Opportunities for Offshore CCS in the Gulf of Mexico: Perspectives from Texas *

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Abstract

Since 2009, the Gulf Coast Carbon Center at the Bureau of Economic Geology (UT-Austin) has undertaken multiple integrated geologic and geophysical studies to evaluate the continental shelf in the Gulf of Mexico for CO_2 storage. Funding for this has come primarily from the U.S. Department of Energy (NETL), but also from the State of Texas General Land Office, which administers the State offshore resources. A recent award-winning publication (BEG Report of Investigations No. 283) compiles the diverse topics explored during this long history of characterization: *Geological CO_2 Sequestration Atlas for Miocene Strata Offshore Texas State Waters*. This is the first attempt to comprehensively address CO_2 storage topics for the near offshore in the Gulf Coast. Topics addressed in the volume that will be summarized in this presentation include Miocene stratigraphy and depositional systems with regional cross sections, implications of petroleum systems for CO_2 storage, microscopic and stratigraphic evaluation of anticipated primary seals, regional static capacity estimates, and field-scale examples of storage reservoirs (including modelling and simulation).

Detailed stratigraphic and structural interpretation of hundreds of wells and faults using integrated 3D seismic data is now continuous over an area greater than 5,000 square kilometres (2,000 square miles). In three localities a total of 137 square kilometres (53 square miles) of novel high-resolution 3D seismic data has been acquired to understand technological capabilities for imaging the overburden and shallow injection reservoirs, and to address characterization, risk reduction, and monitoring needs. General conclusions from this work are that the inner shelf of the Gulf of Mexico presents superb geology for CCS with ample storage capacity and that sources and developing pipeline infrastructure are well located for development of offshore storage hubs. The thick and relatively young and porous clastic Miocene stratigraphy has multiple regional confining intervals deposited during regional sea level transgressions. Static CO_2 storage capacity estimates beneath the Texas State waters between Mexico and Louisiana total more than 30 Gt, including both depleted hydrocarbon reservoirs and saline intervals. This offshore geologic CO_2 storage resource is regionally and nationally significant, is available for both CO_2 sequestration and enhanced oil recovery (EOR), and is likely to be the most appropriate region for giga-tonne scale storage in the United States.

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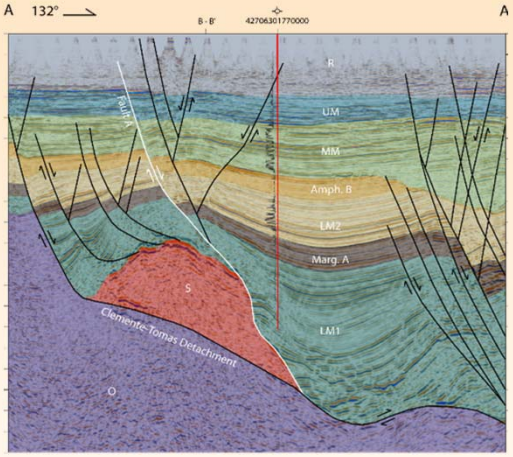
The University of Texas at Austin

Bureau of Economic Geology



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TEXAS Geosciences
Bureau of Economic Geology
Jackson School of Geosciences
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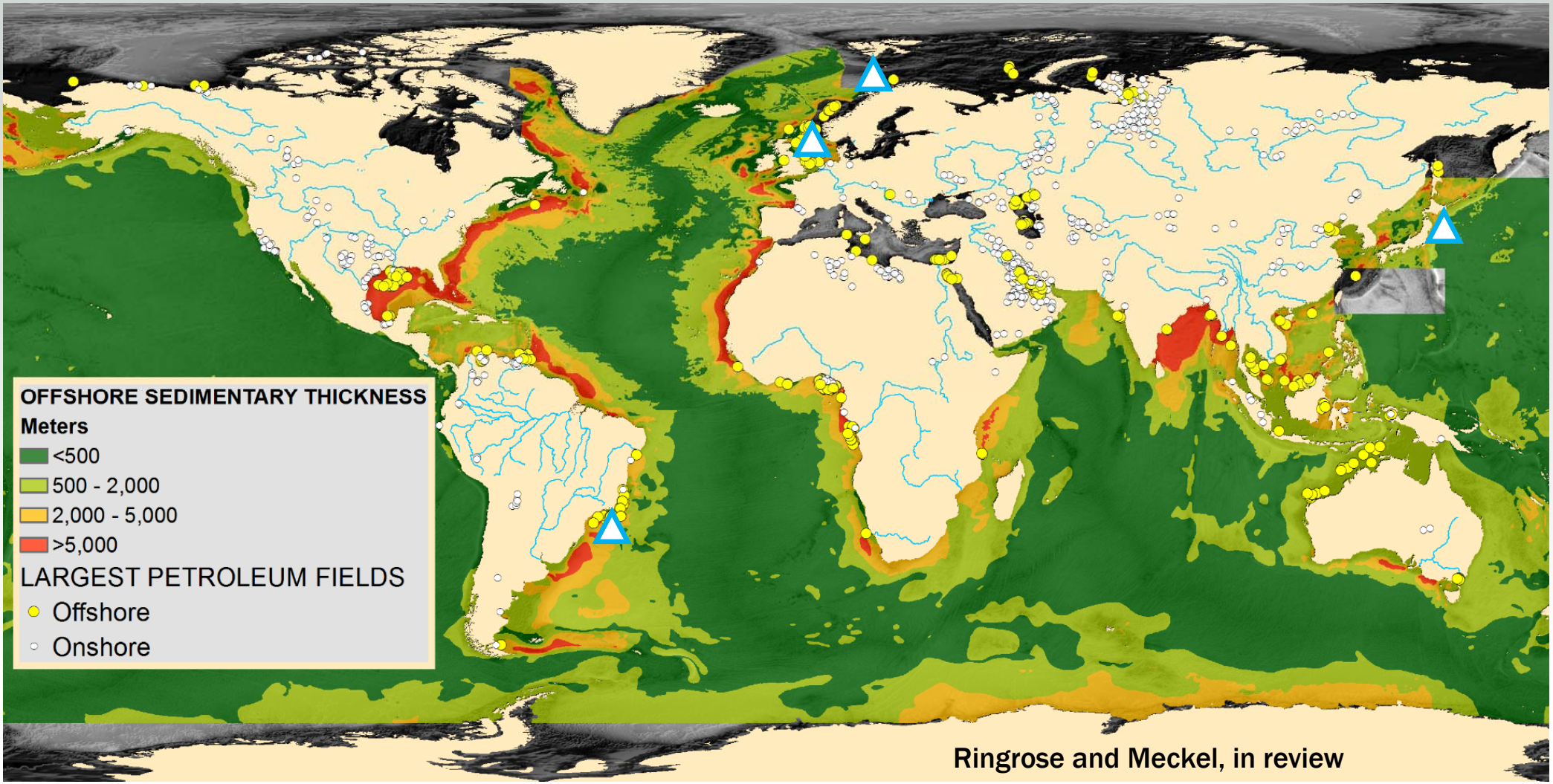
TOPICS

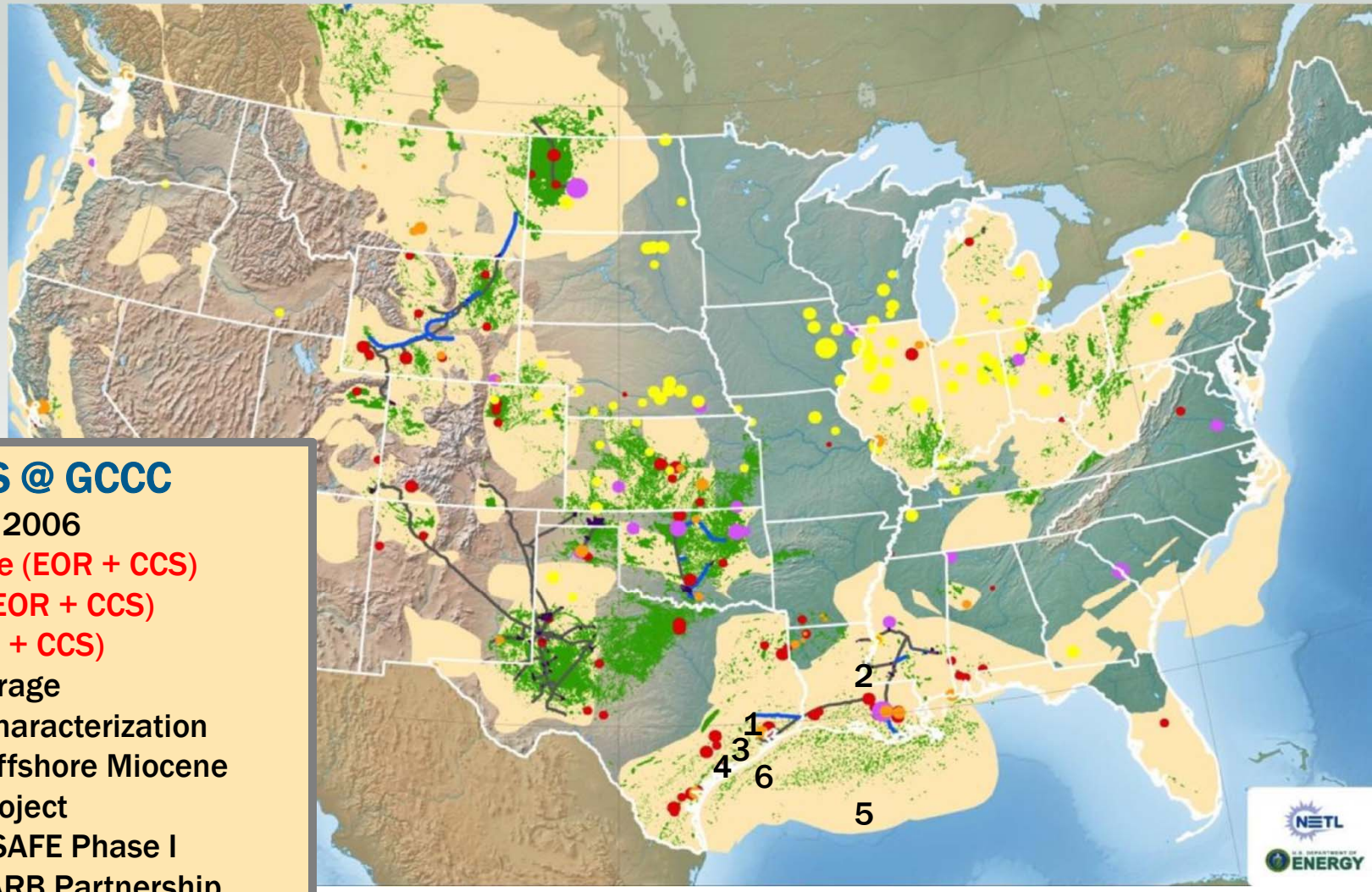
- What is the maturity of CCS in the Gulf Coast region?
  - Many prior projects (research/demo, industrial).
  - Existing capture and pipeline transport infrastructure, upper coast.
  - Current 45Q Tax Credits make CCUS attractive.
- Prior and current work to mature near offshore storage in the Miocene geology
  - Summary of prior geologic storage assessments since 2009.
  - Atlas publication summary.
- Examples of Miocene-age reservoir capacity estimates

