Geologic Storage of CO_2 from Refining and Chemical Facilities in the Midwestern United States

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Introduction

- A hypothetical scheme with three scenarios to inject CO_2 from midwestern U.S. facilities was evaluated to better understand the potential for storage of CO_2
- CO_2 was assumed to be collected from refining and chemical facilities in the region and transported along existing pipeline routes to nearby injection locations
- The study included assessment of geologic setting, reservoir simulations, geochemistry, engineering, and economics issues

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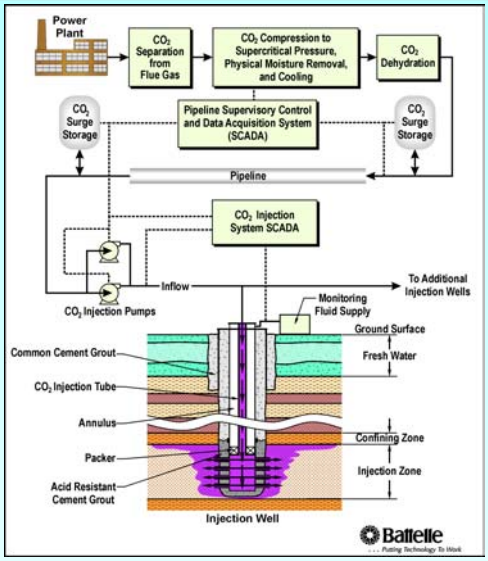
Conceptual CO_2 Storage System

- Pure CO_2 was assumed to be delivered
- Only compression, dehydration, transport, and injection were evaluated



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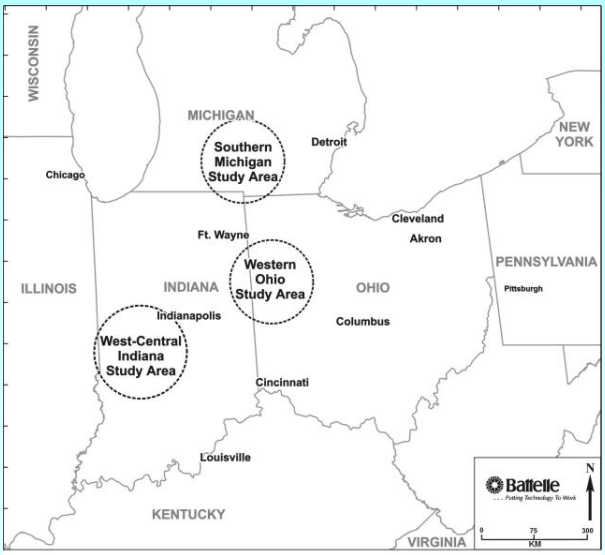
Base Map of Study Area

Scenarios

- 5 mt/yr in Indiana
- 2 mt/yr in Michigan
- 2 mt/yr in Ohio



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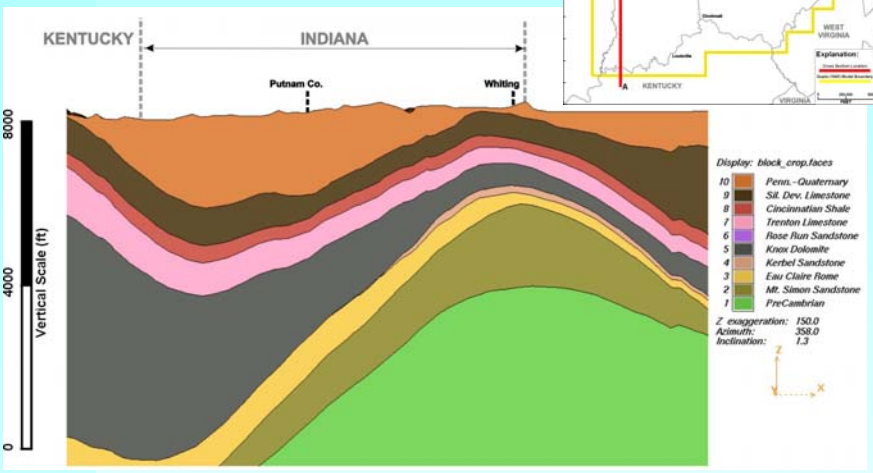
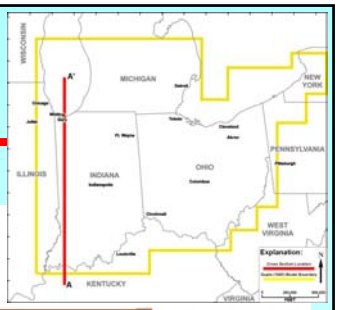
Hydrostratigraphic Units Through Indiana Site





