PROJECT facts

U.S. DEPARTMENT OF ENERGY
OFFICE OF FOSSIL ENERGY
NATIONAL ENERGY TECHNOLOGY LABORATORY

Sequestration

03/2006

ANALYSIS OF DEVONIAN BLACK SHALE IN KENTUCKY FOR POTENTIAL CARBON DIOXIDE SEQUESTRATION AND ENHANCED NATURAL GAS PRODUCTION

CONTACTS

Sean Plasynski
Sequestration Technology Manager
National Energy Technology Laboratory
626 Cochrans Mill Road
P.O. Box 10940
Pittsburgh, PA 15236
412-386-4867
sean.plasynski@netl.doe.gov

William O'Dowd
Project Manager
National Energy Technology Laboratory
626 Cochrans Mill Road
P.O. Box 10940
Pittsburgh, PA 15236
412-386-4778
william.odowd@netl.doe.gov

Brandon C. Nuttall
University of Kentucky Research Foundation
Center for Applied Energy Research
201 Kinkead Hall, 2nd Floor
Main Campus
Lexington, KY 40506
606-257-0272

Background

Global climate change is an area of increasing concern, and many scientists believe the cause is due, at least in part, to increased emissions of CO_2, especially from the combustion of fossil fuels. These concerns are driving initiatives to develop carbon management technologies. One promising approach is geologic sequestration of CO_2. Options being investigated include sequestration in saline aquifers, oil and gas reservoirs, and unminable coal seams In analogy with sequestration in coal seams, another option may be sequestration in Devonian black shales, organic-rich rocks that serve as both a source and trap for natural gas. Most of the natural gas is adsorbed on clay or kerogen surfaces, very similar to the way CH_4 is stored within coal beds. It has been demonstrated in gassy a coal that, on average, CO_2 is preferentially adsorbed, displacing methane at a ratio of about one molecule of methane for two molecules of CO_2. Black shales may similarly desorb CH_4 in the presence of adsorbing CO_2. If this is the case, the black shales of Kentucky could be a viable geologic sink for CO_2, and their extensive occurrence in Paleozoic basins across North America would make them an attractive regional target for economic CO_2 storage and enhanced natural gas production.

Primary Project Goal

To test the hypothesis that organic-rich shales can adsorb significant amounts of CO_2 while releasing CH_4. This will be accomplished by examining core samples of Devonian shales for CO_2 adsorption capacity and developing a technique for estimating the CO_2 sequestration potential of shales in Kentucky.

Objectives

- To characterize the petrology, total organic content, and elemental composition of selected shale samples, and to correlate these properties with CO_2 adsorption capacity
- To determine CO_2 adsorption isotherms of these samples
- To determine the relationship between CO_2 adsorption and CH_4 desorption
- To locate zones within shale deposits that have high CO_2 adsorption capacities
- To delineate the vertical and aerial extent of these zones

PARTNERS

University of Kentucky Research Foundation

Kentucky Geological Survey

COST

Total Project Value
$532,966

DOE/Non-DOE Share
$364,453 / $168,513

ADDRESS

National Energy Technology Laboratory

1450 Queen Avenue SW
Albany, OR 97321-2198
541-967-5892

2175 University Avenue South
Suite 201
Fairbanks, AK 99709
907-452-2559

3610 Collins Ferry Road
P.O. Box 880
Morgantown, WV 26507-0880
304-285-4764

626 Cochrans Mill Road
P.O. Box 10940
Pittsburgh, PA 15236-0940
412-386-4687

One West Third Street, Suite 1400
Tulsa, OK 74103-3519
918-699-2000

CUSTOMER SERVICE

1-800-553-7681

WEBSITE

www.netl.doe.gov

Accomplishments

- 43 samples and two advanced well logs (ECS) were acquired and analyzed for this project.
- CO_2 and CH_4 adsorption isotherms indicate CO_2 is adsorbed at 5.3 times the volume of CH_4.
- Log analysis indicates TOC content of the shale can be estimated from density log data.
- A linear relation developed between TOC and CO_2 adsorption data indicates TOC data can be used as a proxy to estimate adsorptive capacity of the shale.
- It was determined that within the Devonian shale of eastern Kentucky, the Lower Huron Member of the Ohio Shale has the greatest CO_2 adsorption capacity.
- Whole rock cores are more representative of in-situ conditions expected in the subsurface, but the low permeability of shale resulted in flow-through and adsorption isotherm experiments that took longer than expected.
- Limited data (one sample) suggests adsorption isotherm data determined from whole rock samples are comparable to that data derived from powdered drill cuttings.
- Limited data (four samples) from the Illinois Basin suggest the Devonian New Albany Shale has adsorption characteristics similar to those of the Ohio Shale of the Appalachian Basin.
- Estimates using the distribution of gas storage capacity of CO_2 from TOC data indicate a sequestration capacity of 6.8 billion tonnes in the five-county area of the Big Sandy Gas Field of eastern Kentucky.
- Assuming a conservative thickness weighted average adsorption capacity of 40 scf/ton (at 400 psia), as much as 28 billion tons total in the deeper and thicker portions of the Devonian shales in the Appalachian and Illinois Basins of Kentucky.
- Enhanced production of natural gas displaced by injected CO_2 would contribute to a long-term increase in the supply of what is considered a “greener” fuel.
- Adsorption data indicate that black, organic-rich gas shales can serve as targets for sequestration of significant volumes of anthropogenic CO_2.

Benefits

To meet the President’s goal of decreasing CO_2 emissions per dollar of GDP by 18% by 2012, it will probably be necessary to sequester CO_2 in geologic and terrestrial sinks. Having a range of viable options for CO_2 sequestration increases the likelihood of successfully meeting this goal. This project has evaluated an option that has received relatively little attention—storing CO_2 in organic shale deposits while simultaneously producing natural gas, the sale of which can help offset sequestration costs. The potential capacity of shales to sequester CO_2 is very large, and being able to store CO_2 in shales could significantly increase the life of fossil fuel based power plants, if reductions in anthropogenic greenhouse gas emissions are required. Where the shales are not viable sequestration targets, data developed will assist in evaluating shales as seals for any deeper sequestration targets.