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Frictional behaviour and evolution of rough faults in limestone

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Fault roughness is an important parameter which influences the frictional behaviour of seismically active faults, in particular the nucleation stage of earthquakes. Here we investigate frictional sliding and stability of roughened micritic limestone surfaces from the seismogenic layer of the Northern-Central Apennines of Italy. Samples are roughened using #60, #400 and p1000 grit and deformed in a single direct shear configuration at conditions typical of the shallow upper crust (30-100 MPa normal stress). We perform velocity steps between 0.01-2 μm/s to obtain rate-and-state friction parameters a, b and L. We observe velocity strengthening friction accompanied by increases in a-b and L for faults deformed at 30 MPa, indicating that faults become increasingly stable during progressive slip. Microstructural observations show that faults become rapidly covered in a gouge layer, which has shiny mirrors comprised of nanometric particles. With progressive slip the gouge layer becomes more widespread, which we interpret to result in progressive strain delocalisation and thus an increase in a-b and L values. Also of note is the systematic observation of negative b values (frictional evolution term), we will offer preliminary interpretations of this behaviour. Overall our observations indicate that on carbonate hosted faults or joints sliding maybe largely accommodated by plastic processes occurring in nanoparticle layers, which may also act as barriers to earthquake nucleation.