Borehole Based Monitoring of CO_2 Storage: Recent Developments in Fiber-Optic Sensing

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The overarching objective of monitoring geologic storage of CO_2 is to demonstrate safe and effective long-term storage integrity in the target reservoir. This is typically accomplished through a multi-faceted monitoring program, including borehole monitoring for direct access to the subsurface. CO_2 storage, unlike CO_2 enhanced oil recovery (EOR), is expected to rely upon dedicated monitoring wells, as demonstrated by early CO_2 storage pilots. Effective use of monitoring wells is one of our research goals.

LBNL has been involved in borehole based monitoring at multiple pilot tests. Among the borehole tools designed, developed and/or deployed are U-tube fluid sampling for geochemistry, seismic sensors for imaging or microseismic monitoring, seismic sources and electrodes for continuous monitoring, heat-pulse monitoring, and discrete downhole pressure/temperature gauges. Recently, we have focused on distributed fiber-optic (FO) technology because of its ability to provide data at high spatial and temporal resolution with robust, cost-effective deployment. LBNL has assisted in FO deployments and/or testing for CO_2 storage pilots at the SECARB Cranfield test, GFZ's Ketzin Site, the CO2CRC Otway Project, SECARB's Citronelle and the PTRC operated Aquistore Project.

Distributed acoustic sensing (DAS) and heat-pulse FO monitoring are tools taking advantage of development of distributed FO sensing technology. In particular, DAS is a new and potentially game-changing seismic monitoring technology. This talk will focus on the development and testing of DAS, with discussion of distributed FO heat-pulse monitoring and the deployment of borehole instruments.

Deployment is a key factor affecting cost and effectiveness of borehole monitoring. Through a commission by the CO_2 Capture project, we designed and deployed a unique modular borehole monitoring (MBM) system that incorporates monitoring technologies (fluid sampling, seismic monitoring, precision pressure and temperature sensing, distributed heat-pulse monitoring and distributed acoustic sensing) for cost effective deployment in a flexible, robust package. The MBM system was fabricated and deployed in a ~3km deep monitoring well at the Citronelle Dome CO_2 storage site, Citronelle, Alabama, USA, operated by the U.S. Dept. of Energy's Southeast Regional Carbon Sequestration Partnership (SECARB).

The initial DAS testing at Citronelle demonstrated potential and led to follow-up tests at Otway, Ketzin, Aquistore and repeat tests at Citronelle and Aquistore. Through this series of tests, we have acquired comparative information on deployment and use of DAS, which indicates great potential for borehole based CO_2 monitoring.