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Crystal plastic earthquakes in dolostones

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Dolostone is the most dominant lithology of the seismogenic upper crust around the Mediterranean Sea. Understanding the internal mechanisms controlling fault friction is crucial for understanding seismicity along active faults. Displacement in such fault zones is frequently highlighted by highly reflective (mirror-like) slip surfaces, created by thin films of nanogranular fault rock. Using saw-cut dolostone samples coming from natural fault zones, we conducted friction experiments under triaxial loading conditions. To reproduce the natural conditions, experiments were conducted at 30, 60 and 90 MPa confining pressure at respectively 30, 65 and 100 degrees C. At 30 and 65 degrees C, only slow rupture was observed and the experimental fault exhibits frictional behaviour, i.e. a dependence of normal stress on peak shear stress. At 65 degrees C, a strengthening behaviour is observed after the main rupture, leading to a succession of slow rupture. At 100 degrees C, the macroscopic behaviour of the fault becomes ductile, and no dependence of pressure on the peak shear stress is observed. In addition, the increase of the confining pressure up to 60 and 90 MPa allow the transition from slow to fast rupture, highlighted by the records of acoustic activity and by dynamic stress drop occurring in a few tens of microseconds. Using strain gages located along the fault surface and acoustic transducers, we were able to measure the rupture velocities during slow and fast rupture. Slow ruptures propagated around 0.1 m/s, in agreement with natural observations. Fast ruptures propagated up the supershear velocities, i.e. faster than the shear wave speed (>3500 m/s). A complete study of the microstructures was realized before and after ruptures. Slow ruptures lead to the production of mirror-like surface driven by the production of nanograins due to dislocation processes. Fast ruptures induce the production of amorphous material along the fault surface, which may come from melting processes. We demonstrate that the transition from slow to dynamic instabilities is observed when the entire fault exhibits plastic processes, which increase the stiffness of the fault.