SECARB Black Warrior Coal Test

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Geological Survey of Alabama
University of Alabama (SCGCS)
Southern Company
PRINCIPAL SPONSOR
U.S. Department of Energy - NETL

PROGRAM TEAM
SSEB, Virginia Tech - Administrative Lead
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SCGCS (University of Alabama) - Engineering
Southern Company/EPRI – MMV
Univ. British Columbia - Analytical
Oak Ridge National Laboratory - Analytical
ARI - Reservoir Simulation
Denbury Resources - CO₂
Southern Natural Gas/El Paso - CBM well
CO₂ STORAGE OPTIONS

Geological Storage Options for CO₂
1. Depleted oil and gas reservoirs
2. Use of CO₂ in enhanced oil recovery
3. Deep unused saline water-saturated reservoir rocks
4. Deep unmineable coal seams
5. Use of CO₂ in enhanced coal bed methane recovery
6. Other suggested options (basalts, oil shales, cavities)

Benson et al., 2008
CO₂ Sequestration

SECARB II Black Warrior and Virginia Coal Tests (DOE, SSEB, VT, SOCO, EPRI, El Paso, CNX, Denbury)

SECARB III Anthropogenic Test, Plant Barry (DOE, SSEB, SOCO, EPRI, ARI, Denbury)

SECARB III Offshore Assessment (DOE, SSEB)

CO₂-EOR, Citronelle Field (DOE, UAB)

Gorgas Site Characterization (DOE, UA, SOCO, SLB)

SECARB-Ed (DOE, SSEB, VT)
WHY COAL?

$\text{CO}_2$ capacity $\sim 173 \text{ Gt (49 yr)}$ in US.

$\text{CO}_2$-ECBM potential $\sim 4.3 \text{ Tcm (150 Tcf)}$.

Shallow reservoir (150-1500 m) with low P&T can reduce compression cost

Coal is abundant near major $\text{CO}_2$ emission sources, such as power plants.

Gas is stored in coal securely by adsorption rather than by free storage or solution.
BLACK WARRIOR BASIN
COALBED METHANE

Production

- Gas production (Bcf)
- Water Production (MMbbl)

Year

Image © 2005 DigitalGlobe

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Southeast Regional Carbon Sequestration Partnership
CUMULATIVE GAS PRODUCTION

SECARB test site

Gorgas
Miller

EXPLANATION

- 1.2 - 3.2 Bcf
- 0.9 - 1.2 Bcf
- 0.6 - 0.9 Bcf
- 0.3 - 0.6 Bcf
- 0.1 - 0.3 Bcf
- 0.0 - 0.1 Bcf

- Longwall mine
- Room-and-pillar mine

Contour interval variable

Sequestration > 6 Tcf
ECBM = 0.6-1.2 Tcf
POTTSVILLE STRATIGRAPHY

Well 17-09-122
Permit 12450-C-GI-10-01
Blue Creek Field

Bridge plug
COAL PERMEABILITY

\[ k = \frac{a^3}{12s} \]
PRODUCTION HISTORY

Time producing = 7 years
Peak gas production = 69 Mcf/d
Cumulative gas production = 76,006 Mcf

Peak water production = 7 bbl/d
Cumulative water production = 7,546 bbl
## Reservoir Characteristics

<table>
<thead>
<tr>
<th>Coal group/bed</th>
<th>Pratt</th>
<th>Mary Lee</th>
<th>Black Creek</th>
</tr>
</thead>
<tbody>
<tr>
<td>Depth (ft)</td>
<td>940</td>
<td>1435</td>
<td>1797</td>
</tr>
<tr>
<td>Original pressure (psi)</td>
<td>394</td>
<td>398</td>
<td>772</td>
</tr>
<tr>
<td>Original pressure gradient (psi/ft)</td>
<td>0.42</td>
<td>0.28</td>
<td>0.43</td>
</tr>
<tr>
<td>Hydrofrac Pumping rate (bpm)</td>
<td>34.8</td>
<td>36.3</td>
<td>20.0</td>
</tr>
<tr>
<td>Fluid Volume (gal)</td>
<td>12,000</td>
<td>12,000</td>
<td>4,000</td>
</tr>
<tr>
<td>Fracture gradient (psi/ft)</td>
<td>0.84</td>
<td>0.71</td>
<td>Screenout (0.72)</td>
</tr>
<tr>
<td>Max CO₂ injection pressure (psi)</td>
<td>752</td>
<td>1005</td>
<td>1258</td>
</tr>
<tr>
<td>At reservoir depth</td>
<td></td>
<td></td>
<td></td>
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</tbody>
</table>
SURFACE MONITORING

Soil Gas Monitoring

Groundwater Monitoring

SOUTHERN COMPANY
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SITE DEVELOPMENT

Coring

Laboratory Analysis

![Graph showing CO₂ and CH₄ adsorption](image)

- **CO₂**
- **CH₄**

2E-PR-03-0895.1

Sample Cell Equilibrium Pressure (PSIA)

- Dry, ash-free
- As-received
CORE TESTING

76 MMscf produced
84 MMscf

86 MMscf

121 MMscf
290 MMscf
CAPILLARY TUBING

Coiled tubing

Workover Rig

Wellbore installation

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MONITOR WELLHEAD
PRODUCTION AND INJECTION TESTS

Production test | Water and CO₂ treatments | Production test
--- | --- | ---

| 286 bbl H₂O | 80 tons CO₂ | 286 bbl H₂O | 80 tons CO₂ | 286 bbl H₂O | 80 tons CO₂ |

Pressure

0

Time

All zones

Black Creek coal zone

Mary Lee coal zone

Pratt coal zone

Pressure buildup test

Pressure falloff test

T1

T2

T3

T4

T5

T6

T7

T8

All zones

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RESERVOIR MODELS

Black Creek zone

Pratt zone

Grid blocks = 10,000 ft²

COMET3 models by Advanced Resources International
SLUG TESTING

Black Creek coal
Well 3N

Pressure (psia)

Time (days)
INJECTION SYSTEM

Compression  Storage

Propane  Heating  Injection

Injection system used at SECARB Plant Daniel and Black Warrior test sites