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Using data from geomechanical modeling for a slip tendency analysis of 3D faults in Germany

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Fault reactivation and associated seismic events are of concern in the context of site selection for a repository for the long-term safe storage of high-level radioactive waste. The stress state acting on a fault is one major factor for the fault reactivation potential. However, the in-situ stress state is often only poorly constrained. Stress data are usually only available for certain areas and even where stress data are available, they usually only describe parts of the full stress tensor and are limited to certain depths.

The use of geomechanical-numerical models allows a spatially-continuous first-order estimate of the stress tensor even for areas with limited stress data. For Germany, a 3D geomechanical-numerical model by Ahlers et al. (2002) provides such an estimate of the stress state throughout the whole country. We use the modeled 3D stress field and resolve the shear and normal stress on 10.000 3D fault geometries provided by geological models of federal states and project regions to estimate the reactivation potential of faults in Germany. As a measure for the fault reactivation potential, we use the effective slip tendency (T_S), i.e. the ratio between the maximum resolved shear stress and effective normal stress. The results of the T_S analysis can be used to identify areas of comparatively higher or lower fault reactivation potential. One area that shows high T_S values is the Upper Rhine Graben where T_S reaches and exceeds values of 0.6. The lowest overall T_S distribution is found throughout the Molasse basin, where T_S values rarely exceed 0.3. Faults striking in NNE-SSW direction and NW-SE direction show the overall highest T_S values, whereas faults striking in ENE-WSW direction show the overall lowest T_S .

Fault reactivation¹ is considered likely, when T_S exceeds the coefficient of static friction. For most faults, this property is unknown and is often assumed to be 0.6 based on laboratory observations. To better interpret the results of the T_S analysis, further information about the frictional properties of the considered faults is required. Furthermore, hydrostatic pore pressure is assumed for the calculation of the effective stresses as data regarding the pore pressure are not yet available for all areas covered by the T_S analysis. The consideration of local pore pressure variations could further improve the T_S analysis as the pore pressure critically influences T_S . Further local effects such as stress modifications at faults are likely to influence the fault reactivation potential. Such effects can be more accurately captured in prospective smaller-scale models for specific regions and sites. Lastly, 3D fault geometries or high-quality data for their generation are not available all throughout

Germany resulting in areas where no T_S could be calculated. Filling these gaps is a further step towards an improved prediction of the fault reactivation potential throughout Germany.

Ahlers, S., Henk, A., Hergert, T., Reiter, K., Müller, B., Röckel, L., Heidbach, O., Morawietz, S., Scheck-Wenderoth, M., Anikiev, D., 2022. The Crustal stress state of Germany - Results of a 3D geomechanical model v2. <https://doi.org/10.48328/tudatalib-437.5>