

Quarterly Report

Grant No. DE-SC-0001761

Report period: From June 30, 2010 to September 30, 2010

1) Project activity during this quarter

(a) Planned activities

1. Development of data archive and resource center
 - Create statewide digital databases for samples and well records for Michigan's geological formations relevant to CO₂ storage, containment and potential for enhanced oil recovery
 - Accumulate data with which to construct maps and tables of physical properties
 - Implement internal data share (intranet) to facilitate compilation of information into a digital atlas
2. Conduct technical research on CO₂ sequestration:
 - Conduct basic and applied research to characterize Michigan saline reservoirs for CO₂ storage potential volume, injectivity and containment
 - Integrate any new data from wells drilled primarily by the oil and gas industry.
3. Data acquisition and software implementation to conduct geologic and fluid flow modeling to address specific predictive uses of CO₂ storage and enhanced oil recovery, including:
 - Compile data for geological and fluid flow models
 - Formulate models, integrate data, and run the models
 - Apply models to specific predictive uses of CO₂ storage and enhanced oil recovery
4. Establish effective technology transfer to members of industry and governmental agencies by:
 - Establish an Internet Website at which all data, reports and results will be accessible (site usage statistics will be maintained)
 - Introduce MICHCARB programs at industry and governmental workshops and meetings
5. Create and deploy educational materials for public outreach
 - Construct physical demonstration models and displays that can be used in outreach and other educational events
 - Work with partners in Michigan geo-resource industries, energy utility companies, State and local governments, K-12 classrooms and teachers and public groups

(b) Actual activities: All planned activities were conducted and good progress was made as described in detail in attachments.

2) Results achieved on the project during this QPR time period

(a) Results planned consisted mainly of:

- See *Planned Activities* 1) (a) 1-5, above.

(b) Results consisted of:

- See Attachments 1-5, *Reports on Planned Activities and Press Release*

- 3) **Activities which went better or worse than expected:**
 - (a) Digital data atlas challenges continue in coordinating and managing data produced by multiple users with varying types of formatting needs, while still maintaining data integrity. This is an ongoing issue which we are addressing through software and experience.
 - (b) Installing and integrating Petrel and ECLIPSE packages from Schlumberger as well as additional computer modeling software from Computer Modeling Group has been time consuming, but we largely accomplished that task.
- 4) **Project problems, solutions and changes during the quarter--**No significant problems occurred this quarter. Implementing the digital asset management system was a change, and one which will foster our interrelational datasets.
- 5) **Other topics of interest:** Please see attachments
- 6) **Status of project at end of period:** Project is on time and on budget to date.

Authors: David A. Barnes and William B. Harrison

Date: November 9, 2010

Please see following Attachments 1-5.

Attachment 1 Report on *Establishing the Resource Center at MGRRE*

- **Developing statewide and site-specific digital research databases—Data added this quarter:**
 - Core analysis data (largely porosity and permeability data)—hand entered from paper records 53 wells
 - Mudlogs—43 scanned and added to database
 - Wireline logs—inventoried 930 donated logs to be added to database
 - Cuttings—We have now inventoried about half of the State Geological Survey’s cuttings collection, obtained during the last 80 years. We estimate this inventory will be complete by next April.

- **Compiling all information into a digital atlas**

A. We are in the process of evaluating new software (Avamar) for remotely backing up data for off-site storage and recovery. On-site backups have been partially automated with full backups scheduled once weekly and incremental backups conducted daily. We continue to review new software and tools to help us in the creation of a unified data network. Challenges include coordinating and managing data produced by multiple users with varying types of formatting needs, while still maintaining data integrity. Project goals include defining and documenting the processes associated with managing the many versions of data so as to ensure that the most current and accurate data is available to users. Technical issues which need to be addressed is the creation of a comprehensive catalog system for core, log, and related geographic data which supports direct attribute-based querying and searching of all available data existent across and within database schema.

B. We continue to implement our digital asset management system (DAMS), working primarily with the State’s cuttings collection.

