Gulf of Mexico Miocene CO2 site characterization mega transect DE-FE0001941

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Capacity; Characterization; Field study; Modeling-Flow simulation; Overview; Regional study-Gulf Coast; Site selection

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Gulf of Mexico Miocene CO_2 Site Characterization Mega Transect

DE-FE0001941

Ramon Trevino

Texas Bureau of Economic Geology

U.S. Department of Energy
National Energy Technology Laboratory
Carbon Storage R&D Project Review Meeting
Developing the Technologies and
Infrastructure for CCS
August 20-22, 2013

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The University of Texas at Austin
John A. & Katherine G. Jackson School of Geosciences

Gulf Coast Carbon Center

Presentation Outline

- Project Overview & Past Accomplishments
- Regional Static Capacity
- Model Area
  - Simple Dynamic Analytical Model
  - Flow Simulation Model Runs
- Hi-Res 3D Seismic (HR3D)
- CO_2 "Plays" Atlas
- Summary & Acknowledgments

Benefit to the Program

Program goals addressed

Develop technologies that:

1. Predict CO_2 storage capacity within ±30%
2. Demonstrate 99% containment

Benefits Statement –

The research will develop 1) an atlas of existing traps (e.g., hydrocarbon fields) and regional data (e.g., existing well data, formation properties, etc.), 2) a best practices manual. The resulting data and techniques will help industry identify and evaluate future sequestration sites. In addition the study is using a new, high-resolution 3D (HR3D) seismic acquisition system to image the shallow geologic section and identify natural leakage pathways (i.e., areas to avoid), which contributes to programmatic goals 1 and 2 (above).

Project Overview:
Goals and Objectives

Study Goal – characterize regional Miocene-age geologic section ("formations") of Texas State Waters.

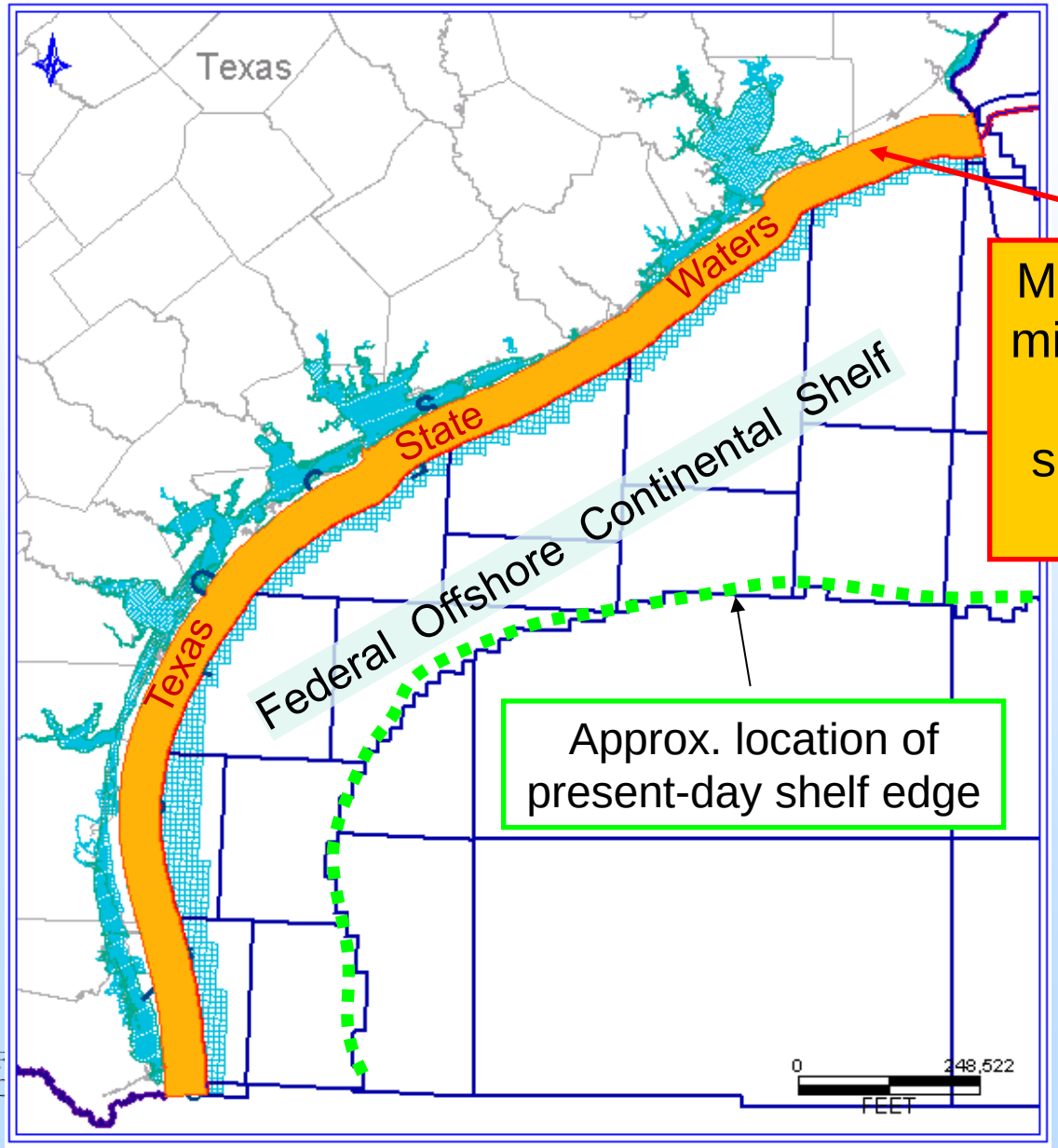
Objectives:

1. Assess & analyze existing energy industry data

2. Verify Miocene strata's ability to safely and permanently store large amounts of anthropogenic CO_2.

3. Identify at least one specific site (capacity ≥ 30 MT CO_2) for future commercial CCS operations.

Study Area



Main focus on 10-mile wide swath of inner shelf seaward of main shoreline

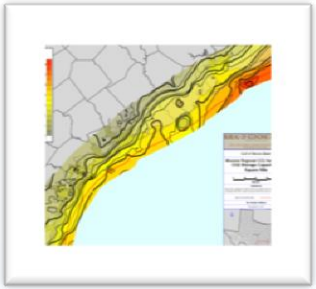
Project Overview:
Goals and Objectives

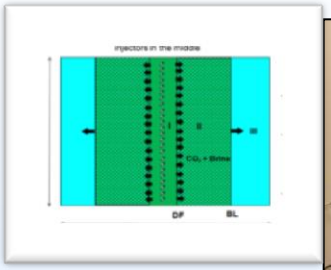
Success Criteria

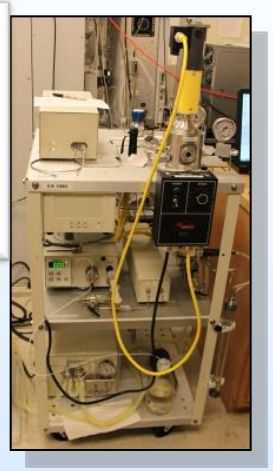
- ✓Minimum necessary data *is* available
- ✓ Identify one or more specific sites
  - Meet / exceed capacity cutoff
  - ✓Complete geologic model(s)
  - ✓Complete flow simulation model(s)

