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CO_2 Storage in Texas Gulf Coast: Insights and Challenges

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Outline

- Motivation
- Oil and Gas Fields in Texas Gulf Coast
- Texas Gulf Coast Geology
- Insights for storing CO_2
- Opportunities and Challenges for CCS in Texas Gulf Coast

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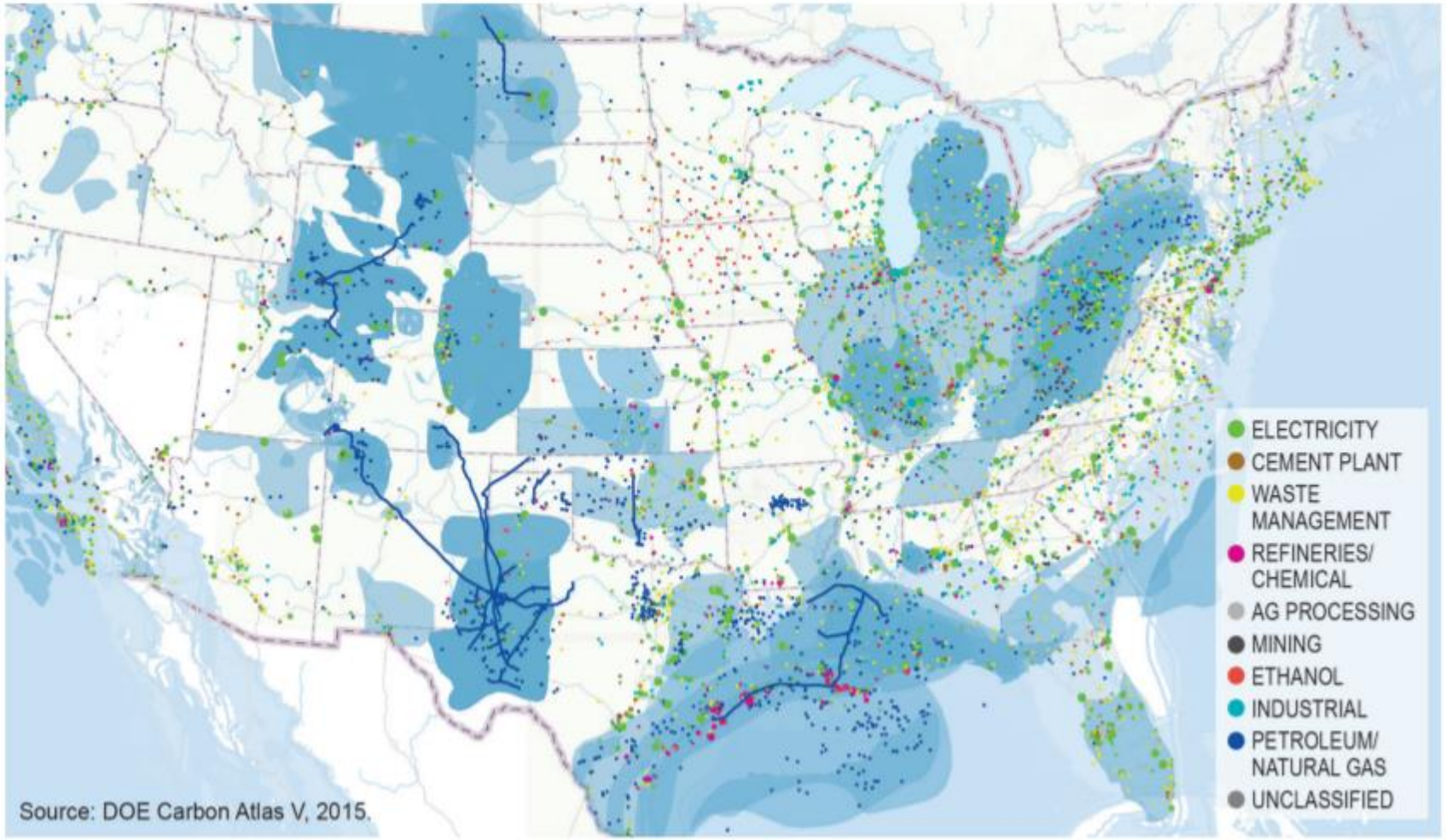
Motivation



US Stationary Sources of CO_2 Emissions by Type (DOE Atlas V 2015)

- US Gulf Coast has large concentration of CO_2 sources
- Large cheaper to capture CO2 sources (e.g. Ethanol, Natural Gas, AGRU in LNG)
- Infrastructure, skills, familiarity with subsurface activities

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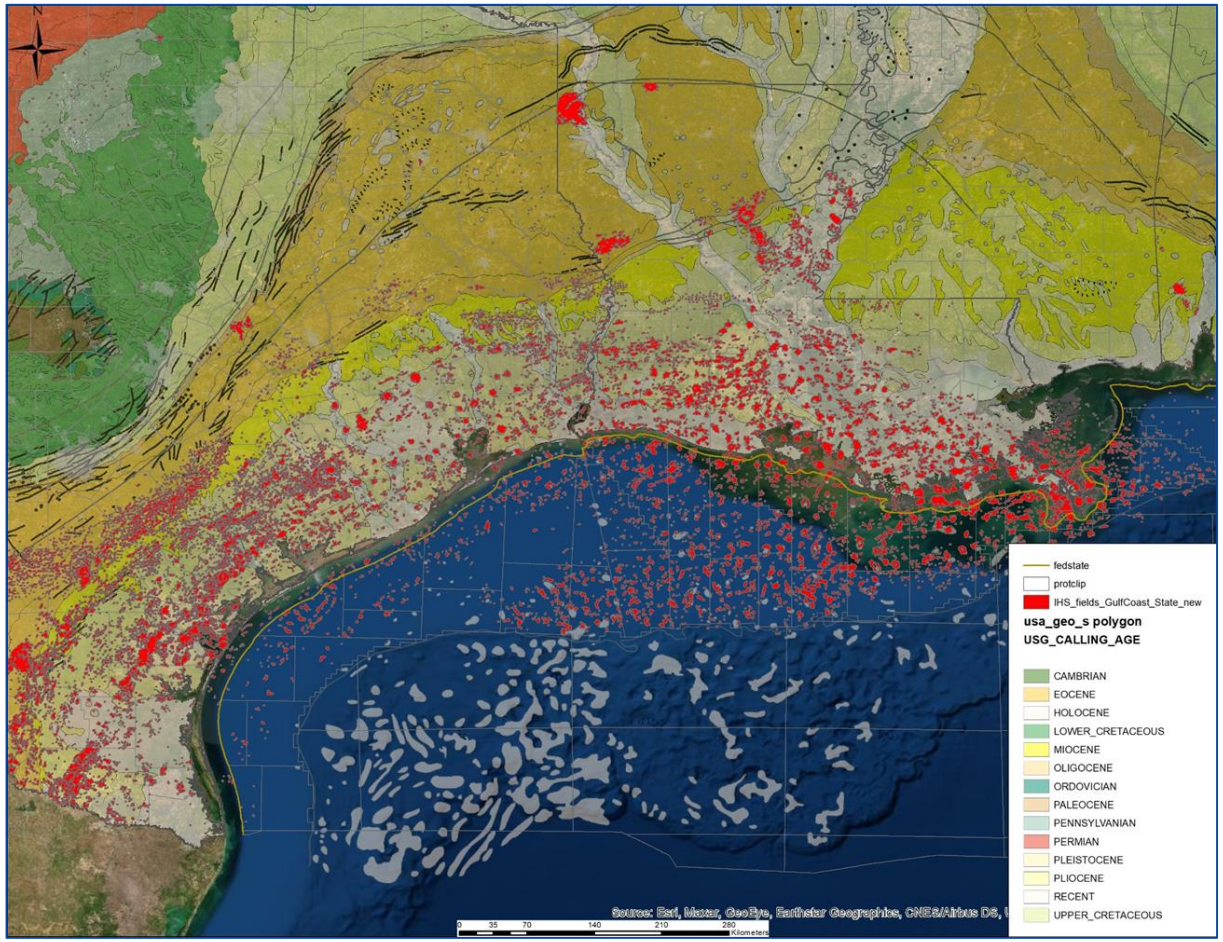
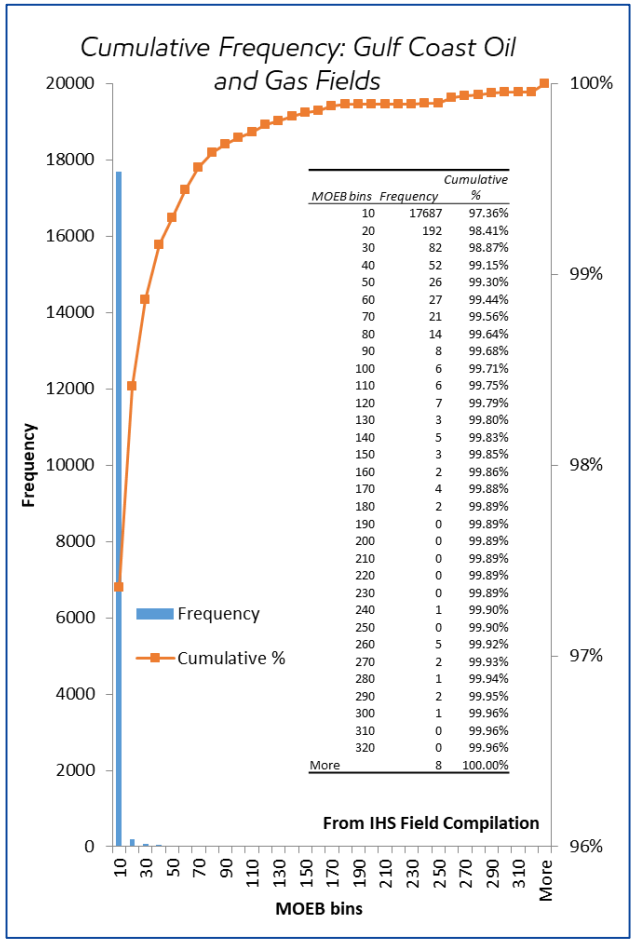
Oil and Gas Fields in Gulf of Mexico