C. Establishing MichCarb’s Web site—please see attachment 5.

Attachment 2 Report on Technical Research on CO2 Sequestration and Enhanced Oil Recovery

- **Technical Research on CO2 Sequestration**

- Dr. Barnes and Hampton supervised geological characterization research activities that were conducted by graduate research assistants (Farsheed Rock and Kyle Patterson) with a focus on 2 important saline reservoir sequestration targets in Michigan:
 1. Cambrian Mount Simon Sandstone
 2. Devonian Sylvania Sandstone
- See also Attachment 3 below.

Attachment 3 Report on Conducting Geologic and Fluid Flow Modeling

- **Dr. Hampton focused on three goals:**

1. Working with graduate students Tony Clark, Amy Manley, Kyle Patterson, and Farsheed Rock to help them accomplish project goals, including conceptual geologic model formulation, deployment of modeling software, such as STOMP, and general guidance and coordination.
2. Acquiring new modeling software, including Petrel, ECLIPSE, and GEM.
3. Helping Tony and Farsheed complete their paper for presentation at the Eastern Section meeting of the American Assoc. of Petroleum Geology on Tuesday, Sept. 28. **Numerical Simulation of Carbon Sequestration in the Sylvania Sandstone**, Anthony Clark, Farsheed Rock, Drs. Barnes and Hampton worked with Tony Clark and Farsheed Rock

- **Results: All three goals were accomplished and work continues on goal 1.** As for goal 2, we have acquired the Petrel and ECLIPSE packages from Schlumberger, and are in the process of installing them. We also received GEM from Computer Modeling Group, and will install it soon. This GEM software will likely be our main modeling software in the future. The 30-minute oral presentation at ES AAPG was successful. Tony is refining one of the simulations he reported so it could be part of a paper to be submitted for publication. Farsheed and Kyle are wrapping up their work as well. At the ES AAPG conference, Dr. Hampton met with Joel Sminchak of Battelle Ohio, which is in charge of our DOE Arches grant. We reached an agreement on what Amy would do for her work as part of that grant. We will model a site in the Mt. Simon in Michigan, and do a geomechanical study in conjunction with a traditional model of CO2 injection. Battelle, in turn, will pay for core analysis to obtain parameters needed for that research. We will use GEM to investigate the limits of injection pressure before damaging the mechanical integrity of the storage layer and the capping layer.

In conclusion, we have made noteworthy progress toward achieving project objectives during the last calendar quarter.

Attachment 4 Report on Technology Transfer to Members of Industry and Governmental Agencies

- **Disseminating information about MICHCARB/accelerating the deployment of CC&GS in Michigan**
 - See Attachment 3 above.

Attachment 5 Report on Outreach to Industry, the General Public and K-12 Community

- **Outreach to the general public.**

- Lolita Krievs worked with Stephanie Ewald and MGRRE faculty and staff to make significant progress in establishing an online presence for MichCarb at <http://wsh060.westhills.wmich.edu/MichCarb>. Serving as an informational hub for the general public is a primary goal. Toward accomplishing that goal, hundreds of "carbon sequestration" web pages and resources were reviewed for design layout, descriptive

content and instructive clarity. Resources were selected for two primary groups, each with seven subgroups:

Primary group	Subgroups	Associated Links
Online resources available world	Resources	Glossaries, link lists, frequently asked questions (FAQs), geographic/geologic software and software tools
	Partnerships	Regional, international, and governmental organizations
	News	Sites to news related to carbon sequestration and dynamic news feeds with automated update capabilities
	Data	Project databases for CO2 emissions, greenhouse gas inventories, global carbon budgets, climate monitoring and fossil energy research
	Publications	Reports published by the United States Congress, U.S. Geological Survey, and the International Energy Agency; related journal articles, conference proceedings and workshop presentations
	Multimedia	Videos describing carbon capture and storage technologies, demonstration projects, global summits, symposia sessions, professional interviews, and animated learning series
MichCarb at Western Michigan University	Home About Mission Contact Research People Photos	These sites describe who we are, what we do and what we would like to accomplish

In summary, we are striving to lay down a solid foundation upon which to build our information systems. Future plans include

- (1) continued web content development, update and maintenance
- (2) review of statistical packages to help us understand who is visiting our web site and what they are looking for and
- (3) continued review of related software packages and technologies for database development, management and update.

