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Gas trapping mechanism and the potential impact on productivity of geothermal reservoirs

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Entrapment of the non-wetting phase in porous media has been observed in a variety of fields such as petroleum engineering or geological storage of carbon dioxide. Our study aims to monitor gas trapping under in-situ conditions using X-ray computed micro-tomography to evaluate gas trapping as a possible mechanism for a decreasing productivity index of geothermal reservoirs. The transient behavior of the productivity index in the test site of Groß Schönebeck (north of Berlin, Germany) indicates irreversible changes of the reservoir characteristics caused e.g. by scaling's or the accumulation of free gas and/or fines due to changing mechanical loads i.e. changes of pressure and temperature (Blöcher et al. 2016). Typically, these gas bubbles can migrate upward due to buoyancy, but while they grow in size they may get trapped in the pores (Mahabadi et al. 2018). Consecutive X-ray computed tomography (CT) scans of a typical siliciclastic rock were generated while the pressure was decreased stepwise to mimic gas bubble generation. The cylindrical sandstone core with a diameter of 5 mm was coated with a viton-sleeve and positioned inside a self-manufactured core-holder design made from aluminum and resin using stereolithography 3-D printing (SLA) for prototype production. The cell is placed inside a µCT scanner with a 225 kV multifocal X-ray tube for high resolution X-ray tomography resulting in a resolution of about 6 µm. A scan of the sandstone with a porosity of about 10 % was gathered after nitrogen was injected to the core. Further images were obtained after water injection at pressures up to 4 MPa. The scanning procedure was repeated after flow through experiments with flow-rates of 2 ml/min were carried out for an hour each. Images were analyzed using the software Avizo Fire, Version 9.0.1©. The images were filtered in 3D with an edge preserving non-local means filter and binarized using a modified Otsu thresholding procedure (Otsu 1979). Further quantification algorithms were implemented in Phyton. A pore-network model was extracted from the three-dimensional data and will be used to evaluate the changes in hydraulic conductivity at each timestep. The distributions of the volume of trapped gas bubbles is estimated from the scanned images by subtracting the timesteps from the fully water saturated sample to highlight changes in density. The trapped gas fluctuates and generally higher trapped gas saturation is observed in larger pores and the more porous layers. This results in a clear reduction of permeability that could potentially explain the decreasing productivity index observed in several geothermal sites.

Participation

In-Person

References

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