Statistical analysis of microseismicity during the stimulations at Soultz-sous-Forêts (France) EGS site

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Monitoring the microseismicity according to the fluid injection is necessary for assessing better the reservoir behavior at Enhanced Geothermal System or other subsurface exploitation. Mechanical modeling is helpful, but it is still difficult to consider all the aspects due to the limits of numerical frameworks and poor knowledge of certain model parameters. We then alternatively aim to analyze the statistically microseismicity to follow the temporal evolution linked to the injection operation. Earthquakes occur due to any loading forces (regional stress accumulation and/or pore pressure increase). On the other hand, once an earthquake occurs, it redistributes the stress in the surrounding and leads to other earthquakes (called 'aftershock'). We need to distinguish them. In seismology, statistical models have been developed and successfully applied in various seismicity in the world, including Epidemic-Type Aftershock Sequence (ETAS) model (e.g. Ogata, Ann. Inst. Statist. Math, 50:379-402, 1998). We apply the ETAS model on the microseismicity for the 1993 and 2000 stimulation experiments at Soultz-sous-Forêts EGS site (Alsace, France). Thousands earthquakes in the published catalogue (Data Center for Deep Geothermal Energy; https://cdgp.u-strasbg.fr/) allow us to analyze the temporal change of the seismicity rate. Among the five model parameters in ETAS model, some parameters are too sensitive to decide reliably, however our analyses show an important launch of the seismicity rate at the beginning and a gradual decrease with time. This is qualitatively consistent with the observations.