Pore-scale simulation technology for oil & gas business

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1 Introduction

Exactly 60 years ago, Fatt published his papers where a network of pores was used to study two-phase flow in porous media. His seminal work as well as that of many others who followed has led, thanks to ever increasing computation capacity, to today's developments in micro- and nano-scale imaging, modelling and simulation. These are allowing the scientific community to probe the pore-scale at unprecedented level conducting both real and virtual experimentation in 3D realistic, although miniaturized, rock models. This has all been good news for the Oil & Gas Industry whose interest is to understand and optimize multi-phase flow processes and recovery protocols in an energy scenario where resources are becoming scarcer or less easy to produce (brown fields, unconventional) or where environmental constraints impose new technological agendas (CO2 storage).

In this context, pore-scale simulation technology has followed a trend of progressive industrialisation. One main interest is the possibility of enhancing the value of existing experimental petrophysical datasets, also implicitly, by means of improved knowledge of the underlying mechanisms; a second interest is the potential to explore domains or problems for which knowledge is simply hard-to-get or hard-to-explain by means of conventional experimentation techniques. In both cases there is a fundamental need which is the validation of the the robustness and reliability of information provided by simulation. This comes through carefully conducted validation experiments.

2 Validation of a pore-scale simulator

2.1 Pore-scale experiments and data dispersion

A transparent glass micromodel is used to perform two-phase flow experiments and the data are then analysed to verify their reliability or statistical dispersion. Of course, in any field, experiments can only be repeated a given number of times due to imperatives from experimental procedures, availability of human resources, costs or time. In this work, using tools from microfluidics, we explore the dispersion of data such as capillary desaturation curves and secondary waterflood recoveries using micromodels of different sizes and different pore patterns. Using datasets with low sampling (low number of repeats of an experiment) and with very large sampling (Figure 1), we document the type of data dispersion, we analyze its reasons and we verify to which extent truly quantitative conclusions can be drawn from these datasets. Their utilisation as a simulator validation dataset is discussed.

2.2 Pore-scale simulation and validation

Pore-scale simulations for digital petrophysics (or Digital Rock Physics) are performed on segmented 3D images of rocks or on representative simplified pore networks: the main industrial objective is to compute the relative permeability, because this is a difficult and costly property to measure in the Lab. In this work, we privilege the approach of extracting a simplified form of pore network from the original image and we develop a workflow to validate a computationally efficient pore network model against micromodel experiments at the same scale, by means of 2D simulation. Considering that the ultimate goal is the comparison with experiments on real 3D rocks at Darcy scale (say 10cms), we conclude with observations on simulation data scattering at pore-scale, core level heterogeneity and the challenge of scale.

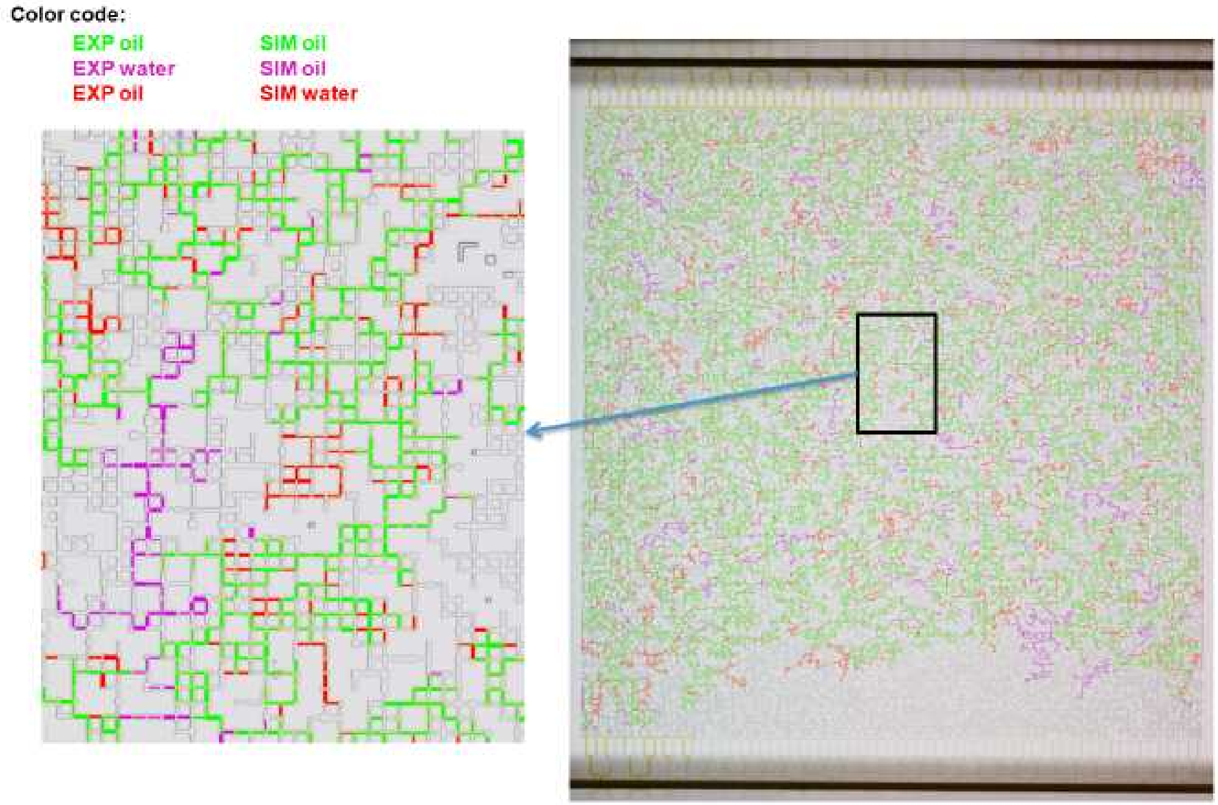

Figure 1: Highlighted match and mismatch with colors on pore to pore basis between micromodel experiment image and pore-scale network simulation.

References

[1] Fatt, I.: "The network model of porous media III. Dynamic properties of networks with tube radius distribution", Trans AIME, 207, 164-181, 1956c.

[2] Yang, J., Bondino, I., Regaieg, M. and Moncorge, A.: "Pore to pore validation of Pore network modelling against Micromodel experiment results", presented at the 15th European Conference on the Mathematics of Oil Recovery (ECMOR XV), 29 August - 1 September 2016, Amsterdam.