the ENERGY lab

PROJECT FACTS

Carbon Storage - GSRA

# Development of Improved Caprock Integrity Analysis and Risk Assessment Techniques

## Background

The overall goal of the Department of Energy's (DOE) Carbon Storage Program is to develop and advance technologies that will significantly improve the effectiveness of geologic carbon storage, reduce the cost of implementation, and prepare for widespread commercial deployment between 2020 and 2030. Research conducted to develop these technologies will ensure safe and permanent storage of carbon dioxide ($CO_2$) to reduce greenhouse gas (GHG) emissions without adversely affecting energy use or hindering economic growth.

Geologic carbon storage involves the injection of $CO_2$ into underground formations that have the ability to securely contain the $CO_2$ permanently. Technologies being developed for geologic carbon storage are focused on five storage types: oil and gas reservoirs, saline formations, unmineable coal seams, basalts, and organic-rich shales. Technologies being developed will work towards meeting carbon storage programmatic goals of (1) estimating $CO_2$ storage capacity +/- 30 percent in geologic formations; (2) ensuring 99 percent storage permanence; (3) improving efficiency of storage operations; and (4) developing Best Practices Manuals. These technologies will lead to future $CO_2$ management for coal-based electric power generating facilities and other industrial $CO_2$ emitters by enabling the storage and utilization of $CO_2$ in all storage types.

The DOE Carbon Storage Program encompasses five Technology Areas: (1) Geologic Storage and Simulation and Risk Assessment (GSRA), (2) Monitoring, Verification, Accounting (MVA) and Assessment, (3) $CO_2$ Use and Re-Use, (4) Regional Carbon Sequestration Partnerships (RCSP), and (5) Focus Area for Sequestration Science. The first three Technology Areas comprise the Core Research and Development (R&D) that includes studies ranging from applied laboratory to pilot-scale research focused on developing new technologies and systems for GHG mitigation through carbon storage. This project is part of the Core R&D GSRA Technology Area and works to develop technologies and simulation tools to ensure secure geologic storage of $CO_2$. It is critical that these technologies are available to aid in characterizing geologic formations before $CO_2$-injection takes place in order to predict the $CO_2$ storage resource and develop $CO_2$ injection techniques that achieve optimal use of the pore space in the reservoir and avoid fracturing the confining zone (caprock). The program's R&D strategy includes adapting and applying existing technologies that can be utilized in the next five years, while concurrently developing innovative and advanced technologies that will be deployed in the decade beyond. For this project, researchers are improving and advancing simulation tools and risk assessment techniques to better predict and help control system failures, and to enhance performance of geologic storage.

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## PARTNERS

None

## PROJECT DURATION

| Start Date | End Date |
|---|---|
| 10/01/2012 | 09/30/2014 |

## COST

**Total Project Value**
$977,221
**DOE/Non-DOE Share**
$781,857 / $195,364

## AWARD NUMBER

DE-FE0009168

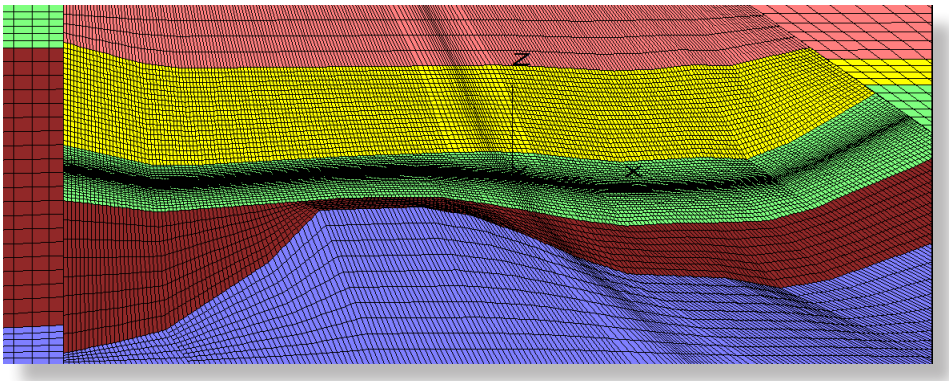


*Figure 1. Sample FLAC3D geomechanical simulation to evaluate induced deformations, stresses, and fault activation risks for the Wilmington Graben Characterization Project located offshore near Long Beach, California. A graben is a fault-bound structural feature considered to be potentially significant for long-term carbon storage operations.*

