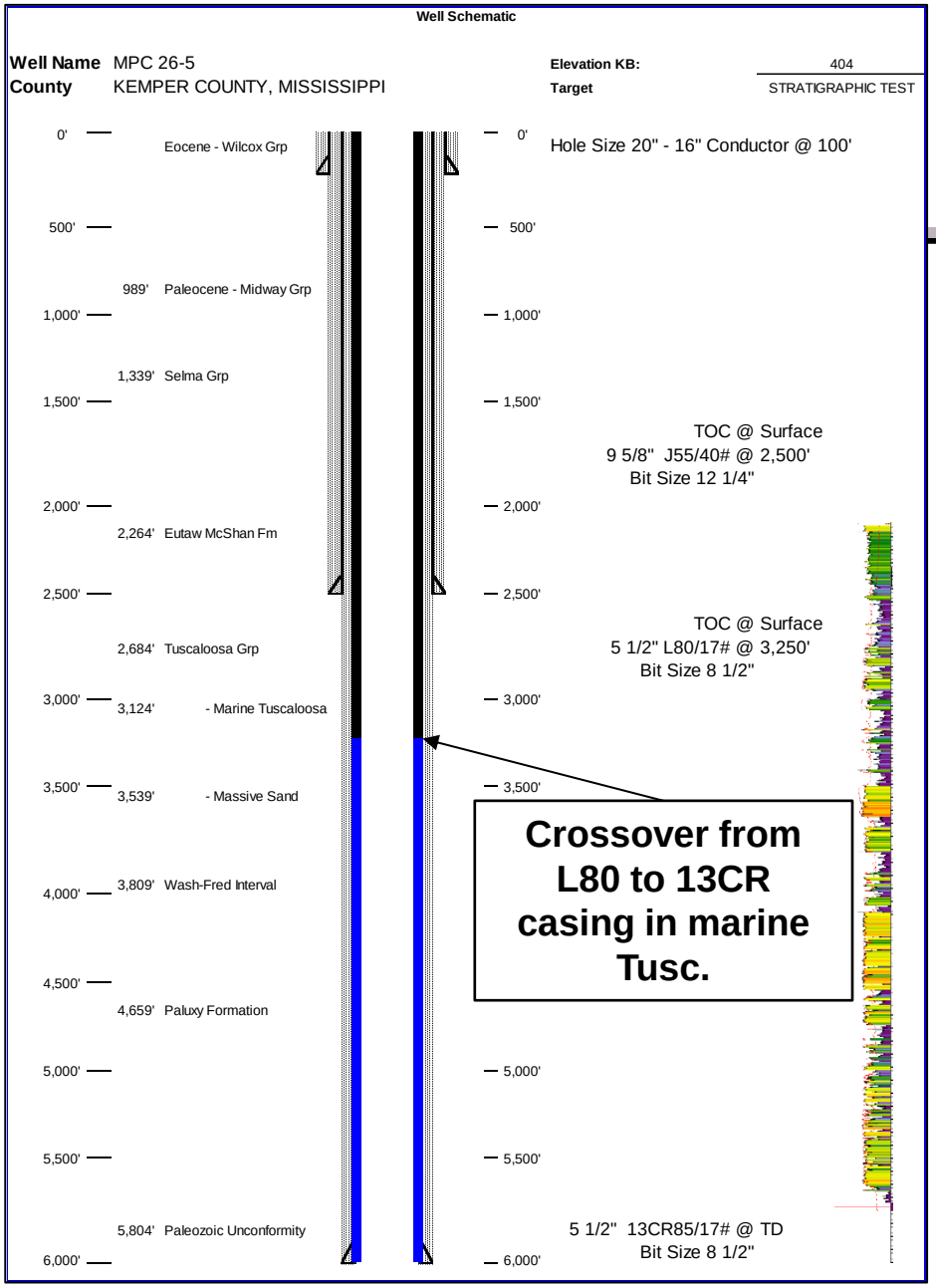


ECO_2S Geologic Studies

- Confirm storage reservoir volumetric properties; develop dataset on flow properties
  - Geophysical log response
  - Petrophysical properties observed in core
  - Advanced core tests, including rel-perm, CT scans under steady-state flow
- Caprock studies including
  - Threshold pressure tests, minimum capillary displacement pressure
  - Clay mineralogy
- Describe depositional facies, rock types, mineralogy, facies and environments of deposition for storage reservoirs and caprocks
- Develop a conceptual geologic model honoring interpreted depositional style
- Develop initial rock mechanics model
- Extend evaluation to regional framework
- Fluid-rock interactions
- Evaluation of existing 2D data, Identify any structural concerns

