
Cooperative Agreement Number: DE-FE0002068

Hannes E. Leetaru
University of Illinois
Presentation Outline

• Project Overview
  – Goals and Objectives
  – Benefits of Program
  – Scope of Work
• Accomplishments
• Summary
• Backup Material
Benefit to the Program

Program goals.
Reduce storage risk by documenting the uncertainties related to natural fractures, injectivity, and geochemical interactions for the St. Peter Sandstone and Knox strata.

Project benefits statement.
This project delineates potential new geologic intervals for carbon storage in Illinois, Indiana, Michigan, and Western Kentucky, which will enhance the North American carbon storage resource potential.
Support the DOE program initiative to develop BPMs for site selection, characterization, site operations, and closure practices.
Project Overview:
Goals and Objectives

- Develop a Best Practices Manual that illustrates the methodology for reducing storage risks
- This Cambro-Ordovician project will highlight areas of high risk and low risk for carbon storage in the St. Peter and Knox strata in the Illinois and Michigan Basins.
- Show how seismic reflection data can be used to delineate high and low risk areas
- Study seals and reservoirs for faulting and fracture risk (geomechanical studies), as well as their interactivity and reactions with CO$_2$ in the presence of brine (geochemical studies).
Project Overview: Goals and Objectives

- Reservoir simulation of commercial injection into St. Peter and Knox to show carbon storage potential
- Perform CO$_2$ injection test in an existing well in Hancock County, Kentucky to evaluate injectivity of the Knox sandstone.
- Develop regional CO$_2$ storage resource estimates for the Knox and St. Peter for use in future version of DOE’s North American CO$_2$ Storage Resource Atlas.
Partners

- Illinois State Geological Survey
- Western Michigan University
- Indiana Geological Survey
- Kentucky Geological Survey
- Schlumberger Carbon Services
- Brigham Young University
Leverage Other Existing Projects

- State of Kentucky
- Illinois Basin Decatur Project
Operations
CO₂ injection test
Knox sandstone,
Sept. 20-21, 2010

Open-hole interval 5,038 – 5,268 ft
367 tonnes CO₂
3 bbl per minute
1,000 psi wellhead
2,538 psi final bottom hole pressure
Results of Kentucky Well Test

• $\text{CO}_2$ storage well comparable to the Marvin Blan No. 1 would require approximately 103 surface hectares to store 1 million tonnes of $\text{CO}_2$. 
Lithology and Stratigraphy
FMI Log
Core interval
(4540-4600)
Potosi lost circulation zone

Solution cavities

Core was recovered from Decatur, Illinois
Potosi

CT Scan

Geomechanical testing of core
Tuscola, Illinois
A real Example

• Since 1970, the Tuscola hazardous wells have injected 18 billion Gal of liquid (68 kl) into the Potosi
  – Equivalent to injecting more than 50 million metric tons of CO₂ into the Potosi
  – Still injecting equivalent to 60,000 tonnes per month of CO₂

• From an injectivity/ falloff test, the estimates of Potosi permeabilities were greater than 9000 mD
SW-NE cross section of St Peter Ss with interpretive fill from gamma-ray log
Acquisition of 140 miles of 2D Seismic Reflection Data

Seismic line

Manlove Area

Decatur Project
Faulting through the St. Peter Sandstone
Seismic Inversion: Density
St. Peter Sandstone

Top St. Peter

Top Knox

Verification #1 Well  CCS #1 Well
Potosi Lost Circulation Zone

VW2  VW1  CCS1
Geobody extraction
Injectivity
ASME Review Panel Recommendation

• NETL recommended that we increase the injection rate to 3.2 million tonnes per year for 30 years of injection and 100 years of simulation after injection ceases.

• The new simulations suggest that more realistic models with additional information do give significantly different results.
Models with different reservoir Properties

The three modeled St. Peter depths

- Base
- Mid
- Lower

Vertical Exaggeration: 10x

Elevation (ft, mean sea level)

CCS1_STP

Feet

Porosity

y = -0.0027x + 19.084

Depth (ft)
N-S and E-W oriented permeability cross-sections through Base, Mid, and Lower static models (15 mile by 15 mile).
CO$_2$ injection into Potosi. CO$_2$ plume plan view at the end of 20 years (injection rate of 2 million tonnes per year) has an approximate radius of 5 miles based on seismic and well data from Decatur Illinois.
Potosi plume extent during injection

injection rate (3.2 MTPA) could not be achieved before the end of the injection period. Estimated cumulative injection after 30 years from single well.
Potosi plume extent during injection