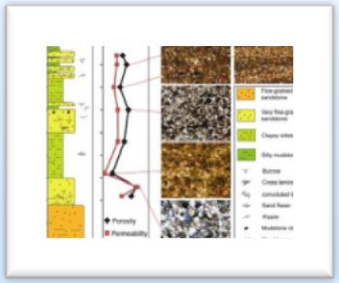
Project Research Scope

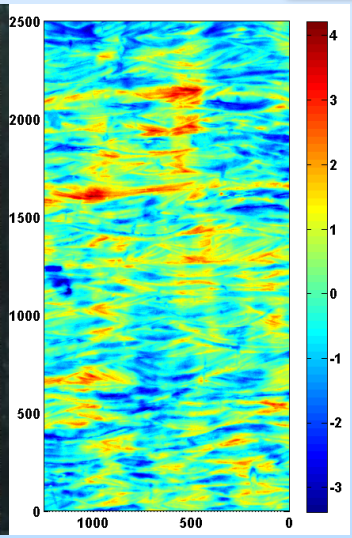
- Static capacity calculations
- Dynamic capacity calculations
  - Analytical & geocellular modeling
- Geochemistry
- Mudrock sealing capacity
- Fluid migration
- Fault seal
- Hi-Res
  digital model
- HR3D
  Seismic

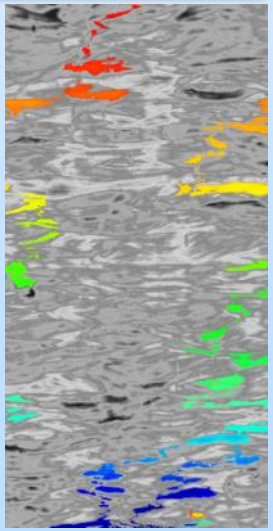


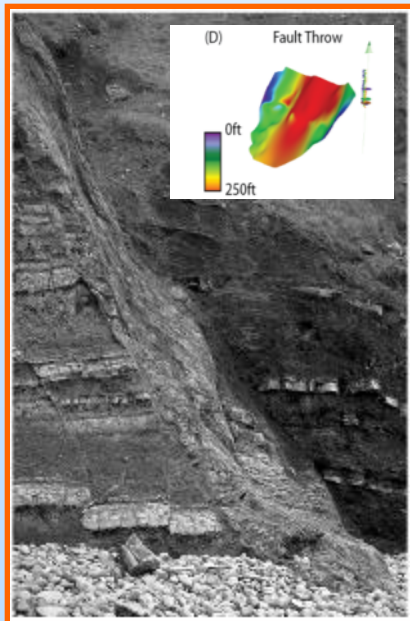












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Accomplishments to Date

- Static regional capacity estimated for Texas State water
- Static regional capacity tested in small portion of study area by:
  - Simple Dynamic Analytical Model
  - 3D flow simulation
- 1st Hi-Resolution 3D (HR3D) Dataset acquired
  - Initial processing complete
  - Re-processing almost complete
  - Field test (land) conducted to verify positional accuracy
- Atlas (draft)

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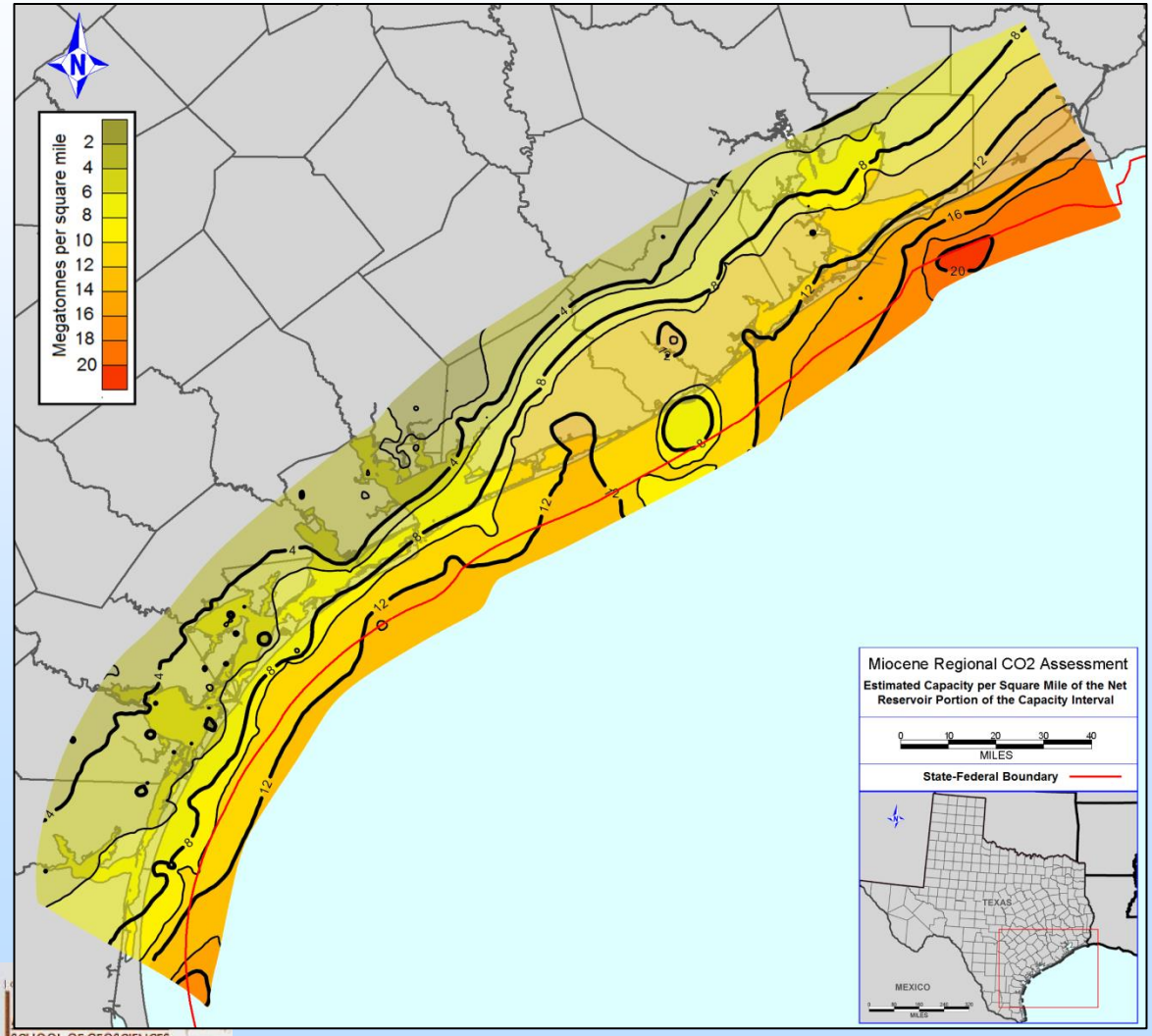
Static Storage Capacity Per Sq. Mile

$$G_{CO_2 net} = A_t \, h_{net} \, \varphi_{tot} \, \rho E_{net}$$

Total Net Storage Capacity = **129 GT**

(**86 GT** in study area)



