Supplementary file

Experimental investigation of CO_2 residual trapping in naturally water-wet and artificially tailored oil-wet limestones: Implications for geological CO_2 storage

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Appendix A

The experimental apparatus is an automated advanced core-flooding equipment (LXRS-300) manufactured by CoreLab. Operational parameters can go up to 15,000 psi and 350 °F (103 MPa and 176 ºC). As for working principles, it consists of typical core-flooding experiments, which include the injection of fluids from stainless steel accumulators into the core sample placed inside an aluminum-carbon fiber core holder. At the outlet of the core holder, a beaker was used to collect the outflow fluid from the core holder. The injection rate is controlled by ISCO pumps that can operate at rates up to 100 cc/min. The system is fully automated and can be controlled by software. The system contains a physical pressure gauge panel to monitor pore pressure, confining pressure, inlet/outlet pressures, back-pressure regulator, and air-actuated valves. Also, they are monitored using the software through a control window. Additionally, the equipment is equipped with a data acquisition system to generate several operational parameters (pressure, rates,..) vs time plots.

Fig. A1. Experimental apparatus used for core-flooding experiments showing the core holder, collector beakers, operational system, pressure gauges panel, valves, ISCO pumps, and fluid accumulators at the back.

Appendix B

The characterization of rock samples was performed using SEM images to highlight the similarity of the pore throat sizes, pore connectivity, and pore structure of the three samples. This is crucial to showcase that the only difference among the three samples (D1, D2 and D3) is the wettability state, while they share the same petrophysical and mineralogical properties. Additionally, NMR analytical technique was used to provide further information on the pore size distribution of the rock samples and their structure. The experimental procedure and analytical correlations used can be found in Mouallem et al. (2025) study. Fig. B1 below depicts the SEM images of the three samples at a resolution of 500 micron. As can be noticed, the three samples share almost the same porous structure with similar pore throat sizes and connectivity, which further validates the similarity in their structure.

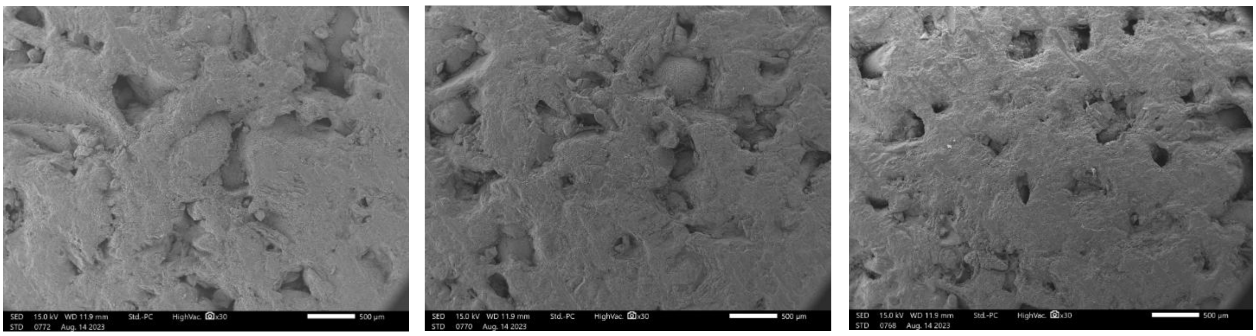

Fig. *错误!文档中没有指定样式的文字。* **1.** SEM Images displaying similarity in the structure of the three samples.

Fig. B2 depicts the NMR results showing the pore size distribution in core sample D1. It can be noticed that sample D1 shows double-connected peaks in the NMR T2 spectrum. Consequently, it can be concluded that the core samples exhibit two pore systems with a high heterogeneity compared to sandstone samples with only one major peak. Therefore, NMR T2 spectrum suggests the heterogeneity of the core samples used which is relevant and highly affects the residual trapping mechanism.

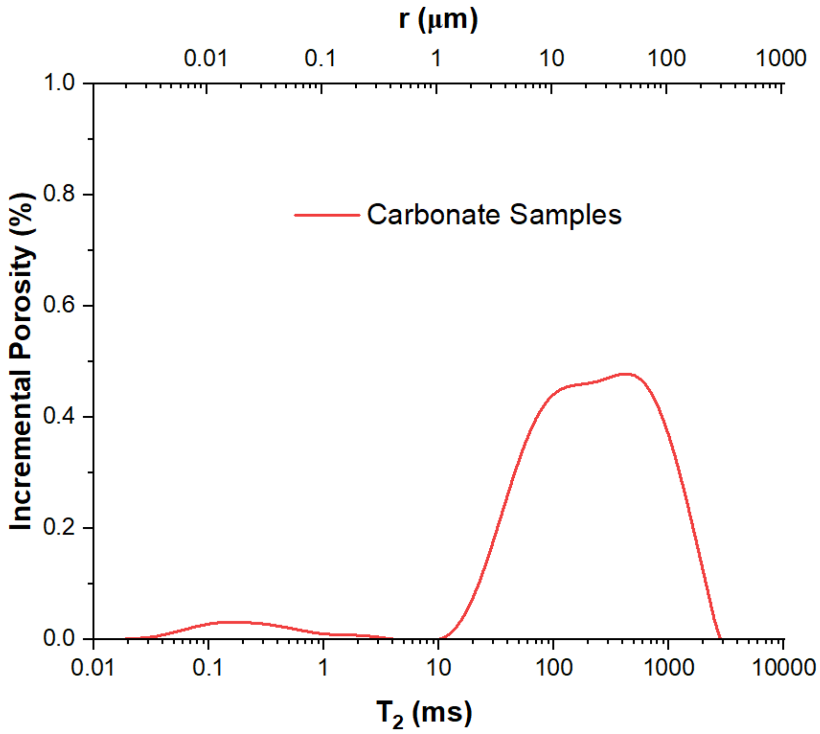

Fig. B2. NMR results showing further details on the core samples pore structure.

References

Mouallem, J., Raza, A., Mahmoud, M., et al. Impact of petrophysical properties on CO_2 residual trapping in limestone formations. Fuel, 2025, 396: 135327.