CASE STUDY – ENERGY

Monitoring Carbon Storage

Microseismic monitoring of CO_2 injection in Alberta, Canada.

Figure 1: Carbon Management Canada (CMC) Newell County Facility in Alberta, Canada (Image courtesy of Maurice Shevalier).

Background

Carbon capture, utilisation and storage (CCUS) is attracting rapidly growing interest worldwide as a valuable set of technologies that can assist in reaching climate emissions targets. The carbon storage element is achieved by injecting CO_2 into deep geological formations including depleted oil and gas reservoirs. As a relatively new concept, research is ongoing to inform governments and regulators on suitable methods of injection, including safe ground motion parameters that should be adhered to during operations.

Carbon Management Canada (CMC) is a non-profit organization that was founded in 2009 with the aim of supporting research into technologies that can help to reduce carbon emissions. CMC operates the Newell County facility in Alberta, Canada where CO_2 injection technologies can be subjected to extensive monitoring using state-of-the-art instruments and techniques around a 300m deep CO_2 injection site.

Research undertaken at the site is informing the Government of Canada and other authorities seeking to establish safe CO_2 storage monitoring protocols within a regulatory framework, as well as informing industry best practices.

Monitoring Carbon Storage

Project Scope

The University of Oxford and the University of Bristol are working on a joint project with CMC to monitor CO_2 injection at the CMC site using broadband seismometers.

Initially, the sensors were deployed to monitor the baseline seismicity of the region to allow for discrimination between induced and natural events as well as advising on monitoring parameters for induced events. In addition to detecting local microseismic events, the sensors are also being used to map underground structures in the vicinity of the injection site.

Induced seismicity can cause damage to nearby infrastructure and, in some rare cases, can pose a hazard to local populations. In addition, induced seismicity can also have an effect on the integrity of the CO_2 reservoir as faulting may reduce cap integrity.

Monitoring the injection activity ensures that ground motion thresholds are not exceeded and allows for operational adjustments to be made, if needed, to mitigate risks.

Güralp Solution

Four Güralp 6TD medium motion seismometers and three 3ESPC weak motion seismometers have been used for the monitoring at the facility due to their high dynamic range and sensitivity. This allows for the detection of both very small and larger felt seismic events, but also improved source characterisation due to the broadband response of the instruments.

A broad frequency range also allows noise interferometry to be used to image subtle changes in sub-surface properties, an important monitoring technique for assessing the structure and integrity of stored CO_2.

Figure 2: 6TD Seismometer shown with optional Wi-Fi.

The 6TD offers a convenient digital solution in a single, light-weight, low-power and rugged form factor with a response of 30 s to 100 Hz

Figure 3: 3ESPC Seismometer.

The 3ESPC is a low-power and portable instrument for areas with low to moderate noise with a response of 60 s to 100 Hz.

Monitoring Carbon Storage

Deployment

In 2015, the seven Güralp Broadband sensors were installed by the University of Bristol and local partner, Echo Seismic, at distances of between 200m and 3km from the injection well.

The sensors were deployed one year prior to injection activity, to establish a baseline for the site that will be used as a comparison to activity detected after injection.

The sensors were installed in shallow pits with solar panels providing off grid power to the systems and cattle fences were used to shield the sites from grazing animals.

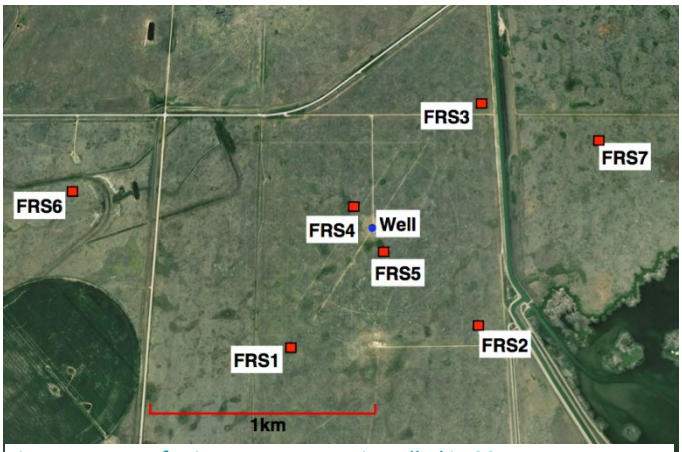

Figure 4: Map of seismometer array installed in 2015.

Echo Seismic, provides servicing of the array twice a year, including firmware updates, data harvesting, archiving and sharing.

The stations are still in situ and continue to monitor the site, despite dramatic seasonal changes in temperature, providing high quality data to the research team.


Figure 5: Seismometers are installed in shallow pits.

