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Seismic Monitoring at Different Stages of Deep Geothermal Sites in the Upper Rhine Graben

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Summary

The induced seismicity recently observed in Rittershoffen and in Soultz-sous-Forêts highlights the need to perform a seismic monitoring, even during the exploitation phase of power plants, which is now explicitly required by the French mining authorities for getting the exploitation license.

After a long period of research at Soultz-sous-Forêts (France), a complete renovated power plant, with a new ORC unit, has been built. The commissioning of the plant started in 2016 to exploit geothermal brine at 150-160°C with a flowrate of about 30 l/s to produce a gross power of about 1.7 MWe since the beginning of July 2016. In the same area, the geothermal project located at Rittershoffen, 6 km east of Soultz-sous-Forêts, in Northern Alsace, exploits geothermal brine trapped in the fractured hard rocks. This geothermal project is designed to produce 24 MWth (170°C, 70 l/s) which is delivered to a bio-refinery located 15 km away. Two deep wells have been drilled between 2012 and 2014 to 2500 m TVD (True Vertical Depth) for targeting local normal-faults located close to the interface between the clastic Triassic sediments and the top crystalline basement. The second well was good enough hydraulically after drilling operation and thus, it was not necessary to enhance its natural permeability. The geothermal plant commissioning started in May 2016.

In parallel, the Illkirch-Graffenstaden (France) deep geothermal project plans the construction of a power plant located 10 km south from the city of Strasbourg (France) to produce electricity and heat for a district heating with a maximum of expected thermal power of 20 MWth. The project involves the drilling of two wells (doublet) at a depth of 2700 m TVD, to produce a geothermal fluid at a flow rate of 70 l/s and a temperature around 150 °C. The targeted reservoir is a fractured zone in the Buntsandstein sandstones and the top granitic basement. The drilling of the first well is currently ongoing.

In order to detect any rise of micro-seismicity induced by the geothermal operation, the mining authorities required the deployment of a permanent seismic network. At least, five surface stations around each geothermal plant are required. Since 2012 for both Soultz-sous-Forêts and Rittershoffen geothermal plants and since 2015 for Illkirch-Graffenstaden, the micro-seismicity activity has been monitored by a permanent seismic network and by a temporary surface network installed during strategic operations (drilling, development of wells, commissioning of a plant).

Since 2016, an almost continuous production and re-injection loop was performed in both geothermal fields of Rittershoffen and Soultz-sous-Forêts. As low magnitude seismic events are occasionally associated with deep circulations of such projects, the micro-seismic activity has been carefully monitored in real–time since the beginning of the production. Since then, a couple of thousands of induced low magnitude earthquakes were detected (Ml_{max} = 1.7), all located in the vicinity of the injection wells, GRT-1 for Rittershoffen and GPK-4 for Soultz-sous-Forêts. So far, no induced seismicity was detected during the drilling of the first well GIL-1 in Illkirch-Graffenstaden.

The induced seismicity recently observed in Rittershoffen and in Soultz-sous-Forêts highlights the need to perform a seismic monitoring, even during the exploitation phase of power plants, which is now explicitly required by the French mining authorities for getting the exploitation license. In the framework of the DESTRESS European project, an experiment was planned to install seismic sensors in private houses located in villages located around the Soultz-sous-Forêts and the Rittershoffen plants. The goal was to record the ambient noise and to draw a vulnerability model allowing to adapt damage forecasts. In total, 11 houses were monitored, previously selected to have a representative sample of the different type of masonry in the sector. A sensor was also installed for one year in the town hall of the village of Keffenach (Alsace). The sensor will be customized with the specific fragility model of the building (the building has been previously screened). The sensor collects and sends a real-time 3-axis strong-motion data stream. In case of an induced event, the system has been designed to issue a local and remote warning in case the non-structural damage, encoded in the fragility model, is expected to be exceeded. Since the detection methodology is based on P-waves analysis, the warning can be issued even before the arrival of the strongest ground shaking at the sensor location, thus implementing a prototype decentralized early warning system.