MOEB bins	Frequency	Cumulative %
10	17687	97.36%
20	192	98.41%
30	82	98.87%
40	52	99.15%
50	26	99.30%
60	27	99.44%
70	21	99.56%
80	14	99.64%
90	8	99.68%
100	6	99.71%
110	6	99.75%
120	7	99.79%
130	3	99.80%
140	5	99.83%
150	3	99.85%
160	2	99.86%
170	4	99.88%
180	2	99.89%
190	0	99.89%
200	0	99.89%
210	0	99.89%
220	0	99.89%
230	0	99.89%
240	1	99.90%
250	0	99.90%
260	5	99.92%
270	2	99.93%
280	1	99.94%
290	2	99.95%
300	1	99.96%
310	0	99.96%
320	0	99.96%
More	8	100.00%

In Texas and Louisiana shallow waters, large number of O&G fields are < 10 MOEB

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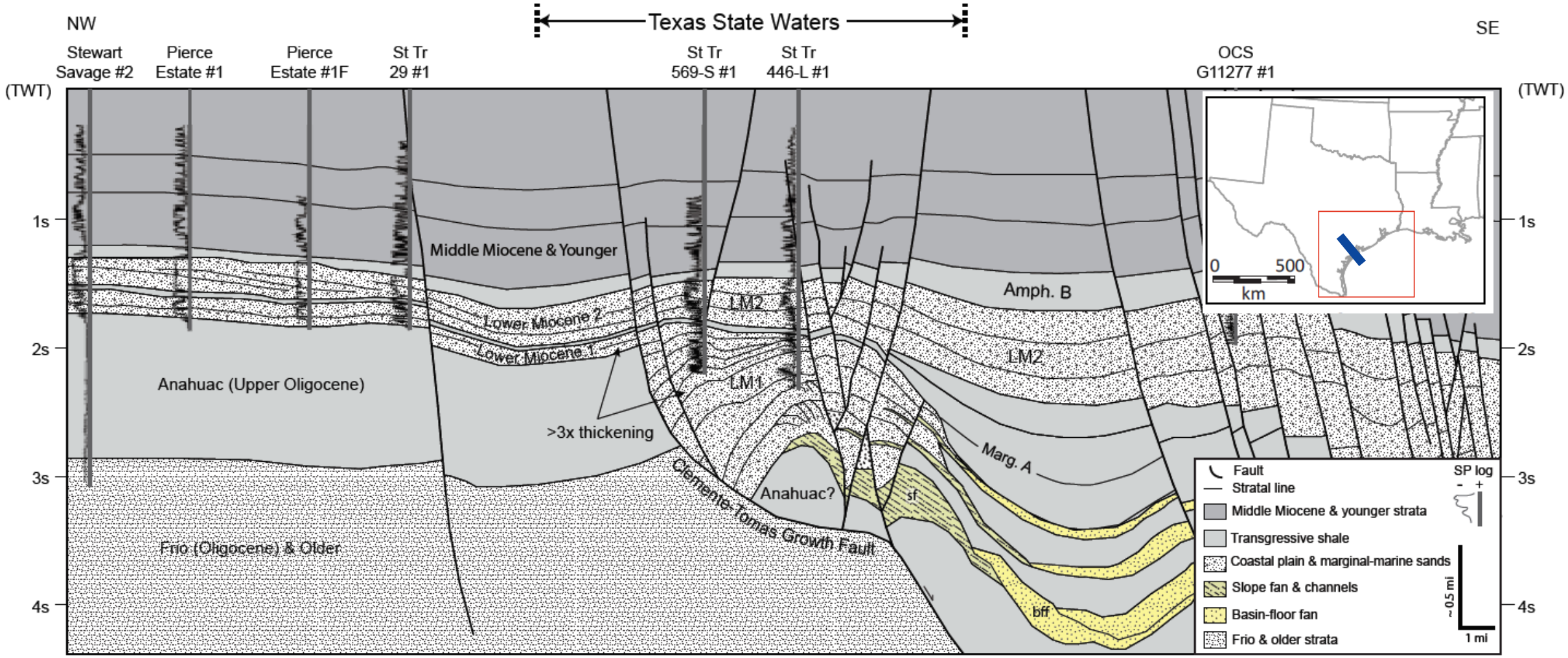
Reservoir-Seal Systems in Texas Gulf Coast



Two primary reservoir-seal systems: Frio sands and Anahuac seal & Miocene sand and Amph. B seal

