Novel Pressure Decay Technique For Measuring Co2-water Diffusion Coefficient: Application To Co2 Trapping In Saline Aquifers

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Abstract

Objectives/Scope: Carbon dioxide (CO2) storage in deep saline aquifers is a viable solution to mitigate carbon emissions. The difference in density between the formation brine and the injected CO2 leads to gravity stratification and the formation of a gas cap. However, CO2 solubility in brine provides an effective mechanism for carbon entrapment. This process is limited by the molecular diffusion of CO2 in water. Hence, it is essential to determine the diffusion coefficient to better understand the potential of CO2 solubility trapping.

Methods, Procedures, Process: Density-driven convective mixing occurs due to a denser CO2-saturated water layer on top of a less dense water layer. Eliminating the interference of natural convection is crucial for reliable measurements of diffusion coefficient values. To overcome this challenge, we used single-ended borosilicate capillary tubes filled with water, synthetic brines, and spherical glass beads to represent water-saturated porous media. Different salinities, pressures, and grain sizes were considered. Then, the capillary tubes were placed with their open end facing down inside a high-pressure vessel to carry out pressure-decay tests.

Results, Observations, Conclusions: This developed technique allows for a stable bottom-top diffusion of CO2 in water, which is opposite to the traditional unstable top-bottom diffusion. Results have demonstrated the successful elimination of gravity-driven convective mixing, providing a gravity-stable diffusion of CO2 in bulk water and porous media arrangements. We observed that the CO2 diffusion coefficient reduces as salinity increases. Pressure changes had little to no effects on the calculated diffusion coefficient. The effects of pressure and salinity on the measured diffusion coefficient values were in agreement with those reported in the literature. On the porous media arrangements, we found that smaller grain sizes lead to smaller effective diffusion coefficient values.

Novel/Additive Information: This work introduces a novel experimental approach to determine diffusion coefficient values of CO2 in aqueous solutions and porous media systems in isolation of convective mixing. These results are crucial to correct the current models in the literature that assume instantaneous equilibrium of CO2/water, leading to unrealistic assessment of solubility entrapment in underground CO2 storage systems.