Comparison of Different Numerical Approaches and Grid Geometries to Represent Faults in Geomechanical Finite Element Reservoir Models

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Abstract

As exploration and production move to more complex hydrocarbon reservoirs, geomechanical modelling and a robust prediction of stresses and strains in the subsurface gain more relevance. Thereby, faults are an important model constituent as they can strongly influence both the in-situ stress field and the local strain patterns. Different approaches exist how to incorporate faults in numerical-geomechanical reservoir models. However, all of them are faced by a major difficulty: the proper representation of the faults due to their complex geometry and small-scale material heterogeneity regarding the typical size cell size of such reservoir models. Our study utilizes a simple generic fault zone model to compare different numerical approaches commonly used to generate fault representations in finite element geomechanical reservoir models: (1) a basic rectangular grid with fault rock properties mapped as homogenized continuum on elements intersected by the fault. (2) Usage of the same numerical approach but with a curvilinear grid adapted to the fault geometry. (3) A discontinuous grid connected by contact elements as slipping surface. Modelling results show remarkable differences in the calculated stress and strain patterns. Representation of the fault as a stair-step structure in a rectangular grid has the least impact on local stresses and strains, particularly, if the fault zone is described by a single row of elements. In contrast, the continuous curvilinear grid is showing the relatively strongest perturbations. The use of contact elements has an intermediate effect. Finally, we summarize some general recommendations relative to the appropriate approach of representing faults in a numerical-geomechanical reservoir models

depending on the fault geometry, model scale and scope of interest. For example, if the well target is within about 200 m of a fault, a detailed geomechanical model with the specific fault geometry is required. In contrast, for large-scale reservoir models, where local variations around faults are less important, simpler fault modelling approaches, which are less time-consuming to generate, can be used instead.

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