the ENERGY lab

PROJECT FACTS

Carbon Sequestration

Quantification of Wellbore Leakage Risk Using Non-Destructive Borehole Logging Techniques

Background

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 and risk assessment, of possible carbon dioxide (CO_2) leakage at CO_2 geologic storage 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 stored underground permanently. Effective application of these MVA technologies will ensure the safety of geologic storage projects with respect to both human health and the environment, and can provide the basis for establishing carbon credit trading markets for geologically storing CO_2. Computer simulation can be used to estimate CO_2 plume and pressure movement within the storage formation as well as aid in determining safe operational parameters; results from computer simulations can be used to refine and update a given site's MVA plan. Risk assessment research focuses on identifying and quantifying potential risks to humans and the environment associated with geologic storage of CO_2, and helping to ensure that these risks remain low.

Project Description

Schlumberger Carbon Services (SCS) and partners have identified leaky wellbores as an important risk to storage integrity that warrants further study to develop methods to quantify the risk of leakage in active and abandoned wellbores. This three-year project is working to develop methods for risk quantification that can be directly applied to individual wells using measurements from borehole logging tools. Models for leakage risk of wells can be developed that use collected data to establish the overall probability of leakage of a given well. Logging information is input into a model to evaluate the probability of leakage for specific zones in the well, e.g., the casing, cement, cement-casing interface, cement-formation interface, and any existing defects (Figure 1).

Goals/Objectives

The primary objective of the DOE's Carbon Storage Program is to develop technologies to safely and permanently store CO_2 and reduce Greenhouse Gas (GHG) emissions without adversely affecting energy use or hindering economic growth. The Programmatic goals of Carbon Storage research are: (1) estimating CO_2 storage capacity in geologic formations; (2) demonstrating that 99 percent of injected CO_2 remains in the injection zone(s); (3) improving efficiency of storage operations; and (4) developing Best Practices Manuals (BPMs).

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PROJECT DURATION

Start Date	End Date
1/1/2010	10/31/2012

COST

Total Project Value
$2,159,431

DOE/Non-DOE Share
$1,517,626 / $641,805

PROJECT NUMBER

DE-FE0001040

U.S. DEPARTMENT OF ENERGY

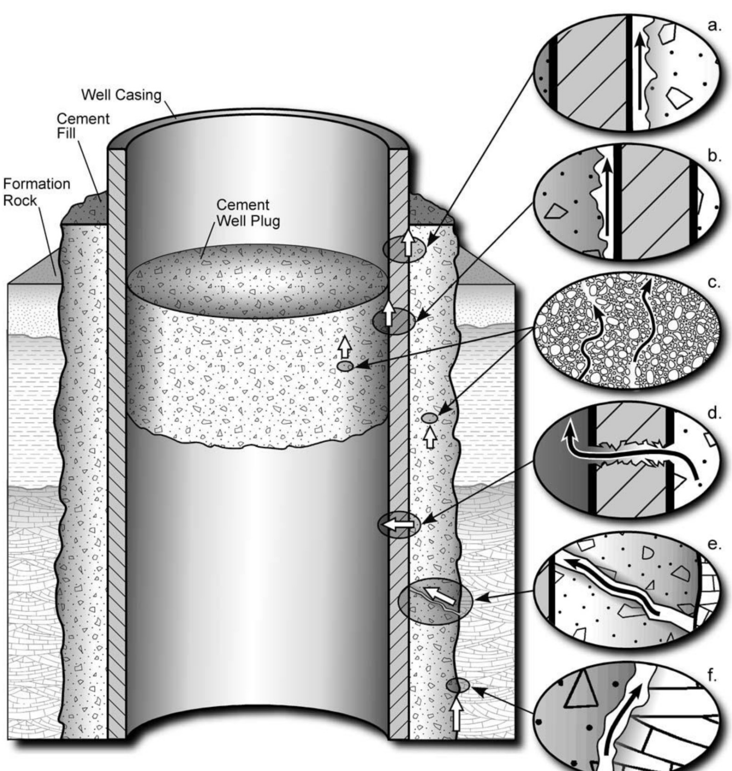
The main goal for this project is to develop a new method to relate the risk of leakage of existing wells at CO_2 geologic storage sites to data collected by tools used to non-destructively determine well cement integrity. This goal will help to demonstrate and ensure CO_2 permanence in the subsurface. The data will be taken from existing wells that have not been exposed to CO_2 in order to quantify the risk of leakage at the start of a project (prior to injection) and populate risk models. Supporting objectives include the following:

- Develop methods to establish the average flow parameters (porosity and permeability or mobility) from individual measurements of the material properties and potential defects in a well.
- Develop a correlation between field flow-property data and cement logs that can be used to establish the flow-properties of well materials and well features using cement mapping tools.
- Establish a method that uses the flow-property model (previous objective) to analyze the statistical uncertainties associated with potential individual well leakage that can provide a basis for uncertainty in risk calculations.

Accomplishments

This study is being conducted to better understand pre-injection leakage risks and similarities between wells in a given field. Geologically, the study focused on well sections through shales and caprocks. Data were collected to establish the baseline condition of five existing wells in two fields in the state of Wyoming. The wells ranged from 6- to 25-years in age. The cements in the wells were light cements, pozzolan cements, and Class G well cements. The results of the study provide insight into the pre-injection condition of existing wells and are summarized as follows:

- Ultrasonic maps of the wells show similarities in cement jobs in different wells in the same field occur within specific formations.
- In-situ point-measurements and laboratory measurements of permeability were generally in the microdarcy-to-nanodarcy range and indicate that the well cements have likely not degraded from exposure to the formation brines.
- Vertical interference tests, when compared to point measurements, imply interfaces between casing and cement or cement and formation are more significant with respect to leakage than the cement itself with values in the millidarcy range.
- Work on modifying the software in an existing down-hole tool may yield an analytical method to determine the risk of well-bore leakage, which has applications in carbon storage within abandon or mature oil and gas fields.



Benefits

It will be necessary to improve existing monitoring technologies, develop novel systems, and protocols to satisfy regulations to track the fate of subsurface CO_2 and quantify any emissions from reservoirs. The Carbon Storage Program is sponsoring the development of technologies and protocols by 2020 that are broadly applicable in different geologic storage classes and have sufficient accuracy to account for greater than 99 percent of all injected CO_2. If necessary, the tools will support project developers to help quantify emissions from carbon capture, utilization, and storage (CCUS) projects in the unlikely event that CO_2 migrates out of the injection zone. Finally, coupled with our increased understanding of these systems and reservoir models, MVA tools will help in the development of one of DOE's goals to quantify storage capacity within ± 30 percent accuracy.

In anticipation of a large number of carbon storage sites starting in the next several years, it is important to understand the risk of CO_2 leakage through existing wells. This project is leading to the development of a rigorous data set that can be used to understand well leakage probability and risk. In addition, this project may lead to the development of a down-hole tool and analytical method to determine the risk of well-bore leakage. This would improve the ability to assess the integrity of well-bores within mature oil and gas fields as part of any CO_2 storage efforts. Model validation and calibration resulting in quantitative risk of leakage will have a significant impact on both the quality and uncertainty in site performance and risk models. A reduction in uncertainty will allow for better decisions on the use of resources to repair wells and determine appropriate MVA technologies.

Figure 1 - Potential CO_2 wellbore migration pathways: between cement and casing (Paths a and b), through the cement (c), through the casing (d), through fractures (e), and between cement and formation (f). Image is from Celia, M.A., Bachu, S., Nordbotten, J.M. Gasda, S.E. and Dahle, H.K. 2004. Quantitative estimation of CO_2 leakage from geologic CO_2 storage—analytical models, numerical models, and data needs. Princeton Environmental Institute. The Princeton papers at Vancouver GHGT-7, Paper ID #228. http://uregina.ca/ghgt7/PDF/papers/peer/228.pdf.