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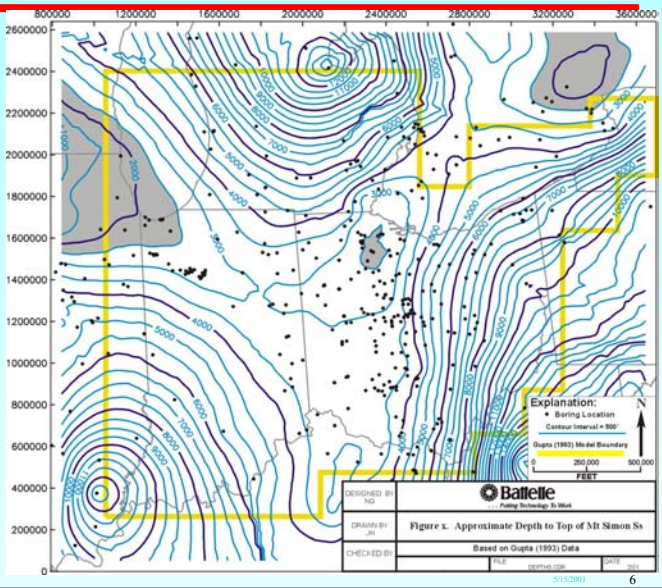
Depth to Mt. Simon Sandstone

- Depth to the reservoir is greater than 2,500 ft in most areas in the region



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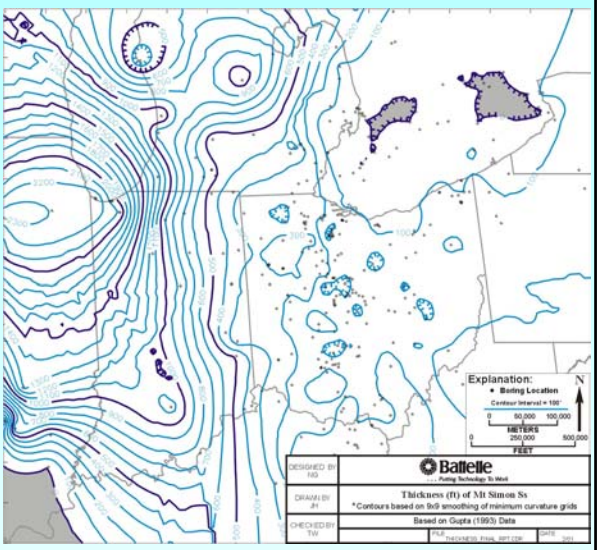
Thickness of Mt. Simon Sandstone

- Indiana Location
  - 1,000 – 1,200 ft
- Michigan Location
  - 400 – 600 ft
- Ohio Location
  - 300 – 400 ft
- On a regional basis the storage capacity near these sites is in the range of several billion tons



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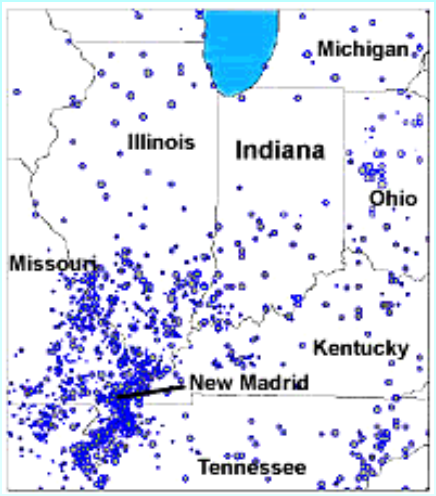
Regional Seismicity

- Most of the Midwest U.S. has a low earthquake hazard rating
- The New Madrid Seismic zone is the most active area in the region

Earthquake Activity in the Midwest U.S.



