Seismotectonic regions in Germany and adjacent areas - Concept and results

GEORG-AUGUST-UNIVERSITÄT GÖTTINGEN

Bundesanstalt für Geowissenschaften und Rohstoffe
BGR GEOZENTRUM HANNOVER

Tim Hahn[1], Jonas Kley[1], Diethelm Kaiser[2], Thomas Spies[2], Jörg Schlittenhardt[2], Claudia Geisler[2]

[1] Department of Structural Geology and Geodynamics, Geoscience Centre, Georg-August-Universität Göttingen [2] Unit ‚Engineering Seismology', Federal Institute for Geosciences and Natural Resources, Hannover, Germany

Seismotectonic regions are a basic input in seismic hazard assessment. We have developed a new regionalization based on the definition in the Safety Standard of the Nuclear Safety Standards Commission of Germany KTA 2201.1 (2011-11): "A seismotectonic unit is a region for which uniformity is assumed regarding seismic activity, geological structure and development and, in particular, regarding neotectonic conditions. A seismotectonic unit may also be an earthquake source region."

1. Concept and goals

Our new concept focusses on two aspects of a seismotectonic region that were not considered in detail in previous studies: (1) a transparent implementation of the required criteria of uniform geological structure and development (Fig. 1), and (2) the role of geological history. The new regionalization only considers geological boundaries that can be assumed to continue to mid-crustal depth.

The analysis of geological history focussed on the evolution of major fault systems (outside the Alpine region) over six time slices, from ca. 300 Ma (Permian) to Recent (< 25 Ma).

For each time slice we identified a subset of active faults based on geological evidence for fault activity at that time (Fig. 2). Using fault density and magnitude of fault displacements we assigned classes of deformation intensity to areas and coded them by use of different transparencies T in the maps (Figs. 2, 3) as follows: (a) no deformation (T = 100 %), (b) no known deformation (T = 90 %), (c) moderate deformation (T = 85 %) and (d) strong deformation (T = 70 %). When different time slices are superimposed, areas with repeated strong deformation appear darkest, areas without deformation remain white.

