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Effect of CO2 injection on porosity and texture of reservoir chalk assessed by 1H low-field gradient NMR measurements

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Chalk reservoirs are ubiquitous in the Danish north sea basin, making up to about 90% of the country's historical hydrocarbon reserves. Oil and gas production from these fields peaked in 2005, and they are expected to be abandoned within the next 10 to 20 years. The existing knowledge of the basin accumulated during over 50 years of exploration and development allied with the existing infrastructure makes these fields good candidates for geological CO2 storage. Nevertheless, carbonate reservoirs have been viewed unfavorably compared to clastic reservoirs regarding CO2 storage. This is because calcite is chemically unstable when exposed to weak acids, such as brine containing dissolved CO2, a likely scenario close to the CO2 saturation front.
In this study, we assess the permeability, porosity, and matrix texture changes along a chalk core subjected to seven alternating water and gas injection cycles (WAG cycles), using calcite-equilibrated formation water for the water phase and supercritical CO2 for the gas phase. Bulk Nuclear Magnetic Resonance (NMR) experiments were carried out before and after flooding, using a Geospec 2-53 NMR Core Analyser at the frequency of 2.25 MHz. The core analyser was equipped with a y-axis gradient coil, which allows the application of a varying external field to the core along its length, adding spatial resolution to the acquisition. This gradient coil was used to perform volume profile measurements and slice-selective T2 relaxation acquisitions.
Bulk NMR T2 relaxation distributions show an increase in total porosity, in agreement with porosity measured by helium expansion. The T2 relaxation distribution after flooding also indicates an increase in the sample's surface-to-volume (S/V) ratio, suggesting possible precipitation of fines and a decrease in sample permeability (Figure 1.A). This agreed with Klinkenberg permeability measured before/after the core flooding. Both NMR gradient-based measurements (Slice-selective T2 relaxation, not shown, and volume profile measurements, Figure 1.B) indicate that the gain in porosity is located close to the injection inlet. Towards the outlet, porosity is slightly lower than in the original core. Overall, the results show that gradient 1H low-field NMR measurements provide useful quantitative insights into textural changes happening within core plugs undergoing CO2 flooding.

Participation

In-Person

References

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