EGU21-8704, updated on 01 Dec 2021
https://doi.org/10.5194/egusphere-egu21-8704
EGU General Assembly 2021
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Effects of varying injection rate on dynamic slip nucleation along a frictional weakening fault

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Anthropogenic injection of fluid into tight fractured reservoirs is known to alter the stress state of the Earth`s crust, inducing micro-seismicity and eventually significant earthquakes. The injection scenario, in terms of injection pressure or injection rate, is one of the key controlling parameters for injection-induced seismicity. Although a number of studies have been carried out on understanding the effects of injection strategy on seismicity rates, less is known about its effect on the nucleation of dynamic slip on a pressurized fault, especially for non-stationary injection protocols.

In this contribution we study the effects of injection rate variation on the transition between aseismic and seismic slip along a frictional weakenig fault. Notably, we parametrize the injection strategy by assuming an initial linear increase of injection rate in time, up to a value after which it remains constant. We perform a scalying analysis and identify the governing parameters that control the fault response. We solve numerically the coupled hydro-mechanical problem using a fast boundary element solver for localized inelastic deformations [1]. Upon benchmarking the numerical results with the semi-analytical ones of Garagash and Germanovich [2] for the specific case of constant injection rate, we investigate the effect of injection rate variation on critically stressed and marginally pressurized faults. We derive analytical expressions for nucleation time and we confirm them via numerical results. Furthermore, we present a small scale yielding solution for marginallly pressurized faults and investigate the influence of injection scenario on shear crack run-out distances (when occuring).

References

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