# Possible mechanism of preseismic sliding and silent earthquakes beneath seismogenic zones

# Naoyuki Kato[1]

[1] ERI, Univ. Tokyo

Models of seismic cycles on the basis of rate- and state-dependent friction laws can simulate many geophysical phenomena such as pre- and post-seismic sliding and episodic aseismic sliding events. Preseismic sliding and episodic aseismic slip events may occur at regions of velocity-weakening frictional properties, where the rate dependence of the steady-state friction coefficient dfss/d(lnV) is negative. Seismic slip may also occur at such regions. In existing models of seismic cycles with rate- and state-dependent friction laws, preseismic slip occurs in seismogenic zones (e.g., Kato and Hirasawa, 1999).

However, observed events of preseismic sliding have often been estimated to occur at depths deeper than seismogenic depths. For example, crustal deformation prior to the 1944 Tonankai earthquake can be explained by aseismic sliding at depths deeper than coseismic slip (Linde and Sacks, 2002). Such preseismic sliding cannot be simulated with existing models with rate- and state-dependent friction laws.

Kamiya and Kobayashi (2000) suggested that the existence of serpentine controls the transition from unstable to stable slip at depth. Rate dependence of frictional strength of serpentine is complicated, and dfss/d(lnV) is positive at some velocities and negative at the other velocities (Moore et al., 1997). Similar complicated rate dependence of friction was observed for some other rocks (e.g., Weeks, 1993). When dfss/d(lnV) is negative for V smaller than Vt and dfss/d(lnV) is positive for V larger than Vt, slip is accelerated for V smaller than Vt and is decelerated at higher velocities. In this case episodic aseismic slip is expected to occur. This is actually shown by Weekes (1993) for a single-degree-of-freedom spring-block system.

In the present study, I perform a numerical simulation of seismic cycles at a subduction zone applying the equation of steady-state friction fss=f*-aln(V*/V)+bln(V*/V+V*/Vt) assumed by Weeks (1993). It is remarked that Shibazaki and Iio (2002) presented a model for episodic aseismic slip events on the basis of a similar idea of rate dependence of steady-state friction.

In the present model, constitutive parameters a, b, and the characteristic slip distance L are assumed to be uniform independent of depth. Vt is taken to be 1 m/s at depths shallower than 25 km, and Vt increases with depth for depths deeper than 25 km. The simulation result for L = 1 cm indicates that episodic aseismic slip events repeatedly occur at depths around 30 km during an interseismic period, and significant preseismic sliding occur almost the same depths. Seismic slip never occurs at these depths. In the case of L = 2 cm, similar simulation result is obtained, though an episodic aseismic slip event occurs once during a seismic cycle. In the case of L = 5 cm, no episodic aseismic slip event occurs and significant preseismic sliding occur in the seismogenic depths.

The simulation result for L = 1 cm may explain the episodic aseismic slip event observed in the Tokai region and significant preseismic sliding of the 1944 Tonankai earthquake. It is important to determine the regions of coseismic slip and preseismic slip and to examine frictional behavior of rocks at wide range of sliding velocity.

References

Kamiya and Kobayashi, 2000, Geophys. Res. Lett., 27, 819-822.
Kato and Hirasawa, 1999, Bull. Seismol. Soc. Am., 89, 1401-1417.
Linde and Sacks, 2002, Earth Planet. Sci. Lett., 203, 265-275.
Moore et al., 1997, J. Geophys. Res., 102, 14787-14801.
Shibazaki and Iio, 2002, Eos, Trans. AGU, 83, Fall Meeting Suppl., F358.