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Simultaneous Interpretation Of Multiphase Fluid Flow Characteristics In Porous Media from Steady State SCAL Experiments Performed in a Microfluidic Approach

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Introduction: This work aims to conduct, interpret and derive the multi-phase fluid flow behaviour more efficiently and feasibly from microfluidic experiments. The goal is to conduct SCAL experiments using a microfluidic setup on a chip. Additionally, interpret the in-situ results, where the parameters influencing the multi-phase fluid flow in porous media, such as wettability, capillary pressure, and relative permeability, are measured simultaneously. There are numerous economic and technical advantages of this approach. Conventionally, SCAL measurements are conducted through core samples using X-ray and multi-phase fluid flow parameters in porous media are measured separately. These properties can be simultaneously determined in digital rock physics (DRP) by applying micro-CT imaging but with high costs.
Materials and Methods: The steady-state method was utilised in this study and re-designed for microfluidic flooding. The measurement was conducted using one oleic and one aqueous phase, applying different fractional flow steps, mimicking the range of varying water saturation in the reservoir during the depletion process (imbibition). The used microchip has a synthetic pore-structure design with circular grain shapes. The measurements conducted are visible in real-time using a microfluidic approach.
Results: The experimental results show that it is possible to adapt the microfluidic flooding for conducting and interpreting SCAL measurements. An additional advantage of this method is that the wettability and capillary pressure could be successfully determined by means of image processing using only the data obtained from the steady-state method in a microchip. Since the measurements are visible live, and images of the microchip are captured with the desired frequency, the image processing facilitates the understanding and interpretation of multi-phase fluid flow in porous structures, which is not possible with cores. Overall, to overcome the technical and economic limitations of digital rock physics, the application of SCAL through microchips representing the porous media is a good alternative.
Addition: The SCAL-on-Chip is a promising approach to contribute in describing and analysing multi-phase fluid flow on a Darcy- and pore-scale. Image processing contributes to developing more feasible interpretation tools for estimating wettability and capillary pressure. It provides the possibility to derive mathematical models of the relationship between multi-phase flow characteristics. The derivation of a general function between the measured properties could be possible with machine learning and a sufficient amount of experiments using pore structures that closely resemble porous media.

Participation

In-Person

References

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Primary authors: Dr JENEI, Bettina (Clausthal University of Technology); SAMARA, Hanin (TU Clausthal); Mr LANGANKE, Nils (Clausthal University of Technology); Mr MANASIPOV, Roman (Datagration); Mrs AL-ISMAILI, Safa (Clausthal University of Technology)

Presenter: Dr JENEI, Bettina (Clausthal University of Technology)

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