Offshore continental margins are the most promising for near-term Gigatonne-scale storage



Regional Gulf Coast setting for rapid large-scale carbon management in U.S. heavy industry

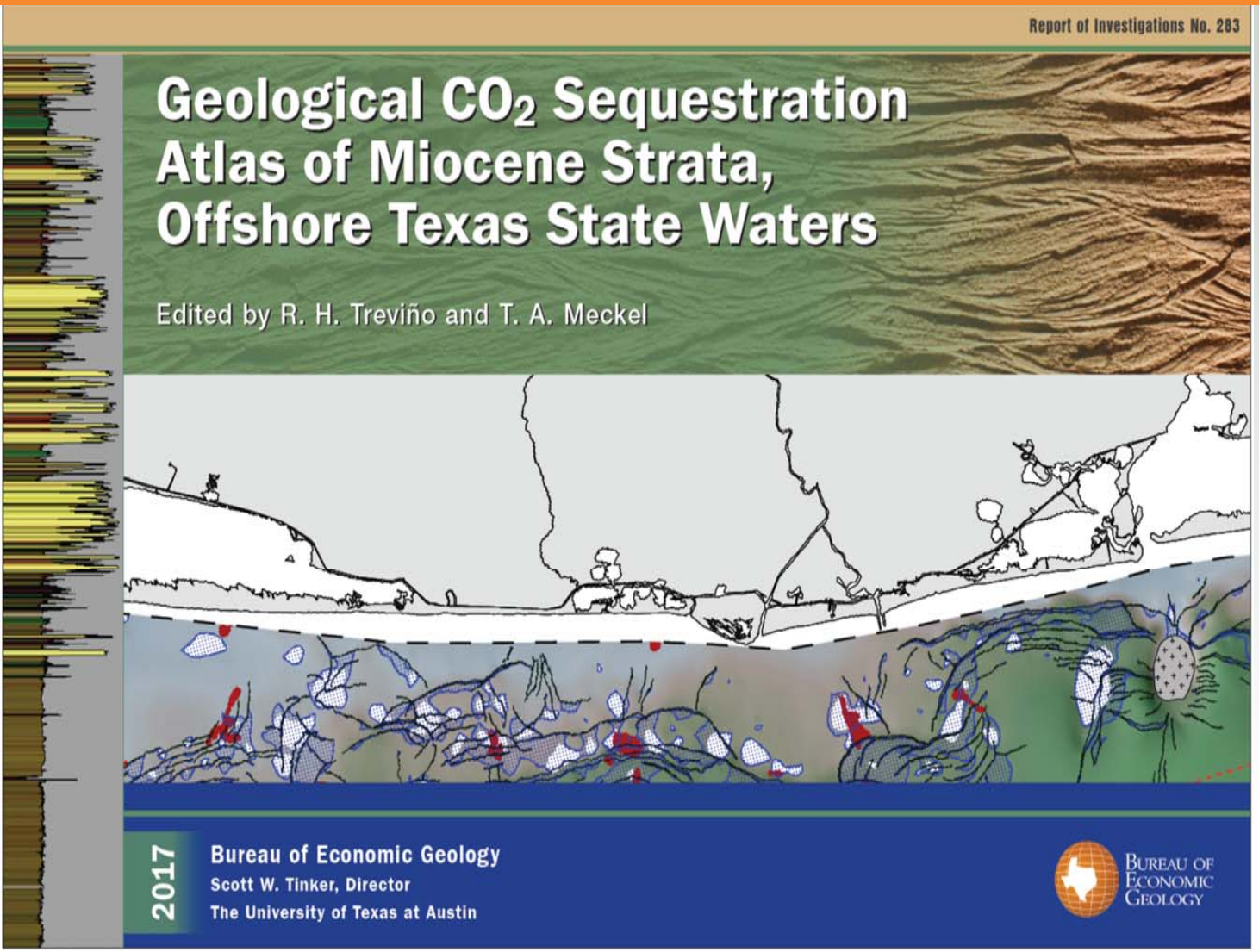
Gulf Coast Carbon Center



Gulf Coast CCS @ GCCC

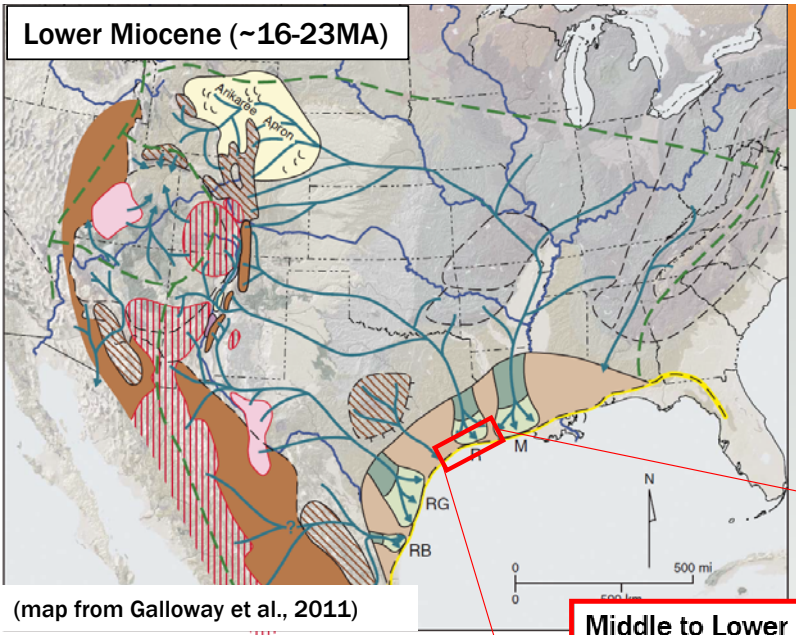
1) Frio Saline tests 2004 & 2006
2) Cranfield stacked storage (EOR + CCS)
3) Air Products - Hastings (EOR + CCS)
4) NRG – West Ranch (EOR + CCS)
5) BOEM BPM Offshore Storage
6) Offshore GoM Storage Characterization
   A. 2009-2014 Texas Offshore Miocene
   B. 2015-2018 TXLA Project
   C. 2016-2018 CarbonSAFE Phase I
   D. 2018–2023 GoMCARB Partnership

2017 Comprehensive Study of CO_2 Storage in Texas State Waters



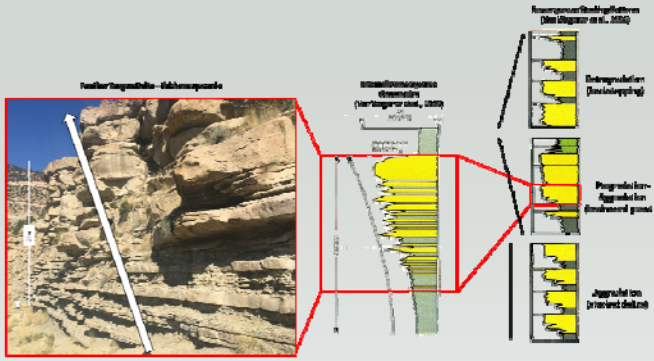
1. Regional Geology of the Gulf of Mexico and the Miocene Section of the Texas Near-offshore Waters
2. Implications of Miocene Petroleum Systems for Geologic CO_2 Storage beneath Texas Offshore Lands
3. Evaluation of Lower Miocene Confining Units for CO_2 Storage, Offshore Texas State Waters, Northern Gulf of Mexico, USA
4. Capillary Aspects of Fault-Seal Capacity for CO_2 Storage, Lower Miocene, Gulf of Mexico
5. Regional CO_2 Static Capacity Estimate, Offshore Saline Aquifers, Texas State Waters
6. Field-scale Example of Potential CO_2 Sequestration Site in Miocene Sandstone Reservoirs, Brazos Block 440-L Field
7. Estimating CO_2 Storage Capacity in Saline Aquifer Using 3D Flow Models, Lower Miocene, Texas Gulf of Mexico
8. Appendix A: Regional Cross Sections, Miocene Strata of Offshore Texas State Waters

