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Low intensity of plate-boundary S-S reflections within a region of high intensity of P-P reflections and low seismicity

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It has been pointed out that space distribution of microearthquakes along the forearc slope of the Japan Trench in northeast Japan is not uniform. A location map of the microearthquake epicenters determined by Tohoku University show clustered seismically active zones, which are oriented perpendicular to the trench axis. One of clear seismic-aseismic boundaries can be identified in latitude 39 degrees north. A seismic velocity structure survey was conducted in 1996 with one experiment line running over the boundary. A P-wave velocity structure model was obtained by travel-time inversion (Fujie, 1999). A quite good anti-correlation between plate-boundary-reflected P-P wave intensity and seismicity was found (Fujie et al., 2002). They discussed that a thin layer with its thickness up to a few hundred meters and with its P-wave velocity of 3~4 km/s could explain the intense reflections. Results of finite-difference waveform calculations support this estimation (Moghaddam, 2002). For a good estimation of materials and the physical properties along the plate boundary, it is important to obtain S-wave velocity structure. The objectives of this study are to determine S-wave velocity structure, and verify the anti-correlation between the intensity of S-S relfected waves and the seismicity.

There was only one survey line parallel to the trench axis across a seismic-aseismic boundary in the 1996 experiment. It was not possible to verify applicability of the observed anti-correlation to a landward-extended region. We carried out a seismic experiment in 2001 in the same region as the 1996 experiment. Thirty-nine OBSs were deployed along seven survey lines. One of the lines closely overlaps a part of the 1996 NS-line. Airguns were used as artificial seismic sources, and their total chamber volume was ~57 liters. Absolute orientations of OBS horizontal-component seismometers were determined using horizontal-component waveforms of the direct water-wave arrivals (Yoneshima, 2001). Substantial P-S conversion at the base of the sediment layer was observed by most of the OBSs. S-wave velocity in shallow structure was determined by the tau-p mapping of the OBS horizontal component. Vp/Vs ratios for the sediment were derived to be 5.2 for the upper and 2.3 for the lower sections. Vp becomes larger than 4.0 km/s below the sedimentary layers, and Vp/Vs ratios of 1.8 to 1.74 were applied to the deeper structure. The calculated travel-times for the P-S converted refracted waves explained the observations well.

Such intense amplitude as observed for the plate-boundary P-P reflections were not identified for the S-S reflections. The incident angles of P-S converted waves to the plate-boundary are smaller than those of P-P reflected waves. However, differences in the incident angles do not seem an important factor. The plate-boundary P-P intense reflections could be explained by putting a thin low-velocity layer with Vp=3~4 km/s (Fujie et al., 2001). However, in order to suppress the S-S reflections, Vs contrast across the plate boundary must be low. Vp becomes 6km/s at the bottom of the overriding plate (Fujie et al., 2001), and if Vp/Vs=1.8 is assumed, Vs is expected to be 3.3 km/s. The S-wave velocity in the thin layer must be close to the value of 3.3 km/s in order to restrain contrasts in Vs. However, this is not realistic for a thin layer with Vp=3~4 km/s. Therefore, additional features such as a very high S-wave absorbability may be required. Smectite contains inter-layer water in itself, and shows a low-permeability characteristic. If smectite is highly contained at the top of the thin layer, it can work as a sealing material to pack water within the layer. The packed water can be a factor for high S-wave absorption. Further investigations incorporating finite-difference waveform calculations are needed for more detailed discussions.