Approaching Risk Mitigation through Real-Time Monitoring of Injection-Induced Microseismicity at the Illinois Basin – Decatur Project

**CHALLENGE**
Reduce the risk of carbon dioxide (CO₂) injection operations causing a felt seismic event.

**SOLUTION**
Use Carbon Services, which would deploy WellWatcher PS3* passive seismic sensing system to provide continuous real-time monitoring of microseismic activity and near-real-time microseismic characterization that can guide operations procedures.

**RESULTS**
An effective microseismic monitoring system for detecting and characterizing induced microseismicity was developed, helping to better understand the microseismic effects caused by CO₂ injection in reservoirs. Used in conjunction with other reservoir characterization and operational data, the microseismic monitoring system can provide data essential to operational procedures aimed at reducing the probability of a felt induced seismic event.

**Introduction**
Designing and implementing a successful microseismic monitoring program requires balancing technical, operational, and commercial factors. Analyzing the microseismic events within a comprehensive geological and geomechanical context, a better understanding of microseismic event mechanisms may be gained and potentially used to construct an event-forecasting framework.

Characterizing individual microseismic events is only one step in the monitoring workflow. These characterized microseismic events needed to be evaluated in the context of the complete Illinois Basin – Decatur Project (IBDP) subsurface characterization program, which included 3D seismic data, geophysical and geomechanical borehole data in all wells, multilevel pressure monitoring, and repeat CO₂ saturation measurements at nearby wells. These data have been integrated to develop a high-fidelity geological model. Coupling the geological model with the fluid flow/geomechanical numerical models provides an integrated, well-defined dataset for microseismic monitoring and evaluation.

**Overview of the Illinois Basin – Decatur Project**
The Midwest Geological Sequestration Consortium (MGSC), led by the Illinois State Geological Survey, together with Archer Daniels Midland Company (ADM) and Schlumberger Carbon Services, is currently injecting CO₂ in the first million-tonne demonstration of carbon sequestration from a biofuel source in the U.S. The CO₂ is being injected over a 3-year period and stored in the Mt. Simon Sandstone, more than a mile beneath the surface at Decatur, Illinois. The CO₂ is captured from the fermentation process used to produce ethanol at ADM’s corn processing complex and is then compressed into a dense liquid to facilitate the injection process and long-term storage at a depth of 7,000 feet.
CASE STUDY: Approaching Risk Mitigation through Real-Time Monitoring of Injection-Induced Microseismicity at the Illinois Basin – Decatur Project

Deployment of the WellWatcher PS3 system for microseismic monitoring

Although geophones in dedicated offset wells could meet the technical requirements for microseismic observation redundancy and geometry at the target level, this would have been an expensive option. The injection well itself was an attractive location for in- or near-zone microseismic observations, but well construction and fluid flow noise posed severe operational and technical challenges to sensor deployment and signal fidelity.

To meet these challenges, Carbon Services opted to use a combination of four-component sensors of the WellWatcher PS3 system in the injection well and three-component vertical seismic profile (VSP) array sensors permanently installed in a nearby shallow geophysical monitoring well at the IBDP. Deployed near the injection zone of the CO$_2$ injection well, the WellWatcher PS3 system array performed well, yielding high-fidelity microseismic observations. Microseismic data from the injection well were supplemented by data obtained from a shallow, permanently installed VSP sensor array in a nearby geophysical monitoring well. Together, the two arrays provided a cost-effective technical solution to the measurement challenges and directly resulted in a gain in operational efficiency.

Real-time simultaneous data collection

In evaluating the complex relationships between CO$_2$ injection operations and induced microseismic activity, the precise and accurate time registration of data is essential. To better understand these relationships, Schlumberger implemented the RTAC* real-time acquisition and control software at the IBDP site, collecting extensive seismic data and correlating it with nonseismic data, such as pressure, temperature, and injection rate. With real-time data obtained through RTAC software, the effects of operational changes were tracked from their origin at the CO$_2$ supply line into the reservoir and those changes were correlated with potential induced seismicity. Via secure web access for both onsite and remote users, RTAC software enabled time-sensitive data analysis and feedback, directly resulting in informed operational decisions and efficient microseismic forecasting.

Microseismic data analysis and workflow

Schlumberger developed the successful microseismic analysis workflow and algorithms used on this project by integrating geophysical and geomechanical expertise gained in microseismic monitoring within WesternGeco and other Schlumberger segments. With this project, Schlumberger continues its commitment to leading-edge research in geophysics and geomechanics for subsurface characterization.

Key findings

Continuous real-time monitoring of microseismic activity and near-real-time microseismic event characterization can be achieved by combining four-component sensors of the WellWatcher PS3 system in the injection well with a three-component VSP array in a nearby monitoring well.

Nonseismic data must be integrated into microseismic event analysis. Employing RTAC software ensures the real-time, simultaneous tracking of both seismic and nonseismic data for both onsite and remote analyses.

Evaluating microseismic events in the context of the complete subsurface characterization program, including 3D seismic data, geophysical and geomechanical borehole data in all wells, multilevel pressure monitoring, and repeat CO$_2$ saturation measurements at a monitoring well may provide leverage to guide injection operations.

“Used in conjunction with other reservoir characterization and operational data, the microseismic monitoring system may lead to better-defined operational procedures that will reduce the chance of induced seismicity.”

“With this project, Schlumberger continues its commitment to leading-edge research in geophysics and geomechanics for subsurface characterization.”