Geological and seismological conditions required for operating coseismic OSL zeroing of quartz gouge

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Attempts to determine the age of faulting recorded on a rock have been made using methods such as the K-Ar dating, FT dating, and ESR dating(e.g.,Murakami & Tagami, 2004, GRL). Among the proposed methods, the luminescence dating method has an applicable time range of few decades to few hundred thousand years ago, and hence it is suitable for dating an active fault. Early trial demonstrated a successful determination of the latest earthquake event along the active fault in central Japan (Ganzawa et al., 2013, JGSJ). These methods are usually based on the idea that the age value will be reset due to heating event such as high-velocity fault slip or hydrothermal fluid flow. However, since a phenomenon in fault zone accompanied with seismic slip is quite complicated due to the combined frictional wear, fracturing, and thermally activated physic-chemical processes, the age resetting with seismic fault slip must be confirmed in a laboratory by conducting high-velocity friction experiment. Here we show the clear reduction (zeroing) of optically-stimulated luminescence (OSL) signal of quartz gouge after the laboratory experiments and estimate seismological and geological conditions required to occur age resetting in natural fault zones.
In the experiments, we used quartz powder with a particle size of <150 μm which is extracted from Tsushigawa granite, located in the northern part of Awaji island, Hyogo Prefecture. We irradiated 400 Gy of gamma-ray for the quartz powder before the experiments to simulate natural radiation damage. Friction experiments were conducted under the following conditions in darkroom environment using a rotary-shear, high-velocity friction apparatus in Yamaguchi University; slip rate of 200 μm ⁄ s to 1.3 m ⁄ s, normal stress of 1 to 5 MPa, and displacement of 2 to 10 m. To eliminate the effect of crushing on OSL signal, we measured coarse grains (75–150 μm) extracted from recovered sample. In the experiment conducted under normal stress of 1.0 MPa, OSL signal start to decrease from the slip rate of 0.25 m ⁄ s and becomes zero at slip rate ≧ 0.65 m ⁄ s. Signal zeroing was also observed from the experiments sheared at 1.3 m ⁄ s under water-added condition. At slip rates of 0.25 and 0.40 m ⁄ s, we found “partial resetting” which is characterized by coexistence of both particles with signal and without signal. OSL signal intensities (Lx ⁄ Tx) have a strong correlation between power density, $\tau_e V$ (DiToro et al., 2011, Nature) which is proposed as a parameter of heat generation during high-velocity friction, and measured ⁄ calculated temperature in the fault zone; that is, the measured ⁄ calculated temperature exponentially rises and Lx ⁄ Tx exponentially decreases with increasing the power density. The power densities required for the partial and complete resetting are 0.24 MW ⁄ m^2 and 1.0 MW ⁄ m^2, respectively. Assuming a coseismic fault slip rate of 0.65 m ⁄ s, depth conditions required for operating partial and complete resetting of OSL age are expected to be 35 and 141 m respectively.
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