the ENERGY lab

PROJECT FACTS

Carbon Sequestration

# Geo-Chemo-Mechanical Studies for Permanent $CO_2$ Storage in Geologic Reservoirs

## Background

Increased attention is being placed on research into technologies that capture and store carbon dioxide ($CO_2$). Carbon capture and storage (CCS) technologies offer great potential for reducing $CO_2$ emissions and, in turn, mitigating global climate change without adversely influencing energy use or hindering economic growth.

Deploying these technologies in commercial-scale applications requires a significantly expanded workforce trained in various CCS specialties that are currently under-represented in the United States. Education and training activities are needed to develop a future generation of geologists, scientists, and engineers who possess the skills required for implementing and deploying CCS technologies.

The U.S. Department of Energy's (DOE) National Energy Technology Laboratory (NETL) has selected 43 projects to receive more than $12.7 million in funding, the majority of which is provided by the American Recovery and Reinvestment Act (ARRA) of 2009, to conduct geologic sequestration training and support fundamental research projects for graduate and undergraduate students throughout the United States. These projects will include such critical topics as simulation and risk assessment; monitoring, verification, and accounting (MVA); geological related analytical tools; methods to interpret geophysical models; well completion and integrity for long-term $CO_2$ storage; and $CO_2$ capture.

## Project Description

NETL is partnering with Columbia University to test and quantify the effects of rapid $CO_2$ capture and storage via mineral carbonation in peridotitic and basaltic rocks. These ubiquitous rock types have a chemical makeup that could convert all of the injected $CO_2$ in a geologic storage project to a solid mineral form, thus isolating it from the atmosphere permanently without reducing the $CO_2$ storage capacity, $CO_2$ injectivity, or volume of the target formation. During the mineralization process, cracks and fractures may be caused by increased pressure due to changes in mineral composition (also known as "reactive cracking") which would expose additional rock surface area. The net effect of this process would be to enhance formation porosity, permeability, and reactive surface area, and, in turn, to increase $CO_2$ absorption.

The project includes mineral carbonation rate experiments to maximize reaction rates in peridotite and basaltic rocks, and coupled geo-chemo-mechanical experiments to delineate the conditions for reactive cracking of peridotite and, perhaps, basaltic rock. It is vital to characterize the conditions under which fast carbonation and reaction-driven cracking occurs for in situ mineral carbonation in basalt and peridotite and determine how these processes affect permeability and reactive surface area. Typical

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## PARTNERS

None

## PROJECT DURATION

**Start Date**

12/01/2009

**End Date**

11/30/2012

## COST

**Total Project Value**

$469,268

**DOE/Non-DOE Share**

$299,857/$169,411

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fluid-rock reactions that increase the solid volume in the formation are often self-limiting, because they fill porosity, reduce permeability, and create reaction layers that act as a diffusive boundary layer between un-reacted minerals and fluid. In CCS applications, this type of phenomena could reduce target formation storage capacity. However, crystallization in pore space can also fracture rocks and increase permeability; for example, when salt crystallizes from pore water in limestone. If in situ carbonation of peridotite and basalt is rapid and self-cracking, it may present a rapid, permanent, and safe method for $CO_2$ capture and storage.

In situ mineral carbonation in peridotite and basalt can potentially provide a vast, permanent, and safe storage environment for $CO_2$. To understand and quantify the rapid $CO_2$ capture and storage via mineral carbonation during alteration of peridotitic and basaltic rocks, Columbia University is identifying carbonation rates of peridotite and basalts in a laboratory setting and studying catalytic effects using differential bed reactors and autoclaves. Columbia University is also performing enhanced, in situ capture and storage of $CO_2$ via mineral carbonation experiments across varying temperature, pressure, and fluid composition regimes. The project's central research effort will be conducted by two graduate students. Results from the project will be used to develop robust predictions for variability of reactive cracking as a function of depth in potential mineral carbonation reservoirs by

## Goals/Objectives

Columbia University is testing and quantifying the effects of rapid $CO_2$ capture and storage via mineral carbonation in peridotitic and basaltic rock formations.   Specific project objectives include:

- Defining rates of dissolution and carbonation of peridotite and basalt at $CO_2$ storage conditions.
- Quantifying the catalytic effect of various reactant solutions on reaction kinetics.
- Defining optimal conditions for reactive cracking, and its effects on permeability and reactive surface area.
- Developing a coupled geo-chemo-mechanical model to study the feedback between dissolution/precipitation reactions and cracking.
- Continuing the assessment of rate and natural peridotite carbonation in the field.

## Benefits

The project will make a vital contribution to the scientific, technical, and institu-tional knowledge base necessary to establish frame-works for the development of commercial-scale CCS.  Improved understanding of coupled geo-chemo-mechanical processes in-duced by $CO_2$ injection has a direct benefit to CCS end-users. The potential to permanently "sequester" $CO_2$ in mineral form without reducing storage capacity or injectivity is a major advantage and provides the opportunity for safe and effective future CCS oppor-tunities. Data from this study will contribute to the development of new and improved models. Additionally, the project will offer graduate student research opportunities that will help cul-tivate a workforce trained in the skills and competencies required to implement CCS technologies on a commercial-scale

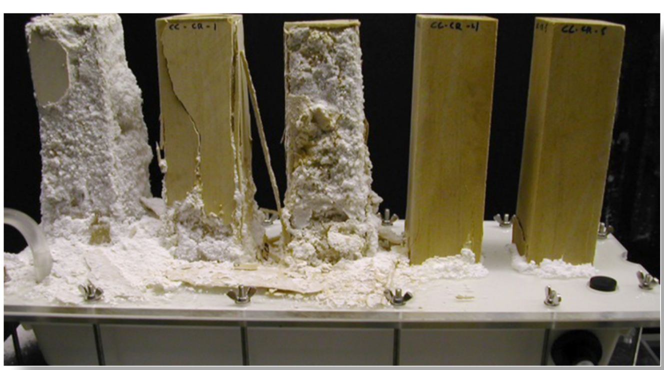

*Figure 1.  Reaction driven cracking in a salt limestone due to mineral carbonization.*

*Figure 2.  Field observations showing cracks and carbonation in peridotite rocks.*