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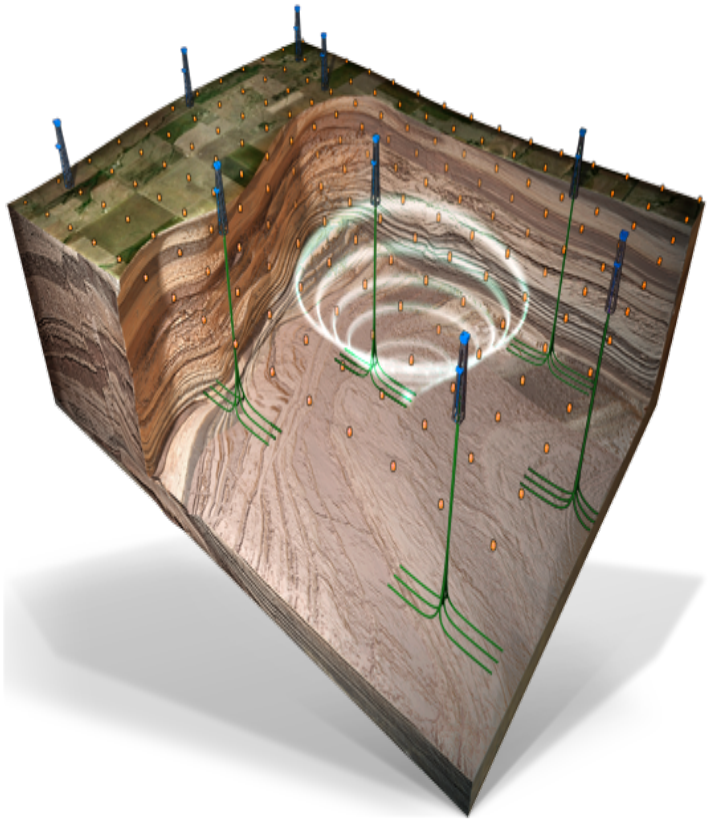
Permanent Microseismic Buried Array for CO_2 MMV Protocols



CO_2 Sequestration projects are growing in number as the practicality of carbon capture, utilization, and storage (CCUS) to offset GHG emissions becomes a reality. A key element of any CCUS project is the monitoring, measurement, and verification (MMV) of the sequestered CO_2, for the purpose of qualifying tax credits and ensuring environmental compliance. A CCUS operator must:

1) Confirm the injected CO_2 is confined within the target formation,
2) Monitor and confirm caprock integrity such that no CO_2 escapes, and
3) Measure microseismic events to ensure the injection does not induce seismicity that could potentially damage nearby infrastructure.

Conventional reflection seismic data is usually acquired over the project area to locate faults and assess the structural integrity of the injection site. However, this is a static image that *by itself*, without monitor 3D data, fails to address the dynamic issues associated with an active CO_2 injection.

CO₂SeQure

Microseismic monitoring before, during, and after injection is a proven technology for:

- Assessing the seismic hazard in the project area.
- Mapping faults through the reservoir, including those that may not have been imaged by reflection seismic.
- Detecting movement of faults and fractures that could compromise caprock integrity.
- Detecting small precursor seismic events that can predict larger magnitude induced seismicity.
- Tracking the CO_2 plume as it grows during the injection process.

The cost-effective vehicle for monitoring a CCUS project over its lifecycle is MSI's **BuriedArray®**. Multicomponent geophones are cemented in shallow boreholes at depths (<300 ft) and intervals (~2,000 X 2,000 ft) custom designed for each project. Each station is equipped with telecommunication devices that collect and transmit the data to a central processing facility for real time analysis. The recording and telecommunications hardware is powered by wind and solar, and function autonomously except for semiannual maintenance visits.

The array will typically be installed before injection begins to calibrate the baseline ambient microseismicity in the area. Once injection begins, the continuous data stream can be analyzed to detect microseismic events that would indicate caprock failure, or slippage on regional faults that could lead to larger magnitude induced seismicity. A "**stoplight system**" can be established to automatically notify the operator when events surpassing certain critical levels of magnitude, frequency, or location are identified.

Most importantly, the permanent buried array of geophones can be used to acquire surface 3D monitor surveys (i.e., 4D) with a high-density source effort to mitigate the sparse receiver grid. This approach results in significant cost reductions compared with traditional 3D acquisition and provides a more consistent 4D data set by using receiver station locations that are identical for all monitor surveys.

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