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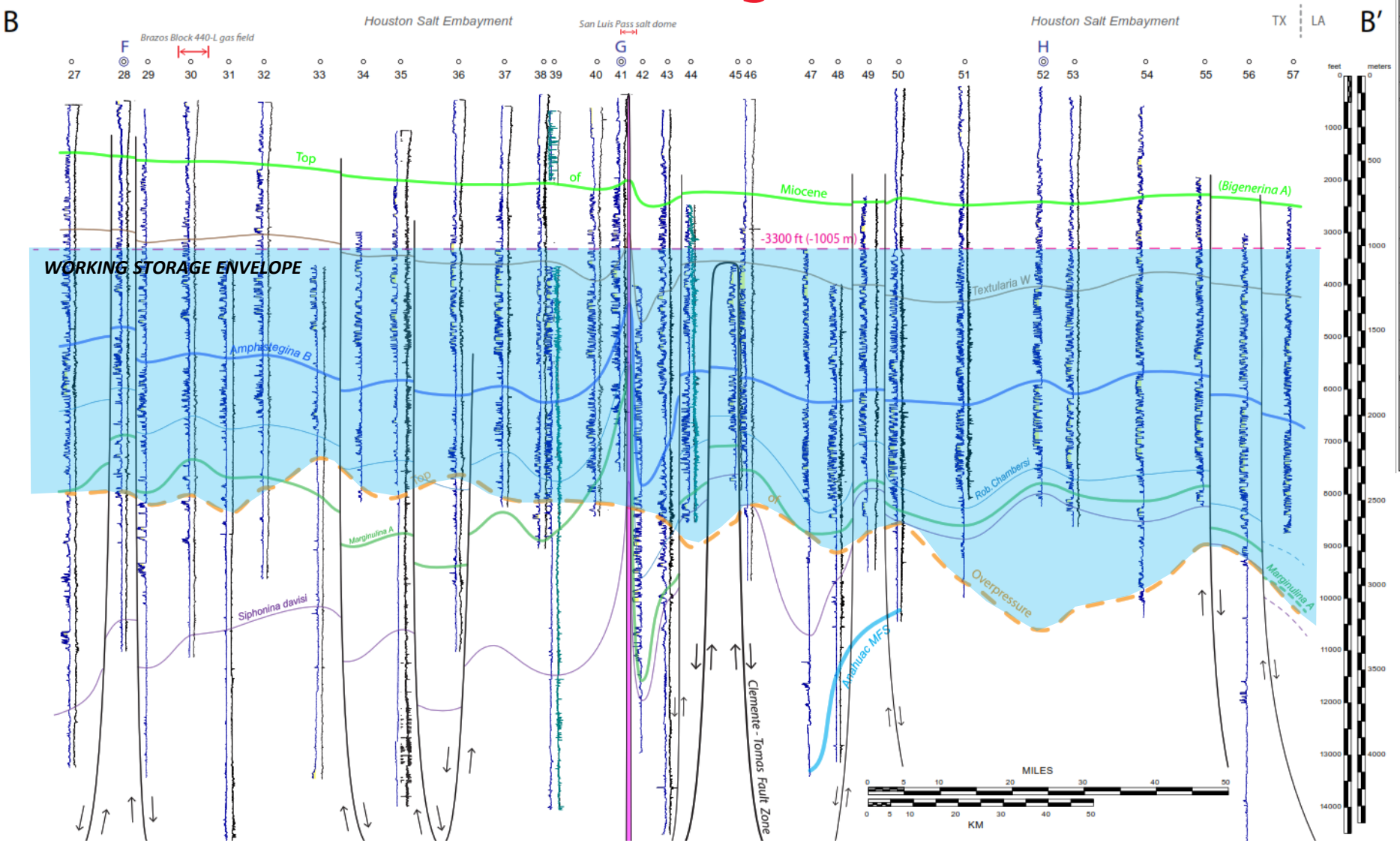
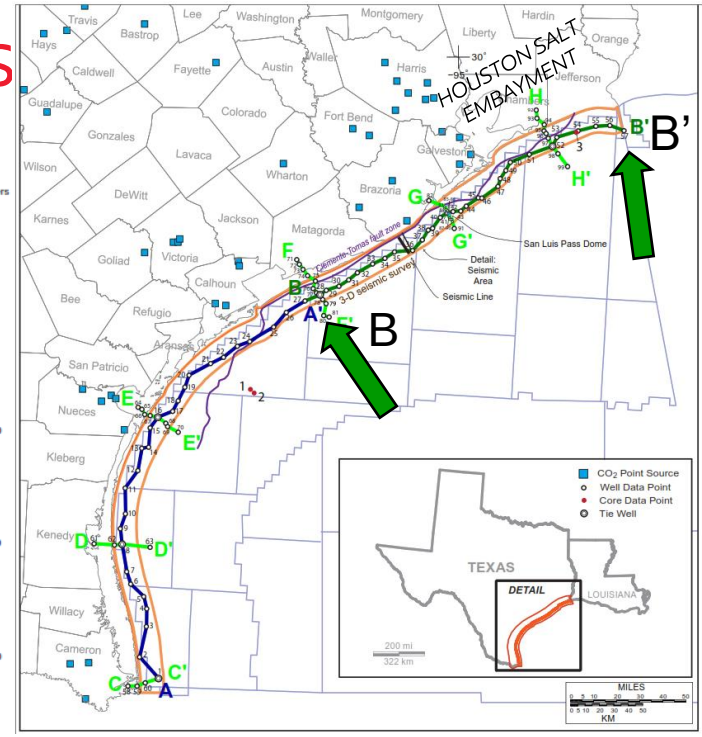
Source: Geological CO2 Sequestration Atlas of Miocene Strata. Offshore Texas State Waters, Bureau of Economic Geology, 2017.

Gulf Coast Section Along Strike. Miocene Sands





- Relatively thick interval (up to 2 km) of sand/shale pairs of normally pressured reservoirs
- Regional flooding surfaces that can be associated lithologically as sealing intervals (e.g., Amph B, etc.)
- Top of overpressure in the NE TX Gulf Coast shelf lies between 2500-3400 m subsea.

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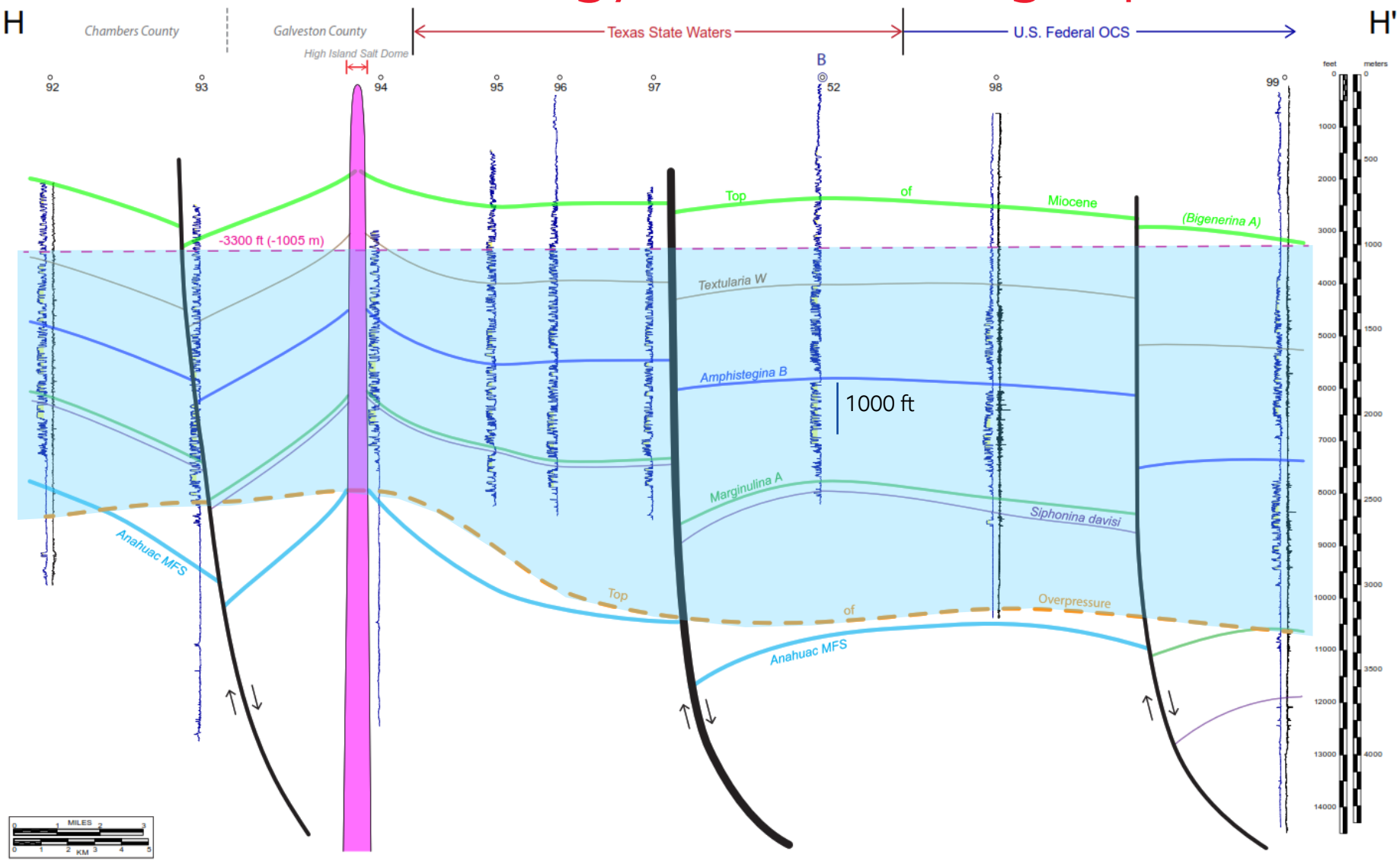
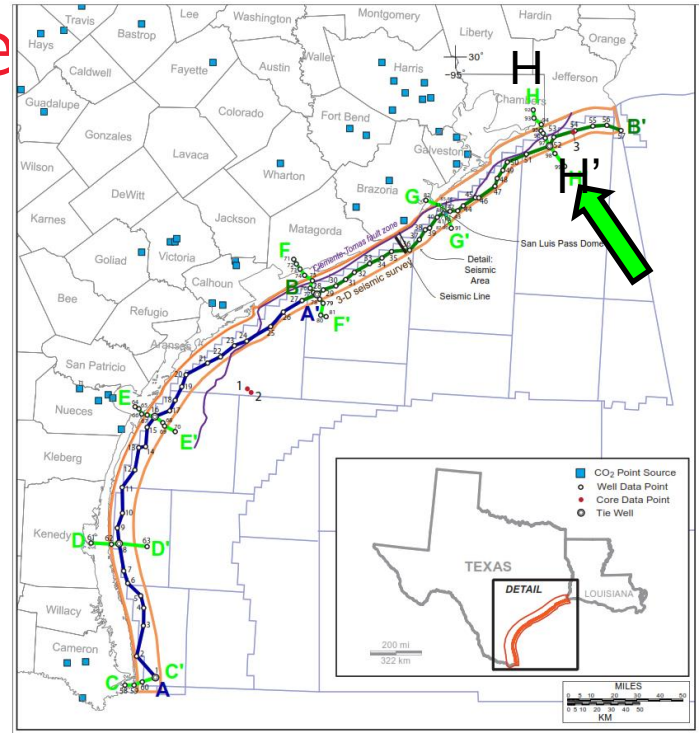
Source: Geological CO2 Sequestration Atlas of Miocene Strata. Offshore Texas State Waters, Bureau of Economic Geology, 2017.

