the ENERGY lab

PROJECT FACTS

Carbon Storage

Improving MVA of CO_2 Sequestered in Geologic Systems with Multicomponent Seismic Technology and Rock Physics Modeling

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. Computer simulation can be used to estimate CO_2 plume and pressure movement within the storage formation as well as aid in determining safe operational parameters; results from computer simulations can be used to refine and update a given site's MVA plan. Risk assessment research focuses on identifying and quantifying potential risks to humans and the environment associated with geologic storage of CO_2, and helping to ensure that these risks remain low.

Project Description

The Bureau of Economic Geology (BEG) at the University of Texas at Austin is conducting this research project that combines multicomponent seismic technology and rock physics modeling to develop more accurate tools for MVA of stored CO_2. The research will use conventional seismic sources and data-acquisition systems, as well as new seismic sources that emphasize shear waves and new seismic data-acquisition concepts based on cable-less data recording. These sources and systems will be used to acquire seismic research data across one or more saline formation systems appropriate for CO_2 storage.

Research tasks will involve acquiring, processing, and interpreting both conventional seismic data and multicomponent seismic data. Scientists at PNNL and BEG will analyze well logs, cores, and reservoir test data to construct geological models of CO_2 storage formations and seal units across each study site. By combining compressional wave (P-wave) and shear wave (S-wave) seismic attributes with appropriate rock physics models, the research team will show how multicomponent seismic technology allows

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PROJECT DURATION

Start Date	**End Date**
10/01/2009	09/30/2012

COST

Total Project Value
$1,476,422

DOE/Non-DOE Share
$1,137,860 / $338,562

PROJECT NUMBER

DE-FE0001317

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definition of formation storage compartments, detection of leaky seals, mapping of fluid-flow paths, segregation of high and low gas saturations, and quantification of intra-reservoir permeability barriers that cannot be achieved with conventional single-component seismic data.

Goals/Objectives

The primary objective of the DOE's Carbon Storage Program is to develop technologies to safely and permanently store CO_2 and reduce Greenhouse Gas (GHG) emissions without adversely affecting energy use or hindering economic growth. The Programmatic goals of Carbon Storage research are: (1) estimating CO_2 storage capacity in geologic formations; (2) demonstrating that 99 percent of injected CO_2 remains in the injection zone(s); (3) improving efficiency of storage operations; and (4) developing Best Practices Manuals (BPMs).

The main goal of this research is to investigate using a combination of multicomponent seismic technology and rock physics modeling as a superior scientific technique for accomplishing CO_2 MVA tasks. The project will also use new cable-less technology equipment to acquire three-dimensional, multicomponent seismic data across saline formation strata that can be used for CO_2 storage (Figure 1a and 1b). In addition, rock physics principles will be used to show that the combination of P and S seismic attributes provides more rock, fluid, and geologic information to use in MVA tasks than does the use of P seismic data only, which are the only seismic data used in conventional CO_2 storage projects. These goals will help refine CO_2 storage capacity estimates and provide valuable information regarding the integrity of injection formations and caprock seals to demonstrate CO_2 storage permanence. Specific project objectives include:

- Acquire, process, and interpret multicomponent seismic data across at least one site where the participant's seismic-contractor partners will operate in Project Year 1, and where the participant and DOE agree that the geology is typical of that needed for CO_2 storage.
- Analyze local well log data to characterize the targeted saline formation and its sealing unit(s).
- Develop rock physics models that best relate P and S seismic attributes to rock/fluid properties needed for improved MVA analyses.
- Compile evidence showing that multicomponent seismic technology, when combined with rock physics modeling, is the best seismic approach for optimizing CO_2 storage.

Figure 1a and 1b - (a) Deployment of a 240-channel cable-less data-acquisition system consisting of 80 stations. Several hundred stations will be used in the project under discussion. (b) Just some of the cables that do not have to be deployed in a cable-less operation. In terms of size, weight, manpower demands, and repair costs, seismic spread cables are the major component of conventional cable-based seismic data-acquisition systems.

Accomplishments

- The project team has selected the study site and initiated the construction of the geological and petrophysical database. In addition, the project has acquired multi-component seismic data for analysis and integration into the modeling effort.
- The BEG performed a detailed interpretation of the interval between the interpreted tops of the Tully Limestone and Tichenor Limestone to determine how P and S seismic data react to these particular sandstone targets. These formations are porous, brine-filled sandstones and are good candidates for geologic storage of CO_2 (Figure 2). The Tully unit was characterized by a strong reflection peak (black in Figure 2) immediately followed by a high-amplitude wavelet trough (red) in all three data volumes and is easily mapped across the image area. In contrast, the Tichenor Limestone appears as a modest-amplitude reflection in the P-P data volume, and has an even lower amplitude response in both the P-SV1 data and the P-SV2 volumes.
- The research team conducted a subsurface investigation in the northeastern portion of the Appalachian Basin in Bradford County, Pennsylvania. The primary focus of the geological analysis was to describe porous brine-filled units throughout the entire stratigraphic column to ensure all possible CO_2 storage targets were considered local to Bradford County. Geological investigations began with Lower Devonian-aged CO_2 storage candidates and proceed to deeper Basal Cambrian sandstones.
- Seismic data collection for the research team focused on mapping unconformity surfaces in the lower Paleozoic sections of Bradford County. Foremost among sequestration possibilities are porous, transgressive sandstone reservoirs deposited on unconformity surfaces during local subsidence. Other possibilities are porous carbonate units that have been exposed to dissolution processes and/or dolomitic replacement during uplift and surface exposure. Both of these conditions, commonly associated with unconformities, create rock units that could be attractive CO_2 storage reservoirs.

