

## Using continuous fiber optic for Carbon storage monitoring – DSS and DAS applications from the CMC-CaMI Newell County Facility

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### Summary

Early warning of containment or conformance anomalies is one of the principles for Carbon Capture and Storage MMV (Monitoring, Measurement and Verification). It requires the implementation of a monitoring strategy that is continuous, has a high spatial resolution, and is cost-effective. At the CaMI Field Research Station, fiber optics are tested for strain, temperature, and acoustic recording. Results on low-frequency Distributed Acoustic Sensing (DAS) and Distributed Strain Sensing (DSS) illustrate the efficacy, high sensitivity and spatio-temporal resolution of fiber optic methods to detect and characterize subsurface changes and the complex geomechanical response of the CaMI.FRS to CO<sub>2</sub> injection.

### Dataset

Carbon Management Canada has developed and operates the CaMI Field Research Station (CaMI.FRS) in Newell County, Alberta, Canada. At the FRS, a small and controlled amount of CO<sub>2</sub> is injected (85 tonnes as of the end of 2023) into a shallow reservoir (300 m depth), simulating a leakage from a deep large-scale CCS project. This research site enables the development and evaluation of monitoring technologies, particularly focused on early detection of conformance or containment anomalies. One of the technologies tested at the CaMI.FRS uses fiber optics deployed in the wells as a (semi) continuous, high spatial resolution method to monitor the subsurface due to CO<sub>2</sub> injection. Figure 1 shows the deployment of optical fiber cable at the site. Fiber optics can be used as distributed temperature sensing (DTS), active and passive distributed acoustic sensing (DAS), and for quasi-static non-DAS strain change sensing (DSS). This study focuses on the low-frequency DAS and the DSS datasets.

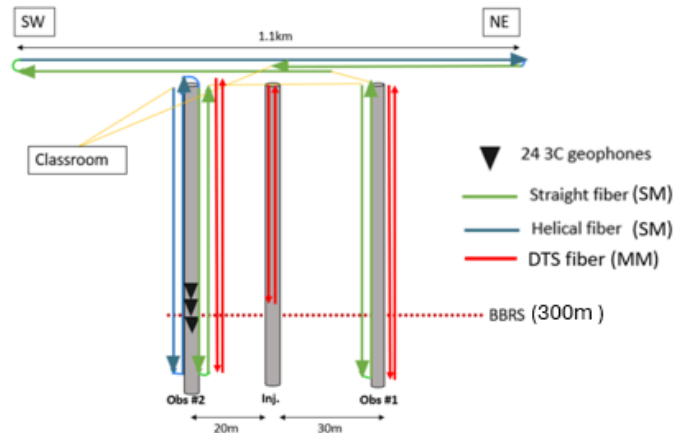


Figure 1: Schematic cross-section of the fiber optic deployment at the Newell County Facility. BBRs: Basal Belly River Sandstones. SM is single mode, MM is multimode.

## Results

### Low-frequency DAS

Continuous recordings of low-frequency (1 Hz) DAS signals on the 5-km fiber optic loop in March and May 2022 and since June 2023 detected events with clear upward travelling propagation, detected only on the helical fiber in the cable that is cemented in the observation well #2 (Figure 2.a). These appear to be aseismic event “trains” with low apparent vertical velocity (9 to 15 cm/s). These distinct features originate at distinct depths in the well. No DTS based temperature anomalies or features are observed on the co-located multi-mode fiber or DTS data.

### Rayleigh Frequency Shift Distributed Strain Sensing (RFS DSS)

In May 2023, Neubrex Energy Services conducted a continuous 10-day DSS monitoring experiment at the CaMI.FRS. Data was acquired on the same 5-km fiber loop. During the experiment, 787 kg of CO<sub>2</sub> was injected in 3 cycles in the offset injector well, inducing a maximum pressure difference of ~2MPa. Figure 2.b shows the strain change in the offset monitor well. Electrical resistivity tomography surveys ran in the monitor well during the injection period, inducing thermally induced strain changes due to electrodes warming up. Layers of strain increase are clearly detectable on the RFS DSS data, some being at the same depth as the DAS slow-event origins and propagation depth intervals.

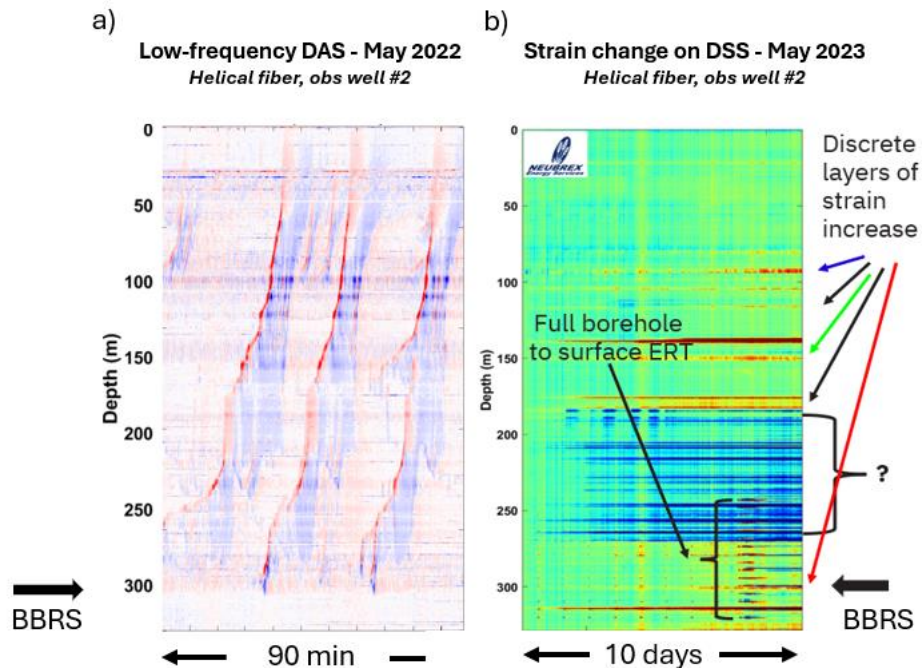


Figure 2: a) Slow events - low-frequency DAS, HWF, observation well #2. Channel sampling is 90 cm. b) 10 days of strain change (micro-strain) – DSS, HWF, observation well #2 (Jurick and Guzik, 2023). Channel spacing is 9 cm.

## Findings and Assessments

The versatility of fiber optic based distributed sensing technologies (temperature, acoustic, and strain), its high detection sensitivity, high spatial resolution (meter to sub-meter), high coverage (from surface to below the reservoir), time-lapse change detection capability, and ability to record continuously make fiber optics a very promising technology for CCS monitoring. Each different application has its own pros and cons; low-frequency DAS, for instance, requires continuous measurement to detect strain change, whereas RFS DSS can capture changes by being sparsely deployed in time. Fibre optic technologies rapidly evolve to increase their sensitivity (Kishida et al., 2013). Fibre optics will be a particularly useful technology for developing large-scale, proximal projects, which can potentially interfere with each other and have complex pressure and strain build-up. Integrating all the observations with a geomechanical model will be the next step to fully understand the effect of CO<sub>2</sub> injection on the subsurface at the CaMI.FRS.

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