Modeling of Miscible Filtrate Cleanup with Wireline Formation Testers

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Acquisition of representative fluid samples in Wireline Formation Testers (WFTs) is of paramount importance and has been greatly impeded by miscible oil-based mud (OBM) filtrate contamination. Predicting pumpout times needed to obtain representative formation samples is essential for planning, interpretation, and the design of new generation WFT probes/snorkels that can operate in OBM filtrate environments with enhanced efficiency.

Analytical as well as numerical models reported in the literature rely predominantly on simplifying assumptions in terms of the compositions of flowing fluid phases and typically assume either single phase or 2 to 3-component hydrocarbon phases in cases of black-oil/extended black-oil formulations. As a result, accurate modeling of the flow dynamics into has been difficult to achieve because modeling of the OBM invasion process is quite complex and very different from the water-based mud invasion process. Here, we take a different approach. We have constructed a numerical model for OBM filtrate cleanup using a compositional fluid-flow simulator that honors the physics of multi-component fluid flow and the thermodynamics of phase behavior. We have simplified the effect of invasion by initializing an invasion profile at the time of sampling using a depth of invasion parameter, allowing the inclusion of nonzero crude oil fractions at the sand face when required. We have focused on building a geometrically realistic model of the probe and its surroundings and identifying the various invasion, formation and fluid parameters that most affect the sampling process. To verify the robustness of the model, history matching has been performed on a number of field data sets. Without little tuning if any, excellent agreement has been obtained between predicted and observed cleanup profiles during sampling. Our modeling results are not tool specific and can be used by anyone involved in the design and operation of new and existing sampling probes.