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Pulverized sedimentary rocks along the Mojave section of the San Andreas Fault: implications for rupture mechanism

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Recent mapping established the existence of a ∼100 m wide layer of pulverized crystalline rocks parallel to the slipping zone of the San Andreas Fault (SAF) in the Mojave (Dor et al., EPSL 2006). This mapping also suggests that pulverization occurred at a shallow depth ($<$ 3 km) and that the zone of pulverized rock is shifted to the NE side of the fault, which is the block with faster seismic velocities at depth.

To further assess the likely pulverization depth, we examined the extent of damage in sedimentary rocks from the Juniper Hills, Anaverde and Hungry Valley formations; these rocks were not buried deeply while being displaced along the SAF. Our observations, made in optical and electron microscopy on samples taken in various distances from the fault, indicate the following: 1. Samples collected meters to 10s of meters from the fault are significantly damaged (pulverized) while samples collected 100s of meters from the fault show minimal or no damage. 2. Damage is highly heterogeneous in all samples, with some grains pulverized down to the micron scale while others remaining intact. 3. Visually, fault-parallel and other shear components are apparently absent at all scales: sedimentary fabrics are intact and even the most fractured grains preserve their original outline, with the fragments appearing to fit together in a hierarchical self-similar fashion.

Additional results are obtained using optical analysis of photomicrographs of samples taken at various distances from the fault. The analysis method compares the length of the perimeter of a grain and the cumulative length of the perimeter of fragments that belong to that grain. We apply these measurements to many grains from different size bins in every sample. The preliminary results show that the factor of increase in perimeter length between grains and the fragments they contain in samples taken within the fault zone is at least 5.3 times larger than in samples taken far from the fault. This is a conservative estimate of the contrast in damage, and further analysis is expected to show higher contrast.

The fabric of the pulverized sediments is compatible with a tensile failure mechanism, which may be similar to that responsible for the pulverization of crystalline rocks described by Dor et al. (EPSL 2006), and is likely associated with the stress field of earthquake ruptures. This is supported by the clear spatial correlation that the highly damaged and pulverized rocks have with the trace of the fault. These observations support earlier inferences about the likely occurrence of pulverization at shallow depths. Shallow generation depth of damage, abundance of tensile features and asymmetric fault zone structure correlated with the velocity structure (as also expressed by the pulverized rocks layer and by smaller scales observations of Dor et al., PAGEOPH 2006) are expected outcomes of repeated ruptures on a bimaterial interface (e.g. Ben-Zion and Shi, EPSL 2005).