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CT visualization of the CO_2 degassing process in porous media

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Geothermal fluids tend to contain large quantities of dissolved gasses such as CO_2 and N_2. A drop in pressure towards the production well means that free gas bubbles can form as the solubility limits can be exceeded. These bubbles occupy part of the pore space thereby leading to a decrease of the water relative permeability, thus leading to reduced production of geothermal waters. In addition, the presence of free CO_2 can enhance the rates of precipitation of minerals such as calcite (Stefánsson et al., 2016).

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. In addition, the influence of presence of free gas bubbles on the water relative permeability of the porous medium is assessed.

A series of coreflood experiments was carried out where CO_2 along with an aqueous phase (either tap water, 1 M NaCl brine or 1.5 M $CaCl_2$ + 2 M NaCl brine) were co-injected into a Berea sandstone core at ambient temperature. The CO_2 concentration ranged from 0.2 to 1.3 mol/L to assess its influence on the degassing pressure. Initial coreflood tests outside the CT scanner using a vertically oriented core showed an abrupt decrease in the water relative permeability of approximately 90% at pressures just slightly below the degassing pressure. This implies that the free gas bubbles function as an effective blocking agent in these rocks thus limiting the water production rate. The onset of degassing (i.e. pressure below which degassing is observed) is also found to correlate well with CO_2 solubility values that were obtained using the Van 't Hoff equation (Smith and Harvey, 2007) when using tapwater as the aqueous phase, but with larger deviations found at higher brine salinities.

The first series of CT assisted corefloods was performed using a medical CT scanner and the same experimental conditions as the earlier experiments. Here the core had to be placed horizontally due to limitations of the scanner. Free gas saturations within the core were determined at various different back pressure levels and compared with differential pressure logs. Again, an abrupt transition in the water relative permeability was found once degassing started, but the process also suffered from gravity override of the free gas especially at higher CO_2 concentrations.

Additional coreflood experiments are currently being prepared utilizing a new CT scanner that allows for vertical placement of the rock core along with higher resolution scans. This enables performing tests without gravity override problems. Also, the higher resolution scans allows capturing of more details of the degassing process, such as mineral precipitation.

Participation

In-Person

References

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