the ENERGY lab

PROJECT FACTS

Carbon Sequestration

# Prototype Development and Testing Advanced $CO_2$ Leakage Mitigation Using Engineered Biomineralization Sealing Technologies

## 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 research will develop a biomineralization-based technology for sealing preferential flow pathways in the vicinity of injection wells and help to maximize injectvity and containment effectiveness.

## Project Description

Researchers at Montana State University plan to build and test a mesocsale (~1 m-diameter), high-pressure rock test system; develop a biomineralization seal experimental protocol; and create biomineralization seals in different rock types and under actual field conditions. The integrity of the seals—both within the wellbore and between the wellbore and the geologic formation—is critical in minimizing $CO_2$ leakage through formation fractures or within the wellbore during $CO_2$ injection operations. The project is designed to study biomineralization processes that will be effective at sealing flow or leakage pathways near wellbores in subsurface environments. The concept proposed for enhancing geologic sequestration is based on the use of engineered microbial biofilms capable of biomineralization. The engineered

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## PARTNERS

Southern Company
The University of Alabama – Birmingham
Shell International Exploration and Production B.V.

## PROJECT DURATION

**Start Date**
10/01/2010

**End Date**
09/30/2013

## COST

**Total Project Value**
$2,000,000

**DOE/Non-DOE Share**
$1,599,997 / $400,003



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biomineralization process produces biofilm and mineral deposits that reduce the permeability of geologic media while modifying the geochemistry of brines to enhance $CO_2$ solubility and mineral precipitation. This process can be targeted to the geologic media surrounding sequestration injection wells to provide long-term sealing of preferential $CO_2$ leakage pathways. Because the fluids involved in biofilm formation and biomineralization are low viscosity aqueous solutions, this technology has the potential to seal small aperture leaks or the porous rock itself potentially providing a leakage mitigation technique that can address issues problematic for cement use.

The research will investigate whether mineral deposits can be formed at a field scale under conditions that mimic subsurface reservoirs and whether they can be kept uniform over relevant distances. The project will also determine whether sealing in disturbed rock-cement and cement-well bore interfaces can be achieved through biomineral deposits that remain stable when exposed to injection and formation fluids. This project will examine these effects by creating a large, tightly controlled testing facility that will replicate actual field conditions and use it to conduct proof-of-principle testing and methodology development for biomineralization.

## Goals/Objectives

The goals of the project are to use the results from focused laboratory studies to demonstrate that (1) mineral deposits can be formed at a field-relevant scale under environmental conditions appropriate to subsurface reservoirs; (2) the mineral deposition can be kept uniform over relevant distances; (3) the degree of sealing in disturbed rock, cement, and cement-well bore interfaces reaches an acceptable level; and (4) the biomineral deposits remain stable when exposed to brine and supercritical $CO_2$.

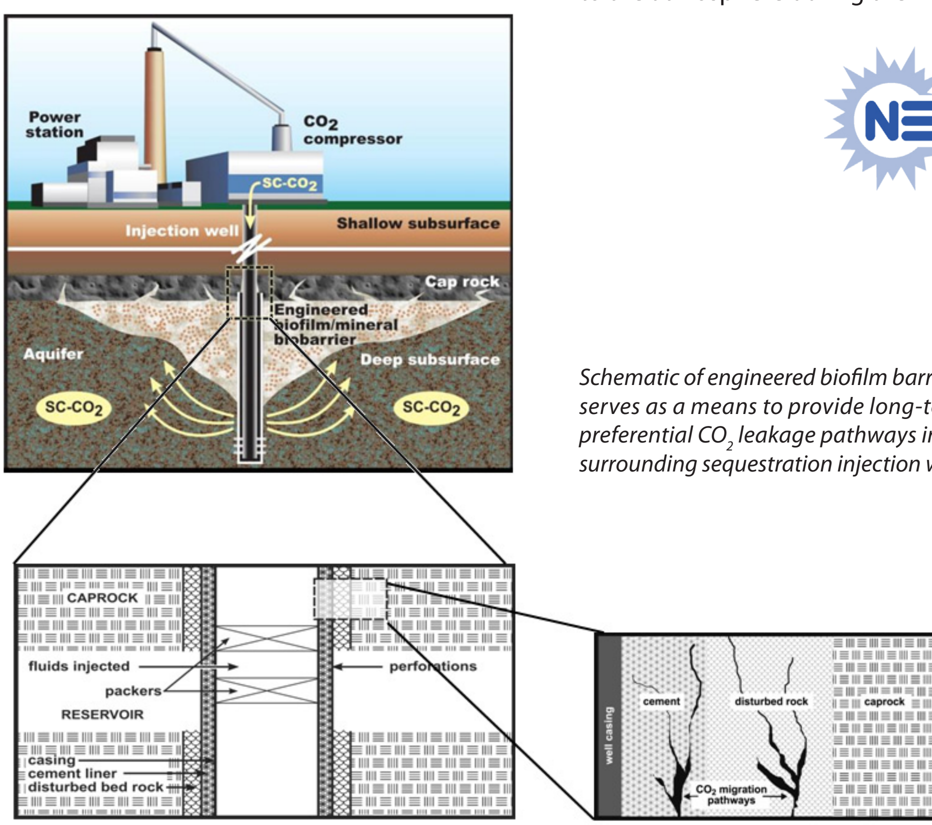
The project consists of three primary objectives:

- Assemble a mesoscale high-pressure rock test system.
- Development of a biomineralization seal experimental protocol.
- Creation of biomineralization seals in different rock types and under actual field conditions.

The project will be conducted through applied research into the theoretical and applied aspects of biomineralization for different lithologies and at different conditions (environmental parameters) in multiple geologic reservoir types.

## Benefits

This project will benefit $CO_2$ sequestration in geologic reservoirs by analyzing how borehole seal integrity can be improved in multiple geologic reservoir types. Successful project research will advance the development of an optimized protocol for construction and evaluation of biomineralization seals at field sites for geologic $CO_2$ sequestration. Improving wellbore integrity helps maximize $CO_2$ injection into the target geologic formation and minimize the potential for $CO_2$ to migrate back to the atmosphere during the injection process.




*Schematic of engineered biofilm barrier. The biofilm serves as a means to provide long-term sealing of preferential $CO_2$ leakage pathways in caprock and surrounding sequestration injection wells.*