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Surface Monitoring and Seepage Verification of Geologic Carbon Dioxide Sequestration and Carbon Dioxide EOR

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Summary

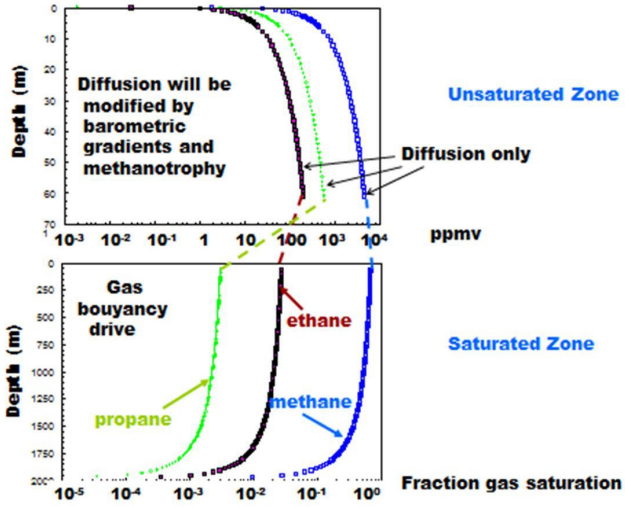
Examples are provided utilizing surface and near-surface geochemical techniques for initial characterization and proposed monitoring protocols for three different locations. 1) A large, currently operating CO2-EOR at Rangely, Colorado, USA. 2) A large, depleted oil field that was proposed for CO2-EOR and CO2 sequestration at Teapot Dome, Wyoming, USA. 3) An allegation of leakage from a CO2-EOR operation at a farm located over the Weyburn-Midale field, Saskatchewan, Alberta, Canada. Using near-surface geochemical methods, it was subsequently verified to not be leaking at detectable rates.

Method

Modeling of the potential seepage from the Rangely Oil Field was done as part of a research proposal. Subsequent funding enabled the research to be done in two steps; 1) a reconnaissance gas flux and shallow soil gas measurements of CO2 and CH4 in both winter and summer seasons, 2) auguring of five 10-m holes at selected locations with nested sampling intervals to allow a more rigorous evaluation of the presence/absence of deep-sourced seepage.
At the Teapot Dome field, only winter measurements of gas flux and shallow soil gas measurements were made, followed by auguring of five 10-m holes with nested sampling intervals to allow rigorous evaluation of the presence/absence of deep sourced seepage. Faulted locations were measured and one trenched for visual evaluation of the condition.
At Weyburn-Midale, the author critically evaluated the geochemical measurements previously made by other authors on a farm where leakage was alleged. The conclusion was reached, based on the previous measurements and the geochemical processes observed at Rangely that detectable leakage was not occurring.

Results

The figure illustrates the results of the modeling of the slightly overpressured Rangely system after approximately 25 years of a CO2 flood. Triplicate flux measurements at 41 locations on the field and 18 locations off the field resulted in a total annual CO2 flux < 200 tonnes/year and 500 tonnes/year of CH4 over the 78 km2 of the field. The selection of the location of the five 10-m holes was found to be correct in order to have a mix of anomalous and non-anomalous locations based on the reconnaissance survey. Stable isotopic measurements of carbon and carbon-14 were used to provide verification of evidence for a deep source and of shallow methanotrophic oxidation of CH4 to CO2.



At Teapot Dome, only winter measurements were made as the winter results at Rangely provided the best data, due to decreased shallow biological interference. The flux measurements at 40 locations indicated approximately “zero” microseepage of CH4. An additional focus on transverse faults at Teapot strongly supported faults as potential pathways for seepage if the field were re-pressured by a CO2-flood. Despite a present-day condition of underpressure, the faults were charged with residual hydrocarbons based on the 10-m hole measurements. The results at Teapot also were supported by stable carbon and oxygen isotopes, and measurements of carbon-14. A limited amount of data on inert gas isotopes was provided by Sarah Mackintosh and Chris Ballentine from the University of Manchester, UK.

The author evaluated soil gas measurements by Katherine Romanak and Changbing Yang of the University of Texas, stable inert gas isotopes by Stuart Gilfillan of the University of Aberdeen, Scotland, and soil gas measurements by Paul Lefevre of Petrofind for the plantiff. This was a requested critical review and no personal measurements were made at the site.

Based on the localized Weyburn-Midale data and previous experience at Rangely and Teapot Dome, concurrence for a result of “no detectable leakage” was made. The results of Petrofind of small amounts of C2H6 in soil gas in both summer and winter was cited as evidence for seepage. The result of higher CH4 in the summer, relative to winter, supported the role of methanogenesis in organic rich surface materials, rather than a decline in methanotrophy during winter.

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References

Reference Style (Latest and Most Inclusive)

Klusman, R.W., 2018, Faults as windows to monitor gas seepage: Application to CO2 sequestration and CO2-EOR. Geosciences. doi:10.3390/geosciences 8030092.