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CO2 degassing kinetics in porous media

Tuesday, 31 May 2022 12:00 (15 minutes)

Geothermal fluids often contain significant amounts of minerals and gasses such as CO2 and N2. As these fluids are extracted, a change in pressure and temperature will occur in or near the production well. These changes disturb the equilibrium the water is in with its dissolved minerals and gases and can result in degassing, that is, the formation of free gas bubbles. These bubbles take up space inside the reservoir's pore space, which limits the ability for the water to flow, thus leading to reduced production of geothermal waters. This project is aimed at experimentally investigating the conditions at which the onset of the degassing process starts (i.e. the conditions where the first free gas bubble forms) inside porous media. Furthermore, the influence of the degassing process is on the apparent permeability of the porous medium (i.e. the extent to which the water's ability to flow is altered). Knowledge on these parameters will enable operators to adapt their procedures such that fluid production can be maintained in the long-term.
To this end, coreflood experiments were performed in which CO2 along with water (tap water or brine with a higher salinity) were co-injected into either a Bentheimer or Berea sandstone core under a variety of conditions. The first sets of coreflood experiments were carried out under moderate conditions (tap water, p = 50 bar and T = 30 ℃). Here, the onset of the degassing process can be predicted accurately using CO2 solubility values obtained from Henry's law combined with the Van 't Hoff equation (Smith (2007)). At these conditions CO2 degassing near the wellbore will cause the apparent permeability to decrease by a factor 2 to 5 in a high permeability, 2.3 Darcy, Bentheimer sandstone core. At the same conditions the apparent permeability will decrease by about a factor 10 in a low permeability, 140 millidarcy, Berea sandstone core. The change in apparent permeability is gradual in the Bentheimer sandstone while in the Berea sandstone the change is near-instant. For rocks with small pore sizes and low initial permeability, the reduction in apparent permeability is larger and the rate of permeability decrease is faster. The onset of the degassing process is not influenced by the pore size and initial permeability.
Experiments at temperatures between 30 and 90℃ show that with increasing temperature the onset of degassing shows deviates more from Van 't Hoff theory. The pressure where degassing initiates increases with temperature, but is still significantly lower than that predicted by the Van 't Hoff equation. Using a high-salinity brine (1.5 M CaCl + 2 M NaCl) leads to further deviation from theory, with bubbles forming at significantly higher pressures compared to the tap water experiments. However, the observed reduction in apparent permeability is similar for both sets of experiments.

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References

1. F. L. Smith, Environmental Management Where do Henry's constants come from? (2007).

Time Block Preference

Time Block A (09:00-12:00 CET)

Participation

In person

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