Gulf Coast Geology Section Along Dip. Miocene





- Fault systems associated with salt mobilization may form independent closures
- Salt diapers are common
- Depth of overpressure can be related to the general lack of sand observed in wells between the Marginulina A and Anahuac MFS surfaces.

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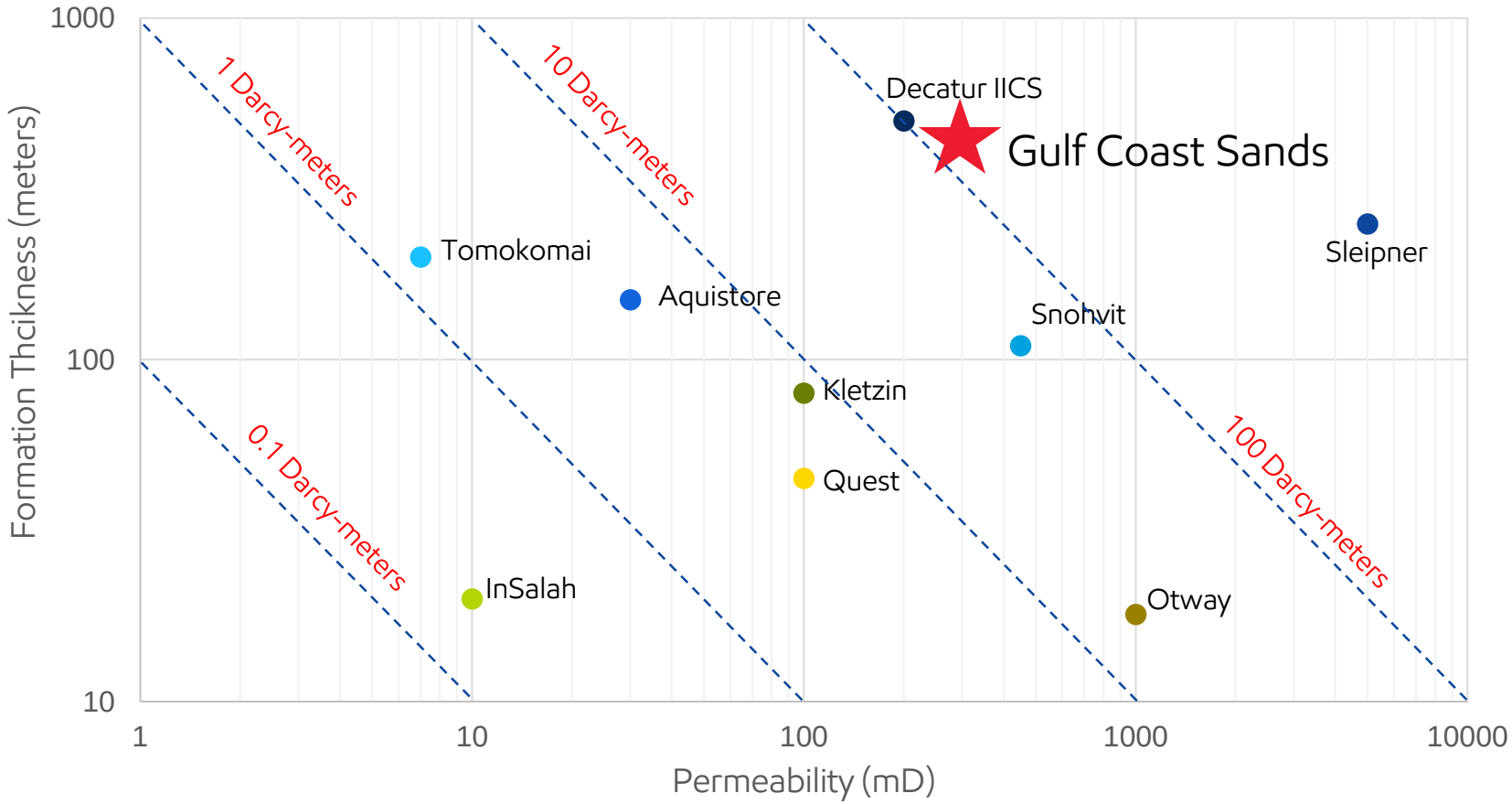
Source: Geological CO2 Sequestration Atlas of Miocene Strata. Offshore Texas State Waters, Bureau of Economic Geology, 2017.

Gulf Coast Sands Thickness and Permeability Compared



Favorable permeability and thickness in US Gulf Coast sands compared to on-going CCS projects worldwide

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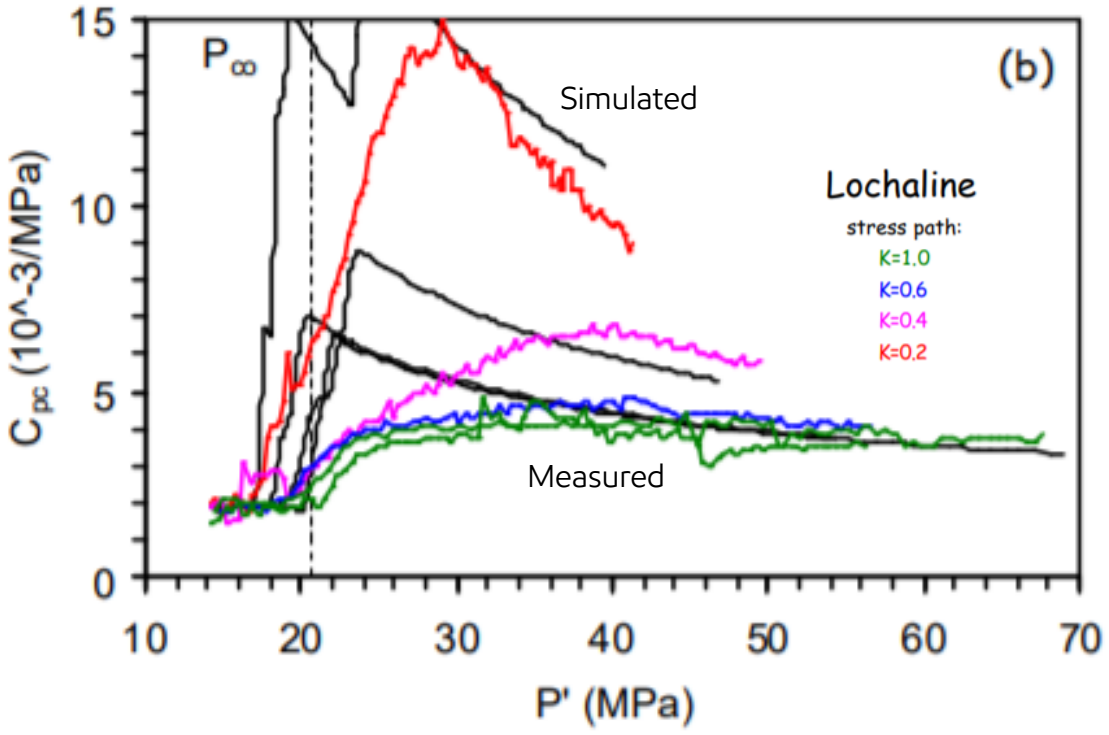
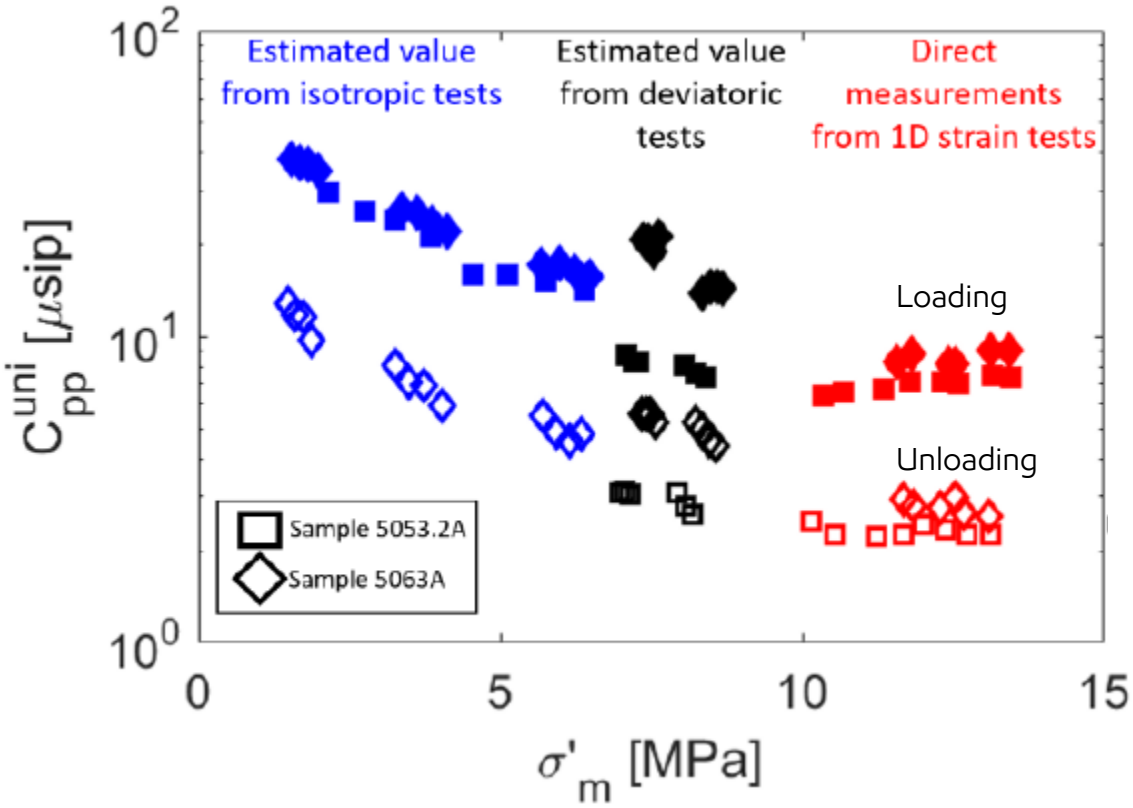
Gulf Coast Rocks Geomechanical Properties

