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The stability of chalk during flooding of carbonated sea water at reservoir in-situ conditions

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Injection of CO_2 into carbonate oil reservoirs has been proposed as a possible utilization of the captured CO_2 due to its capability to enhance the oil recovery. For offshore reservoirs such as Ekofisk and Valhall it has been discussed to alternate the CO_2 and sea water injection (WAG) to reduce costs and keep the beneficial effects of both sea water (SSW) and gas injection. Water and CO_2 mix to form carbonic acids that enhance the solubility of carbonates, thus a serious concern has been raised upon the potential de-stabilization of the reservoirs during CO_2 injection. In this study we focus on how carbonated sea water alters the mechanical integrity of carbonate rocks both to evaluate safety of carbon storage sites and in the planning of production strategies in producing oil fields since enhanced compaction may have both detrimental and beneficial effects.
Here we will present results from long term experiments (approx. half year each) performed on Kansas outcrop chalk (38-41% porosity), which serves as model material to understand the physical and chemical interplaying processes taking place in chalk reservoirs. All tests are performed at uni-axial strain conditions, meaning that the confining radial stresses are automatically adjusted to ensure zero radial strain. The tests are performed at in-situ conditions and run through a series of stages that mimic the reservoir history at both Ekofisk and Valhall fields. We observe the strain response caused by the injected brine. The experimental stages are: (a) axial stress build-up by pore pressure depletion to stresses above yield with NaCl-brine which is inert to the chalk; (b) uni-axial creep at constant axial stresses with NaCl-brine; (c) sea water injection; and (d) injection of carbonated water ($SSW+CO_2$) at various mixture concentrations. Two test series were performed in which the pore pressure was increased (re-pressurized) before stage (c) to explore the stress dependency of the fluid induced strain triggering.
The main findings of our investigations are:

1. The creep rate in the plastic phase is pore fluid dependent. The injection of sea water induces a period of accelerating creep.
2. The injection of CO_2 and sea water reduces the deformation rate, a result which is in contrast to what has previously been shown.
3. The solid weight of the plugs is maintained during flooding which indicates that the observed carbonate dissolution at the inlet side is counteracted with secondary precipitation, possibly calcium sulphate, within the plug.

These recent obtained results show that chalk cores maintain their mechanical integrity during flooding of carbonated water. This experimental study, however, separates from earlier studies by the low injection rate which allows secondary precipitation processes to equilibrate within the plugs, chalk type, test temperature, and stress conditions, which all are factors that will affect the reported dynamics.