Preliminary results of the InStRikE project: risk-assessment of induced seismicity in geothermal fields

Levi, Nicola[1]; Diessl, Julia[2]; Bruno, Mike[3]; Nazari, Fatemeh[4]; Roters, Bastian[1]; Young, Jean[3]

1 NiMBUC Geoscience, Degengasse 41/5, A-1160 Vienna, Austria; 2 Pulverturmgasse 17/3, A-1090 Vienna, Austria; 3 GeoMechanics Technologies, East Lemon Avenue 103, Suite 210, Monrovia, CA 91016, USA; 4 Department of Geology, University of Vienna, Josef-Holaubek-Platz 2, A-1090 Vienna, Austria.

In recent years, the transition to more sustainable energy put a lot of attention on geothermal energy, seen as a carbon-free alternative. However, geothermal energy is not completely free of environmental risk and, in some circumstances, proved to be associated with an unacceptable level of induced seismicity, which resulted in the termination of several projects worldwide. This led to a progressive concern on geothermal activities, resulting into intense research on the potential relation of induced seismicity with those activities. Induced seismicity occurs mostly after massive fluid injection during the stimulation phases (when necessary), but it might happen also during regular operations, mainly due to pore pressure and thermal perturbation of the reservoir. However, an assessment of the induced seismicity risk on geothermal plants during the planning phase is still challenging. The Induced Seismicity Risk Estimation (InStRikE) project supported by FFG (Österreichische Forschungsförderungs GmbH) aims to develop a smart planning tool for the assessment of the risk of induced seismicity during geothermal activities. The first part of the project is a systematic collection of various parameters from already existing geothermal projects, retrieved from various publicly available sources (papers, abstracts, published reports, various databases, etc.). The aim is to create a database as much comprehensive as possible. Subsequently, the database will be further integrated with data provided by the geothermal operators, willing to share their experience and information. The various entries in the database will be analyzed by advanced statistical methods, such as multivariate analysis, neural networks, combinatorial optimization. We intend to gain new knowledge to better understand the relationship between geothermal operations, geologic and geomechanical settings, and the risk of induced seismicity. Different risk parameters are analyzed including: geologic characteristics (regional setting, play type, lithology, presence of faults, natural seismicity, geodynamic setting, porosity, permeability, etc.); geomechanical parameters (SHmax orientation, rock properties, initial pore pressure, stress gradients, stress regime, etc.); operational conditions (injection/production pressures, injection/production rates, T of produced vs. reinjected fluids, depth of operation etc.). If available, magnitude and date of the maximum seismic event observed during (or after) the operational period are also collected in the database. The project is currently in an early stage; we are in the midst of populating the database starting with about 150 different geothermal fields worldwide. However, the preliminary analysis already allows a good correlation between some of the collected parameters and induced seismicity. We see that about 30 % of the geothermal fields operate without any seismicity, about 23 % show little seismicity during their operations ($M < 2$), 24 % are associated with moderate seismicity ($2 < M < 4$), whereas the remaining ~13 % experienced intense seismicity ($M > 4$). In the current status, there is no reliable seismicity information on the remaining 10 % of the geothermal fields during operations.