With one well it would 45% of the target volume

Will take two wells
Potosi plume extent during injection

27% of the 96 Mt injection target

Will take 4 wells
Containment

• Laboratory analysis of mineral and CO$_2$ interactions
### Before and After

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<th>VW1-4522.3’ Potosi Dolomite</th>
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*Clay Mineralogy from Orientated Clay Slide (% relative to each other)*

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### Duration

- **1 month**
- **1430 psi pressure**
- **43 C temperature**
Best Practices and Risk
Early Assessment

Knox Dolomite is too deep for economic CO₂ storage

Reservoir sealing rocks are too shallow to ensure CO₂ storage
Areas of high and low risk for St. Peter and Knox CCS projects

Each risk factor is a different GIS layer
Risk Evaluation for CO$_2$ Geosequestration in the Knox Supergroup

“Example Top Risks” polling feedback

Risks in executing a Knox CCS Project

- **Reservoir injectivity:** The key uncertainty is assessing the reservoir’s heterogeneity permeability. To complete a well with good integrity, the vugs must be cemented, which increases uncertainty in well log measurements. Means to further understand the dual porosity / dual permeability nature of the Potosi are strongly advised.
- **CO$_2$ plume monitoring:** Current modeling shows far-traveled migration and plume route may be tortuous. Monitoring may become very expensive.
- **Wellbore integrity:** Lost circulation events suggest possibility of a leakage pathway, though thick (900 feet) of overlying dolomite reduce the risk of contamination of shallower aquifers.
- **Caprock:** The seal may effectively be the 900 feet of overlying dolomite, which will complicate the monitoring scheme.
Resource Estimates
St. Peter Sandstone
Geological Carbon Storage Resource Estimate
14.7 – 47.6 Gt (@ p_{10} and p_{90})
Illinois Basin St. Peter Sandstone CO$_2$ Storage Resource
Improving resource estimation through enhanced characterization

Method 1: mean porosity
Method 2: variable porosity model
Method 3: net porosity analysis

storage resource estimate range of 12.2 to 39.7 Gt.
Gross thickness of the Knox Group

The resulting storage resource estimates are 10 to 131 gigatonnes for the Upper Knox unit and 8 to 115 gigatonnes for the Lower Knox unit.
Accomplishments to Date

- Developed a Best Practices Manual that illustrates the methodology for reducing storage risks
- Highlight areas of high risk and low risk for carbon storage in the St. Peter and Knox strata in the Illinois and Michigan Basins.
- Showed how seismic reflection data can be used to delineate high and low risk areas
- Evaluated seals and reservoirs for faulting and fracture risk (geomechanical studies), as well as their interactivity and reactions with CO$_2$ in the presence of brine (geochemical studies).
Accomplishments to Date

– Reservoir simulation of commercial injection into St. Peter and Knox illustrating injectivity and storage potential
– Performed CO$_2$ injection test in an existing well in Hancock County, Kentucky to evaluate injectivity of the Knox sandstone.
Summary

– Key Findings
  • Both the Knox and the Potosi are viable targets for CCS

– Lessons Learned
  • Karst type systems such as the Potosi would have unpredictable plume migration pathways

– Future Plans
  • Complete the final and topical reports
Appendix

– These slides will not be discussed during the presentation, but are mandatory
Organization Chart

Hannes E. Leetaru
Principal Investigator
Coordinate entire project
and mapping of St. Peter
and Knox in Illinois

David Barnes
Western Michigan University
Michigan Basin analysis of
St. Peter and Knox

John Rupp
Indiana Geological Survey
Final regional maps and
cross sections

Scott Marstellar
Schlumberger Carbon
Services
Operations at Decatur, Illinois
including specialized seismic
processing, core retrieval,
and core analysis

John McBride
Brigham Young University
Seismic interpretation and
visualization

David Harris
Kentucky Geological Survey
Operations at Blan well in
Hancock County, Ky
## Project Gantt Chart

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– David A Barnes, Stephan Zdan (2014), Regional CO2 storage resource assessment in a geologically complex, deep saline aquifer, the Middle Ordovician St. Peter Sandstone, Michigan Basin, USA. Greenhouse Gas Control Technologies, GHGT-12, Oct. 5-9, Austin TX. Abstract accepted, conference proceedings paper, in prep.


Bibliography (Michigan)


Bibliography (Michigan)


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