GOM Paleogeography



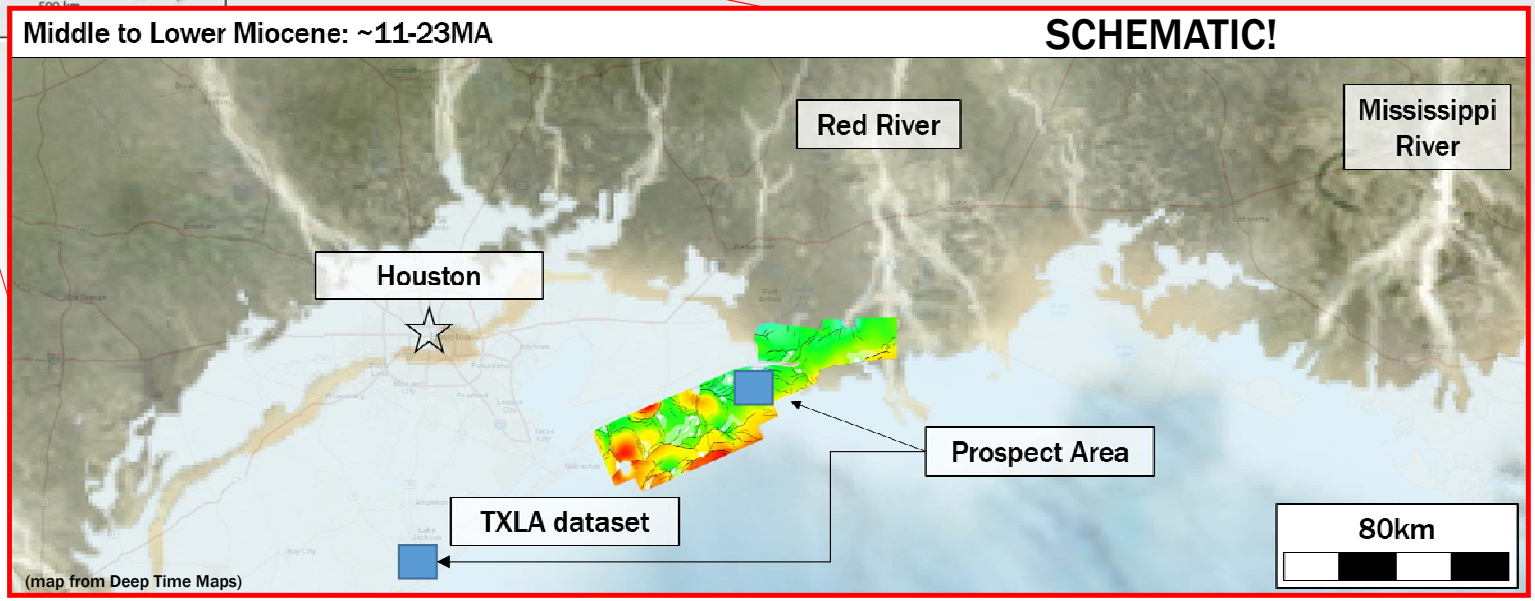
(map from Galloway et al., 2011)

- Dominant environment: Coastal-Deltaic, shallow marine
- Red River merging with Mississippi River



Receiving Basin Elements

Depositional coastal plain
Fluvial axes
Deltaic depocenters
Max. progradational shoreline



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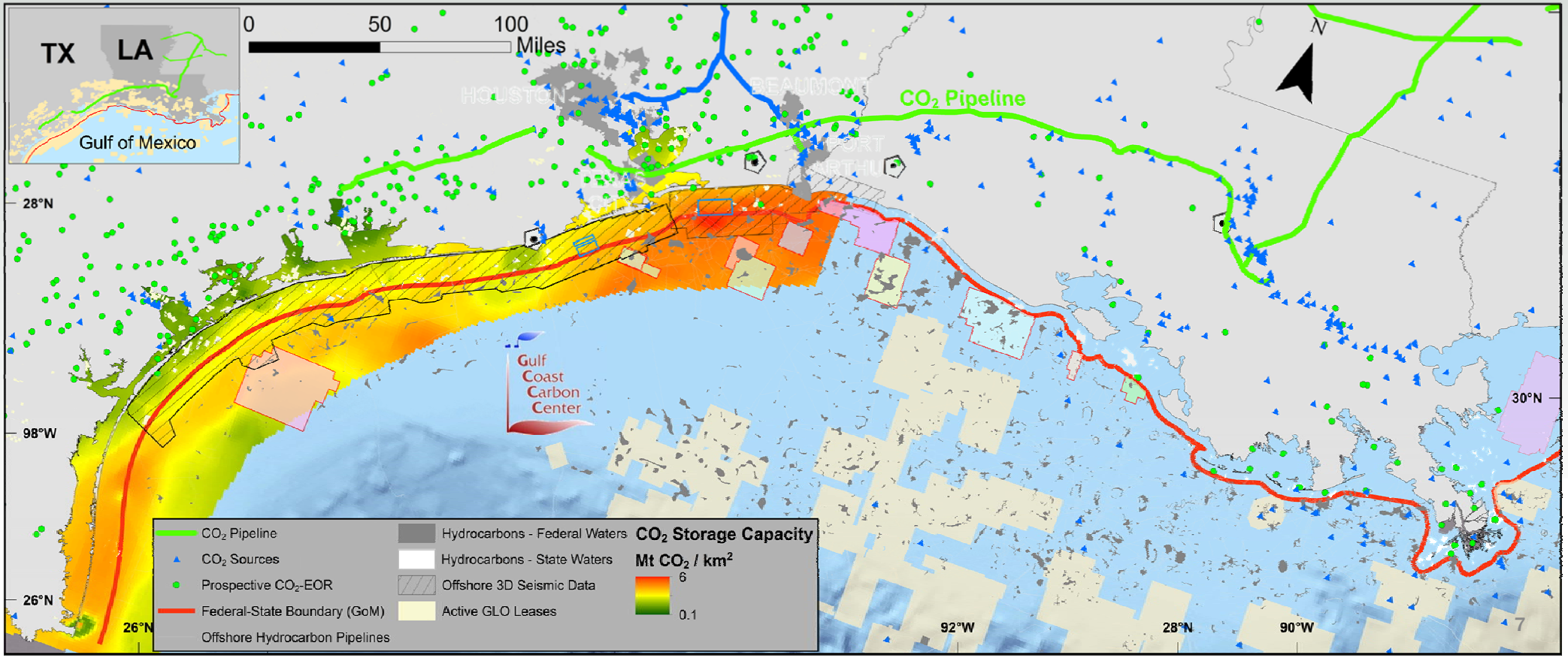
Static Regional Capacity

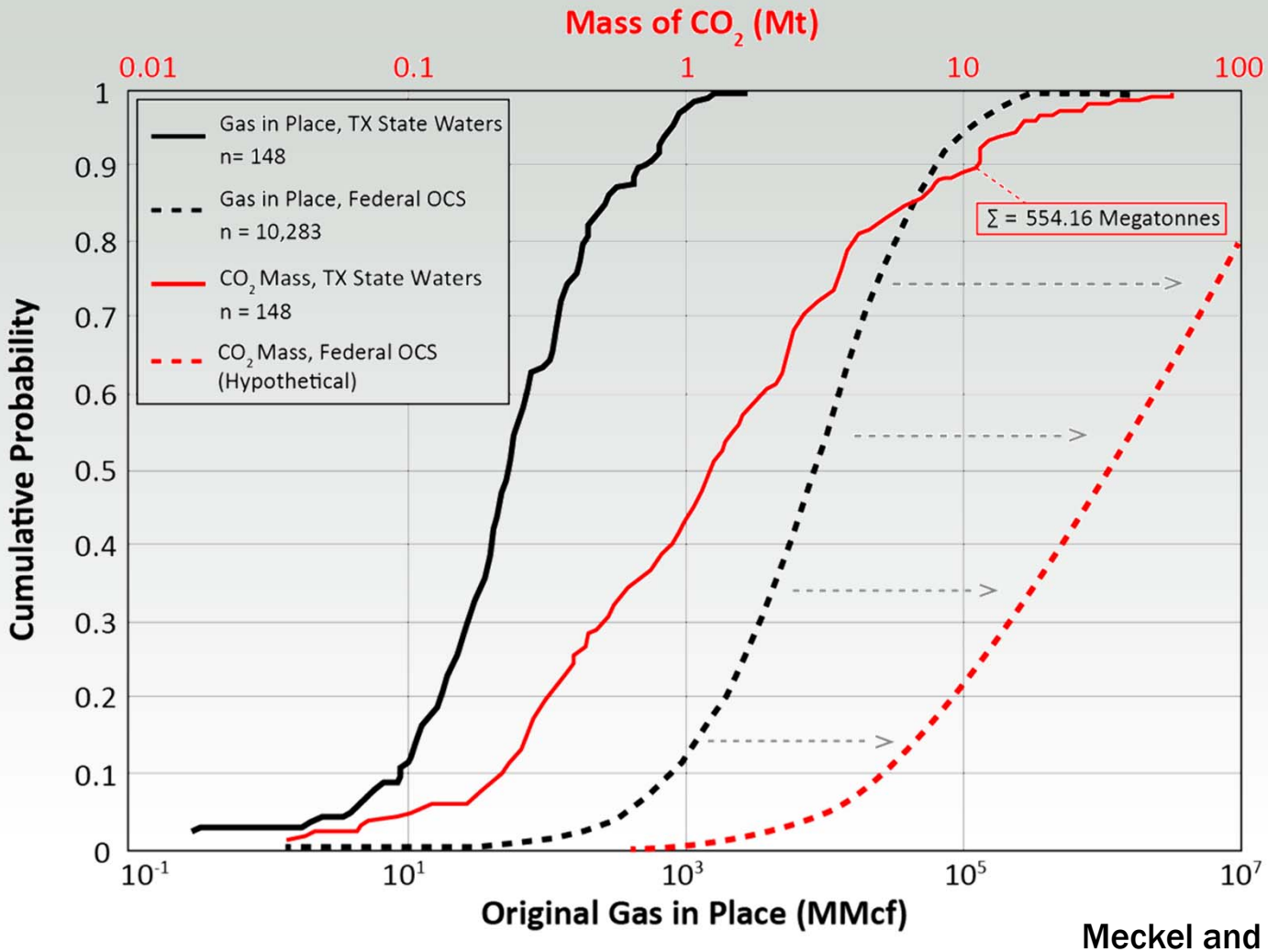
- NETL Methodology
- 40,000 sq. km.

