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The influence of permeability anisotropy on effective stress and fault stability

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Changes in pore fluid pressure can trigger the reactivation of a fault through variations in effective stress. In order to understand the process of reactivation, discerning how pore fluid pressure is distributed, spatially and temporally, within a fault zone is necessary. Imperative to this is an accurate quantification of the permeability – and any anisotropy of permeability – of the rocks that comprise the fault zone

A recent experimental study has provided insight into the distribution of permeability anisotropy surrounding a normal fault in a porous sandstone (Farrell et al. 2014). In the study performed here, we use this data to populate a model of a critically stressed normal fault in order to investigate the impact of permeability anisotropy on fault stability and the potential for reactivation.

A coupled hydrological-mechanical simulator, FLAC3D, is employed to simulate changes in pore fluid pressure in the area surrounding the modelled normal fault. To increase the pore pressure in the model and reduce effective stress along the fault zone, two scenarios are examined; firstly, through regional stress and secondly, through variations in fluid flux to the modelled region.

Systematic variations in the model parameters are performed in order to assess the sensitivity of fault reactivation to the various properties. These parameters include the degree of permeability anisotropy and the fault core and damage zone poroelastic properties and dimensions. All variations are guided by experimental data and field observations.

The results of these models can be used to understand how permeability anisotropy and fluid flow affect fault slip and guide assessment of fault stability. Fault zone permeability can evolve through deformation due to reactivation, and therefore our longer term aim is to understand how permeability anisotropy evolves with fault growth, slip and reactivation.