

Stress and effective frictional coefficient estimated by micro-fault inversion method in Chi-Chi seismogenic fault, Tai

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Introduction: Stress changes spatially and temporally in seismic cycles. Chelungu-pu fault is a seismogenic reverse fault that can be drilled from on land. In Taiwan Chelungu-pu Fault Drilling Project (TCDP) detailed structural data was obtained from drilled core. Additionally the surface rupture zone of the fault is well traceable in surface topography. In this study, we estimated paleo stress and effective friction coefficient from micro-faults, and then, discuss the relationship between spatial and temporal changes of stress and seismic cycles.

TCDP core: Deformation structures such as micro-fault, open crack, and fault rock were described from TCDP core observation. Slip data including displacement orientation and slip sense is obtained from slickenlines, rake and slickensteps. Calcite vein accompanies with some micro-fault or open crack.

Fault data from on land outcrops: In order to compare with slip data of TCDP core, we gathered slip data from a surface rupture zone on land. The surface rupture zone exposes 450m long along the river located at southern part of Dakeng Earthquake Park. Lithofacies is composed mainly by gray shale and slightly thick sandstone. Most of micro-fault which we could get slip data presented in range of 100m.

Grouping of slip data: We classified slip data into two, as the hangingwall side (T1) and footwall side (T2). The boundary is at 1153m. We have classified the micro-fault as that with vein, vein (T1c or T2c), without vein (T1n or T2n), fault zones (FZ), all of data (ALL) for TCDP data. Slip data from surface rupture zone is classified into 4 on the basis of resulted stress ratio (s1-s4). Stress ratio shown in $\phi = (\sigma_2 - \sigma_3) / (\sigma_1 - \sigma_3)$. Number of the slip data is following, ALL is 153, Fz is 10, T1c is 33, T1n is 65, T2c is 27, T2n is 31, s1 is 32, s2 is 26, s3 is 28, and s4 is 28.

Micro-fault inversion method: We used inversion method Hough transformed inversion method (HIM) (Yamaji et al., 2006) that uses Hough conversion. We estimated effective friction coefficient μ from minimum of the ratio of normal stress to shear stress on each micro fault.

Result: Direction of compressional axis for ALL, T1c, and T1n are WNW-ESE, NNW-SSE for FZ and EW for T2c and T2n. As a consequence, directions of compressional axis for T1 and T2 are different at the boundary of fault zone 1153m. Direction of compressional axis from surface rupture zone, for s2 and s4 are WNW-ESE, NNW-SSE for s1 and NS for s3.

Over all, stress ratio estimated from drilled core represent a small, about 0.008-0.274. The stress ratio from surface rupture zone is 0.0194-0.6448. Effective friction coefficient μ of core is 0.08-0.70 for ALL, 0.51 for FZ, 0.74 for T1c, 0.18-0.65 for T1n, 1.14 for T2c, 0.51-1.44 for T2n. μ of surface rupture zone in 0.04 for s1, 0.08 for s2, 0.13 for s3, and 0.09 for s4. μ of T1 is higher than that of T2.

Discussion: Compressional direction of T1 coincides with the direction reported in Lin et al (2010) which estimated the modern stress state by borehole breakout. T2 direction, however, indicates slightly different from the modern state. s2 and s4 show almost the same direction as T1 direction. s1 is consistent with that in FZ. Lin et al (2010) also represented that compressional direction rotated about 90 degree from other place in vicinity of fault zone. Compressional direction of s3 is rotated but the rotation is only about 60 degree. High effective friction coefficient of micro-fault with veins suggests low fluid pressure along the fault. Micro-faults without vein are expected relatively high fluid pressure, which reduce effective frictional coefficient. Stress ratio for FZ shows one order lower than the others, suggesting that the fault zone was formed under large axial compression in seismic events.

Reference:

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