- 3,300 logs
  - Tops, net sand, porosity

- 172 Gt CO_2 storage total TX State Waters



Converting methane gas accumulation experience to CO_2 storage



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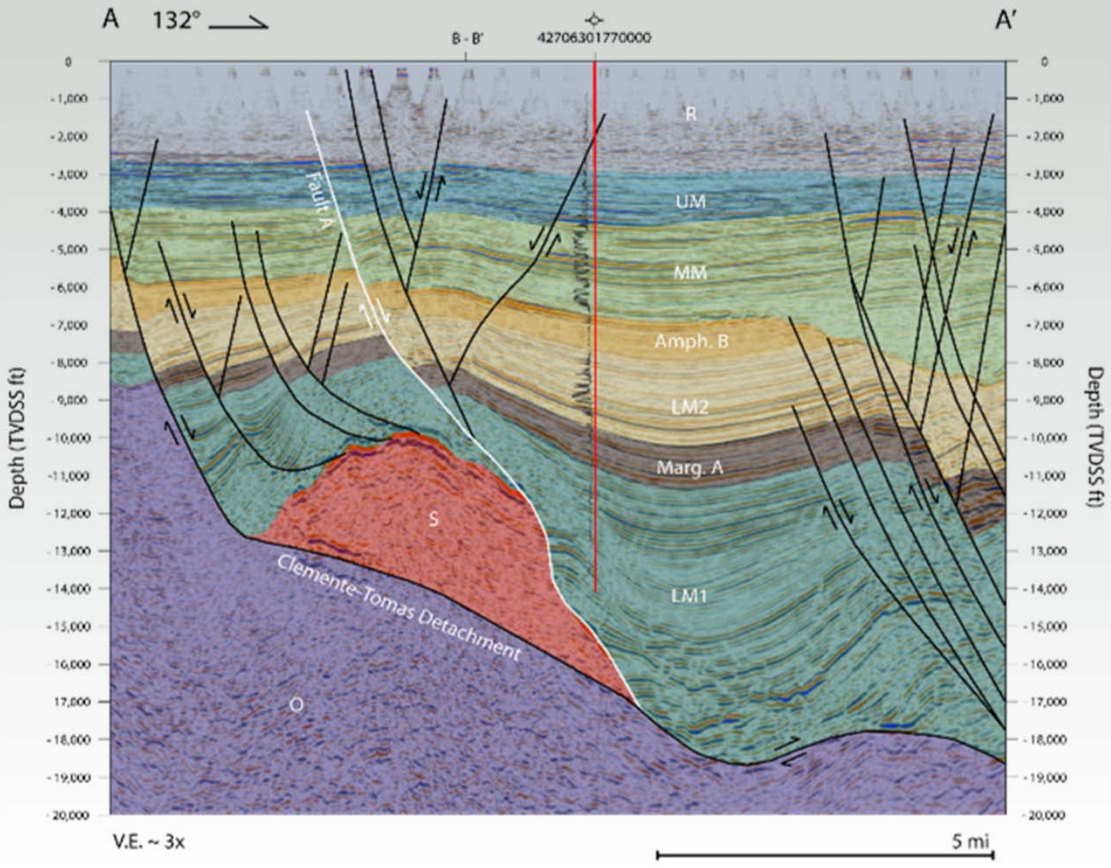
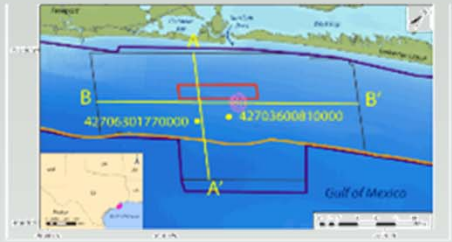
Meckel and Rhatigan, 2017

Typical large growth fault setting on inner shelf – Dip Section



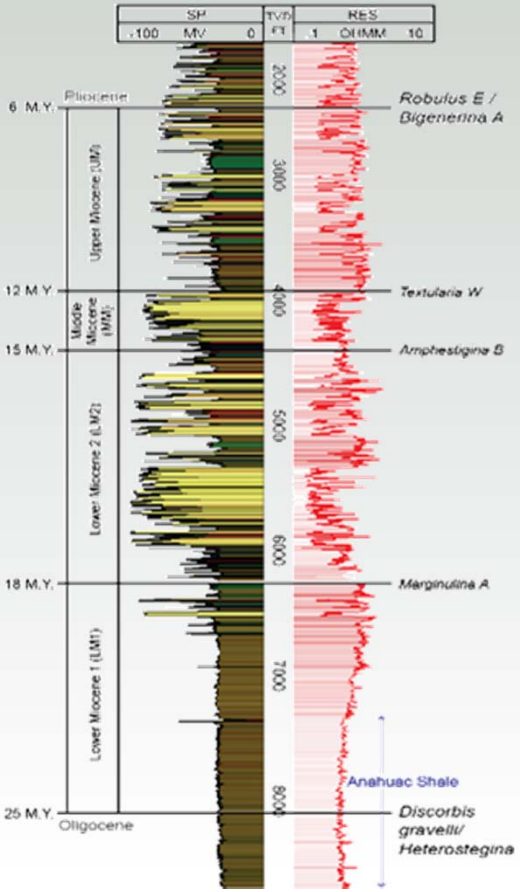


Key to Geologic Features and Symbols

R	Recent through Pliocene Siliciclastics
UM	Upper Miocene Siliciclastics
MM	Middle Miocene Siliciclastics
Amph. B	*Amphestegina chipolensis* Shale
LM2	Lower Miocene 2 Siliciclastics
Marg. A	*Marginulina ascensionesis* Shale
LM1	Lower Miocene 1 Siliciclastics
O	Oligocene Anahuac Shale and Older
S	Jurassic Allochthonous Louann Salt
	Faults

OBS Amplitude + −

SP Log − +



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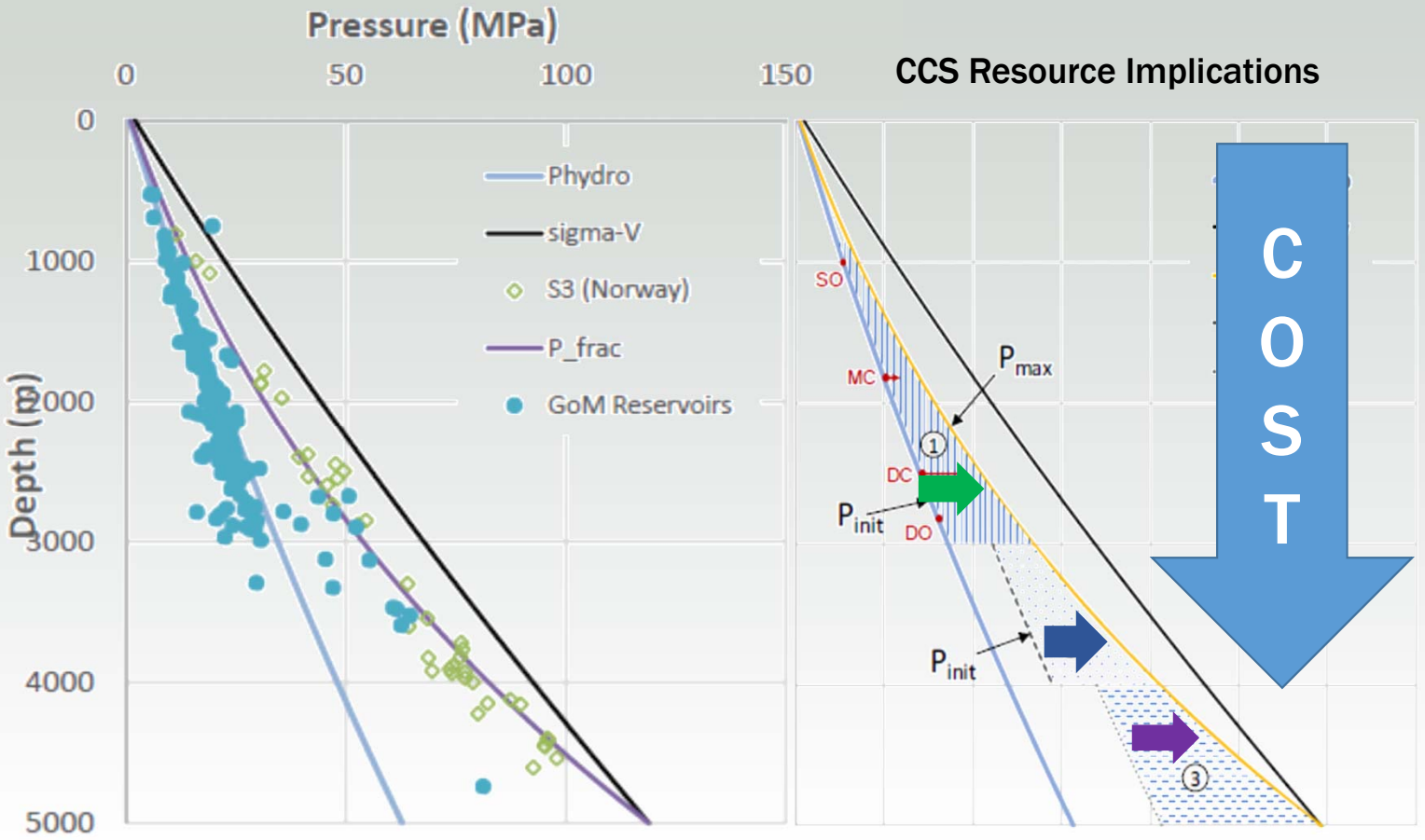
Osmond, 2016

