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Impact of Synthetic Laminar and Vugular Heterogeneities on USS Core Flooding Outputs

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SCAL (Special Core Analysis) tests are essential for determining the properties of heterogeneous porous media under multiphase internal flow, including capillary pressure, relative permeability, and wettability. These tests are pivotal for predicting reservoir performance. Among them, the USS (Unsteady-State) core flooding test is particularly noteworthy. In this test, an oil-saturated rock sample, initially at irreducible water saturation, is subjected to a controlled water flow at one end. This process displaces oil, which is produced at the opposite end until breakthrough occurs, after which both oil and water are produced. The test enables the evaluation of permeability and saturation under conditions that mimic a petroleum reservoir environment. The significance of this experiment is heightened when the goal is to investigate the properties of highly heterogeneous rocks characterized by elongated and irregular volumetric discontinuities, such as laminar and/or vugular heterogeneities. These structures significantly influence the dynamics of water saturation within the porous medium. However, boundary experimental data, such as cumulative oil production and pressure differential, often fail to capture these changes, making distinguishing between strongly heterogeneous structures challenging. In this context, the present study examines the impact of synthetic laminar and vugular heterogeneities on the experimental outcomes of the USS core flooding test, intending to determine whether these features can be characterized in a transient test. Three primary experimental outputs were analyzed: the pressure differential between the two ends of the rock, cumulative oil production, and saturation profiles along the core. The investigation focused on parameters such as the thickness, quantity, and permeability ratio of laminations relative to the core in laminar heterogeneity, as well as the quantity, size, and distribution of vugs in vugular heterogeneity. Three-dimensional simulations were conducted using the CMG software in a computational environment. The experimental design revealed that certain parameters exert a significantly greater influence than others and that some experimental outputs cannot differentiate the medium's heterogeneity. This limitation renders these outputs potentially ineffective for subsequent uncertainty quantification in the analysis of these porous media of interest.

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References

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