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Interactive comment on "Potential influence of overpressurized gas on the induced seismicity in the St. Gallen deep geothermal project (Switzerland)" *by* Dominik Zbinden et al.

Anonymous Referee #2

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In the manuscript entitled "Potential influence of overpressurized gas on the induced seismicity in the St. Gallen deep geothermal project (Switzerland)", the authors conducted a detailed study on induced earthquakes in a geothermal project during which gas kick occurred. After a comprehensive introduction on observation data, the authors set up a hydro-mechanical numerical model to compute the stress perturbations caused by operations in different stages, e.g. injection test, acid stimulations, and gas kick and well control. The modeling results support the hypothesis in that unexpected gas kick induced earthquakes with magnitudes up to ML 3.5. Overall the manuscript is well written and I can easily follow the logic. I think the manuscript can be accepted after minor revisions.

In the Introduction the authors list a number of anthropogenic activities that may induce earthquakes. One type of activity, which has direct connection and may benefit from the results of this study, is large underground gas storage (UGS) where cyclic injection and extraction of natural gas is conducted. UGSes have been built globally, with notable examples with large capacity in China. It has been recently reported that the injection and extraction of natural gas in a large UGS may induce earthquakes (Zhou et al., 2019; Jiang et al., 2020).

Zhou, P., H. Yang, B. Wang, and J. Zhuang (2019), Seismological investigations of induced earthquakes near the Hutubi underground gas storage facility, J. Geophys. Res., doi:10.1029/2019JB017360

Jiang, G., X. Qiao, X. Wang, R. Lu, L. Liu, H. Yang, Y. Su, L. Song, B. Wang, and T.F. Wong (2020), GPS observed horizontal ground extension at the Hutubi (China) underground gas storage facility and its application to geomechanical modeling for induced seismicity, Earth Plane. Sci. Lett., 530, https://doi.org/10.1016/j.epsl.2019.115943

Indeed the Hutubi UGS was bounded by different faults, which now seal the reservoir. The reported findings in this study have implications on potential changes on fault permeability by smaller earthquakes and thus causing gas flow/leakage from the reservoir or repository. This can be added in discussion and help expand the horizon.

Is that necessary to add another fracture zone to explain those deeper earthquakes? If using fully coupled poroelastic model, poroelastic stress perturbation would be sufficient to induce earthquakes that were 300 m away. Even for injection of gas, poroelastic stress changes are sufficiently large to induce earthquakes (e.g. Jiang et al., 2020). The argument in lines 385 to 392 seems to draw a conclusion based on the horizontal fracture zone (Fig. 8d&e). While the earthquakes are probably too small to derive focal mechanisms, Coulomb failure stress is quite sensitive to receiver fault geometry. So I do not think the justification here is very convincing. Indeed it is quite common to observe induced earthquakes beneath the injection or extraction zone, depending on

fault orientation.

In the model the fault core is set as 5 m wide low permeability zone. According to observations of exhumed faults, most crustal faults have fault cores in cm scale, where earthquake slip is concentrated. Such 5 m scale is limited by the model, or is intended to set in such a scale? What is the effect of such scale, for example, if you decrease it by one order?

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