Pressure will be the primary factor limiting capacity



Primary:
Normal pressure (CENOZOIC)

Secondary:
Elevated pressure (MESOZOIC)

Tertiary:
High pressure, brine extraction?

Ringrose and Meckel, in review

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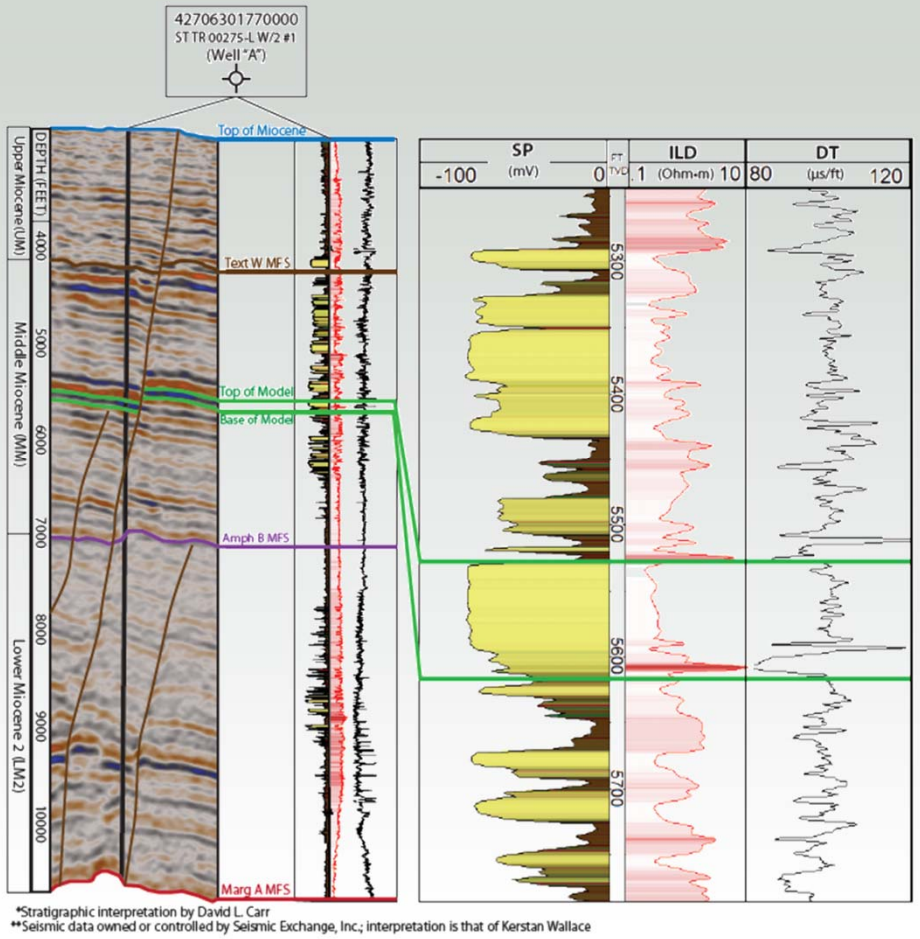
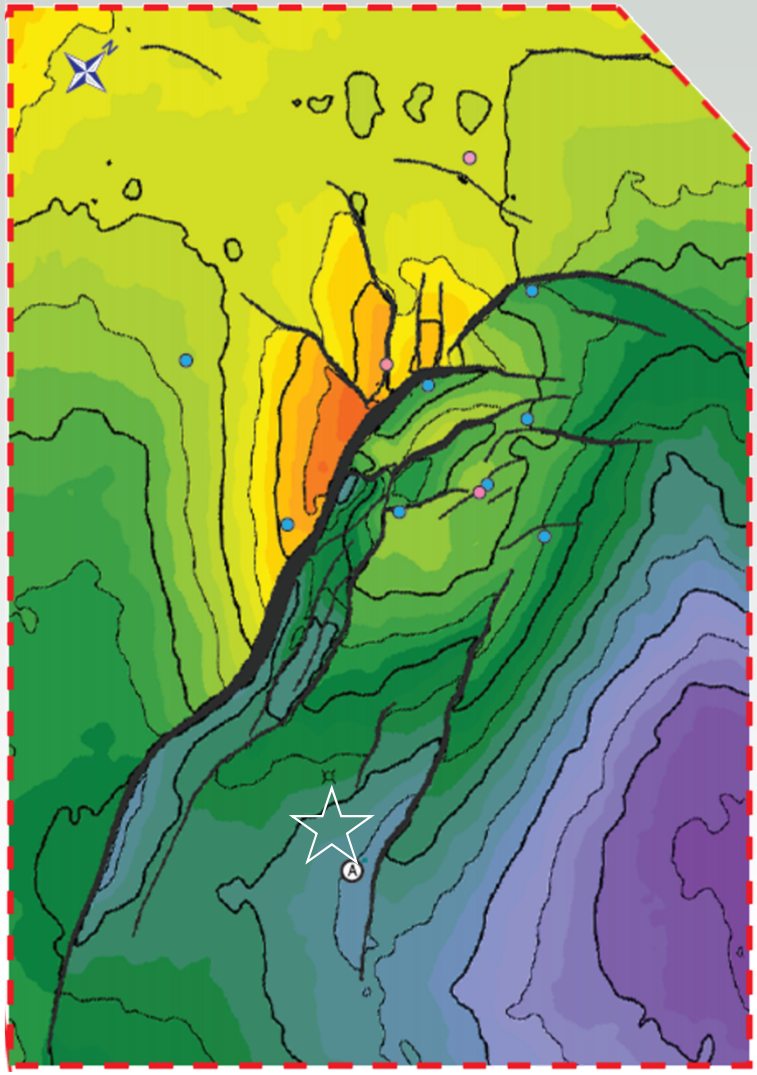
Reservoir Performance – Nonproductive Setting (San Luis Pass)



*Stratigraphic interpretation by David L. Carr
**Seismic data owned or controlled by Seismic Exchange, Inc.; interpretation is that of Kerstan Wallace



