Transport property within fault zones and its importance for dynamic slip behavior of Taiwan Chi-Chi earthquake

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1999 Taiwan Chi-Chi earthquake (Mw7.6) that occurred at the central-western Taiwan showed remarkable difference in fault behavior between northern and southern sites. It is noticeable that large displacement (10m) had occurred in the northern site and several drilling projects that penetrate activated Chelungpu Fault were started to reveal such faulting behaviors. At present, shallow drillings at northern and southern site and deeper drilling at northern site (TCDP) have been conducted. We have measured transport and frictional properties of fault zones in laboratorial scale using both core and surface samples so as to investigate the thermal pressurization mechanism. Thermal pressurization (TP) is one of fault weakening mechanisms that weakening is induced by pore pressure generation due to frictional heating. Our results suggest that northern site is more effective for TP than the southern site, and TP is more effective at deeper horizon than shallower horizon. This time we collected the TCDP Hole-B samples that are less weathered and covered most part of the fault zone. Therefore if we use these samples, it might be possible to get more accurate data for mathematical analyses. In this study, we introduce the result using TCDP hole-B core samples.

All samples are shaped into cubic that each length is about 12mm, then dried at 60 {o}C in the oven for one week. Then permeability and porosity changes for confining pressure changes are measured using the consolidation and fluid flow testing machine in Kochi core center. Nitrogen gas was used for pore fluid for both tests, and permeability was measured by gas constant differential pressure flow method. Gas flow rate was measured using handy gas flowmeters of ADM 200 and Alicat gas flowmenter. Gas permeability was transformed to water permeability from gas permeability dependence on pore pressure of Klinkenberg equation.

Confining pressure cyclic test, that different pressure to other cycles is loaded and unloaded to investigate the permeability dependence on pressure history, are performed for all samples. Permeablity and porosity for all kind of rocks, fault gouge, fault breccia and siltstone, showed elast-plastic behaviors. Permeability showed various ranges, though permeability of most rocks showed around 10^{-15} to 10^{-16} m^2. Permeability of black gouge (permeability = $4*10^{-15}$ m^2 at 1 km depth), gray gouge (10^{-17} m^2) and fault breccia ($3*10^{-15}$ m^2) were used for TP analysis. For porosity tests, initial porosity is much different among samples, though, porosity changes with pressure changes are much similar, which porosity was decreased 1% from the initial porosity at 60 MPa. Therefore specific storages that are approximated from porosity test do not show the difference between samples and mostly showed 10{-10} Pa^{-1} at 1 km depth. With increasing confining pressure the value becomes stable to 10^{-10} Pa^{-1}.

Using the measured transport properties and frictional properties, pore pressure changes during and after slip events are calculated to investigate the weakening behavior. The results showed that pore pressure was generated 10 MPa just after slip happened, then generated pore pressure was decreased nearly 0 MPa within 2 minutes after slip event. Temperature was increased up to 400 {o}C, then decreased within several minutes. Our results indicate that weakening had enhanced by TP mechanism in this location, and suggests that the large displacement in the northern site is also trigged by TP mechanism.