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(Wallace, et al. *in review*)

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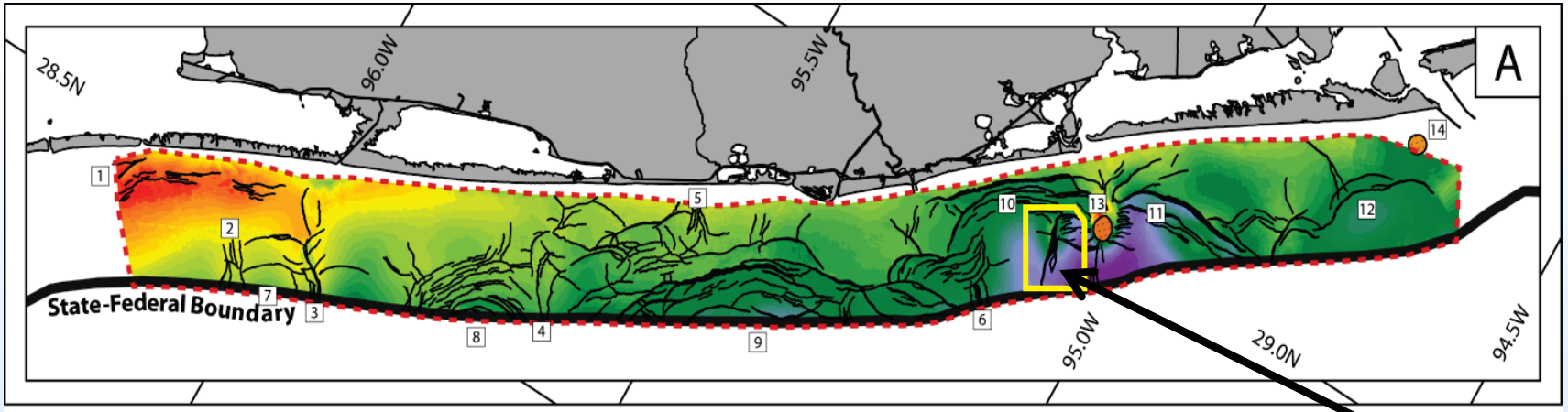
Simple Dynamic Analytical Model



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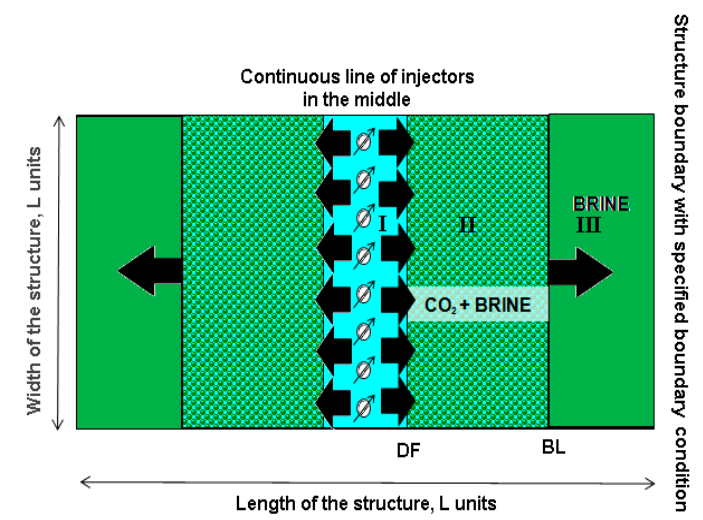
Simple Dynamic Analytical Model, Jain and Bryant (2011)

Summary of Simple Dynamic Analytical Model Inputs			
Parameter	**Property**	**Value**	**Source**
S_{wirr}	Irreducible Water Saturation	10-78%	6,206 Miocene reservoirs
Φ	Porosity	0.12-0.37	6,206 Miocene reservoirs
T	Temperature	135.6° F (57.6° C)	11 log headers in DRMA
P	Pressure	2,105 psi (14.5 Mpa)	Hydrostatic gradient
Z	Depth	4,828 feet (1,472 meters)	Seismic mapping
κ	Permeability	0.08-3686 mD (7.9×10^{-17} -3.6×10^{-12} m^2)	6,206 Miocene reservoirs
h	Thickness	99.5 feet (30.3 meters)	Seismic mapping
A	Area	4742 acres (19.2 km^2)	Closure analysis
μ_w	Water Viscosity	0.8177 cP (0.8177 mPa·s)	CREWES calculator
μ_g	Gas Viscosity	0.0467 cP (0.0467 mPa·s)	NIST calculator
k	Salinity	190,000 ppm	ILD and DT (well A)
n	Corey exponent (gas)	2.6	Inter-comparison project
m	Corey exponent (water)	10	Inter-comparison project
K^o_{rg}	End point gas saturation	1	Inter-comparison project
P_l	Pressure limit	3,527 psi (24.3 Mpa)	80% of lithostatic pressure
ρ	CO_2 density	.792 g/cc	NIST calculator



Model Assumptions

- Properties Homogeneous
- Structure not considered, BUT *model inputs require accurate depth-structure map*

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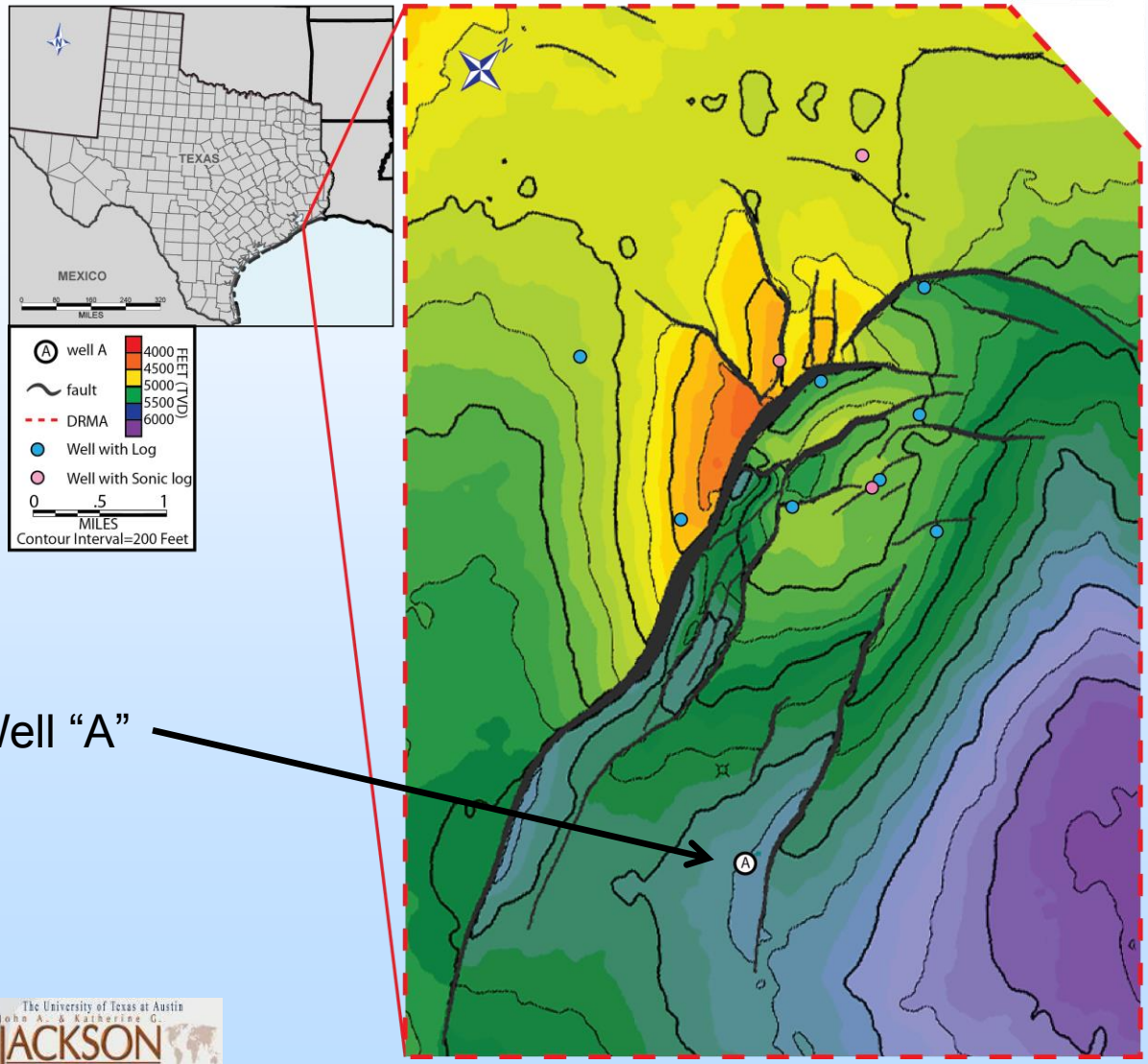
Simple Dynamic Analytical Model
Modeled Area



