Effects of Saline water and CO₂ Injection on Improved Oil Recovery in Fractured Reservoirs

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Waterflooding and CO₂ injection have been recognized to be the main oil recovery processes being applied in many reservoirs worldwide. Also, the alternation slugs of water and gas, i.e., Water Alternating Gas (WAG), has been common practice to obtain better mobility ratios and improve sweep efficiency. For favourable conditions this is also true for fractured carbonate reservoirs. To use CO₂ as the gas phase has the additional advantage to combine oil recovery with greenhouse gas storage. The injectivity decline with time, however, is an important aspect in designing WAG projects. Both experimental and field studies confirm that mineral scale deposition is one of the most important problems behind the water and CO₂ injection systems that arise primarily when two incompatible waters and carbonate rocks are involved. Two waters are assumed to be incompatible if they interact chemically and precipitate minerals when mixed. Scale precipitation from the injection water may happen behind the mixing zone as a consequence of temperature and pressure changes. This is particularly true for waters containing salts whose solubility decreases with increasing temperature and decreasing pressure.

There are three principal mechanisms by which scales form in both offshore and onshore oil field system:

1. Variations in temperature and pressure. These normally lead to unequilibrium conditions and as a result brine tends to a reduction in the solubility of the salt (most commonly this leads to precipitation and deposition of carbonate scales, such as CaCO₃).
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   \text{Ca(HCO₃)}_2 \leftrightarrow \text{CaCO}_3 + \text{CO}_2 + \text{H}_2\text{O} \quad (1)
   \]

2. Mixing of two incompatible saline waters (usually formation water which is rich in cations such as barium, calcium and/or strontium mixing with sulfate rich seawater as invading fluid, leads to the deposition of sulfate scales, such as BaSO₄).
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   \text{Ba}^{2+} (\text{or Sr}^{2+} \text{or Ca}^{2+}) + \text{SO}_4^{2-} \leftrightarrow \text{BaSO}_4 (\text{or SrSO}_4 \text{or CaSO}_4) \quad (2)
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3. Increase in salt concentration due to brine evaporation, resulting in salt concentration increasing behind the solubility limit and leads to salt deposition (as may occur in HP/HT gas wells where a dry gas stream may mix with a low rate brine stream resulting in dehydration and most commonly the precipitation of NaCl).

The conditions of mineral scale deposition and scale prevention have been studied by many researchers for many years and they came out with many conclusions.

The main goal of this project is to investigate the different interactions between injected water/CO₂/Rock/oil in fractured carbonate reservoirs. In this fashion we will be able to provide suitable operational conditions in industrial scale to improve oil recovery as well as enhanced CO₂ storage and sequestration in deep reservoirs. Therefore this would be a win-win situation: CO₂ sequestration and improved oil recovery. On the other hand, productivity decline during CO₂ and saline water injection due to permeability decline will be studied. This has an adverse effect on CO₂ and saline water injection processes especially in carbonate reservoirs.