PROJECT facts

Carbon Sequestration

04/2008

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

Feasibility of Large-Scale CO_2 Ocean Sequestration

Background

The increase of carbon dioxide (CO_2) and other greenhouse gas emissions, due in large part to the burning of fossil fuels for energy consumption, has spawned debate over global climate change and prompted the emergence of various remediation strategies. The option of ocean sequestration involves capturing and separating CO_2 from the flue gas of fossil fuel-burning power plants and then converting it into a liquid state that is then transported by a submerged pipeline for injection into the deep ocean. Oceans offer enormous potential as carbon storage sinks, but the current level of scientific understanding to support ocean sequestration as a major CO_2 storage option remains uncertain. DOE had ocean sequestration as one of its research pathways in the past but, due to the need for further understanding, concluded projects in its portfolio in this area.

The Monterey Bay Aquarium Research Institute (MBARI) developed a novel set of experimental techniques for the deployment of small quantities of liquid CO_2 in the deep ocean in order to investigate the fundamental concepts of CO_2 ocean sequestration, particularly the behavior of CO_2 hydrates. Using an advanced Remotely Operated Vehicle (ROV) technology, MBARI carried out controlled releases of CO_2 to observe and measure the processes taking place.

Description

Through a series of experiments conducted offshore California and at the MBARI, researchers investigated the physical, biological, and chemical behavior of CO_2 hydrates on the seafloor at depths up to 3,600 meters. Similar to methane hydrates—the ice-like complexes of water and methane—CO_2 can also form hydrates, and the storage of CO_2 in hydrate pools at the bottom of the ocean were investigated. A number of research cruises using the ROV to study the ocean storage of CO_2 hydrate off Monterey Bay have been completed. The physical chemistry and the biological effects of hydrate formation in the deep ocean were examined by means of small-scale batch experiments.

The research group at Washington University, with MBARI, used in situ Raman spectroscopy to carry out the first direct in situ analysis of CO_2 hydrates on the ocean floor, in the entrained and surrounding fluids, and in the sediments adjacent to the hydrates. Information on hydrate-sediment interaction is essential for the evaluation of ocean sequestration of CO_2.

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PERIOD OF PERFORMANCE

09/18/2000 to 03/31/2008

COST

Total Project Value

$1,593,777

DOE/Non-DOE Share

$1,270,041 / $323,736

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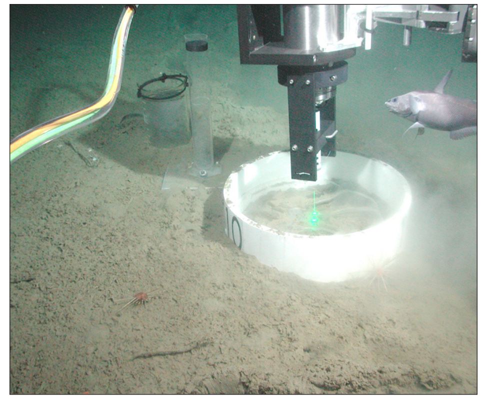
Primary Project Goal

The primary goal of this project is to investigate the chemical, physical, and biological behavior of CO_2 hydrates in the deep ocean. These data are necessary to help evaluate the storage of CO_2 in hydrate pools at the bottom of the ocean, an option that has been considered for long-term CO_2 storage.



Testing the waters: An experiment to investigate the fundamental science of ocean CO_2 sequestration at a depth of 3,600 meters off the coast of California. A small pool of liquid CO_2 is sensed by the beam of a laser Raman spectrometer to record the chemical status of the material. This sea floor laboratory is controlled by a remotely operated vehicle.

Objectives

- Determine the long-term fate of CO_2 and CO_2 hydrates on the sea floor.
- Study biological responses to the disposed material.
- Examine geochemical interactions with sediments and pore waters.

Benefits

This project will provide further understanding of the behavior of CO_2 within the ocean environment and will afford individuals interested in ocean engineering and the study of CO_2 and methane hydrates with useful information. The research will demonstrate that hydrate pools at the bottom of the ocean have the potential for long-term storage of large quantities of CO_2.

Formation of CO_2 hydrate mounds at 3,610 meters.

Accomplishments

MBARI used a small-scale delivery system with a capacity of 56 liters to study CO_2 interactions in the ocean. Five controlled delivery dives were executed, with the CO_2 delivered to a central corral complex. Results showed a strong tidal periodicity in the water plume of lowered pH and a complex set of biological responses. Below a depth of about 3,000 meters, the density of liquid CO_2 exceeds that of seawater, and the CO_2 is quickly converted into solid hydrate by reaction with the surrounding water. An analysis of the acoustic detection and modeling of a rising deep-sea liquid CO_2 plume was also completed. The results are applicable to detection of leakage of CO_2 from the sea floor, either from natural CO_2 vents or from purposefully disposed CO_2 in sub-sea geologic formations. Research results have been published in peer-reviewed literature and disseminated at scientific meetings, symposia, and conferences.

Planned Activities

The research team will prepare the final project report, as well as articles for publication in the scientific literature.