Seismotectonic regions in Germany and adjacent areas
- Concept and results -

GEORG-AUGUST-UNIVERSITÄT GÖTTINGEN

BGR

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Seismotectonic regions are a basic input in seismic hazard assessment. We are developing 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 explicitly takes into account the two aspects of a seismotectonic region, which were not considered in detail in the previous studies: (1) a transparent implementation of the required criteria of uniform geological structure and development (Fig. 1), and (2) the role of the geological history. The new regionalization will consider geological boundaries that continue to mid-crustal depth.

The geological history will be tracked by the evolution of major fault systems (without the Alpine region) over six time slices: (1) Permian, (2) Triassic, (3) Jurassic to Early Cretaceous (Fig. 2), (4) Late Cretaceous, (5) Cenozoic (> 25 Ma) and (6) Recent (< 25 Ma).

For each time slice we have delimited areas according to deformation intensity and coded them by use of different transparencies *T* of deformed areas in the maps (Fig. 2 and Fig. 3): (a) without deformation (T = 100 %), (b) with unknown deformation (T = 90 %), (c) with moderate deformation (T = 85 %) and (d) with high deformation (T = 70 %). When different time slices are superimposed, areas with repeated strong deformation appear darkest, areas without deformation remain white.

In a futher step that is still in progress, for each time slice, a subset of active faults will be identified based on geological evidence for fault activity at that time (Fig. 2).