2. Geological overview

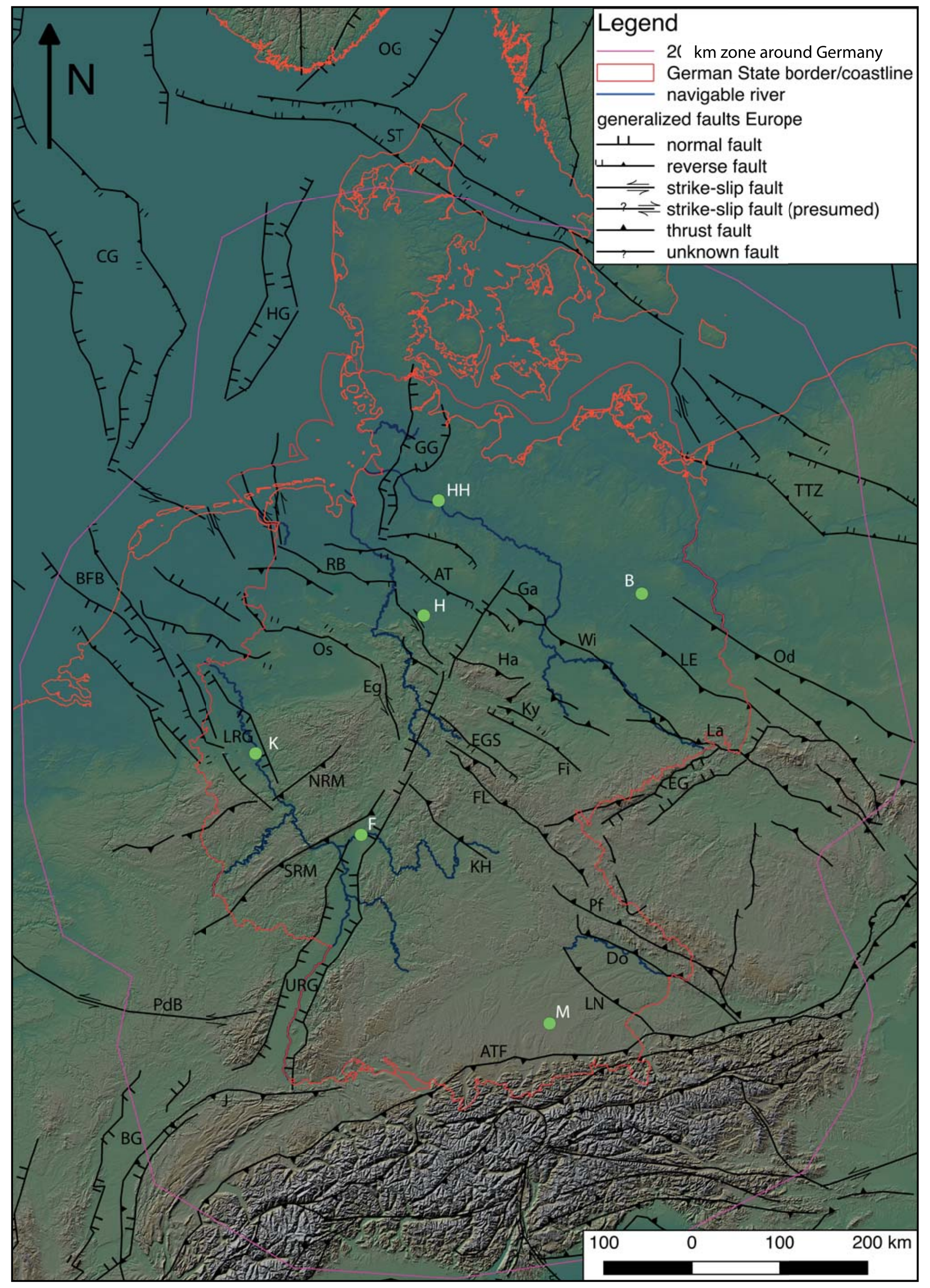

Fig. 1: Overview of the main tectonic structures in the area of interest (modified after Jähne-Klingberg, 2014).

(AT Allertal fault, ATF Alpine Thrust front, BFB Brourd Fourteens Basin, BG Bresse Graben, BGZ Braunschweig-Gifhorn Zone, CG Central Graben, Do Donau fault, Eg Egge System, EG Eger Graben, EGS Eichenberg-Gotha-Saalfeld fault, Fi Finne fault, FL Franconian Line, Ga Gardelegen fault, GG Glückstadt Graben, Ha Harz mountains, HG Horn Graben,J Jura Mountains, KH Kissing-Haßfurt fault, Ky Kyffhäuser fault, La Lausitz thrust fault, LE Lausitz Escarpment, LN Landsberg-Neuötting fault, LRG Lower Rhine Graben, NRM Northern Rhenish Massif, Od Odra fault, OG Oslo Graben, Os Osning thrust, PdB Pays de Bray fault, Pf Bavarian Pfahl, RB Rheder Moor-Blenhorst fault, SRM Southern Rhenish Massif, ST Sorgenfrei-Tornquist Zone, TTZ Tornquist-Teisseyre Zone,Wi Wittenberg fault; B Berlin, F Frankfurt M., H Hanover, HH Hamburg, K Cologne, M Munich)

