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Quantifying the value of information for uncertainty reduction in chemical EOR modeling

Sarah Leray, Christopher Yeates, Frédéric Douarche, and Frédéric Roggero
IFPEN, Department of GéoHydroMécanique, Rueil-Malmaison, France (sarah.leray1@gmail.com)

Reservoir modeling is a powerful tool to assess the technical and economic feasibility of chemical Enhanced Oil Recovery methods such as the joint injection of surfactant and polymer. Laboratory recovery experiments are usually undertaken on cores to understand recovery mechanisms and to estimate properties, that will be further used to build large scale models. To capture the different processes involved in chemical EOR, models are described by a large number of parameters which are basically only partially constrained by recovery experiments and additional characterizations, mainly because of cost and time restrictions or limited representativeness. Among the most uncertain properties, features the surfactant adsorption which cannot be straightforwardly derived from bulk or simplified dynamic measurements (e.g. single phase dynamic adsorption experiments). It is unfortunately critical for the economics of the process.

Identifying the most informative observations (e.g. saturation scans, pressure differential, surfactant production, oil recovery) is of primary interest to compensate deficiency of some characterizations and improve models robustness and their predictive capability. Building a consistent set of recovery experiments that will allow to seize recovery mechanisms is critical as well. To address these inverse methodology issues, we create a synthetic numerical model with a well-defined set of parameter values, considered to be our reference case. This choice of model is based on a similar real data set and a broad literature review. It consists of a water-wet sandstone subject to typical surfactant-polymer injections.

We first study the effect of a salinity gradient injected after a surfactant-polymer slug, as it is known to significantly improve oil recovery. We show that reaching optimal conditions of salinity gradient is a fragile balance between surfactant desorption and interfacial tension increase. This high dependence on surfactant adsorption properties indicates that two recovery tests with and without salinity gradient are of great interest for model inversion and characterization of surfactant adsorption.

Second, we analyze our capacity to find again the reference model using an assisted history matching method to reproduce a set of synthetic core-scale experiments. To do so, we use the reference model over five configurations with respect to chemicals injection to provide baseline recovery data. Then, we consider some uncertainty on model parameters, regarding surfactant adsorption properties amongst others, leading to a total of twelve uncertain parameters. Finally, we extensively explore the parameter space to find several reasonable matches. We show that an additional sixth recovery experiment is necessary to fully constrain the model, and specifically characterize surfactant adsorption. We besides show that production data are not equally informative: pressure differential is for instance the less informative data while a saturation scan at the end of the polymer post-flush can greatly help in the inversion. The inverse methodology carried out here has also been successfully tested with a real set of coreflood experiments.