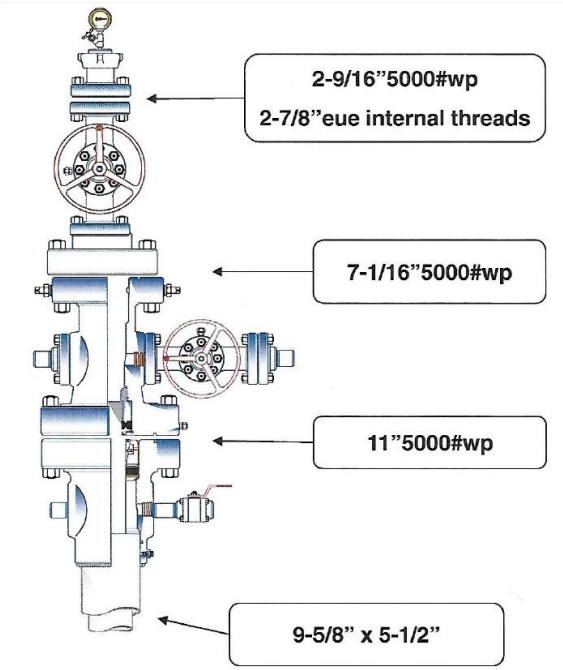
ECO_2S Geologic Data Gathering

- Drill three wells to gather drilling performance data, whole and sidewall core, logs
- Openhole Logs
  - Triple combo (caliper, array induction, gamma ray, density porosity, neutron porosity, spontaneous potential, photoelectric)
  - Combined magnetic resonance (CMR)
  - Formation micro imager (FMI)
  - Dipole sonic (mechanical properties)
  - Rotary sidewall cores
- Whole core of reservoir and caprock intervals
- Evaluation of existing 2D seismic



Well Design

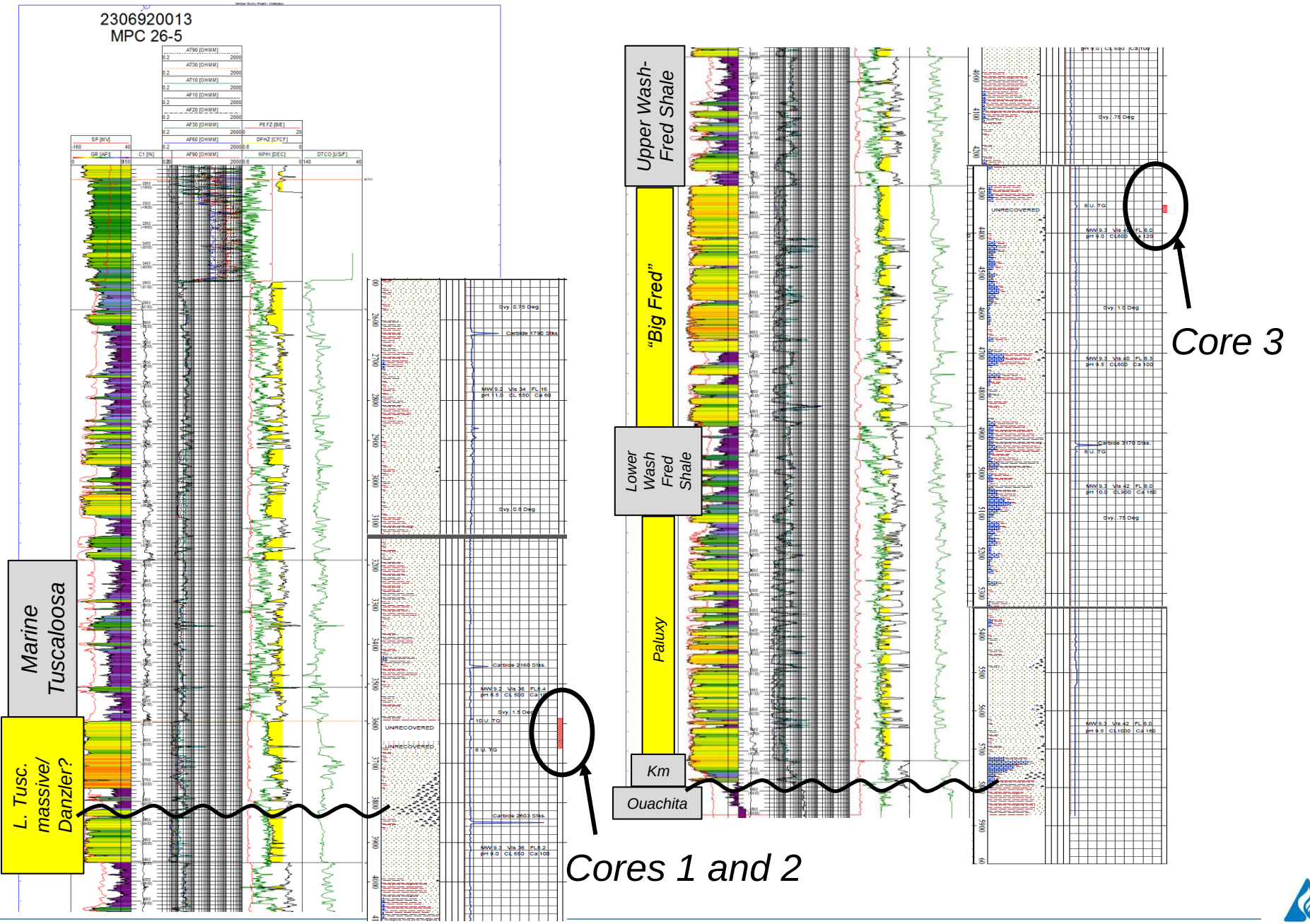
- Crossover from carbon steel to chrome casing in marine Tuscaloosa
- Surface and long string casing cemented to surface



