Lawrence Livermore National Laboratory's Research Activities to Support DOE's Carbon Storage Program

Agreement Number: FWP-FEW0191

Performer: LLNL - Lawrence Livermore National Laboratory

Key Technologies:

- **Task 1 – CO_2 Storage Carbonate Reservoirs**
  The objective is to assess the storage potential of CO_2 in carbonate reservoirs as a consequence of mineral dissolution since the storage potential of carbonate reservoirs is poorly understood compared to sandstone reservoirs. Recent experimental results suggest that in many carbonate reservoirs CO_2 injection and transport is dominated by fracture flow. The empirically constrained reactive transport model (RTM), which captures the evolution of permeability in both porous and fracture-dominated carbonate cores from two sites in Kansas, is being tested and validated and the NMR permeability equation is being refined using carbonate core from one or two other sites where CO_2 storage is planned. Predictions of the evolution of porosity and permeability are being compared against experimental results. Additional work includes: (1) calibration of the NMR tool to estimate permeability, (2) calibration of the RTM and the refined NMR permeability equation using cores from the Big Sky Partnership, and (3) the analysis of Midwest Regional Carbon Sequestration Partnership cores for CO_2 enhanced porosity and permeability.
- **Task 2 – Microseismic Toolset for Fault Detection and Seismicity Mitigation**
  This study is addressing induced seismicity challenges associated with geologic carbon storage. The aim is a data collection and analysis methodology with a fast turn-around time and substantial automation that can be used to quickly characterize and respond to changing subsurface conditions.
- **Task 3 – Implications of Stress State Uncertainty on Caprock and Well Integrity**
  The project is studying the effects of stress on well integrity and is developing

improved simulation tools for modeling injection-induced hydraulic fracturing and its impact on caprock integrity. The key motivation for this work is field observations at the In Salah CO_2 storage project, which indicate that the injection of cold CO_2 at high pressures may have been sufficient to cause thermo-hydraulic fracturing in the reservoir and lowermost caprock units. The end result will be a model that may be used to simulate CO_2 wellbore integrity and allow well operators to test the value of mitigation strategies on wellbore operations.

- **Task 4 – Industrial CO_2 Demonstrations**
  The objective of this task is to develop new projects with industrial partners, such as Statoil, who are actively storing CO_2 in the geologic reservoirs. These partnerships are important because they apply state-of-art expertise within the U.S. DOE to large-scale international projects to help enable the commercialization of CO_2 storage. Current efforts are focusing on the development of a fast-running tool to continuously forecast reservoir pressure behavior based on real-time data (Figure 1). The robustness of this methodology and the concept of pressure reservoir management is being tested using data sets provided by Statoil. Additional proposed work includes the development of a pressure forecasting tool and active CO_2 management. Both tasks will use Statoil data from the phase 2 Stø Fm injection and from Regional Carbon Storage Partnerships. Both of these data sets represent two geologically different case studies associated with CO_2 storage where gas or oil is also being recovered.
- **Task 5 – Novel Monitoring Techniques for CO_2 Storage Using Large-N Seismic Arrays**
  The objective of this task is to apply novel monitoring techniques to CO_2 storage. The first is a method to image the subsurface using background noise, called ambient noise correlation (ANC). The second technique, the virtual seismometer method (VSM), significantly increases resolution in tectonically active features. This will help monitor changes in pressure fields related to microseismicity. The third technique will use combined seismic and electromagnetic monitoring in porous media to image subsurface fluids. The different yet complementary measuring sensitivities of seismic and electromagnetic monitoring will likely yield a superior image. Finally, particular interest will be given to the testing of fiber optic arrays, as both ANC and VSM become more powerful as the number of sensors increase. Additional data gathered using this technique could help expand these monitoring techniques to CO_2 storage.

Technology Areas:

- Geologic Storage (GS)
- Monitoring, Verification, Accounting, and Assessment (MVAA)