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Hybrid Modelling of Fractured Reservoirs Using the Effective Medium Theory

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Naturally Fractured Reservoirs (NFR) are usually multiscale in nature and exhibit power law length distributions which do not possess any characteristic length scale, rendering the use of continuum methods such as the dual porosity model invalid due to the non-existence of Representative Elementary Volumes (REV) (Berkowitz, 2002). This necessitates the adoption of hybrid models that represent a subset of the fractures as continua and the remainder as discrete fractures. However, the appropriate partitioning of fractures into these two subsets is an unresolved issue.

In this regard, we propose a workflow which utilizes the Effective Medium Theory (EMT) by Sævik et al. (2013) as both an upscaling tool and a partitioning guide for single porosity hybrid modelling. EMT is used to find the largest non-percolating subset of small fractures which will be upscaled into a single porosity background. The remaining fractures will be represented explicitly through the Embedded Discrete Fracture Matrix (EDFM) method (Lee et al., 2001). This workflow allows reservoir engineers to systematically design appropriate partitioning strategies for hybrid modelling within a matter of seconds without the need for trial and error.

The workflow is benchmarked via a two-part study. Part one validates the accuracy of EMT for fracture subset upscaling by comparing results generated from EMT against numerical upscaling via EDFM. The benchmark shows that EMT efficiently produces accurate fracture subset permeabilities and percolation thresholds. Part two compares simulation results generated from different partitioning choices. Single porosity hybrid models are generated using a sequence of upscaling sizes and then subjected to pressure drawdown. Pressure distributions and flowrates are then compared. The results show that hybrid models are accurate, in comparison to the fully resolved model, provided that the upscaling size is below the aforementioned percolation threshold. Altogether, these results show that the workflow is an effective approach to systematic hybrid modelling.

References

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