Source: ARMA 04-611. Crawford et al. (2004)



Source: ARMA 19-379. Zheng et al. (2019)



Frio and other consolidated sands have pore volume compressibility of about 2 - 5 microsips in the range of stresses that are of interest to CCS projects in TX/LA Gulf Coast

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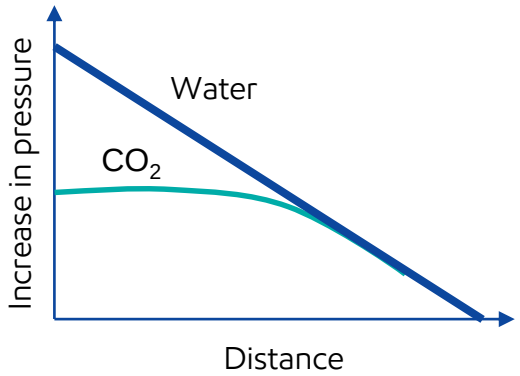
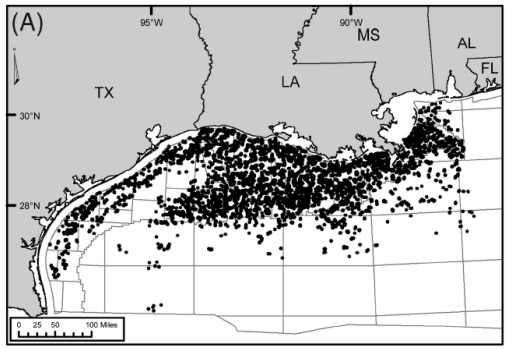
Limits on Use of Sand Thickness for CCS

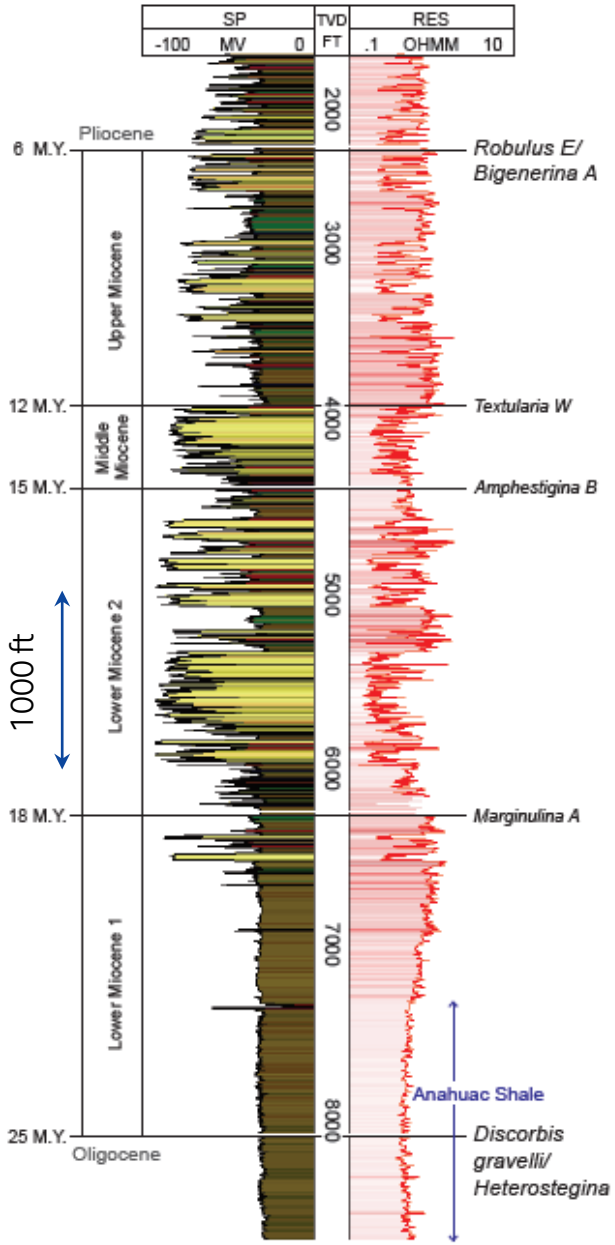
- Bulk compressibility of rock ~1 μsips (pore compressibility 5 μsips)
- Assume pressure increase 400 psi (~2.8 MPa) due to CO_2 injection

Total Thickness, ft	Sand Thickness, ft	Reservoir uplift, ft
500	250	0.1
1000	500	0.2
1500	750	0.3
2000	1000	0.4





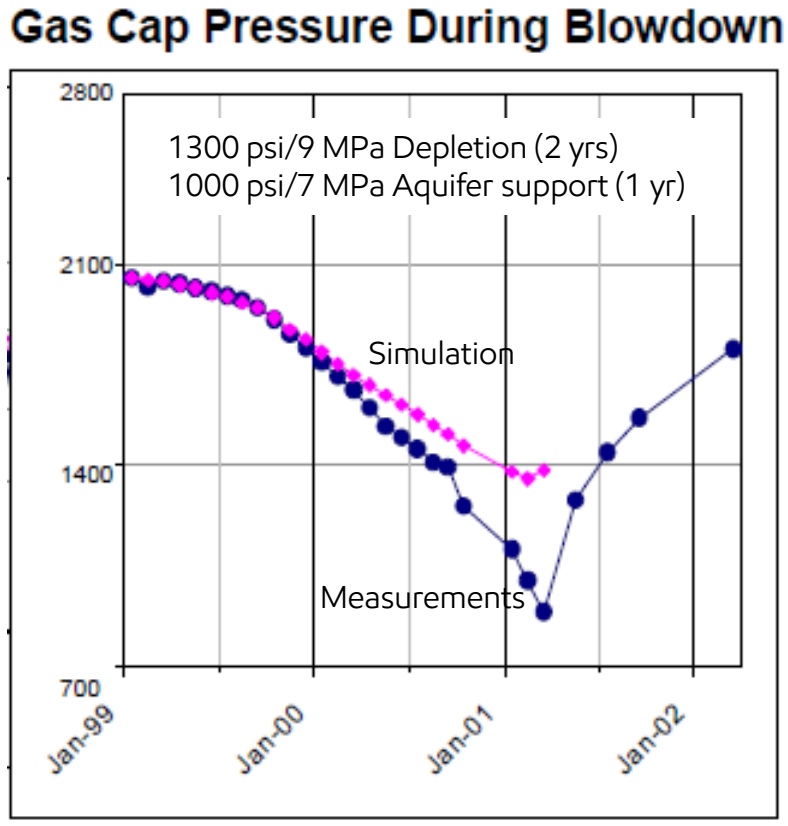
Source: Morris et al. (2015)



