

Deep Very-Low-Frequency Earthquake along the Nankai subduction zone

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Non-volcanic deep low-frequency tremors and slow slip events occur simultaneously in the transition zone from the locked slip to the aseismic slip along the Nankai subduction zone in southwest Japan [Obara 2002; Obara et al., 2004]. To understand the stress relaxation process in the transition zone of the deep portion of the subducting plate interface, it is important to identify all seismic and geodetic phenomena. Recently, we have detected the another slow earthquake with the predominant frequency of 20 s [Ito et al., 2007]. Here, we report the deep very-low-frequency earthquakes (dVLF) occurring on the subducting plate interface along the Nankai subduction zone.

Using the pass band filter of 0.02-0.05 Hz, we succeeded to detect anomalous distinct VLF signals. These signals were observed at several Hi-net tiltmeters and F-net stations. In particular, these wave trains are best identified on the radial and vertical components during high activities of the non-volcanic deep low-frequency tremor. Two peaks of 0.5 and 20 s were identified on velocity amplitude spectra: One of 0.5 s was radiated from the sources of tremors; the other was probably radiated from other sources. We also investigated velocity amplitude spectra of some other time windows, in which tremors were only observed without arrivals of distinct VLF signals. Only one peak of 0.5 s was observed on the velocity amplitude spectra. These results suggest that seismic sources radiating signals of 20 s were difference with those of non-volcanic deep tremors. We considered the sources of the VLF signals as VLF earthquakes, and we calculated their centroid location and moment tensor solutions.

To detect VLF signals systematically, we adopted the grid moment tensor inversion (GMTI) approach [e.g. Kawakatsu 1998]. By using this approach and the continuous seismogram, we calculated the point source moment tensor solution at each of 0.1 degrees and 3 km depth grid point. These measurements were performed at intervals of 1 s. We used continues observed data obtained from the four broadband stations closest to each grid point and bandpassed filtered from 0.02-0.05 Hz. After the calculation of variance reductions (VR) between observed and synthetic waveforms for all the points, the maximum VR over the grid was evaluated. The possible events with a VR exceeding the threshold value of 40, which were not contaminated by teleseismic and ordinary local earthquakes, were sampled from all moment tensor solutions at all grid points. To calculate the location and moment tensor solutions of dVLF events, we applied the centroid moment tensor inversion (CMTI) approach [Ito et al., 2006] to the possible events.

The dVLF events with seismic moment magnitudes of 3.1-3.5 were located on the belt-like distribution of deep low-frequency tremors along the strike of the subducting Philippine Sea plate. The focal depths of VLF earthquakes are distributed across a slightly wide range of 35-40 km. The dip angles of the nodal planes that dip landward are consistent with the slope of the Philippine Sea plate. The fault strikes of these nodal planes are generally subparallel to the depth contours of the plate interface. These results show that VLF earthquakes may occur on the subducting plate interface.