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A pore scale network modelling study of gravitational effects during solution gas drive: results from macroscale simulations.
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ABSTRACT
Although experimental work for solution gas drive processes is routinely carried out and interpreted for the purpose of defining critical gas saturations and relative permeability data, reaching a unique and complete understanding of the results for a confident application to the field is a hard task. Existing macroscopic models cannot reproduce or account for several different features of the experiments: the formation of saturation gradients and the relation with the outlet boundary conditions are still unclear subjects as well as what governs the transition between the stages of disconnected immobile gas phase, disconnected mobile or continuous gas flow. On the other hand, pore scale network models, in the few cases where they are refined enough to include viscous or gravitational forces, have perhaps their greatest limitation in the number of pores that can be simulated, which makes it difficult or impossible to simulate real life effects of non capillarity.
In this work a pore scale network modelling approach is presented which is capable of reproducing gravitational effects during oil depressurisation through simulation in samples of macro-scale height, anchored to the real rock and including several hundreds thousands pore elements. The primary objective is to simulate at the same scale routinely used lab samples, in this way reproducing the real scale and pressure dependent balance of forces: this permits to show how the ratio gravity to capillarity changes in relation to the rates of depletion (bubble densities), the rock properties, the
fluid properties and the scale of the sample, and how this contributes to affect relative permeabilities and critical gas saturations. In particular it is shown that relative permeabilities can be predicted at each phase flow stage (dispersed and/or continuous) and how flow is largely determined by the size and density of gas clusters, whether originating from nucleation or from break-up of larger structures during migration. Furthermore the modalities by which different saturation gradients can develop along the sample and the relation to the outlet boundary conditions are explained. The results are compared to available experimental data.