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Mechanical heterogeneities along carbonate-bearing faults constrained from field and rock deformation experiments

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Recent high-resolution GPS and seismological data have revealed that tectonic faults exhibit complex, multi-mode slip behavior. One way to improve our understanding of processes controlling the mode of slip is to study fault rock microstructures, collected from ancient faults exposed at Earth's surface or in deep boreholes and to characterize friction of the collected fault rocks. In several seismically active regions, like Italy, Greece, Iran, and China, a significant number of earthquakes nucleate and/or propagate through carbonates. For these reasons, we have been working to improve the characterization of carbonate bearing faults by integrating field and microstructural studies with mechanical data. Along some portions of carbonate fault zones: 1) the localization of deformation along sharp principal slipping zones (0.1-1 mm) made of fine-grained (0.1-10 μm) ultracataclasite and 2) the velocity weakening behavior of this material suggest a fast and seismic mechanism. Microstructural evidence indicates that seismic mechanisms are associated with thermally activated processes (i.e. dehydration and decarbonation). In other portions of these fault zones: 1) the distribution of deformation over thick (< 200 m) shear zones affected by pressure solution of carbonates and frictional sliding along foliated and clay-rich (illite-smectite) horizons, and 2) the velocity strengthening behavior of these foliated rocks indicate a slow and aseismic slip behavior. Sharp principal slipping zones that show high friction and significant re-strengthening during hold periods, indicate a fault patch capable of unstable slip with the ability to regain elastic strain energy. Conversely, phyllosilicate-rich shear zones showing low friction with no frictional healing suggest fault patches that can slip slowly and continuously with time. We are currently using a new biaxial apparatus with a pressure vessel to work on a large, 20x20 cm, experimental fault. In this fault we are reproducing the mechanical heterogeneities observed in both field and laboratory and try to characterize their interaction during shearing.