Carbonated water injection (CWI) effects on very low and very high permeability limestones

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Abstract

Carbon Capture and Storage (or CCS) is considered a key technology for minimizing greenhouse gas emissions and reducing climate change. Since, for this, CO_2 is stored in the pore space of subsurface rocks, often carbonate rocks, understanding the effects of injecting CO_2 – which, when reacts with water, forms carbonic acid, highly reactive with carbonate minerals – in these rocks is vital.

To the best of the authors' knowledge, very few studies have been conducted on CCS in carbonate rocks with very low and very high permeabilities. This study aims to contribute to knowledge on the subject by presenting a study on the dissolution and mineralogical alteration caused by saline carbonated water injection (CWI) – CO_2 enriched water flooding – and its effects on the petrophysical properties (porosity and permeability) of four limestone samples with very low permeability (< 5 mD) and two samples with very high permeability (> 1700 mD). The samples underwent laboratory tests carried out before, during, and after CWI including gas porosity and permeability measurement, NMR, micro-CT, and ion chromatography. XRD analysis and petrographic thin sections observations were also performed.

The experimental results showed that samples with high permeability showed a small decrease in permeability, possibly indicating formation damage, while low permeability samples presented a significant increase in permeability with little change in porosity, indicating feasibility for CCS in similar samples in likewise experimental conditions. For samples with more pore volumes injected, the pressure stabilization seems to have favored dissolution in the later injection stages, indicated by the highest output of calcium ions. In all samples occurred salt precipitation during injection – especially in the more heterogeneous ones –, presenting a possible issue.

The analyzed samples are composed of lacustrine microbialites from the Mupe Member, of Upper Jurassic age, part of the Purbeck Group lower portion, located in southern England and northern France. These limestones are a partial analogue of the Brazilian pre-salt Aptian carbonates, the most important oil reservoir in Brazil. These reservoirs present large amounts of CO_2 that are reinjected into the formation. Therefore, Mupe Member limestones show promise for studies on CCS in Brazilian pre-salt carbonates as well.