Effective Fracture Network Permeability: Comparative Study of Calculation Methods

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Abstract

Description of the material

Reservoir performance evaluation of naturally fractured reservoirs (NFR) strongly depend on suitability and reliability of flow simulation models. Discrete fracture systems are generally represented as equivalent continuous media coexisting with a porous matrix, and interacting with it. Such models require that effective or equivalent flow properties be calculated over a flow simulation grid (block or inter-block properties). These include fracture system permeability tensor, and recovery-dependent fracture-matrix flow exchange parameters, all necessary input data for flow simulation. They are attached to an observation scale, and are functions of individual fracture-set properties (fracture densities, orientations, lengths and conductivities). This paper focuses on the calculation of effective fracture systems permeability tensors, evaluated locally at a particular observation scale, for full-field simulations. Three different methods are presented and compared, according to their performances, including algorithm efficiency, and their capability of evaluating within mechanical-unit permeability tensors and vertical inter-unit permeabilities. The former relate to the lateral continuity of fracture systems. The latter strongly depend on the persistence of fractures.

Application

The methods are compared on benchmark cases for various NFR complexities, in terms of static and dynamic impacts.

Results, Observations, and Conclusions

The evaluated methods are the analytical ODA method, flow-simulation based methods on 3D discrete fracture networks (DFN), and innovative methods we developed for fast calculation of within-layer permeability tensors and inter-layer permeabilities. It is demonstrated that analytical methods may suffer from simplified or subjective assumptions, and that numerical methods applying to 3D DFN are flow condition dependent, heavily time consuming, and difficult to manage. Our proposed method might be a convenient compromise.

Significance of Subject Matter.

Besides the comparison of methods, this work aims to validate and identify techniques that are relevant and can be used efficiently (fast and well controlled) for conditioning NFR models to dynamic and production data.