the ENERGY lab

PROJECT FACTS

Carbon Sequestration

Experimental Design Applications for Modeling and Assessing Carbon Dioxide Sequestration in Saline Aquifers

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: deltaic, coal/shale, fluvial, alluvial, strandplain, turbidite, eolian, lacustrine, clastic shelf, carbonate shallow shelf, and reef. Basaltic interflow zones are also being considered as potential reservoirs. These formations contain different fluids such as saline water, oil and natural gas. A principal element of 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. Current research is working to develop effective assessments to characterize the engineering and scientific impacts that CO_2 sequestration operations have on geologic storage formations.

Project Description

Researchers at Fusion Petroleum Technologies will develop and demonstrate a method to rapidly, cost effectively, and efficiently perform technical assessments of major engineering and scientific issues considered to be critical to the design, implementation, and operation of a saline aquifer CO_2 sequestration storage site. The proposed method includes using sensitivity analysis, uncertainty analysis, optimization methods (Figure 1), experimental design modeling, and response surface methods to evaluate the many factors that affect the successful characterization, engineering design, and operation of a saline formation site. The project is primarily a computer modeling effort incorporating multiple modeling methods to examine geologic and fluid effects of factors on CO_2 injection, capacity, and plume migration.

Fusion is implementing "seismic through simulation" to characterize a reservoir and capture its geologic structure, including faulting and petrophysical attributes. Geo-statistical analysis will be used to gain an understanding of the effects of how rock type variations and distributions, layering and vertical permeability variations, and high and low permeability streaks can create lateral and vertical baffles and barriers to plume migration. This type of analysis will be coupled with a study of how geologic

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PROJECT DURATION

Start Date
09/20/2010

End Date
04/05/2012

COST

Total Project Value
$1,010,879

DOE/Non-DOE Share
$808,702 / $202,177

and well construction variations affect plume migration, storage capacity, and injectivity.

Goals/Objectives

The key objectives of the project are to evaluate, based on data obtained from focused laboratory research, the applicability of experimental design modeling, response surface methods, sensitivity analysis, uncertainty analysis, and optimization methods to the many factors that affect the successful characterization, engineering design, and operation of a saline aquifer site. The purpose is to provide a better insight into how the various inputs affect the capacity, injectivity, and plume migration for geologic CO_2 sequestration in a saline aquifer.

The project will consist of four primary objectives:

- Evaluating the fluid flow in a candidate reservoir as it pertains to migration of the CO_2 plume due to vertical and lateral heterogeneity, relative permeability effects and changes due to dissolution of the rock, pressure migration, fault distribution, and seal integrity.
- Evaluating the use of multilateral horizontal wells as opposed to vertical or single lateral wells.
- Modeling the effects of competing thermodynamic and chemical effects within saline aquifers on the geologic formation and cap rocks by injecting impurities associated with the CO_2 gas stream.
- Evaluating the applicability of experimental design and response surface methods.

The project will be conducted by applying research into the theoretical and applied aspects of multiple modeling parameters and the effects of those parameters, to multiple simulation models dealing with the injectivity, storage capacity, and CO_2 plume migration in a saline aquifer geologic reservoir. Fusion Petroleum Technologies is focusing on the Crow Mountain saline formation within the Teapot Dome in Wyoming as its candidate testing reservoir (Figure 2). The Teapot Dome region has extensive existing geologic data, typically in shallower formations than the Crow Mountain due to oil exploration efforts in the region.

Benefits

This project will benefit CO_2 sequestration in geologic reservoirs by analyzing how CO_2 can be efficiently stored and contained in saline aquifers. The data generated by these modeling simulations will allow for a more cost-effective CO_2 sequestration operation. More precise modeling will improve the understanding and characterization of potential saline aquifer geologic reservoirs associated with CO_2 injection.

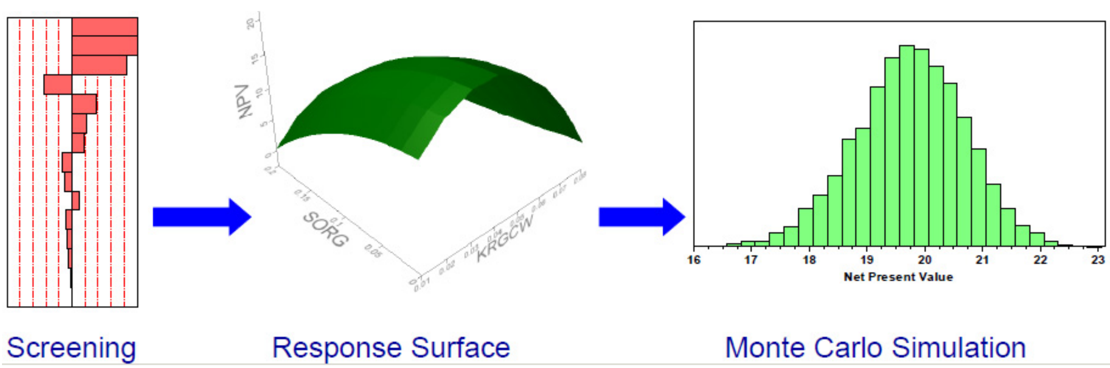

Figure 1: Uncertainty assessment with experimental design that includes a three step process involving: (1) key parameter identification, (2) response surface modeling, and (3) Monte Carlo simulation.

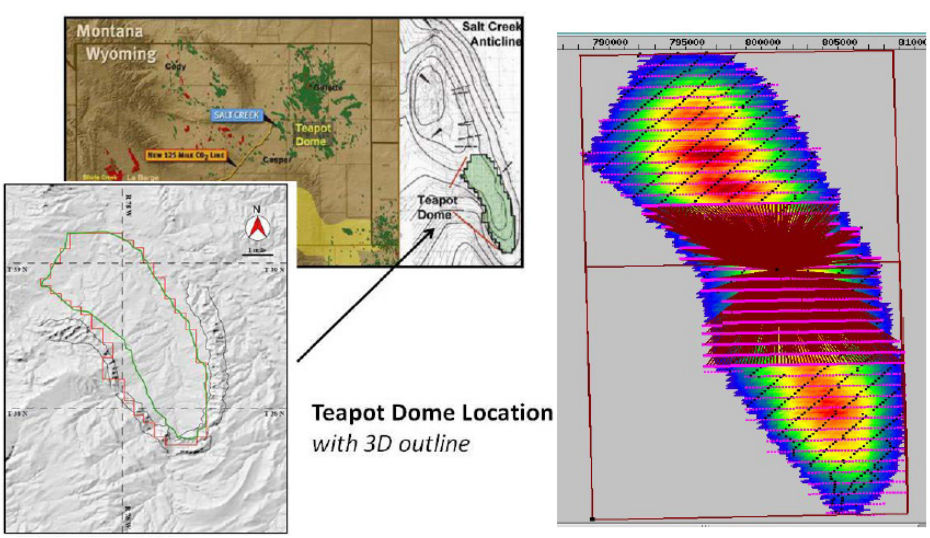

Figure 2: Location of Teapot Dome field site in Wyoming and 3D seismic survey location (green line in bottom left corner).