Resource Assessment Methods for CO₂ Storage in Geologic Formations
Project Number 1022403

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Office of Research and Development / National Energy Technology Laboratory

U.S. Department of Energy
National Energy Technology Laboratory
Carbon Storage R&D Project Review Meeting
Developing the Technologies and Infrastructure for CCS
August 12-14, 2014
Presentation Outline

• Resource Assessments
  – CO$_2$ Storage Method Development for Unconventional Systems, Oil and Gas Systems, and Saline Systems
  – Experimental Measurement of Microscopic Displacement Efficiency in Geologic Systems

• Geospatial Data Management
  – Atlas Development and NATCARB
  – Geodatabase Development in Support of Geologic Storage Research (EDX)
Benefit to the Program

• Carbon Storage Program Major Goals
  – Support industry’s ability to predict CO$_2$ storage capacity in geologic formations to within ±30 percent.

• Project Benefits Statement:
  – This research project aims at developing and maintaining tools/resources that facilitate regional- and national-scale assessment of carbon storage
Project Overview:
Goals and Objectives

Project Objectives.

- **Resource Assessments** – How can available geospatial data be best used to assess storage resource to ±30% accuracy?
  - Develop a Defensible DOE Methodology for Regional Assessments

- **Geospatial Data Management (EDX and NATCARB)** – What spatially related datasets exist in support of carbon storage R&D and can they be provided in a user-friendly system to allow for advanced use and research?
  - Develop and maintain geospatial platforms that support research and assessment and that facilitate preservation and transfer of data (EDX and NATCARB)
Technical Status

• Resource Assessments

  – CO₂ Storage Method Development for
    • Unconventional Systems
    • Oil and Gas Systems
    • Saline Systems

  – Experimental Measurement of Microscopic Displacement Efficiency in Geologic Systems
Prospective Storage Resource for CO₂ storage at the regional and national scale at the Exploration Phase.

- Based on **physically** accessible pore volume without consideration of regulatory or economic constraints.
- broad energy-related government policy and business decisions

<table>
<thead>
<tr>
<th>Petroleum Industry</th>
<th>CO₂ Geological Storage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reserves</td>
<td>Capacity</td>
</tr>
<tr>
<td>On Production</td>
<td>Active Injection</td>
</tr>
<tr>
<td>Approved for</td>
<td>Approved for</td>
</tr>
<tr>
<td>Development</td>
<td>Development</td>
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<tr>
<td>Justified for</td>
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<td>Development</td>
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<table>
<thead>
<tr>
<th>Contingent Resources</th>
<th>Contingent Storage Resources</th>
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</thead>
<tbody>
<tr>
<td>Development Pending</td>
<td>Development Pending</td>
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<tr>
<td>Development Unclarified or On Hold</td>
<td>Development Unclarified or On Hold</td>
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<tr>
<td>Development Not Viable</td>
<td>Development Not Viable</td>
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</table>

<table>
<thead>
<tr>
<th>Prospective Resources</th>
<th>Exploration</th>
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</thead>
<tbody>
<tr>
<td>Prospect</td>
<td>Qualified Site(s)</td>
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<tr>
<td>Lead</td>
<td>Selected Areas</td>
</tr>
<tr>
<td>Play</td>
<td>Potential Sub-Regions</td>
</tr>
</tbody>
</table>

DOE Classification of CO₂ Storage Estimates (2010)
**Prospective CO₂ Storage Resource Methods**

**Volumetric approach: geologic properties & storage efficiency**

- Method for prospective CO₂ Storage Resource
  - Simple Geometric-Based Formula
  - Extensive Peer-Review
  - Extensive Statistical Rigor
- Applied by Regional Carbon Sequestration Partnerships
- Refined Estimates in U.S. DOE’s Carbon Utilization and Storage Atlas

