MICRO-SCALE CFD MODELING OF TIGHT ROCKS

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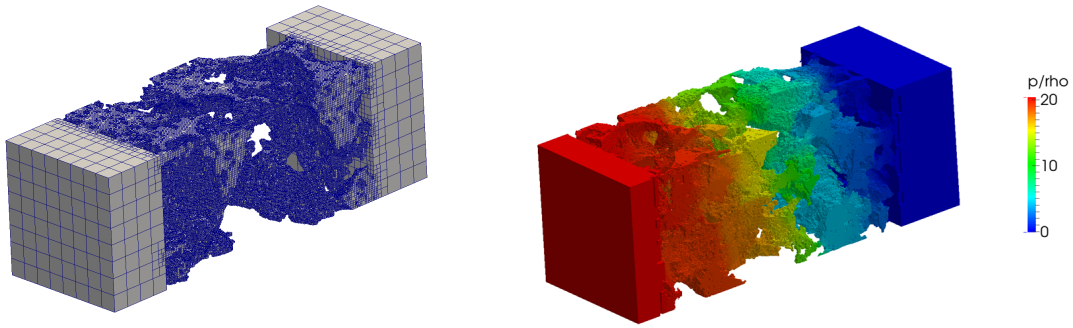
The study of fluid flow at the microscale level is of interest in many engineering fields, including material science, biomedical and petroleum engineering. In the oil and gas industry, understanding the relationship between the microstructure of rocks and fluid flow is fundamental, especially for the planning of enhanced recovery programs when exploiting unconventional resources.
As a matter of fact, digital rock analysis has proven to be an effective tool for reservoir characterization, as it allows to calculate physical properties directly on real rock geometries [1]. The typical workflow that is followed ([2, 3]) starts from an acquired tomographic dataset and consists of: (i) image processing (ii) generation of a computational mesh (iii) numerical simulation (iv) post-processing. In the present work, specific methods are implemented to perform each of these steps on the basis of open-source tools, namely Fiji/OpenCV for image processing and OpenFOAM for meshing, simulating and post-processing. The proposed methodology has been tested on samples of rocks with different geological characteristics.
With regard to image processing, an automatic histogram-based thresholding strategy is proposed for the identification of the void space and solid phases on the denoised image stack. A new mesh generation utility has been developed, able to work directly on the image dataset without the need of an intermediate step for extracting the geometrical surface of the void space.
Single- and two-phase incompressible flow simulations are run on different configurations to investigate the fluid behavior inside the pore structure and to show how pressure drop may be affected. Moreover, the well-known issue of sub-resolution features is addressed, and a simple model for the local resistivity of unresolved porous regions has been implemented and tested. Specific post-processing utilities have been implemented to characterize the morphology of the void space and to compute rock properties, such as porosity and absolute permeability.



(a) (b)

Figure 1: Examples of image-based mesh generation in a rock sample (a) and of a simulation at the pore-scale (b).

References

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