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Stress field perturbations from faults

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Faults are crucial structures in the subsurface with respect to seismic hazards or the exploitation of the subsurface. However, even though it is clear that the released elastic energy changes the stress field, it is not well known at what distance these change leave a significant imprint on the stress tensor components. In particular, it is assumed that stress tensor rotations are a measure of these changes. Furthermore, from a technical point of view, the implementation of faults in geomechanical models is a challenging task. There are several implementation concepts are to mimic faults in geomechanical models. The two main classes are the continuous approach (soft of low plastic elements) and the discontinuous approach (contact surfaces). However, only partial aspects of the complex behaviour of faults or fault zones are represented by these techniques.

Knowing this limitation, we investigate the influence of the implementation concepts, fault properties and numerical resolution on the resulting stress field in the vicinity of a fault. The main focus of the generic models is to investigate, up to which distance from a fault, significant stress changes of the stress tensor components can be observed. In doing so, the respective models undergo a deformation that produces a similar stress state. The resulting stress magnitudes are investigated along a horizontal line at a depth of 660m, parallel to the shortening direction.

The result indicates, that stress magnitude pattern varies significantly close to the modelled fault, depending on the used implementation concept. However, beyond 500 m distance from the fault, the changes in stresses are < 0.5 MPa, regardless of the concept. Even a significant coarser resolution causes comparable stress patterns and magnitudes away from the implemented fault. Similarly, the dip angle, as well as the strike angle, have little effect on the observed distance effect. For stiff rocks having a higher Young's modulus, significant stress changes can also exceed the distance of 1000 m away from the fault.

The results indicate, that faults alone have limited effect on the far-field stress pattern. On the other hand, data of stress magnitudes or the stress tensor orientation close to a fault (< 500 m) are most likely affected by the particular fault geometry and fault characteristics. This is also the case for the vertical stress magnitude.