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Depth-dependent activity of nonvolcanic tremor in the Nankai subduction zone

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For the last decade, some types of slow earthquakes have been detected in the Nankai subduction zone based on densely distributed seismic and geodetic observation networks. At the deeper part in the transition zone between the locked and stable sliding zones, the tremor is distributed within a narrow belt with a 600 km along the strike of the subducting Philippine Sea plate (Obara, 2002). The spatiotemporal activity of tremor is divided into some segments with a certain regular recurrence interval of three or six months (Obara, 2010). The major tremor burst is often accompanied by the short-term slow slip event (Obara et al., 2004) and deep very low frequency earthquake (Ito et al., 2007) with duration of a several days. Between the belt-like tremor zone and locked zone, the long-term slow slip event with duration of years and recurrence interval of a several years occurs at western and eastern edges of the tremor belt-like zone; Bungo channel (Hirose et al., 1999) and Tokai area (Ozawa et al., 2002).

These slow earthquakes represent a clear depth-dependent property. The slip behavior in time is drastically different between the shallower long-term slow slip event and deeper coupling events. Within the tremor source area, the temporal behavior of tremor activity is different in depth. In western Shikoku and northeastern Kii where major tremor bursts associated with short-term slow slip events occur at regular recurrence interval of months, the tremor distribution is separated into double peaks at shallower and deeper edge in the dip direction (Obara et al., 2010). The updip tremor activity is modulated by the major tremor burst; on the other hand, the downdip tremor activity is composed of more frequent occurrence of minor burst. The initiation of the tremor activity often occurs from the deeper part and migrates updip direction, then propagates along strike laterally. Between the bimodal distribution of downdip and updip tremor activity, the tremor propagates through the inactive region. This indicates that the rupture front propagates through this region without active tremor triggering. Ide (2010) relocated the tremor activity in western Shikoku based on the improved envelope correlation method and pointed that the tremor with longer duration is concentrated in the inactive region.

In Bungo channel, the long-term slow slip event with duration from a half to one year occurs every 6 years in 1997, 2003 and 2010. The transient slip event strongly affect to the tremor activity. Especially, the updip part of the tremor activity in Bungo channel is clearly correlated to the GPS displacement caused by the long-term slow slip event; however, the downdip part activity is very stable even during the transient slip period (Fig.2b). This indicates that the long-term slow slip source region is adjacent to the tremor region and the contact interface of the uppermost tremor region is only triggered by the transient slip. The difference between the tremor and the long-term slow slip event might be a change in the structure of the hanging wall, like as continental lithosphere and wedge mantle.