Frictional melting during experimental stick-slip events: Detection of melting time and its implication to slip behaviour

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We conducted stick-slip experiments for mirror finished surface of granite samples under the 150Mpa confining pressure. The mechanical and electromagnetic signals were detected by sensors set in the pressure vessel; the axial load and slip by strain gages, tribo-electric potential by two electrodes dug on the slip surface, the electric potential induced by the current along slip surface by troidal coil set at a right angle to the slip direction. These signals were recorded in sync with each other at 500kHz response frequency and 2MHz sampling rate.

The series of 6 stick-slip events shows the characteristics below.

(a) The 300Hz and 10kHz proper vibrations of the machine and its parts were detected. The oscillation of the electrode potential was completely synchronous with that of the axial load. Therefore, the former is concluded as piezoelectric.

(b) The duration of rise time is 20 to 30 micro-sec, and the mean slip velocity attained 100m/sec.

(c) When the slip event is small, high frequency vibration dominated. In the cases of large events, high frequency vibrations were associated during the early slip phase, and the slip became smooth thereafter.

(d) High frequency and low amplitude oscillations of the axial load and slip preceded the main slip by several micro-sec.

(e) The electrode potential also began to oscillate before the initiation of the main slip, the amplitude maximized at the midst of slippage, and decreased suddenly thereafter.

(f) The amplitude of the electric potential induced in the troidal coil increased just after the electrode potential became maximum.

(g) The induced potential can be converted to the current parallel to the slip surface, and the electric resistance is calculated from the ratio of the electrode potential to the current. The calculated resistance shows the sudden decrease after 4 to 8 micro-sec of the initiation of slip, and it decreased 3- to 5- order of magnitude finally. Therefore, we conclude that:

(i) slips generated the frictional electromotive force and electric charges increased between the electrodes,

(ii) a conductive material, probably melt layer, was generated at the early phase of slip, and

(iii) the charges began to flow and electric potential was induced in the triodal coil.

(h) The friction coefficient was around 0.7 before slip, but it drastically decreased to 0.2 after about 10 micro-sec. However, the effect of frictional melting to the frictional resistance is not clearly recognized.

The next presentation by Otsuki et al. will report the characteristics of the melt layers observed and analyzed by SEM and EPMA.