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Seismological monitoring of the GRT1 (Rittershoffen, Alsace, France) hydraulic stimulation

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The deep geothermal project ECOGI at Rittershoffen, 6 km south-east of Soultz-sous-Forêts, in Northern Alsace was initiated at the end 2012. A first well GRT1 has been drilled up to 2580 m. Water injection has been carried out in June 2013 to enhance the connections between the well and the reservoir by inducing hydro-shearing along the pre-existing fracture network. The operation resulted in significant induced microseismicity that was recorded by a surface seismic network made of a permanent and a temporary surface seismic network composed of 18 surface stations in total (Stations sampling frequency ranging between 100 to 300 Hz). We computed a detection function based on the ratio of the signal averaged over long and short period and reviewed manually all detections to isolate only those corresponding to seismic events with clear arrival times visible at least at 6 stations. With this procedure we identified a total of 682 seismic events. Two periods of activity can be observed: a main swarm of two days (27 and 28 June) during the injection and a second swarm that occurred on 2 July, three days after water injection ended. The first swarm includes 82% of the events in the catalog. Interestingly we also noticed that when the second phase of the injection that took place between 11:00 and 17:00 PM on the 28th of June, no seismic event was observed. The absence of seismicity during this second injection at a lower rate than the preceding one the day before is characteristic of a Kaiser effect. The second noticeable feature of the seismicity is the complete absence of seismic events between the two swarms with no earthquake recorded during the 3 days time interval. We then performed a manual picking on compressive and shear phases (P and S) for all events. Location of seismic events shows that the second swarm is located around 500m away from the first one and relative relocation using the HypoDD software was performed in order to improve the resolution of the earthquake location. Earthquakes relative relocations enhanced the clustering of the seismicity observed previously and confirmed the spatial gap between the two swarms. Local magnitudes for all events of the sequence range between -0.9 and 1.3 and the estimated magnitude of completness is 0.1. We clearly observe larger magnitudes for events of the second swarm.