Particle Size Distribution of Taiwan Chelungpu Fault Zone Gouges

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Gouge formation is found to exist in brittle faults at all scales. This fine-grain gouge is thought to control earthquake instability. And thus investigating the gouge texture property is very important to an understanding of the earthquake process. The characterization of particle size distribution, porosity and 3D structure of the fault rocks in transition from the fault core to damage zone are related to the comminuting, fluid behaviors and fracture energy in the earthquake faulting. The results may ascertain the implication of the nucleation, growth, transition structure and permeability of the fault zones.

The 1999 Chichi, Taiwan earthquake (M7.7) had very large surface displacements. In the southern part of the fault, the vertical offsets was 2 m and increased to 8 m in the north, which is the largest offset ever measured for modern earthquakes. The slip displacement reached 12 m at the depth of 1 km. Recovering deep cores which penetrate the fault zone is essential for the studying the physical fault structure. Fault zone rocks are extremely fragile and easily altered by weathering, so surface outcrops can provide only limited information. Cores from the region of large slip on the Chelungpu fault provide us a unique opportunity to sample the fault in a recent earthquake.

Fig. 1 shows the location of Taiwan Chelungpu-fault and the fault core gouges those were drilled in the fault zone of 1999 Chi-Chi earthquake under the Taiwan Chelungpu-fault Drilling Project (TCDP). Employing the nano-transmission X-ray microscope (TXM), transmission electron microscope (TEM), scanning electron microscope (SEM) and optical microscope (OM), we study the particle size distribution of a 12 cm thick primary slip zone (PSZ) core gouges. Fig. 2 shows the preliminary result of the TXM 2D phase contrast images of fault core gouge within 12 cm about 1111.29 m depth. The particle size distribution of the ultracataclasite from all images is shown in Fig. 3, which is consistent with the power law $N(D) = aD^{-b}$, where D is particle diameter, N(D) is the number of particles for each size diameter per unit area (mm^2), and constants a= 0.017, b=2. The grain size of 50 nm to 150 μm were observed for PSZ. We determined a particle surface area of 4.0×10^6 m^2/m^2 assuming the spherical grains. Assuming free-surface energy is 1 J/m^2, and the geometric surface should be increased by about a factor of 5 to account for non-spherical grains shapes, we obtained a value of 2.0×10^7 J/m^2 for surface fracture energy in PSZ.

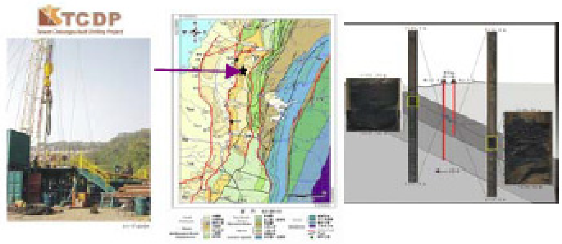

Figure 1. Taiwan Chelungpu-fault Drilling Project. We measured the gouge at about 1111.29 m depth.

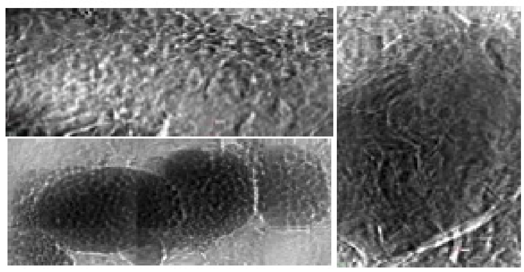

Figure 2. 2D phase contrast image of the gouge within 12cm about 1111.29 m depth.

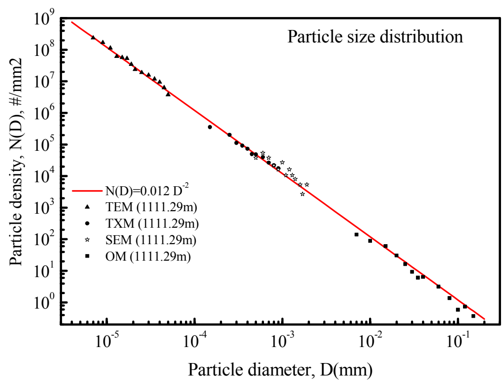

Figure 3. Particle size distribution from 2D phase contrast image of the gouge within 12cm about 1111.29m depth.

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