Contribution ID: **505**

Type: **Oral Presentation**

Injectivity losses in sandstones during CO2 hydrates formation

Wednesday, 24 May 2023 10:15 (15 minutes)

Sequestration of captured CO2 in geological formations to reduce its content in the atmosphere is one proposed solution to mitigate global warming. This solution, generally referred as carbon geo-sequestration (CGS), involves the injection of CO2 into depleted reservoir or saline aquifers. The success of CGS relies on many technical aspects, including CO2 plumes extension, gravity segregation, capillary trapping, and well's injectivity. Well's injectivity, which refers to the ability of the injected CO2 to flow near the wellbore zone, is crucial in the design of CGS operation as it constrains the maximum flow rate at the well. In the case of depleted reservoir, pressure of the reservoir can be as low as 20 bars. In the other hand, to fulfill a minimum volume flow rate, CO2 is injected with pressure higher than 50 bars. This pressure difference near the well bore causes the CO2 to undergo both a considerable adiabatic depletion and a phase transition, reducing the temperature of the fluids and the rock. The co-existence of both CO2 and brine, at relatively high pressure and low temperature may bring the system in hydrates stability zone and led to a CO2 hydrates formation. This crystallization can increase the volume of immobile phases in the pore-space. Consequently, the relative permeability of the rock to CO2 can be drastically reduce. In the worst scenario this can lead to the complete clogging of the injection wells.
The formation of CO2 hydrates in partially saturated porous media has been widely investigated at local scale using high resolution micro-computed tomography (micro-CT). To a lesser extent, the reduction of CO2 injectivity has been explored under flowing conditions in coreflooding devices. The purpose of this work is to trigger and observe the formation of CO2 hydrates in sandstones under flowing conditions, and to evaluate the loss of CO2 injectivity during the crystallization process as a function of initial water saturation. Experiments have been conducted using a high throughput experimentation setup (CAL-X [1]) equipped with a coreflooding device allowing running experiments on small rock plugs, with respectively length and diameter of 2 cm and 1 cm. It uses X-ray to live-monitor changes in fluids saturation. Experiments of hydrate formation have been conducted at 25 bars and 5°C, for different initial brine saturations, and on various rock-types, targeting different porosities, permeabilities and clay content. Relative permeabilities curves accounting for the formation of CO2 hydrates in the porous media were interpreted from those experiments.

[1] Youssef, S., Mascle, M., and Vizika, O., 2018, High Throughput Coreflood Experimentation as a Tool for EOR Project Design, Paper SPE-190166 presented at the SPE Improved Oil Recovery Conference, Tulsa, Oklahoma, USA, 14–18 April. DOI: 10.2118/190166-MS

Participation

In-Person

References

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Session Classification: MS01

Track Classification: (MS01) Porous Media for a Green World: Energy & Climate