ECO_2S Field Status

- First project well, the MPC 26-5, spud in May
  - 17 days from spud to TD including two core points
- Second well, the MPC 34-1, spud in June
  - 14 days from spud to TD including two core points
- Third well, the MPC 10-4, will be spud in early August

MPC 26-5 triple combo and mud log



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MPC 26-5 Coring Results

Core 1 (shale above L.T. massive)

- 3,587 – 3,643 ft
- Cored 56ft, Recovered 4ft
  - *Gray-brown and red-brown shale*

Core 2 (L.T. massive)

- 3,645 – 3,662 ft
- Cored 17ft, Recovered 10.5ft
- Recovered Portion:
  - Gray to gray-brown shale
  - Medium to fine grained sandstone

Core 3 (Wash-Fred)

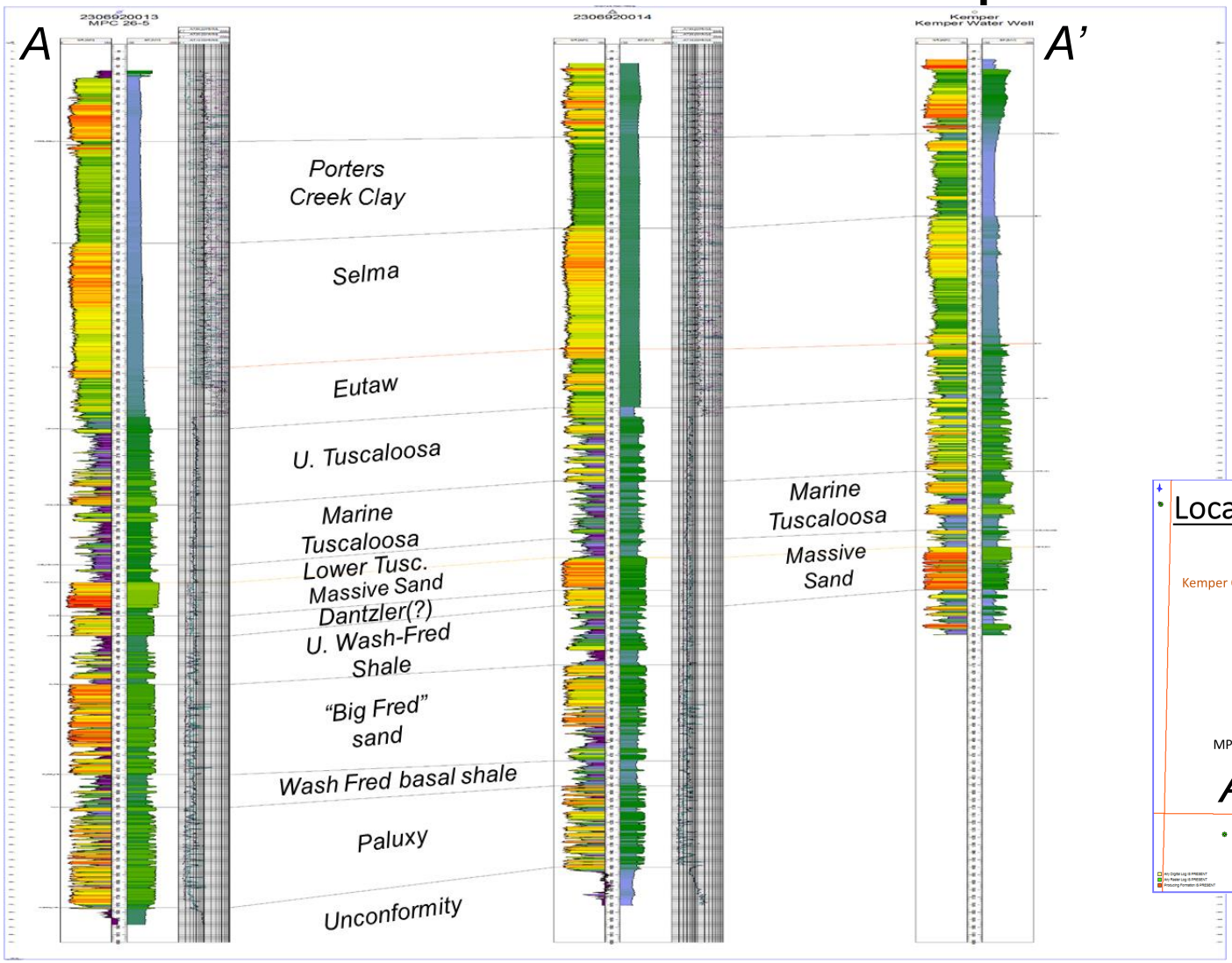
- 4,331 – 4,349 ft
- Cored 18ft, Recovered 4.3ft
- Recovered Portion
  - Medium to fine grained sandstone

