
Geothermal induced seismicity: Understanding the 2019 earthquake crises of Strasbourg

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Abstract

Geothermal energy is an alternative renewable and green potential energy source. But it has several drawbacks, the most important of which is the risk of seismicity. Two kinds of seismicity are related to well operations: the induced one and the triggered one.

Alsace is one of the most important regions in Europe in geothermal resources. Geoven was a geothermal plant pilot situated in the commune of Vendenheim at the north of Strasbourg city. It aimed at exploiting the geothermal energy by circulating fluid at depth along the Robertsau fault.

In this site two clusters of earthquake, one of them close to the site and other one at the Robertsau area, 5km south, were observed in 2019. The idea of a physical connection between earthquakes at the Robertsau area and the pumping at the Geoven site has been formed. The large distance between the injection well and the cluster and the fact that no earthquake was observed between them, have caused some polemics between scientists and the company in charge of Geoven.

The main goal is to evaluate a possible link, through a simple methodology based on fluid/solid deformation and mechanical coupling, with numerical modeling.

The methodology follows:

1. Identifying the geometry of the fault by extracting the angles and tectonic stresses along the main faults.
2. Modeling pressure perturbation in the area due to water injection by solving a quasi 2D pressure diffusion equation with the proper injection parameters, permeability, and porosity.
3. Evaluating the stress on the fault and analyzing the risk of earthquake triggering by

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using a Mohr-coulomb failure criterion and activation by fluid pore pressure rise.

We find out that, in the northern cluster, the fault is strong and a large activation pressure is needed for slip to occur. This slip of microcracks in the vicinity of the injection well is required to improve the reservoir. Indeed, the increase in pore pressure in this area close to the well is very high, and micro-earthquakes occur – this sliding is the objective of stimulation. On the other hand, around the southern cluster, the pressure required for sliding drops sharply: the fault is weak at this point. This means that slip occurs even with a small increase in pressure. We show that, at this point, the pore pressure increases enough to trigger earthquakes. But between these two clusters, the fault is resistant due to its orientation, and the increase in pore pressure is not large enough for sliding. For this reason, there is a distance of 5km between the two clusters, without earthquakes.

It can be concluded that the fault geometry corresponds to a weak configuration around the southern cluster. That leads to an activation pressure required for sliding at this point, much lower than in other locations. We show that mechanically, the pressure perturbation resulting from Geoven operation, even if tiny in this distant location, can be enough to trigger earthquakes in that zone.