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Non-Newtonian fluids based method for characterizing the pore structure of spherical glass bead particles

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Transport processes and mechanical properties of porous media are extensively related to microscopic features of the pore structure, and especially to the pore size distribution (PSD). Unlike with other soil characteristics, e.g., porosity and specific surface area, for which there is a consensus over the estimation approach, the available methods for estimating PSDs are often costly and instrumentally demanding while having specific limitations in terms of applicability or, e.g. the laboratory sample preparation [1].

With micro-computed tomography (μCT) limitations in terms of spatial resolution and cost, toxic mercury intrusion porosimetry is nowadays the prevailing technique to determine PSDs of most porous media. Recently, using non-Newtonian fluids for obtaining the PSD of porous media has been identified as a promising safe, and cheap alternative method to MIP and micro-CT. Despite water (as a Newtonian fluid), the flow of some non-Newtonian fluids through porous media is related to the geometry of the pores in a way that allows backtracking of some information, particularly the approximate distribution of the effective pore sizes. This can be (and has been) done in various ways, cf. The yield stress fluid porosimetry method (YSM) [2], extracts the PSD of a given material from the pressure drop vs. flow rate measurements during injection of a yield stress fluid, or more recently the model presented by Abou Najm and Atallah (ANA model) [3], derives the effective pore size distributions of the porous sample based on a set of saturated flow experiments with different shear-thinning fluids.

This project will be based on both laboratory experiments and computational modeling, with an emphasis on the link between the experiments and the modeling.

In the experimental part, we will apply the ANA method to synthetic porous media systems to assess the model's ability to characterize the pore structure, both in terms of producing accurate pore radii and in providing more information than would be available from traditional, single-fluid based approaches [4]. A series of one-dimensional column experiments will be conducted with varying porous medium packings consisting of spherical glass bead particles in mono-sized and binary mixtures. For each packing, distilled water and varying concentrations of xanthan gum will be injected over a range of flow rates and pressure gradients.

In the numerical part, the discrete element method (DEM) will be used to generate random packings of monosizes and binary mixtures of spheres in cylindrical columns. Subsequently, having the simulated configuration of grains in each packing, the pore network (pore body and pore throat) will be extracted using different image analysis algorithms, and computational fluid dynamics (CFD) approaches [5].

We are particularly interested in how the extracted pore networks from some available image processing techniques will be represented by the effective PSD obtained by the ANA method to compare their performance on a selection of synthetic images of packs of spherical glass beads.

Participation

In-Person

References

[1] Houston, A.N., Otten, W., Falconer, R., Monga, O., Baveye, P.C., & Hapca, S. (2017). Quantification of the pore size distribution of soils: Assessment of existing software using tomographic and synthetic 3D images. Geoderma, 299, 73-82.
[2] de Castro, A. R., Omari, A., Ahmadi-Sénichault, A. et al. (2014). Toward a New Method of Porosimetry: Principles and Experiments. Transp Porous Med 101, 349–364.
[3] Abou Najm, M. R., & Atallah, N. M. (2016). Non-Newtonian fluids in action: Revisiting hydraulic conductivity and pore size distribution of porous media. Vadose Zone Journal, 15(9).
[4] Hauswirth, S. C., Abou Najm, M. R., & Miller, C. T. (2019). Characterization of the pore structure of porous media using non-Newtonian fluids. Water Resources Research, 55(8), 7182-7195.
[5] de Castro, A. R., Agnaou, M., Ahmadi-Sénichault, A., & Omari, A. (2020). Numerical porosimetry: Evaluation and comparison of yield stress fluids method, mercury intrusion porosimetry and pore network modeling approaches. Computers & Chemical Engineering, 133, 106662.

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