Karlsruhe Institute of Technology

Ecole et Observatoire des Sciences de la Terre

Title: Long term reservoir behavior from induced seismicity monitoring: the case study of the Rittershoffen deep geothermal site

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Recent advances in earthquake monitoring techniques, in particular for geothermal reservoirs, are exploiting more and more continuous recording of dense and distributed seismic networks. The newly developed EGS site in Rittershoffen, Alsace (France), is a good example where to apply new methodologies for obtaining the long term monitoring of the geomechanical status of the reservoir. Indeed, how seismogenic reservoir structure develops, how persistent are seismic repeaters, how stress evolve with time or how can we a priori evaluate the magnitude of largest induced events are key questions to address.

The PhD project will rely on the continuous waveform database acquired at Rittershoffen by up to 41 seismic stations over two years covering the drilling, the stimulation of the well doublet and the beginning of the circulation.

To optimize the processing of large seismic datasets in an automatic manner, we propose to use the matched filtering technique, as performed by Lengliné et al. (2017) for the hydraulic stimulation of the GRT1 well. This technique outperforms the traditional, automatic, real-time techniques in terms of detection capability and picking consistency, and offers subsequent advantages. We also wish to further develop this matched filtering approach in two directions: the automatic determination of 1) focal mechanisms and 2) magnitudes. These developments must take into account uncertainties by using a Bayesian framework. To assess the matched filtering technique, a comparison with other techniques like fully automatic time based migration to locate and compute focal mechanisms (Grigoli et al, 2014) should be performed.

The application of this method to the Rittershoffen geothermal reservoir over the initial stages of the reservoir life would then allow addressing several general scientific questions such as:

- What are the differences in terms of location, triggering and magnitude over the different stimulation stages and during the circulation? Is there a Kaiser effect? Can we infer the geometry of the fracture network? Is there a normalization of the seismic energy based on the total injected water volume? Can we predict the behavior of the seismicity during the circulation based on the analysis of the stimulation stages?

- Can we track the local pore-pressure based on the stress field knowledge and the inverted focal mechanisms? How does the pore pressure evolve with time, space?
- What controls the magnitude of the induced events? How does the magnitude distribution evolve with time and space? Is the magnitude related to the mechanism, the fault plane orientation and thus possibly the local pore pressure reduction/effective normal stress. Can we have insights on the geomechanical modelling of the largest magnitude event?

The PhD project will be performed within a Co-tutelle framework between Strasbourg University (Labex G-eau-thermie Profonde, EOST) and Karlsruhe Institute of Technology (geothermal chair). The candidate is expected to share his/her time between both institutes. The project (3 years) is funded by Labex G-eau-thermie Profonde (Investissements d'Avenir) and the chair of deep geothermal energy (KIT).

Expected skills of the candidate: seismology, geothermal energy, reservoir engineering, advanced programming, fluent English language.

Submission deadline: June 15, 2017 – Starting date: Sept 1st, 2017.

Candidates have to submit an extended CV and a motivation letter in English to Emmanuel Gaucher (emmanuel.gaucher@kit.edu) and Olivier Lengliné (lengline@unistra.fr).

Bibliography

Grigoli, F., S. Cesca, O. Amoroso, A. Emolo, A. Zollo, and T. Dahm (2014), Automated seismic event location by waveform coherence analysis, *Geophys J Int*, *196*(3), 1742–1753, doi:10.1093/gji/ggt477.

Lengliné, O., M. Boubacar, and J. Schmittbuhl (2017), Seismicity related to the hydraulic stimulation of GRT1, Rittershoffen, France, *Geophysical Journal International*, *208*(3), 1704–1715, doi:10.1093/gji/ggw490.