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Experimental demonstration of high-temperature fluid generation during coseicmic fault slip

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The generation of a high-temperature hydrous fluid by frictional heating crucially affects on the fault-slip behavior. Thermal pressurization is widely known dynamic weakening mechanism, by means of which fluid pressure generated by shear-related heating reduced the fault strength during seismic slip. In the case of Taiwan Chelungpu fault, anomaly of fluid-mobile trace elements (Sr, Cs, Rb and Li), and Sr isotope ratios was reported, and it was attributed to fluid-rock interaction at high temperature (>350C) and being an evidence that thermal pressurization occurred during 1999 earthquake. However, the anomaly in trace elements and isotopes have not been demonstrated and verified experimentally. So, we here performed high-velocity frictional experiments on simulated fault gouge under wet condition, and analyzed the trace elements and Sr isotope of the samples after the experiments with an inductively coupled plasma spectrometer.

We used a rotary shear testing apparatus at the Kochi Core Center. The pore pressure and normal stress can be controlled during experiments. A series of experiments was performed at a 14-15 MPa normal stress, 2-5 MPa pore pressure and 0.2-0.4 m/s slip velocity with several displacements between 14.7-29.3 m. With increasing slip, the shear stress decreased, and the temperature reached at 300C. We found distinct depletion of Li in the sample experienced 300C. Because Li is known as fluid-mobile element and significantly mobilizes into fluids above 300C, the change of Li concentration in the sample indicate fluid-rock interactions at high temperatures. Therefore, our experimental results verify that trace element compositions can be good proxy for generation of high-temperature fluid during coseismic slip.