

# Low-frequency converted waves from the earthquakes off the Pacific coast of the Tohoku district

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Seismic waves are converted at the structural boundaries with large acoustic impedance, for example, the Earth's surface and plate boundary. High-frequency converted waves visible on seismic records, such as the sP phase, have been used to investigate offshore earthquakes' source depths and focal mechanisms where the station coverage is poor. However, the nature of low-frequency converted waves has not been examined so far because they are almost invisible on seismograms even if they exist. Here we tried to find and characterize the low-frequency converted waves from the broadband seismograms by correcting for the instrumental response and some simple visualization techniques. The former correction enables us to investigate seismogram's lower frequency components that are less sensitive to short-wavelength heterogeneities in the lithosphere. The other technique is the amplitude modulation by auto-gain-control and station averaging (stacking) of seismograms with variable reduction velocity (slant stack). We first picked up several traces with a large amplitude from the slant stacked seismograms. We obtained about 3,000 vertical and radial components traces from 1,056 earthquakes with focal depths less than 70 km located offshore from Hokkaido to Ibaraki prefecture. Next, we calculated the cross-correlation of the waveforms and grouped earthquakes by the correlation clustering for several bins of reduction velocity (apparent velocity). The spatial distribution characteristics of grouped earthquakes depend on neither the apparent velocity nor clustering parameters. Focal depths and focal mechanisms are typical among the earthquakes in a group. In other words, the earthquakes with reverse faulting and normal faulting are separated into different groups. The earthquakes in some groups tend to align along the iso-depth contour of the Pacific plate. One interesting feature is observed for earthquakes located west of the Japan Trench off Iwate and Miyagi prefectures. There are several groups in an area of 100 km in the E-W direction and 200 km in the N-S direction. The spatial extent of some groups partly overlaps. Though the depths and focal mechanisms do not differ significantly among the groups, the difference in waveform characteristics is evident. This observation suggests some unknown mechanisms to produce the difference in seismograms from the earthquakes with nearly the same location and focal mechanisms. One possibility is the difference in the focal depths of earthquakes at the plate boundary, in the overriding pale, oceanic crust, and oceanic mantle. Though the centroid depths and CMT solutions are useful for distinguishing them, our results imply the resolution is insufficient. The low-frequency converted waves may additionally help distinguish earthquakes occurring near the plate boundary far off the Pacific coast, particularly for earthquakes that occur before the operation of the S-net. The 3-D numerical simulation of seismic waves is useful to investigate the origin of the difference in the seismograms mentioned above, which is the next step of this study.

Keywords: converted waves, low-frequency, off the Pacific coast, Tohoku