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Envelope broadening of S-waves from the inter- and intraplate earthquakes in the northeastern Japan forearc

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It is well known that the double-planed deep seismic zone is observed within the Pacific slab subducting beneath the northeastern Japan arc. Recently, the double-planed structure is also found in the shallow inter- and intraplate seismicity beneath the NE Japan forearc region. Appearances of observed seismograms are remarkably different between the earthquakes in the upper plane and those of the lower planes: Seismograms of the upper plane events show 1) indistinct direct P- and S- waves, 2) many later phases following direct P- and S-waves, and 3) comparatively low frequency. In contrast, seismograms of the lower plane events show 1) distinct direct P- and S- waves, 2) almost no later phases, and 3) comparatively high frequency. In this study, we evaluated the difference in the seismograms by measuring a time difference between the onset and the peak amplitude of S-wave envelope, a peak delay time. The peak delay time is mostly controlled by the strength of multiple forward scattering and diffraction due to the heterogeneous structure of short wavelength along a seismic ray path.

We analyzed seismograms recorded at the seismic stations in the forearc side of the NE Japan arc. Focal depths of the target earthquakes, the earthquakes belonging to the double-planed shallow seismic zone, were determined by using arrival times of sP depth phases recognized clearly on the seismograms. We calculated root means square (rms) envelopes of velocity seismograms of horizontal components in four frequency bands 2 - 4, 4 - 8, 8 - 16, and 16 - 32 Hz to measure the peak delay time (PDT). The measured PDTs grow as hypocentral distances increase. In order to evaluate the dependence of the PDTs on the hypocenter locations, we corrected the distance dependence of the PDT by taking deviations from a linear regression line of log-PDT against log-travel time (delta log PDTs) in each frequency band.

As a result, it turns out that the earthquakes belonging to the shallow double seismic zone can be divided into two groups according to the delta log PDTs. The delta log PDTs measured for the interplate earthquakes are significantly large and show no noticeable frequency dependency. In contrast, the intraplate events are characterized relatively small delta log PDTs. The PDTs measured for the intraplate earthquakes show positive frequency dependence: PDTs are larger for the higher frequency band. Conspicuous difference in S-wave envelopes between interplate and intraplate earthquakes indicates that the envelope shape is strongly dependent on the hypocenter locations in relation to the plate boundary. We suggest that formation of guided wave through the low velocity layer along the plate boundary contributes to considerable broadening of S-wave envelopes of the interplate earthquakes.

Keywords: oceanic lithosphere, intraplate earthquake, S coda wave