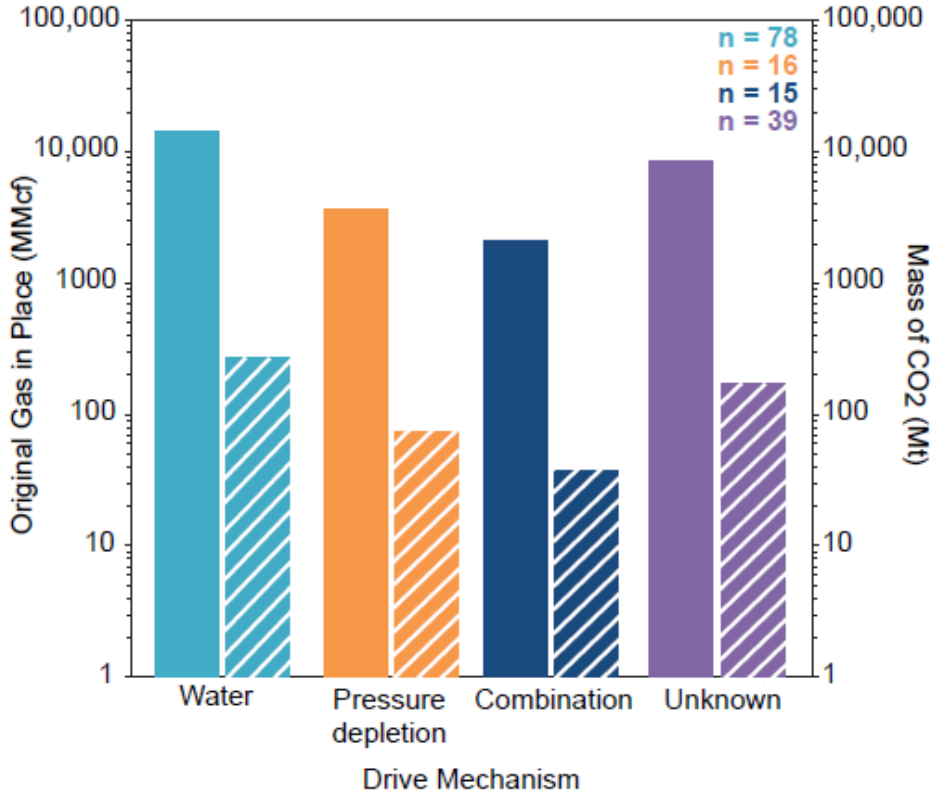
Source: Geological CO2 Sequestration Atlas of Miocene Strata. Offshore Texas State Waters, Bureau of Economic Geology, 2017.

Drive Mechanisms Vary in TX/LA Onshore/Shallow Water Fields

- Majority of onshore/shallow water O&G reservoirs have aquifer support
- Older depleted reservoirs in these shallow waters are likely to be at hydrostatic pressure



Source: SPE 77640. Friendswood Field – A case study in reservoir management



Source: Geological CO2 Sequestration Atlas of Miocene Strata. Offshore Texas State Waters, Bureau of Economic Geology, 2017.

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Stress Changes due to Depletion and Injection

FG change due to depletion

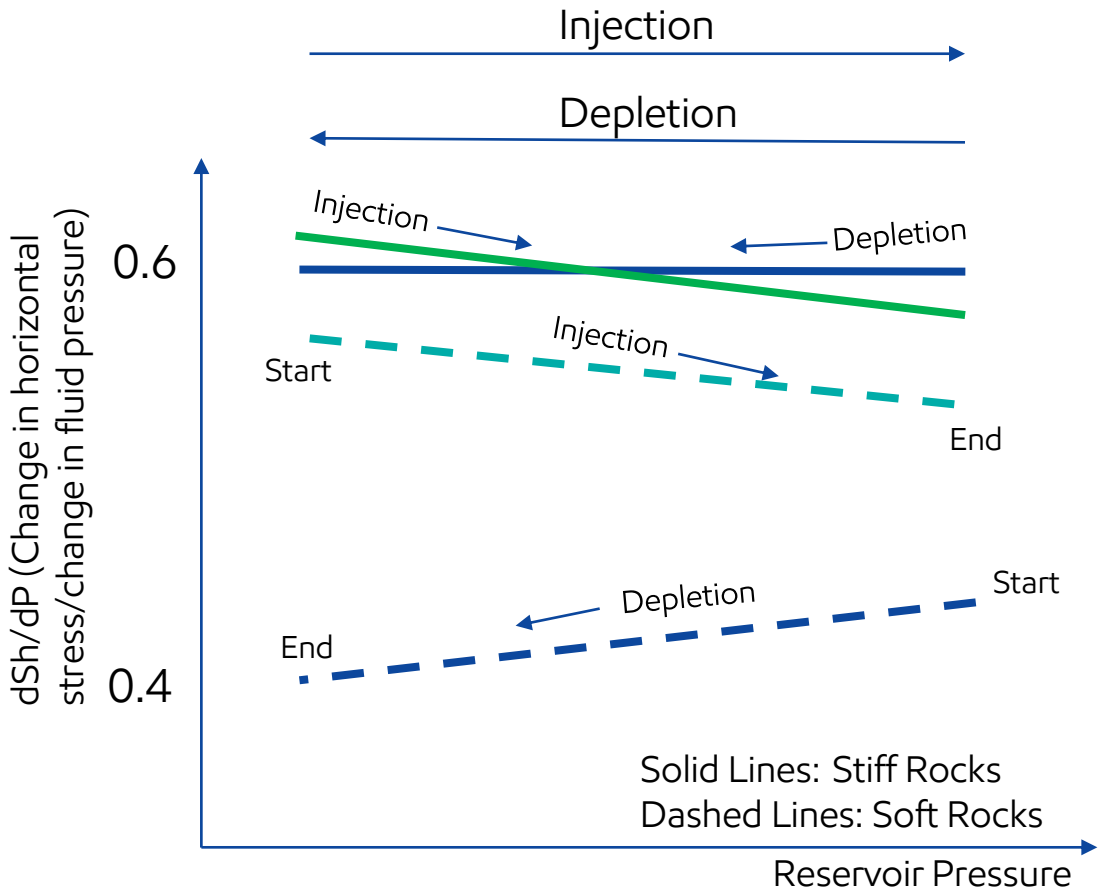
Region	$d\sigma_3/dP_p$	Back-calculated Poisson's ratio
Vicksburg Formation	0.53	0.32
Ekofisk Field	0.80	0.17
Waskom Field	0.46	0.35
Waskom Field	0.57	0.30
Magnus Field	0.68	0.24
West Sole Field	1.18	-
Wytch Farm Field	0.65	0.26
Venture Field	0.56	0.30
Gulf Coast	0.46	0.35
Lake Maracaibo	0.56	0.3
Brunei	0.486	0.34

Source: Addis (1997). Reservoir depletion and its effect on wellbore stability.

