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An Uncertainty Quantification Workflow for Naturally Fractured Reservoirs using Proxy Modelling based on Poro-mechanically Informed Flow Diagnostics Simulations

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Carrying out uncertainty quantification and robust optimisation workflows for naturally fractured reservoirs (NFR) is very challenging because exploring and capturing the full range of geological and mechanical uncertainties requires a large number of numerical simulations and hence computationally intensive. Specifically, the integration of poro-mechanical effects in full-field reservoir simulation studies is still limited, mainly because of high computational cost. As a result, poro-mechanical effects are often ignored in uncertainty quantification and optimisation workflows, which may result in inadequate reservoir performance forecasts. Computationally efficient poro-mechanical screening methods are therefore important to identify if poro-mechanics could impact reservoir dynamics and identify individual models from a model ensemble for more detailed full-physics reservoir simulations.

Here we introduce a new methodology that extends traditional uncertainty quantification workflows, through the use of poro-mechanical informed flow diagnostics and proxy models. This approach provides first-order approximations of the complex interactions between poro-mechanics and hydrodynamics using existing steady-state dual-porosity flow diagnostics and coupled dual-continuum poro-mechanics. The calculations are computationally efficient and allow us to quickly quantify their impact of poro-mechanics on reservoir dynamics and further enable us to select representative reservoir models that capture the uncertainty quantified in a reservoir model ensemble. These representative models can then be used in further, more detailed and computationally intensive full-physics coupled reservoir simulations. The proposed poro-mechanical screening hence provides an efficient complement to traditional reservoir simulation and uncertainty quantification workflows and enable us to assess a broader range of geological, petrophysical and mechanical uncertainties.

Using a series of case studies based on a fractured carbonate reservoir analogue, we demonstrate how (1) uncertainty quantification workflows can be improved by considereing different hydrodynamical-poro-mechanical scenarios, (2) how bias in the uncertainty estimation can be reduced by carrying out by thousands Monte Carlo realisations using ANN-based proxy models, and (3) how cluster analysis can be performed to identify a suitable set of representative models from a much larger model ensemle without reducing uncertainty in reservoir performance preiductions. The proposed framework has been implemented using the open-source MATLAB Reservoir Simulation Toolbox MRST and was linked to a commercial reservoir simulation package to carry out the experimental design, construct the proxy model, and perform the sensitivity and uncertainty analysis.

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References

Time Block Preference

Time Block B (14:00-17:00 CET)

Participation

Unsure

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