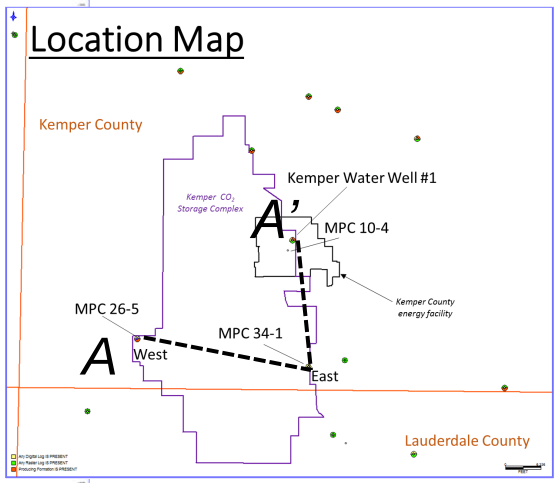
Core Pictures MPC 26-5

Core 2 Lower Tuscaloosa massive – very poorly indurated sandstone, well caked

Core 3 Wash-Fred – less indurated than Tuscaloosa core

Storage Complex Reservoir Continuity





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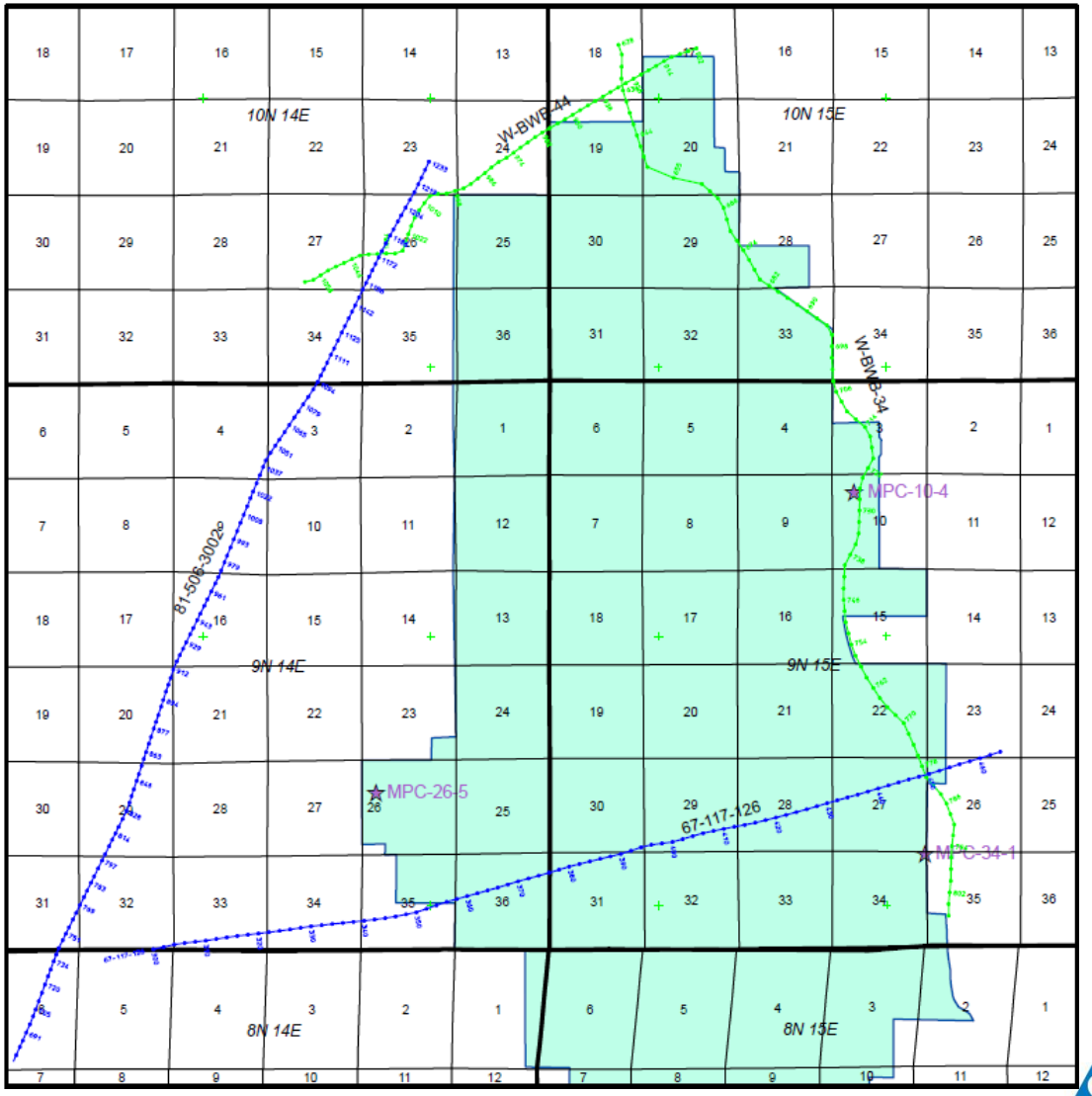
Existing 2D Seismic

- 30 miles of existing 2D seismic was acquired to evaluate structure, regional stratigraphy



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Kemper Storage Complex Capacity

Net thickness* and porosities** from MPC 26-5

Reservoir	Net Pay (ft)	Porosity
L. Tusc. Massive	162	28%
Wash.-Fred.	630	28%
Paluxy	370	26%
TOTAL	**1,162**	**27%**

- Calculate CO_2 storage capacity at 100% pore volume utilization for 30,000 acres (approximate Kemper Storage Complex area)
- Apply DOE capacity estimate approach with *site specific*** saline formation efficiency factors for clastics of 3.1% (P10), 6.1% (P50) and 10% (P90) (Goodman et al., 2011)

** shale volume less than 20% using gamma ray index*
*** log density porosity*
**** site specific efficiency factors assume that the net/gross area and net/gross thickness terms are fixed at the P90 level*

Kemper Storage Complex Capacity

Formation	100% Storage Capacity (MMte)***	P10 (3.1%) Storage Capacity (MMte)***	P50 (6.1%) Storage Capacity (MMte)***	P90 (10%) Storage Capacity (MMte)***
Tusc. Massive Sand	760	20	50	80
