Multi-phase hydromechanical modeling of induced seismicity: general insights and the case study of the deep geothermal project in St. Gallen, Switzerland

Dominik Zbinden, Antonio Pio Rinaldi, Tobias Diehl, and Stefan Wiemer
Swiss Seismological Service, ETH Zürich, Zürich, Switzerland (dominik.zbinden@sed.ethz.ch)

Industrial projects that involve fluid injection into the deep underground (e.g., geothermal energy, wastewater disposal) can induce seismicity, which may jeopardize the acceptance of such geo-energy projects and, in the case of larger induced earthquakes, damage infrastructure and pose a threat to the population. Such earthquakes can occur because fluid injection yields pressure and stress changes in the subsurface, which can reactivate pre-existing faults. Many studies have so far focused on injection into undisturbed reservoir conditions (i.e., hydrostatic pressure and single-phase flow), while only very few studies consider disturbed in-situ conditions including multi-phase fluid flow (i.e., gas and water). Gas flow has been suggested as a trigger mechanism of aftershocks in natural seismic sequences and can play an important role at volcanic sites. In addition, the deep geothermal project in St. Gallen, Switzerland, is a unique case study where an induced seismic sequence occurred almost simultaneously with a gas kick, suggesting that the gas may have affected the induced seismicity.

Here, we focus on the hydro-mechanical modeling of fluid injection into disturbed reservoir conditions considering multi-phase fluid flow. We couple the fluid flow simulator TOUGH2 with different geomechanical codes to study the effect of gas on induced seismicity in general and in the case of St. Gallen. The results show that overpressurized gas can affect the size and timing of induced earthquakes and that it may have contributed to enhance the induced seismicity in St. Gallen. Our findings can lead to a more detailed understanding of the influence of a gas phase on the induced seismicity.