Note Well “A”

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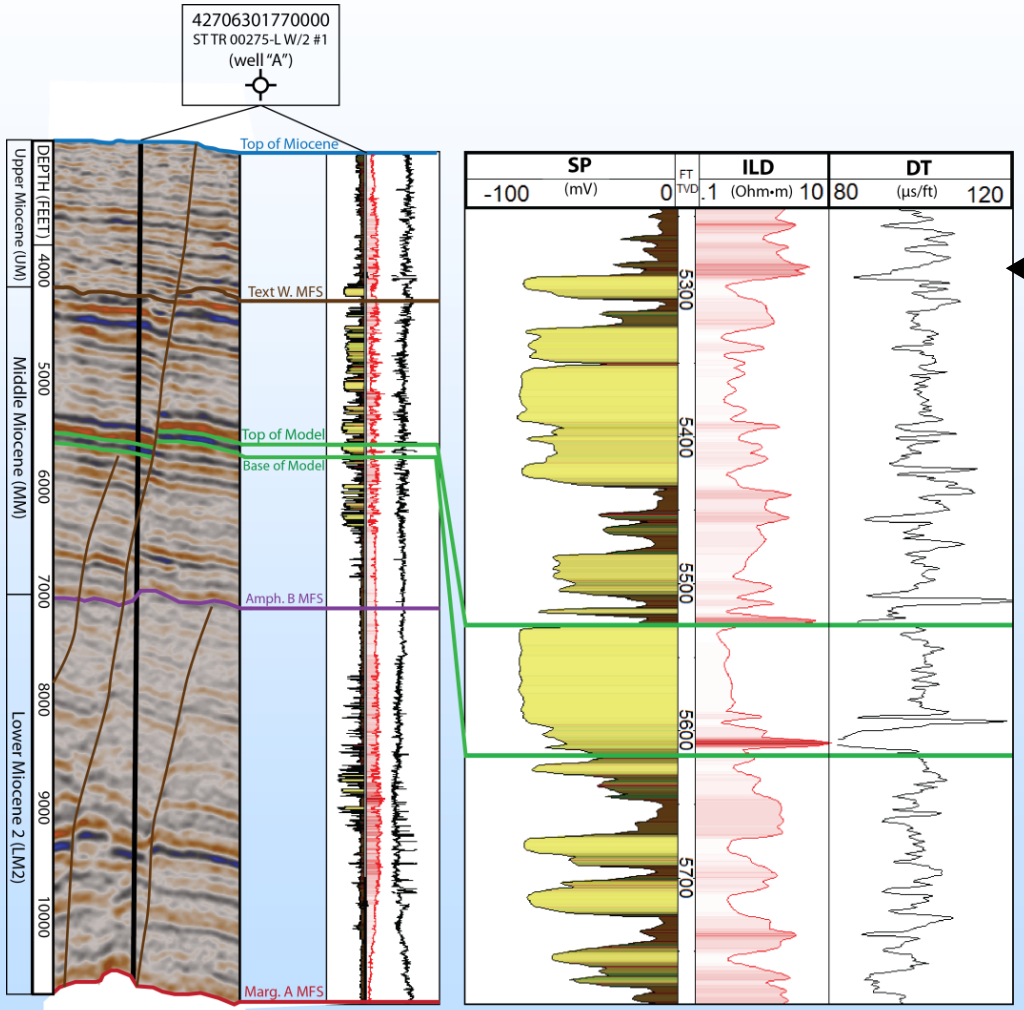
Simple Dynamic Analytical Model "Well A"

Seismic Column and corresponding Well Log



Φ Derived from DT

Reservoir Interval

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

Simple Dynamic Analytical Model Results

6,206 samples of:

