The relationship between slow earthquake activity and frictional property on the plate boundaries around Japan islands

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On the subducting plate boundaries, slow earthquakes are distributed mainly in the downdip and updip vicinities of seismogenic zones of megathrust earthquakes and we expect some relationships between both earthquakes. The relationships could be revealed by spatial variation of slow earthquake activity reflecting the heterogeneity of the frictional condition on the plate boundary. We focus on very low frequency earthquakes (VLFEs) which are one type of slow earthquakes and whose signal has a predominant period of 20-50 s, because they have the potential to clarify detailed spatiotemporal slip behaviors in the updip and downdip sides of the seismogenic zone.

Around Japan, the Philippine sea plate and the Pacific plate subducts from the Nankai Trough and the Japan and Kuril Trenches, respectively. Along the Japan and Kuril Trenches, Baba et al. (2020) detected VLFEs comprehensively by the matched-filter technique. They used synthetic waveforms from virtual sources on the plate boundary using a three-dimensional velocity model as templates. In this study, to compare all VLFE activities across Japan, we detected VLFEs along the Nankai Trough by the same method as Baba et al. (2020) by using continuous NIED F-net seismograms from January 2003 to June 2019.

We detected 1,925 deep VLFEs and 18,298 shallow VLFEs. Deep VLFE activity in the depth range of 30-40 km accompanies with short-term SSEs, which occur in the interval of several months (Nishimura et al., 2013). Shallow VLFEs in the depth range of 5-10 km activated episodically in the interval of several months to several years and the interval of the activation of shallow VLFEs is longer and more various than that of deep VLFEs. Shallow VLFE activity off the Kii peninsula had been high during the period of shallow SSEs in 2009 and 2017-2018 (Yokota and Ishikawa, 2020).

The distribution of shallow VLFE activity rate is more heterogeneous along trench axes and clearly shows an anti-correlation relationship with the spatial distribution of interplate coupling rate (Hashimoto et al., 2012, GJI; Noda et al., 2018, JGR), whereas the variation of deep VLFE activity rate is small and deep VLFEs are distributed only in weak coupled areas. This suggests that the along-strike heterogeneity of frictional property is stronger in the shallow part than in the deep part. Temporal changes in shallow VLFE activity synchronized with the interplate coupling change after huge earthquakes. Furthermore, shallow VLFEs are mainly hosted within low seismic velocity anomalies, thus slow earthquakes can be encouraged by decreased effective stress due to high pore fluid pressure within regions with weak interplate coupling. Our results suggest that slow earthquake activity is an indicator illuminating interplate slip behavior surrounding the seismogenic zone.

Keywords: Slow Earthquakes, Very low frequency earthquakes, Slip deficit rate

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