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Effect of water on slip weakening of cohesive rocks during earthquakes (EMRP Division Outstanding ECS Award Lecture)

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Fluids play an important role in fault zone and in earthquakes generation. Experimental studies of fault frictional properties in presence of fluid can provide unique insights into this phenomenon. Here we compare rotary shear experiments and tri-axial stick slip tests performed on cohesive silicate-bearing rocks (gabbro and granite) in the presence of fluids. Surprisingly, for both type of tests, the weakening mechanism (melting of the asperities) is hindered in the presence of water. Indeed, in rotary shear experiments, at a given effective normal stress (σn-pf), the decay in friction is more gradual and longer in the presence of pore water (32% of friction drop after 20 mm of slip) than under room humidity (41% after 20 mm of slip) and vacuum conditions (60% after 20 mm of slip). During stick slip tests, at a given effective confining pressure (Pc-pf), the dynamic shear stress drops are lower (30%) and slip distances were shorter (30 to 40%) in the presence of high pressure pore water (Pc=95 MPa; Pf=25 MPa) than under room humidity conditions (Pc=70 MPa; Pf=0 MPa). Thermal modeling of the asperity contacts under load shows that the presence of fluids cools the asperities and delays the formation of melt patches, increasing weakening duration.