Contribution ID: **41**

Type: **Oral Presentation**

Geometrical analysis of the pore space through the A* algorithm: application to 3D micro-CT images

Tuesday, 23 May 2023 12:45 (15 minutes)

The definition of an optimal reservoir management strategy is fundamental for the primary production of oil and gas, Enhanced Oil Recovery, Underground Gas Storage, Underground Hydrogen Storage, CO2 storage, and geothermal systems. Due to the complexity of geological formations, the uncertainty associated to the fluid-rock interaction parameters must be estimated and possibly mitigated by the acquisition of further information at all stages of reservoir life. The characterization and analysis of fluid flow phenomena at the pore scale can contribute to minimizing such uncertainties. Thanks to micro-CT images, a realistic representation of the reservoir rock is obtained, and it can be used as input for further analyses of pore space characteristics. In this work, the A* search algorithm (Hart et al., 1968) is used to compute the shortest connected paths across micro-CT images of rocks in the three main flow directions. This information is employed to calculate tortuosity, effective porosity, constriction factor, pore size distribution, permeability and anisotropy ratio of the rock. This process was introduced by Salina Borello et al. (2022) but was not applied to real 3D images of rocks obtained by micro-CT techniques. In this work, a sandstone and two carbonate rocks are analyzed. Fluid flow is intrinsically influenced by all the features of the pore space (i.e. tortuosity, effective porosity, constriction and pore radius) and the porous medium is usually characterized by a single parameter, the permeability, which takes into account all these properties. In fluid flow simulation, permeability can be calculated directly by inverting the Darcy's law. In the geometrical analysis instead, all pore space characteristics are evaluated individually and combined through the Kozeny-Carman equation. The geometrical tortuosity is calculated as the average length of the shortest (or geometrical) paths divided by the edge length of the sample. The effective porosity is computed as the portion of pore space crossed by the geometrical paths. The constriction factor expresses the variation of the pore cross-section orthogonal to the path. The pore size is estimated as the distance between the pore walls locally orthogonal to the path. In order to calculate the permeability, the Kozeny-Carman equation is used by including the geometrical tortuosity, effective porosity, and a representative pore radius in the equation. Finally, the anisotropy ratio is calculated using permeability values in the three main directions. Results are compared with those obtained by single-phase CFD simulation directly in the pore space using OpenFOAM, with the exception of pore size distribution and constriction factor. Geometrical analysis and CFD simulations are run at the pore-scale directly on binary images of rocks. The values of tortuosity, effective porosity, permeability, and anisotropy ratio calculated with the geometrical analysis and CFD simulation are in good agreement in all the cases. The outcome of this investigation evidences that the geometrical analysis used in this research can provide a reliable characterization of rocks.

Participation

In-Person

References

Hart, P. E., Nilsson, N. J., & Raphael, B. (1968). A formal basis for the heuristic determination of minimum cost paths. IEEE transactions on Systems Science and Cybernetics, 4(2), 100-107.

Salina Borello, E., Peter, C., Panini, F., & Viberti, D. (2022). Application of A* algorithm for microstructure and transport properties characterization from 3D rock images. Energy, 239, 122151.

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Session Classification: MS09

Track Classification: (MS09) Pore-scale modelling