**Geologic Formation**

1. Saline
2. Coalseams
3. Oil and Gas
4. Shale

**Mass Resource Estimate**

\[
G_{CO₂} = A_t \ h_g \phi_{tot} \rho \ E \\
G_{CO₂} = A_t \ h_g \ C_s \rho \ E \\
G_{CO₂} = A_n \ h_n \phi_e \rho \ E \\
G_{CO₂} = [(A_t \ h_g \phi_{tot} \rho_{CO₂r}E_{\text{free}}) + (A_t \ h_g (1-\phi_{tot})C_s\rho_{CO₂s}E_{\text{sorbed}})]
\]
A fraction of the total volume of the formation that will effectively store CO₂ represents variability in geologic parameters used to calculate $G_{CO₂}$.

$$ E_{\text{saline}} = E_{An/At} E_{hn/hg} E_{\phi e/\phi \text{tot}} E_v E_d $$

**Saline Formation Efficiency Factors**

<table>
<thead>
<tr>
<th>Lithology</th>
<th>$P_{10}$</th>
<th>$P_{90}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clastics</td>
<td>0.51%</td>
<td>5.4%</td>
</tr>
<tr>
<td>Dolomite</td>
<td>0.64%</td>
<td>5.5%</td>
</tr>
<tr>
<td>Limestone</td>
<td>0.40%</td>
<td>4.1%</td>
</tr>
</tbody>
</table>

Log Odds Method applied with **Monte Carlo** sampling

$$ E = \left( \frac{1}{1 + e^{-X(E_{An/At})}} \right) \left( \frac{1}{1 + e^{-X(E_{hn/hg})}} \right) \left( \frac{1}{1 + e^{-X(E_{\phi e/\phi \text{tot}})}} \right) \left( \frac{1}{1 + e^{-X(E_v)}} \right) \left( \frac{1}{1 + e^{-X(E_d)}} \right) $$

Technical Status

• Resource Assessments
  – CO₂ Storage Method Development for Unconventional Systems
  – Team Members: Isis Fukai¹, Angela Goodman¹, Robert Dilmore¹, Dan Soeder¹, Scott Frailey², Grant Bromhal¹, George Guthrie¹, Traci Rodosta¹

Simplified sketch of an organic-rich shale storage formation showing the portion of the formation that is accessed during CO₂ storage.
Method for Estimating the CO$_2$ Storage Resource of Organic-rich Shales

<table>
<thead>
<tr>
<th></th>
<th>Fracture</th>
<th>Matrix</th>
</tr>
</thead>
<tbody>
<tr>
<td>SRV*</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>USRV^</td>
<td>3</td>
<td>4</td>
</tr>
</tbody>
</table>

CO$_2$ Storage Efficiency:
- High
- Low

*Stimulated Reservoir Volume
^Unstimulated Reservoir Volume

<table>
<thead>
<tr>
<th></th>
<th>fracture</th>
<th>matrix</th>
</tr>
</thead>
<tbody>
<tr>
<td>SRV*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>free</td>
<td>✓</td>
<td>✓ in φ</td>
</tr>
<tr>
<td>sorbed</td>
<td>X</td>
<td>✓ in clay &amp; kerogen</td>
</tr>
</tbody>
</table>

| USRV^   |          |                   |
| free    | ✓        | ✓ in φ            |
| sorbed  | X        | ✓ in clay & kerogen|

In the table above, the symbols ✓ and X represent the presence or absence of CO$_2$ storage in the respective locations within the fracture and matrix components.
Methodology for Estimating the CO$_2$ Storage Resource of Organic-rich Shales

