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Hydro-mechanical modelling of induced seismicity during the deep geothermal project in St. Gallen, Switzerland

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The St. Gallen deep geothermal project in 2013 was the second geothermal project in Switzerland with the objective of power production after the Enhanced Geothermal System in Basel in 2006. In St. Gallen, the seismic risk was expected to be smaller than in Basel, since the hydrothermal resource was an aquifer at a depth of about 4 km, not expected to require permeability enhancement and associated hydroshearing of the rock. However, after an injectivity test and two acid stimulations, unexpected gas release from an unidentified source forced the operators to inject drilling mud into the well to fight the gas kick. Subsequently, several seismic events were induced, the largest one having a local magnitude of 3.5, which was distinctly felt by the nearby living population. Even though the induced seismicity could not be handled properly, the community still strongly supported the geothermal project. The project was however halted because the target formation was not as permeable as required to deliver sufficient power. Still, controlling induced seismicity during deep geothermal projects is a key factor to successfully operate future geothermal projects. Hence, it is crucial to understand the physical relations of fluid injection, pressure and stress response at reservoir depth as well as associated induced seismicity. To date, these processes are yet not fully understood.
In this study, we aim at developing a hydro-mechanical model reproducing the main features of the induced seismic sequence at the St. Gallen geothermal site. Here, we present the conceptual model and preliminary results accounting for hydraulic and mechanical parameters from the geothermal well, geological information from a seismic survey conducted in the St. Gallen region, and actual fluid injection rates from the injectivity tests. In a future step, we are going to use this model to simulate the physical interaction of injected fluid, gas release, hydraulic response of the rock, and induced seismicity during the St. Gallen project. The results will then allow us to more accurately estimate the seismic hazard for future geothermal projects.