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Wallace, 2013

RESERVOIR PERFORMANCE

Approximately 5 Mt in 90’ sand, unless completely open flow boundaries

Cumulative Injection Results for 27 dynamic 3D flow simulations

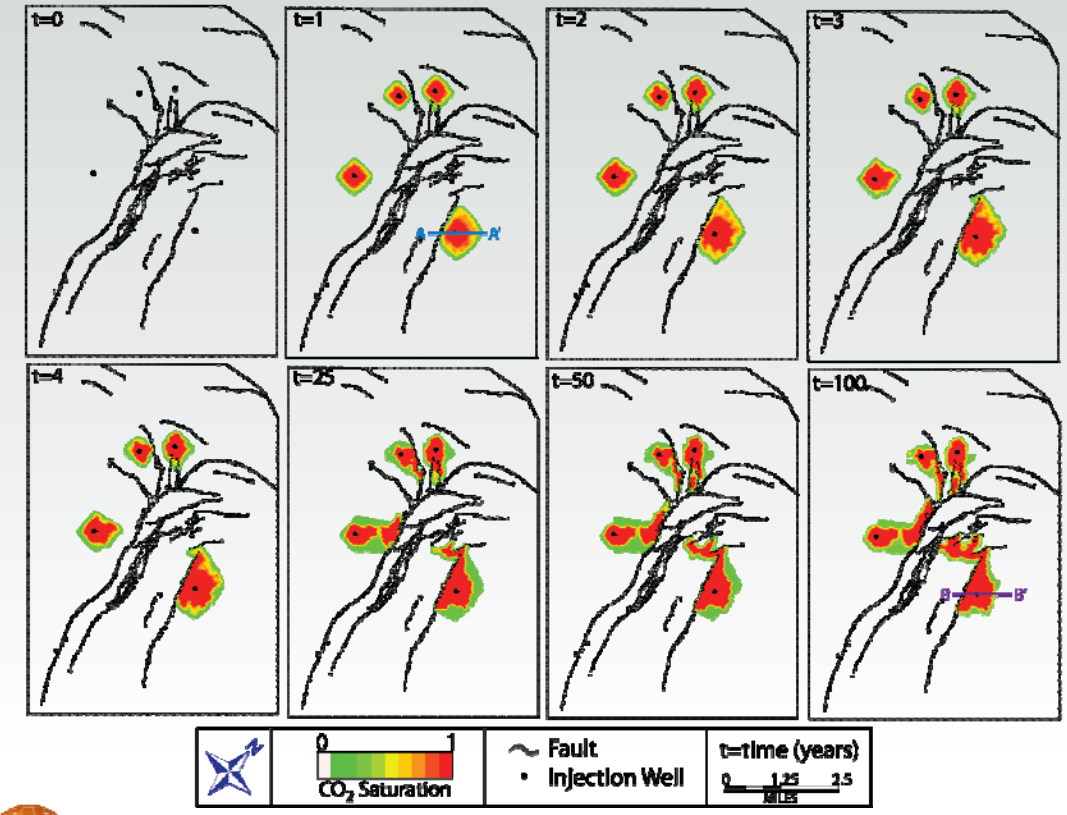

Table 7.2. Cumulative injection results for 27 model cases of dynamic 3D flow model

3D Flow Model Injected-Mass Results (Mt)			
	Homogeneous	Statistic-Based Heterogeneous	Seismically Derived Heterogeneous
Base case	5.4	5.3	4.5
High-quality reservoir	6.9	6.8	5.7
Low-quality reservoir	3.7	3.5	3.1
Open boundaries	*116.2*	*114.4*	*64.0*
Open faults	5.6	5.3	4.6
1 well	6.0	5.7	5.0
15 wells	5.4	5.2	4.8
Optimized array	5.4	5.3	4.9
Constant-rate injection	4.8	5.1	4.5

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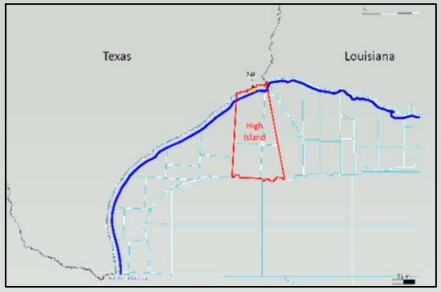
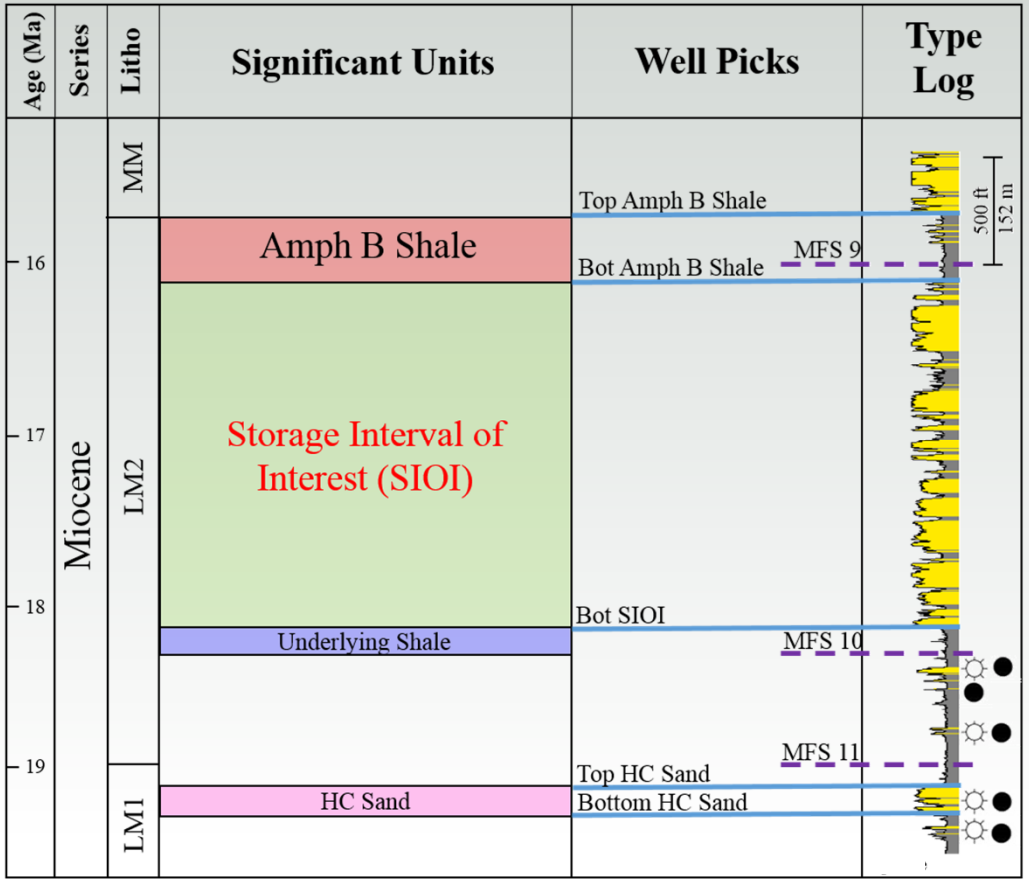
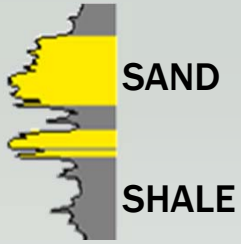
CCS Perspectives Benefit from Knowing Petroleum History



High Island 24-L Field
~10% of all oil and gas from Texas state waters





MFS 9-10 Interval

- 1720' total thickness
- 1066' net sand
  - 62%
  - Average of 37 SP curves
- No productive intervals