2. Geological overview

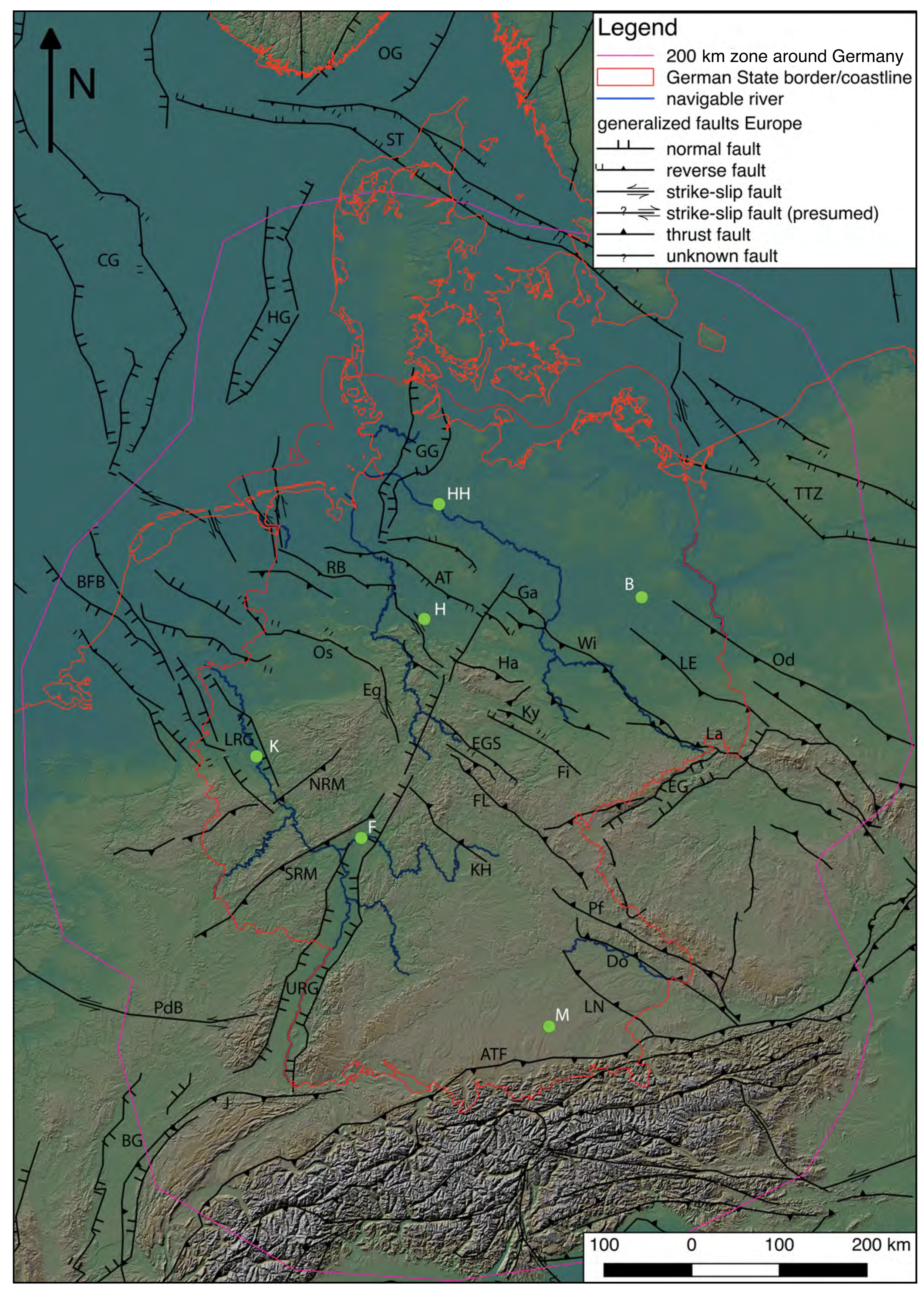

Fig. 1: Overview of the main tectonic structures within the area of interests (modified after Jähne-Klingberg, 2014).

(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 Jurassic to Early Cretaceous

