



Using Ultrasensitive Detection to Monitor Carbon Capture Sequestration

A primary mode of Carbon Capture and Sequestration (CCS) is geologic sequestration in which carbon dioxide (CO₂) is injected into underground geologic sinks. Critical to the success of geologic sequestration is the need to ensure that underground storage sinks have adequate seal and do not leak to pose a potential threat to human health and the environment.

However, the ability to determine if these subsurface structures have adequate seal prior to CO₂ injection and that those seals remain leak-proof is difficult since there are not many CO₂ monitoring technologies available to provide adequate sensitivity and coverage for underground sequestration. However, ultrasensitive passive geochemical sorbers at the surface **provide the ability to monitor leakage over reservoirs, faults, as well as natural fractures.**

Amplified Geochemical Imaging's (AGI's) proprietary passive surface detection and compound mapping technology provides a unique ability to detect hydrocarbons at parts per billion (ppb) levels **which is 1,000 times more sensitive than traditional methods.**

The AGI passive sampler, **Figure 1**, contains a specially engineered polymeric adsorbent encased in a microporous membrane. These membrane pores are small enough to prevent soil particles and water from entering, but large enough to allow vapor molecules to pass through and concentrate on the adsorbent material.

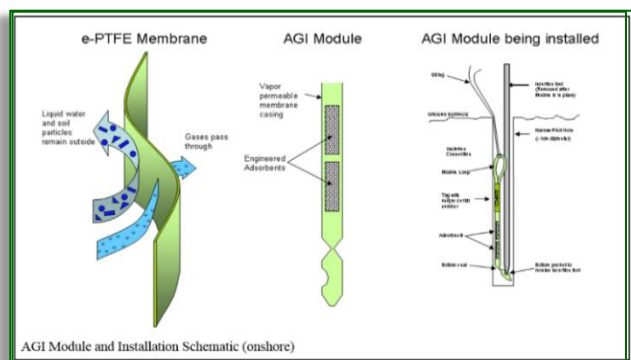


Figure 1.

The first case study took place in the Yibal field located within the Fahud Salt Basin in northwestern Oman, ~310 km SW of Muscat. The Yibal field produces oil from the Cretaceous Natih A Formation, with significant faulting throughout. Field and facilities covered ~115 km².

The purpose of the survey was to ground-truth the ability of AGI's high sensitivity surface geochemical imaging to map hydrocarbon seepage along faults, as a proxy for CO₂ tracers, and thus to identify segments of potential fault leakage from the Natih A reservoir.

Approximately 152 samplers were deployed for 20 days over structural closures at depth (i.e. depleted petroleum reservoirs) along specified fault projections to monitor indications of natural leakage pathways. Samples were deployed along single transects and double transects with 200 m spacing (see **Figure 2**).

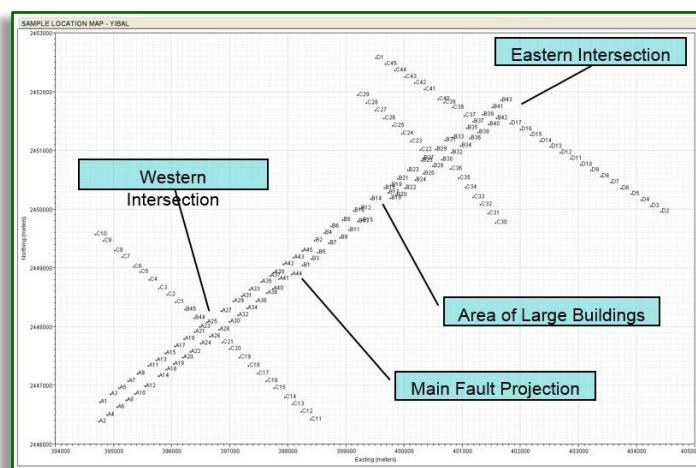


Figure 2.

Statistical evaluation of the data using Hierarchical Cluster Analysis (HCA) indicated three primary signatures: baseline, surface contamination, and sub-surface leakage along faults, see **Figure 3**.

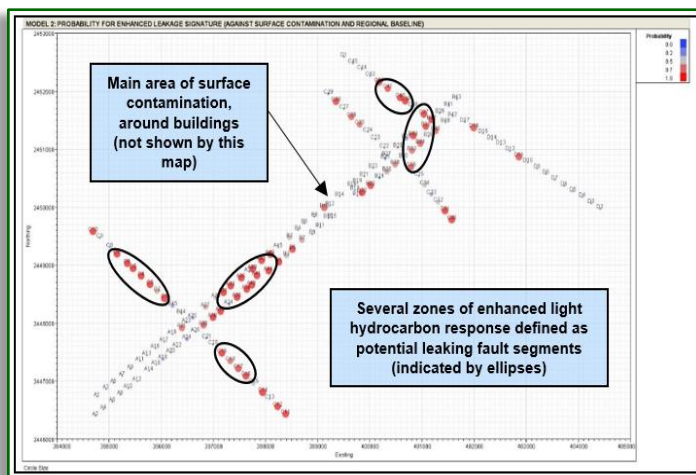


Figure 3.

