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The slip tendency of 3D faults in Germany

Luisa Röckel[1], Steffen Ahlers[2], Sophia Morawietz[3,4], Birgit Müller[1], Tobias Hergert[1], Karsten Reiter[2], Andreas Henk[2], Moritz Ziegler[3], Oliver Heidbach[3,4], and Frank Schilling[1]

[1]Institut für Angewandte Geowissenschaften, KIT, 76131 Karlsruhe, Germany
[2]Institut für Angewandte Geowissenschaften, TU Darmstadt, 64287 Darmstadt, Germany
[3]Helmholtz Zentrum Potsdam, Deutsches GeoForschungsZentrum GFZ, 14473 Potsdam, Germany
[4]Institute of Applied Geosciences, TU Berlin, 10587 Berlin, Germany

Correspondence: Luisa Röckel (luisa.roeckel@kit.edu)

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Abstract. Fault reactivation potential is a crucial aspect for many underground utilizations, such as the construction and long-term safety of a nuclear waste repository, as seismic events can endanger these operations. An estimation of the fault reactivation potential requires information about the stress field, but stress data are only available pointwise and are not evenly distributed throughout Germany. Geomechanical–numerical modeling can be used to derive a spatially continuous description of all six independent components of the stress tensor as shown by the model of Germany by Ahlers et al. (2022). Information about the geometry of faults extending several kilometers in depth is provided for most areas in Germany by the geological models of the federal states and geological models created in the framework of projects such as GeoMol (Assessing subsurface potentials of the Alpine Foreland Basins for sustainable planning and use of natural resources) or GeORG (Geopotenziale des tieferen Untergrundes im Oberrheingraben). We use the 3D fault geometries provided by such models and map the stress data from the Germany model by Ahlers et al. (2022) onto these faults. Then, assuming hydrostatic pore pressure, we calculate the so-called slip tendency (T_S), the ratio between resolved shear stress and the effective normal stress on the fault plane as a measure of fault reactivation potential. A fault is considered critical when its T_S value exceeds its coefficient of friction.

In general, T_S ranges between 0 and 0.7 for the analyzed faults. The highest overall T_S values are observed along the NNE–SSW-striking Upper Rhine Graben, where T_S routinely reaches and exceeds values of 0.7. In the North German Basin, the Ore Mountains and Saxony only very few T_S values exceed 0.7. The area with the lowest overall T_S is the Molasse Basin, where the T_S of the mostly WSW–ENE-striking faults only rarely exceeds values of 0.4. In general, N–S- to NNE–SSW- and NW–SE-striking faults show the highest T_S values, whereas WSW–ENE-striking faults show the overall lowest values. With increasing depth, T_S decreases. Pore pressure and overpressure have the potential to significantly influence the resulting T_S.

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