Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)

SSS27-P06 会場:コンベンションホール 時間:5 月 23 日 17:15-18:30

Lateral structure beneath the Izu-Nankai collision zone: Implication of a plate split in the subducting Philippine slab

Lateral structure beneath the Izu-Nankai collision zone: Implication of a plate split in the subducting Philippine slab

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On July 5, 2011, an earthquake with a magnitude of 5.5 occurred off the Kii Peninsula in the northern Wakayama Prefecture in southwest Japan within the subducting PHS plate at depth of around 10 km. The earthquake caused strong shaking in the area near the epicenter. We analyzed the waveforms from this earthquake recorded at Hi-net and F-net stations in Japan. Such waveform analyses exhibit most of the earlier observations like dominance of low-frequency ($f < 0.25$Hz) onset and following high-frequency ($f > 2$Hz) energy with long coda due to the stochastic waveguide effect of the subducting plate, proposed earlier by Furumura and Kennett (2005). Interestingly, we observed a clear difference in wave propagation pattern between east and west of the epicenter. For example, the waveforms for eastern part show S-coda are depleted with high frequency energy as compared to the western part. The duration of S-coda varies alternatively between high and low from east to west through center of the epicenter. The central stations show loss of low-frequency precursor to P-waves and presence of converted phases in P-coda. Such complexities in the observed waveforms are difficult to explain due to the radiation pattern of P- and S-waves and/or by anomalous propagation of seismic waves in existing plate model, indicating sudden lateral change in the wave guiding properties of the subducting slab, such as caused by the splitting of the slab as proposed by Ide et al. (2010).

To explain the observations, we employ two-dimensional finite-difference method (FDM) simulations of complete high-frequency P-SV wave propagation taking thinning of the PHS slab into account. In the plate model we included stochastic random heterogeneities described by von Karmann distribution function with a longer correlation length of 10 km in horizontal direction and much shorter correlation length of 0.5 km in depth and standard deviation from background P- and S-wave velocities of 5% following the study of Furumura and Kennett (2005). We expect that the observed guided wave energy decouples from the waveguide where the slab is split. Low frequency energy leaks out of the slab in the low velocity mantle surrounding the slab. Taking into account the distribution of seismicity and focal mechanisms (Ide et al., 2010), and receiver function analyses (Shiomi et al., 2004) in the PHS plate, we expect a local velocity discontinuity or splitting of the plate at least to a depth of 30 km. Such a split in the PHS plate structure could also be manifested as non-volcanic tremor sources in the southwest Japan (Obara, 2002). The preliminary results, which suggest that the Philippine Sea slab is strongly split or partitioned beneath the Izu-western Nankai Trough in southwestern Japan, is the cause of the complicated waves from shallow inslab events. These effects need to be tested further with a 3-D FDM simulation employing high-performance computers with a variety of possible slab geometries. We finally discuss the implications of the new split plate model on the seismogenic potential of the area and the dynamics of the Nankai subduction in southwest Japan.

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