PROJECT facts

U.S. Department of Energy
Office of Fossil Energy
National Energy Technology Laboratory

Carbon Sequestration

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A Novel Approach to Experimental Studies of Mineral Dissolution Kinetics

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Background

DOE is conducting pilot CO_2 injection tests to evaluate the concept of geologic sequestration. One strategy that has the potential to enhance CO_2 solubility and reduce the risk of CO_2 leaking back to the surface is dissolution of indigenous minerals in the geological formation and formation of secondary carbonate precipitates. This both increases the brine pH and immobilizes the CO_2. Clearly, the rates at which these dissolution and precipitation reactions occur directly determine the efficiency of this option. However, one of the fundamental problems in modern geochemistry is the persistent two to five orders of magnitude discrepancy between laboratory-measured and field-derived feldspar dissolution rates.

To date, there is no real guidance on how to predict silicate reaction rates for use in quantitative models. Current models for assessment of geological carbon sequestration have generally opted to use laboratory rates in spite of the dearth of such data for compositionally complex systems and the persistent disconnect between laboratory and field applications. Therefore, a firm scientific basis for predicting silicate reaction kinetics in geological formations containing injected CO_2 is urgently needed to ensure the reliability of the geochemical models used for the assessment of carbon sequestration strategies.

Feldspar is the most abundant mineral in earth's crust.

PARTNERS

Indiana University

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PERFORMANCE PERIOD

09/01/2004 to 08/31/2008

COST

Total Project Value
$426,701

DOE/Non-DOE Share
$426,701/$0

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The proposed experimental and theoretical study attempts to resolve this outstanding scientific issue by a novel experimental design and theoretical interpretation to measure silicate and dawsonite dissolution rates and iron carbonate precipitation rates at conditions pertinent to geological carbon sequestration. Additionally, this project will experimentally test the novel idea of storing CO_2 together with SO_2 contaminants in redbed sandstones that contain both feldspars and iron oxides. It is expected that SO_2 will reduce ferric iron to ferrous iron, which reacts with CO_2 and precipitates iron carbonate. If the SO_2 impurity in flue gas has a beneficial use in geological carbon sequestration, this represents a major cost reduction in front-end processing. The proposed experimental design and data interpretation depart significantly from the state-of-the-art practice, and the results will provide a guide to the evaluation of geological sequestration. Furthermore, an atomic scale, or near atomic scale, electron microscopic study will reveal reaction mechanisms that will also benefit the ongoing mineral carbonation and brine carbonation programs.

Primary Project Goal

The primary goal of this project is to resolve a long-term controversy that laboratory measured silicate dissolution rates are consistently two to five orders of magnitude faster than field-derived rates. This controversy is one of the major obstacles to quantitatively evaluating the efficacy of geological carbon sequestration.

Objectives

- To develop an experimental design and an interpretation of results to determine the rate of feldspar dissolution in geologic formations.
- To experimentally test the novel idea of storing CO_2 together with SO_2 contaminants in redbed sandstones that contain both feldspars and iron oxides.

Benefits

The results of this work will provide guidance relative to the rates and rate laws that should be used in performance assessments and will also benefit the mineral carbonation and brine carbonation programs. This may lead to improvements in the geologic sequestration of CO_2. Any reduction in the cost of CO_2 sequestration would have a positive effect on the economy should it become necessary to reduce the emissions of CO_2 to the atmosphere.

Accomplishments

- Completed three batch-type feldspar dissolution experiments, two batch-type and one flow-through Navajo sandstone experiments, and validation runs
- Characterized the reaction products of the feldspars using scanning electron microscopy, transmission electron microscopy, x-ray photoelectron spectroscopy, and x-ray diffraction
- Conducted geochemical modeling to interpret the results
- Established the coupling between the dissolution and precipitation reactions
- Completed a dawsonite experiment including preliminary electron microscopy