NETL

the ENERGY lab

R&D FACTS

Carbon Sequestration

Degradation of Wellbore Cement Due to CO_2 Injection

Background

The majority of locations that are being considered for carbon dioxide (CO_2) injection and sequestration are typically found in areas that have a history of oil, natural gas, and/or coalbed methane production. This is due to value-added opportunities such as enhanced oil recovery (EOR), enhanced gas recovery (EGR), and enhanced coal bed methane (ECBM) recovery. There also exists a greater knowledge base for saline formations that lie either above or below oil and gas reservoirs due to well logging and exploration activities. As a result of human activity, these formations are typically punctured by a significant number of wells from both exploration and production. No matter how impermeable an overlying caprock is, the sealing integrity may be compromised by the presence of wells. Well bores thus represent the most likely route for leakage of CO_2 from geologic carbon sequestration.

Abandoned wells are typically sealed with cement plugs intended to block vertical migration of fluids. In addition, active wells are usually lined with steel casing, with cement filling the outer annulus (Note: in oilfield terminology, an annulus is a ring-shaped hole which extends the length of the well bore) in order to prevent leakage between the casing and formation rock. The permeability and integrity of the cement will determine how effective it is in preventing leakage.

After CO_2 is injected into a saline formation, it may continue as a separate free-gas phase, a supercritical phase, or dissolve in the formation water. When CO_2 is in a separate free-gas phase, if the density of the CO_2 is less than that of the formation water—and even at depths equal to or greater than 800 m where CO_2 is supercritical—the buoyancy of the CO_2 will cause the it to rise and spread laterally beneath the reservoir caprock. When the CO_2 contacts the formation water, it will dissolve and lower the pH of the solution. The exposure experiments of this study have been structured to study both of these processes since both types of "plumes" can come into contact with existing wells.

It is very important to understand the chemical interactions between injected CO_2 and existing cements that could potentially lead to leakage. Monitoring efforts need to focus on wells as likely sources of leakage. In addition to locating and focusing monitoring efforts on existing wells, it is necessary for the process of cement degradation to be studied. This information will factor into sequestration site-selection decisions. In some cases, it may be necessary to recomplete wells that will be particularly vulnerable to leakage, based on cement type and expected exposure conditions. All of these issues must be considered prior to injection of CO_2 in order to mitigate the risk of leakage.

CONTACTS

Brian Strazisar
Physical Scientist
Environmental Science Division
National Energy Technology Laboratory
626 Cochrans Mill Road
P.O. Box 10940
Pittsburgh, PA 15236
412-386-5988
brian.strazisar@netl.doe.gov

Barbara Kutchko
Physical Scientist
Environmental Science Division
National Energy Technology Laboratory
626 Cochrans Mill Road
P.O. Box 10940
Pittsburgh, PA 15236
412-386-5149
barbara.kutchko@netl.doe.gov

George Guthrie
Focus Area Leader
National Energy Technology Laboratory
626 Cochrans Mill Road
P.O. Box 10940
Pittsburgh, PA 15236
412-386-6571
george.guthrie@netl.doe.gov

Donald Martello
Division Director
Environmental Science Division
National Energy Technology Laboratory
626 Cochrans Mill Road
P.O. Box 10940
Pittsburgh, PA 15236
412-386-5948
donald.martello@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

CONTACTS (cont.)

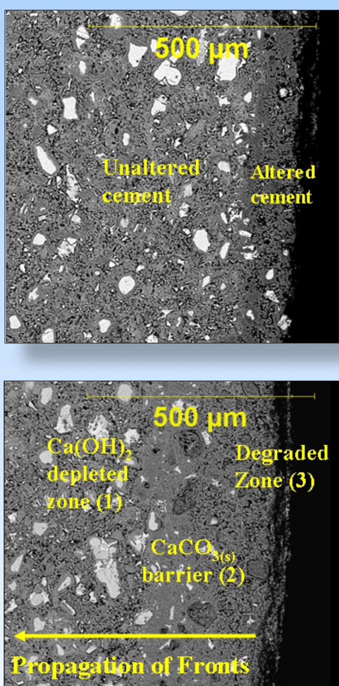
Sean Plasynski
Sequestration Technology Manager
National Energy Technology Laboratory
626 Cochrans Mill Road
P.O. Box 10940
Pittsburgh, PA 15236
412-386-4867
sean.plasynski@netl.doe.gov

PRIMARY PARTNERS

National Energy Technology Laboratory
Carnegie Mellon University
RJ Lee Group, Inc.

COST

Total Estimated Cost
$450,000 over 3 years



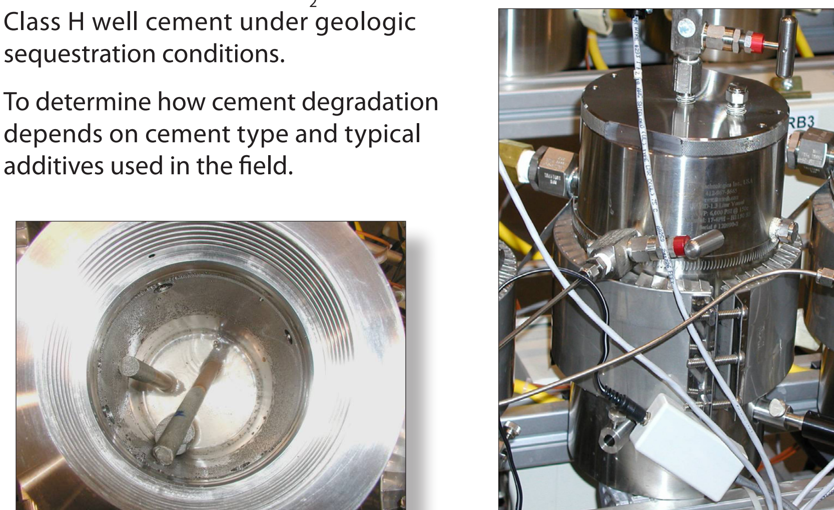
Images of degraded cement samples.

Primary Project Goal

The goal of this project is to determine the risk to the storage integrity of CO_2 from existing deep wells—more specifically, risk from the cement that is in place in deep wells to prevent vertical migration.

Objectives

- To determine the effect of CO_2 exposure to the physical and chemical properties of cements under deep-well conditions (e.g., elevated pressure, temperature, and salinity).
- To determine the rate of CO_2 attack on Class H well cement under geologic sequestration conditions.
- To determine how cement degradation depends on cement type and typical additives used in the field.



High-pressure vessels for CO_2 exposure experiments.

Accomplishments

Experiments have been conducted that involve curing cement samples and exposing them to high pressure CO_2 under geologic sequestration conditions. Based on the experiments carried out in the NETL Core Flow Laboratory, an understanding has been developed of the chemical dynamics of neat (absence of additives) cement alteration upon exposure to sequestered CO_2, as well as how the cement's curing temperature and pressure influence that alteration. Extrapolation of penetration rates measured for 1-year exposure experiments for neat cement suggest penetration depths limited to about 1 cm after 50 years. However, bentonite, a commonly used additive, was determined to dramatically decrease the cement's resistance to acid attack. More work on additives is forthcoming.

Benefits

The main benefit is developing a greater understanding of the factors affecting wellbore integrity in a geologic carbon sequestration project. This will be a key factor in site characterization and evaluation for large-scale sequestration projects. Potential weaknesses in a site may be addressed before they become a problem.

R&D044, August 2009