# Repeating earthquakes in EGS reservoirs: the case study of Soultz-sous-Forêts, France

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Although aseismic motions are manifest in geothermal reservoirs, their detection and characterisation result to be an arduous task as they often derived from indirect observations. For instance, during the 1993 hydraulic stimulations of the Soultz-sous-Forêts EGS reservoir, France, the slow slip movements have been inferred from borehole geometry monitoring.
During the aforementioned stimulation, a large number of repeating earthquakes have been observed. A family of repeating earthquakes, namely a multiplet, is interpreted as an asperity which operates several times and is generally thought to be driven by the surrounding slow slip movement.

This study aims at improving our knowledge on these repeating fluid-induced seismic events. In particular, we examine the induced seismicity associated with the 1993 stimulation of the Soultz-sous-Forêts, France EGS reservoir, in order to better understand the relationship with the slow slip movements.

We analysed seismic data from borehole accelerometers in proximity of the injection well. More than 15000 seismic events associated with the injection were recorded at depth. We classified these events into families of similar waveforms and limited the multiplets to families of overlapping rupture events. We classified in this manner about 4500 repeating earthquakes into hundreds of multiplets.

Despite similar waveforms and comparable sources dimensions, the multiplet events present a significant variation of the amplitudes of the repeating events on a single asperity (for about 2 orders of magnitude). This is interpreted as a large variation in stress drop and consequently, of the seismic slip. It therefore provides a local measurement of the variation of seismic slip at the scale of the patch. Beside a clear evidence of a link between multiplet activity and injection flow rate, we also observed an increase in event amplitudes over the time of stimulation. We suppose that the associated slip variation is related to the fluid pressure as we observe a large-scale dependence of this amplitude through the stimulation. Furthermore, consistently with observations from other geothermal contexts as Basel, Switzerland, the b-values associated with magnitude distributions computed from multiplet catalogs, decrease with the distance from injection source supporting a hydraulic control on the event amplitude distribution.

Keywords: induced seismicity, geothermal reservoirs, multiplets

 