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Grain size and shape evolution of experimentally deformed sediments: the role of slip rate

Fabrizio Balsamo (1), Fabrizio Storti (1), and Nicola De Paola (2)

(1) NEXT - Natural and Experimental Tectonics Research Group - Department of Physics and Earth Sciences, University of Parma, Italy (fabrizio.balsamo@unipr.it), (2) Rock Mechanics Laboratory, Earth Sciences Department, Durham University, Durham, UK.

Sediment deformation within fault zones occurs with a broad spectrum of mechanisms which, in turn, depend on intrinsic material properties (porosity, grain size and shape, etc.) and external factors (burial depth, fluid pressure, stress configuration, etc.). Fieldworks and laboratory measurements conducted in the last years in sediments faulted at shallow depth showed that cataclasis and grain size reduction can occur very close to the Earth surface (<1-2 km), and that fault displacement is one of the parameters controlling the amount of grain size, shape, and microtextural modifications in fault cores. In this contribution, we present a new set of microstructural observations combined with grain size and shape distribution data obtained from quart-feldspatic loose sediments (mean grain diameter 0.2 mm) experimentally deformed at different slip rates from subseismic (0.01 mm/s, 0.1 mm/s, 1 mm/s, 1 cm/s, and 10 cm/s) to coseismic slip rates (1 m/s). The experiments were originally performed at sigma n=14 MPa, with the same amount of slip (1.3 m), to constrain the frictional properties of such sediments at shallow confining pressures (<1 km). After the experiments, the granular materials deformed in the 0.1-1 mm-thick slip zones were prepared for both grain size distribution analyses and microstructural and textural analyses in thin sections. Grain size distribution analyses were obtained with a Malvern Mastersizer 3000 particle size laser-diffraction analyser, whereas grain shape data (angularity) were obtained by using image analysis technique on selected SEM-photomicrographs. Microstructural observations were performed at different scales with a standard optical microscope and with a SEM. Results indicate that mean grain diameter progressively decreases with increasing slip rates up to ~20-30 [U+F06D]m, and that granulometric curves systematically modify as well, shifting toward finer grain sizes. Obtained fractal dimensions (D) indicate that D increases from ~2.3 up to >3 moving from subseismic to coseismic slip rates. Grain angularity also changes with increasing slip rates, being particles more smoothed and rounded in sediments deformed at coseismic slip rates. As a whole, our results indicate that both grain size and shape distributions of experimentally deformed sediments progressively changes from subseismic to coseismic slip rate, thus helping to understand the deformation mechanisms in natural fault zones and to predict frictional and permeability properties of faults affecting shallow sediments.