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Healing rates of natural and experimental granitoid Fault Gouges.

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Many laboratory studies have been performed to measure the healing rate (fault strength recovery rate) of experimentally produced gouge from slide-hold-slide friction. Most of these studies have been performed at room temperature, without or at very low confining pressure on different kinds of gouges. The healing rate in these studies has been defined as the change in static friction, $\Delta\mu_s$, which is the measure of the friction peak after a holding period in a friction experiment. Since the values of $\Delta\mu_s$ are very small, extrapolation to natural systems is difficult. We therefore adopt another approach for determining the healing rate: we base our study on the microstructures of laboratory experiments and natural fault systems, especially the grain size distribution of fault rock to quantify the healing process.

Coaxial deformation experiments were carried out on isotropic Verzasca gneiss using a Grigg's deformation apparatus at $300 - 500\,^{\circ}\mathrm{C}$, 500 MPa, strain rates of 10^{-4} to $10^{-7}s^{-1}$ and 0.2 %wt H_2O added. Experiments were performed in three ways. 1) Samples were deformed and quenched immediately after fracturing (gouge formation). 2) After fracturing the samples were kept at hydrostatic conditions for 4 hours to 14 days at 300 or $500\,^{\circ}\mathrm{C}$ (healing). 3) Samples were deformed at variable strain rates for 4 to 30 days to study the interaction between deformation and healing. Digital images with different magnifications were used for the analysis of the microstructures and the grain size distribution. The experimentally deformed granitoids were compared to natural fault rock samples originating from the Nojima Fault Zone (deformed in Early Tertiary and Pliocene to Quaternary) and from the Black Forest (Tertiary).

Fracturing of rock in natural and experimental fault zones produces fault gouge. The grain size distribution of fresh fault gouge, described by its D-value (defined as the slope of the log frequency - log grain size histogram), is ≤ 2.0 in both natural and experimental fault zones (Stünitz et al., this conference). For healed granitoid fault gouge D is reduced, typically to $1.5 < D < 1.6$ for older natural fault and in our samples. Whether or not healing occurs depends on temperature, time and degree of mixing of the gouge. In natural granitoid gouge both polymineralic (well mixed) and monomineralic gouge fractions occur. Polymineralic gouge shows virtually unchanged D-values, even after > 50 Myrs. From our experiments the healing rate of monomineralic quartz and feldspar gouge, described as the change in D-value, is derived. Extrapolation of the laboratory data to the Nojima Fault Zone shows that healing of the monomineralic fraction of the gouge may have occurred within $\approx$ 50,000 years.

Healing experiments under a differential stress produce more efficiently healed gouge than those healed under hydrostatic conditions (lower D-values), at an axial shortening rate $< 10^{-7} s^{-1}$. A process similar to pressure solution is probably dominant during slow deformation in these experiments simulating post-seismic creep after the main stress release in earthquake zones.