

Quarterly Report

Grant No. DE-SC-0001761

Report period: From April 1 through June 30, 2011

1) Project activity during this quarter

(a) Planned activities—continued to

1. Develop 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. Acquire data and implement software 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. Conduct technology transfer to members of industry and governmental agencies
 - Establish an Internet Website at which all data, reports and results will be accessible (site usage statistics will be maintained)
 - Introduce MICHCARB programs to industry and government at workshops and individual meetings
5. Create and use 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 in items 1 through 4 above were conducted and good progress was made as described in detail in attachments. Because of personnel loss, we were not able to conduct some activities for item 5. See Attachments 1-5, *Reports on Planned Activities*

2) Project problems, solutions and changes during the quarter

(a) We have applied for a no-cost extension for one year so that we can incorporate the results of four related geological carbon sequestration assessment projects the team has undertaken. Those projects began shortly after MICHCARB was funded. Results from those projects add significant technical content to our overall MICHCARB goal of accelerating the deployment of geological sequestration in Michigan. With an extension, we will be able to complete all of the tasks established for MICHCARB.

(b) Because our collections of specimens and data are growing so rapidly, server users have begun to experience unacceptable waiting times for data requests. We have now completed an analysis of server needs and have designed a server which will accommodate very large data collections and process requests quickly. We expect to have this on-line next quarter.

(c) We needed access to some cores currently archived in Texas to complete our reservoir studies. We applied for and received a grant to bring those cores to this facility and will house them here. We are looking forward to conducting research on these cores in the fall.

(d) Working with a large set of cores, we working to improve our metadata accuracy by individually hand-checking 37,000 core boxes with more than 150,000 feet of core.

(e) We are developing standardized guidelines by which this data can be quantified and described so it can be used with other analytical and geospatial software programs.

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Date: June 15, 2011

Please see Attachments

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 for 121 wells
 - Core gammas scanned for 231 wells and now compiled in a dataset which we will place on-line for the first time next quarter
 - Mudlogs—53 scanned and added to database
 - Wireline logs—inventoried 115 donated logs to be added to database
 - Cuttings—we have now completed our inventory of the State Geological Survey’s cuttings collection, obtained during the last 80 years. These cuttings are from every formation in Michigan. These are often the only physical samples available from wells. They are now fully searchable on-line and available in-house for the first time
 - Cuttings—one pallet of cuttings was donated to MGRRE from Chesapeake. Those have all been inventoried and bar coded, adding 53 wells to our cuttings dataset
- **Acquiring funding for additional cores**
 - We applied for and received a grant from industry to transport at least two 53-foot truckloads of Michigan core to our facility. Those cores are currently archived in Texas where they are largely unavailable to Michigan industry. Many of these cores represent the Glenwood/St. Peter/PdC formations. We plan to produce reservoir property data from these rocks to evaluate their perspective use in CO2 sequestration.
- **Compiling all information into a digital atlas**

As part of our work toward building a comprehensive database for our physical samples and well records, we are continuing to resolve issues concerning descriptive formats, data quality, and types, unite sample data with related documentation from other sources, and add new data to our inventory and collections.

- As our data stores increase and our collections grow, requests for our data are also increasing, resulting in much heavier server loads. This is beginning to cause a longer “lag time” for users as they wait for tasks to complete. To address this issue we have:
 - Completed a preliminary estimate for minimum and maximum server load potentials
 - Considered new server designs to accommodate larger amounts of data and greater recovery speed
 - Considered not only current demand but also allowed for future growth and enhanced data exchange capabilities

We anticipate having a new server in place and fully operational by the end of next quarter to address all these considerations.

- We are improving metadata accuracy for our cores. For the MICHCARB work alone, we are working with more than 37,000 core boxes containing more than 150,000 feet of core from more than 1000 wells. Challenges we are overcoming involve:
 - Uncovering the metadata and assessing its validity cannot be automated: each piece of data must be individually acquired and verified
 - Some of the core boxes arrived without documentation
 - Some of the documentation misidentified cores and footages
 - Some core boxes have yet to be opened to verify their contents
- Issues posed by this dataset include developing standardized guidelines by which this data can be quantified and described so it can be used with other analytical and geospatial software programs.

