Representation of Faults in Reservoir-Scale Hydromechanical Finite Element Models — A Comparison Based on Grid Geometry, Fault Geometry and Model Resolution

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Abstract

A proper representation of faults is fundamental for hydromechanical reservoir models to get robust qualitative insights into the spatial distribution of stress and strain. Challenges are the representation of the fault in the numerical model regarding its complex geometry and difference in the scale between the hydromechanical property variations within the fault zone and the typical size of such reservoir models. Here, we utilize a simple generic reservoir model containing a reservoir layer displaced by a fault and increase pore-pressure by injection into the reservoir. We address three major difficulties due to consistent incorporation of faults in hydromechanical simulations. (1) Resolution problems due to different element sizes between the typical cell size of the FE reservoir models of tens to hundreds of meters and the fault element size needed to proper reproduce the fault structural geology. (2) The geometry of the FE grid with respect to the fault geometry and (3) fault dip in geomechanical simulations. Different fault descriptions were implemented and compared to the impact on the modelling results, which show remarkable differences in the calculated stress and strain patterns. The main difference between both curvilinear grid and rectangular grid geometries is the location of the stress and strain throughout the fault as well as their peak values. While extended stress and strain peaks is located at the fault edges for the curvilinear grid, the rectangular grid offers a way smoother distribution over the whole fault

body with decreasing strain values at the edges. The grid-resolution has a high impact for very low resolutions, but for higher resolution within the fault zone more elements are only sharpening the peak values of both stress and strain results. Remarkably different results occur for different dipping angles, the typical normal fault dipping of 60° and the often-used simplification as 90° fault surface. The modelling results are used to infer some general recommendations concerning the implementation of faults in hydromechanical reservoir models depending on fault geometry, model scale and scope of interest. The goal is to gain more reliable results regarding faults in reservoir models to improve production, lower cost and reduce risk during petroleum operations.

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