3. Example time slice 3

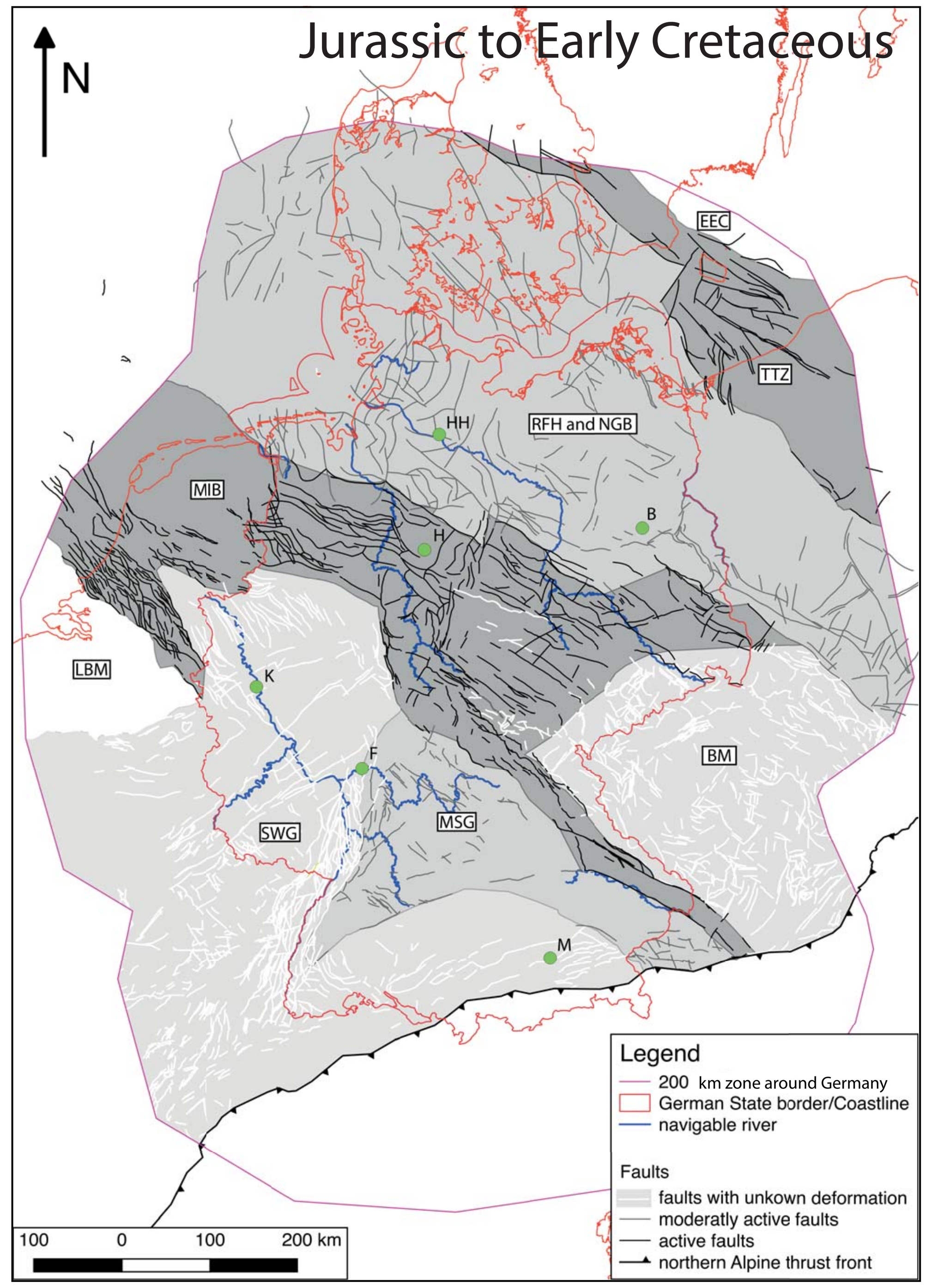

Fig. 2: Time slice Jurassic to Early Cretaceous. Deformation intensities are shown in different greytones. Fault system shown at higher detail than in Fig. 1. Faults are black when active in this period, grey when moderately active (smaller displacement), white when inactive.