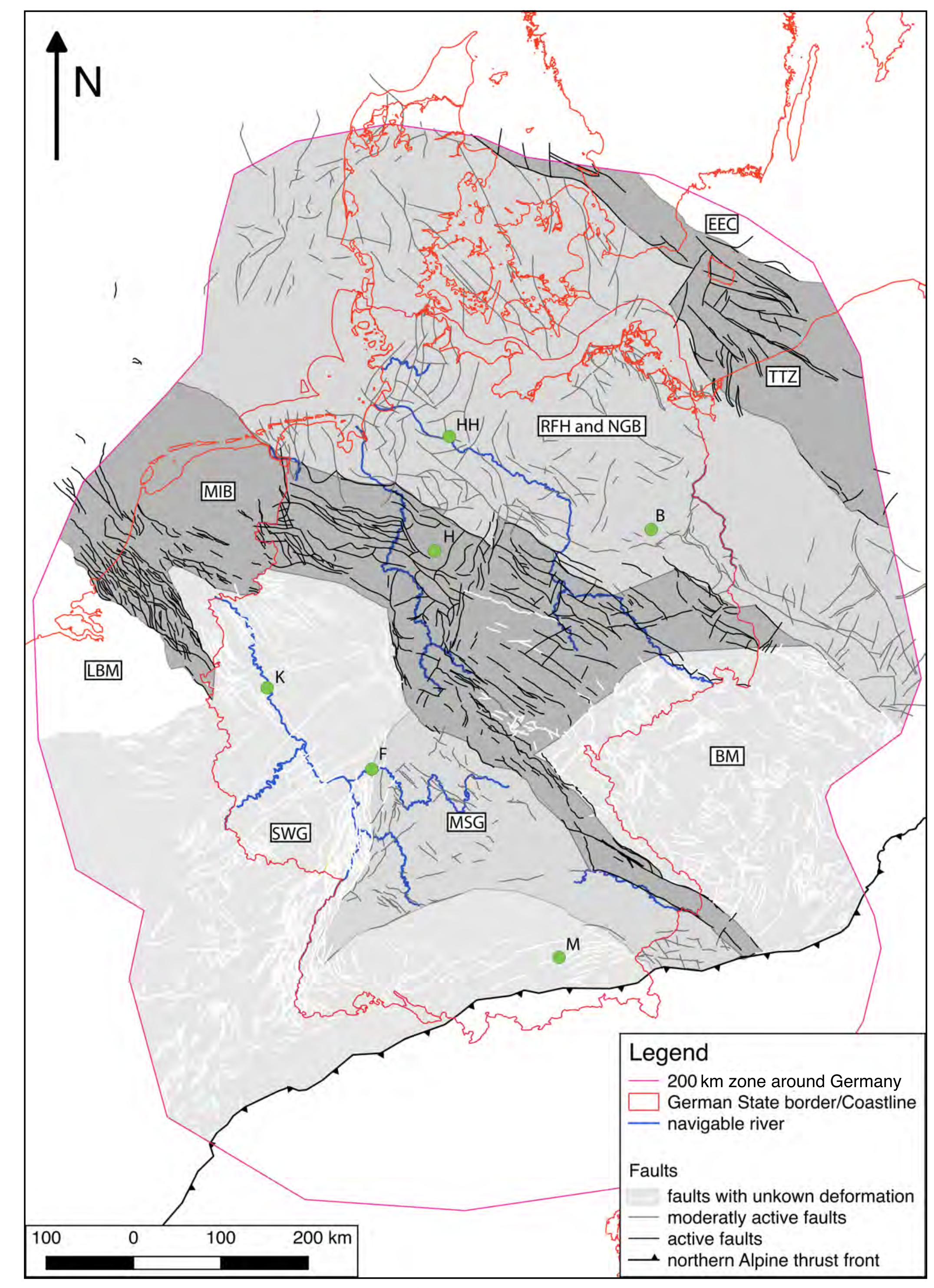

Fig. 2: Time slice Jurassic to Early Cretaceous. The different deformation intensities are shown in different greytones. The more detailed (cf. Fig. 1) extensional/ transtensional fault systems that are active in this period are shown in black, moderately active faults are grey, faults with no or unknown activity are white.

(Compilation of the fault traces: Schulz et al. (2013), Japsen et al. (2003), Cháb et al. (2007), Dadlez et al. (2000), Carte géologique de la France (1968), Géologie - Atlas de Belgique (1950), different tectonic maps of the Dutch Ministry of Econimic Affairs; EEC East European Craton, TTZ Tornquist-Teisseyre Zone, RFH and NGB Ringkøbing-Fyn High and North German Basin, MIB Mesozoic Inversion Belt, LBM - London-Brabant Massif, MSG Mid- and South Germany, SWG Southwest Germany, BM Bohemian Massif, Cities see Fig. 1).