(Source: Indiana Geological Survey, 2000.)

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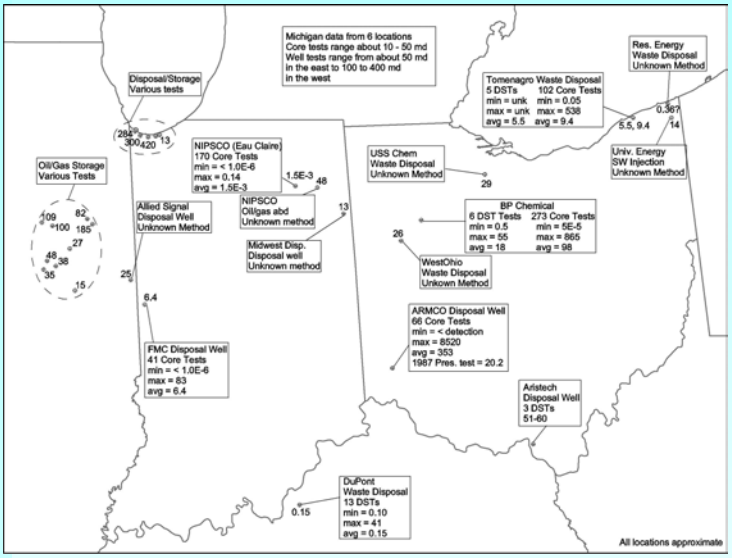
Compilation of Permeability Data



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Flow and Transport Models

- Compositional simulations using modified UTCOMP code were conducted to estimate injection potential, pressure increases, CO_2 spreading, dissolution, and containment
- 2-D radial simulations using field data from deep wells in the region were conducted
- Limited Sensitivity analysis was conducted

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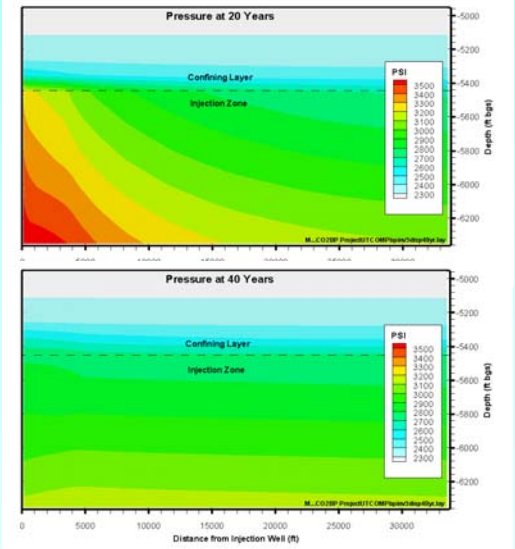
Simulated Pressure for Indiana Scenario at 20 and 40 years

- Simulated pressures increases are below the fracture pressure limits normally observed in the region
- Pressure subsides rapidly after injection stops
- Up to 5 injection wells may be needed for 5 mt/yr storage

