The fault weakening process inferred from physical properties of fault zone cores from Taiwan Chelungpu-fault Drilling Project

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The Taiwan Chelungpu-fault Drilling Project penetrated the earthquake fault of the 1999 Chi-Chi earthquake recovering drilled cores from 500-2000 m depth. Description of the recovered cores reveal that the Chelungpu fault system exist in the depth range between 1050-1250 m, where 3 major fault structures were encountered at 1111, 1153, and 1222 m depths. Fault rock presence was sharply concentrated to these 3 fault structures, and thus one of the 3 fault structures is/are likely to have been the slip plane during the 1999 Chi-Chi earthquake.

Laboratory studies were conducted using fault rock samples from the fault structure at 1111 and 1153 m depths focusing on their transport and frictional properties, to study the effect of thermal pressurization (Sibson, 1973) and the evolution of the frictional coefficient during high- velocity fault slips, which may have controlled the fault weakening process at these 2 faults during the 1999 Chi-Chi earthquake. (1) Permeability measurements show that the permeability of fault rocks from 1111 m depth were lower (10ˆ-15 to 10ˆ-19 mˆ2) than fault rocks from 1153 m depth (10ˆ-14 to 10ˆ-17 mˆ2). Thus thermal pressurization is likely to be more effective in the fault at 1111 m depth. (2) High-velocity frictional experiments using gouge samples (Mizoguchi, 2004) from both faults were conducted, however no systematic variation of the frictional properties were found between the two samples. Both samples show a peak frictional coefficient of about 0.8 after the initiation of slip, and then the frictional coefficient decreases to a value lower than 0.2 as slip accumulates.

The fault weakening process was estimated by considering the two possible weakening mechanisms above through numerical analyses using the measured transport and frictional properties. The Dc value for each result was 3-6 m, which agrees in the same order with the result derived from seismological inversions (Dc=5.06m; Ma et al., 2005). However, the strength reduction resulted in between 6-8 MPa which are consistently greater than the inversion solution 4.5 MPa (Ma et al., 2005). Since the over-estimation of fault strength reduction is enhanced by the effect of thermal pressurization, further weakening by such process may not be a necessary component in explaining the fault weakening process at this particular fault segment on the Chelungpu fault during the 1999 Chi-Chi earthquake. We will also apply the analyses to greater depth conditions for further comparison with results from seismological inversions.