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Later Phases Generated at an Intermediate-depth Discontinuity, Observed on Seismograms of Intraslab Earthquakes beneath SW Japan

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The Philippine Sea (PHS) plate is being subducted from Suruga and Nankai troughs beneath southwest Japan. Various later phases are observed on seismograms of intraslab earthquakes occurred within the PHS plate and the origins of two groups of later phases have been discussed in previous studies. One is a distinct pair of P and S direct waves (or channel waves) throughout the oceanic crust that are observed after the weak initial arrivals of P and S waves that travel throughout the oceanic mantle (e.g. Fukao et al., 1983). The other is a clear set of depth phases (e.g. pPmP, sPmP, sSmS) reflected at the free surface and the island arc Moho discontinuity or reflectors within the island-arc crust (Miyoshi and Ishibashi, 2007; Sekiguchi et al., 2008). In this study, we report preliminary results concerning another group of later phases that we detect on seismograms of intraslab earthquakes.

We examined waveform data recorded by the high-sensitivity network of Japan (Hi-net) for events of M4.0 or larger, occurred within the PHS plate, at 30-100 km depth beneath southwest Japan. On seismogram paste-ups prepared to detect later phases, an unknown, rather sharp later phase (referred here as X phase) can be observed. The X phase cannot be identified for all the target events, however we can detect it on vertical seismograms of many earthquakes. For example, X phases are identified on seismograms for the events beneath western part of Shikoku district, including some aftershocks (around 40-50 km depth) of the 2001 Geiyo earthquake, the event beneath the Kii Peninsula (Apr. 28, 2002; M4.1; 55.6 km depth) and the event beneath the eastern coast of Lake Biwa (Sept. 4, 2002; M4.3; 38.5 km depth).

The main features of the detected X phase are: (1) Apparent velocities are of about 10 km/s or larger, which is faster compared with the apparent velocity of the initial P-wave. (2) X phases are identified on vertical component seismograms. (3) They are clearly observed at about 150-200 km epicentral distance. (4) They arrive about 25-30 seconds after the arrival of the initial P-waves and are detected between the arrivals of sPmP and S waves.

The features of the detected X phase suggest that it might be a wave reflected (or converted) at an intermediate-depth discontinuity. To understand the origin of the X phase, we calculated theoretical travel-times assuming a 1-D velocity model and compared them with observed travel times. We search for the depth of the discontinuity by computing theoretical travel-times of PP and SP phases. As a preliminary result, X phase is considered a SP phase: a P-wave converted from the S-wave at about 100-180 km depth discontinuity. The depth of the reflector might be depending on focal depth.

If the observed X phase is a reflection (or conversion) wave generated at the bottom of the PHS plate (boundary between lithosphere and asthenosphere), the thickness of the PHS plate can be estimated to be about 90 km.