



Investigation of CO₂ Injection and Storage Using Low-Field 2 MHz Nuclear Magnetic Resonance and Supercritical Sorption Studies

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Introduction

We have performed two sets of experiments to study possible trapping mechanisms for the application of CO₂ sequestration. Experiments have been performed on saturated Berea and Niobrara samples in order to determine if changes in the rock due to CO₂ injection can be captured with the Nuclear Magnetic Resonance (NMR) response. This change in response will be investigated to see if the NMR response aides in the determination of total CO₂ adsorbed by rocks of differing mineralogies, preferential pathways of CO₂ dissolving in rock pore spaces, and potential permanence of CO₂ storage. Changes in NMR relaxation times have been recorded. We present our preliminary results for CO₂ injection in these rock types at 50 psi injection pressure.

Methods

Two types of samples were used in this work to study the effects that CO₂ injection has on NMR response: a Berea sandstone core and a powdered Niobrara mud pack that was loosely placed in a glass vial. Transverse relaxation (T₂) experiments for the NMR measurements occurred on a low-field (2 MHz) Magritek™ NMR and Prospa™ Programming was used for data inversion. T₂ magnetic relaxation was acquired using Carr-Purcell-Meiboom-Gill (CPMG) pulse sequences (Carr and Purcell, 1954; Meiboom and Gill, 1958). Minimum signal-to-noise ratios of 100 and sufficiently long inter-experimental delay and number of echos were selected for full decay of the magnetic signals.

Results and Discussion

In order to quantify long-term changes with CO₂ exposure, a batch process NMR experiment was run for 69 days on the combined Berea sandstone and Niobrara mud pack. Following complete saturation of the Niobrara and Berea samples, CO₂ pressure was released after a period of 69 days. NMR spectra were once again recorded in a batch process for 5 days in order to determine if the reduction in amplitude of the NMR signal in larger pores could be recovered. This would indicate that a fluid effect from CO₂ presence was the cause of the peak shift and not a property of the rock matrix. This was observed to not be the case.

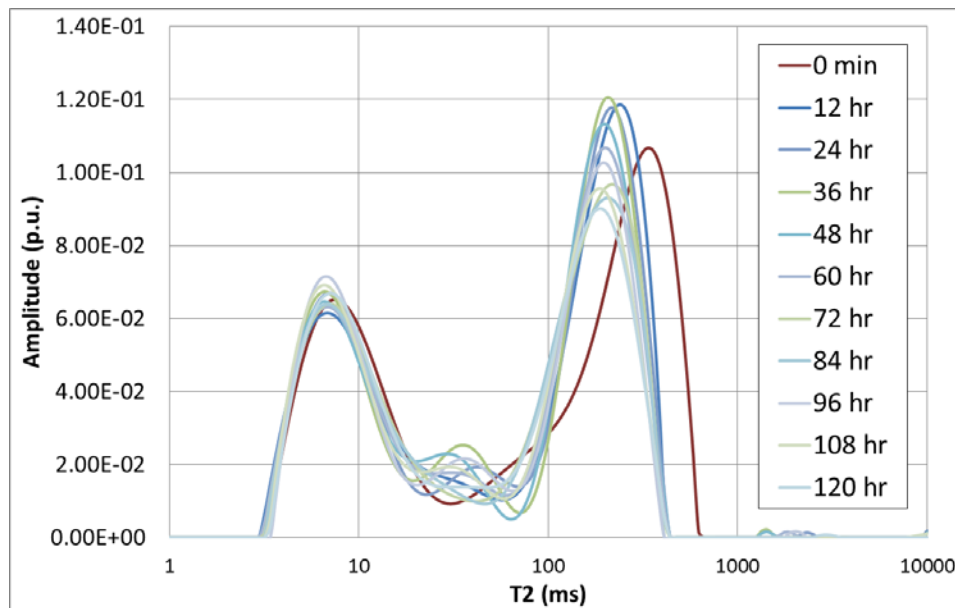


Figure 1: Change in NMR response with applied CO₂ pressure at 50 psi for the first 5 days of this experiment.

The rise in signal amplitude of pore sizes corresponding to times greater than 100 ms and a decrease in signal at smaller pore sizes is most likely caused by the dissolution of the carbonate Niobrara matrix with CO₂ presence, thus less small pores are present and larger pore sizes are created as a result. Respective changes in T2 NMR response is caused by CO₂ injection at large pore sizes, which are not reflected at faster relaxation times in shale formations. We find that large shifts in T2 relaxation and signal amplitude with CO₂ injection occur in NMR measurements and these must be taken into account when evaluating the NMR response for CO₂ sequestration.

The significant reduction in relaxation time and amplitude indicate that CO₂ storage has occurred in the rock matrix, or from precipitation of minerals in larger pore spaces from CO₂ presence. In either case, the observed phenomenon does not seem to be reversible.

Conclusions

Our results highlight the importance of conducting the experiment with water immersed samples to mimic subsurface conditions. Additionally, the results from the NMR studies presented in this work indicate the presence of CO₂ storage mechanisms, potentially by mineralization or solubility of CO₂ in water. We plan to conduct similar experiments on various samples to have better understanding of the storage capacity due to adsorption, mineralization, and solubility.

References

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