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Linking relocated hypocenters with modeled fault planes in NW Germany Part of DGMK Project 773

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Though northern Germany is regarded as a low-seismicity area, the region was affected by 77 earthquakes with magnitudes between 0.5 and 4.3 M_L within the time period of January, 1st 1993 to December, 31st 2016. The aim of DGMK Project 773 is to analyse trigger mechanisms for the recent earthquakes in NW Germany in order to better differentiate between potential anthropogenic and natural tectonic drivers. Possible trigger mechanisms are stress changes related to the extraction of natural gas and/or processes of the ongoing glacial isostatic adjustment. The project consists of three steps. Firstly, seismological analyses were carried out to characterize earthquakes and to derive their source parameters, such as the hypocenter depth and the fault plane solution. In the second step, these source parameters were connected to the regional fault patterns with 3-D subsurface models to identify potential seismogenic faults and to verify their kinematics. In the third step these faults will be tested for their reactivation potential. Results of the first step revealed that the vast majority of the epicenters is located in the vicinity of the gas fields. Their focal depths are in a range of 3.5 to 9 km. Five earthquakes are interpreted as natural events because of their hypocenter depths of more than 13 km and their location far away from gas fields.
For the regions Cloppenburg, Syke, Sulingen/Nienburg, Langwedel/Völkersen, Rotenburg/Söhlingen and Walsrode 3-D subsurface models were constructed based on depth maps and cross-sections from the “Geotektonischer Atlas von Nordwest-Deutschland und dem Deutschen Nordsee-Sektor” (Baldschuhn et al., 2001) for the base Zechstein, the base Lower or Middle Buntsandstein and base Upper Buntsandstein. Digitization and geo-referencing was carried out with the geo-information software AutoCAD Map 3D© and the subsequent geological modeling was performed with GOCAD©.
Each modeled region is dominated by different salt structures and a characteristic fault array. Based on the hypocenter locations in combination with the 3D model, we assume that the earthquakes in the vicinity of active hydrocarbon fields were mostly caused by movements along major Permian rift-related faults, which today are located below the base Zechstein. These faults mainly trend W-E, NW-SE, NNW-SSE and roughly N-S. We were able to identify 24 potential seismogenic faults that are characterized by focal mechanisms, which indicate normal fault movements. Currently, numerical simulations are carried out to test the potential of these faults for a reactivation due to deglaciation related stress changes.

References:

Baldschuhn, R., Binot, F., Fleig, S. and Kockel, F. - Geotektonischer Atlas von Nordwest-Deutschland und dem deutschen Nordsee-Sektor. Geol Jb, A, 153, pp. 3 - 95, (2001).