Benefits

It will be necessary to improve existing monitoring technologies, develop novel systems, and protocols to satisfy regulations to track the fate of subsurface CO_2 and quantify any emissions from reservoirs. The 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 carbon capture, utilization, and storage (CCUS) projects in the unlikely event that CO_2 migrates out of the injection zone. Finally, coupled with our 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 aims to establish the superiority and cost-effectiveness of the combination of multicomponent seismic technology and rock physics modeling as a science that is well suited for CO_2 MVA tasks. A valuable benefit from transfer of this technology is the education of the CO_2 geologic storage community on the use of modern logs, cores, and rock physics for optimal detection and evaluation of fracture, fluid, rock type, and mineralogy influences on MVA task objectives. The multicomponent seismic technology used in this project can produce maps of fracture orientation within CO_2 storage formation/seal intervals (essential for defining possible leakage paths), as well as the azimuth of maximum horizontal stress (important for knowing whether CO_2 injected under high pressure alters local stress fields). The technology will also be valuable for segregating low-saturation CO_2 zones from high-saturation zones.

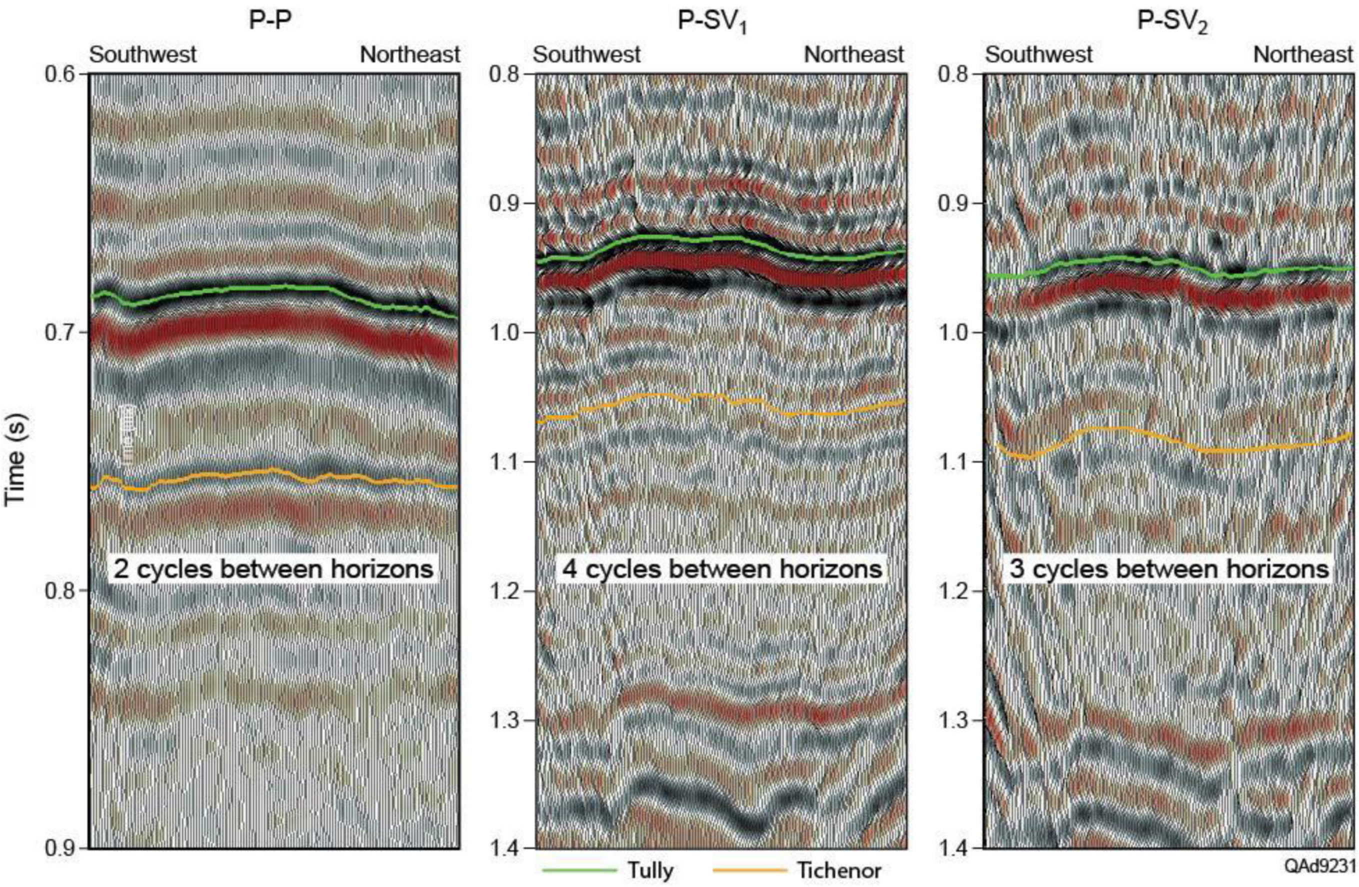

Figure 2. Profiles comparing Tully (green horizon) to Tichenor (orange horizon) intervals in (a) P-P, (b) P-SV1, and (c) P-SV2 seismic image spaces.