Contribution ID: **315** Type: **Poster Presentation**

Evaluation of fluid flow behavior and trapped non-wetting phase saturation with modified pore morphological approach in clastic reservoirs

Wednesday, 1 June 2022 14:50 (1h 10m)

The quantification of fluid flow properties and residual non-wetting phases in petroleum reservoirs is essential to understand hydrocarbon recovery or CO2 storage capacity of the subsurface reservoirs. Specific core experiments used to derive such properties, e.g., trapping curves and relative permeabilities can be time-consuming, difficult to conduct and sometimes not representative for the entire reservoir. Recent developments in Digital-Rock-Physics (DRP) are promising for effective prediction of fluid flow behavior based on 3D pore-scale images of rock samples. In this study, we will focus on the pore morphological approach (PMM) and its applications for OMVs clastic reservoirs.

The PMM is a quasi-static method that predicts the distribution of two fluids inside a porous medium and assumes that capillary forces are dominant. The method distributes the fluids using morphological operations to model drainage and imbibition processes. PMM shows very good results for primary drainage, but has shortcomings, when describing imbibition processes. Therefore, modifications were necessary to improve this simulation part, which is key in understanding hydrocarbon recovery. Sub-resolution wetting layers, which can swell while running a waterflood simulation and the possibility to assign different wetting conditions, by using multiple contact angles, were implemented in the application. Furthermore, a combined modeling of an imbibition and drainage sequence, allowed to extend the imbibition branch from spontaneous to forced imbibition.

The modified PMM was tested on clastic water-wet reservoirs, which have good to medium quality reservoir properties (e.g. porosities > 10 % and permeabilities from 100 –5000 D). The primary drainage and imbibition processes were simulated for several plugs covering two rock types per reservoir. The initial and the residual non-wetting phase saturations were used to derive trapping curves. The simulated results were then compared to industry-wide excepted correlations, such as the Land correlation, and to available core data. The comparison showed good agreement between simulated and measured data. Furthermore, two-phase fluid flow simulations for the imbibition process were conducted with the modified PMM approach for all rock types and compared to available core data. Again, the simulated relative permeabilities match well with available core data per rock type. If core data was not available, we compared it to analogue data from our internal rock-fluid database and subsequently with log upscaling.

Overall, the results from modified PMM showed that the simulations for the imbibition processes are in line with expected trends, e.g. the residual non-wetting phase saturation decreases with increasing contact angle and that the results are in good agreement with core and log data. After simulation of imbibition relative permeabilities, there are still some snap-offs mainly in intermediate rock types for the non-wetting phase branch observed, which results quickly in connectivity loss and therefore steep decrease of non-wetting phase relative permeabilities. However, these are topics to be addressed in follow-up studies in the upcoming year next to addressing mixed wet and heterogenous reservoirs.

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References

Time Block Preference

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

Participation

Unsure

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Session Classification: Poster

Track Classification: (MS06-A) Physics of multiphase flow in diverse porous media