

Carbon Dioxide Injection into Shallow Sedimentary Aquifer Systems to Assess Potential Degradation of Groundwater Quality at Geological Carbon Sequestration Sites

(Project No. 4265)

Periodic Report No. 4, Period covered: Feb 1 2011 – May 1, 2011

**Principal Investigator: Bridget Scanlon
Co-Principal Investigator: Changbing Yang**

Bureau of Economic Geology, University of Texas at Austin

Project Start Date: 5/1/2010 End Date: 5/30/2012

Participating Utilities: Mr. Broussard, Lafayette Utilities, Louisiana; Mr. Coleman, City of College Station, Texas; Mr. Hovsepian, City of Houston, Texas; Mr. Hunsinger, East Bay Municipal Utility District, CA; Ms. Owen, Tampa Bay Water, Florida.

Project Funding: \$235,008

Project Objectives of this study are to (1) assess impacts of CO₂ leakage on groundwater quality using field studies based on push-pull tests in shallow sedimentary aquifers at a geological carbon sequestration site in the Gulf Coast, (2) conduct laboratory batch experiments to determine impacts of CO₂ on major and trace elements, (3) simulate test results to assess mechanisms dominating mobilization of major and trace elements in the event of a CO₂ leak, (4) evaluate which geochemical parameters are most diagnostic of CO₂ leakage into underground sources of drinking water (USDWs), and (5) communicate study results to water utilities and regulators.

II. Status Summary

Because of delays in conducting the field push-pull tests, we conducted additional laboratory batch experiments. We hope to obtain permission for conducting the push-pull tests in the fall of 2011.

II. 1. Summary of Work Tasks Completed and Accomplishments

Task 1. We completed the batch experiments described in the original proposal; however, we conducted additional batch experiments with different rocks. Samples from the two original sites in the Gulf Coast were repeated in these experiments and additional rock and groundwater samples from the Edwards Aquifer near San Antonio and Brackenridge alluvial aquifer in Austin were included. During this reporting period batch experiments were conducted for the Helena, Cranfield, Brackenridge, and Edwards samples.

For the batch experiments, groundwater taken from the sites was used in the lab and reacted with CO₂ and sediments, instead of distilled water which was used in the batch experiments described in the literature.

Before conducting batch experiments, sediment samples were characterized using XRD. Mineralogic data show that sediment samples from the Cranfield site and the Helena site contain trace amount of carbonate. Edwards (Castle Hill site) contains 98% carbonate and Brackenridge sediments contain 17% carbonate. Surface area of sediment samples, which is a very important parameter for geochemical modeling, was also measured with the SA 3100 Surface Area and Pore Size Analyzer

A total of 121 water samples were taken for chemical analysis with ICP-MS method for cations and IC method for major anions and cations. In addition, alkalinity was measured in 56 water samples using a titration method. We are currently analyzing these samples.

Once CO₂ was introduced into groundwater, lowering of groundwater pH varied depending on the buffering capacity of the sediments, primarily depending on the amount of carbonates in the sediments. Groundwater pH decreased from 7.8 to 5.4 for the batch experiments with sediments from the Helena site, while groundwater pH decreased from 6.6 to 4.9 and then gradually increased after CO₂ was introduced for the batch experiment with aquifer sediments from the Cranfield site. In Brackenridge and Edwards batch experiments the pH decreased from 7.2 to 5.6 and from 7.4 to 5.4 respectively. Release of major ions was dominated by

dissolution of carbonates and silicate minerals whereas release of trace elements and metal elements was dominated by desorption. This last experiment is still going on and we will continue sampling the flasks in order to obtain three months of data collection period.

Task 2.

Modeling design of field push-pull tests for Task 2 was continued. In this reporting period, a scoping calculation using the numerical tool, CORE2D 4 (Yang, 2006; Yang et al., 2007a) were conducted to determine optimal approaches for conducting the push-pull tests. However, many of parameters used in the numerical model were obtained from the literature. Detailed results of these simulations will be provided in the next quarterly report.

Task 3.

Baseline characterization of regional groundwater chemistry of the shallow aquifer for Task 3 at the Cranfield site has been completed. Regional groundwater chemistry is dominated by silicate mineral weathering which is supported by XRD mineralogic analyses of aquifer sediments obtained from wells drilled at this site. Groundwater pumpage is minimal at this site, with only a few water wells used for domestic supply.