4. Superposition of all time slices and seismicity

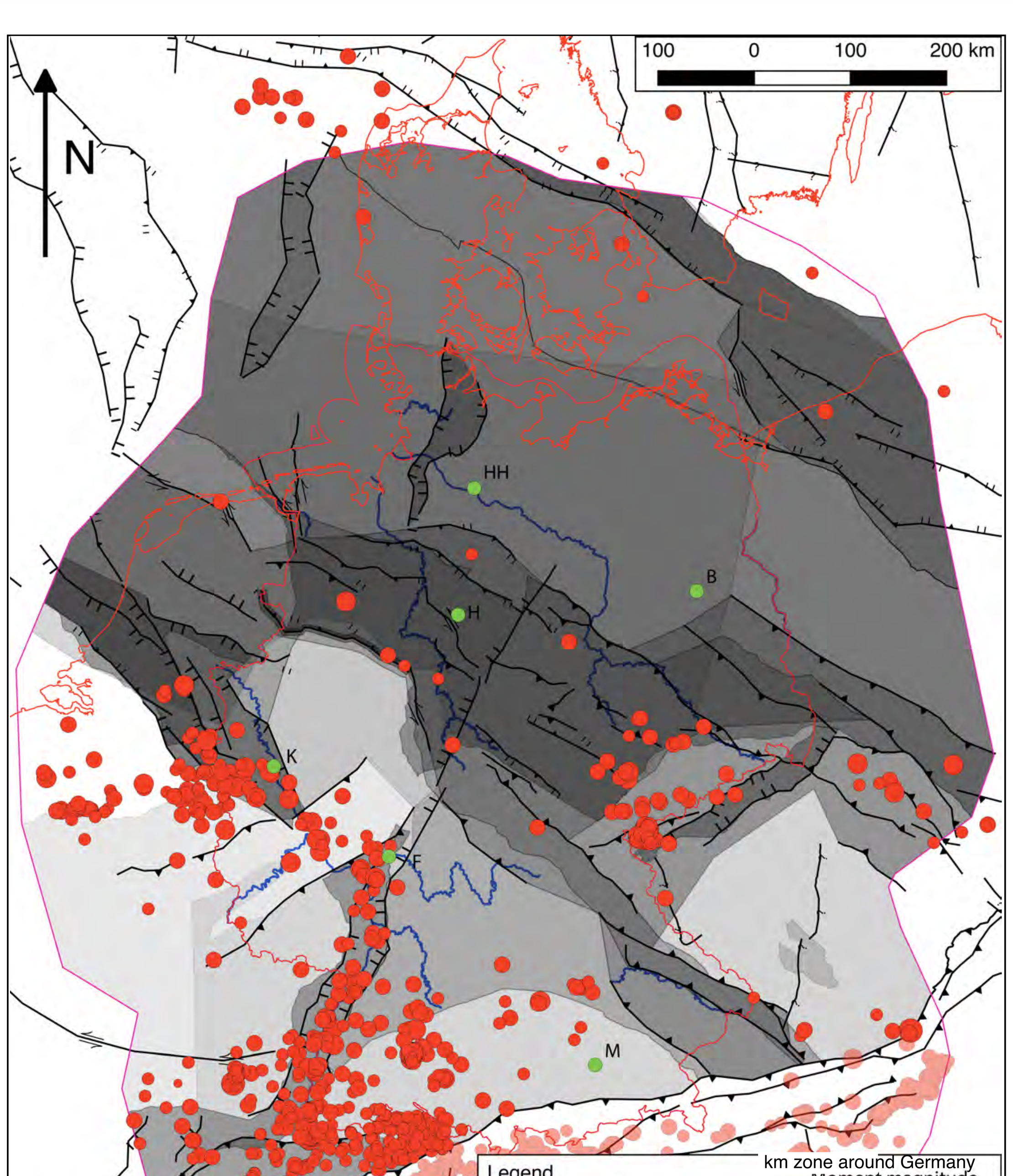

Fig. 3: Superposition of all time slices and seismicity for the period 1000-2006 from SHARE European earthquake catalog (SHAREver3.3). Earthquake activity and regions with strong or repeated past deformation do not always coincide, e.g. London-Brabant Massif (LBM) with no deformation is characterized by high earthquake activity, Tornquist-Teisseyre-Zone (TTZ) with high deformation show only rare single earthquake events (faults and cities as in Fig. 1).

