Partnership Overview

• Funding
  – DOE: $14 million (5 years)
  – Cost Share: $3.5 million

• Overall Project Performance Dates
  – BP 1 (4/1/2018 → 12/31/20)
  – BP 2 1/1/21 – 3/31/23

• Partnership Objectives
  – Develop / validate technologies & best practices
    • Ensure safe, long-term, economically-viable offshore carbon storage
<table>
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<tr>
<th>Institution</th>
<th>Location</th>
<th>Expertise</th>
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<td><strong>University of Texas at Austin</strong></td>
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<td>Project Lead</td>
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<td><strong>Gulf Coast Carbon Center</strong></td>
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<td>Geo-Sequestration</td>
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<td>GoM Basin Regional Geology</td>
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<td>Subsea Infrastructure</td>
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<td><strong>Fugro</strong></td>
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<td>Beaumont, TX</td>
<td>Risk Assessment; Outreach</td>
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<td><strong>Trimeric</strong></td>
<td>Buda, TX</td>
<td>Engineering; Infrastructure &amp; Operations</td>
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<td><strong>USGS</strong></td>
<td>Reston, VA</td>
<td>Characterization &amp; Capacity Assessment</td>
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<td>Database Development</td>
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<td>Ocean &amp; Environmental Science</td>
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<td><strong>LBNL (&amp; Rice University)</strong></td>
<td>Berkeley, CA (Houston, TX)</td>
<td>Risk Assessment; MVA Technologies</td>
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<td><strong>LLNL</strong></td>
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<td>Risk Assessment</td>
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Overview
Progress and Current Status

• Injecting off-structure viable strategy
• CO$_2$ marine water dissolution & sea surface dispersion
• Offshore TX & LA coasts very viable
• Infrastructure re-use potential
• Critical pressure offshore vs onshore
Overview

Progress and Current Status

• Injecting off-structure viable strategy
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Siting within compartments: Fetch and Trap

- Structural highs = “traps” for buoyant fluids
  - May develop column height of mobile fluids
  - Exploration and production wells
  - May be faulted
  - May have sand pinch out
- “Fetch”
  - In synclinal areas
  - No expectation of hydrocarbons, few penetrations
  - CO₂ will migrate and be trapped by capillary processes
  - May accumulate thick sands
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Seawater - CO$_2$ Dissolution

Offshore CO$_2$ blowouts different from onshore

Strong water column effects

Curt Oldenburg, Lehua Pan and Yingqi Zhang
Seawater - $\text{CO}_2$ Dissolution

Curt Oldenburg, Lehua Pan and Yingqi Zhang
Results: Downwind Dispersion Length (DDL) varies with depth and windspeed

- Source term for the MSLR is the output from TAMOC (i.e., flow rate of CO₂ out of sea surface).
- Ran the MSLR for the different water depths and wind speeds.
- Results show downwind dispersion length (DDL) is max @ ~400 m (5 m/s; 10 m water depth).
- Deeper systems: DDL = 100 m (or less).
Gas doesn't move much = short downwind safety distance

Gas moves but disperses safety distance longer up to a point ...
Higher wind = shorter

Why the reversal in trend at low windspeed?

Tradeoff between wind transporting CO₂ & wind dispersing/diluting CO₂
Results

CO₂ leakage strongly controlled by dissolution water column

- Above sea surface, plume dispersed by dense gas flow & wind
- DownwindDispersion Length (≈radius of safety exclusion zone)
  1. Several 100s meters shallow-water
  2. Deep-water = less DDL
For more details


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Wells Targeting Miocene Reservoirs

Alex Bump, Gillian Apps, Frank Peel
Wells Targeting Miocene Reservoirs

Seismic interpretation courtesy of Mike DeAngelo; Well data: IHS Enerdeq, 2022

Alex Bump, Gillian Apps, Frank Peel
Miocene Dry Holes

Seismic interpretation courtesy of Mike DeAngelo; Well data: IHS Enerdeq, 2022
Miocene Dry Holes

Why did they fail?

Seismic interpretation courtesy of Mike DeAngelo; Well data: IHS Enerdeq, 2022
Upper TX / Western LA Coast

Hydrocarbon Exploration Successes / Failures

Play Elements
Upper TX / Western LA Coast

Hydrocarbon Exploration Successes / Failures

Play Elements

Charge access
- Thermal maturity
- Migration path

Source
Upper TX / Western LA Coast

Hydrocarbon Exploration Successes / Failures

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Source

immature oil mature
Upper TX / Western LA Coast

Hydrocarbon Exploration Successes / Failures

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Hydrocarbon Exploration Successes / Failures

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Source

• Immature oil
• Mature oil
Upper TX / Western LA Coast

Hydrocarbon Exploration Successes / Failures

Play Elements

Reservoir

Charge access
- Thermal maturity
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Source

Immature oil mature
Upper TX / Western LA Coast

Hydrocarbon Exploration Successes / Failures

Play Elements

Trap
Reservoir

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immature oil mature
Upper TX / Western LA Coast

Hydrocarbon Exploration Successes / Failures

Play
Elements

Confining Zone (Seal)
Trap
Reservoir

Charge access
- Thermal maturity
- Migration path

Source

immature oil mature
Upper TX / Western LA Coast

Hydrocarbon Exploration Successes / Failures

Play Elements

Confining Zone (Seal)
Trap
Reservoir

Charge access
• Thermal maturity
• Migration path

Source

Oil mature
Immature oil
Upper TX / Western LA Coast

Hydrocarbon Exploration Successes / Failures

Play Elements

Confining Zone (Seal)
Trap
Reservoir

Charge access
• Thermal maturity
• Migration path

Source

All elements need to work to create a producible hydrocarbon accumulation
Early (Oligocene) thrustcut terrane cut by later (Miocene) extension

