Approaches to evaluations: Inner-shelf deltaic example GoM

High-level Summary
Paleogeography

• Dominant environment: Deltaic

Galloway et al. (2011)

Lower Miocene (~16-23MA)

Middle Miocene (~11-16MA)

Red River merges with Mississippi River
Aggradational sands to retrogradational sands
Static Regional Capacity
Texas Coast & Offshore

- NETL Methodology
- 40,000 sq. km.
- 3,300 logs
  - Tops, net sand, porosity
- 172 Gt CO2 storage total
  - TX State Waters

Wallace et al., 2013, *Regional CO$_2$ sequestration capacity assessment for the coastal and offshore Texas Miocene interval*, http://doi.org/10.1002/ghg.1380
Leveraging UTIG GBDS Consortium
Inner-shelf data

The Offshore OBS Dataset

- 3D P-Cable Survey
- 2D Lines (approx. 7,000 miles)
- TXLA 3D Seismic Survey (approx. 1,200 miles²)
- Additional 3D Seismic Surveys (approx. 880 miles²)
Geological CO₂ Sequestration
Atlas of Miocene Strata, Offshore Texas State Waters

Edited by R. H. Treviño and T. A. Meckel

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 CO₂ Storage beneath Texas Offshore Lands
3. Evaluation of Lower Miocene Confining Units for CO₂ Storage, Offshore Texas State Waters, Northern Gulf of Mexico, USA
4. Capillary Aspects of Fault-Seal Capacity for CO₂ Storage, Lower Miocene, Gulf of Mexico
5. Regional CO₂ Static Capacity Estimate, Offshore Saline Aquifers, Texas State Waters
6. Field-scale Example of Potential CO₂ Sequestration Site in Miocene Sandstone Reservoirs, Brazos Block 440-L Field
8. Appendix A: Regional Cross Sections, Miocene Strata of Offshore Texas State Waters
Southeast Texas is a major industrial hub undergoing substantial expansion and billions in investment currently.

The region is an evolving CO$_2$ hub, with existing infrastructure and EOR development.

The coastal and near-offshore geology holds the majority of US CO$_2$ storage capacity and is a key market for CCS technology. Storage assessment studies are mature for the regions covered by integrated 3D seismic data.
GOM Paleogeography

- Dominant environment: Deltaic
- Red River merging with Mississippi River

[Map showing paleogeography of the Gulf of Mexico during the Lower Miocene (~16-23Ma) with key features such as depositional coastal plain, fluvial axes, deltaic depocenters, and max. progradational shoreline.]

[Map showing the Middle to Lower Miocene (~11-23Ma) with labels for Red River, Mississippi River, Houston, and Prospect Area.]

(map from Deep Time Maps)
Deltaic Environments of Deposition

- Predictable and identifiable architecture
Subsurface Application

- GOM historical hydrocarbon reservoirs:
  - High Island Field 10L
- Establish sequence stratigraphic framework from stacking patterns
  - HST-LST-TST
- Seismic Mapping:
  - Regional seal
  - Maximum regressive surface
  - Lower flooding surface
- Map historical production
  - Accumulation under regressive surfaces
  - Majority at transition of LST-TST
XES02 Data

• Sand tank data—XES02
  • St. Anthony Falls Laboratory
  • Variable ‘sea level’
    • Slow cycle
    • Rapid cycle
    • Composite sequence
  • Realistic deltaic architecture
    • Black sediment → shale
    • White sediment → clean sand

• Significance of data
  • Computer generated models vs. natural systems
  • XES02 provides a realistic deltaic framework

• Goals:
  • Understand relationship between architectural surfaces and migration distance

(Schematic from Kim et al., 2006)
XES02 Geologic Model

1. Import model and scale

2. Populate the model according to greyscale

3. Drill wells and run buoyancy driven injection simulations

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**GOM Values**

<table>
<thead>
<tr>
<th>Model Facies</th>
<th>Description</th>
<th>Outcrop Facies</th>
<th>Field Picture</th>
<th>Photomicrograph</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clean Sand</td>
<td>Porosity: 35% Permeability (k): 1000mD kv/ko: 0.1 Sw: 20% Socr: 3% Pth: 1.45Pa</td>
<td>Proximal clinoform</td>
<td><img src="image1.png" alt="Field Picture" /></td>
<td><img src="image2.png" alt="Photomicrograph" /></td>
<td>Medium sand, planar laminations, well sorted</td>
</tr>
<tr>
<td>Unclean Sand</td>
<td>Porosity: 25% Permeability (k): 100mD kv/ko: 0.1 Sw: 30% Socr: 3% Pth: 3.9Pa</td>
<td>Medial clinoform</td>
<td><img src="image3.png" alt="Field Picture" /></td>
<td><img src="image4.png" alt="Photomicrograph" /></td>
<td>Upper fine to lower medium sand, trough cross stratification, planar laminations, moderate sorting</td>
</tr>
<tr>
<td>Siltstone</td>
<td>Porosity: 15% Permeability (k): 10mD kv/ko: 0.1 Sw: 40% Socr: 3% Pth: 10kPa</td>
<td>Distal clinoform</td>
<td><img src="image5.png" alt="Field Picture" /></td>
<td><img src="image6.png" alt="Photomicrograph" /></td>
<td>Very fine sand to silt, silt capped combined flow ripples</td>
</tr>
<tr>
<td>Shale</td>
<td>Porosity: 15% Permeability (k): 1E-05mD kv/ko: 0.1 Sw: 50% Socr: 3% Pth: 100kPa</td>
<td>Prodelta</td>
<td><img src="image7.png" alt="Field Picture" /></td>
<td><img src="image8.png" alt="Photomicrograph" /></td>
<td></td>
</tr>
</tbody>
</table>

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**Loyd Outcrop Comparison**
XES02 Mapping

1. Import/scale geomorphic scanned surfaces into the XES02 Geologic Model

2. Use slope break trajectory and sea level curve to place in sequence stratigraphic framework
Injection Simulation Results

- CO₂ migrates below regressive surfaces
- Migration pathways converge in TST
- Local regressive surfaces = baffles
- Regional (maximum) regressive surface = barrier

2. Maciel, R.S., 2017, Pre-injection reservoir characterization for CO₂ storage in the inner continental shelf of the Texas Gulf of Mexico, MS Thesis, The University of Texas at Austin, 90 p.


