Contribution ID: **931** Type: **Poster**

Automatic switching from quasi-static to dynamic geomechanical modeling of friction in rate-state faults

Thursday, 17 May 2018 12:15 (1h 30m)

Earthquake mechanics relies on the ability to simulate frictional failure of faults. One of the dominant characteristics of seismic events is unstable frictional failure, that is, the occurrence of fast runaway slip.

In their seminar work, Dieterich [1] and Ruina [2] proposed a mathematical description of friction, the rate and state friction law, which is capable of reproducing stick-slip behavior observed experimentally. The resulting frictional behavior has been analyzed in detail using a fully dynamic description for zero-dimensional (block-spring) models [e.g., 3]. One of the key features of the system is stick-slip displacement, whereby the block is stagnant for the majority of time, with sudden bursts of high velocity and acceleration. This behavior suggests combining a quasi-static (non-inertial) description during the stick phase, and a dynamic description during the slip phase.

In order to properly assess the seismic hazard associated with the earthquake, a dynamic simulation is needed to capture the unstable slip response. However, performing full-scale coupled flow-geomechanics dynamic simulations is a formidable task due to the requirement of using very small timesteps (~ 1ms) within multiple earthquake cycles (~ tens of years). In fact, such an approach would be so computationally intensive that is well out of reach and will continue to be in the foreseeable future.

In this work, we address this challenge by extending a simulation approach of coupled flow-geomechanics of faulted reservoirs by automatically switching from a quasi-static description of mechanics while the faults are locked to a dynamic description when slip occurs. We investigate the proper definition of this switching criterion with zero-dimensional models, and test them on two-dimensional poroelastic models with a strike-slip fault, for which a fully dynamic simulation is feasible. Finally, we evaluate the applicability of a quasi-dynamic formulation (which relies on a viscous approximation of the inertial term [5] during the slip phase) for fully coupled models in realistic three-dimensional geologic structures.

References

[1] Dieterich, J. H. (1979). Modeling of rock friction: 1. Experimental results and constitutive equations. Journal of Geophysical Research: Solid Earth, 84(B5), 2161-2168.
[2] Ruina, A. (1983). Slip instability and state variable friction laws. Journal of Geophysical Research: Solid Earth, 88(B12), 10359-10370.
[3] Rice, J.R. and Tse, S.T. (1986). Dynamic motion of a single degree of freedom system following a rate and state dependent friction law. Journal of Geophysical Research, 91(B1), 521.
[4] Jha, B. & Juanes, R., 2014. Coupled multiphase flow and poromechanics: A computational model of pore pressure effects on fault slip and earthquake triggering. Water Resources Research, 50(5), 3776–3808.
[5] Thomas, M. Y., Lapusta, N., Noda, H., & Avouac, J. P. (2014). Quasi-dynamic versus fully dynamic simulations of earthquakes and aseismic slip with and without enhanced coseismic weakening. Journal of Geophysical Research: Solid Earth, 119(3), 1986-2004.

Acceptance of Terms and Conditions

Click here to agree

Primary authors: HAGHIGHAT, Ehsan; JUANES, Ruben (MIT)

Presenter: HAGHIGHAT, Ehsan

Session Classification: Poster 4

Track Classification: MS 2.19: Advances in Observation and Modeling of Coupled Flow and Deformation in Fractured Rock