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

- Technical Research on CO2 Sequestration
 - Drs. Harrison and Barnes together with graduate students Kate Pollard and Stephen Zdan are working on geological characterization of the Sylvania Sandstone and related strata. Core descriptions and thin-section studies will provide important control on geological facies models and constrain conceptual models of brine reservoir geometry.
 - Farsheed Rock, a graduate student research assistant, completed his Masters of Science thesis “Investigation of Carbon Sequestration Potential of the Middle Devonian Sylvania Sandstone, Michigan Basin, USA” and graduated in May, 2011. Farsheed’s work set the stage for our determination of CO2 storage capacity in Michigan and established this subsurface formation as a major sequestration target. Much of this work involved the petrophysical interpretation of subsurface well log data.
 - Together with co-authors Katherine Pollard and David A. Barnes, Farsheed submitted an abstract, “Geological Controls on Geological Carbon Storage Capacity, Efficiency, and Security in the Middle Devonian Sylvania-Bois Blanc Saline Aquifer, Central Lower Michigan, USA.” That paper will be presented at the 2011 Eastern Section AAPG meeting in Washington, D.C., Sept. 25-27.
 - Kyle Patterson, a graduate student research assistant, completed his Masters of Science thesis, “Geologic Controls on Reservoir Quality and Geologic Carbon Sequestration Potential in the Upper Cambrian Mount Simon Sandstone”, and graduated in May, 2011. This work established the basic geological and petrophysical properties of the most important geological sequestration target in Michigan, the Mount Simon Sandstone. Kyle’s geological models, both local and regional are important starting points for CO2 injection simulation modeling in this important sequestration target in Michigan.
 - Dr. Harrison has been compiling production history data from Niagaran reef fields to calculate recovered volumes of oil, natural gas and water from over 1000 individual reef fields. This compilation will enable us to estimate the potential additional recoverable oil and gas from these fields using CO2 EOR.
 - Dr. Harrison has also compared the few current CO2 EOR projects (6 total) with several secondary recovery projects using water-flooding or re-injecting produced gas.
 - Dr. Harrison notes that Niagaran reefs in the Michigan Basin have already produced more than 500 million bbls of oil and 3 trillion cubic feet of natural gas. He estimates that number represents about 25% of the original oil in place, so it may be possible that EOR in these reservoirs could produce another 200 million bbls of oil or more.

Attachment 3 Report on Conducting Geologic and Fluid Flow Modeling

- Dr. Barnes and Farsheed Rock discovered and acquired well core from four brine extraction wells in Midland, Michigan. These were previously held in a private collection by a minerals operator. We became aware of the cores because we uncovered core analyses from them in public records. These cores and core analysis data are the best collection of material representing the Devonian Sylvania Sandstone and related strata, an important brine aquifer in the Michigan basin. In order to produce core data that is critical to high resolution flow modeling of CO2 injection in the Sylvania Sandstone:
 - Drs. Barnes and Harrison supervised slabbing and sampling of these cores
 - We sent samples to the Center for Multiscale Reservoir Modeling and Characterization at Texas Tech University (TTU)
 - We requested that Dr. Shameem Siddiqui and his students at TTU conduct Micro-CAT scans and acquire relative brine/CO2 permeability data

- Dr. Hampton continued to focus on conceptual geologic model formulation, deployment of modeling software, e.g., STOMP, and general guidance and coordination. He
 - Worked with Tony Clark to solve problems with his injectivity simulation models for the Sylvania Sandstone Formation in Michigan
 - Continued to work with graduate students Kyle Patterson, and Farsheed Rock to help them accomplish these project goals
 - Corresponded with Joel Sminchak of Battelle Memorial Institute concerning the details of what graduate student Amy Manley and he planned to include in their geomechanical simulation of CO₂ injection into the Mount Simon sandstone
 - Worked with Dr. Barnes, John Rupp of Indiana Geological Survey, and graduate student Amy Manley to determine appropriate and prospective geomechanical core tests to be conducted by Dr. Shameem Siddiqui of TTU
 - Delineated anticipated follow-up on geomechanical tests to be performed at Weatherford Labs
 - Attended the Arches project meeting with Dr. Barnes at Houston Woods State Park, Ohio, where he gave a PowerPoint presentation about his plans for geomechanical simulation of CO₂ injection in the Mount Simon sandstone in southwestern Michigan

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**
 - Dr. Barnes met several times with colleagues from Consumers Energy to discuss potential CO₂ sequestration.
 - Dr. Barnes had several conferences with personnel from Core Energy concerning on-going CO₂ injection by that group in the Niagaran Reef trend.
 - Dr. Harrison met with representatives of private industry to discuss potential EOR opportunities using CO₂ derived from Michigan ethanol plants. Industry was interested and is developing a business plan using two existing ethanol plants and flooding Niagaran reefs.
 - Dr. Harrison also answered an industry inquiry about developing some existing reefs that are nearing depletion through primary production, possibly using CO₂ sequestration.

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

- **Outreach to industry and the general public.**
 - MICHCARB's WebPages received 1300 visitors. We had 1400 specific requests for data, which is 50% more than last quarter. We continue to review, revise, update and standardize our on-line datasets. This process is detail intensive and time consuming, but we are making headway.
 - We have identified key wells of interest and are working diligently to coordinate, validate, and share information from these wells with geologists, students and the general public.
- Outreach to the K-12 and higher education community—because of personnel loss, we were not able to conduct these activities this quarter.