Contribution ID: **932** Type: **Poster Presentation**

Comparisons between a dual-pore-network model and a hybrid pore-network-continuum model for predicting permeability and formation factor of multiscale carbonate digital rocks

Tuesday, 14 May 2024 09:25 (1h 30m)

Many underground rocks have been found to possess complex multiscale porous structures with bimodal/multimodal pore size distributions, such as carbonate rocks, tight sandstones, and shales (Bultreys et al., 2016; Shan Wang et al., 2022; Nijat Hakimov et al., 2022). Flow and transport in these rocks play an important role in many subsurface applications. In addition to in-situ core experiments, several pore-scale numerical models have been developed to simulate flow and transport in multiscale porous structures, including dual-pore-network, micro-continuum and pore-network-continuum models (Francisco J. Carrillo et al., 2020; Zhang et al., 2021; Tom Bultreys et al., 2015). Compared to micro-continuum and pore-network-continuum models, a dual-pore-network model is computationally efficient and can be used to the full core analysis. However, the effect of smearing heterogeneity of microporous domains (i.e., sub-resolution domains) on numerical predictions needs to be studied.

In this work, absolute permeability and formation factor of Estaillades carbonate rocks are modelled by both a dual-pore-network model and a hybrid pore-network-continuum model. We show the key difference between the dual-pore-network model and pore-network-continuum model for treating microporous domains. By comparing numerical predictions of the two models, the influence of microporous heterogeneity on seepage characteristics of carbonate rocks is extensively explored. Moreover, the dual-pore-network model is used to study the influence of image resolution on the prediction of permeability and formation factor. As reducing the resolution of the original image, it is observed that more and more resolved pores are identified as microporosity, while the modelled permeability decreases.

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Session Classification: Poster

Track Classification: (MS09) Pore-scale modelling