Wash-Fred	3,140	100	190	310
Paluxy	1,830	60	110	180
Total	**5,720**	**180**	**350**	**570**

** Assume 0.43 psi/ft hydraulic pressure gradient*
*** from IPCC 2005 Annex Chart*
****million metric tonnes*

Conclusions

The Kemper County Storage Complex appears to be a world class CO_2 storage prospect

- Potential storage reservoirs have exceptional storage capacity
  - Reservoirs are vertically confined, increasing the potential for "stacked storage"
- Caprocks are laterally continuous, appear to have confining properties
- No structural "show stoppers"
- Well drilling is predictable, low risk
- There is still a lot of work to do….

Acknowledgements

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Project ECO_2S Characterization Objectives

1. Demonstrate that the subsurface at the storage complex can store commercial volumes of CO_2 safely and permanently within the saline reservoir system,
2. Rigorously establish and optimize the CO_2 storage capacity of the storage complex, including the areal extent of the CO_2 plume,
3. Confirm the viability of each of the reservoir seals as a long-term, reliable confining system for the CO_2 storage site,
4. Undertake rock mechanics and geomechanical modeling to define the potential for induced seismicity at the CO_2 storage site,
5. Conduct a comprehensive risk assessment utilizing reservoir modeling and the NETL-sponsored integrated assessment models.