Outreach to industry:

- New posters (see below) were created for display at the **Eastern Section AAPG meeting** in Kalamazoo in September 2010 and were viewed by many petroleum geologists and university students. Posters will be used for other exhibits for adult audiences and also at K12 science fairs.
- Eastern Section AAPG meeting MichCarb Booth: Preexisting EOR display and porosity permeability displays were available along with new posters. Many documents on GCS and Climate Change were available for visitors to examine at the booth, and some were available as takeaways.

What is MichCarb?

MichCarb is a center for research and education focused on **geological carbon sequestration** or **GCS**, a technology for using subsurface rock formations to permanently store carbon dioxide captured from a point source, such as a coal burning power plant.

MichCarb, funded by the U.S. Department of Energy, is a project of the Michigan Geological Repository for Research and Education (MGRRE), part of Western Michigan University's Geosciences Department.


MichCarb's mission is to accelerate deployment of safe carbon capture and geological sequestration in Michigan.

MichCarb Objectives

- Create a data archive and resource center at MGRRE
- Conduct technical research on CO₂ sequestration and enhanced oil recovery
- Conduct geologic and fluid flow modeling to evaluate site specific use of GCS and enhanced oil recovery.
- Effect technology transfer to members of industry and governmental agencies.
- Create a geological carbon sequestration outreach and education center for Michigan at MGRRE.

Why Store Carbon Dioxide?

- > Climate scientists have determined that Earth is currently warming
- > Strong evidence indicates that it is very likely that most of the warming observed over the past 50 years can be attributed to human activities.
- > Greenhouse gas (GHG) emissions, especially CO₂ produced by the combustion of fossil fuel for energy and transportation, are the chief contributors to this process.



- > There is a pressing need to substantially reduce GHG emissions as soon as possible.
- > There are many ways to reduce GHG emissions:
 - Increase energy efficiency and conservation
 - Develop alternative energy sources such as nuclear, wind, solar, biomass, etc.
 - Develop "clean" fossil fuel technologies such as less carbon intensive fuels, and carbon capture and storage.
- > Coal fired electric power generation has comprised nearly 80% of total generation in Michigan in the recent past.
- > Renewable energy technologies currently constitute about 4% of total electric power generation, and although renewable and low/no greenhouse gas emissions technologies are growing rapidly, Michigan will rely on coal for substantial electric power generation for decades.

Visit MichCarb at: <http://wsh060.westhills.wmich.edu/MichCarb/index.shtml>

GCS in Michigan – We Can Do It Here!

Michigan's subsurface geology is especially suited for geological carbon sequestration because of very deep porous rock formations to hold the carbon dioxide and overlying impermeable layers, or caprock, that seal the reservoir.

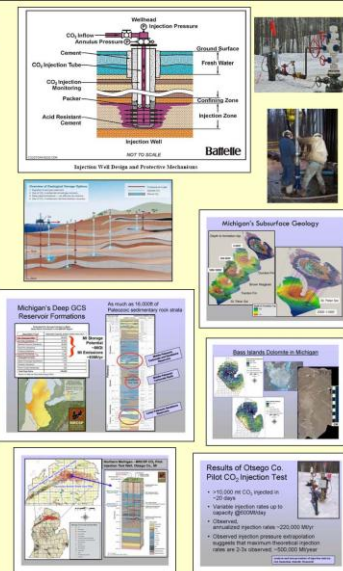
The petroleum industry has used carbon dioxide for enhanced oil recovery operations (EOR) for many years, so much is already known about the storage and containment potential of Michigan's rocks.

A test well was drilled in November 2006 by the Midwest Regional Carbon Sequestration Partnership (MRCS)P (www.mrcsp.org) in Otsego Township, MI. The research team applied for and received a Class V Experimental Technology, Underground Injection Control permit from US EPA Region 5 in 2007, and just over 10,000 tons of CO₂ were injected into a deep saline reservoir over a six week period starting in February 2008.

The test site is located at the northern rim of the Michigan Basin, an area of active enhanced oil recovery projects and natural gas processing plants. CO₂, which is a byproduct of natural gas production, periodically is used for enhanced oil recovery in the Niagaran Reefs. The host for this test was DTE Energy, which owned the gas processing plant that supplied the CO₂ for the test. The operator and lease holder of the test well site was Core Energy.

