Coupled Thermo-Hydro-Mechanical-Chemical Analysis of CO_2 Injection in a North Sea Chalk Reservoir

Growing global demand for renewable energy and reducing CO_2 emissions drive researchers to materialize Carbon Capture and Storage (CCS) to achieve a net-zero emission by 2050. With several depleted offshore hydrocarbon fields, Denmark is taking this opportunity to reduce the CO_2 levels during the energy transition from fossil fuels to renewable energy. However, most reservoirs in the Danish part of the North Sea are chalk, and contrary to sandstone formations, chalk formations show reactive behavior in the presence of CO_2. Moreover, calcite dissolution in the presence of carbonated water in chalk reservoirs may also induce compaction around the injection well and within the reservoir [1]. Other than that, low matrix permeability and high porosity chalk reservoirs have been subjected to geomechanical alteration due to the cold seawater injection that has been started at the early field lifetime. This geomechanical alteration consists of the softening of rock mechanics properties such as yield stress and bulk modulus, referred to as the water weakening effect, which occurs due to *i*) the adsorption of specific ions from seawater to the calcite rock surface and *ii*) calcite and quartz dissolution at high temperature, and Ca-Mg substitution at the grain surface [2]. Therefore, CO_2 injection may expedite the weakening mechanical properties of chalk even further by inducing chemical interactions with the surface of chalk [3].

Considering the impact of the coupled interactions on the non-isothermal transport of multi-phase fluids and reservoir deformation, this study aims at illustrating the dynamic behavior of a mature North Sea chalk reservoir for the CO_2 injection after injecting cold seawater. A wrapper in Matlab is developed that integrates Eclipse reservoir simulator and Visage geomechanics simulator to update the mechanical properties at each time-step based on Eclipse's output and developed yield stress correlations at various temperatures, ions concentrations, and CO_2 saturation.

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