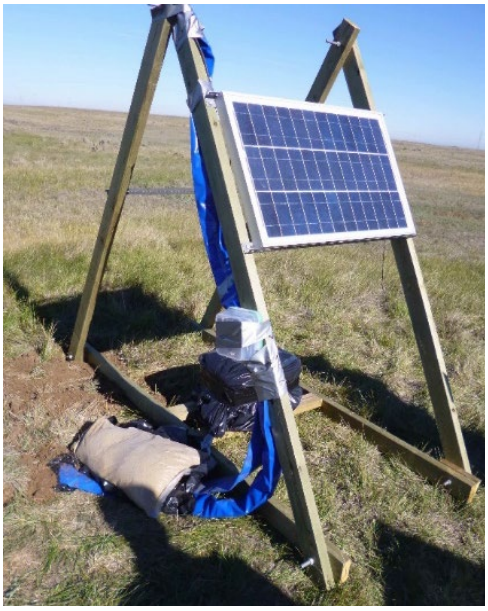
Figure 6: One of four 6TD stations.


Figure 7: One of three 3ESPC stations, protected by cattle fencing.

Monitoring Carbon Storage

Outcome

During the baseline monitoring period, the array detected 335 large events exceeding M4.5, almost all of which were teleseismic. 556 regional events were detected, and no local events were recorded.

Following the baseline period, very few local microseismic events have been detected, but the Güralp broadband stations have been invaluable in determining the magnitudes of these events. A number of regional events and mine blasts have been well recorded.

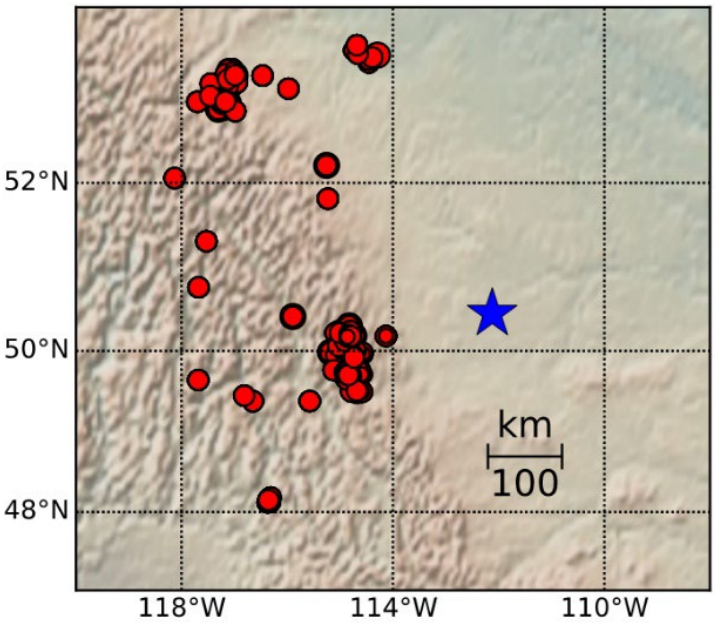

Figure 8: Map of recorded regional events, the Blue Star indicates the location of the well.

Current work includes the use of coda wave interferometry to image small changes in seismic velocities associated with changes in pore fluid properties. Noise sources include those associated with local highways and waterways, including local water storage reservoirs.

The instruments have been actively recording during numerous intensive experiments, including a week in September, 2021, when nearly a tonne of CO_2 was injected. The broadband sensors compliment other monitoring techniques using larger arrays of short period sensors and the use of Distributed Acoustic Sensing (DAS) with a network of fibre optic cable.

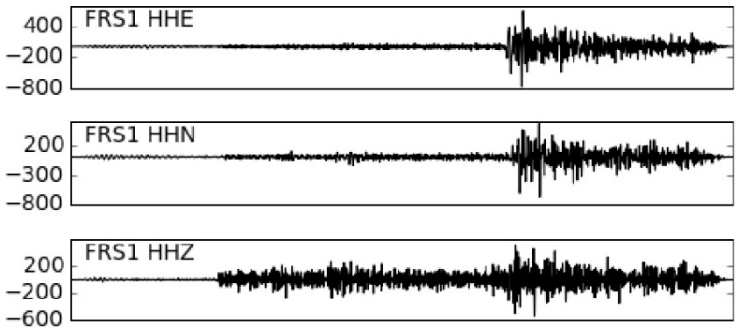

Figure 9: Waveforms from a detected regional event.

- At a local scale, the data will be used to monitor and image the plume as well as establish a seismic activity time series to establish the effect that the injection is having on local ground motion. The magnitude and location of these events will be important for discriminating between natural and induced activity.
- At the larger scale, data collected from the facility will contribute to and influence the global effort for monitoring CCUS activity.

Güralp Systems Ltd
Midas House, Calleva Park
Aldermaston
Reading RG7 8EA
United Kingdom

T +44 118 981 9056
F +44 118 981 9943
E sales@güralp.com

www.guralp.com