Mechanism of Large Displacement Faulting in the 1999 Chi-Chi Taiwan Earthquake

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Many hypotheses have been proposed to elucidate how a fault with large displacement loses strength during sliding. There are slip weakening, thermal pressurization, mechanical lubrication, frictional melting, normal interface vibrations, acoustic fluidization, elastohydrodynamic and silica gel lubrication. The activity of Chelungpu fault, induced the 1999 destructive Chi-Chi earthquake with magnitude Mw = 7.7, caused a total surface rupture of about 80-90 km long and the largest measured vertical offsets reaching as much as 5-9 m in west-central Taiwan. It, thus, provide us an opportunity to examine aforementioned hypotheses of large displacement faulting. The purpose of the Taiwan Chelungpu-fault Drilling Project (TCDP) is to obtain physical samples of the slip zone of 1999 Chi-Chi earthquake in the deep to make progress in understanding how mechanism of large displacement seismic faulting occurs.

We have finished drilling the TCDP hole-A which it has the cuttings from 0 to 431.34 m and cores from 431.34 to 2003.26 m deep in the end of 2004. Meanwhile, the Hole-B with a branch was cored between 950 m to 1350 m in May, 2005. At least six fault zones have been identified in the cores. Based on the surface trail of rupture, regional geology, shallow seismic reflection, well logging, thermal measurement and core examinations, the slip zone of 1999 Chi-Chi earthquake may be occurred in the black material of fault zone FZ1111 around the depth of 1111.26 m. It is composed of 12 cm thick ultracataclasites with slickenline. The XRD and TEM analyses show that the black materials consist of amorphous phase, pseudotachylyte and rich in smectite which reach as high as 85% of total clays. However, the smectite-rich gouges can not find in other parts of the FZ1111 and the other fault zones. The smectite-rich gouge may be resulted from the devitrification of pseudotachylyte, produced by frictional melting after the rapid slip of the seismic earthquake. Co-existences, thus, of pseudotachylyte and smectite-rich in the black materials of FZ1111 indicate that the mechanism of large displacement seismic faulting occurred in 1999 Chi-Chi earthquake may be due to the lubrication of thermal pressurization following the frictional melting.