<table>
<thead>
<tr>
<th>Criteria for CO$_2$ Storage in U.S. Organic-rich Shale Formations</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) <strong>Organic-rich shale formations must have a TOC ≥ 2.0 wt. % and be methane-bearing.</strong> These formations have sufficient volumes of sorptive kerogen &amp; void spaces where CH$_4$ is able to reside, suggesting they will also be amenable for CO$_2$ storage.</td>
</tr>
<tr>
<td>(2) <strong>Structural, stratigraphic, &amp; hydrodynamic traps (faults, seals, &amp; capillary pressures) must exist</strong> in order to prevent the migration of CO$_2$ into adjacent formations or to the surface.</td>
</tr>
<tr>
<td>(3) <strong>The organic-rich shale formation has been, or will be produced for methane before or during implementation of CO$_2$ storage.</strong> This is to reduce the likelihood of formation over-pressurization and ensure space is available to allow in-situ methane and fluids to be displaced and/or managed via production.</td>
</tr>
</tbody>
</table>
CO₂ Storage Resource Methodology for Organic-rich Shales

Represents the physically accessible, *effective* CO₂ storage volume

**Volumetric Equation:**

\[
G_{CO₂} = [(A_t \ h_g \ φ_{tot} \ ρ_{CO₂r} \ E_{free}) + (A_t \ h_g \ (1-φ_{tot})C_s \ ρ_{CO₂s} \ E_{sorbed})]
\]

(1) *Free phase* storage in Stimulated Reservoir fractures and matrix pores

(2) *Sorbed* storage on kerogen & clays

**Efficiency:** *fraction* of the total formation volume that will be accessed for CO₂ storage

\[
E_{free} = \frac{E_{An/At} \ E_{hn/hg} \ E_{ϕe/ϕt} \ E_V E_d}{E_{free}}
\]

\[
E_{sorbed} = \frac{E_{An/At} \ E_{hn/hg} \ E_{Ce/Ct} \ E_V E_d}{E_{sorbed}}
\]

Accounts for technical storage limitations, *e.g.*, unconstrained geologic & displacement variables, that may prevent CO₂ from accessing 100% of the theoretical storage volume (*e.g.*, Goodman et al., 2011)
Application of Methodology for Estimating the CO$_2$ Storage Resource of Organic-rich Shales

10 Major Formations Included in Calculation

Map after NETL-NATCARB (2013)
## U.S. Organic-rich Shale Formation Data Incorporated in CO₂ Storage Resource Equation

\[
G_{CO2} = A_t h_g \left[ \phi_{tot} \rho_{CO2r} E_{free} + (1-\phi_{tot}) C_s \rho_{CO2s} E_{sorbed} \right]
\]

<table>
<thead>
<tr>
<th>Formation</th>
<th>Total Area (km²)</th>
<th>Gross Thickness (m)</th>
<th>Total Porosity (%)</th>
<th>TOC (%)</th>
<th>Shale Density (g/cm³)</th>
<th>Langmuir Volume (m³/kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Marcellus</td>
<td>246,049</td>
<td>103</td>
<td>0.07</td>
<td>7.3</td>
<td>2.48</td>
<td>0.00852</td>
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<tr>
<td>Barnett</td>
<td>23,310</td>
<td>139</td>
<td>0.05</td>
<td>5.6</td>
<td>2.54</td>
<td>0.00709</td>
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<td>Ohio</td>
<td>85,470</td>
<td>135</td>
<td>0.08</td>
<td>3.4</td>
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<td>0.00179</td>
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<tr>
<td>Woodford</td>
<td>28,490</td>
<td>108</td>
<td>0.07</td>
<td>8.3</td>
<td>2.54</td>
<td>0.00933</td>
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<tr>
<td>Haynesville</td>
<td>23,310</td>
<td>70</td>
<td>0.08</td>
<td>2.8</td>
<td>2.60</td>
<td>0.00468</td>
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<tr>
<td>Fayetteville</td>
<td>23,310</td>
<td>52</td>
<td>0.06</td>
<td>6.5</td>
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<td>0.00777</td>
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<tr>
<td>Utica</td>
<td>73,815</td>
<td>133</td>
<td>0.03</td>
<td>2.9</td>
<td>2.69</td>
<td>0.00476</td>
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<tr>
<td>New Albany</td>
<td>22,015</td>
<td>73</td>
<td>0.12</td>
<td>16.0</td>
<td>2.40</td>
<td>0.01592</td>
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<tr>
<td>Lewis</td>
<td>7,122</td>
<td>269</td>
<td>0.04</td>
<td>2.3</td>
<td>2.54</td>
<td>0.00420</td>
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<tr>
<td>Eagle Ford</td>
<td>19,425</td>
<td>65</td>
<td>0.10</td>
<td>4.4</td>
<td>2.60</td>
<td>0.00601</td>
</tr>
</tbody>
</table>