The team was able to test innovative monitoring methods including repeated cross-well seismic tests. An additional 50,000 tons of CO₂ was injected by July of 2009 into saline formations (known as the Bass Islands Dolomite) located adjacent to the Niagaran Reefs.

Detailed information on this ongoing project is available on the MRCS)P website at www.mrcsp.org.



The collage includes: a cross-section diagram of a well showing CO₂ injection, fresh water, and injection zones; a map of Michigan's subsurface geology; a map of the Bass Islands Dolomite; a photo of a well site; and a diagram of the Otsego CO₂ injection test results.

- Dr. Barnes was an invited speaker and Co-Convener/Session Co-Chair of the AAPG Geosciences Technology Workshop (GTW); Carbon Capture and Sequestration: New Developments and Applications, Case Studies, Lessons Learned. Title of Presentation: A Reservoir Geologists Approach to Characterization of Geological Sequestration Targets.
- Dr. Barnes was a delegate and presenter of peer reviewed paper at the tenth International Greenhouse Gas Control Technologies Conference (GHGT-10); Amsterdam, Netherlands; Combined Sustainable Biomass Feedstock Combustion, CO₂/EOR, and Saline Reservoir Geological Carbon Sequestration in Northern Lower Michigan, USA: Towards Negative CO₂ Emissions, Co-Authors: Robert E. Froeseb, R.G. Mannesc, and Brain Warnerd (bForestry Res. and Env. Sciences, Michigan Technological University, Houghton, MI, cCore Energy LLC, Traverse City, MI, and dWolverine Power Cooperative, Cadillac, MI.
- Farsheed Rock gave a professional oral presentation at the AAPG Eastern Section, Titled: Regional Geological Sequestration Potential of the Middle Devonian Sylvania Sandstone, Michigan Basin, USA.
- **Outreach to the K-12 community**
 - **Partnership development**
 - MGRRE's K-12 Outreach Program, CoreKids, has continued to establish new partnerships with K-12 schools, scouting groups and other youth organizations which are now part of MICHCARB's network.
 - **Creation of Educational Materials**
 - Posters about climate change and geological CO₂ sequestration and model of EOR remains on display at MGRRE for all visitors to observe.
 - CoreKids' K12 carbon sequestration website (<http://www.wmich.edu/corekids/CarbonDioxideSequestration.html>) continues to be visited via Internet searches. CoreKids website now links visitors to the official MichCarb website.
 - **Dissemination of educational information on GCS**
 - Teacher Workshop: CO₂ sequestration and EOR were major topics included in Keystone Science School Climate Status Investigations teacher training held at

WMU July 27-28, 2010. Approximately 40 teachers from around the state of Michigan participated. In addition to labs on EOR/GCS, Dave Barnes was guest speaker.

- Keystone Science School held 2nd Youth Policy Summit in partnership with CoreKids, MGRRE and MICHCARB July 24-29, 2010. Forty high school students and their teachers spent a week discussing energy related issues, including CO₂ sequestration, and came to consensus on recommendations to be made public. This document (pages 16-19 of 62 cover GCS) can be accessed at http://youthpolicysummit.org/images/Reports/2010_michigan_final_report_web_quality.pdf.
- Since July 1, 2010, outreach staff has presented CO₂ sequestration educational content to:
 - July 8, 2010: Teacher Professional Development Workshop; Grand Valley State University, Middle and High School teachers
 - July 13-14, 2010: Kalamazoo Communities in Schools (KCIS) summer program students, 120 students grades 1-5; 80 students grades 6-8.
 - July 15, 2010: Kalamazoo Nature Center Summer Camp, 20 students grades 4-8.
 - July 24-29, 2010: Youth Policy Summit – students studied GCS as one piece of their recommendations on “Energy Innovation in Michigan.”
 - July 27-28, 2010: Dave Barnes presented to teacher workshop at Keystone Science School’s CSI: Climate Status Investigations teacher training. 40 middle and high school teachers from across Michigan.