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## Damage coalescence controls slow and fast faulting: Insights from dynamic X-ray microtomography experiments

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During fast and slow earthquakes deformation localizes along narrow and quasi-planar fault surfaces. However, processes controlling the localization process develop not only on the fault surface but also in the volume surrounding the fault zone. How these processes transition from a dispersed to more localized distribution of damage remains controversial. Moreover, to what degree the localization process controls the speed of coseismic slip is an open question. We perform a series of 4D X-ray microtomography experiments on crystalline rocks (granite, marble), with and without a pre-existing slip surface, and image the development of damage while each sample is loaded until system-size brittle failure. We image and deform the samples under in situ stress conditions of a few kilometers depth using the Hades deformation apparatus installed on the tomography beamline ID19 at the European Radiation Synchrotron Facility. By imaging all the microfractures that develop in the samples, we characterize their individual geometry and the geometry of the entire microfracture network. The results show that, when a pre-existing slip surface exists in the sample, slow earthquakes can generate damage in the volume around the fault, leading to catastrophic faulting. When no pre-existing fault is present, microfractures accumulate and can lead to two end-member types of earthquakes. One type is a catastrophic failure of the sample that occurs when the microfractures link into a macroscopic fault, producing a fast earthquake. Alternatively, the microfractures can grow without significant fracture coalescence, leading to the slow development of a fault network with a transient increase of macroscopic deformation rate that resembles that of a slow earthquake. We conclude that damage coalescence influences the slow and fast behaviours of earthquake slip.