ARMA Future Leader Webinar Series

Every Two Weeks on Fridays 9-10 AM MT

20th Lecture: 26th January 2024

Speaker: Kyungjae (KJ) Im

Abstract

We present an earthquake simulator, Quake-DFN, which allows simulating sequences of earthquakes in a 3-D Discrete Fault Network governed by rate and state friction. The simulator is quasi-dynamic with inertial effects being approximated with radiation damping and a lumped mass. The lumped mass term allows accounting for inertial overshoot and, in addition, makes the computation more effective. Quake-DFN is validated against three benchmark problems: (i) the rupture of planar fault with uniform prestress (SEAS BP5-QD), (ii) the propagation of a rupture across a step-over separating two parallel planar faults (RSQSim and FaultMod), and (iii) a branch fault system with a secondary fault splaying from a main fault (FaultMod). Examples of injection-induced earthquake simulations are shown for three different fault geometries: (i) a planar fault with a wide range of initial stresses, (ii) a branching fault system with varying fault angles and principal stress orientations, and (iii) a fault network similar to the one that was activated during the 2011 Prague earthquake sequence in Oklahoma. The simulations produce realistic earthquake sequences. The time and magnitude of the induced earthquakes observed in these simulations depend on the difference between the initial friction and the residual friction $\mu_i - \mu_f$, the value of which quantifies the potential for run-away ruptures (ruptures that can extend beyond the zone of stress perturbation due to the injection). The discrete fault simulations show that our simulator correctly accounts for the effect of fault geometry and regional stress tensor orientation and shape. These examples show that Quake-DFN can be used to simulate earthquake sequences, most importantly magnitudes, possibly induced or triggered by a fluid injection near a known fault system.

Bio

KJ is a senior research scientist at the Caltech-Industry Cooperative Research Center known as GMG Center. He obtained his phd degree from Penn State in 2019 and BS degree from Seoul National University in 2007. Before he started grad school, he worked in a Korean company as a geologist on oil field acquisition projects in the Permian basin and the Gulf of Mexico. His research interests are in exploring the thermo-hydro-mechano-frictional properties of rock and faults and earthquake rupture processes.