5. Results: The new seismotectonic regions

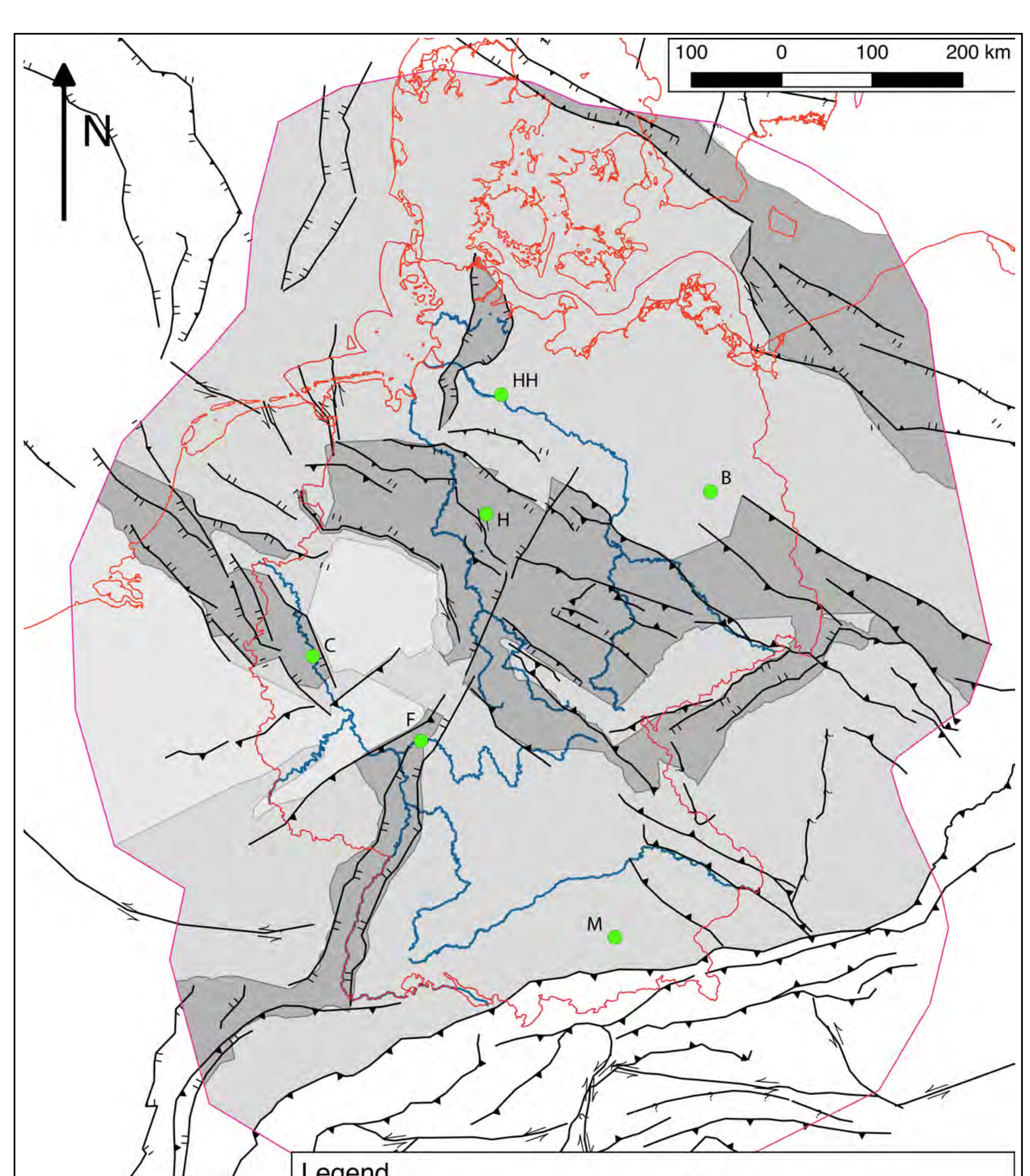

Fig. 4: Seismotectonic regions of Germany and adjacent areas. For better illustration the residual light transmitted through all time slices was classified into high (T=70%), moderate (T=85%), less (T=90%) and no deformation (T=100%). The main areas with high deformation over the time are the URG and LRE, the GG, the EG, the TTZ and wide areas in Mid-Germany. Only the EEC is not deformed (faults and cities as in Fig. 1).

6. Conclusions and Outlook

(1) Areas with strong accumulated deformation during all time slices are: the central part of Germany, the Lower Rhine Embayment, the Glückstadt Graben, the Horn Graben, the Eger Graben and the Tornquist-Teisseyre-Zone.

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

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

(4) In the Cenozoic rift system strong geological deformation coincides with historical earthquakes (Lower Rhine Graben, Upper Rhine Graben, Eger Graben; Fig. 3).

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

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

(7) The final regionalization will ***combine the regionalization based on geological history (Fig. 4)*** as shown here ***with another one based on seismicity***. Both can be modified independently and assigned different weights.

References: Jähne-Klingberg (2014): Geology of Europe. Geologisches Jahrbuch, Reihe B, Heft 103, p.47-70, Cháb et al. (2007): Geological map of the Czech Republic 1:500.000, Dadlez et al. (2000): Mapa geologiczna Polski bez utworów kenozoiku 1:1.000.000, Japsen et al. (2003): Upper Jurassic - Lower Cretaceous of the Danish Central Graben: structural framework and nomenclature. Geological Survey of Denmark and Greenland Bulletin 1, p. 233-246, Schulz et al. (2013): Geothermieatlas zur Darstellung möglicher Nutzungskonkurrenzen zwischen CCS und Tiefer Geothermie. Endbericht, LIAG, Hannover, 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, 2013.
Other geological maps: Carte géologique de la France 1:1.00.000 (1968), Bureau de recherches géologique et miniérs, Géologie - Atlas de Belgique 1: 500.000 (1950) Institut géographique militaire (Belgium), different tectonic maps of the Dutch Ministry of Economic Affairs, The Hague.