Geologic Storage (Almacenamiento Geológico) Carbon Dioxide (CO₂)

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Field study-Cranfield-MS, Monitoring-design, Overview

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GEOLOGIC STORAGE
(ALMACENAMIENTO GEOLÓGICO)
CARBON DIOXIDE (CO₂)

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Overview

• What is Geologic Storage?
  – Capacity
  – Storage Security
  – Role of EOR (Enhanced Oil Recovery)

• GCCC Research – Geologic Storage
  – Historical
  – Current
What is Geologic Storage?

To reduce CO₂ emissions to air from point sources..

Captured - concentrated high pressure fluid

Shipped - pipeline

Injected & isolated potable water.

Stored (pore space) Geologically significant time

Carbon extracted from a coal or other fossil fuel...

is currently burned and emitted to air
What is Known about Storage Capacity?

- Abundant volume
- Microscopic spaces (pores) between grains
- Sedimentary rocks
- Currently brine- (or locally oil or gas) filled

Sandstone thin section photomicrograph, Frio Formation
Blue areas were filled with brine now are 10-30% filled with CO₂
Is Storage Security Adequate?

What are the risks?

Brine or CO₂ Escape
- Groundwater,
- Surface water,
- Air (long flow-path)

Earthquake

Brine or CO₂ Escape
- Flaws in Seal

Failure of well cement or casing resulting in leakage
Techniques Currently Used to Assure Safe Injection of CO$_2$

- CO$_2$ pipelines health and safety procedures
- Pre-injection characterization and modeling
- Isolated from Underground Drinking Water Sources
- Maximum allowable surface injection pressure (MASIP)
- Mechanical integrity testing (MIT) of engineered system
- Well completion / plug & abandonment standards
- Reservoir management
Role of EOR in Sequestration

- **EOR**
  - Only fraction of point sources
  - Offset some capture cost
  - Pipeline infrastructure development
  - Site characterization
  - Public acceptance

- **Brine storage**
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GCCCC Field Study Sites

- SACROC
- Frío Test Site
- Cranfield Field
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Frío Brine Pilot near Houston, TX
Monitoring at Frío Test Site

- Injection Well
- Observation Well
- U-tubes 30 m
- RST logs
- Downhole P and T
- Frío “Blue” Sandstone 15 m thick
- Tubing hung acoustic source and hydrophones
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Gulf Coast Carbon Center (GCCC) Collaboration – Cranfield

- DOE-funded

- Southeast Regional Carbon Storage Partnership (SECARB)
  - Managed: Southern States Energy Board
  - Host: Denbury Resources, Inc.
    - Phase II “Stacked Storage” = EOR+Brine storage
    - Phase III “Early” demonstration
Unique Opportunity at Cranfield
Abundant Data
Near Original Reservoir Conditions

- > 100 historical well logs
- > 10 new wells / modern logs
- Two whole cores
- New 3D seismic survey
- Near original reservoir pressures
## Stratigraphic Column - Cranfield Area

<table>
<thead>
<tr>
<th>Litho Stratigraphic Unit</th>
<th>Hydrologic function</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pleistocene-Holocene alluvial sediments and loess</td>
<td>Vadose - unconfined</td>
</tr>
<tr>
<td>Miocene - Oligocene undivided</td>
<td>Fresh water aquifer system-confined</td>
</tr>
<tr>
<td>Cockfield Fm. Cook Mountain Formation</td>
<td>Confining system</td>
</tr>
<tr>
<td>Sparta Formation</td>
<td></td>
</tr>
<tr>
<td>Wilcox Group</td>
<td>Gas producer-pressure sink</td>
</tr>
<tr>
<td>Midway- Navarro - Taylor</td>
<td>Confining system</td>
</tr>
<tr>
<td>Selma-Austin chalks</td>
<td>Buffering system</td>
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<tr>
<td>Eutaw-upper Tuscaloosa</td>
<td>Monitoring zone</td>
</tr>
<tr>
<td>Middle Tuscaloosa Fm.</td>
<td>Injection zone confining system</td>
</tr>
<tr>
<td>Lower Tuscaloosa Fm.</td>
<td>Injection zone</td>
</tr>
<tr>
<td>Washita-Fredericksburg Groups</td>
<td>Bottom seal</td>
</tr>
</tbody>
</table>