**Data Sources:** Hill and Nelson, 2000; Curtis, 2002; Nuttall et al., 2005; Braithwaite, 2009; DOE-NETL, 2010; Roth, 2010; Strapoc et al., 2010; Bruner and Smosna, 2011; EIA, 2011; Kulkarni, 2011; Lahann et al., 2011; NY-DEC, 2011; Walls and Sinclair, 2011; Chalmers et al., 2012; Curtis et al., 2012; Jarvie, 2012; Clarkson et al., 2013b; Gasparik et al., 2013; Liu et al., 2013; Ruppert et al., 2013; Yu and Sepehrnoori, 2014

Gross thickness, Total Porosity, TOC-content, and Shale Density values are averages based on 3-7 values reported in peer-reviewed literature.
Estimating CO$_2$ Storage Efficiency of Organic-rich Shales

**Probability (p) values:** fractions representing the percentage of each parameter that will be utilized for CO$_2$ storage

P-values must account for several different storage scenarios

P-ranges are calculated stochastically to produce $E_{\text{free}}$ and $E_{\text{sorbed}}$ values

GoldSim v. 11 (GoldSim Technology Group, 2013), Monte Carlo simulation (10,000) & Log-Odds distribution

### High and Low P-values Assigned to Efficiency Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>$P_{10}$ (low)</th>
<th>$P_{90}$ (high)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Geologic</td>
<td>$E_{\text{An/At}}$</td>
<td>hydraulically stimulated vs unstimulated shale volumes</td>
<td>*</td>
</tr>
<tr>
<td></td>
<td>$E_{\text{hn/hg}}$</td>
<td>gas porosimetry, SANS/USANS*</td>
<td>*</td>
</tr>
<tr>
<td></td>
<td>$E_{\phi_c/\phi_t}$</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td></td>
<td>$E_{\text{Ce/Ct}}$</td>
<td>$\text{Langmuir}<em>{\text{res}} / \text{Langmuir}</em>{\text{max}}$</td>
<td>*</td>
</tr>
<tr>
<td>Displacement</td>
<td>$E_{V}$</td>
<td>injection-well scenarios / infrastructure</td>
<td>*</td>
</tr>
<tr>
<td></td>
<td>$E_{d}$</td>
<td>*</td>
<td>*</td>
</tr>
</tbody>
</table>

**Shale Storage Efficiency Preliminary Results**

<table>
<thead>
<tr>
<th>Percentile:</th>
<th>$P_{10}$ (low)</th>
<th>$P_{50}$ (mid)</th>
<th>$P_{90}$ (high)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$E_{\text{free}}$</td>
<td>*</td>
<td>*</td>
<td>In progress</td>
</tr>
<tr>
<td>$E_{\text{sorbed}}$</td>
<td>*</td>
<td>*</td>
<td>*</td>
</tr>
</tbody>
</table>

Values assigned based on professional expertise, experimental data, & model simulations (in-house & external): Curtis, 2002; DOE-ICMI, 2012; Clarkson et al., 2012; Jarvie, 2012; Ruppert et al., 2013
Technical Status

• Resource Assessments
  – CO₂ Storage Method Development for Oil and Gas Systems
  – Team Members: Russell Johns, Nick Azzolina, Dave Nakles, Liwei Li, Saeid Khorsandi, Angela Goodman
Refined Methodology