φ, κ, and S_{wirr}

Only conditions

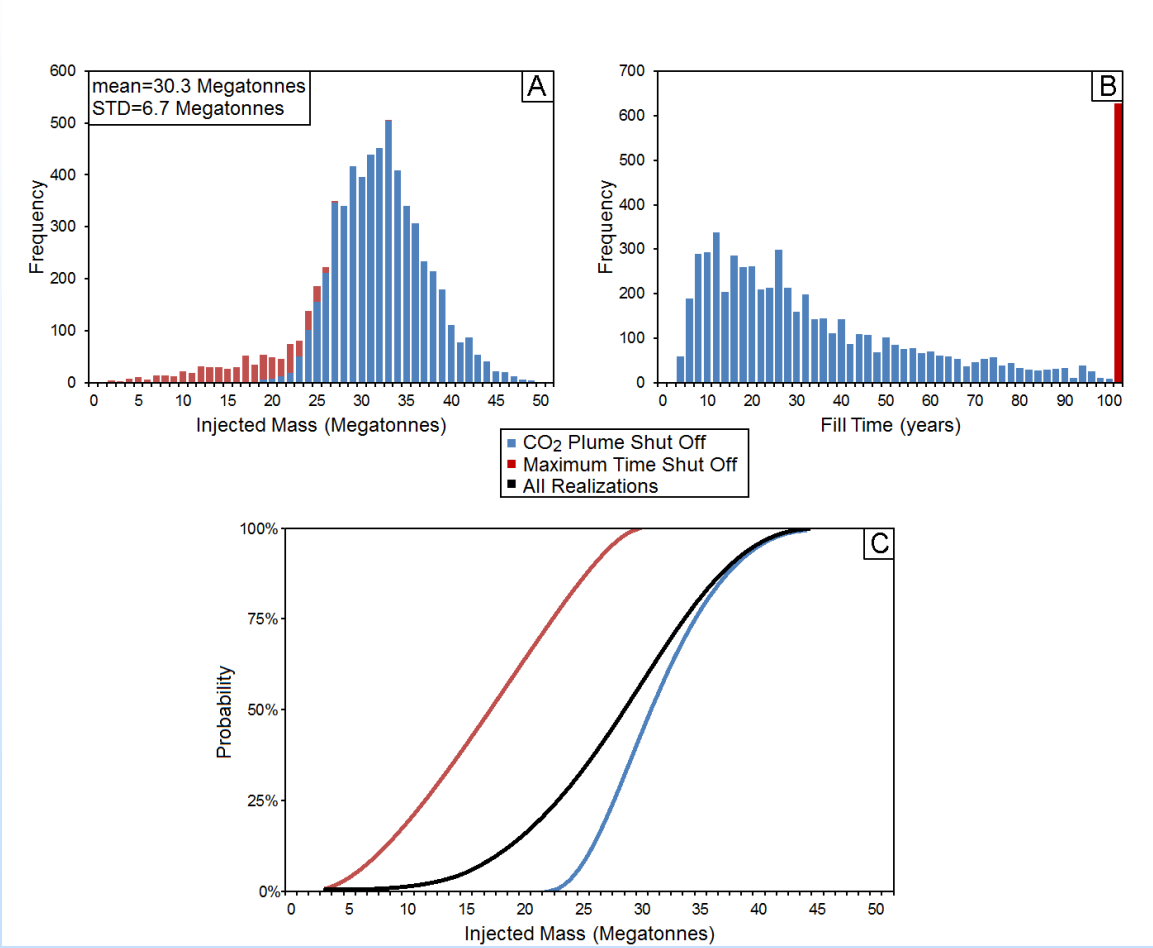
1 (***plume shutoff***) and

3 (***time shutoff***) are met.

Condition 2 (***pressure limit***) not reached.

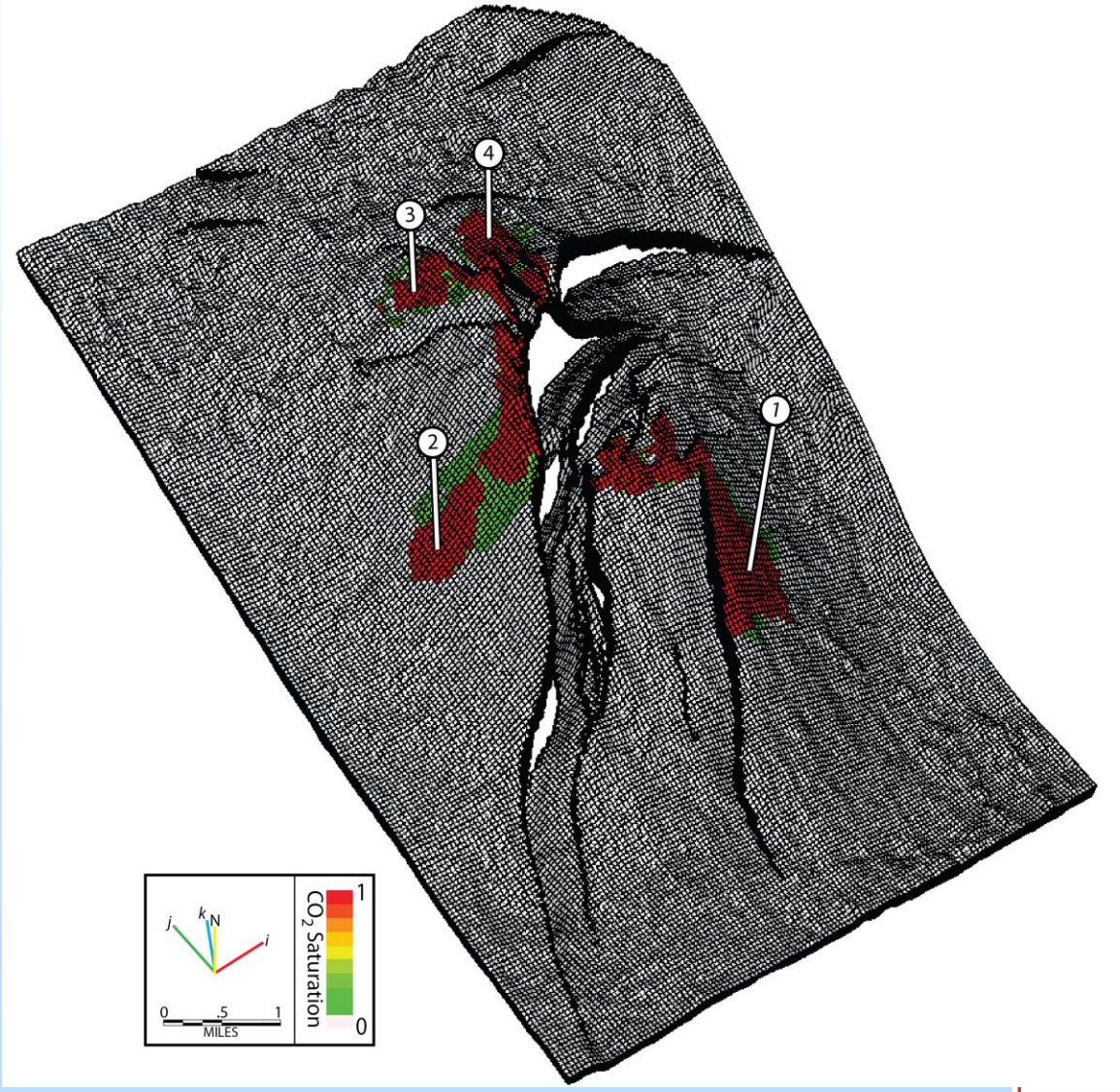
Avg. capacity = 30.3 MT

Avg. fill-time = 38.3 years



3D Dynamic Fluid Flow Simulation Homogeneous Base Case

- 27 model cases
- 9 each of 3 scenarios
  - Homogeneous (shown here)
  - Statistical Heterogeneous
  - Seismic-based Heterogeneous

