TESTING SEAL CAPACITY FOR CARBON STORAGE - AN EXPERIMENTAL APPROACH

Ralf J. Weger, Peter K. Swart, and Gregor P. Eberli

PROJECT OBJECTIVES

- Design an experimental set-up that allows testing how CO_2 injection alters the seal capacity in carbon storage sites.
- Run experiments to assess the dissolution and potential leakage of strata that seal storage reservoirs.
- Monitor chemical and physical changes in the rock
  - Document and quantify amount of dissolution and/or precipitation from injection of CO_2 saturated fluids into these rocks.
  - Assess changes in acoustic velocity resulting from injection of CO_2 saturated fluids.

PROJECT RATIONALE

Carbon Capture Utilization and Storage (CCUS) will be a crucial component in reducing global CO_2 emissions in the coming years. Although the utilization of the captured CO_2 is an important component, it is likely that carbon capture with permanent storage will play a more important role in achieving faster, large-scale reduction of CO_2 emissions. Permanent storage requires natural reservoirs with a seal that resists dissolution by CO_2 saturated fluids. Many theoretical modeling studies dealing with such rock-fluid interactions have been published in recent years (André et al., 2007; Gaus et al., 2005; Yuan et al. 2019; amongst many others) but actual laboratory experiments are rare. Luquot and Gouze (2009) have shown that CO_2 injection triggered dissolution increased permeability, while inducing only minimal modification of porosity.

Changes in elastic properties resulting from the removal of the smaller particles (i.e., those with highest surface area), the creation of pits of dissolution on the grain surfaces, and changes at grain contacts such as grain welding caused by injection of CO_2 saturated solution have been reported by Vialle and Vanorio (2011). This project aims to contribute to the experimental side of rock fluid interaction for carbon storage by building on past precipitation/dissolution experiments that we conducted in carbonate rocks (Fig. 1; Weger et al., 2012) addressing the potential changes in the seal rocks resulting from CO_2 injections.

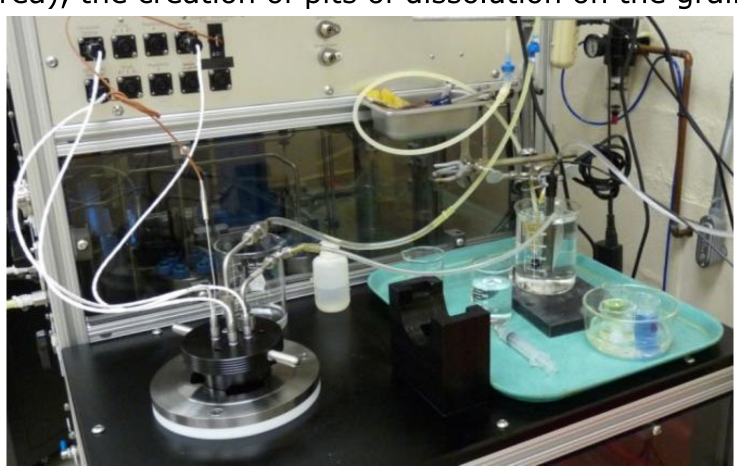

Figure 1: Set-up of previous dissolution experiments using the Autolab 1000 where the fluid composition is constantly monitored.

WORK PROPOSED

Phase 1 of the project is the design and testing of the experimental setup. The following workflow will be tested first on various rock samples in our New England Research Autolab 1000 system. We will be using a semi-closed system experimental design where pore fluid with predetermined geochemical composition is emplaced in the sample, CO_2 pressure is established, and only the existing fluid volume within the intensifiers (~5-10 pore volumes of the sample) will be used to create flow of fluid within the sample. This limited fluid injection will ensure that any chemical reaction of the fluid with the rock proceeds before the system reaches equilibrium with the host and the chemical reaction halts.

Monitoring of possible reactions that result in dissolution or mineralogy changes is a crucial element in the experiment. We plan to monitor physical changes with time series measurements of velocity. For this, the upstream pore fluid connection is closed. Five MPa pore pressure is installed at 60 MPa confining pressure, resulting in 55 MPa Ep. Time series measurement of VP and VS will be conducted for 72 hours (3 days) taking an acoustic measurement each hour.

After each three-day reaction time, the pore fluid will be extracted and chemically analyzed. In addition, all samples will be documented using SEM and CT scans before and after the experiment.

SIGNIFICANCE

This work will improve our understanding of how rock-fluid interaction changes microstructure and its elastic properties when CO_2 enriched fluids are injected in rocks with seal capacity. The quantification and high resolution image documentation of the resulting rock alterations will further enhance our understanding of the rate of changes resulting from CO_2 injection.

REFERENCES

André, L., Audigane, P., Azaroual, M., Menjoz, A., 2007. Numerical modeling of fluid–rock chemical interactions at the supercritical CO2–liquid interface during CO2 injection into a carbonate reservoir, the Dogger aquifer (Paris Basin, France). Energy conversion and management, 48(6): 1782-1797.

Gaus, I., Azaroual, M., Czernichowski-Lauriol, I., 2005. Reactive transport modelling of the impact of CO2 injection on the clayey cap rock at Sleipner (North Sea). Chemical Geology, 217(3-4): 319-337.

Luquot, L., Gouze, P., 2009. Experimental determination of porosity and permeability changes induced by injection of CO2 into carbonate rocks. Chemical Geology, 265(1-2): 148-159.

Vialle, S., Vanorio, T., 2011. Laboratory measurements of elastic properties of carbonate rocks during injection of reactive CO2-saturated water. Geophysical Research Letters, 38(1).

Yuan, T., Wei, C., Zhang, C.-S., Qin, G., 2019. A numerical simulator for modeling the coupling processes of subsurface fluid flow and reactive transport processes in fractured carbonate rocks. Water, 11(10): 1957.

Weger, R.J., Swart, P.K., Eberli, G.P., and Knackstedt, M., 2012, Rock Fluid Interaction: How Dissolution Induced Changes in Pore Structure Affect Acoustic Velocity. CSL Annual Review Meeting, Miami, p. 30-33.