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Comparing 2D micromodel patterns for pore-scale Underground Storage studies

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Among the strategies that are being undertaken to decarbonize the energy sector, many options involve underground hydrogen and carbon dioxide storage facilities. Therefore, efforts are being addressed to understand and characterize flow phenomena occurring in underground porous systems.

In this context, microfluidics offers a cost-effective option to extract large sets of information at the pore-scale. Microfluidics makes it possible to perform a wide series of experiments, having full control over the porous system and the experimental conditions, with little consumption of materials and fluids. Although microfluidic works on pore-scale analysis for underground fluid storage can already be found in literature, to the best of our knowledge a comparison between different porous patterns within the same experimental conditions is still missing.

In this work, we design, characterize, and fabricate four different micromodels, and we perform cycles of air/water drainage and imbibition, at different capillary numbers, to observe the influence of the network geometry on the fluid dynamics.

The four micromodel patterns respectively represent a regular grid, a Voronoi diagram, a mosaic composed of repeated images extracted from real Hostun rock thin sections, and a synthetic anisotropic porous medium generated with the QSGS algorithm. The design of these porous networks follows an increased level of complexity. All these patterns are fully characterized in terms of porosity, tortuosity, and pore size distribution using a methodology based on the A* algorithm and CFD simulation. Air/water drainage and imbibition tests are performed at standard conditions.

With this approach, we create a set of pore-scale observations that are meaningful for further understanding and future modeling of underground fluid storage sites. In particular, we describe and compare the pore-scale phenomena and percolation patterns observed in the four micromodels, under the same experimental conditions. The strengths and limitations of 2D microdevices applied to the study of underground porous systems are discussed with respect to the observed results.

Participation

In-Person

References

Massimiani, A.; Panini, F.; Marasso, S.L.; Vasile, N.; Quaglio, M.; Coti, C.; Barbieri, D.; Verga, F.; Pirri, C.F.; Viberti, D. Design, Fabrication, and Experimental Validation of Microfluidic Devices for the Investigation of Pore-Scale
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