4. Geologic deformation and seismicity

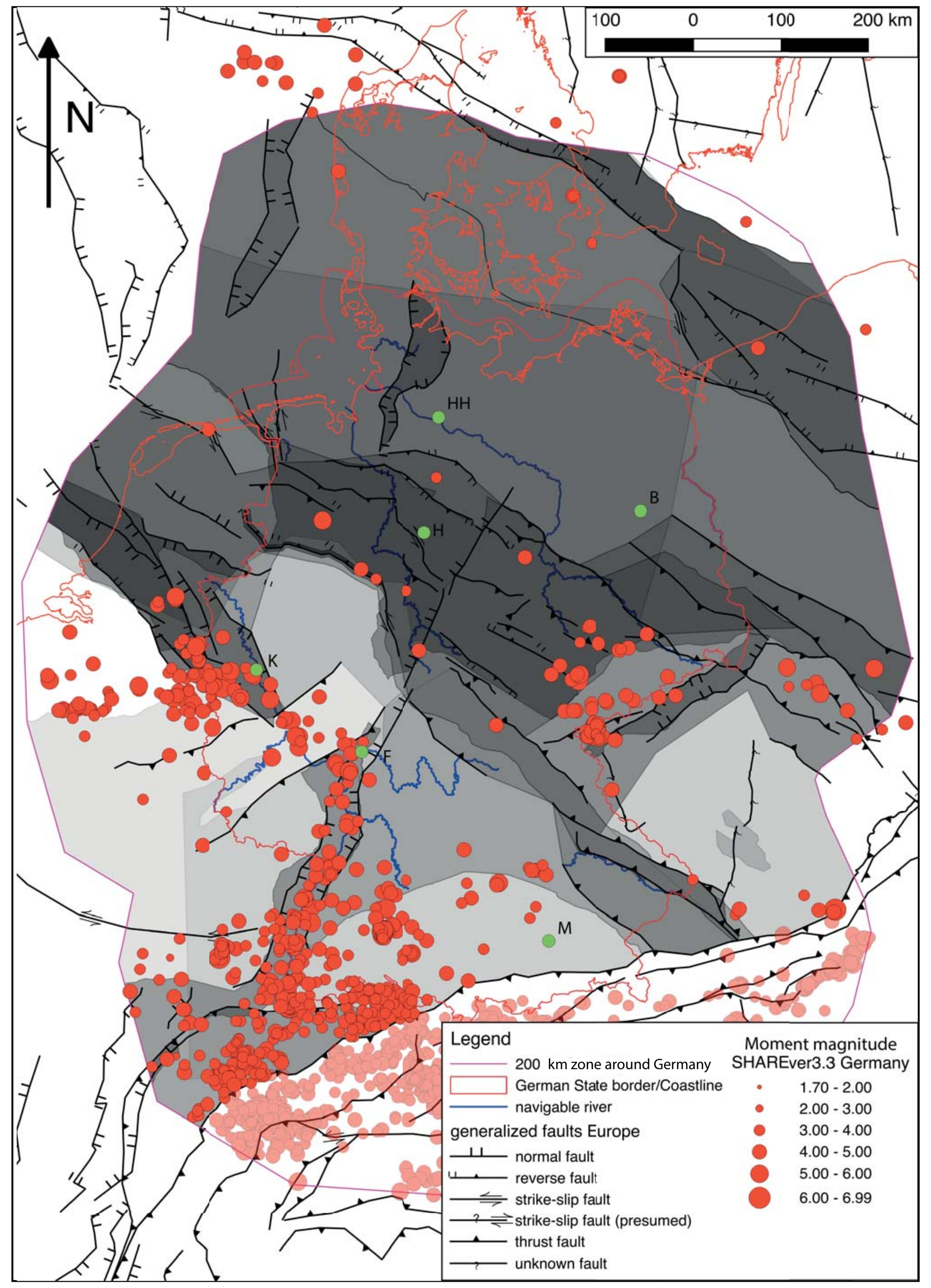

Fig. 3: Superposition of all time slices and seismicity for the period 1000-2006 from SHARE European earthquake catalog (SHAREver3.3). Earthquake activity and regions with strong or repeated past deformation do not always coincide.

