the ENERGY lab

R&D FACTS

Carbon Sequestration

Computed Tomography (CT) Scanning for Petrophysical Applications

Background

Traditional core-evaluation techniques evaluate minerals from exterior properties until all testing is concluded and the rocks can be sectioned and observed by a microscope. For real-time evaluations or in situ observation, an alternative is to use X-rays to see inside the cores. A good technique to observe the actual progression of fluids (movement) inside rocks is to use computer tomography (CT), scanning at successive time intervals to record the displacement or flooding process. Since the CT scanner procedure uses three-dimensional (3-D) coordinates that do not change unless the sample is removed from the instrument, changes in the conditions of each 3-D "voxel" can be recorded versus time. The "slices" can be reconstructed to provide 3-D images of scanned objects from many perspectives.

Sometimes minerals have interactions with fluids contained inside them. Although the mechanisms and causes are not completely known, it is well established experimentally that coal reacts with both methane and carbon dioxide (CO_2) to alter the nature of some of its minerals. It has been observed that coal swells upon adsorption of CO_2. Loss of permeability from coal swelling is a serious issue in carbon sequestration in unmineable coal seams. In situations where the desire is to use CO_2 to displace coal-bed methane, significant complications may arise due to the shrinking and swelling interactions.

Description

Regardless of which in situ processes are under consideration, it is necessary to evaluate the suitability of the selected site (site characterization) for application of the process. One of the techniques used to characterize the internal reactions and/or behavior of coal with CO_2 is dual-energy CT scanning. The core is scanned at two different (high and low) X-ray tube voltages. By comparing these scans to known standards, changes in effective atomic number can be determined. Knowing that simultaneous changes in density (from CT number) and atomic number (dual energy results) occur, important and necessary information is made available for every internal voxel to simulate numerical efforts. Since it is possible to simultaneously vary experimental simulations of in situ stresses on the cores and fluid pressures, site characterization is greatly enhanced.

CONTACTS

David Wildman
Division Director
Geosciences Division
National Energy Technology Laboratory
626 Cochrans Mill Road
P.O. Box 10940
Pittsburgh, PA 15236
412-386-4913
david.wildman@netl.doe.gov

T. Robert McLendon
Geosciences Division
National Energy Technology Laboratory
3610 Collins Ferry Road
P.O. Box 880
Morgantown, WV 26507
304-285-2008
t.mclen@netl.doe.gov

Duane H. Smith
Geosciences Division
National Energy Technology Laboratory
3610 Collins Ferry Road
P.O. Box 880
Morgantown, WV 26507
304-285-4069
duane.smith@netl.doe.gov

Sean I. 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

NATIONAL ENERGY TECHNOLOGY LABORATORY

Albany, OR • Fairbanks, AK • Morgantown, WV • Pittsburgh, PA • Houston, TX

Website: www.netl.doe.gov

Customer Service: 1-800-553-7681

U.S. DEPARTMENT OF ENERGY

PARTNERS

University of Pittsburgh
Carnegie Mellon University
Georgia Institute of Technology
West Virginia University

COST

Project Total
$220,000

Figure1. Computed Tomagraphy Scanner

For evaluation of carbon sequestration in inert rocks (such as displacement of brine from sandstone), or oil and/or gas production by displacement (e.g. waterflood), real time in situ progress of fluid displacement can be observed. Since the voxels are all recorded in a 3-D coordinate system, quantitative, volumetric, and linear measurements are all available for retrieval by using the software.

Primary Project Goal

To evaluate target carbon sequestration or hydrocarbon production cores from in situ real time perspectives. This will allow for the possibility of more accurate numerical simulations and economic evaluations, as well as enhancing the assessments of project feasibility.

Objectives

The CT scanner test results on coal will be used in conjunction with results from the Geologic Sequestration Flow Lab (GSCFL) at NETL to help determine behavior of coal when CO_2 is injected into deep coal seams for geologic sequestration of the CO_2. More specifically, objectives are—

- To use the data to assist computer simulations of CO_2 injection and the development of coal-swelling models for realistic evaluation of technical and economic feasibility of CO_2 sequestration in coal seams.
- To obtain real-time in situ images with the CT scanner of CO_2 injection in a sandstone core with total brine saturation, until CO_2 breakthrough occurs.
- To obtain data that will assist computer simulation efforts of CO_2 sequestration in brine-saturated sandstone formations.
- To observe the fingering in high-permeability strata as well as core anomalies that can be discerned in situ while testing is progressing.
- To test identical cores in both NETL's Morgantown and Pittsburgh laboratories, which will allow more complete evaluation of the cores.

Benefits

Reservoir cores can be evaluated at realistic confining pressures while simultaneously observing in situ changes in pore fluids and mineral densities and/or effective molecular weights. This information is essential to realistic numeric simulation, economic evaluations, and site characterization efforts.

Numeric modeling can project the volumes of CO_2 that can be sequestered in each potential reservoir in an area adjacent to older power plants. Estimates of the number of porous and permeable lithologic units required to sequester and store CO_2 will be useful in controlling greenhouse gases.

Accomplishments

Coal is being scanned with dual energy settings to evaluate coal interactions with CO_2 at varying pore fluid and confining pressures.

Development of brine displacement models for CO_2 sequestration in brine-sandstone formations has proceeded using idealized two-dimensional flat plates that were visually transparent. While this effort has provided valuable information on fractal behavior, fingering, breakthrough, etc., advancement of simulation capability requires that actual brine-saturated sandstone cores be tested using actual sandstone in 3-D configurations. NETL's CT scanner will obtain sequential real-time, in situ images of brine displacement by injected CO_2 from a no-saturation to full-saturation condition until after breakthrough. This work will be coordinated with a cooperative research effort being initiated among Carnegie Mellon University, West Virginia University, and NETL.

Planned Activity

- Evaluate mineral cores for the Carbon Sequestration Partnerships, both for target and cap and/or seal rock properties.
- Evaluate methane hydrate formation and decomposition in a variety of geologic conditions.
- Evaluate cement degradation upon exposure to CO_2.
- Evaluate the process of electromagnetic radiation used for retorting of oil shale and heavy oil.

NETL

R&D050, August 2009