# Fault rocks from from boreholes penetrating Shalung-pu fault, Taiwan; Suggestions to slip behaviors during 1999 Chu-Chu earthquake

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The fault slip during 1999, the Chu-Chu earthquake (M7.3) was smooth, high-velocity and large in the north, while in the south the slip velocity was irregularly fluctuated and the slip was much smaller than the north. We analyzed the fault rocks obtained from two shallow boreholes (Fengyuan site: 450m, and Nantou site: 210m) penetrating Shelung-pu fault, and try to explain the contrastive slip behaviors mentioned above.

I.Characteristics of fault rocks from Fengyuan site

Many fault gouge layers are developed in the depth range from 150m to 420m. The thickness of the gouge layers ranges from 1cm to 3m. Their main characteristics are as follows.

1. The matrix of fault gouge layers is composed of high-water content soft clay.
2. The gouge layer is associated with a zone of high deformation concentration 1-3cm thick.
3. The major part of each gouge layer is occupied by fault breccias with soft clay matrix.
4. Injection veins of clay are well developed. These veins start from the main slip zone to extend into the breccia zone and the fault wall rock.

II.Suggestions to seismic fault slip behaviors

The breccias in the clay veins were comminuted during injection. The relative velocity that is sufficient for the breccias to be collapsed by their head-on collision is calculated at several cm/sec to several tens m/sec. This indicates that the clay injection occurred during seismic events. The injection veins demand the pressure gradient, and the lubricant model by Brodsky and Kanamori, 2001) will be appropriate. This mechanism worked effectively and caused the smooth, high-velocity and large slip during the Chu-Chu earthquake.

III.Characteristics of fault rocks from Nantou site

At the Nantou site, the Shelung-pu fault was penetrated at the depth of 175m. The fault zone is about 2m thick and composed of comminuted granules of old pseudotachylyte (PT). The observational results are as follows.

1. Clay minerals in the samples suggest the alteration at around 100 deg. after the comminution.
2. In the coarse grains of the PT, thin (about 1mm) layers are well developed. These layers are in the scraping or scraped relationships with the adjacent layers, suggesting that each layers is likely to correlate to one seismic slip event.
3. Based on the volume fraction of un-melted grains in many PT fragments, the degree of melting of PT was classified into 6 ranks: MD0(un-melted), MD1(smaller than 44%), MD2(ca. 31%), MD3(ca. 22%), MD4(ca. 14%), and MD5(ca.10%). The total frequency of MD0, MD1 and MD2 attains 80%, while it is only 5% for MD4 and MD5.
4. Softening and flow of the marginal part of un-melted various mineral species in PT are the useful makers to estimate temperature of melt (Otsuki et al., 2003). We can correlated MD1 to MD2 to 750 to 900 deg., MD3 to 1,150 deg., and MD5 to 1,750 deg.
5. The degree of melting of old PT fragment is higher than the new PT that is the matrix of old PT.

Iv.Suggestions to seismic fault slip behaviors

The Nantou PT is a product of repeating old seismic slip events, and we know already that the probability of the melting degree smaller than MD2 attains 80%. Therefore, it is likely that the case of the Chu-Chu earthquake also was the same. PT melt lower than 900 deg. Restrains seismic slip (Otsuki et al., 2003). Therefore, when the rupture front of the Chi-Chi seismic fault encountered the barrier of low melting degree, slip would have been restrained. The fault plane tends to melt patchily, and hence the fault plane would have slipped irregularly associating the radiation of high frequency elastic waves.