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Multiscale Integration of Discrete Fracture Network and Pore Network Modes Focused on the Pore-Fracture Interface

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The characterisation and quantification of fractures are essential for the analysis of naturally or artificially fractured porous media. Moreover, fractures and faults can dominate flow across scales, from the reservoir to the core scale. Fractures often dominate flow at a larger scale, whilst, at the micro-scale, pore and micropore physics are highly important, and the fractures can act as a cross-scale link. The current study uses micro-CT images as the input for the flow analysis of fractured geological media, emphasising naturally fractured carbonates.

The method selected for this analysis is pore network modelling (PNM). This simulation approach idealises the porous medium as a network of elements (traditionally only focused on pores) connected by throats, significantly improving the cross-scale analysis capability and computational efficiency. Additionally, fractures have been modelled via discrete fracture networks (DFN) that can integrate multiple resolution scales. However, it is only recently that research has begun on integrating fracture and pore networks of data extracted from micro-CT scans, with fractures modelled with their characteristic flow physics (for instance, modelling the intra-fracture flow as a Couette rather than Poiseulle problem, as is typical for pore throats).

The current work integrates the discrete fracture network (DFN) and pore network, maintaining the size characteristic of each fracture element from DFN, hence maintaining improved interpretability, robustness and efficiency. The known issue of the intra-fracture impedance is solved by introducing a novel empirical relationship that accounts for the relative differences between the connection and position of every fracture-adjacent throat. Artificial neural networks and stochastically fitted parameterization solutions are considered and compared. The data for training, validation and testing is obtained by analyzing varied real and semi-synthetic micro-CT cases, using the direct simulation (via the finite element method algorithm implemented in the OpenFOAM code) and using the results as ground truth.

This analysis result improves the prediction accuracy and efficiency of network models when tackling fractured porous media and cross-scale analysis, particularly improving the flow boundaries between fractures and pores and harmonising with previous research concerning pore-to-pore flow and fracture network flow.

Participation

In-Person

References

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