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# Diffracted P and S Waves Excited by Shallow Inland Earthquakes

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We investigate effects of subsurface structure on diffracted P and S waves excited by shallow inland earthquakes. A shallow earthquake (Mw4.6) occurred on December 2, 2010 beneath the Ishikari plain. The record sections of velocity waveforms along a profile in the NNW direction from the epicenter (NNW profile) show conspicuous later phases at about 2 sec and 4 sec after the direct P and S waves. Both of the direct and later phases have apparent velocities of about 6 km/s and about 3 km/s for P and S waves, respectively; these values are nearly the same as P and S wave velocities of the seismic basement. The amplitudes for the direct and later phases attenuate with $L^{-2}$, where L is the epicentral distance, beyond a certain distance, but the amplitudes of the later phases are larger than those of the direct waves. These conspicuous later phases are also visible on the observed aftershock records along the NNW profile. However these phases are not visible on the records at stations with the different directions.

Ben-Menahem and Singh (1981) obtained approximate solutions for the wave field from a point source in a layered half-space; these solutions were derived from manipulation of integral paths in the complex wavenumber plane. The solution for a point source in the layer is well known as generation of head waves (or conical waves). They also showed the solution for a point source in the half space generates diffracted waves when the source is located very near the interface. The latter case is similar to our observation, because the source is laid beneath the sediment-seismic basement interface as shown below. In this case, the ray of the later phase is reflected 2 times inside the layer before it reaches the observer; the 2 times reflection points are the free surface and the interface. Shigefuji et al. (2012) made theoretical consideration of the wavefield from a point source in the layered half space. They concluded the direct and later phases mentioned above are diffracted waves. Here, to understand the generation mechanism of the conspicuous later phases on the observed records along NNW profile, we make the finite difference method simulation (Aoi and Fujiwara, 1999; Pitarka, 1999) using the 3D velocity structure model of deep sedimentary layers after AIST (Yoshida et al., 2007) and the source parameters after Shigefuji et al. (2012). The seismic basement of the NNW profile is roughly flat and the thickness of the sedimentary layer is about 4 km, and the focal depth is set at a depth of 5 km.

The synthetic waveforms well reproduce the features of the observed waves along the NNW profile. On the basis of the above considerations, we revealed that the direct waves and the conspicuous later phases on the NNW profile are the direct and reflected diffracted P and S waves generated when the source is located near the sediment-seismic basement interface. These also indicate that the AIST velocity structure along this NNW profile is reasonable. The analysis of the diffracted wave is important to verify the structure.

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Keywords: Diffracted P and S waves, Shallow Inland Earthquakes, Three dimensional simulation, Deep subsurface structure