$$\frac{dSh}{dP} = \frac{1-2v}{1-v}$$

$$\frac{dSh}{dP} = \frac{2}{3} \; for \; v = 0.25$$

$$\frac{dSh}{dP} = \frac{1}{3} \; for \; v = 0.4$$



Summary of Uniaxial Laboratory Tests

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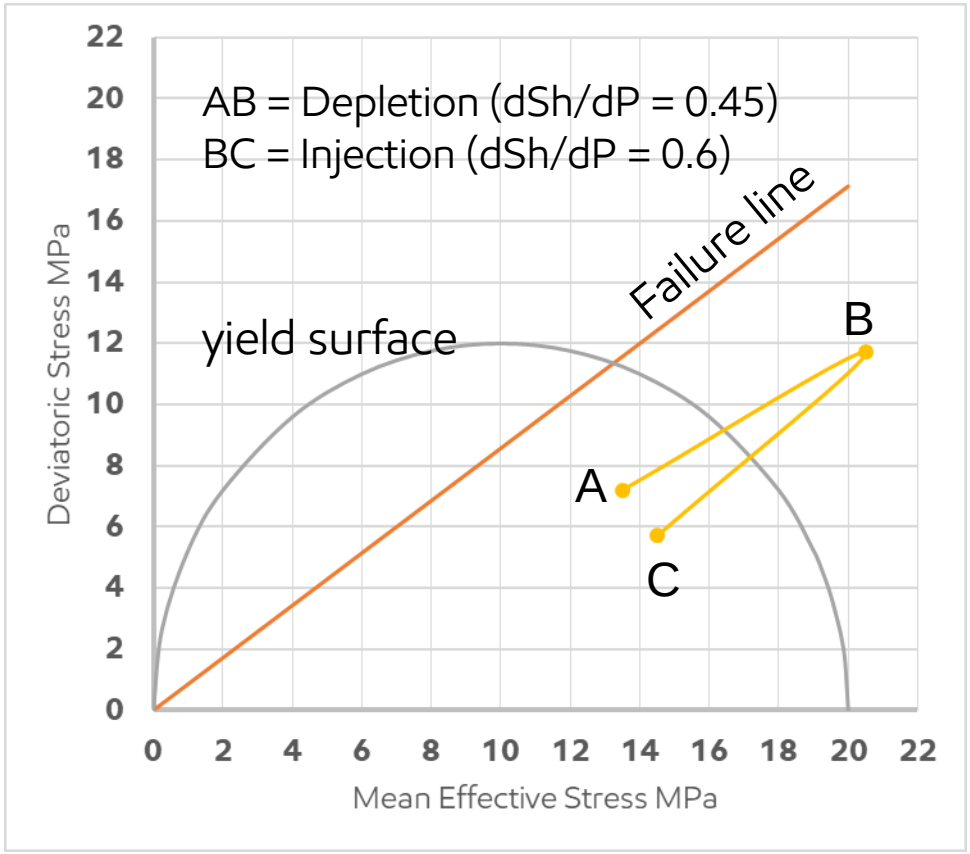
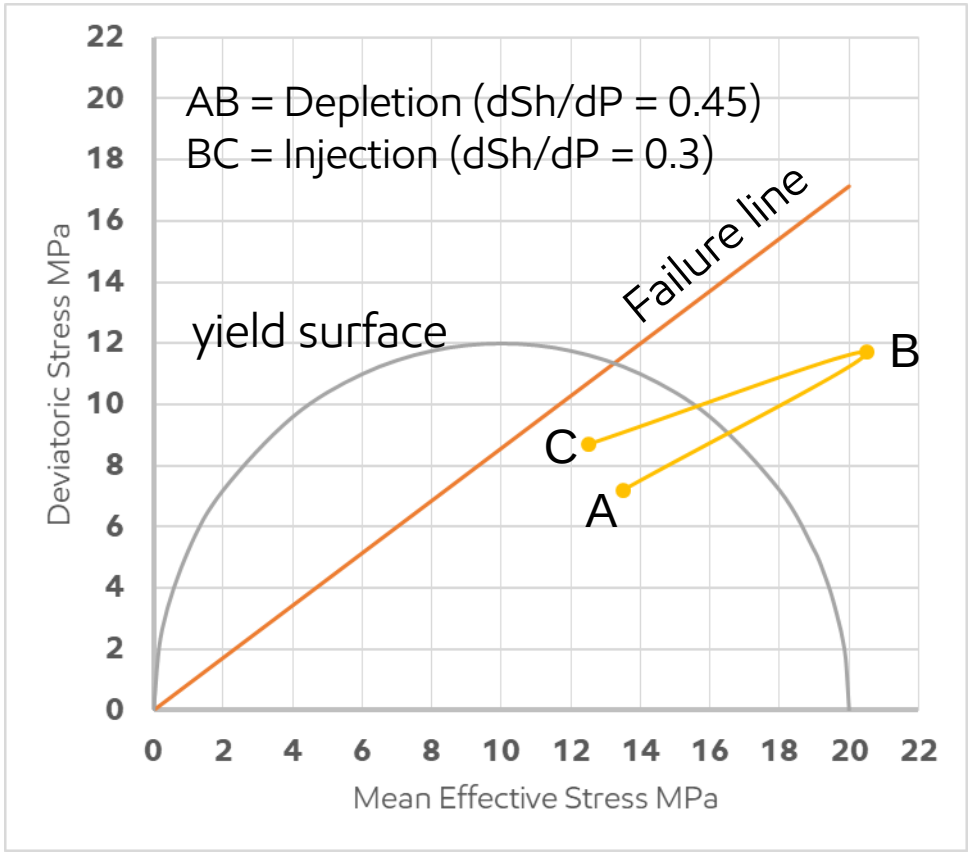
Stress Changes due to Depletion and "Injection" in O&G Fields



- Injection leads to a geomechanically stable state
- Gulf Coast replenished depleted O&G fields are desired



- Injection leads to a geomechanically unstable state
- Gulf Coast replenished depleted O&G fields are not desired

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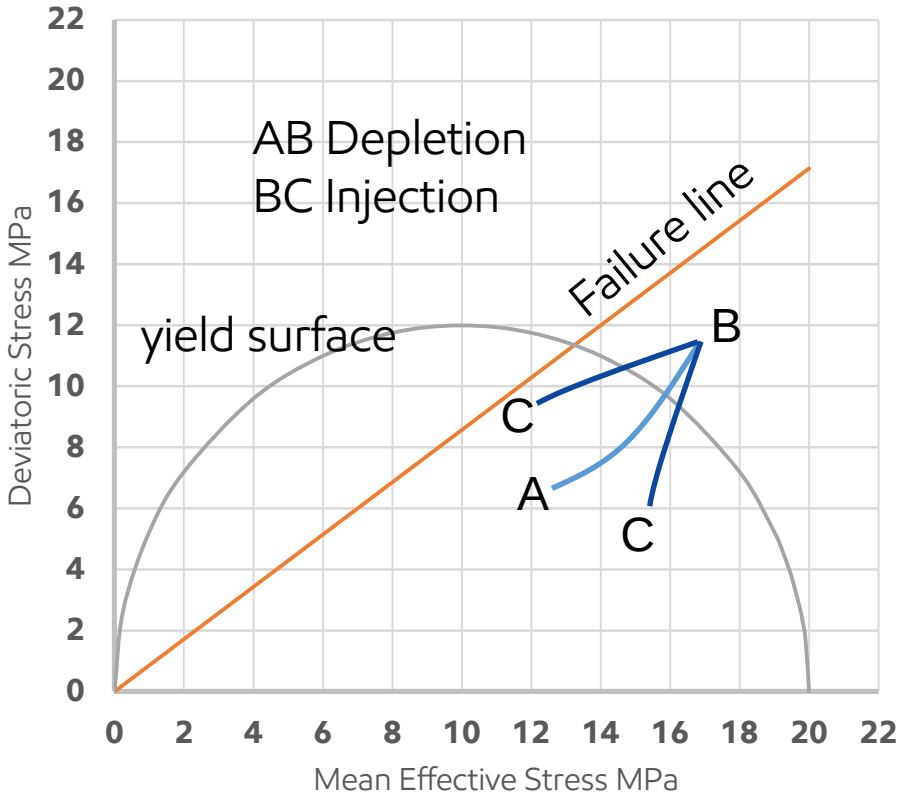
Challenges and Opportunities to Store CO_2 in Gulf Coast - I



- What is the injection path (BC)? What are the controls?
- Can we address this question using existing laboratory data or laboratory tests on representative sand samples