• Production-Based Equation

\[ G_{\text{CO}_2-\text{production}} = \frac{A_n \cdot h_n \cdot \phi_e (1 - S_{wi}) \rho_{\text{CO}_2-\text{standard conditions}} \cdot E_{\text{oil/gas}}}{B_{\text{oil}}} \]

• Volumetric Equation

\[ G_{\text{CO}_2-\text{reservoir volume displacement}} = A_n \cdot h_n \cdot \phi_e [E_v \cdot E_d] \cdot \rho_{\text{CO}_2-\text{reservoir conditions}} \]
Approaches to Characterize $E_v \times E_d$

Three Approaches

1. Analytical modeling of continuous miscible CO$_2$ flood
2. Reservoir simulation and reduced order modeling of a next-generation CO$_2$-EOR scheme with high flood efficiency
3. Performance from a set of industry data with regression of those data to predict reservoir performance at higher HCPV CO$_2$ injection
Koval/Claridge Approach

Simulation of Gravity-Assisted Flood

Projection from Production History in Real Fields

Monte Carlo Simulations varying:
- Oil API Gravity
- Associated gas specific gravity
- Initial Oil Saturation
- Vertical Permeability
- Dykstra-Parsons Coefficient

a reduced-order model (ROM) for continuous CO2 flooding in heterogeneous oil reservoirs

\[ \text{Production Efficiency} \]

\[ \text{Mobility Ratio} \]

\[ \text{HCPVI} \]

\[ \text{CO2 Purchased} \]

\[ \text{CO}_2 \text{ HPVI up to 5} \]

\[ \text{Production Efficiency} \]

\[ \text{Oil recovery} \]

\[ \text{PDF} \]

\[ \text{% Net Pore Volume CO}_2 \text{ Storage Efficiency} \]

\[ \text{Net Revenue vs. % CO}_2 \text{ Injection} \]

\[ \text{Net Revenue vs. CO}_2 \text{ Injection} \]

\[ \text{Net Revenue vs. CO}_2 \text{ Injection} \]

**Sources:**
- Li, Liwei, Khorsandi, Saied Johns, Russell T. Dilmore, R. Reduced-Order Model for CO2 Enhanced Oil Recovery and Storage Using a Gravity-Enhanced Process. SPE-ATCE,
Technical Status

- **Resource Assessments**
  - CO$_2$ Storage Method Development for Saline Systems
  - *Team Members*: Angela Goodman, Kelly Rose, Jen Bauer, Corinne Disenhof, Grant Bromhal, Bob Dilmore, and George Guthrie
NETL’s Variable Grid Method (VGM)

The VGM is a *flexible method* that allows for the communication of different data and uncertainty types, while still preserving the *overall spatial trends and patterns*.

- Point Density
- Sample Variance
- Kriging Standard Error
Applications of the VGM at NETL

**CO₂ Storage Assessment**
*Oriskany Formation*
New approach for defining spatial uncertainty & trends for CO₂ Storage estimates

**Unconventional Resource Risk Assessments**
Estimating the depth to the base of groundwater to evaluate risks of groundwater contamination

**NETL VGM approach can be used to address questions such as:**
- Resources evaluation
- Impact assessments
- Identifying Knowledge Gaps
- Understanding trends in the data
- Calculating Project Feasibility
Contact Information:
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Kelly Rose
kelly.rose@netl.doe.gov

Acknowledgements
Thank you to my other developer, Kelly Rose, the ‘brains’ behind the idea, as well as the NETL Technology Transfer Team for their help developing and submitting the patent, Corinne Disenhof and Angela Goodman for their help with applying the VGM to CO₂ storage estimates, and Aaron Barkhurst and Tim Jones working on the development of the Variable Grid Tool

Notes
A U.S. provisional patent application was filed February 12, 2014 (61/938,862)

Useful Links:
VGM Technology Sheet:
VGM Technology Video:
http://youtu.be/9vLa1HM1IKY
New Geospatial Approach for CO₂ Storage Assessment

Developing new geospatial analysis approach to characterize, interpret, and display subsurface geologic characteristics to provide detailed inputs needed for assessing Prospective CO₂ Resource Storage Estimates.

