Japan Geoscience Union Meeting 2015
(May 24th - 28th at Makuhari, Chiba, Japan)

SSS26-P02 Room:Convention Hall Time:May 26 18:15-19:30

Seismic wave propagation in the heterogeneous structure associated with the subducting Philippine Sea Plate

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Introduction

In the southwestern Japan, where the Philippine Sea Plate (PHS) is subducting from Nankai Trough, several distinct later phases were observed during intraslab earthquakes (e.g., Ohkura, 200; Miyoshi and Ishibashi, 2007; Hayashida et al., 2010). Since such later phases propagate through wider area compared with direct body waves, we examine the characteristics of distinct later phases in the southwestern Japan derived from dense Hi-net observations and three-dimensional (3D) numerical simulations in order to reveal heterogeneous structure around the subducting PHS.

Observed characteristics of high-frequency seismic waves

We used observed waveforms from dense Hi-net network during earthquake (Mw 4.2) that occurred at southern Hiroshima, southwestern Japan, on 2004 September 21. In fore-arc side of southwestern Japan (Shikoku region), distinct later phases were not observed and spindle-shape S waves with strong peak delay were dominant at stations, where the PHS exists at shallower depths. On the other hand, in back-arc side of southwestern Japan (Chugoku region), several distinct later phases were observed and effectively propagated at distance over 300 km. Especially, amplitudes of sSmS (Moho reflection of S waves) were lager than those of direct S waves and provided the peak ground velocities (PGV) at stations with distance larger than 150 km.

Simulation of seismic wave propagation

To clarify causes of such observations, we conducted finite-difference-method (FDM) simulation of seismic wave propagation in 3D layered structure JIVSM (Koketsu et al., 2008). The 3D model covered a region of 512 km$\times$320 km$\times$80 km, including Chugoku and Shikoku region of southwestern Japan. Since the model was discretized by grid intervals of 0.25 km in horizontal directions and 0.2 km in vertical direction, the FDM simulations can examine seismic wave propagation for frequency less than 1.5 Hz.

Although distinct later phases were also found in simulation results of JIVSM, simulation results did not perfectly reproduced the observed features, such as large amplitude sSmS and spindle-shape S waves in fore-arc side.

By travel-time tomography, the low-velocity anomaly (LVA) with high VP/VS ratio was detected just above the PHS at depths of 30-50 km (Hirose et al., 2008). Thus, according to this observation, we introduced the LVA in the simulation model, where the seismic S-wave velocities were reduced by 10% compared with the original JIVSM. By introducing LVA, impedance contrast between oceanic crust and mantle became smaller and consequently maximum amplitudes were found in sSmS rather than direct S waves. The LVA associated with subducting PHS affect the distribution of PGV of intraslab earthquakes in southwestern Japan.

Acknowledgement

We acknowledge the National Research Institute for Earth Science and Disaster Prevention, Japan (NIED) for providing the Hi-net waveform data and F-net CMT solutions. The computations were conducted on the computer system of the Earthquake and Volcano Information Center of the Earthquake Research Institute, the University of Tokyo.

Keywords: Seismic wave propagation, intraslab earthquake, Philippine Sea Plate, crustal structure, numerical simulation