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

(Project No. 4265)

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Project Objectives of this study are to (1) assess impacts of CO_2 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 CO_2 on major and trace elements, (3) simulate test results to assess mechanisms dominating mobilization of major and trace elements in the event of a CO_2 leak, (4) evaluate which geochemical parameters are most diagnostic of CO_2 leakage into underground sources of drinking water (USDWs), and (5) communicate study results to water utilities and regulators.

II. Status Summary

II. 1. Summary of Work Tasks Completed and Accomplishments

The low temperature-low pressure batch experiment was stopped after ~4610 hours of reaction. Current work centers on graphically representing the data and preparing a manuscript for publication and inclusion in future reports. The low temperature, low pressure batch experiments include five different sedimentary samples, Edwards' limestone, Brackenridge sand, Helena sand, Cranfield sand, and Cranfield clay. Continued analysis of the batch experiment data has led to the conclusion that significant water rock interactions have slowed and calcite dissolution reactions have stopped or reached equilibrium.

The numerical model for designing push-pull tests was further improved by: 1) carefully checking charge balance of the initial and boundary waters; and 2) taking into account mineral dissolution/precipitation and adsorption/desorption. It should be noted that the numerical model was conducted to simulate five different synthetic cases (see previous quarterly report). However, this doesn't mean that the push-pull tests will be conducted for the five different simulated cases, particularly for the high regional hydraulic gradient. On the other hand, the numerical model provides valuable information that we need to consider when we design the field push-pull tests. The model presented in Task 2 (see previous quarterly report) is not the calibrated model. The model will be calibrated with data from the push-pull test.

Preparation of the push-pull test is underway. Purchasing majors parts for the instrumentation of the push-pull test is almost finished. The major parts used for conducting push-pull test are listed below.

Storage tank and conduit

A 325 gallon poly-ethylene tank was purchased for storing groundwater where CO_2 will be released and dissolved. Groundwater will be moved to and from the tank and circulated inside the tank by a network of PVC pipes. These pipes will also be fitted for inline water sampling and monitoring by water chemistry meters.

Pumping and circulation

A Grundfos pump will be used to pump groundwater from the test wells to the surface and into the storage tank. In addition to the Grundfos pump, we will have an 18 gallon/minute magnetic booster pump to circulate water in the storage tank so that CO_2 gas can dissolve into

groundwater and reach equilibrium with water in the storage tank under one atmospheric pressure.

The pH, temperature, and conductivity meter

The chemistry of the water will be monitored in the field to ensure the water has reached equilibrium. An in-line pH, temperature, and conductivity meter will be used to monitor these parameters while water is equilibrating with the 100% CO_2 atmosphere. Equilibrium will be assumed when the pH stabilizes at a value predicted by PHREEQC modeling of the groundwater chemistry in equilibrium with a 100% CO_2 atmosphere. During injection and sampling, these in-line meters will be used to monitor these basic parameters to ensure sampling is done when changes in pH, T, or conductivity occur.

Gas meters

The gas phase in the storage tank will be monitored with a Bacharach O_2-CO_2-temp meter to ensure the atmosphere in the tank remains at or close to 0% O_2 and 100% CO_2 during equilibration.

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

Table 1 lists the research status of this project. Lab experiments for Task 1 have been completed. Task 2 on modeling design of the push-pull tests was improved during the current reporting period. The major parts of the instrumentation has been purchased and integrated. Testing the system and conducting push-pull tests is scheduled in the next reporting period.

Table 1 Research status of project 4265

Tasks			Past					Ongoing			
			05/2010-07/2010	08/2010-10/2010	11/2010-01/2011	02/2011-04/2011	05/2011-10/2011	11/2011-01/2012	02/2012-04/2012	05/2012-09/202	10/2012-04/2013
			Reporting Period 1	Reporting Period 2	Reporting Period 3	Reporting Period 4	Reporting Period 5	Reporting Period 6	Draft Report	Final Report	Project end
Task 1	Conduct Lab experiments	Scheduled									
		Progressing									
Task 2	Model the design of field push-pull tests	Scheduled									
		Progressing									
Task 3	Conduct push-pull tests	Scheduled									
		Progressing									
Task 4	Simulate results of push-pull tests	Scheduled									
		Progressing									
Task 5	Communication	Scheduled									
		Progressing									

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

In the coming period, the following tasks will be conducted.

1) We will finalize the data from the batch experiments conducted in Task 1 and prepare the data for publication.
2) We will test the instrumentation for the push-pull test, the water storage tank, the pumping system, and the sampling system before the entire system is mobilized to the Cranfield, MS site. The local test site is located at the Brackenridge field lab at the University of Texas at Austin. The aquifer is shallow, with the water table ~4 m below land surface. Several wells have been drilled at the site, however, two new wells at depths about 7 – 10 m will be drilled to allow access for instrumentation. The diameter of existing wells is too small. The test is scheduled for mid-February.
3) We will conduct a hydraulic test at the Cranfield, MS site. The main objective of the hydraulic test is to obtain basic parameters, such as hydraulic conductivity, groundwater velocity, and regional hydraulic gradient. The test is scheduled for the end of February or early March.
4) We will conduct the push-pull test. Representatives from WRF will visit this experiment at the Cranfield site. The experiment currently is scheduled for April. Because the test site is on Denbury's property, a waiver form related to potential injuries from Denbury will be sent out to people planning on visiting the site for the experiment

II.2. Problems encountered

Currently, we have not encountered any serious problems.

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

Currently, we are following the proposed scope of work.

II.4. Presentations, papers, reports

We did not make any presentations or publish any results during the last reporting period.