Evaluation of CO_2, He, C1-C5 gaseous hydrocarbons at an engineered CO_2 injection, Cranfield, Mississippi

GCCC Digital Publication Series #10-04

Katherine Romanak
Tongwei Zhang
Kimberly Gilbert
Changbing Yang
Philip Bennett
Susan Hovorka

Keywords:
Field study-Cranfield-MS, Modeling-Geochemical, Rock-water-CO2 reaction, Rock-CO2-water interaction

Cited as:
Romanak, K.D., Zhang, T., Gilbert, K., Yang, C., Bennett, P., and Hovorka, S., Evaluation of CO2, He, C1-C5 gaseous hydrocarbons at an engineered CO2 injection, Cranfield, Mississippi: presented at the 9th Annual Conference on Carbon Capture & Sequestration, Pittsburgh, PA, May 10-13, 2010. GCCC Digital Publication Series #10-04.

Evaluation of CO2, He, C1-C5 Gaseous Hydrocarbons at an Engineered CO2 Injection, Cranfield, Mississippi

Katherine Romanak[1], Tongwei Zhang[1], Kimberly Gilbert[2] Changbing Yang[1], Philip Bennett[2], Susan Hovorka[1]

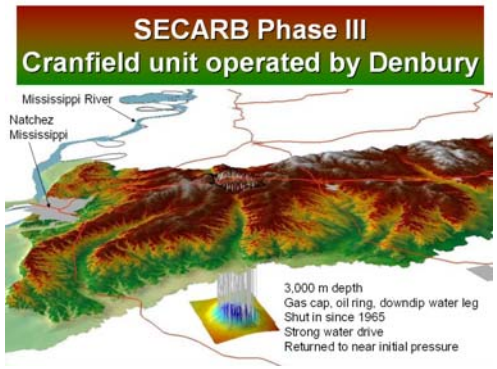
[1]*Bureau of Economic Geology, Jackson School of Geosciences, The University of Texas at Austin, P.O. Box X, Austin, TX, 78713, USA*

[2]*Department of Geological Sciences, Jackson School of Geosciences, The University of Texas at Austin, P.O. Box X, Austin, TX, 78713, USA*

1.Introduction.

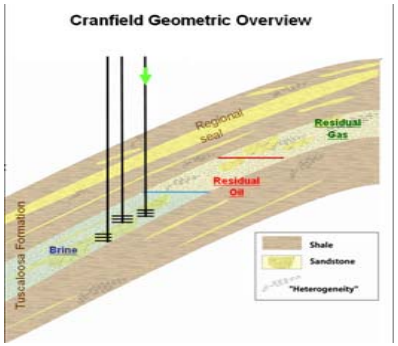
Sampling gases and fluids during deep CO_2 injection is challenging, but yields important information on deep subsurface processes. During an engineered CO_2 injection at Cranfield, MS, samples from 2 observation wells (~3000m depth) were continuously collected over 30 days using a pressure-loop U-Tube sampler and analyzed by gas chromatography. The target oil and gas reservoir has hydrocarbon-rich brines (93.6% CH_4, 3.9% CO_2, 2.2% C_2H_6, 0.24% C_3H_6, 0.061% He), while the injected gas is similarly complex, (2.36% CH_4, 97.4% CO_2, 0.21% C_2H_6, 0.007% C_3H_8, 0.005% He). A gas mixing model with these two end members and He to calculate mixing fractions during the course of CO_2 injection was used to characterize the origin of the sampled gas during the observation period. Mixing of gases from heterogeneous CO_2 invasion, assumed to occur, 1) during transport of the CO_2 plume to the observation wells due to aquifer heterogeneities, and 2) in the wellbore during sampling, is one of the main physical processes. Deviations from the model may identify chemical processes between injected and reservoir gases and brine.

2. Background



- SECARB Phase 3 in the Cranfield Unit is operated by Denbury Resources East of Natchez, Mississippi

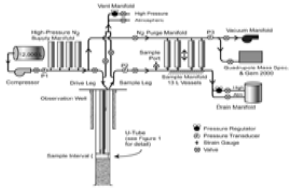
Fig. 1. Pilot injection set at the Cranfield Site. Figure by Tip Meckel and Susan Hovorka



- **Cranfield is part of the Upper Cretaceous Tuscaloosa-Woodbine Trend of the Mississippi Salt Basin**

Fig. 2. Figure courtesy of Tip Meckel and Susan Hovorka

3. Sampling

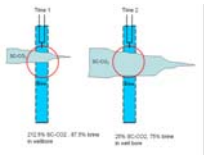


Schematic of U-tube Sampler (Source:????)