Play Elements

Confining Zone (Seal)
Trap
Reservoir

Charge access
- Thermal maturity
- Migration path

Source

All elements need to work to create a producible hydrocarbon accumulation
Oligocene Focus
Miocene dry holes

Circles show defocused charge

Well data: IHS Enerdeq, 2022
Dry Holes w/Valid Trap but No Charge Focus
Implications for seal risk

For the upper Texas Coast, we can show that most of the dry holes resulted from either:
• no valid trap
• no charge

For the remaining dry holes, the locations of adjacent production wells suggest failure from either:
• missing channelized reservoirs
• drilling down-dip of a small column, most likely limited by fault seal

Elimination of the Bayesian inference (a.k.a. update) allows us to discount the dry holes in our assessment of top seal for CCS
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Texas state waters infrastructure re-use

- **Pipelines:**
  - **Scale** of pipeline re-use opportunity limited by size and pressure rating
  - Re-use vs. new is not binary
    - **Incremental Capacity:** Pair existing with new (reduce total investment)
    - **“Phased” Investment:** Start-up with existing, build-out new (flexibility)
  - Existing right-of-way, existing routes have inherent value

- **Wells:**
  - Quality of records and condition of wells represent a risk to CCS projects
  - Opportunities for re-use will be case specific, risk for leakage will be general

- **Platforms:**
  - Limited stock of “newer” platforms
  - Cost to retrofit vs. new platform is case-specific

- Engineering studies = drive specific decisions on assets
- Decommissioning “best practices” not always followed
  
  Urgency to identify assets before abandonment

---

Trimeric Corp. - Darshan Sachde, Katherine Dombrowski
Overview

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Critical Pressure Analysis
Offshore vs. Onshore

• GoM is highly prospective for CO₂ storage
  • Large point-source emissions
  • Abundant subsurface data
  • Proven reservoirs and seals
  • Potentially re-usable infrastructure

• Attraction of offshore
  • Single landowner
  • Relatively few wells
  • Relatively few competing uses
  • Relatively modern infrastructure

Data: US EPA FLIGHT database and IHS Enerdeq (2022)

Analysis by Alex Bump
Critical Pressure Analysis
Offshore vs. Onshore

• GoM is highly prospective for CO₂ storage
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Data: US EPA FLIGHT database and IHS Enerdeq (2022)

Analysis by Alex Bump
Injection at 2500m Depth

\[ \Delta P_{\text{max}} = \text{pressure increase amount before frac pressure reached} \ (>\# = \text{larger capacity}) \]
- depth below top key horizons: 1) top of rock col and 2) top of wtr col.

\[ \Delta P_{\text{crit}} = \text{pressure increase that defines AOR} \ (>\# = \text{smaller AOR}) \]
- little variability either end of LoS (deep USDW; deep seawater)

All cases: Injection at 2500m depth into brine with 60Kppm TDS; USDW = 6Kppm TDS; Seawater = 35Kppm TDS

\[ \Delta P_{\text{max}} = 11.9 \text{ MPa (Based on San 0.12 MPa Antonio line)} \]
- 11.8 MPa
- 11.6 MPa
- 11.3 Mpa (OP)
- 6.4 MPa

\[ \Delta P_{\text{crit}} = \frac{1}{2} \text{ MPa (OP)} \]
- 0.81 MPa
- 0.89 MPa
- 0.80 Mpa (OP)
- 0.26 MPa

1 MPa = 145 psi
Plans for future testing/development/commercialization

1. Partnership Plans
   a) Assess OCS Opportunities
   b) GoMCarb learnings heavily used to support multiple, in-progress commercial projects
   c) Will acquire two HR3D seismic surveys
   d) Extend infrastructure analysis

2. Next Phase

3. Scale-up potential

Photo courtesy Tip Meckel
Plans for future testing/development/commercialization

1. Partnership Plans
   a) Assess OCS Opportunities
Plans for future testing/development/commercialization

1. Partnership Plans
   a) Assess OCS Opportunities

Publicly available Leased
100 Miles
Plans for future testing/development/commercialization

National Archive of Marine Seismic Surveys (NAMSS)
Assessing OCS Opportunities
Plans for future testing/development/commercialization

1. Partnership Plans
2. Next Phase
   a) Collect whole core from Miocene age units.
   b) Support developing projects
   c) Assure containment (faults, dip, penetrations)
   d) Monitor complex areas with multiple uses (e.g., with wind farms / hydrogen storage)
   e) Optimize infrastructure (coastal crossings, OCS, compatible uses)
   f) Monitoring: shallow, microtidal, warm waters of GoM *(not North Sea!)*
Plans for future testing/development/commercialization

1. Partnership Plans
2. Next Phase
3. Scale-up potential is HUGE
   a) XoM announcement – 100 MMT
   b) Talos / CarbonVert / Chevron
   c) Several others (as yet unannounced)
Calculating Critical Pressure

• onshore vs. offshore

• Key variables:
  1. Depth below USDW (*mudline?*)
  2. Salinity contrast between injection zone and protected zone (*mudline?*)

*tbd by BSSE*
Appendix

- These slides will not be discussed during the presentation but are mandatory.
# Gantt Chart

## Partnership for Offshore Carbon Storage Resources and Technology Development in the Gulf of Mexico

<table>
<thead>
<tr>
<th>Task</th>
<th>2018</th>
<th>2019</th>
<th>2020</th>
<th>2021</th>
<th>2022</th>
<th>2023</th>
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<td>Project Management, Planning, and Reporting</td>
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