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Title

Multiphase flow in geological porous media: new insights and application perspectives

Abstract

Transport phenomena in porous media are encountered in many situations of practical and scientific interest. They may concern natural porous media, such as soils, aquifers or hydrocarbon reservoirs, as well as artificial ones, such as filters, fuel cells, catalysts and concrete.

Multiphase flow in geological porous media is essential in a wide range of phenomena and applications in geosciences. The objects and phenomena studied extend over several orders of magnitude in terms of size and characteristic time, ranging from nanometer to kilometer and from millisecond to geological time. This understanding is of course fundamental for an eco-efficient and responsible recovery of hydrocarbon resources. However, it is also essential for optimized and safe management of new types of exploitation, more in line with the energy transition, such as geothermal energy, underground energy or CO2 storage, H2 storage, water resources management, soil remediation or climate / environment interactions with particular reference to carbon stocks in soils.

The complexity of transport processes in these systems is due to the natural complexity and heterogeneity of geological structures as well as to the dynamics of the multiphase fluid displacement and its coupling with mechanical, thermal, chemical and biological processes.

To understand and predict fluid transport at the large scale, a multi-scale approach combining field observation, lab experimentation and modeling is needed. Information on the pore space geometry and topology and on fluid displacement is essential to understanding of mechanisms and modeling. In 2D, advances in microfluidics bring qualitative and quantitative information on the motion of fluid/fluid interfaces in model systems down to the micron scale. In 2D or 3D, X-Ray imaging has proved to be a key technology to study multiphase flow in porous media with a continuous quest for space and time resolution. Experimental observation has to be intimately linked to pertinent theoretical modeling taking into account the relevant physics of the studied phenomena at the right scale. Advances in molecular dynamics, lattice-Boltzmann or pore-network modeling methods combined to upscaling considerations permit to simulate complex flow regimes and to run laboratory and numerical experiments on comparable sample volumes.

In the presentation, examples of implementation of the multi-scale approach and the complementarity between observations, modeling and numerical simulation will be highlighted.