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Field and experimental evidence for coseismic ruptures along shallow creeping faults in forearc sediments of the Crotone Basin, South Italy

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Large seismic slip occurring along shallow creeping faults in tectonically active areas represents an unsolved paradox, which is largely due to our poor understanding of the mechanics governing creeping faults, and to the lack of documented geological evidence showing how coseismic rupturing overprints creep in near-surface conditions. In this contribution we integrate field, petrophysical, mineralogical and friction data to characterize the signature of coseismic ruptures propagating along shallow creeping faults affecting unconsolidated forearc sediments of the seismically active Crotone Basin, in South Italy. Field observations of fault zones show widespread foliated cataclasites in fault cores, locally overprinted by sharp slip surfaces decorated by thin (0.5-1.5 cm) black gouge layers. Compared to foliated cataclasites, black gouges have much lower grain size, porosity and permeability, which may have facilitated slip weakening by thermal fluid pressurization. Moreover, black gouges are characterized by distinct mineralogical assemblages compatible with high temperatures (180-200°C) due to frictional heating during seismic slip. Foliated cataclasites and black gouges were also produced by laboratory friction experiments performed on host sediments at sub-seismic ($\leq$ 0.1 m/s) and seismic (1 m/s) slip rates, respectively. Black gouges display low friction coefficients (0.3) and velocity-weakening behaviours, as opposed to high friction coefficients (0.65) and velocity-strengthening behaviours shown by the foliated cataclasites. Our results show that narrow black gouges developed within foliated cataclasites represent a potential diagnostic marker for episodic seismic activity in shallow creeping faults. These findings can help understanding the time-space partitioning between aseismic and seismic slip of faults at shallow crustal levels, impacting on seismic hazard evaluation of subduction zones and forearc regions affected by destructive earthquakes and tsunamis.