EXPLORING THE INTERPLAY OF FAULT SLIP, POROELASTICITY, AND PERMEABILITY BARRIERS IN SEISMIC SWARMS

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Understanding the dynamic interactions among pore pressure, fluid flow in the fault-zone, and fault mechanics is essential for comprehending earthquake swarm activity. In this study we use the Hydro-Mechanical Earthquake Cycles (H-MECs) model to explore the relationships between frictional slip, poroelasticity, and fluid flow in the occurrence of seismic swarms. We employ a 2-D anti-plane model with a poro-visco-elasto-plastic medium and a fault governed by rate- and state-dependent friction. We model pockets of high pore-fluid pressure, encapsulated by permeability barriers characterized by low permeability and low pore-fluid pressure. Permeability evolution, accommodating changes due to fault slip and healing, provides critical feedback on the dynamics of pore-fluid pressure and fault slip. Our results show that pockets of high pore-fluid pressure coupled with low effective stress generate stable fault creep, while seismicity arises within permeability barriers with relatively lower pore-fluid pressure, which act as seismic asperities. By varying the size of permeability barriers or high pore-fluid pressure pockets, our models display an interplay between aseismic creep, slow-slip transients, foreshocks, and large seismic ruptures. Additionally, back-propagating rupture is observed when the rupture propagates from low permeability barriers into high pore-fluid pressure pockets, due to the transition from pulse-like to crack-like rupture. Notably, seismic ruptures unseal permeability barriers, thus triggering pore fluid pressure diffusion and affecting the seismic moment release. Comparing our findings with observational data reveals the primary role of poroelastic effects and fluid flow in fault stability and the interplay between seismic and aseismic fault slip.