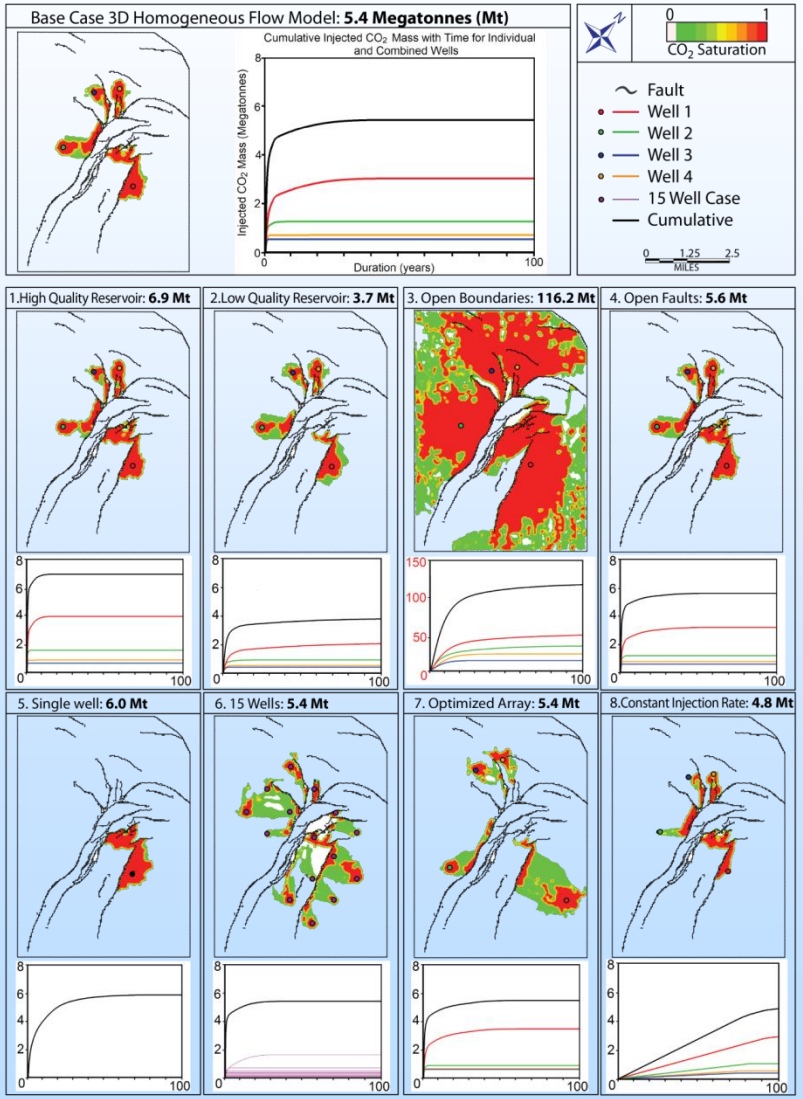


Homogeneous 3D Flow Model Scenario

- Cases 1-8 final plume geometries

Open boundaries effect (case #3) ***by far*** the most significant variable parameter

(Note scale change in case #3)



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Fluid System Analysis Strategy using HR3D

- DOE goal to find secure 30 Mt CO_2 storage site(s)
  - Collect data to reduce barriers to near-term commercial utilization
  - Map storage geometries: compartmentalization.
  - ***Characterize traps and seals***

HR3D insight:
Shallow interval
Poor conventional coverage

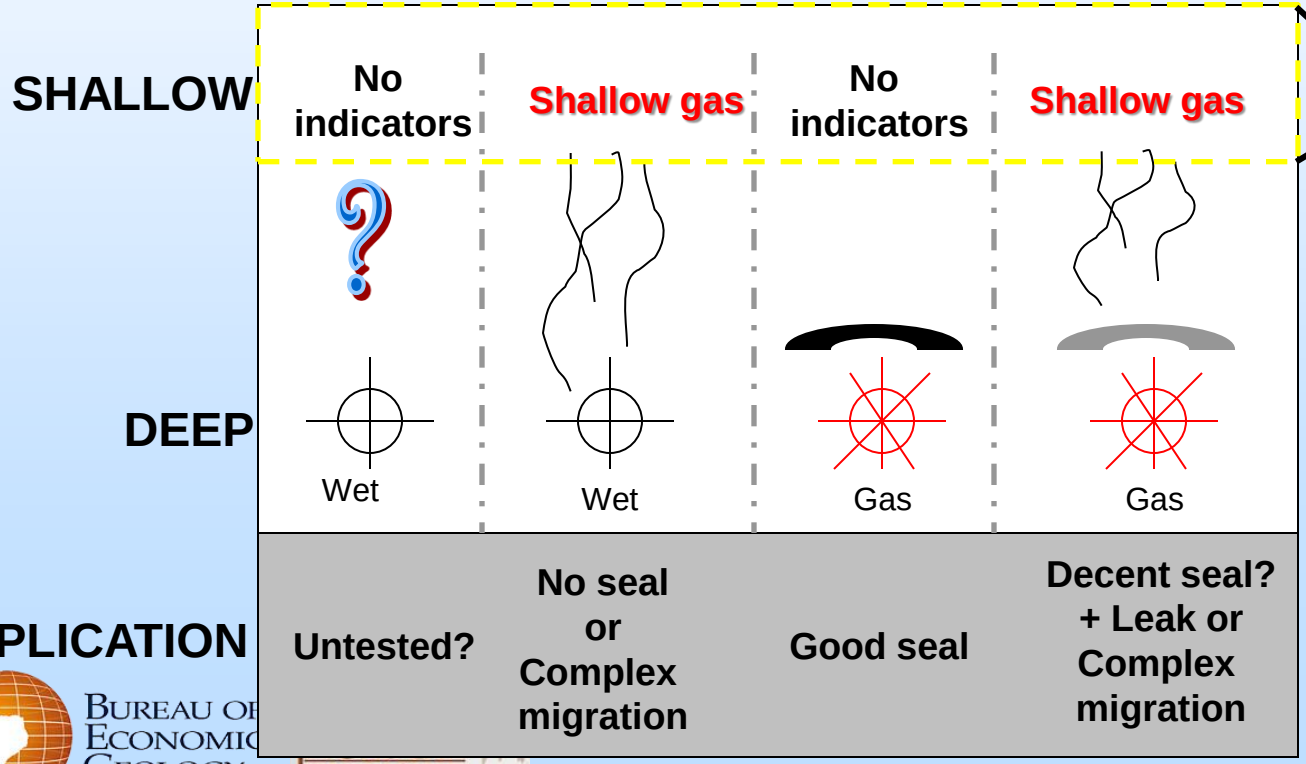

Figure omitted due to proprietary nature of the data presented.

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Hi-Res 3D (HR3D) Seismic

- 1st P-Cable HR3D Survey
  - Dataset Successfully Acquired
  - Initial processing challenges
  - Field testing resolved issues related to receiver position accuracy
  - Re-processing almost complete

Conventional 3D

$$= \left(\frac{1}{25\ hz} * 1500\ m/s\right)/4$$

$= 15\ meters$

$Vertical\ Resolution$

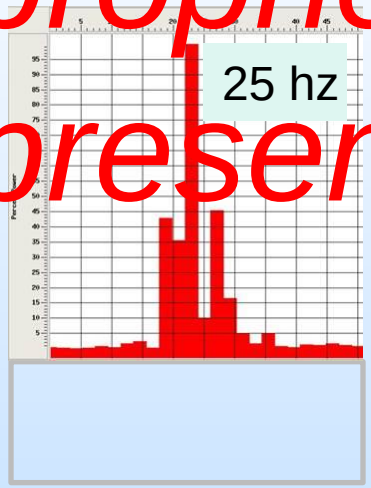
$$= \left(\frac{1}{f} * V\right)/4$$

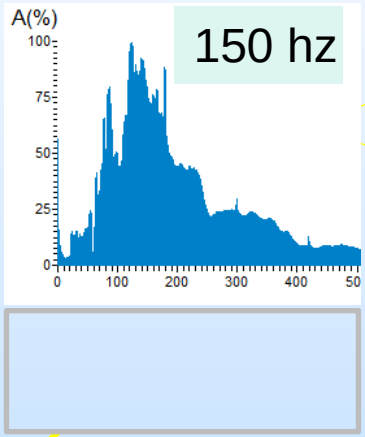
HR3D - PCable

$$= \left(\frac{1}{150\ hz} * 1500\ m/s\right)/4$$

$= 2.5\ meters$

Figure omitted due to proprietary nature of the data presented.





