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Microstructural and petrophysical characterization of a "structurally oversimplified" fault zone in poorly lithified sands: evidence for a coseismic rupture?

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We studied an extensional fault zone developed in poorly lithified, quartz-rich high porosity sandy sediments of the seismically active Crotone basin (southern Italy). The fault zone cuts across interlayered fine- to coarse-grained sands and consists of a cm-thick, discrete fault core embedded in virtually undeformed wall sediments. Consequently, it can be described as “structurally oversimplified” due to the lack of footwall and hanging wall damage zones. We acquired microstructural, grain size, grain shape, porosity, mineralogical and permeability data to investigate the influence of initial sedimentological characteristics of sands on the final faulted granular products and related hydrologic properties. Faulting evolves by a general grain size and porosity reduction with a combination of intragranular fracturing, spalling, and flaking of grain edges, irrespective of grain mineralogy. The dominance of cataclasis, also confirmed by fractal dimensions >2.6, is generally not expected at a deformation depth <1 km. Coarse-grained sand shows a much higher comminution intensity, grain shape variations and permeability drop than fine-grained sands. This is because coarser aggregates have (i) fewer grain-to-grain contacts for a given area, which results in higher stress concentration at contact points, and (ii) a higher probability of pre-existing intragranular microstructural defects that result in a lower grain strength. The peculiar structural architecture, the dominance of cataclasis over non-destructive particulate flow, and the compositional variations of clay minerals in the fault core, strongly suggest that the studied fault zone developed by a coseismic rupture.