- **Monitoring Zone**: Indicates the zone for monitoring purposes.
- **Seal**: Represents the impermeable layer that acts as a barrier to fluid flow.
- **Reservoir - Injection Zone**: Shows the zone where reservoir fluids are injected and the zone where the injection occurs.
Core Box 1

- **Top**
- **Chert Pebble Conglomerate**
- **Braided Stream**
- **Sharp Basal Contact**
- **Bottom**

**Marine Mudstone**

**Lower Shoreface**

Shell fragments (oyster, gastropod) and Trace fossils
Core Photo - Unconformity

- Sharp Contact
- Gravel conglomerate above – marine mudstone below

Unconformity

Cranfield Unit 29-12 well core, Cranfield Field, MS. Sequence Boundary? Lower part of core #2 Pic taken July 28, 2008 Depth = 10,334 ft.
Gakona – Copper River Junction, Alaska
Modern Analog – Braided Stream

http://www.uwsp.edu/geo/faculty/ritter/glossary/a_d/braided_streams.html
USGS Digital Data Series DDS-21
Modeling Potential Leakage

Map view of Open Hydrologic Systems

Dr. JP Nicot
Impact Assessment & Comparison Metrics

MODFLOW / 1Mt/yr/well – 50 wells – 50 years

MODFLOW – STO × 10

Dr. JP Nicot
Mudrock Seal – Key for Successful Storage

Methods:
SEM, XRD, X-ray texture goniometry, porosimetry, C&O isotope, etc.

Questions:
Mud Rock Robust (CO\textsubscript{2} Storage)?
What is good seal?
- Mineralogy
- texture
- mechanical stress
CO\textsubscript{2} Effect on Seal?
CO\textsubscript{2}-mineral reactions reduce seal integrity?

Jiemin Lu, Postdoctoral Fellow
Near-Surface Geological Conditions

sediment samples were collected for analysis of water potential, soil gas, mineralogy and hydraulic properties.
Near-Surface Monitoring System

- Surface weather information monitoring system (SWIMS)
  1. Air temperature
  2. Wind speed & direction
  3. Solar radiation
  4. Precipitation,
  5. CO₂ concentration (air),
  6. Barometric pressure

- Underground geo-sensor pack (UGP)
  1. Water content
  2. Soil gases (CO₂ and CH₄) concentration
  3. $^{13}$C
  4. Gas pressure
  5. pH
  6. Soil temperature & electrical conductivity

- Groundwater quality monitoring system (GQMS)
  Concentrations
  1. Major ions
  2. Metal ions
  3. pH and dissolved gases (CO₂, CH₄, …)
Near-Surface Numerical Modeling

Objectives – Optimize
- Near-Surface Monitoring System Design
- Tracer Injection Experiments

Mesh used in the numerical model of tracer injection test

Spatial distributions of simulated tracer concentrations at different times

Time evolutions of tracer concentrations at different observing locations
Acknowledgments

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• Southern States Energy Board

• Gulf Coast Carbon Center (Sponsors)

• Jackson School (Equipment Matching Grants)
KM currently operates SACROC and is providing much assistance with the project.

- ~140 Million Tons CO₂ (since 1972)
- ~60 Million Tons CO₂ Recovered

GCCC Research
Test for detectable CO₂ in groundwater

Rebecca Smyth BEG
Southwest Partnership
Led by New Mexico Tech / Utah
DOE / NETL
Proposed CO$_2$ Pipeline Network
Texas Gulf Coast Region

Joseph Essandoh-Yeddu (visiting scholar)
SUMMARY

Major Societal Questions
Geologic CO$_2$ Storage Possible / Practical?

UT Jackson School’s GCCC – Finding Answers

Frío
Cranfield
SACROC
Geologic Storage of Carbon – Put it Back

Carbon extracted from coal or other fossil fuel...

Returned into the earth where it came from