the ENERGY lab

PROJECT FACTS

Carbon Sequestration

Geomechanical Simulation of CO_2 Leakage and Caprock Remediation

Description

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, of possible carbon dioxide (CO_2) leakage at CO_2 sequestration sites, along with risk assessment of those 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 permanently sequestered. Effective application of these MVA technologies will ensure the safety of sequestration projects with respect to both human health and the environment, and provide the basis for establishing carbon credit trading markets for sequestered CO_2. Risk assessment research focuses on identifying and quantifying potential risks to humans and the environment associated with CO_2 sequestration, and helping to ensure that these risks remain low.

This three-year project—performed by Missouri University of Science and Technology in partnership with City Utilities of Springfield (Missouri)—will couple a reservoir model with a geomechanical model to simulate caprock leakage for the City Utilities of Springfield's CO_2 sequestration demonstration site. Materials and methods for stopping leakage through the caprock will be examined and tested under elevated stresses to simulate in-situ conditions. The approach is designed to be applicable to other types of CO_2 injection sites, including deep saline aquifers. If the tests are successful, a second phase of the project will simulate the effect of fracture-filling materials on fracture flow and growth. This project is expected to help those responsible for MVA of CO_2 to identify and focus on areas of high future leakage risk potential, in order to stop possible eventual leakage through seal fractures and faults.

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PARTNERS

City Utilities of Springfield (MO)

COST

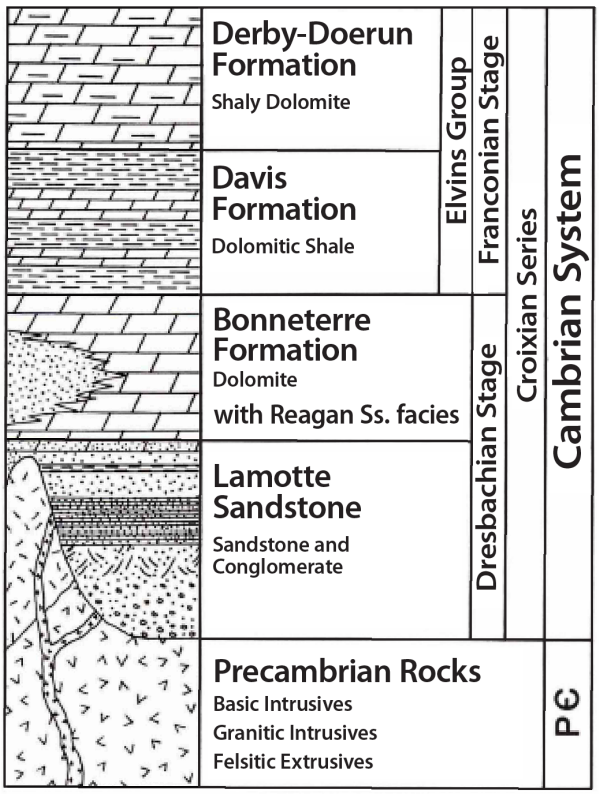
Total Project Value
$1,257,533

DOE/Non-DOE Share
$917,604 / $339,929

Primary Project Goal

The main goal of this project is to develop a novel approach to simulate caprock leakage—and simulate the success of remediation of leakage paths—for a shallow CO_2 injection site through coupled reservoir and geomechanical modeling. The specific objectives are to:

- Develop a detailed three-dimensional (3-D) shared-earth model, including in-situ stresses, rock, and geomechanical properties, to use as a consistent data set with coupled reservoir and mechanical simulations.
- Develop the methods to perform a more geologically correct, explicit, coupled 3-D reservoir and multiscale geomechanical simulation approach using existing commercial software, and conduct simulations on a detailed shared-earth model for the City Utilities of Springfield's CO_2 sequestration demonstration site.
- Develop remediation methods for sealing fractures and faults if a leak through the caprock occurs, and develop modeling capabilities for evaluating the success of fracture remediation. This work will include laboratory experiments into fracture flow and deformation characteristics after various fracture remediation techniques have been applied.



Detailed stratigraphy of Cambrian Lamotte sandstone shows overlying shale formations that potentially provide barriers against upward migration of fluids (modified after Houseknecht and Ethridge, 1978).

Accomplishments

This project was awarded on September 30, 2009. Anticipated accomplishments relate to the scope of work. During the first phase, the project team will develop a coupled 3-D geomechanical and reservoir modeling approach to simulate the possibility of leakage of CO_2 through the caprock and novel remediation technologies for sealing faults. The proposed approach will use a detailed shared-earth model to conduct a coupled reservoir and geomechanical simulation to capture the effects of increased pore pressure and reduced temperature on the stability of the caprock. This approach will give a higher measure of reliability on the likelihood and location of leakage. The project scope also includes development of methods to remediate leakage of CO_2 by sealing leaking faults or fractures. Options for fracture-sealing materials will be tested in the laboratory. If the tests are successful, the project will proceed to a second phase, during which a coupled numerical simulation of the effect of fracture-filling materials on fracture flow and growth will be studied. The effect that different filling materials have on fracture strength as a means of stopping further fracture growth will be analyzed in particular detail.

Benefits

Coal-fired power plants generate more than 50 percent of the nation's electricity and will continue to play a critical role in meeting the nation's electrical needs in the foreseeable future. To reduce emissions of greenhouse gases, injection of CO_2 into the subsurface is seen as the most promising near-term solution. To ensure public safety, as well as obtain carbon credits in a future cap-and-trade system, methods to identify potential leakage and eventual leakage are needed.

This project pursues a novel simulation approach that will improve leakage detection by developing a better predictive tool for where and when leakage might occur. This tool will enable those responsible for MVA of CO_2 to identify and focus on areas of high leakage risk potential. The project also addresses another important issue: how to stop possible leakage through seal fractures and faults.