the ENERGY lab

PROJECT FACTS

Carbon Sequestration

Influence of Local Capillary Trapping on Containment System Effectiveness

Background

The U.S. Department of Energy (DOE) National Energy Technology Laboratory (NETL) is currently funding research aimed to advance state-of-the-art technologies that address geologic storage of carbon dioxide (CO_2) in multiple formation types and across all phases of CO_2 geologic storage operations.

Geologic storage involves the injection of CO_2 into underground formations that have the ability to securely contain it over long periods of time. Research efforts are currently focused on several geologic storage formation types: several clastic and carbonate types, coal, organic rich shale, and basalt formations. These formations contain different fluids such as saline water and oil and natural gas. A principal element of the DOE's Carbon Sequestration Program is Core Research and Development (R&D) and one of the R&D focus areas—geologic storage—is aimed at addressing the challenges of CO_2 storage in these formations.

Critical challenges identified in the geologic storage focus area include CO_2 well bore integrity, geochemical and mechanical responses, fluid flow and containment, and development of mitigation technologies. For this project, researchers are conducting computer simulations and laboratory experiments to establish the feasibility of a new technique for assessing capillary trapping in geologic formations.

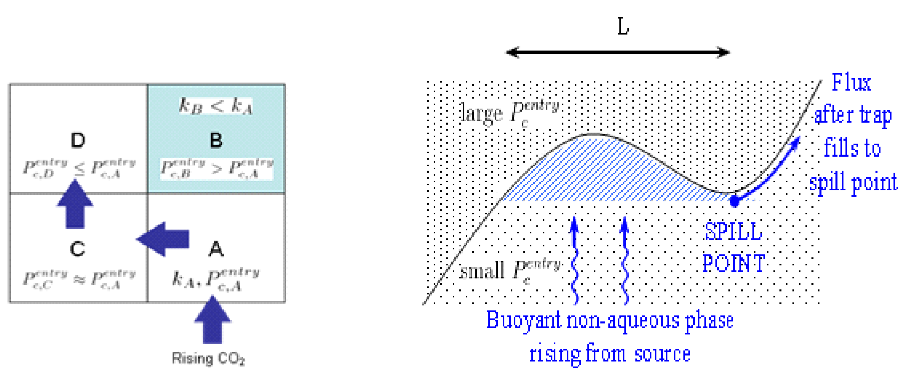

Figure 1: Capillary heterogeneity controls the structure of buoyancy-driven CO_2 plume. Left : Schematic of plume re-direction by heterogeneity. Right: Concept is analogous to the spill point in an oil/gas trap.

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PARTNERS

None

PROJECT DURATION

Start Date
10/1/2010

End Date
9/30/2012

COST

Total Project Value
$539,097

DOE/Non-DOE Share
$428,925 / $110,172

U.S. DEPARTMENT OF ENERGY

Project Description

Researchers at the University of Texas at UT Austin are conducting simulations and experiments to establish proof-of-feasibility of a novel concept for assessing capillary trapping in storage formations, as well as to confirm that storage formations have characteristic, spatially correlated distributions of transport properties. Local capillary trapping is a potentially important mechanism for immobilization of CO_2 in the subsurface. It occurs at scales from centimeters to tens-of-meters during buoyancy-driven movement of CO_2 through heterogeneous storage formations. The distribution of transport properties may vary according to the geologic characteristics of each formation. The spatial correlation shows that geologic structures within the formation can become local capillary traps for rising buoyant fluid (Figure 1). This project is developing techniques to identify and predict these geologic structures using a geostatistical description of the formation. Project researchers are using numerical simulation and laboratory experiments to analyze the extent to which local traps fill with stored CO_2, and systematically determining the geologic controls on potential capillary trapping structures. This requires characterizing the structure of potential local capillary traps in a storage formation from some measure of its heterogeneity. UT Austin will gather correlations between key formation properties from technical literature and a suite of geostatistical models typical of target formations, and then construct a set of model storage formations to be used for subsequent investigation. Potential local capillary traps will be identified in the models from maps of their capillary entry pressures ($P_C$entry). Using this method to identify potential traps, UT will study the influence of the geologic setting (dip angle, maximum height of CO_2 column) on potential trapping structures and establish a protocol for conducting buoyancy-driven fluid displacements with supercritical CO_2 in heterogeneous, bench-scale porous media.

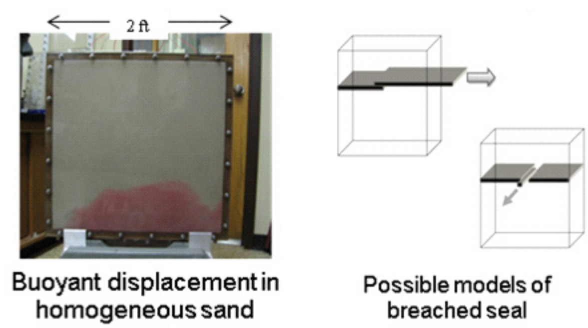

Figure 2: Bench-scale buoyant immiscible displacement in heterogeneous sandpacks with examples of possible breached seals

Once they have identified potential traps, the researchers will (1) quantify and upscale local capillary trapping (Figure 2); (2) conduct bench-scale experiments in which the overlying seal is breached, demonstrating and potentially validating the buoyant phase fluid's ability to escape from the local capillary traps; (3) determine the influence of CO_2 injection operating conditions on local trap filling; and (4) examine the limitations of the filling of capillary traps by buoyancy dominated displacement. UT researchers will then simulate filling when CO_2 emplacement occurs at a range of gravity numbers, corresponding to a range of injection rates, and will repeat these simulations with various volumes of CO_2 added to the storage formation. After researchers establish the extent of capillary trap filling, they will quantify the extent of trapping capacity that persists after the overlying seal fails.

Goals/Objectives

The overall goal of this project is to obtain a high-quality assessment of the amount and extent of local capillary trapping expected to occur in typical geologic storage formations. The goal is being accomplished by addressing several key project objectives that include (1) quantifying the influence of key geologic and petrophysical parameters on the structure of local capillary barriers in a heterogeneous formation, and hence on the potential number and volume of local capillary traps, (2) determining what fraction of these traps is filled during prototypical CO_2 emplacement operations (injection followed by buoyancy-driven migration) by simulation and laboratory experimentation, and (3) simulation and experimentation to quantify what fraction of the filled local capillary traps retains CO_2 if the top seal of the storage formation loses integrity and allows CO_2 to leak.

To accomplish the overall project objectives, researchers anticipate completing the following tasks:

- Characterizing petrophysical and geologic controls on the number and volume of potential local capillary traps.
- Determining the degree to which potential local capillary traps are filled in anticipated geologic storage schemes.
- Quantifying the extent of immobilization persisting after loss of integrity of the seal overlying the geologic storage formation.
- Incorporating the results into a functional form which can be easily integrated into existing reservoir simulation packages.
- Conducting lab-scale experiments to validate simulation modeling.

Benefits

The proposed modeling simulations and laboratory experiments will systematically establish proof of feasibility of a novel concept: that of the long-term security of CO_2 that fills numerous small-scale capillary traps in heterogeneous geologic storage formations. The result of this research will be a method for quantifying the extent of such trapping. The method can be implemented with simulation capabilities already being used to predict geologic storage containment. The impact will be a potential reduction in risks associated with long-term storage containment, achieved by considering the physical implications of geologic heterogeneity.