Multi-disciplinary approaches toward understanding the fault slip behaviors from surface to depth: a case study of the Chihshang Fault in eastern Taiwan

*Jian-Cheng Lee[1], Shu-Hao Chang[1], Chung-Hsiang Mu[1], Wen-Jeng Huang[2], Horng-Yue Chen[1]

1.Academia Sinica, Taipei, Taiwan, 2.National Central University, Chungli, Taiwan

Based on a multi-disciplinary approach, including geological survey, geodetic GPS and leveling measurements, seismology, frictional properties modeling, kinematics dislocation modeling, hydraulic experiments and analyses and geophysical surveys, we aim at better characterizing the slip behaviors of an active fault from surface to depth and their spatial and temporal variations. Our case study is the Chihshang Fault, which we treat as an example of an on-land mega-thrust at the converging plate suture between the Philippine Sea plate and Eurasia. The geometry of the Chihshang Fault is characterized by a 35-km-long, 25-30-km deep patch, which exhibits a listric shape with dip angle of about 60-70° at the shallow kilometers and of about 20-30° at the depth of 20-30 km. GPS and leveling data indicate that the Chihshang Fault is creeping at a rather high rate of about 3-5 cm/yr for mostly the whole patch during the interseismic peripod. According to seismological studies, the slippage on the fault is accompanied by abundant micro-seismicity distributed on the fault patch at the depths of 5 to 25 kilometers. Amongst this seismicity, repeating earthquakes were observed at some places, especially near the northern edge of the fault patch. It seemed that these numerous interseismic micro-earthquakes had released a substantial part of the strain accumulated on the fault induced by the plate convergence or the attachment of the Luzon arc to the Chinese continental margin. However, the 2003 Mw=6.8 Chengkung earthquake suggests otherwise. How the strain accumulated to produce the Chengkung earthquake is still under investigation. But we do observe a significant decrease of surface fault creeping rate of about 25%, starting about 3-4 years before the Chengkung earthquake, which is also suspected to be due to effect of 1999 Mw=7.5 Chi-Chi earthquake (e.g., stress transfer). It is worthy note that the creep meters data along the surface fault zones at Chihshang site revealed a clear seasonal variation, implying a dry-season lock with no or very little slip. Numerical modeling by applying frictional instability laws suggested this seasonal slip/stress perturbation in relation with rainy season is confined within the upper hundreds of meters level, with a positive value of frictional property (a-b). We tend to interpret that this frictional property is related to the unconsolidated alluvial deposits, which cover the Longitudinal Valley for a thickness estimated to be about 3-5 hundreds meters. Indeed the propagation of the Chengkung earthquake co-seismic slip had decreased drastically in the uppermost 1-2 kilometers. And the accumulated strain in the upper segment of the fault has been released by rapid post-seismic slip following the earthquake. This is also consistent with the dynamic effect on the frictional property of the fault.

Keywords: active fault, creep, earthquake, frictional property

Chihshang Fault in eastern Taiwan