Contribution ID: **330**   Type: **Poster Presentation**

Spatial microporosity mapping in meso-scale rock samples by X-Ray Computed Tomography

Thursday, 25 May 2023 10:45 (1h 30m)

Porosity is one of the main petrophysical inputs to any reservoir modelling technique, because it affects both the transport and storage properties of the rock. At the laboratory scale, digital rock models can be used to investigate the inner structure of the rock by applying non-invasive X-ray tomographic microscopy. In its most basic application, this approach enables identifying solid material (grains) and void space (pores) from the acquired images. The main limitation of the approach is given by the achievable spatial resolution of the images (voxel size). In the digital rock domain, microporosity is defined as the pore space that is below image resolution –typically established at 1 micron. In carbonate rocks, the fraction of unresolved porosity can be quite large (up to 40%)[1], introducing large uncertainties for the modelling of transport and storage processes.

Here, we propose an image-based experimental workflow to map microporosity in rock cores that uses two distinct X-ray Computed Tomography instruments. For this study, we consider two rock samples, namely Bentheimer sandstone, a homogeneous sedimentary rock with uniform high porosity and essentially no microporosity (Diameter = 1.2 cm, Length = 4.6 cm), and Ketton Limestone, an oolitic carbonate with porosity comprising of intergranular macroporosity and intragranular microporosity (Diameter = 1.2 cm, Length = 3.6 cm). The two instruments used are a benchtop microCT scanner (Bruker skyscan 1273) and a medical-grade CT scanner (TOSHIBA Aquilon 64 TSX-101A clinical X-ray CT) to provide 3D imagery of the same, registered rock sample at (8x8x8) µm3 and (27x27x500) µm3, respectively. The latter defines the maximum resolution at which the proposed workflow can be applied. To this end, a map of the total porosity of the sample (including microporosity) is obtained from differential images by combining dry and water-saturated scans of the rock sample obtained using the medical-grade instrument[2]. This 3D map is then combined with the 3D map of resolved porosity obtained upon segmenting the dry image of the rock sample obtained using the microCT instrument to yield a 3D map of unresolved porosity[3].

Key to the application of the proposed method is the quantification of uncertainties arising from image noise and image analysis (e.g. re-sampling, segmentation) in each step of the workflow. We quantify image noise as a function of voxel size and compute its spatial autocorrelation to identify the minimum voxel size for quantitative analysis. We show that for a medical-grade instrument this can be substantially larger (5-10 times) than the voxel size of the original image. A similar conclusion is drawn for images acquired using the microCT instrument, although in this case a systematic drift of grey-scale values is observed that must be corrected for. We compare results obtained upon application of the full workflow to two rock samples and show that reliable mapping of unresolved porosity (microporosity) must account for these uncertainties. Furthermore, we discuss procedures to minimize uncertainties in the estimated porosity maps (resolved and unresolved) at different spatial resolutions.

Participation

In-Person

References

1. De Boever, Eva, et al. "Multiscale approach to (micro) porosity quantification in continental spring carbonate facies: Case study from the Cakmak quarry (Denizli, Turkey)." Geochemistry, Geophysics, Geosystems 17.7 (2016): 2922-2939.

2. Akin, Serhat, and A. R. Kovscek. "Computed tomography in petroleum engineering research." Geological Society, London, Special Publications 215.1 (2003): 23-38.

3. Iassonov, Pavel, Thomas Gebrenegus, and Markus Tuller. "Segmentation of X-ray computed tomography images of porous materials: A crucial step for characterization and quantitative analysis of pore structures." Water resources research 45.9 (2009).

MDPI Energies Student Poster Award

Yes, I would like to submit this presentation into the student poster award.

Country

United Kingdom

Acceptance of the Terms & Conditions

Click here to agree

Energy Transition Focused Abstracts

Primary authors: Mr ROA P., Juan C.; PINI, Ronny (Imperial College London)

Presenter: Mr ROA P., Juan C.

Session Classification: Poster

Track Classification: (MS10) Advances in imaging porous media: techniques, software and case studies