<table>
<thead>
<tr>
<th></th>
<th>Clastics</th>
<th>Dolomite</th>
<th>Limestone</th>
</tr>
</thead>
<tbody>
<tr>
<td>P10</td>
<td>Eh/h</td>
<td>Eh/h</td>
<td>Eh/h</td>
</tr>
<tr>
<td>P50</td>
<td>Ephi/phi</td>
<td>Ephi/phi</td>
<td>Ephi/phi</td>
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<tr>
<td>P90</td>
<td>EV</td>
<td>EV</td>
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<td></td>
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<tr>
<td></td>
<td>0.5%</td>
<td>0.7%</td>
<td>0.4%</td>
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<tr>
<td></td>
<td>2.0%</td>
<td>2.2%</td>
<td>1.5%</td>
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<tr>
<td></td>
<td>5.4%</td>
<td>5.4%</td>
<td>4.0%</td>
</tr>
<tr>
<td></td>
<td>1.6%</td>
<td>2.0%</td>
<td>1.3%</td>
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<tr>
<td></td>
<td>4.4%</td>
<td>5.0%</td>
<td>3.4%</td>
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<td></td>
<td>9.5%</td>
<td>9.1%</td>
<td>6.9%</td>
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<td>5.2%</td>
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<td>17.2%</td>
<td>16.9%</td>
<td>14.7%</td>
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<td></td>
<td>7.4%</td>
<td>15.7%</td>
<td>10.4%</td>
</tr>
<tr>
<td></td>
<td>14.1%</td>
<td>20.6%</td>
<td>15.0%</td>
</tr>
<tr>
<td></td>
<td>24.1%</td>
<td>26.3%</td>
<td>21.0%</td>
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</table>

Oriskany Formation

<table>
<thead>
<tr>
<th>Porosity</th>
<th>Average Porosity (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.00 - 4.20</td>
<td>4.27 - 8.04</td>
</tr>
<tr>
<td>6.05 - 8.02</td>
<td>8.02 - 9.99</td>
</tr>
<tr>
<td>10.01 - 11.19</td>
<td>11.19 - 13.15</td>
</tr>
<tr>
<td>13.15 - 14.92</td>
<td>14.92 - 16.15</td>
</tr>
<tr>
<td>16.15 - 18.48</td>
<td>18.48 - 20.25</td>
</tr>
</tbody>
</table>

Maps show the distribution of porosity and geologic characteristics across different formations.
Technical Status

• Resource Assessments
  – *Experimental Measurement of Microscopic Displacement Efficiency in Geologic Systems*
  – *Team Members: Dustin McIntyre and Angela Goodman*
High Resolution CT Imaging

- Image resolution <5 micron
- Custom X-ray scannable Hassler style core holder
- Pressure and temperature control of confining pressure
- Injection fluid pressure and temperature control
- Micro-displacement efficiency measurement
- Vary brine composition
- Initial saturation composition (Oil/brine/mixed)
Technical Status

• Geospatial Data Management
  – Atlas Development and NATCARB
  – Geodatabase Development in Support of Geologic Storage Research (EDX)
Atlas Development and NATCARB

How-to use www.NatcarbViewer.org

Basemaps

Application Themes

Search EDX Documents

Upload & Download Data

Navigation

Log & 3D Viewers

Layers & Query Results

Brine Database

Visualize Brine Plots

Log Viewer

Visualize las well log files

Brine database overview

Box Plot

3D

3D Viewer

3D view of carbon sequestration potential and CO₂ emission
Atlas Development and NATCARB
• An online platform for rapid and efficient access to priority datasets

