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Deformation and Physical Properties in the Well of Taiwan Chelungpu Fault Drilling Project, Takeng, West-central Taiwan

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The TCDP (Taiwan Chelungpu-fault Drilling Project) for understanding earthquake physics of the Chi-Chi earthquake was commenced in Feb., 2004 in Takeng, west-central Taiwan where a large surface slip (~10 m) is observed. Two holes (Hole-A and B) of 40 meters apart were drilled to 2000 and 1350 m, respectively. Continuously coring and a comprehensive suit of geophysical logging were conducted from 500 to 2000 m in Hole-A and 950 to 1350 m in Hole-B. Three formations (Cholan, Chinshui and Kueichulin) from Early Pleistocene to Late Miocene were encountered in the drilled holes. In Hole-A the boundaries of three formations were temporarily set at depth 1015 and 1290 m (log depth) based on the correlation of the Gamma-ray log, core image and lithologic column from field survey. Most fractures, identified both in the cores and FMI (or FMS) logs, are bedding parallel with an averaging dipping 30 deg. (range 20-40s). Nevertheless, zones of increasing (from 30 to 75 deg.) and decreasing dip (from 70 to 20 deg.) angles were found within 1770-1800 m and 1820-1848 m. Beds below depth of 1860 m oriented at a high-angle (60-80 deg.) regional dip. These prominent features imply structural events and/or fundamental changes of structures occur in these boundaries.

In Hole-A more than 9 fault zones identified are distributed in the Chinshui Shale and Kueichulin Formation. The shallowest one at depth 1111m is the most possible fault zone associated with the recent ruptured Chi-Chi earthquake. This fault is associated with bedding-parallel thrusting with a gentle dip of about 20 degrees. The fault zone is characterized by over 1 m long gouge zone (fault core) and gradational in both upper and lower to breccia and protolith. This implies that the Chelungpu fault may locally cut up-section from bottom (as shown in outcrop ruptures) to the shallow horizon of the Chinshui shale. Well logs show relatively low resistivity, high Vp/Vs ratio (~2.4) and Poisson ratio (~0.4) and indicate a weak fault zone and probably high fluid content. The low energy, slowness and time anisotropy as well as low permeability from shear wave anisotropy are manifestation of the uniformly deformed fault gouge. Results of analysis from DSI (Dipole Shear sonic Imaging) tool show that average fast shear (a proxy of maximum horizontal stress) in the interval of 1000-1300 m is populated in the direction of N60W-S60E and two sub-stress orientations averaging N20W-S20E and N85W-S85E. This prominent feature could be related to the fracture sets (one extensional major set and two conjugate minor sets) developed in the thrusting stress regime.

Keywords: ICDP, Chi-Chi earthquake, Chelungpu fault, TCDP