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Title **Hysteresis in Three-Phase Flow: Experiments, Modeling and Reservoir Simulations**
Authors P. Egermann, O. Vizika, IFP: Institut Français du Petrole; L. Dallet, C. Requin, GDF: Gaz De France; F. Sonier, SMC: Simulation & Modelling Consultancy
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Abstract

A proper modeling of tertiary recovery processes such as gas injection or WAG (Water Alternating Gas) requires an adequate three-phase flow model. This allows to better predict the recovery efficiency, gas storage reservoir performance as well as the well injectivity.

For gas drainage, a previous paper [25] presented a new three-phase flow model based on a theoretical analysis and validated through experimental approach. For WAG injection, there is an additional complexity due to the need to model the imbibition that occurs when gas saturation decreases. To tackle the modeling of hysteresis problem, a comprehensive approach was followed. First, successive drainage and imbibition experiments were conducted under various conditions of initial saturations. A new three-phase model taking into account the hysteresis is presented and validated on the experiments.

Indeed, as shown in previous experimental studies, hysteresis was found to depend not only on the drainage/imbibition process (saturation history) but also on the cycle considered (displacement history) where cycle names the association of two consecutive displacements (drainage and imbibition). In this study, a relevant analytical expression of the hysteresis is proposed avoiding any negative effect of numerical instabilities. The new formulation was implemented in a reservoir simulator and WAG experiments have been successfully simulated. The impact on breakthrough time, overall recovery efficiency was tested through large scale reservoir simulations.