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Raman spectroscopic characterization of fault gouge rapidly healed after dynamic weakening

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How rapidly fault strength recovers after an earthquake is an important question for understanding the earthquake generation mechanism in seismic cycles. Recent friction experiments at coseismic velocities revealed that the fault can completely regain its strength to pre-slip level within few days (Mizoguchi et al. 2009, BSSA). However the factor causing such rapid fault healing after dynamic weakening is still not understood. We expected that the reformation of a certain type of chemical bond is responsible for fault healing. Thus, we performed high-velocity friction experiments on quartz gouge at a slip velocity of 1.3 m/s, normal stress of 1.0 MPa and displacement of $>$10 m. At this condition, the simulated fault weakened markedly with displacement to friction coefficient of ˜0.2. In order to identify the chemical bonds that play a key role in fault healing after dynamic weakening, the slip surface of gouge zone was analyzed immediately after the experiments using a laser Raman microscope. We found a characteristic peak at ˜1600 cm-1 in a Raman spectrum detected only from the dynamically weakened gouge at high velocities. This peak corresponds to bending vibrations of a H2O molecule. The peak appeared just after the experiment and its intensity decreased with time. After two days, the peak totally disappeared. Interestingly the time scale of existence of the peak is almost same as that of gouge healing. We propose a hypothesis that the excitation of bending vibrations of a H2O molecule by shear and/or frictional heat during rapid sliding and the degradation of the vibrations after the termination of the sliding results in the dynamic fault weakening and the rapid fault healing, respectively.

Keywords: fault, healing, H2O