Slow slip events and its implication to deterministic prediction

Ichiro Kawasaki[1]

[1] RCEP, DPRI

http://www.rcep.dpri.kyoto-u.ac.jp/~kawasaki/

1. Summary of silent earthquakes

About 10 silent earthquakes were recently documented in Japan. We can summarize them as follows:

(1-1) They occurred along the transition zone at depths of around 30 km between coupled and uncoupled regions on the subduction interface. All silent earthquakes documented to date in Alaska, Cascade and Mexico occurred along the transition zone.

(1-2) Their time constants were from days to years. Their equivalent magnitudes (Mwa) were less than 7. Slips were less than 20 cm while those of major asperities of Mw8 class giant earthquakes were lager than 3 m on subduction interface of the Philippine Sea plate at depths shallower than 30 km.

(1-3) They were associated with little earthquake activity.

2. Issues toward earthquake prediction

Then, following issues are addressed.

(2-1) What kind of physical phenomena are they?

(2-2) Are there slow earthquakes of Mwa 7 or greater with time constants of hours, faster and larger than silent earthquakes documented to date?

(2-3) Is real-time detection of such silent/slow earthquakes possible? By GPS network of GEONET and the tiltmeters installed at NIED Hi-net borehole, the real-time detection will be possible in near future.

(2-4) Can we predict an occurrence time and its size of impending earthquake based on the real-time observation of the silent/slow earthquake?

3. What kind of physical phenomena ?

Yoshida and Kato (2002) and Kato (2002) attempted interesting numerical simulation of two block model having different frictional properties. Based on their results, we could regard silent earthquakes as one of phases during nucleation process.

4. Do we have measures to predict an occurrence time and a size of impending event?

Based on laboratory experiments of earthquake nucleation, Ohnaka and Shen (1999) derived the power-low between a size and a rupture velocity of nucleation phase. With some assumptions, we can transform the power law into the time-dependent moment as Mon(t)=C*(tE-t)**(-1/2), where Mon(t) is a moment of the nucleation phase, t is a lapse time, tE is the occurrence time and C is a constant. This could give rough estimates of an occurrence time and a size of impending event.

5 . Mapping of silent earthquakes

We have two end members of rupture propagation processes : (1) monotonous acceleration of the nucleation phase following the equation above mentioned on a fault plane having homogenous distribution of frictional strength and (2) the self-organized critical one on a fault plane where frictional strength is strongly inhomogeneous. Real earthquake nucleation process from silent earthquakes of Mwa 6-7 with time constants of days to years, slow earthquakes of Mwa 7-7.5 with time constants of hours to giant earthquakes should be between the two end members, controlled by degree of the inhomogeneity of the frictional strength. Thus, one of major targets of prediction study in coming decade should be mapping of silent and slow earthquakes, leading to the inhomogeneous distribution of the frictional strength, focusing on slow earthquakes of Mwa7-7.5 with time constants of hours.