Japan Geoscience Union Meeting 2014
(28 April - 02 May 2014 at Pacifico YOKOHAMA, Kanagawa, Japan)

SSS31-07 Room:502 Time:April 30 16:15-16:30

HV frictional strength of wet Longmenshan fault gouge and its comparison with the temperature anomaly in WFSD drill hole

TOGO, Tetsuhiro[1*] ; SHIMAMOTO, Toshihiko[1] ; MA, Shengli[1] ; YAO, Lu[1]

[1]Institute of Geology, China Earthquake Adiministration

Estimation of frictional strength from temperature anomaly along coseismic fault in a drill hole after a large earthquake has received much attention recently (e.g., J-FAST project in Japan Trench after the Tohoku-oki earthquake. Surface ruptures more than 250 km long formed along existing Yingxiu-Beichuan fault, a major fault in the Longmenshan fault system, during the 2008 Wenchuan earthquake (Mw = 7.9). Drilling was conducted at Hongkou in Dujiangyan city, a western part of the fault, as a part of Wenchuan Earthquake Fault Scientific Drilling (WFSD). Temperature monitoring is an important task in the project, and WFSD-1 hole was drilled within one year after the earthquake (fastest drilled hole after a large earthquake in the world). Drilling revealed a large scale fault zone for the depth range of 580˜760 m, consisting of cataclasites (about 10 m wide), many thin fault gouge zones and fault breccia (Li et al., 2013, Tectonophysics). Temperature anomaly of only 0.15 degrees Centigrade was recognized at a depth of 590 m along a presumed coseismic slip zone (evidence for coseismic slip zone is not so strong though). Mori et al. (2010, AGU) report friction coefficient less than 0.03 from this temperature anomaly. This friction coefficient was even lower than low friction coefficients (typically 0.05˜0.2) at high slip rates, reported in the last two decades.

We have conducted wet gouge experiments on foliated fault gouge containing 25 wt% of water with Teflon sleeve at slip rates to 1.3 m/s and at normal stresses of 1.0˜4.8 MPa, and compared the results with those on dry gouge with room humidity. Sample was collected from the Hongkou outcrop (see Togo et al., 2011a, EQS), only several hundred meters from the WFSD-1 drill site. Wet gouge has peak friction coefficient of 0.1˜0.36 and steady-state friction coefficient of 0.03˜0.14, as compared with 0.65˜0.8 and 0.15˜0.2 for dry gouge (Togo et al., 2011b, EQS). Wet gouge is substantially weaker than dry gouge, but its frictional strength is still somewhat greater than expected from the near absence of temperature anomaly. However, normal stress expected at the depth of temperature anomaly is expected to be more than twice as high as those of our experiments (experiments could not be done at higher normal stresses due to gouge leak). Both peak and steady state friction coefficients of wet gouge tend to decrease by a power low with increasing normal stresses and the extrapolated steady state friction coefficient at the drilling depth reached from 0.028 to 0.022, which results are consistent with the result by Mori et al. (2010). Thus wet gouge has frictional strength fairly close to that expected from the temperature anomaly.

Wet and dry gouges have completely different deformation textures. Deformed dry gouge is characterized by ultrafine-grained slip zones (typically several to a few tens of microns thick) and weakly deformed gouge. Overlapped slip-zone structures are very common in sheared dry gouge. On the other hand, slight grain-size refinement occurs in wet gouge, and the whole wet gouge zone remains only weakly deformed. We consider that the build-up of pore pressure due to compaction induced and/or thermal pressurization separated grains and suppressed grain crushing in wet gouge.

Keywords: High-velocity friction experiment, Longmenshan fault, Wenchuan earthquake, Frictional heating, Bore hole temperature measurement