Salt precipitation by supercritical CO_2 injection: factors to be considered to avoid injectivity impairment

Jammernegg, B.[1], Stiedl, G.[1], Flemisch, B.[2], Ott, H.[1]
[1]Montanuniversität Leoben, Department of Petroleum Engineering - Chair of Reservoir Engineering, Leoben, Austria, [2]Universität Stuttgart, Lehrstuhl für Hydromechanik und Hydrosystemmodellierung, Stuttgart, Germany

Geological storage of CO_2 is currently considered as the most promising large-scale option to avoid emissions by industrial activities. As suitable subsurface containers, oil and gas reservoirs and the more abundant saline aquifers are considered. The injection of dry or under-saturated supercritical CO_2 into water-bearing formations leads to the formation of a dry-out zone due to evaporation of water from the resident brine into the injected CO_2-rich phase, which leads to the precipitation of formerly dissolved brine constituents – salt precipitates in the pore space of the rock formation. This process negatively affects permeability, which potentially impairs injectivity. Even though the impairment of injectivity poses both, operational as well as financial challenges, minor attention has been dedicated to this research area so far. Anyhow, in earlier studies it has been shown that dry-out is confined to a zone near around the injection well, the magnitude of impairment is strongly rock type dependent, and the amount of precipitated salt is dictated by capillary fluid transport, that may lead to counter current brine transport towards the injection well.
In this presentation, the coupling between displacements, evaporation and capillary transport mechanisms are outlined and discussed, as well as the potential reduction of the formation permeability. A remaining important question is the size of the zone of counter-current flow, which determines the amount of salt that potentially precipitates in the near-wellbore area and the accompanied porosity reduction. Current reservoir simulation tools are not accounting for this effect, because they typically do not capture evaporation kinetics. Earlier studies indicate that in certain cases the respective permeability can be reduced by several orders of magnitude [1], which comes close to a loss of an injection well.
In a recent study (work in progress), we approach this question with meter-scale core flood experiments to determine the size of the zone affected by the undersaturated CO_2, corresponding to the zone of counter current imbibition. The experiment is equipped with a medical CT scanner for real time monitoring of the saturation state during the experiment and for monitoring the locations the salt precipitates. Furthermore, a differential pressure measurement allows to determine the associated permeability reduction. The goal of the study is to establish an experimental/numerical workflow to properly design and to history match experiments with a reservoir simulator. By a continuum scale numerical description, governing parameters can be extracted, and results can be upscaled to the well bore environment. However, meter-scale experiments already correspond to field relevant scales and makes the study directly relevant for operations.

References:
[1] Holger Ott, JeroenSnippe, Kees de Kloe, (2021), Salt precipitation due to supercritical gas injection: II. Capillary transport in multi porosity rocks, Elsevier Ltd., International Journal of Greenhouse Gas Control, https://doi.org/10.1016/j.ijggc.2020.103233