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Forecasting Induced Seismicity for the geothermal UDDGP project –An ongoing experiment

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The occurrence of induced earthquakes is a typical phenomenon in the development and exploitation of geothermal reservoirs targeting crystalline basement. Although most induced earthquakes are of low magnitude and can only be detected by sensitive recording instruments, some isolated earthquakes in the magnitude range ML3.5 have occurred in geothermal reservoirs. Due to their shallow depth, earthquakes of this strength can be felt by humans and can even cause slight damage to buildings. Although the physics leading to induced seismicity are well understood, the earthquake process is critically depending on details of the subsurface conditions. Therefore, forecasting the seismicity response to geothermal activities from a 'green-field'perspective is a challenging task.
We have developed a framework for assessing the range of a potential seismicity response given the subsurface information available at a certain time during geothermal project development. The approach rests on a physics based, dynamic earthquake simulator to study timing and magnitude of induced earthquakes assuming different subsurface conditions. As new information becomes available, the range of the potential seismicity response can be narrowed down. Our strategy provides a basis for seismic risk mitigation in two different ways: we can identify (i) which additional information is required to further narrow the range of the seismicity response and (ii) how geothermal activities need to be adjusted to minimize the seismicity response.
We apply the approach to the United Downs Deep Geothermal Project (UDDGP) in Cornwall, which is currently being developed. A first seismicity prognosis was made in the 'green-field'project phase, prior to drilling the first well. A structural, geological model was constructed from mapping at surface and within mines down to 400 m bgl. and from gravity modeling. Geothermal exploration is targeting a sub-vertical fault zone in granitic rock at a depth level between 2.5 km and 4.5 km. Width, geometry and hydraulic parameters of the fault zone were not well constrained at that time. The initial model, however, indicated that stress strength conditions on the target fault are near-critical with stress criticality increasing with depth. Numerical simulations indicated that seismicity induced during the initial development stage could be up to M3.5.
Subsequent to the initial seismicity prognosis, two geothermal wells were drilled to depth levels between 5 km and 2.5 km, respectively. Induced seismicity observed during drilling the deeper well are consistent with prognosed conditions such as the near-critical state of stress and that the flow is constrained to individual faults.
We are currently performing a parameter sensitivity study to investigate to what extend a pressure limit (rate reduction) impacts the maximum magnitude.

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