the ENERGY lab

PROJECT FACTS

Carbon Sequestration

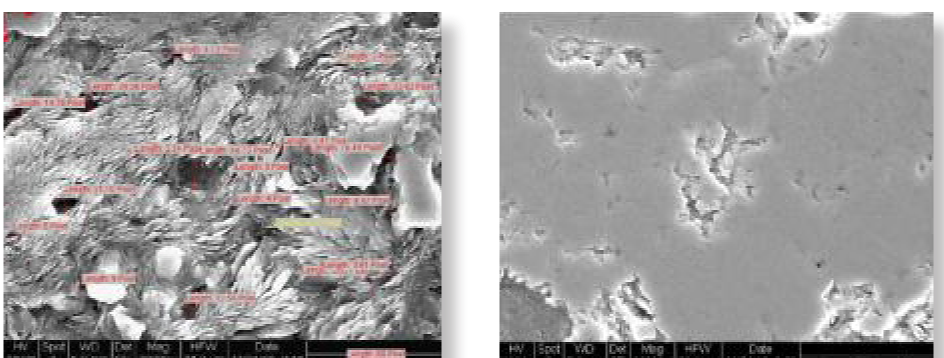
Interdisciplinary Investigation of CO_2 Sequestration in Depleted Shale Gas Formations

Background

The U.S. Department of Energy (DOE) National Energy Technology Laboratory (NETL) is currently funding research aimed to advance state-of-the-art technologies that address geologic storage of carbon dioxide (CO_2) in multiple formation types and across all phases of CO_2 geologic storage operations.

Geologic storage involves the injection of CO_2 into underground formations that have the ability to securely contain it over long periods of time. Research efforts are currently focused on several geologic storage formation types: deltaic, coal/shale, fluvial, alluvial, strandplain, turbidite, eolian, lacustrine, clastic shelf, carbonate shallow shelf, and reef. Basaltic interflow zones are also being considered as potential reservoirs. Organic shales can be found within multiple storage formation types. These formations contain different fluids such as saline water, oil and natural gas. A principal element of the DOE's Carbon Sequestration Program is Core Research and Development (R&D), and one of the R&D focus areas—geologic storage—is aimed at addressing the challenges of CO_2 storage in these formations.

Critical challenges identified in the geologic storage focus area include CO_2 well bore integrity, geochemical and mechanical responses, fluid flow and containment, and development of mitigation technologies. The ability to determine the feasibility of large-scale geologic CO_2 sequestration in depleted shale gas reservoirs is important when looking for alternative storage formations. Should sequestration in such reservoirs prove feasible, the number and total capacity of geologic formations for sequestration of CO_2 will significantly increase.



(a) (b)

Figure 1—Scanning electron microscope images of gas shale: (a) pores are 14-1590 nm in diameter and (b) silica rich regions with organic kerogen (darkly shaded) in the lower left corner. Smaller pores might be either a tip of either a larger pore body or a pore throat (constricture between two pore bodies).

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PARTNERS

None

PROJECT DURATION

Start Date

09/15/2010

End Date

09/30/2013

COST

Total Project Value

$1,436,694

DOE/Non-DOE Share

$1,147,612 / $289,082

Project Description

Stanford University is investigating the feasibility of geologic CO_2 sequestration in depleted shale gas reservoirs. Shale is one of the most common types of sedimentary rock, and is characterized by thin, horizontal layers of rock with extremely low permeability. Many shale types contain approximately 1–2 percent organic material in the form of waxy kerogen, which, along with the abundant clay in shales, provide an adsorption substrate for CO_2 storage similar to that in coal seams. Current shale-related carbon capture and storage research is focused on achieving economically viable CO_2 injection rates, given the shale's low permeability.

The potential for CO_2 sequestration in these formations is attractive for several reasons:

- Organic-rich shales are widely distributed
- Existing infrastructure of wells and pipelines, is available.
- Pore pressure in the shale formations prior to CO_2 injection will be reduced by gas production, thereby decreasing the potential for induced seismicity, which is potentially another problem in many saline aquifers.

The focus of this work is to determine how the physical and chemical processes associated with CO_2 storage in organic-rich shales affect injectivity and storage capacity (over long periods of time), and the ability of the shale to sequester CO_2 (as both a free and adsorbed phase) for thousands of years. This project elucidates mechanisms of CO_2 injectivity, the formation's geomechanical response, CO_2 transport through fractures and matrix, storage security through a trap and seal framework, and lays the foundation for accurate estimates of storage rates and capacity. Experiments provide data for the verification and validation of models to estimate CO_2 sequestration capacity and effectiveness of injection into gas shales under realistic conditions.

Goals/Objectives

The over-arching objective of the study is to conduct a series of multiscale, multiphysics, interdisciplinary laboratory and theoretical studies to assess the feasibility of using depleted organic-rich shale reservoirs for large-scale CO_2 sequestration. All rock sample analyses, simulations, and modeling will be performed at the laboratory facilities at Stanford University. The scientific objectives of this study are to determine how the physical and chemical processes associated with CO_2 interaction with organic-rich shales affect the following: (1) the ability to inject CO_2 over a long period of time, (2) the ability to store CO_2 as a free phase, and (3) the ability of the shale to adsorb and permanently store CO_2. Four main focus areas related to the utilization of organic shales as CO_2 geologic storage formations are addressed in this study:

- The physical and chemical interactions between injected CO_2 and shale within the pore spaces of the reservoir rock.
- Understanding how critical-state CO_2 migrates through hydrofractures (man-made fractures generated during injection well development), naturally occurring fractures, and pore spaces within the reservoir rock.
- The chemical interactions that occur between injected CO_2 and groundwater.
- Understanding how injected CO_2 is trapped and sealed within the reservoir rock.

These four areas address the principal scientific objectives of this work, which are to determine how the physical and chemical processes associated with CO_2 injection into organic-rich shales affect the ability to inject CO_2 over long periods of time, and the ability of the shale to store CO_2 for thousands of years. The study will include the examination of shales from a number of basins in the United States where shale gas is produced, including the Barnett shale, the Haynesville shale, the Woodford shale, the Marcellus shale, and Devonian age shales from the Illinois and Appalachian basins in Kentucky.

Benefits

This research may provide numerous benefits. If the research demonstrates the feasibility of using depleted shale gas formations for sequestration, the number of sites where sequestration of CO_2 can be carried out will increase dramatically as will the storage capacity of geologic formations to sequester large volumes of CO_2. Additionally, depleted shale gas reservoirs will already have much of the infrastructure (pipelines, wells, and developed well sites that were used to remove natural gas) needed to perform CO_2 injection available for immediate use.