## Project Description

A primary requirement for long-term geologic storage and containment of carbon dioxide is ensuring caprock and wellbore integrity by restricting the vertical migration of $CO_2$, which is essential in order to protect overlying underground sources of drinking water (USDW). Most injection and storage operations have proceeded safely and with full containment for several years. However, large-scale $CO_2$ injection requires improved and advanced simulation tools and risk assessment techniques to better predict and help control system failures, and to enhance performance of geologic storage.

GeoMechanics Technologies (former Terralog Technologies USA, Inc.) is developing enhanced simulation and risk analysis approaches to assess and control geomechanics-related system failures (induced fracturing, faulting, bedding plane slip, or permeation through natural fractures and faults) at geologic carbon storage sites. The project will proceed in two phases over a two-year period. During the first phase, GeoMechanics Technologies will conduct an analysis of and describe historical caprock integrity problems experienced in natural gas storage and oil and gas waste injection operations. This analysis will include documentation of theoretical and analytical descriptions of caprock integrity issues, including permeation, occurrences of natural fractures and faults, induced fracturing due to $CO_2$ injection (pressure and temperature effects), induced fault activation and bedding plane slip due to $CO_2$ injection, and induced microseismicity. The second phase will be to initiate development of an advanced geomechanical simulation technique to assess geomechanical damage and caprock integrity problems during large-scale $CO_2$ injection for a range of geologic settings and operating conditions. A quantitative risk assessment tool for caprock integrity will also be developed. The geomechanical simulation and quantitative risk assessment techniques will then be applied to historical situations in which caprock integrity issues have been experienced, as well as historical large-scale injection operations that have been problem free. Practical recommendations and guidelines for caprock characterization and operating practices to reduce caprock integrity damage risks will be developed based on the results of the modeling and risk assessment study.

## Objectives

The primary objectives of this research project are to develop and demonstrate improved confining zone integrity geomechanical simulation and risk assessment techniques to enhance performance of geologic storage systems, ensuring long-term performance.

An important component and objective during the first phase of this research will include a review, analysis, and description of historical confining zone integrity problems experienced in natural gas storage and oil and gas waste injection operations – one that is more detailed and comprehensive than previously documented and currently available to industry. Additional objectives during phase one are to clearly document theoretical and analytical descriptions for confining zone integrity issues, including permeation, occurrences of natural fractures and faults, induced fracturing due to $CO_2$ injection (pressure and temperature effects), induced fault activation and bedding plane slip due to $CO_2$ injection, and induced microseismicity. The first phase of this research effort will also seek to initiate development of an advanced coupled transport flow and geomechanical simulation techniques to assess geomechanical damage and confining zone integrity problems during large-scale $CO_2$ injection, for a range of geologic settings and operating conditions.

Objectives for phase two are to develop a quantitative risk assessment tool for confining zone integrity. The geomechanical simulation technique and the quantitative risk assessment technique will then be applied to historical situations which have experienced confining zone integrity problems, as well as to historical large scale injection operations which have shown no problems. The final objective for phase two is to develop practical recommendations and guidelines for confining zone characterization and operating practices to reduce confining zone integrity damage risks.

## Benefits

The project is making a vital contribution to the scientific, technical, and institutional knowledge base needed to establish frameworks for the development of commercial-scale carbon capture and storage (CCS). This project will improve scientific understanding of the depositional and diagenetic characteristics of caprock formations as well as those related to specific storage projects in order to better characterize $CO_2$ storage permanence in the subsurface through geomechanical simulations. An added benefit of this project is the production of a quantitative risk assessment tool to help identify and mitigate caprock integrity problems, which is needed for the implementation of large-scale CCS projects. This research will advance the programmatic goals of the Carbon Storage Program by ensuring 99 percent storage permanence and improving efficiency of storage operations.