5. The new seismotectonic regions

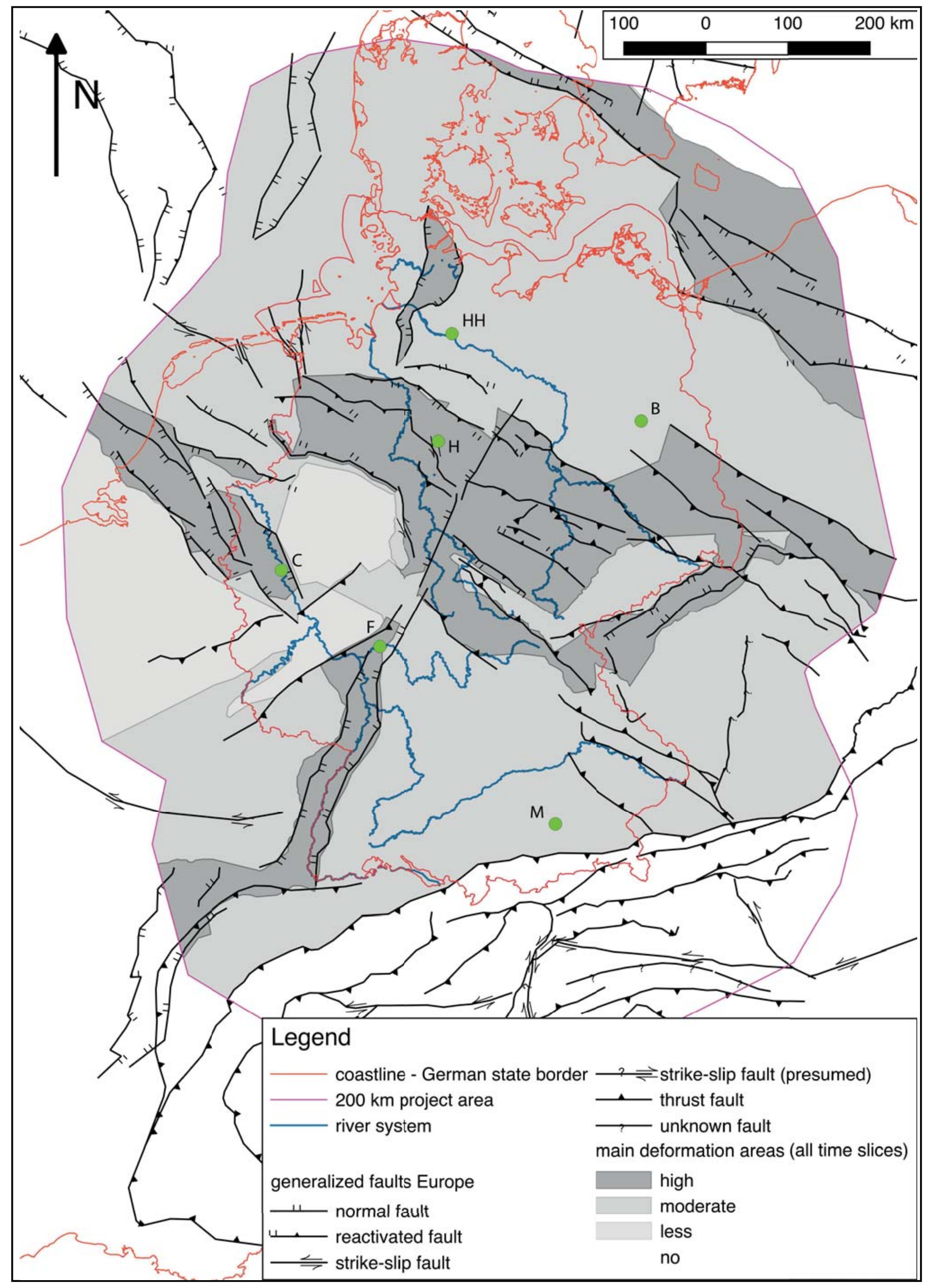

Fig. 4: Seismotectonic regions of Germany and adjacent areas. For better illustration the residual light transmitted through all time slices was classified into high (T=70%), moderate (T=85%), little (T=90%) and no deformation (T=100%).

6. Conclusions and outlook

(1) Areas of Central Europe affected by strong geological deformation in the last 300 Myr are, from north to south: the Tornquist-Teisseyre-Zone, large grabens beneath the North Sea and north Germany (Glückstadt Graben and Horn Graben), the approximately E-W-trending belt of Mesozoic inversion tectonics across the central part of Germany, and the Cenozoic rifts (Upper Rhine Graben, Lower Rhine Embayment, Eger Graben).

(2) Areas of low deformation are the central Bohemian Massif, the Rhenish Massif/Ardenne and the Molasse Basin.

(3) The London-Brabant Massif and East European Craton are almost undeformed.

(4) In the Cenozoic rifts, strong geological deformation coincides with modern and historical seismicity.

(5) North of the Cenozoic rifts, relatively sparse seismicity traces areas of strong Mesozoic deformation (Mesozoic Inversion Belt, Tornquist-Teisseyre-Zone).

(6) Some modern earthquake clusters are located in regions of no or low past deformation (London-Brabant Massif, Albstadt shear zone).

(7) The regionalization based on geological history as shown here (Fig. 4) should be combined with another one based on seismicity. Both might be assessed independently and can be assigned different weights when considering short-term (up to a few 1000 years) or long-term seismic hazard (10^5 to 10^6 years).

References:

Jähne-Klingberg (2014): Geology of Europe. Geologisches Jahrbuch, Reihe B, Heft 103, p. 47-70.

Giardini, D., Woessner, J., Danciu, L., Crowley, H., Cotton, F., Grünthal, G., Pinho, R., Valensise, G., Akkar, S., Arvidsson, R., Basili, R., Cameelbeeck, T., Campos-Costa, A., Douglas, J., Demircioglu, M.B., Erdik, M., Fonseca, J., Glavatovic, B., Lindholm, C., Makropoulos, K., Meletti, C., Musson, R., Pitilakis, K., Sesetyan, K., Stromeyer, D., Stucci, M., Rovida, A., Seismic Hazard Harmonization in Europe (SHARE): Online Data Resource, doi: 10.12686/SED-00000001-SHARE,