• Provides an opportunity for researchers to share and “publish” online datasets & data-driven products

• A secure environment for multi-organizational research teams to share, build, and collaborate in a common workspace

• Online tool to disseminate data, information, and results from DOE’s Fossil Energy intramural research portfolios

https://edx.netl.doe.gov/
Accomplishments to Date

- Draft of new methodology for accessing storage potential in organic-rich shale
- Draft of new methodology for accessing storage potential in conventional oil reservoirs
- Development of the VGM flexible method that allows for the communication of different data and uncertainty types, while still preserving the overall spatial trends and patterns
- DEVELOP A NEW VIEWER FOR NATCARB
- EDX DEVELOPMENT- COORDINATION AND COLLABORATION TOOL --- Online tool to disseminate data, information, and results from DOE’s Fossil Energy intramural research portfolios
Summary

– Key Findings
  • Resource Assessments
    – Develop a Defensible DOE Methodology for Regional Assessments
  • Geospatial Data Management (EDX and NATCARB)
    – Develop and maintain geospatial platforms that support research and assessment and that facilitate preservation and transfer of data (EDX and NATCARB)

– Future Plans
  – Develop Defensible DOE Methodology for Regional Assessments
  – Expand to Include Stochastic Approach for Key Parameters
  – Expand Methodology to Include Geospatially Variable Key Parameters
  – EDX and NATCARB : Develop and maintain geospatial platforms that support research and assessment and that facilitate preservation and transfer of data
Appendix
Organization Chart

- **Task 4.0 Resource Assessments and Geospatial Resources**
  - Subtask 4.1 Resource Assessments (TTC: Goodman)
  - Sub-subtask 4.1.1 Methodology for Assessment of Unconventional Systems (Goodman, NETL)
  - Sub-subtask 4.1.2 Methodology for Assessment of Oil and Gas Systems (Dilmore, NETL; Johns, PSU)
  - Sub-subtask 4.1.3 Methodology for Assessment of Saline Systems (Goodman & Rose, NETL)
  - Sub-subtask 4.1.4 Experimental Measurement of Microscopic Displacement Efficiency in Geologic System (McIntyre & Goodman, NETL)

- **Subtask 4.2 Geospatial Data Management (TTC: Soeder 4.2.1/Rose 4.2.2)**
  - Sub-subtask 4.2.1 Atlas Development and NATCARB (TTC: Soeder)
  - Sub-sub-task 4.2.1.1 NATCARB Database and Viewer Development (Carr, WVU)
  - Sub-subtask 4.2.1.2 Update the Carbon Storage Atlas of the United States and the North American Carbon Atlas (Soeder, NETL)
  - Sub-subtask 4.2.2 Geodatabase Development in Support of Geologic Storage Research (Rose, NETL)
  - Sub-sub-task 4.2.2.2 Evaluation and if Appropriate Development of an ORD CO₂ Storage Program EDX Portfolio
  - Sub-sub-task 4.2.2.3 EDX operations support for collaborative workspace development for CO₂ Storage intramural and extramural projects as requested. To create a collaborative workspace the administrator of the space is required to have a contr.netl.doe.gov or .netl.doe.gov email address however members approved by the workspace administrator with valid EDX accounts can be from outside entities. Thus, EDXsupport@netl.doe.gov will be on hand to support the development, maintenance and improvement of these spaces in support of CO₂ Storage R&D in FY14.
  - Sub-subtask 4.2.2.4 Additional support by the EDX Team for key development and potential integration with outside partners (e.g., PNNL GS3 system) will be supported in FY14 but will be limited by the amount of funding available versus the level of support and development required on a request-by-request basis.
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**Milestone Identifier**

M1.14.4.A

**Title**

Task 4.0 Resource Assessments and Geospatial Resources

**Planned Date**

03/30/14

**Verification Method**

Draft report
Bibliography


