Detection of CO2 leakage in overlaying aquifers using time lapse compressibility monitoring

GCCC Digital Publication Series #13-51

Seyyed Abolfazl Hosseini
Mehdi Zeidouni

Keywords:
Field study; Monitoring-downhole pressure, risk

Cited as:
Hosseini, S.A. and Zeidouni, M., 2013, Detection of CO2 leakage in overlaying aquifers using time lapse compressibility monitoring: presented at the 12th Annual Conference on Carbon Capture Utilization & Sequestration, Pittsburgh, Pennsylvania, 13-16 May 2013. GCCC Digital Publication Series #13-51.

Detection of CO_2 leakage in overlaying aquifers using time lapse compressibility monitoring

Seyyed Abolfazl Hosseini[a], Mehdi Zeidouni

Bureau of Economic Geology, Jackson School of Geosciences, The University of Texas at Austin, Austin, TX

[a] Corresponding Author seyyed.hosseini@beg.utexas.edu

1- Summary

There are several monitoring challenges to demonstrate safe and long term storage of the CO_2 . In this study we are proposing an methodology that uses well known interference well testing for monitoring the Above Zone Monitoring Intervals(AZMI). Some of the advantages of this method is :

1. It helps to distinguish between the brine and CO_2 leakage.
2. It can be used to detect low rate/ long term leakages that may not have a drastic signal as leakage starts.
3. It is designed in a time-lapse form so inherently many uncertain reservoir parameters cancel out in the calculations.

2- Brine vs. CO_2 compressibility

Proposed methodology works on the premises of the fact that at any given depth brine and CO_2 have different compressibility. This means that in a monitoring zone initially filled with brine any leakage of CO_2 will change the total compressibility of the zone.

Obviously cumulative amount of the CO_2 has be enough to change the total compressibility of the system interfered with two or multiple injection/monitoring well. At the same time an analysis of the errors in measurements and tools has to be carried out to ensure that system noises are not mistaken with CO_2 leakage.

Figure 1 shows the difference between the brine and CO_2 compressibility at different depths at various geo-pressure gradients.

Figure 2 shows the difference between the brine and CO_2 compressibility at different depths at various geo-thermal gradients.

Figure 3 shows the difference between the brine and CO_2 compressibility at different depths at various salinity gradients.

3- Theory of interference well test

The area investigated by an interference test is much larger than that of a single well drawdown or buildup test. The minimum area investigated by an interference test between two wells located a distance, r, apart is obtained by constructing two circles centered on each well. This construction is based on the principle of reciprocity which states that the results of the interference test will be the same if the active well and observations well are interchanged. Since there is interference between the wells, the radius of investigation of each well is at least equal to the distance between the wells (**Figure 4**). The approximate area investigated is $6r^2$.

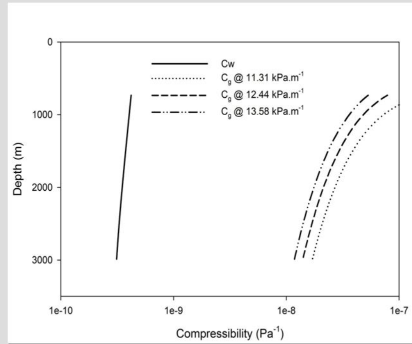

Figure 1.Effect of geo-pressure gradient on compressibility of brine and CO_2

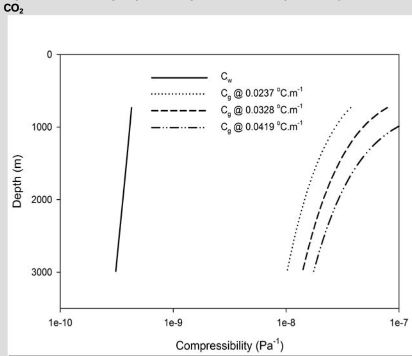

Figure 2.Effect of geo-thermal gradient on compressibility of brine and CO_2

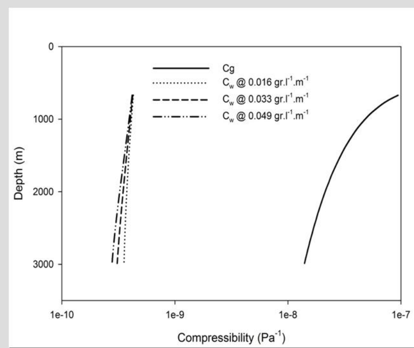

Figure 3.Effect of brine salinity gradient on compressibility of brine and CO_2

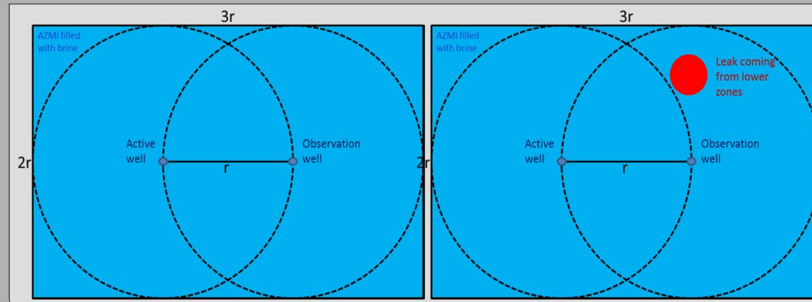

Figure 4. Area of the coverage of an interference well test. Time-lapse monitoring of the compressibility would show if any CO_2 has been leaked or not if the leakage is big and close enough.

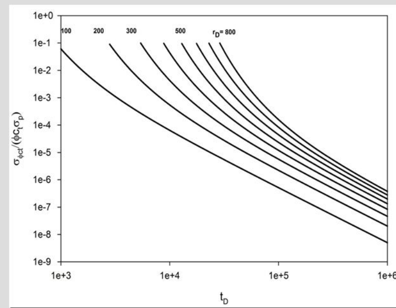

Figure 5 (left). Relationship between error in pressure data and estimated incompressibility.

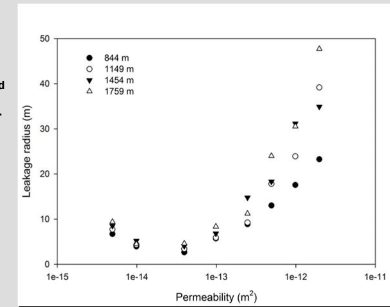

Figure 6 (right). Estimation of the leakage radius based on change in the compressibility.

$$\frac{\sigma_{\phi c_t}}{\phi c_t \sigma_P} = \frac{r_D^2}{2 t_D^2 e^{-\frac{r_D^2}{4 t_D}}}$$

$$c_t = \frac{\pi r_l^2 (c_g - c_w) + 6 r_t^2 c_w}{6 r_t^2}$$

4- Error and leakage size estimation

To successfully use this method we have to ensure that noise in the measurements will not mistaken as leakage. In other words we need to show that well test in repeatable. **Figure 5** shows the relationship between the noise in pressure measurements and estimated compressibility of the system.

Theoretically if observed variation is bigger than the effects of the we can estimate the volume of CO_2 in the surrounding area of the test site. **Figure 6** shows such a calculations for a formation with thickness of 60 ft.

5- Conclusions

1.Change in compressibility (storativity) of the monitoring zone can be used to detect CO_2 leaks.
2.Noise in the systems should be considered in estimations
3.Field data is necessary to validate the repeatability of the measurements.

Acknowledgements

Funding provided by DOE awards DE-FE-0002381 and DE-FE-0003311. We also thank BEG for Career-Development Publications Award given by the GAAC.