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Grain scale investigation of shear reactivation by fluid pressurization

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Fluid pressurization of critically stressed sheared zones can trigger slip mechanisms at the origin of many geological rupture processes such as earthquakes and landslides. It is now well assumed that the reduction of effective stress induced by fluid pressurization can lead to the reactivation of shear zones. However, the micromechanisms that govern this reactivation remain poorly understood. By using discrete element modeling, we simulate pore-pressure-step creep test experiments on a sheared granular layer at a sub-critical stress state in order to investigate the micromechanical processes at stake during fluid induced reactivation. The simulated responses are consistent with both laboratory and in situ experiments, confirming the scale independent nature of fluid induced slip. The progressive increase of pore pressure promotes slow steady slip at sub-critical stress states and fast accelerated dynamic slip once the critical strength is overcome. The analyses of both global and local quantities show that these two emergent slip behaviors correlate to characteristic deformation modes: diffuse deformation for slow slip and highly localized deformation for fast slip. Our results suggest that, besides the control of the fabric of shear zones on their emergent slip behavior, failure is associated to grain rotations resulting from unlocking of interparticle contacts mostly located within the shear band, which, as a consequence, acts as a roller bearing for the surrounding bulk.