Contribution ID: **428** Type: **Poster Presentation**

Sensitivity Analysis and Experimental Design on Relative Permeability and Capillary Pressure Parameters in Experimental USS Core Flooding Data

Monday, 19 May 2025 15:05 (1h 30m)

The computational simulation of petroleum reservoirs is crucial for understanding the dynamics of multiphase flow in geological formations, enabling the development of advanced models and accurate predictions. These simulations rely heavily on parametric constitutive relationships to represent fundamental reservoir engineering properties, such as relative permeability (k_{rel}) and capillary pressure (p_c). These properties are indispensable for modeling multiphase flow on a continuum scale in heterogeneous porous media. Reliable oil production estimates, in turn, require the quantification of uncertainties associated with system property parameters. This quantification establishes upper and lower bounds for the economic feasibility of reservoir development. However, most models in the literature depend on numerous empirical parameters that must be determined. Despite their complexity, these parameters often lack a direct connection to the underlying physics of the problem. Furthermore, preliminary sensitivity and linear dependence analyses of these parameters are essential but are frequently overlooked, especially in unsteady-state (USS) core flooding experiments. Such analyses help determine whether a parameter can be effectively estimated before proceeding to uncertainty quantification. In this context, the present study investigates the sensitivity coefficients and experimental design of relative permeability and capillary pressure parameters, both parameterized using the LET model, in single-step USS core flooding experiments conducted on real rock samples. In these experiments, a core plug saturated with oil is subjected to axial water injection at one end, leading to oil production (and, after breakthrough, water production) at the opposite end. The experimental data include the pressure difference between the water inlet and the oil (and water) outlet, as well as the cumulative oil volume produced. Computational simulations were conducted using the open-source Core2RelPerm code to model the flow, in combination with the heuristic optimization method Particle Swarm Optimization (PSO). This approach was employed to optimize the relative permeability and capillary pressure parameters, using the two experimental outputs as boundary conditions. The optimization process enabled the reconstruction of the water saturation profile along the core—data that are not directly accessible from the experiments. This reconstruction provided valuable insights into the dynamics of water saturation development in different cores. Subsequently, sensitivity coefficients for the experimental design of all investigated parameters were determined across various rock samples, using the experimental outputs and the reconstructed water saturation profiles from the optimization. The results indicate that only a small subset of the studied parameters exhibit significant sensitivity, highlighting the potential overparameterization of the employed parametric model. Additionally, it was observed that certain experimental responses are more critical than others, based on the magnitude of parameter sensitivity associated with those responses. The experimental design also suggests the possibility of conducting these experiments in a shorter time frame, thereby reducing their execution costs.

Country

Brazil

Acceptance of the Terms & Conditions

Click here to agree

Student Awards

I would like to submit this presentation into the student poster award.

Water & Porous Media Focused Abstracts

References

Primary author: Mr DE MELLO STIEVEN, Gianfranco (LRAP/UFRJ)

Co-authors: Mr OLIVEIRA DA SILVA, Filipe (LRAP/UFRJ); Dr HENRIQUE DIAS, Caroline (LRAP/UFRJ); Mr MARQUES DOS SANTOS, Antonio Emanuel (LRAP/UFRJ); Prof. COUTO, Paulo (LRAP/UFRJ)

Presenter: Mr DE MELLO STIEVEN, Gianfranco (LRAP/UFRJ)

Session Classification: Poster

Track Classification: (MS14) Uncertainty Quantification in Porous Media