Geophysical Research Abstracts
Vol. 13, EGU2011-1817, 2011
EGU General Assembly 2011

Tectonic and Induced Seismicity – the Basel (2006) Case

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Many recent (geothermal) projects where fluids are injected into the ground under high pressure display significant induced seismicity. Shapiro et al. (2009) introduced the Seismogenic Index (SI) to characterize the level of induced seismicity in a given seismotectonic environment specified by the critical stress level, the specific storage coefficient, and the density of faults responding seismically to fluid injection. A high SI causes higher seismicity rates at the same level of fluid injection rate as a smaller one. It appears that regions of higher natural (tectonic) levels of seismicity also display a high SI. This paper explores the relation of natural seismicity driven by slow deformation of the crust with induced seismicity caused by reduction of fault strength by fluid pressure. We utilize the theoretical framework of Seismicity Based Reservoir Characterization (SBRC) as developed by Shapiro (2006), which relies on a randomization of the proximity of individual faults to failure prior to injection controlled by a diffusion equation. The seismicity rate of the induced events depends on the SI and the injection rate. If the tectonic events are described by similar means one finds that the tectonic seismicity rate depends on fault density, stress level and strain rate. For the Basel Geothermal Project (2006) the necessary data are available to relate both types of seismicity quantitatively. This results in the hypotheses that fluid injection under high pressure (a) causes higher induced seismicity in tectonic active areas, and (b) activates significantly more faults than slow tectonic deformation.