Macroseismic Re-evaluation of the 2004 Rotenburg ML 4.5 Earthquake

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Abstract

The M_L 4.5 Rotenburg earthquake of 20 October 2004 is the strongest seismic event instrumentally recorded in the intraplate region of northern Germany. Due to its magnitude and location in the vicinity of the Söhlingen natural gas field, the Rotenburg earthquake is a key event for the assessment of the seismicity and seismic hazard of northern Germany. For a reliable assessment of earthquake causes, a well-constrained hypocenter location and reliable focal mechanism is essential. Hypocenter locations published from various institutions and by scientific studies (e.g. Dahm et al., 2007) differ considerably. One main reason is that not all existing data sets have been used in their calculations.

In the framework of the DGMK project 806 we performed a new macroseismic analysis using the complete data set of 1060 questionnaires. It was found necessary to include the macroseismic data into the re-evaluation of the Rotenburg event because the epicenter nearest seismic station is in a distance of about 70 km. It was expected that the high number of macroseismic questionaires in the vicinity of the epicenter can improve the source depth and epicenter estimation.

The macroseismic analysis based only on numerical algorithms. To derive intensities, we followed recommendations of Van Noten et al. (2017), and used an adapted template of the "Did you feel it?"-format (DYFI), which is utilized by the United States Geological Survey and the Royal Observatory of Belgium. The questionnaire formats of the BGR and the University of Hamburg had to be harmonized and answers of selected questions were turned into numerical values that correspond to the numerical classification of the DYFI template. Subsequently, the individual decimal intensities (IDI's) were calculated for each single report by using eight selected questions, which are differently weighted. The calculated and corrected IDI range from 1.0 (not felt) to 6.8. A grid was selected for the area with cell edge length of 3.5 km. An average intensity value was calculated for those cells with a minimum of two IDI's. For the estimation of the macroseismic epicenter, a grid search algorithm was applied to find the cell with the smallest difference between observations and theoretical. A minimum was found for an epicenter in a distance of about 3.5 km SSW to the instrumentally calculated epicenter.

In order to estimate the source depth the parameters I_0 (epicentral intensity), α (absorption coefficient) and h (source depth) of the theoretical intensity distance relation were varied in certain ranges. The least square fit algorithm was applied and a source depth of 8.5 km shows the best correlation with the macroseismic observations. 10 % of the solutions with the best fit were used to estimate the source depth uncertainty.

An asymmetric distribution of the macroseismic observations was observed. The observations lack almost completely south of the Weser-Aller line, in the northwest (Bremervörde) and in the east (Uelzen or Lüneburg). This asymmetry is neither a distortion effect of differences in population density nor an effect of the distribution of daily newspapers and the related news dissemination. The most plausible explanation seems to be amplification effects on ground shaking that relate to less consolidated high Cenozoic sediments north of the Weser-Aller line. In contrast to that, the absence of these sediments in the south of the Weser-Aller line may possibly lead to attenuation effects in distinct frequency bands towards the south, where hardly any observations were reported.