Surface Part of the U-tube sampler

Sampling Procedure

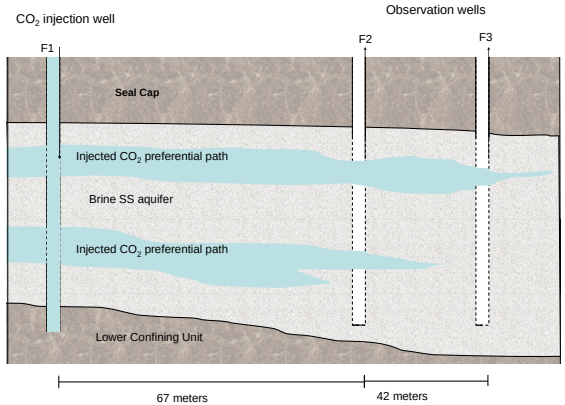
- **Prior CO2 plume arrives at the observation well, N2 gas is used to lift water samples;**
- **After CO2 plume reaches the observation well, CO2 will be self lifted.**



Schematic of CO2 plumes arriving at the observation well at different times

4.Mxing Model

Assumption: Gas sampled from the U-tube Sampler is a mixture of gas injected and gases extracted from brine. This mixing process occurs when CO2 plume moves from the injection well to the monitoring well, as well in the borehole of observation well. Such mixing process is caused by heterogeneity of the resveroir.



Two end members are considered in the mixing model: injected gas and gas extracted from the brine. Based on a conservative component, He, mixing ratio is given by

$$f = \frac{C_n^O - C_n^b}{C_n^I + C_n^b}$$

C_n^O, C_n^b, C_n^I **are concentrations of He measured at the observation well, injectate, and brine**

***f* ranges from 0 to 1**

Then with this mixing ratio, concentrations of other gas components

$$C_n^C = fC_n^I + (1-f)C_n^b$$

n = CO2, CH4, C2, C3

5. Results

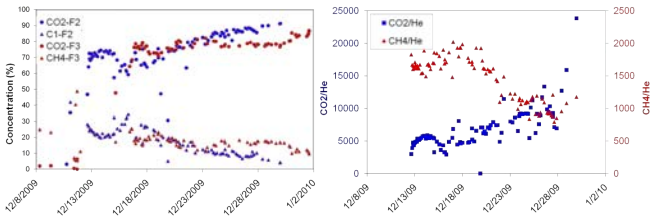


Fig. 5. Observed gas compositional change in observation wells in the course of CO_2 injection. CO_2 and CH_4 versus He ratios suggest an initial source, then depletion of CH_4.

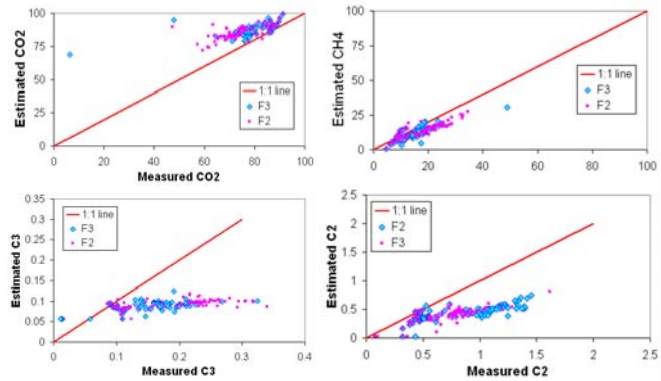


Fig. 6. Enrichment of hydrocarbons shows that CO_2/brine interaction occurs in subsurface aquifer reservoir. The unit of measured and calculated gas concentration is in % mole volume.

Estimated values from the model were plotted against measured values. Deviations from the 1:1 line indicate a loss or gain of the gas in question. The gas mixing model accounts for variability in the two end member components such that chemical processes in the reservoir can be distinguished.

6. Concluding remarks

CO_2 and CH_4 versus He ratios indicate that there is initially a source of CH_4, which is depleted. Preliminary mixing models suggest that measured concentrations of CO_2 and CH_4 deviate slightly from modeled values compared to deviations for C_2 and C_3. Measured CO_2 is slightly lower than modeled values indicating dissolution, while CH_4 concentrations are slightly higher indicating enrichment. Both C_2 and C_3 are enriched in the gas phase during CO_2 transport over 60m. The magnitude of enrichment for hydrocarbons increases with from C_1 to C_4.

Acknowledgements: Department of Energy, National Environmental Technology Laboratory, Kinder Morgan CO_2, GCCC sponsors, and Jackson School of Geosciences. Publication authorized by the Director, Bureau of Economic Geology.