1 mt/yr/well injection



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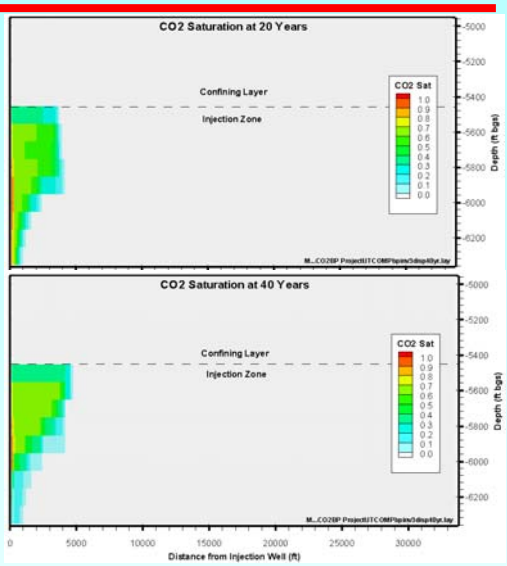
CO_2 Spreading for Indiana Scenario

- CO_2 spreads to about 4,000 ft in 20 years
- There is very little additional spreading after injection stops
- No leakage into confining layers is observed
- Fractures rock scenarios were not considered



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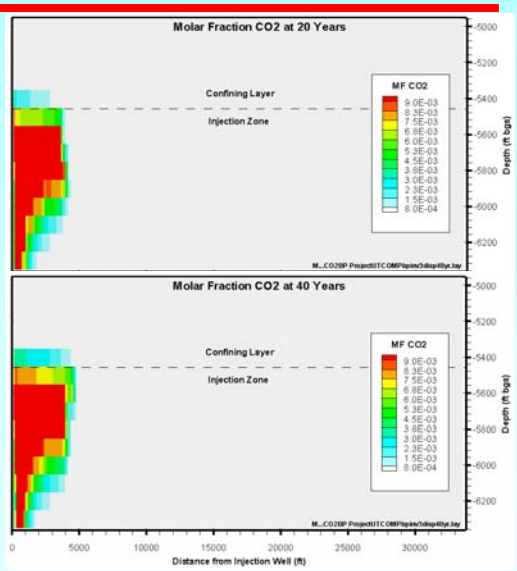
Simulated CO_2 Solubility for Indiana Scenario

- Solubility is a function of pressure, temperature, and salinity
- Almost no movement of dissolved CO_2 into caprock
- About 6% of injected CO_2 is dissolved after 40 years
- Typical CO_2 Mole Fraction ~0.009 (2.3%)
- Dissolution is limited by slow contact between CO_2 and fresh brine



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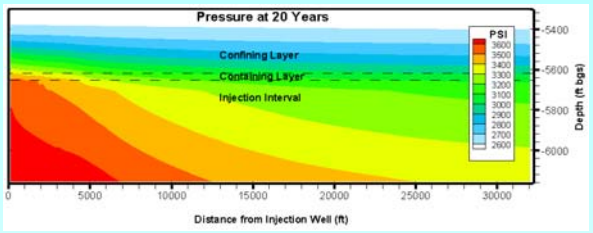
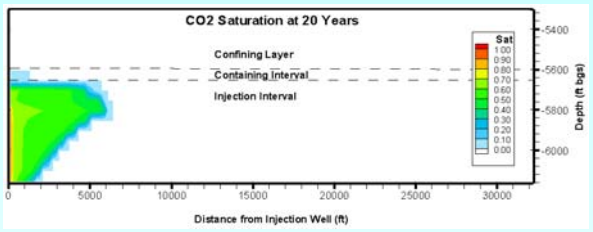
Michigan Scenario

