

Repeating short- and long-term slow slip events with deep tremor activity in western Shikoku and Bungo channel region

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Nonvolcanic deep low-frequency tremor, which occurs in a belt-like zone parallel to the Nankai trough, is thought to be a manifestation of a dehydration process in the subducted Philippine Sea slab [Obara, 2002]. This phenomenon plays an important role in exploring not only water circulation and migration of materials during plate subduction, but also an effect on a shallower great earthquake generation process.

Recently, it has been found that the tremor does not occur uniformly in the belt-like zone, but occurs in several clusters [Obara and Hirose, 2003]. Some of these clusters are activated quasi-periodically [Obara and Hirose, 2003]. In addition, crustal deformation which is coincident with the periodic tremor activity is found [Hirose and Obara, 2003]. This crustal deformation can be explained by repeating slow slip events (SSE) with about five days duration on a deeper end or a deeper part of a transition zone of interplate coupling [Hyndman et al., 1995] on a plate interface between the subducting Philippine Sea plate and a continental plate. In other words, a similar phenomenon to Episodic Tremor and Slip (ETS) found in Cascadia subduction zone [Rogers and Dragert, 2003] possibly occurs in the Nankai trough subduction zone [Hirose and Obara, 2003].

In the Bungo channel region, adjacent to the ETS region in western Shikoku, SSE which lasted about one year occurred during late 1996 to 1997 [Hirose et al., 1999; Ozawa et al., 2001]. Geographical Survey Institute [2003] reported that crustal deformation due to the next SSE in Bungo channel was observed, which began around August 2003 after an interval of about six years, and continues for 2-3 months. Horizontal components of high-sensitivity accelerometer (tiltmeter) equipped with National Research Institute for Earth Science and Disaster Prevention (NIED) high-sensitivity seismometer network (Hi-net) also detected the corresponding tilt changes. This long-term crustal deformation seems to start simultaneously with or just after the ETS in western Shikoku that occurred on late August, 2003 and finished at around December, 2003. During this period, the deep tremor activity continues sporadically at northern Bungo channel region, where the deeper part of the long-term slow slip source area may be located. After early December, 2003, however, the tremor activity is rarely observed at the region. In addition, at the western and the middle western Shikoku, two short-term SSEs with tremor activity (ETSs) were observed on early and late November, 2003, respectively, when the long-term crustal deformation seems to cease.

The observation of the tremor and the SSEs can be summarized as follows: (1) in the western Shikoku, short-term SSE whose duration is about five days occurs coincident, in space and time, with deep tremor activity, and this coincident event recurs quasi-periodically in every 3-6 months; (2) in the Bungo channel, long-term SSE which lasts for several months repeatedly occurs in about six year interval and is sometimes accompanied by minor tremor activity.

The activities (1) and (2) may be an indication of the transition in stability of sliding motion along dip direction on a subducting plate interface. Indeed, the activity (1) occurs more frequently at around a steady sliding zone or the transition zone of interplate coupling at 30-40 km depth, the activity (2) appears less frequently, about several year interval, on shallower part, and on the further shallower part, the great earthquakes recur every several decades to hundreds of years. Because the recurrence intervals of these slip events are expected to be proportional to their stress drops, these observations suggest the sliding stability transition from stable to unstable slip with decreasing depth.