Vel. dependence of friction due to sol.-transfer healing of quartz gouge @200C and its upper cutoff velocity as low as 1E-6m/s.

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Frictional strength (i.e., state, see [Nakatani, 2001]) is often observed to evolve toward a new steady-state following a change in slip velocity [e.g., Dieterich, 1978, 1979]. For Dieterich-type healing mechanism known form room temperature, it has been widely accepted [e.g., Marone, 1998a] that this evolution effect is a manifestation of the time-dependent healing mechanism. Through the effective contact time, which is inversely proportional to slip velocity [e.g., Dieterich, 1978], an e-fold change in slip velocity is expected to induce an evolution effect of magnitude b, where b is the magnitude of healing per e-fold change in hold time. In order to see if the solution-transfer healing mechanism [Nakatani and Scholz, submitted] also leads to such an evolution effect, several velocity-step tests were carried out at 200C.

In a wet experiment at 200C where slip velocity was stepped between 0.13 microns/s and 1.3 microns/s, evolution effect with a magnitude of ~0.03 was observed. This magnitude coincides with what is expected from the healing tests resulting in b = 0.013 (0.03 = 0.013 x ln10, ln10 is for a 10-fold velocity change.) at the same condition. In addition, the evolution occurred over a slip displacement as long as ~500microns, comparable with the slip weakening distance observed in the healing tests, again indicating that the two result from the same mechanism. These values are far greater than the ~ 10microns typical of Dieterich-type healing. A control experiment done with its pore space open to lab. atmosphere (i.e. nominally dry) but at otherwise the same condition did not show significant evolution effect.

An interesting finding is that velocity-step tests at faster velocities (1.3 microns/s - 13 microns/s and 13 microns/s -130 microns/s), also done at 200C wet, showed only minor evolution with a magnitude less than a quarter of the value expected from the healing tests. A simple interpretation of this would be that the effective contact times corresponding to these faster velocities were less than the cutoff time of solution-transfer healing mechanism, so that the effective contact time does not affect the surface state very much. The existence of such an upper cutoff velocity for the evolution effect has been proposed with respect to Dieterich-type healing mechanism [e.g., Okubo and Dieterich, 1986]. Observations [Blanpied et al., 1987, Mair and Marone, 1999] suggest that it occurs at a much higher slip velocity than the range tested here, where the cut-off occurs at about 1.3microns/sec. This difference is consistent with the much larger cutoff time of solution-transfer healing mechanism (1200s at 200C, [Nakatani and Scholz, submitted]).

Test conditions. Sample: crushed natural quartz (grain dia. from less than 1 micron to 63 microns.). Initial layer thickness ~3 mm. Loading block: 37.5 saw-cut with 0.38 mm-deep grooves. Effective normal stress ~100 MPa. Pore pressure: 10 MPa. Temperature: 200C.