1500 ms ~ 2250 meters depth

Geotripper Images

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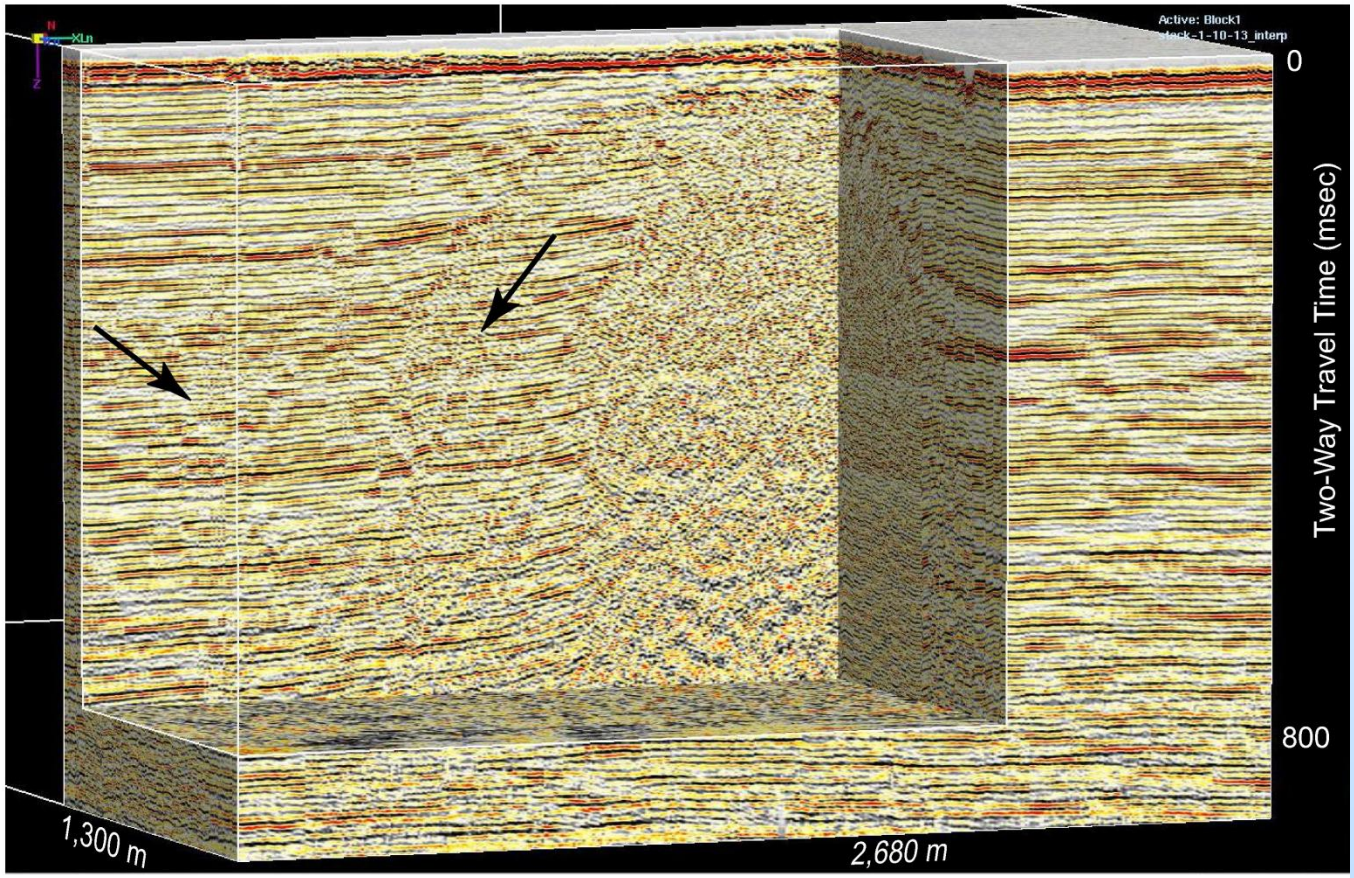
Challenges – Initial Processing

