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Characterizing porous media using experiments and image analysis via maximal inscribed spheres maps

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In this presentation, we explore applications of the maximal inscribed sphere (MIS) map to characterize porous media and show connections with other laboratory measurements. Three-dimensional maps can be computed from x-ray micro-tomography images of porous rocks and have been commonly used to simulate mercury injection capillary pressure (MICP) curves. We present additional applications of MIS maps to porous media characterization, that can be particularly useful in cases of heterogeneous multiscale pore systems.
A frequency distribution of the 3D MIS map can be used also as a definition of pore-size distribution, herein PSD-MIS. We discuss how drainage and imbibition hysteresis curves relate to the PSD-MIS curves. We also show a relationship between NMR and PSD-MIS; by tracking the actual location of the diffusing particles in NMR simulations, we found a clear correspondence between the T2 relaxation times classification and the PSD-MIS classification.
A relationship between 2D MIS-PSD and 3D MIS-PSD is presented, which enables the use of 2D images to estimate 3D MIS-PSD, allowing us, for instance, to take advantage of current SEM imaging technology that produces high resolution very large BSEM stitched images, and combine multiple scales of images to extend the size range from Nano scale to millimeter scale in the computed PSD-MIS. We show how the MIS tool complements MICP lab data for sizes above 100 microns, and gas adsorption lab data for sizes above 300 nanometers.
Finally, we introduce an adjustable 2D particle-particle separation method based on MIS. We apply this method to estimate grain size distributions that are compared with similar results from laser particle analysis. Another application addresses the estimation of MICP curves from 2D images.
Based on the diversity of applications of MIS maps presented here, we conclude by discussing generalized MIS-based models as alternative multiscale approaches for porous media characterization.

References

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