Induced seismicity at the Balmatt geothermal doublet (northern Belgium): Investigate fluid induced seismic triggering mechanisms by means of seismic analysis and geomechanic modelling

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The Flemish Institute for Technological Research (VITO) initiated a geothermal project on the former Balmatt industrial site near Mol (northern Belgium) with the aim to demonstrate the technical, economic and environmental feasibility of developing a deep geothermal plant in the Campine Basin. Drilling commenced in 2015 and operations (production and injection) were started in 2018.
To mitigate associated seismic hazard and risk VITO operates a microseismic monitoring system coupled to a local traffic light system (TLS). Several seismic events with magnitudes -1 < ML < 2.2 have been recorded since December 2018. The strongest event occurred on the 23rd of June 2019 (ML 2.2) which has been felt by the population in the adjacent town of Dessel and triggered a red-light status of the TLS.
Following back analysis studies by Ineris revealed evidence that a classical linear diffusion model and Mohr-Coulomb criteria (direct pressure model) alone cannot fully explain the recorded seismic rates. Indeed, evidence was found documenting the presence of non-linear fluid flow along pre-existing fault zones and seismic triggering related to post-rupture static stress transfer. Beyond that it was emphasized that aseismic slip and seismic triggering from fault creep seems to play a key role at Balmatt.
In the framework of a follow-up research project, VITO has resumed to produce from and inject into the reservoir, accompanied by monitoring of a reinforced seismic network including several borehole sensors close to the injection well. The outcoming data of these tests will provide new detailed insights in the hydrological reservoir characterization and geothermal potential as well as to better understand the (a)seismic response to fluid injection and the implied seismic hazard.

Objective and content of the PhD
As part of the research project, the PhD thesis will focus on the evaluation and quantification of governing trigger mechanisms of seismicity finalized in the construction of a ("conceptional") hydromechanical reservoir model.

The thesis work will be divided into 2 fields of analysis and involve the following main tasks:

1. Geophysical (seismic) data analysis

• Estimate dimension and orientation of the main seismic active fault using new seismic data and advanced processing techniques (source mechanisms, source parameter) and reconstruct fault response history;
• Examine the role of aseismic deformation using analysis on seismic repeaters (multiple analysis and relocation);
• Cross-cut different data sets (e.g. exploitation-production, geological, seismic) to identify and constrain governing physical processes related to rock-fluid interaction and to derive hydro-geomechanic reservoir properties (permeability, conductivity etc.).

2. Geomechanic modelling

• Build and calibrate a conceptual thermo-hydro-mechanical reservoir model based on relevant observations and data identified in 1);
• Quantify the contribution of most determining trigger mechanism (pore-pressure change, aseismic slip, stress-transfer etc.);
• Investigate mechanisms explaining apparent absence of seismicity at the injection well;
• Investigate (distant) triggering at major fault segments (e.g. Retie fault).

The balance of effort of both analyses will strongly depend on the quality and volume of the acquired seismic dataset during the upcoming circulation tests as well as on the background and interests of the candidate

Profile

Master in Geosciences/Geophysics/Physics/Rock mechanics
The candidate should have good knowledge of both seismology and geomechanics, good programming and signal processing skills, as well as a good level of English. He/she will work in Nancy at the Ineris lab with regular and longer mission to Strasbourg (UNISTRA), Belgium (Vito) and possibly other site in Europe.

Supervision
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Ce poste est ouvert aux personnes en situation de handicap

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