the ENERGY lab

PROJECT FACTS

Carbon Storage

Integrated Reflection Seismic Monitoring and Reservoir Modeling for Geologic CO_2 Sequestration

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

This two-year project was working to develop and demonstrate a fully integrated, multidisciplinary CO_2 MVA software system that takes a novel approach to the deployment and utilization of seismic imaging, and the seamless integration of the seismic data with reservoir modeling. The project also employed an active source-reflection seismic imaging strategy based on the deployment of spatially sparse, surface seismic arrays, integrated with a dense complementary baseline array. The project team determined whether a more accurate CO_2 reservoir modeling package than those existing in industry today could be developed using fewer points in a surface seismic array (but collected more frequently), along with new and existing software.

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).

CONTACTS

John Litynski
Carbon Storage Technology Manager
National Energy Technology Laboratory
626 Cochrans Mill Road
P.O. Box 10940
Pittsburgh, PA 15236-0940
412-386-4922
John.Litynski@netl.doe.gov

Karen Kluger
Project Manager
National Energy Technology Laboratory
626 Cochrans Mill Road
P.O. Box 10940
Pittsburgh, PA 15236-0940
412-386-6667
Karen.Kluger@netl.doe.gov

John Rogers
Principal Investigator
Fusion Petroleum Technologies, Inc.
4700 West Sam Houston Parkway North, Suite 150
Houston, TX 77041
281-363-8558
jrogers@fusiongeo.com

PARTNERS

None

PROJECT DURATION

Start Date	End Date
10/1/2009	9/30/2011

COST

Total Project Value
$2,500,175

DOE/Non-DOE Share
$2,000,000 / $500,175

PROJECT NUMBER

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U.S. DEPARTMENT OF ENERGY

The primary goal of this project was to develop and demonstrate a fully integrated, multidisciplinary CO_2 MVA software system, employing a novel approach to the deployment and utilization of seismic imaging, and the seamless integration of the seismic data with reservoir modeling. This effort helps achieve the NETL goal to demonstrate CO_2 storage permanence in the subsurface. The key objectives of the project were to:

- Develop a strategy for high temporal resolution seismic CO_2 storage monitoring; and
- Develop and deliver an integrated reservoir modeling and seismic analysis package to enable a seamless, collaborative CO_2 MVA workflow.

Accomplishments

Major accomplishments to date include:

- Derived a realistic reservoir model, based on the Crow Mountain saline aquifer at the Teapot Dome RMOTC site.
- Processed the Teapot Dome 3-D seismic data and evaluated geological, petrophysical and engineering information and all data available focused on the Crow Mountain aquifer.
- Processed a realistic baseline test 3D seismic data set (RMOTC Crow Mountain Saline Aquifer) through depth migration, reservoir analysis, and geopressure analysis.
- Integrated data and model information to simulate time-lapse reservoir conditions, yielding changes in seismic velocity, reflectivity, and possibly attenuation. These properties were used as input to an advanced three-dimensional (3-D) seismic wave-field modeling code to generate simulated time-lapse surface seismic surveys.
- Interpreted the reservoir structure from the seismic and well log analysis, developed a reservoir geocellular model to characterize the reservoir based on the structural interpretation, and simulated CO_2 injection into the reservoir.
- Used simulated CO_2 plume and reservoir parameters in a rock physics seismic simulation and analysis workflow and software to develop the sparcity analysis portion of the project.
- Integrated and developed the software environment and infrastructure to seamlessly manage the computational and visualization-intensive interdisciplinary components of typical geophysical and reservoir characterization needed in complex analysis of subsurface processes such as CO_2 MVA. The integrated system consists of a flexible and extensible software platform with an advanced graphical user interface providing tip-of-finger access to a diverse set of tools and applications for CO_2 MVA, including high-end 3-D visualization.
- Integrated a number of very specialized software to analyze and characterize a reservoir, including a sophisticated visualization tool, into the GeoPro platform. Improvements to GeoPRO's infrastructure to handle geophysical processing and visualization increases the capability for CO_2 MVA. Some of these improvements include database enhancements, plug-in managers for data processing modules and 2D/3D visualization plug-ins, interpolation features, and 2D/3D visualization widgets. The VizPRO is a 3D Visualization tool contained in GeoPRO and includes: advanced 3D rendering features; time/depth converters; and features to import simulated grid data.

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, storage, and utilization (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 technology provides an integrated approach to the set of Earth science applications (Figure 1) including seismic data, well information, geology, and a reservoir simulation mechanism. This includes CO_2 geochemistry, reservoir geomechanics, and multiphase fluid flow. The system greatly improves operational efficiency and enables the interdisciplinary collaboration required for effective CO_2 geologic storage MVA. This software system provides a substantial advantage over existing practice, and existing systems available from the oil and gas industry today. The commercial nature of the technology will be available in the future for use in all aspects of CO_2 geologic storage. As the CO_2 MVA market widens and new geoscience technologies are developed, the additional technology can be easily incorporated into this software infrastructure. The results from the methodology and the software system helps operators reduce the risks associated with inducing fractures in the caprock and/or reactivating faults during injection, and allows for the prediction and detection of locations where these are occurring. The software and seismic MVA methodologies promote confidence that injected CO_2 will remain securely stored, and allows for accurate monitoring during injection.

NETL

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