Case Study

Microseismic monitoring of a CO_2 sequestration project

Microseismic monitoring of a test CO_2 injection site in the Michigan basin successfully detected an increase in seismic activity with increased injection rates and helped to gain insight into the effects of these injections on the surrounding geology.

Fig. 1: ESG Bowspring sensor array is deployed

Carbon sequestration is considered a promising approach to combating the accelerated effects of global warming due to fossil fuel emissions. The capture and storage of CO_2 in geological formations is not a new idea, however the long-term storage of CO_2 is untested and can benefit from the enhanced geological observation that passive microseismic monitoring can provide.

Challenge

Working in collaboration with the Midwest Regional Carbon Sequestration Partnership (MRCSP), the objective of this particular project was to inject 10,000 metric tons of CO_2 into a target interval containing the porous portions of the Bois Blanc and all of the Bass Islands Dolomite formation, at a depth of 3,190-3,515 feet. This site is located in the northern portion of the Michigan Basin and has a primary seal in the Amherstburg formation, which acts as a caprock layer, overlying the Bois Blanc and Bass Islands Dolomite.

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With the project duration set for 30-60 days, the average injection rate was planned for 100-300 metric tons per day, with a maximum rate of 600 tons per day. Bottom-hole fracture pressure and corresponding maximum surface fracture pressure were used as limits for injection. The MRCSP wanted to ensure they were not injecting at rates that would fracture the formation or breach the capping Amherstburg layer. Assessment of the acoustic emissions created by the injection process was also needed to refine the geomechanical model.

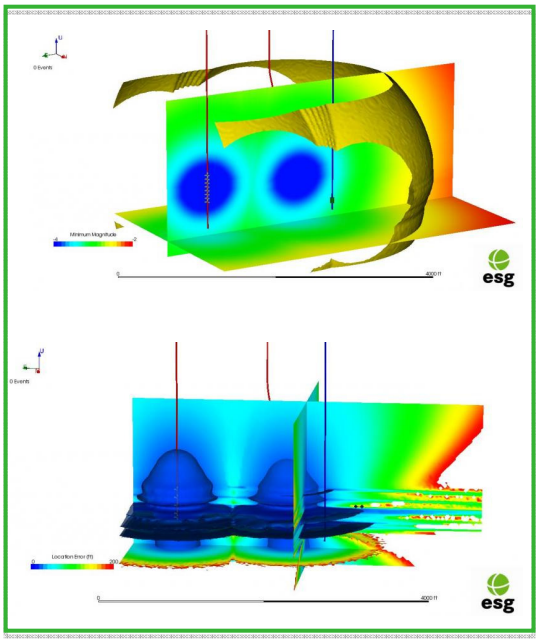

Fig. 2: Sensor array schematics including A) location error and B) ranges of detection

ESG Solution

ESG designed and deployed a temporary ResMap™ solution for monitoring the CO_2 injection. Data was acquired using two 8-level dual 3-component sensor arrays, spaced 15 meters apart and deployed down two monitoring wells on retrievable bow spring clamps. The sensor arrays were also designed to be used for 3D VSP shots. ESG Paladin™ Data Acquisition Units were used to digitize and record the data.

The string shots and four perforation shots were used to orient the sensors. An initial velocity model was developed from the monopole and dipole sonic logs provided by the client. ESG performed its own proprietary Particle Swarm Optimization technique on the orientation shots to refine the velocity model and enhance the event location accuracy.

A total of 26 microseismic events were recorded during the injection period. Of particular importance was the detection of microseismic activity by both sensor arrays that occurred following an increase in the gas injection rates. This activity was located within the upper region of the Bois Blanc, immediately below the Amherstburg formation's capping layer. Because the activity was detected immediately following a period of increased injection pressure, it is likely the injection activated a previously existing structure within the formation, or that the increased injection pressure itself caused a fracture within the formation. The majority of the events recorded were clustered, indicating there may be some form of intersection with a regional structure in the subsurface.

Outcome

The microseismic activity detected near the capping shale gave the operator a clear indication that their injection was influencing the formation, either through fault activation or by the creation of new fractures. Incorporating this information into operating practices helped determine optimal injection rates and provided operators with direct feedback of injection compliance.

ESG continues to work with the MRCSP on a variety of CO_2 sequestration projects, and is the main provider of passive seismic monitoring instrumentation and services for several large scale CO_2 EOR operations, including at Weyburn, SK.

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