Pseudotachylyte from TCDP Hole-B: Its implications of seismic slips

Masahiro Omori[1]; Kenshiro Otsuki[2]; TCDP Hole-B Research Group[3]

[1] Geoenvironmental Science, Tohoku Univ.; [2] Earth Sci., Tohoku Univ.; [3] -

Seismological data elucidated that the seismic slip during the 1999 Chi-Chi earthquake, Taiwan, showed contrastive behavior; on the northern fault segment of the Chelungpu fault with fast (2-4 m/s), smooth and large slip (10 m), while slow (0.5 m/s), irregular and moderate (3-4 m) slip on the southern segment. These data suggest that on the northern fault segment mechanisms of slip instability (elastohydrodynamic lubrication and/or thermal pressurization) worked effectively, especially at the shallow depth.

In order to investigate the nature of this seismic fault, Taiwan Chelungpu fault Drilling Project (TCDP) was conducted, reaching the maximum depth of 1352.60 m. Core samples were recovered from the depth range from 948.42 to 1352.60 m. It is noted that thin black layers are intercalated at three horizons; at 1194 m (thickness of 2 cm), 1243 m (3 cm), and 1314.19 m (7 mm). These black layers have been called 'BM disk'.

We investigate microstructures and chemical compositions of the core samples of these black layers by using EPMA and FE-SEM. The characteristics are as follows.

(1) 'Black disks' are harder than the host rocks.

(2)They are composed mainly of grains of quartz, plagioclase and K-feldspar smaller than a few tens micrometers as well as the small amount of glassy matrix with solid grains smaller than 1 micro meter.

(3)The major element components of the matrix are Na_2O (1.5-2wt. %), MgO (2.5-3.5%), Al_2O_3 (17.4-23%), SiO_2 (56-65%), K_2O (2.7-3.8%), CaO (0.3-0.4%), TiO (0.5-1%), and FeO (5.6-6.5%), which are very close to the composition of pseudotachylyte from the Nojima fault.

(4)Vesicles of several micron meters are found frequently in the matrix. Hourglass structures, which suggest the strings of melted materials, are found sometimes bridging the opposite walls of vesicles.

The characteristics cited above indicate that the materials of 'BM disks' are pseudotachylyte.

(5)The pseudotachylyte layers contain small solid fragments of pseudotachylyte, indicating the pseudotachylyte layers are the products of multiple seismic slip events.

(6)Fragments of pseudotachylyte are included also in the black fault gouge layers which are developed just above and/or below the pseudotachylyte layers. This evidences that the formation of pseudotachylyte layers are older than the gouge layers.

(7)These characteristics indicate that black layers are pseudotachylyte layers made by frictional melting. As volume fractions of unmelted grains are large, each layer is very low melting degree.

These evidences suggest strongly that the pseudotachylyte layers were not formed during the 1999 Chi-Chi earthquake but during ancient earthquakes. Since the total displacement of the northern segment of the Chelungpu fault is about 300m (Yue et al., 2005), the pseudotachylyte layers were likely to be formed at ca. 2km, and it is plausible that frictional melting of low melting degree occurred at ca. there also during the 1999 Chi-Chi earthquake. The results of waveform inversion by some seismologists show the region of relatively small fault slips and slip rate at about 7 km depth(Zeng and Chen, 2001). This may be attributed to the highly viscous melt materials of very low melting degree. The slip zone of shallower depth also may be heated frictionally, and thermal pressurization may have cooperated with clay lubrication.