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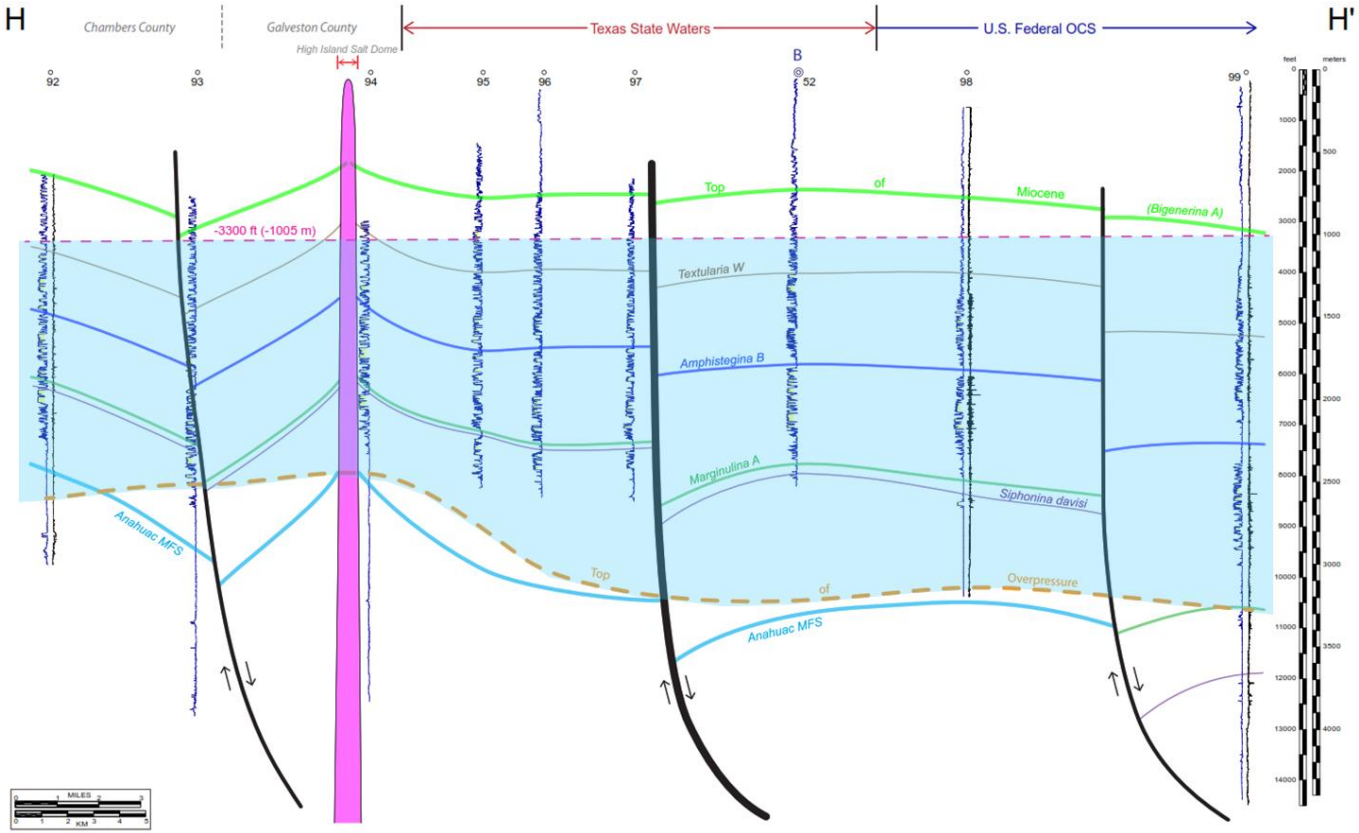
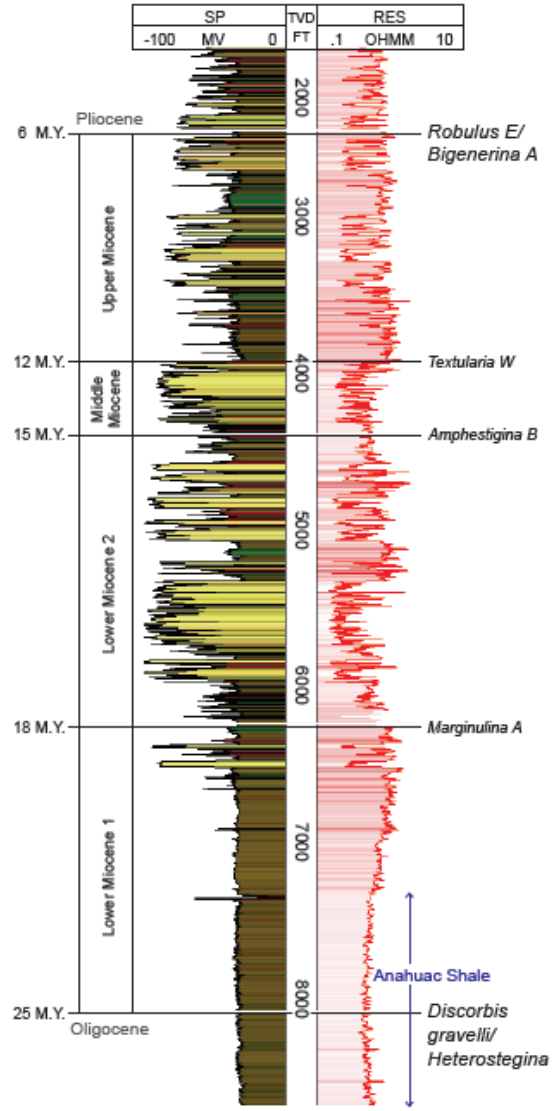
Challenges and Opportunities to Store CO_2 in Gulf Coast - II

How to maximize storage in stacked sand – shale sequences by minimizing rock deformation (legacy wells, fault reactivation)?





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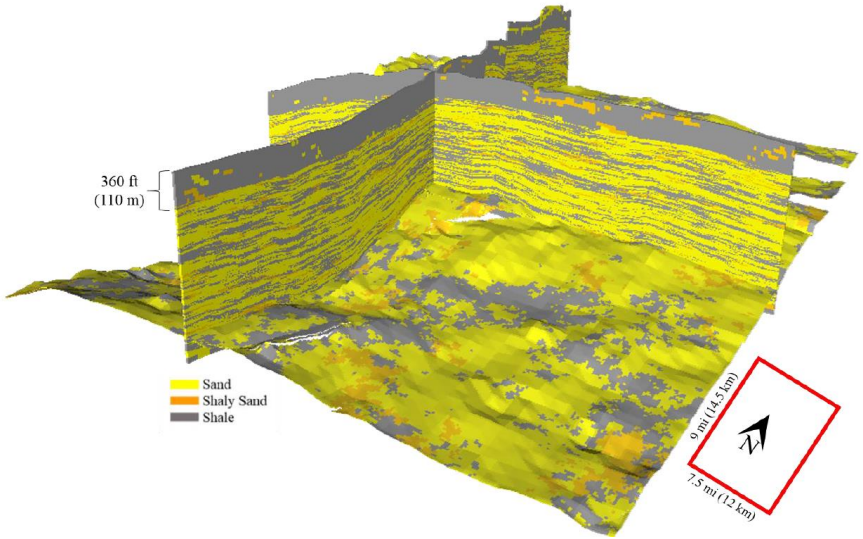
Source: Geological CO2 Sequestration Atlas of Miocene Strata. Offshore Texas State Waters, Bureau of Economic Geology, 2017.

Challenges and Opportunities to Store CO_2 in Gulf Coast - III

When does the heterogeneity cross-over from favorable to unfavorable condition occurs?

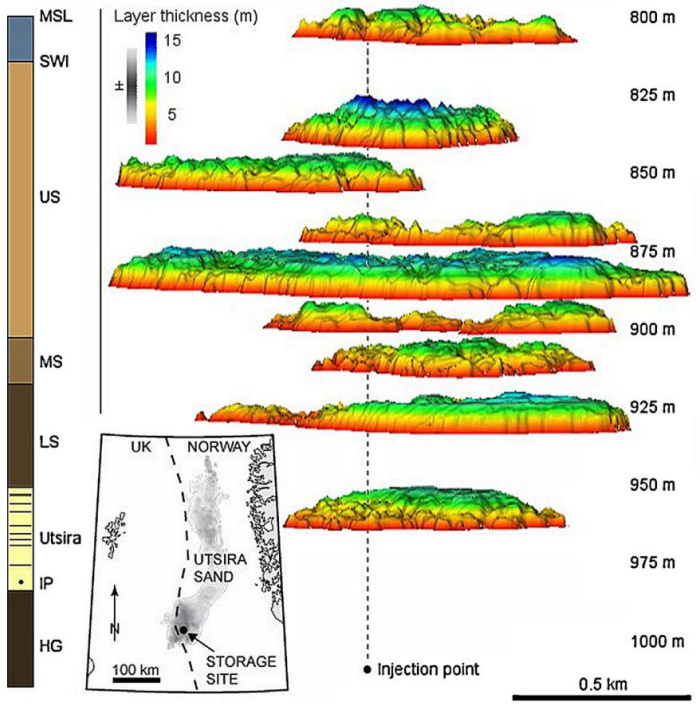
How can we quantify the contribution of heterogeneity and account for it in site selection?

Reservoir scale heterogeneity
At High Island 24L Field



Source Ruiz (2019)

Impact of heterogeneity on CO_2 plume
at Sleipner



Source: Cavanagh et. al. (2015)

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Questions?