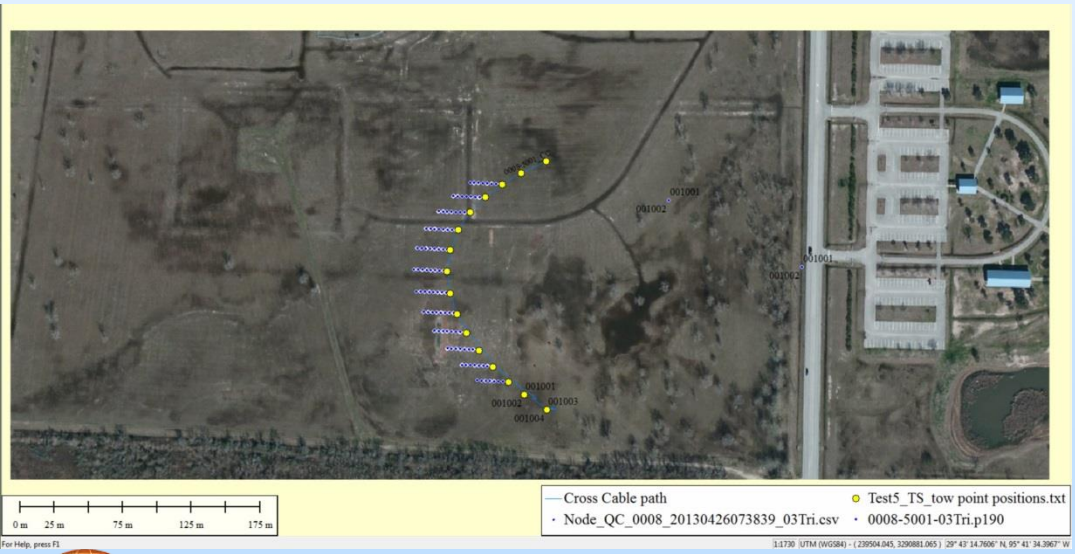


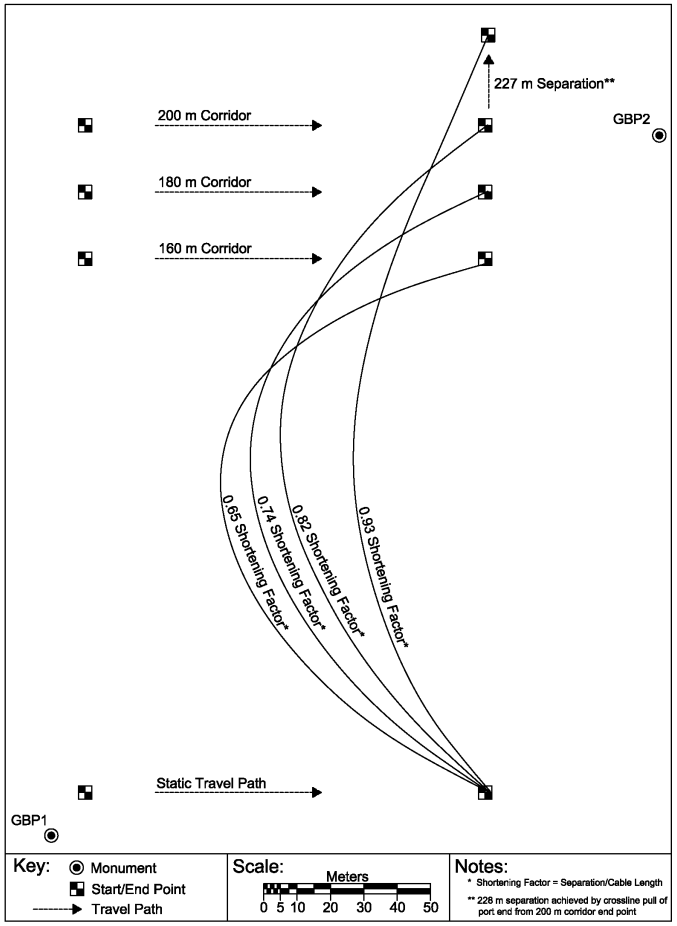
Hi-Res 3D (HR3D) Seismic

- 1st P-Cable HR3D Survey
  - Dataset Successfully Acquired
  - Initial processing challenges
  - Field testing resolved issues
  - Re-processing almost complete

Static Field Test: Compare Calculated Receiver Positions with known (surveyed) positions

1. Software solution (receiver positions) – Robust, and sensitive to:
   - Cross-cable GPS's location distance to 1st junction box and tow point
2. Offsets used for initial processing were less than they should have been.





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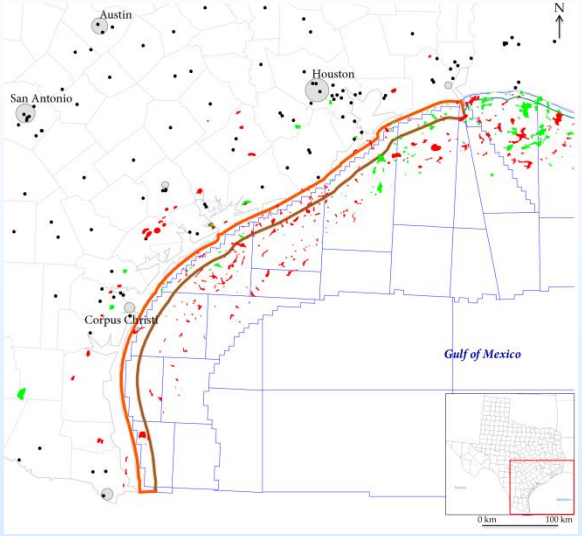
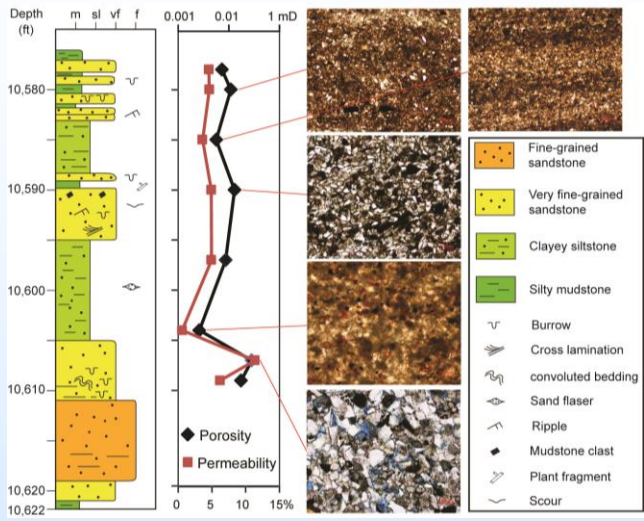
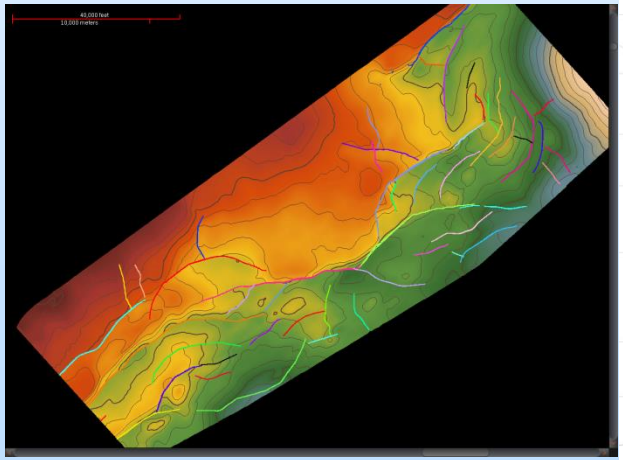
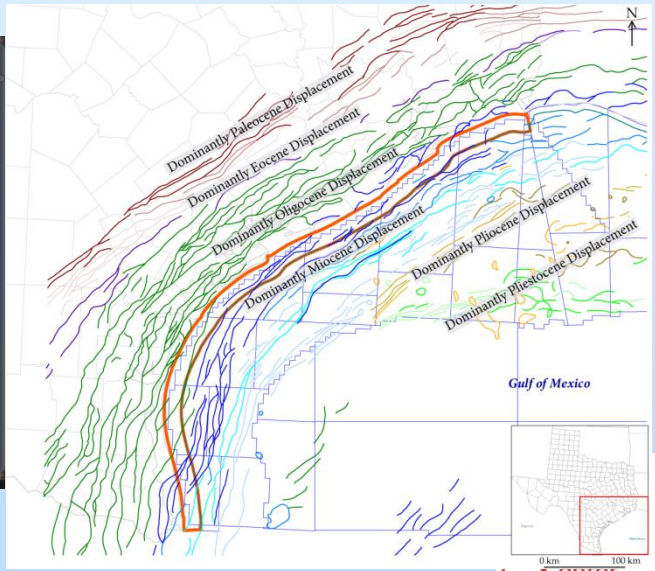
CO_2 Atlas First Draft – Nearing Completion (Focus of Poster)

- Regional geology & petroleum systems (CO_2 analog)
- Confining system overview
- Regional capacity estimate
- CO_2 "plays" prospective storage sites









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Summary

Key Findings

- Estimated Regional Static Capacity per sq. mile probably over-estimates actual storage potential
- Miocene top seals able to trap CO_2
- CO_2 backfilling preferable alternative to capillary flow fingering
- Geochemical experiments' results as expected

Summary

Lessons Learned

- Calculated receiver positions sensitive to cross-cable GPS's location (distance to 1st junction box and tow point)
- P-Cable seismic acquisition cruises logistically complicated but achievable, data-rich and worthwhile

Summary

Future Plans

- 2 more P-Cable surveys
  - Establish subcontract with marine vessel / science partner organization
    - Test different pneumatic sources
  - Test calculated receiver positions / improve processed dataset result
- Publish 2-5 peer-reviewed articles
- Publish atlas
- Characterization best practices manual
- Final report

Acknowledgments

- Landmark Graphics (a Halliburton Co.)
  - University grant program
  - Full suite of geoscience interpretation software
- IHS Petra geoscience interpretation software
- Project PI, Dr. Tip Meckel
- Sandia Tech, LLC

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