the ENERGY lab

PROJECT FACTS

Carbon Storage – MVA

Feasibility of Geophysical Monitoring of Carbon-Sequestrated Deep Saline Aquifers

Background

Through its core research and development program administered by the National Energy Technology Laboratory (NETL), the U.S. Department of Energy (DOE) emphasizes monitoring, verification, and accounting (MVA), as well as computer simulation and risk assessment, of possible carbon dioxide (CO_2) leakage at CO_2 geologic storage sites. MVA efforts focus on the development and deployment of technologies that can provide an accurate accounting of stored CO_2, with a high level of confidence that the CO_2 will remain stored underground permanently. Effective application of these MVA technologies will ensure the safety of geologic storage projects with respect to both human health and the environment, and can provide the basis for establishing carbon credit trading markets for geologically storing CO_2.

Project Description

Monitoring deep saline formations containing injected CO_2 using existing geophysical tools is a challenge. This three-year project, performed by the University of Wyoming with assistance from WesternGeco (Houston, Texas), combines reservoir flow simulation with 3-D, multicomponent seismic waveform modeling to investigate whether seismic waveform inversion can accurately predict and account for post-injection CO_2 saturation within deep saline aquifers. Due to the ease of availability of well and seismic data, and core samples, the University of Wyoming is focusing on local analog systems, namely the Moxa-Arch region, Western Wyoming, where geologic storage projects are taking place. If successful, this research could establish the feasibility of a practical and cost-effective technique to monitor these storage formations, which are considered to be among the most promising for high-capacity storage of CO_2 captured from power plant emissions and other sources.

Goals/Objectives

The project is a three-phase research initiative that combines multiphase flow simulations with multicomponent seismic waveform modeling and inversion to determine whether seismic waveform inversion can accurately predict CO_2 plume movements within storage formations in post-injection scenarios involving rewetting and trapping of CO_2 by bypassing and snap-off mechanisms. This effort will help the Carbon Storage Division

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PARTNERS

WesternGeco
(A Division of Schlumberger)

PROJECT DURATION

Start Date	End Date
10/01/2009	09/30/2013

COST

Total Project Value
$1,517,563

DOE/Non-DOE Share
$1,046,917 / $470,646

PROJECT NUMBER

DE-FE-0001160

meet the goals of improving storage efficiency and ensuring carbon storage permanence in the subsurface. Objectives for each of these phases are as follows:

- Phase 1: Generate 3-D seismic and flow property models for several known potential aquifers, and compute finite-difference synthetic seismic responses at different periods after CO_2 injection.

- Phase 2: Develop a 3-D multicomponent waveform inversion methodology for inverting the computed seismic responses from Phase 1 for aquifer properties and calibrating inverted properties to the post-injection CO_2 saturations within the aquifer.

- Phase 3: Process all 3-D seismic data volumes from Phase 1, use inversion methodology developed in Phase 2 to invert them to estimate the aquifer properties, and utilize the calibration results from Phase 2 to estimate the post-injection movements of CO_2 directly from seismic data.

Accomplishments

- A preliminary 3-D model for the Moxa Arch (a large north-south trending anticline located in southwest Wyoming that has features that may be suitable for geologic storage) was successfully generated

- A seismic waveform inversion on real data was used to verify the baseline model (Figure 1) and computed synthetic responses for the model. Preliminary simulations were successfully run without using saturation data

- Non-linear least squares inversion methodology was developed

- A multi-component seismic inversion was run on the seismic data from a single location. Results of the inversion matched reasonably well with the actual (true) model for that location.

- In the process of using the baseline model and post-sequestration models generated from flow simulation to compute the 3-D finite difference synthetic seismic responses.

Benefits

As carbon capture, utilization, and storage (CCUS) capacity increases and projects become commercial beyond 2020, the importance of accurate geologic models and robust risk assessment protocols will become increasingly important to project developers, regulators, and other stakeholders. NETL's Carbon Storage Program is sponsoring the development of technologies and protocols by 2020 that are broadly applicable in different geologic storage classes and have sufficient accuracy to account for greater than 99 percent of all injected CO_2. If necessary, the tools will support project developers to help quantify emissions from CCUS projects in the unlikely event that CO_2 migrates out of the injection zone. Finally, coupled with increased understanding of these systems and reservoir models, MVA tools will help in the development of one of DOE's goals to quantify storage capacity within ± 30 percent accuracy.

This project's research has the potential to establish the feasibility of a practical and cost-effective technique to monitor carbon stored in deep saline formations, which hold significant promise for high-capacity storage of CO_2 captured due to their vast storage potential across the United States and Canada. This type of technology could aid carbon storage site operators in ensuring CO_2 storage permanence in the subsurface.

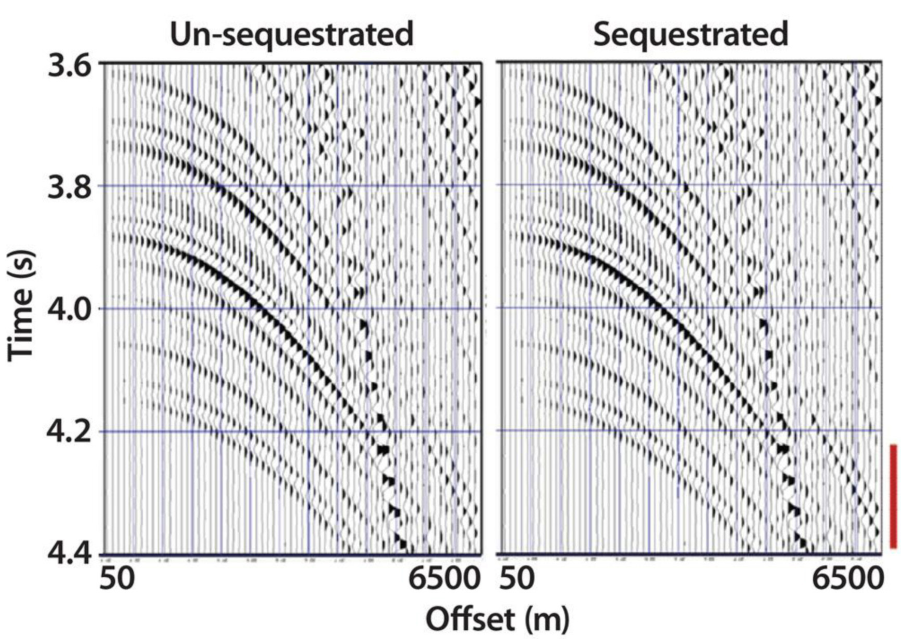

Figure 1 - Offset domain horizontal (radial) component seismic response for the unsequestrated and sequestrated models displays visible differences in the long-offset converted-wave reflection amplitudes.