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Roughness evolution in DEM simulations of fault shear

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The surfaces of most known faults are not flat planes but show roughness at all scales. Due to many field measurements, mainly using LIDAR, the structure of this roughness is relatively well known. However, the mechanisms which generate the fault roughness are not yet fully understood. Fault slip processes are difficult to observe directly in nature and laboratory experiments designed to investigate the details of such processes have some limitations. We therefore use a numerical model to augment the field and laboratory observations. Due to the inherently discrete nature of the investigated processes, which are dominated by brittle fracturing and frictional interactions, we use a Discrete Element Method (DEM) model to investigate the process of fault surface abrasion. The simulation models consist of two blocks of solid material (made of bonded particles that can break apart) with a fault in between which is initially smooth at the macroscopic scale. A constant normal stress is applied to the outer surfaces of the model and the upper and lower blocks are moved at a constant speed so that the fault is sheared. At the edges of the model, in the shear direction, periodic boundary conditions are applied so that the amount of shear displacement is not limited by the model size. During fault shearing particles break away from the intact fault surfaces so that the roughness of the surfaces evolves and a fault gouge develops. Our initial investigation of the roughness spectra of the abraded surfaces produced shows that for sufficiently large displacement and normal stress the spectra evolve towards a power-law relationship. Furthermore, we observe a strong anisotropy of the roughness parallel and perpendicular to the slip direction. In some models slip-parallel striations resembling those commonly seen in natural faults are clearly recognisable. The development of these striations, their influence on mechanical properties of the fault and the role of fault gouge on roughness development are now being investigated.