CMC CaMI-Newell Field Research Station: Advancing sparse monitoring technologies for CCS

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Abstract

Carbon Management Canada (CMC), in collaboration with the University of Calgary, has developed and operates a research site in Newell County, Southeast Alberta, Canada. At the CMC-CaMI Field Research Station (FRS), a small and controlled amount of CO_2 is injected into a brackish aquifer at 300 m depth (Lawton et al., 2019; Macquet et al., 2022) to simulate a leakage from a large deep CCS project. The FRS addresses fundamental principles of CCS Measurement, Monitoring and Verification (MMV), with its primary goal being to develop and test a broad range of monitoring techniques. This paper discusses some of the monitoring used and developed at the FRS.

Results

One fundamental principle for MMV is providing timely warning of any containment or conformance anomalies while being economically achievable. An early warning system requires quasi-continuous surveillance of the reservoir to detect any abnormal transient changes in the subsurface; having a cost-effective method requires moving away from conventional time-lapse 3D seismic.

Sparse seismic monitoring
The Field Research Station is being used to test sparse multi-physics nodes, and initial work has been undertaken for the seismic component. A 25 m-long steel helical screw pile was installed at the site, anchored into the sedimentary bedrock. It provides high-fidelity source-receiver location and performance repeatability when coupled to permanently installed surface and borehole geophones and optical fibre arrays. Several vibrational and impulsive seismic sources have been tested. Figure 1 shows an example of borehole geophone shot gathers recording a nitrogen-driven hammer. When mounted on the screw pile, the source onset signal is sharper with a higher dominant frequency compared to the more attenuated shot on the ground surface. In Figure 1a, the direct arrivals, indicated by arrows, arrive 15 ms earlier due to the shorter travel time through 25 m of steel rather than through the glacial till.

Distributed Fiber Optic Sensing
The FRS has a 5-km loop of straight and helical single mode fibre in both the two observation wells and a 1.1 km surface trench. Multi-mode fibre is also deployed in the two observation wells and the injection well. The fibre optic array is used for continuous temperature monitoring, microseismicity detection, and continuous recording of the strain changes due to the CO_2 injection.

Semi-continuous electrical resistivity tomography
Since 2019, 1174 daily surveys have been run using the permanently installed borehole electrodes cemented in the fibreglass monitoring well. They are used for well integrity monitoring and CO_2 saturation estimation in the storage complex. The surveys' inversion shows CO_2 accumulation in 3 different layers, correlated with injection history at the site and pressurization of the reservoir.

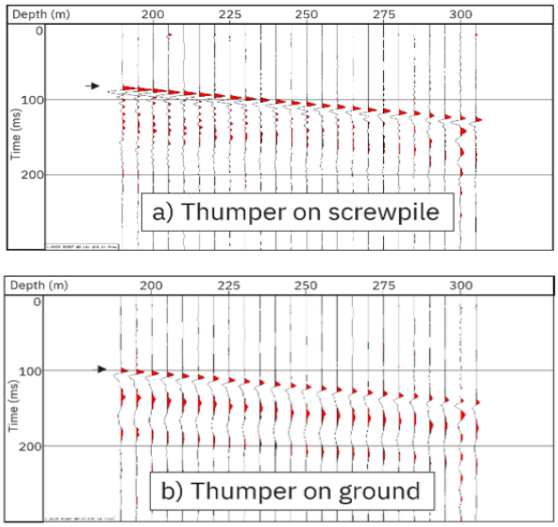

Figure 1: Borehole geophone shot gathers of impulsive nitrogen hammer tested on the screw pile location: a) on the screw pile, b) on the ground adjacent to the screw pile.

Summary

The extensive monitoring program at the FRS enables us to understand the migration of CO_2 in our storage complex. Research CCS sites are necessary to test and develop technologies that comply with MMV principles.

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