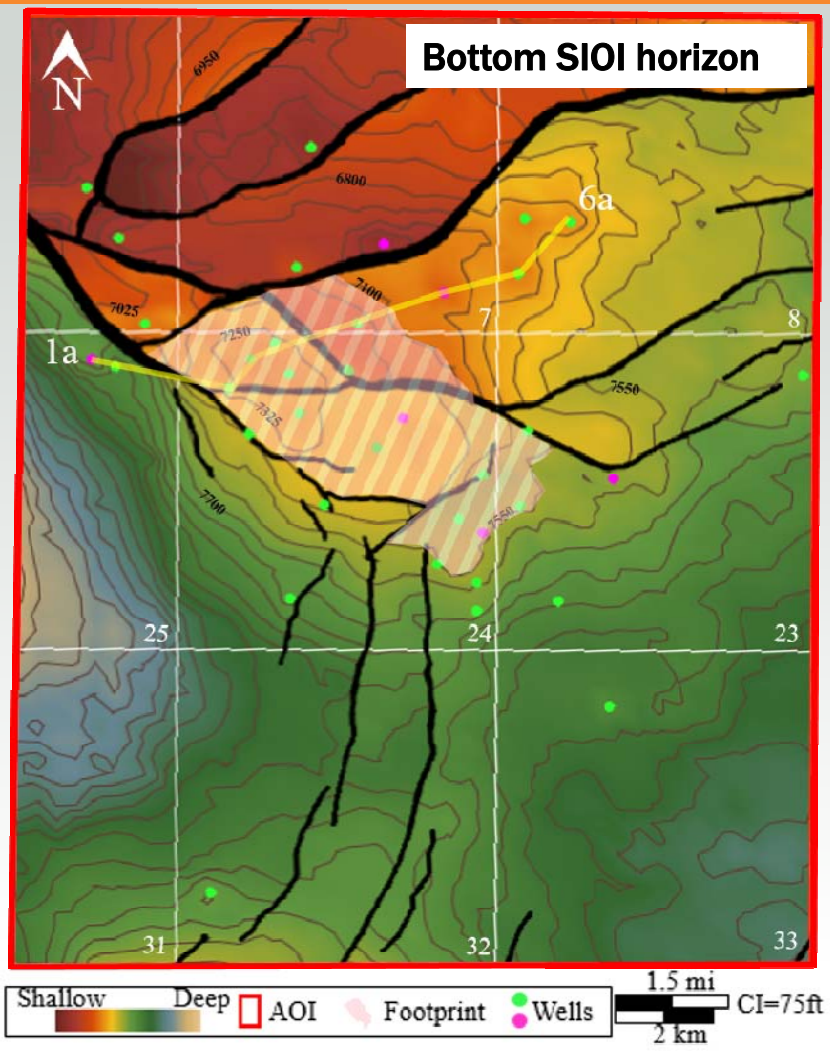
Below MFS 10

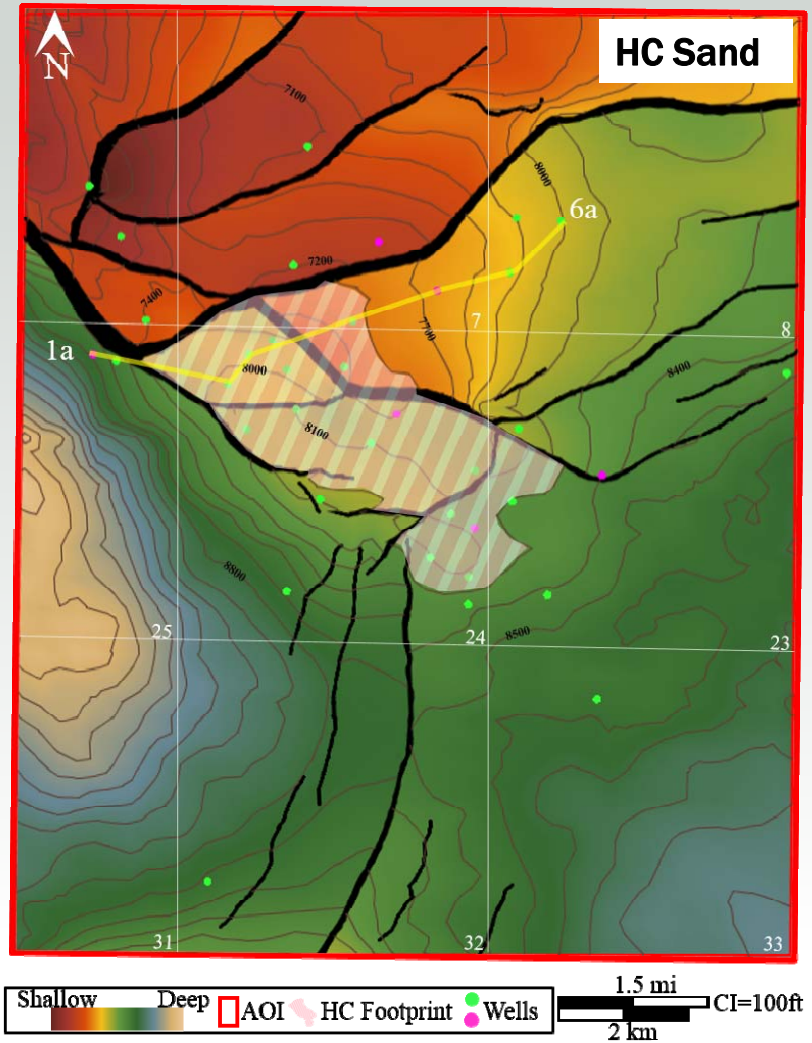
~0.5 Tcf Gas

- 3625 ft total thick package
- 525 ft net sand (15%)
- 225 ft charged sand (43% of net sand)
- HC Sand most productive

MFS = Interpreted Maximum Flooding Surface Horizon (Galloway et al., 1989)

High Island 24-L Field – Southeast Texas





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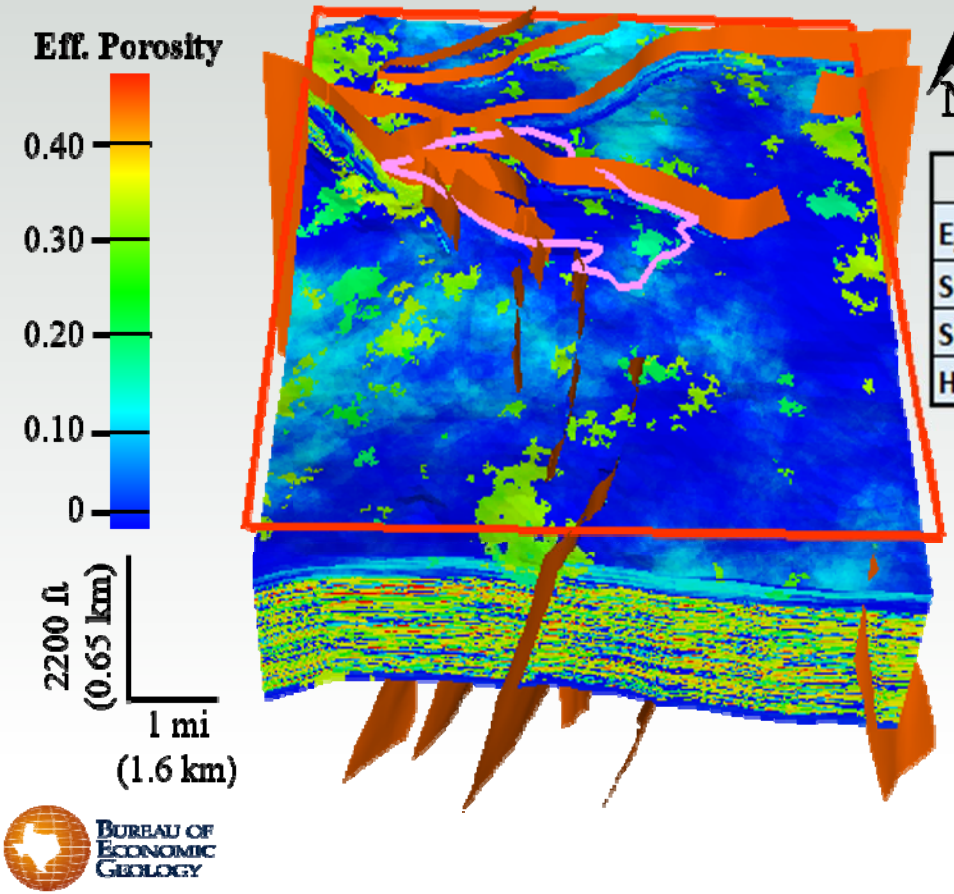
RESERVOIR PERFORMANCE

Approximately 12 Mt in 200’ sand, maybe 100 Mt in thickest intervals



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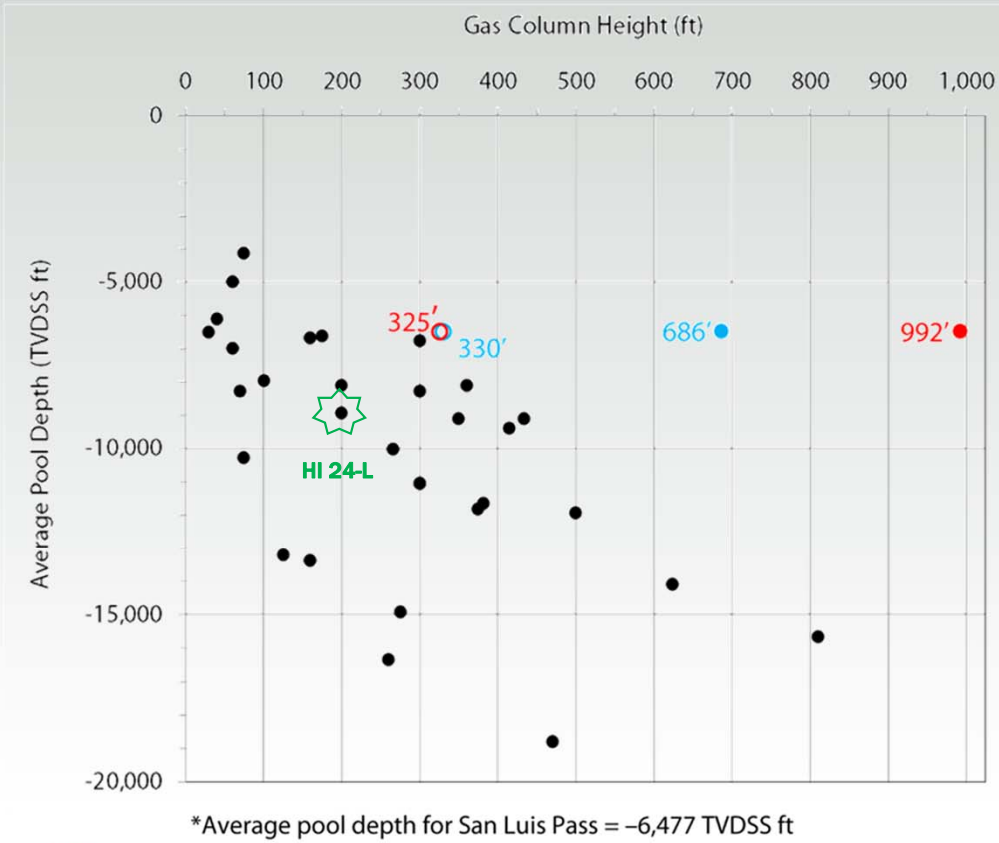
STATIC VOLUMETRIC CALCULATIONS

	P10	P50	P90
$E_{saline} = E_v E_d$	7.4%	14%	24%
SIOI: NETL CO2 Screen (Mt)	63	120	206
SIOI: 3-D Eff. Porosity Model (Mt)	57	108	185
HC Sand: 3-D Constant Avg. Eff. Porosity Model (Mt)	6	12	20

Geologic geocellular effective porosity model used for calculating CO_2 storage capacity in the SIOI. The AOI is outlined in red, SIOI structural footprint in pink, and faults are in orange.

