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Fluid-rock interaction in a fault during coseismic slip

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The generation of a high-temperature hydrous fluid by frictional heating is generally regarded as possible products of coseismic slip. They are critical in controlling effective stress and fault mechanics. For example, in a process termed thermal pressurization, pore fluid pressure produced by frictional heating can reduce the effective normal stress acting on the fault surface. This may lead to a marked reduction in fault strength during slip. This process should be reflected in the chemical composition of slip zone rocks. Recently, records of fluid-rock interaction in a fault during coseismic slip are recognaized in Taiwan Chelungpu, Shimanto Kure, Boso Emi by trace elements and isotope analysis (Ishikawa et al., 2008; Hamada et al., 2011). Concentrations of fluid-mobile trace elements (Sr, Cs, Rb, and Li), and Sr isotope ratios are very sensitive to fluid-rock interaction at high temperature, making them strong indicators of frictional heat in the slip zone. Li, Rb, Cs compositions of these slip zone are lower and Sr higher compared with those of host rock. These changes of trace elements also showed that the temperature of the slip surface have reached more than 350 ^{o}C.

In Shimanto Kure OST, which was an ancient megasplay fault that took place at 2.5-5.5 km depth, we discovered not only records of fluid-rock interaction but also those of melting. These findings suggest the thermally-enhanced pressure might not have reached a sufficient level to cause thermal pressurization, and the temperature continued to increase to cause melting. Comparison with a shallow slip zone at 1-2 km depth (Boso Emi), where only thermal pressurization occurred, indicated that the transition from melt lubrication at depth to thermal pressurization at shallower depths along a megasplay fault may occur during rupture propagation.

We are also just now conducting high-velocity frictional experiments on fault gauge under wet condition to inspect generation of high temperature fluid and influence on slip behavior. The core sample from the Taiwan Chelungpu Fault Drilling Project (TCDP) was used in experiments as a fault gauge sample, which is composed predominantly of siltstone. We analyzed trace element and Sr isotope ratio on samples before and after experiments to estimate whether fluid-rock interaction occurred in fault gauge during shearing. The change of trace element compositions and Sr isotope ratio was not recognized in case of low confining pressure and low slip velocity. The maximum temperature of slip surface in that case was 250 ^{o}C. This indicates that generation of fluid-rock interaction requires more high temperature because fluid mobile elements (Cs, Rb, and Li) in sediments are significantly mobilized in fluids above 300 ^{o}C, and Sr in sediments increases around 300 ^{o}C (You et al., 1996).

We will present these the latest experimental results and natural fault recording fluid-rock interaction at this meeting.

Keywords: coseismic slip, fluid-rock interaction, trace elements, high velocity frictional experiments