the ENERGY lab

PROJECT FACTS

Carbon Sequestratiion

Reducing Uncertainties in Model Predictions via History Matching of CO_2 Migration and Reactive Transport Modeling of CO_2 Fate at the Sleipner Project, Norwegian North Sea

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 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. The ability to predict and model the migration and reactive transport of CO_2 injected into reservoirs is a key component when determining the viability of a reservoir for long term storage. More research is needed to increase the accuracy of models.

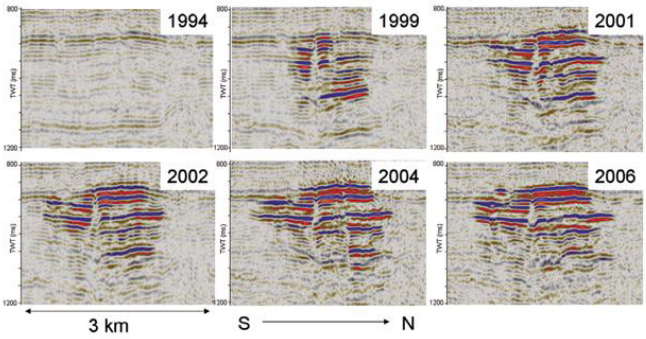

Figure 1: Development of the CO_2 plume over the years imaged with seismic data at the Sleipner site. (Arts, R. et al. 2008. Ten Years' Experience of Monitoring CO_2 Injection in the Utsira Sand at Sleipner, Offshore Norway. First Break, Vol.26, January 2008)

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PARTNERS

None

PROJECT DURATION

Start Date
10/1/2010

End Date
9/30/2013

COST

Total Project Value
$518,503

DOE/Non-DOE Share
$399,418 / $119,085

Project Description

This project is using four dimensional (4-D) seismic data from the Sleipner project in the Norwegian North Sea to conduct multi-phase flow and reactive mass transport modeling of CO_2 migration in a carbon reservoir. The Sleipner project is the world's first commercial scale geologic carbon sequestration project and is managed by StatOil. To date, a total of 11 million metric tons of CO_2 have been injected over a period of 15 years, and 4-D seismic data has been used to delineate the CO_2 plume migration history in the reservoir rock, the Utsira sandstone. StatOil has developed a geologic model of the Utsira Sandstone from this data. The relatively long history of detailed geologic investigation and CO_2 migration, combined with high fidelity data, makes Sleipner one of the best places in the world to conduct multi-phase flow and reactive mass transport modeling.

Researchers at Indiana University are using the geologic model provided by StatOil to develop a reservoir scale multi-phase reactive flow model for CO_2 plume migration and dynamic evolution of CO_2 trapping mechanisms (hydrodynamic/structural, solubility, and residual/capillary) at Sleipner. Indiana University is utilizing comprehensive data, including seismic and well log data, to build the regional reservoir model. Up to 300 testing wells have been drilled at Sleipner, of which 30 are within 20 kilometers of the injection site. Information collected from the wells includes lists of formation tops, geophysical logs, reservoir core material, selected cuttings of caprock and reservoir rocks, and reservoir pressure measurements.

The model will be calibrated through historical matching using information of the progressive CO_2 plume migration delineated by the 4-D seismic data. The calibrated reservoir model will then be extrapolated to a regional scale model of multi-phase reactive mass transport to predict CO_2 fate 10,000 years after injection into the reservoir. A rigorous geochemical reaction kinetics framework will be implemented and a number of sensitivity analysis and bounding calculations will help reduce the uncertainty in predicting geochemical reactions.

Goals/Objectives

The overall objective is to assess and reduce uncertainties of model predictions of CO_2 plume migration, trapping mechanisms, and storage capacity estimates. Because these predictions are necessary at all stages of CO_2 storage operations (site assessment/selection, design, installation, operations and monitoring, and closure/post-closure), improved assessment of model uncertainties is critical to regulatory approval and public acceptance. Specific objectives are:

Reduce model uncertainties through history matching of the CO_2 plume migration over the past 15 years at the Sleipner site.

Reduce uncertainties in prediction of the long-term fate of CO_2 through implementing rigorous chemical kinetics and through a number of bounding calculations and sensitivity analyses.

Benefits

Numerous benefits will result from this research. The Sleipner project is an international collaboration that will demonstrate that prediction and simulations of plume behaviors and trapping mechanisms are robust at a site with favorable geological conditions. Improved stakeholder and public acceptance of sequestration can be achieved through the successful outcome of this highly visible project. An improved understanding of CO_2 behavior will increase our ability to model and predict the behavior of potential reservoirs targeted for investigation by NETL and its partners. This project, by making available a wealth of data from the world's first industrial CO_2 injection site, will greatly benefit the work of regional partnerships conducting large volume injection experiments.

It is expected that this research program will generate at least one Ph.D., scholarly publications in refereed journals, and presentations at professional meetings. The publications will help the Sleipner project become more recognized in the U.S., and make the scientific data generated from the project available to the U.S. carbon capture and storage community.