- Up to 1.8 mt/yr can be injected in one well





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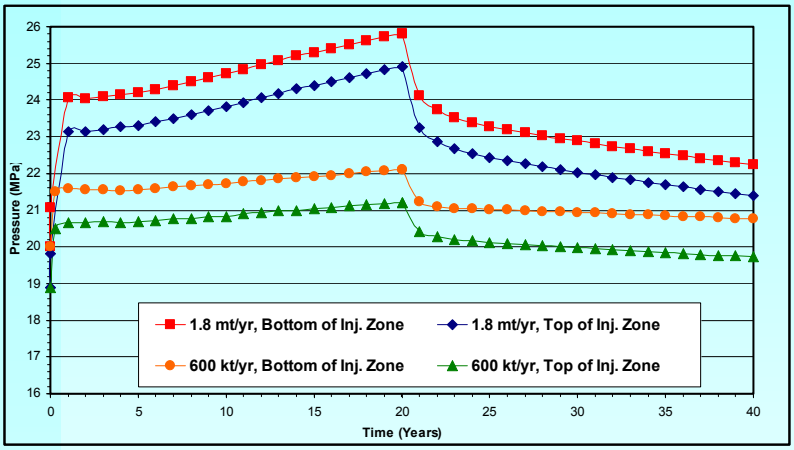
Pressure Profiles for Two Michigan Scenarios



Pressure subsides soon after injection stops

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Sensitivity Analysis

- No major effect from column width, layer thickness, diffusion, and dispersion coefficients
- Horizontal wells: greater injection rates, less pressure buildup, slower vertical movement of CO_2
- A single 3-D scenario showed higher injectivity than the radial models
- A 500 year run showed 8% dissolution and no movement of CO_2 into caprock

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Geochemical Assessment

- Mineral and brine compositions from the deep wells in the region were evaluated
  - TDS Range – up to 300,000 mg/L
  - pH Range – 5.5 to 7
  - Mainly sodium-, calcium-, and chloride-rich brines
- No adverse reactions noticed with equilibrium modeling
- Potential for mineral precipitation through silicate reactions where iron rich glauconite is present
- Experience in EOR may be useful in dealing with operational issues

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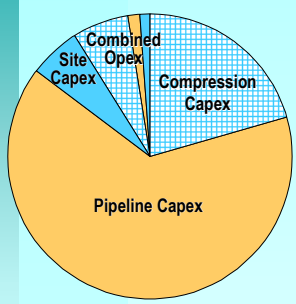
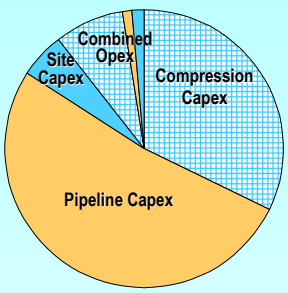
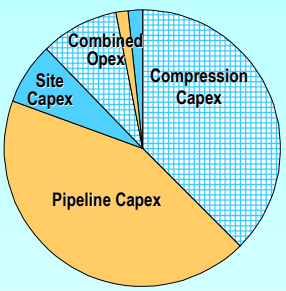
Comparison of Storage Costs in Terms of Capital and Operational Expenses



5 mt/yr in
West-Central Indiana
$18.6/ton



2 mt/yr in
South-Central Michigan
$18.3/ton



2 mt/yr in
Western Ohio
$17.0/ton

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Key Conclusions

- Feasibility of CO_2 storage in the Mt. Simon Sandstone in three areas was evaluated
- Reservoir simulations indicate that the desired amount of injection could be achieved using a reasonable number of wells
- The formation pressure increase and CO_2 spreading distance appear to be in acceptable ranges. Dissolution rates are relatively slow due to slow groundwater movement.
- No major adverse geochemical reactions would be expected
- The storage cost is mainly influenced by the pipelines costs. A regional pipeline network may help reduce this cost.

References

- Gupta, N., B. Sass, S. Chattopadhyay, J. Sminchak, P. Wang, and T. Espie. 2002. *Geologic Storage of CO_2 from Refining and Chemical Facilities in the Midwestern U.S.* Proceedings of the Sixth International Conference on Greenhouse Gas Control Technologies, Kyoto, Japan. October 1-4 (Also to be published in Special Edition of "Energy", 2003)
- Gupta, N., L. Smith, B. Sass, and C. Byrer. 2002. *Engineering and Economic Assessment of CO_2 Sequestration in Saline Aquifers*. Proceedings of the Sixth International Conference on Greenhouse Gas Control Technologies, Kyoto, Japan. October 1-4.