the ENERGY lab

PROJECT FACTS

Carbon Sequestration

Integrated Experimental and Modeling Studies of Mineral Carbonation as a Mechanism for Permanent Carbon Sequestration in Mafic/ultramafic Rocks

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. These formations contain different fluids such as saline water, oil and natural gas. A principal element of 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. This study is exploring the effects of injecting CO_2 into basaltic reservoir rock.

Figure 1: An autoclave is used to create elevated pressures and temperatures. Basalt samples are placed into the autoclave where geochemical analyses can be performed in conditions similar to those encountered within basaltic formations under real world conditions.

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PARTNERS

The University of Hawaii

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PROJECT DURATION

Start Date

10/1/2010

End Date

9/31/2013

COST

Total Project Value

$2,441,180

DOE/Non-DOE Share

$1,938,746 / $502,434

Project Description

Yale University and partners are investigating basic questions about the chemical and mechanical processes that must occur underground for carbonation (the process by which CO_2 reacts with minerals in the reservoir to form solid carbonates) of basaltic (mafic) and ultramafic rocks to be practical on a large scale. Mafic and ultramafic rocks contain low levels of silica and high levels of calcium-rich minerals that react with CO_2 to form solid carbonate minerals, thus permanently isolating it from the atmosphere. The research will determine whether in situ carbonate reactions generate fractures within the target reservoir (increasing overall formation permeability) or if the presence of CO_2 and subsequent mineralization will reduce injectivity by constricting the available pore space (reducing overall formation permeability).

This project is a multi-scale, interdisciplinary laboratory study with two main focus areas: (1) geochemical experiments related to carbonate mineralization reaction rates, with systematic research emphasis on the influence of variables including pressure, temperature, ionic activity, reaction surface area pH, and the extent of reaction; and (2) geomechanical experiments integrated with numerical modeling to study how the available pore space within the basaltic reservoir rocks evolves as the carbonation reaction proceeds. Geochemical testing will be conducted on a multi-scale level with initial micro-scale level testing of powdered minerals typically found in basaltic rocks followed by a macro-scale testing using rock samples. Macro-scale geomechanical testing is focusing on interactions caused by CO_2 injection into the pore-space available within the rock.

Goals/Objectives

The primary goal of this project is to determine the carbon sequestration potential of mafic and ultramafic rocks via in situ carbonate mineralization as described above. A multi-dimensional model will be developed based on data gathered during the geochemical and geomechanical testing phases to achieve greater understanding of CO_2 injectivity and pore space availability for larger scale field testing.

The total effort is designed to provide a basis for scaling up to future field tests of mineral carbonation in basaltic domains. In particular, the project will supply data on the carbonation capacity of several important basaltic rock types in Hawaii to provide ground-truth constraints for a DOE-funded assessment of carbon dioxide sinks in Hawaii as part of Hawaii's inclusion in the West Coast Regional Carbon Sequestration Partnership (WESTCARB).

Benefits

This research could lead to a greater understanding of the effects of CO_2 injection into mafic/ultramafic rock reservoirs and allow for multi-phase modeling of multiple geomechanical parameters, which could lead to larger scale injectivity testing in the future. Mafic/ultramafic rocks are considered promising potential geologic CO_2 storage formations due to their unique chemical makeup, which could potentially convert all of the CO_2 injected into them to a solid mineral form and permanently isolate it from the atmosphere.

The ultimate benefit of this type of research is a better understanding of CO_2 interactions within mafic and ultramafic rocks, in particular how carbonate formation affects CO_2 injectivity and permeability within the rock reservoir. Successful storage of CO_2 in these rocks would reduce its contribution to global warming by permanently removing it from the atmosphere.

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