We are working with a company, Intelligent Optical Systems, Inc. (IOS), based in California for using the newly developed sensors to measure dissolved carbon dioxide in groundwater. The sensors are based on optical fibers coated with doped polymers and designed specifically for spatially resolved shallow water monitoring of carbon dioxide during and after geological sequestration. IOS has demonstrated fiber optic segments coated with the new materials, sensitive to dissolved CO₂ in the range 0.5 to > 800 mg/L, and the potential of these sensors for long-term monitoring (their calibration parameters did not show any drift during the 50 days they were tested). IOS showed interests in the push-pull tests and would collaborate with us for measuring real-time dissolved CO₂ concentrations during the experiments.

Task 4. Simulate results of push pull tests

These simulations will be conducted once the push pull tests have been conducted.

Task 5. Communication

A web site was established to show the results of this study:

<http://www.beg.utexas.edu/gccc/wrf/>. The website is password protected.

We provided the website information to the participating utilities.

II.2. Assessment of actual versus planned progress for each task

The initial lab experiments for Task 1 were completed. However, we decided to conduct additional batch experiments with rock samples taken from representative aquifers in a karst system. The batch experiments will be continued in the next reporting period. Task 2 on modeling design of the push-pull tests was scheduled to be finished in this reporting period; however, it is behind schedule because some model parameters are required from the results of batch experiments and the field push-pull tests have been postponed because of permitting issues until fall 2011. The overall progress of the each task is summarized in Table 1.

II.2. Tasks proposed to be completed in the coming period

In the coming period, data analysis and geochemical modeling of batch experiments in Task 1 will be completed. Modeling design of push-pull tests for Task 2 will be finished. Preparation for field push-pull tests will be initialized.

II.2. Problems encountered

The main problem is permitting issues related to conduction of field push pull tests. We anticipate that we will obtain the permits in Fall 2011.

II.3. Rational for proposed changes (if any) to the scope of work

There are no significant changes to the scope of work. However, four sets of batch experiments (one for the aquifer sediments taken from the Helena site, TX, one for the aquitard sediments from the Cranfield site, one from a shallow alluvial aquifer in Brackenridge in Austin, one from the Edwards aquifer near San Antonio, were not described in the scope of work. We think the four additional batch experiments will provide very valuable information for understanding impacts of CO₂ leakage on shallow groundwater quality and for addressing the following comment from the PAC.

Can the project team provide guidance on how the results of the testing might be applicable to other sites within the US? I'm concerned that the results may be so project specific that we won't be able to draw conclusions for any other aquifers.

II.4. Presentations, papers, reports

Changbing Yang gave a talk on using groundwater geochemistry for leak detection at a carbon sequestration site on TCEQ 2011 trade fair, Austin, TX, May 3-4, 2011 (see attached presentation).

Table 1 Research status of project 4265

| Tasks | | | Past | | | Current | Ongoing | | | | | |
|--------|---|-------------|--------------------|--------------------|--------------------|---|--|--------------------|--------------------|-----------------|-----------------|-----------------|
| | | | 05/2010-07/2010 | 08/2010-10/2010 | 11/2010-01/2011 | 02/2011-04/2011 | 05/2011-07/2011 | 08/2011-10/2011 | 11/2011-01/2012 | 02/2012-04/2012 | 05/2012-09/2012 | 10/2012-04/2013 |
| | | | Reporting Period 1 | Reporting Period 2 | Reporting Period 3 | Reporting Period 4 | Reporting Period 5 | Reporting Period 6 | Reporting Period 7 | Draft Report | Final Report | Project end |
| Task 1 | Conduct Lab experiments | Scheduled | [Grey bar] | | | [Red arrow from start of RP1 to end of RP4] | [Dotted red arrow from end of RP4 to end of RP6] | | | | | |
| | | Progressing | [Cyan bar] | | | | | | | | | |
| Task 2 | Model the design of field push-pull tests | Scheduled | | | [Grey bar] | [Red arrow from start of RP3 to end of RP4] | [Dotted red arrow from end of RP4 to end of RP6] | | | | | |
| | | Progressing | | | [Cyan bar] | | | | | | | |
| Task 3 | Conduct push-pull tests | Scheduled | | | [Grey bar] | [Red arrow from start of RP3 to end of RP4] | [Dotted red arrow from end of RP4 to end of RP7] | | | | | |
| | | Progressing | | | [Cyan bar] | | | | | | | |
| Task 4 | Simulate results of push-pull tests | Scheduled | | | [Grey bar] | | [Dotted red arrow from start of RP5 to end of RP7] | | | | | |
| | | Progressing | | | [Cyan bar] | | | | | | | |
| Task 5 | Communication | Scheduled | | | | | | | [Grey bar] | | | |
| | | Progressing | | | | [Cyan bar] | [Dotted red arrow from start of RP4 to end of RP7] | | | | | |