Detecting Leaks Over Faults & Natural Fractures



Significant mass levels for C₃+ compounds were found primarily around buildings and were attributed to surface contamination. Trace levels ascribed as regional baseline levels showed the lowest relative mass response primarily for C₄ and C₅ compounds emanating from the reservoir. Enhanced light hydrocarbon signatures, primarily C₂ to ~C₇, were mapped along coherent segments of fault projections inferring reservoir leakage along specific fault traces. These segments are encircled by ellipses in **Figure 3**. **Leaking segments were noted along the main fault trace near the western intersection, north and south segments off the western intersection, and eastern-most intersection region.**

The second case study involves the In Salah CCS program in the Algerian Krechba Field. Gas with high amounts of CO₂ was being produced from a ~20 m thick reservoir at ~1850–1900 m, see **Figure 4**. The reservoir is overlain by ~950 m carboniferous mudstones, siltstones, and limestones which is overlain by ~900 m of Cretaceous sandstone deposits (Ringrose, 2009). The CO₂ was injected into

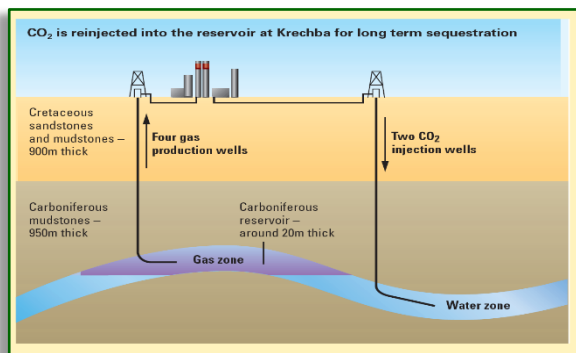


Figure 4.

the ~20m thick down-dip water leg of the gas reservoir at ~1.9 km depth. There were five gas producing wells – colored red inside the yellow shaded area, see **Figure 5**, and three injection wells (the KB-1, KB-2, & KB-3 – colored blue).

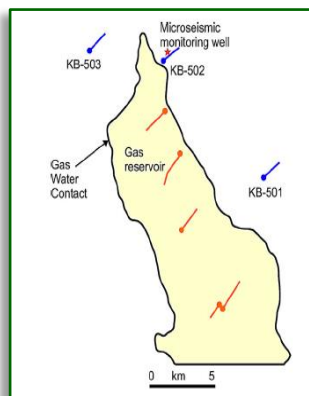


Figure 5.

Response of the reservoir to CO₂ injection had already been observed using geophysical technologies: InSAR (Interferometric Synthetic Aperture Radar), 3D seismic and microseismic. Surface deformation up to several cm was observed above each of the injection wells by InSAR, see **Figure 6**. The 3D seismic survey concluded

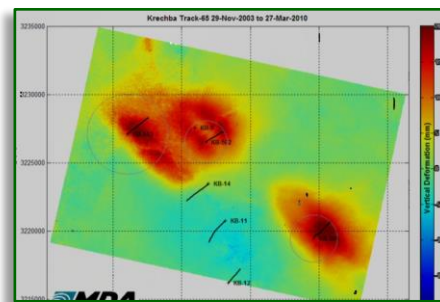


Figure 6.

that the CO₂ injection had activated a deep fracture zone extending several hundred meters wide and extending about 150 m above the reservoir.

Thus, an AGI survey, using fluorinated CO₂ tracers and 143 samples, was employed to evaluate subsurface leakage. A different fluorinated tracer, with a detection limit of ~ 5 ppb, was used for each well.

Background hydrocarbons levels were detected above the reservoir and along fractures. None of the samples recorded detectable levels of perfluorocarbons. **No evidence of leakage from the gas storage reservoir or around the injection wells was observed.**

The study demonstrated the ability of the ultrasensitive method to monitor baseline levels of hydrocarbons and potential leakage of perfluorinated tracers, used as a proxy for CO₂.

Summary:

AGI's **proprietary low parts per billion sensitivity** geochemical surveys have utility in studies of subsurface structures for CO₂ injection and storage for:

- Early stage evaluations, with samples deployed over structural closures (i.e., depleted petroleum reservoirs) for evaluation of **natural leakage pathways as compared to insitu baseline hydrocarbon levels.**
- Contemporaneous evaluations, with samples placed over and around known spill points and fault trends, to **check for leakage during or shortly after injection (involves use of tracer gases);**
- **Longer term monitoring** to detect CO₂ filled subsurface fractures that do not terminate at or leak to the surface.