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A Simple Model for Probabilistic Seismic Hazard Analysis of Induced Seismicity Associated With Deep Geothermal Systems

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In the research project MAGS (Microseismic activity of geothermal systems) funded by the German Federal Ministry of Environment (BMU) a simple model was developed to determine seismic hazard as the probability of the exceedance of ground motion of a certain size. Such estimates of the annual frequency of exceedance of prescriptive limits of e.g. seismic intensities or ground motions are needed for the planning and licensing, but likewise for the development and operation of deep geothermal systems.

For the development of the proposed model well established probabilistic seismic hazard analysis (PSHA) methods for the estimation of the hazard for the case of natural seismicity were adapted to the case of induced seismicity. Important differences between induced and natural seismicity had to be considered. These include significantly smaller magnitudes, depths and source to site distances of the seismic events and, hence, different ground motion prediction equations (GMPE) that had to be incorporated to account for the seismic amplitude attenuation with distance as well as differences in the stationarity of the underlying tectonic and induced processes. Appropriate GMPE's in terms of PGV (peak ground velocity) were tested and selected from the literature.

The proposed model and its application to the case of induced seismicity observed during the circulation period (operation phase of the plant) at geothermal sites in Germany will be presented. Using GMPE's for PGV has the advantage to estimate hazard in terms of velocities of ground motion, which can be linked to engineering regulations (e.g. German DIN 4150) which give prescriptive standards for the effects of vibrations on buildings and people. It is thus possible to specify the probability of exceedance of such prescriptive standard values and to decide whether they can be accepted or not.

On the other hand hazard curves for induced and natural seismicity can be compared to study the impact at a site. Preliminary results for a site in Germany (for stiff soil, ignoring site effects) indicate higher frequencies of exceedance for induced seismicity than for natural seismicity only for low PGV values.