Caveat: Fault Seal Capacity

Estimated Gas Column Heights for the Fault A Structure vs. Regional Data from Seni *et al.*, 1997



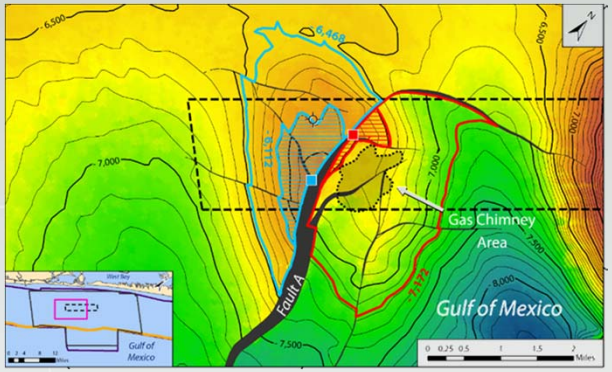
*Average pool depth for San Luis Pass = –6,477 TVDSS ft

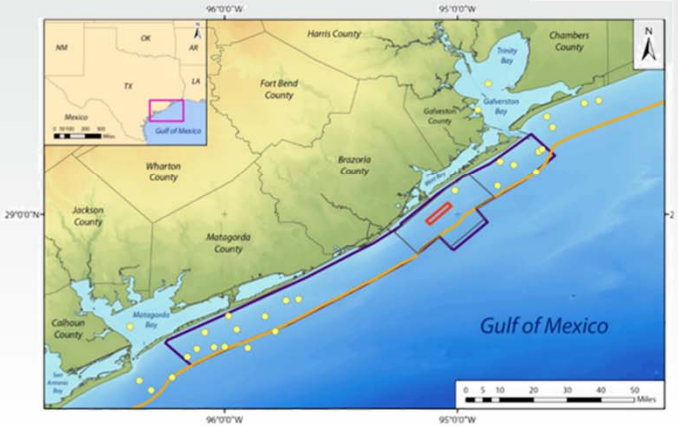
Key to Chart Symbols

- Seni et al., 1997
- Fill-to-Spill: FW
- Fill-to-Spill: HW
- Fault Seal Membrane: FW
- Fault Seal Membrane: HW

Key to Map Symbols

- Accumulation Data Locations from Seni *et al.*, 1997





J. Osmond MS Thesis
UT-Austin, 2016

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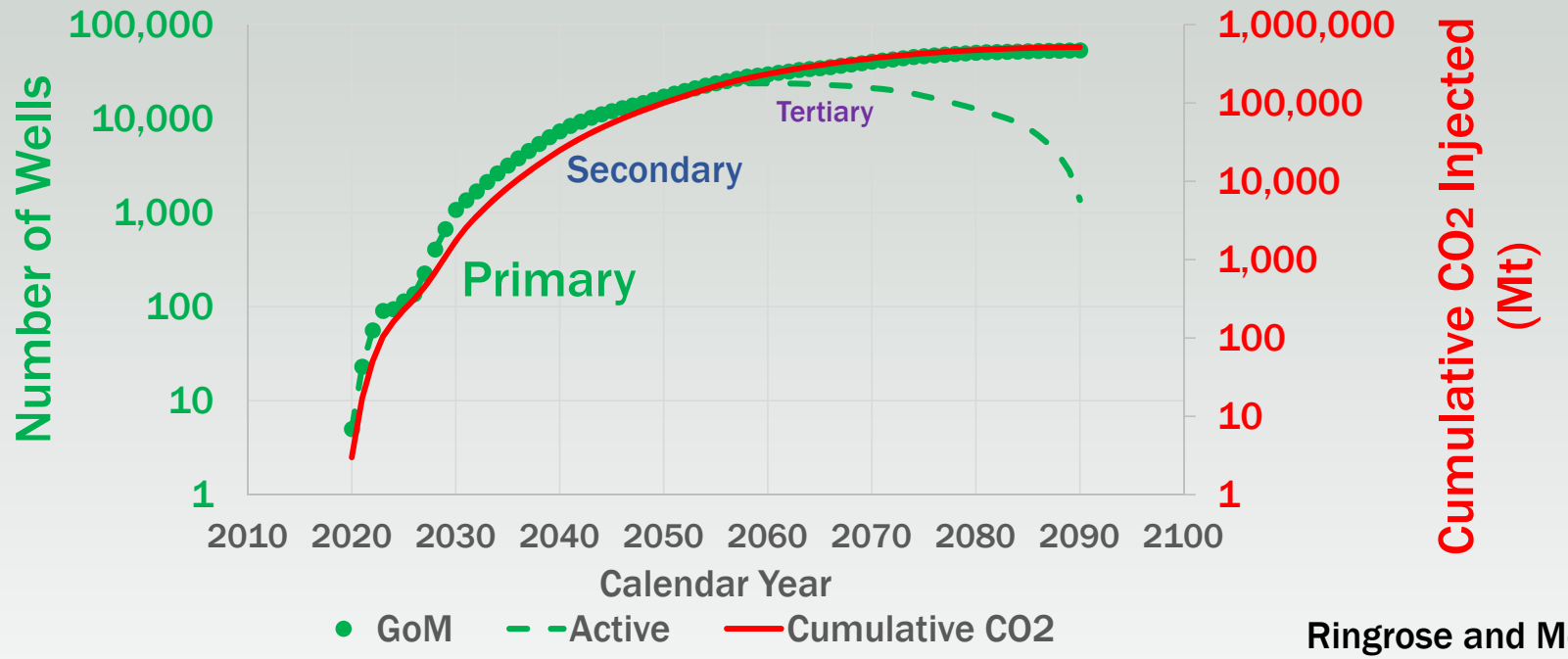
Gulf of Mexico – CO_2 well development scenario

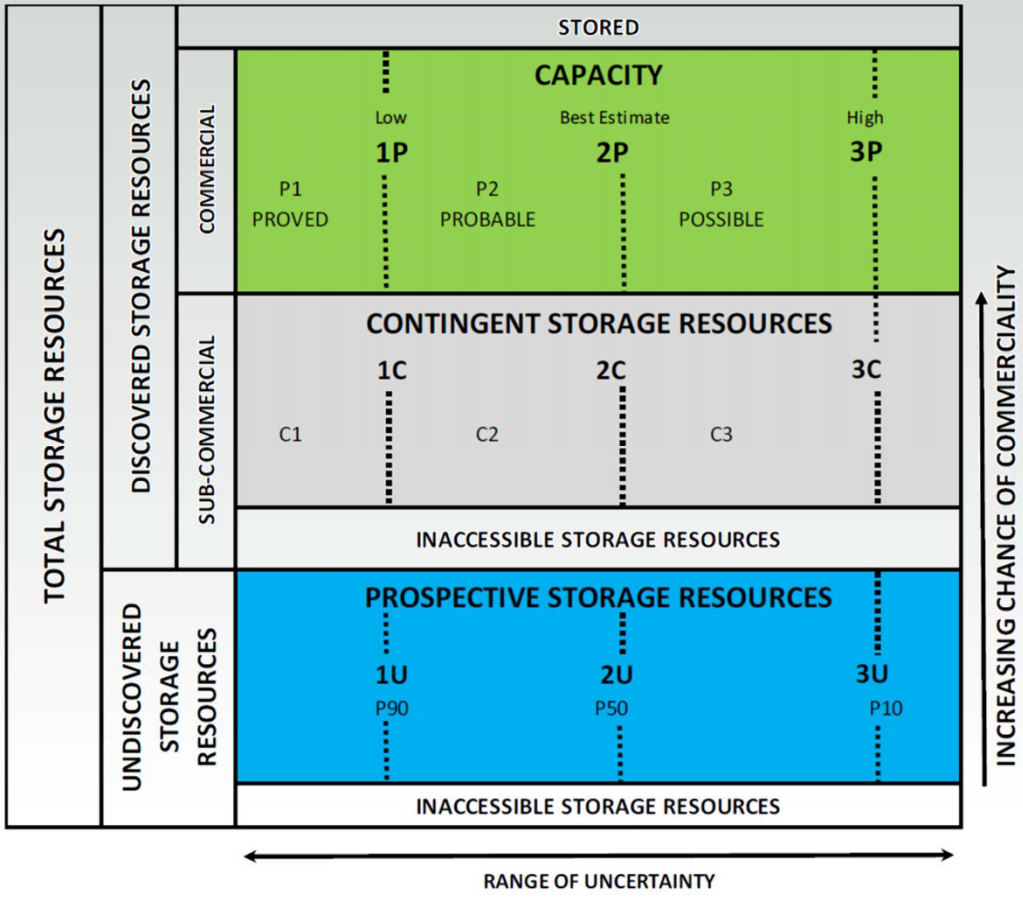


Ringrose and Meckel, in review

2020+ SCENARIO	Avg. Well Inj. Rate Mt/yr	Number of active wells in 2050	Incremental Rate in 2050 Mt/yr	Cumulative Mass in 2050 Mt CO2	Comment
GoM	0.6	17,175	10,305	99,946	Unlikely one region will develop this aggressively; Incremental goal exceeded; Close to cumulative goal
GoM	0.41	17,175	7,000	67,891	Injection rate low, not cost effective; Cumulative goal not met

SPE Storage Resources Management System (SRMS)

- Uniformity, clarity, familiarity
- Bookable storage
- Similar to PRMS
  - SRMS exists
  - https://www.spe.org/industry/CO2-storage-resources-management-system.php
  - Guidelines currently being drafted
  - Training workshops to come.



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SUMMARY

- The global offshore continental margins represent the best near-term opportunity for Gigatonne-scale CCS.
  - Gulf of Mexico is ideal geologically and geographically.
  - Research need: understand impact of Gt-scale pressure perturbation, fault performance.

- We have all the geologic/engineering tools we need to be successful with large-scale CCS deployment.
  - CC(U)S perspectives benefit from knowing your petroleum history: capacity, seal, reservoir performance, well development.

- CCS can deliver needed scales on needed time frames.

- CO_2 storage can be a bookable resource for reassuring investors and evaluating project economics.

Acknowledgements / Thank You / Questions

We gratefully acknowledge:

- **Seismic Exchange, Inc.**, for access to regional 3D seismic data.
- **Halliburton** for integrated Decionspace Desktop software license.

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